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9.0 Green Specialist Body of Knoweldge

"This product was funded by a grant awarded under the Workforce Innovation in Regional Economic Development (WIRED) Initiative as implemented by the U.S. Department of Labor's Employment & Training Administration. The information contained in this product was created by a grantee organization and does not necessarily reflect the official position of the U.S. Department of Labor. All references to non-governmental companies or organizations, their services, products, or resources are offered for informational purposes and should not be construed as an endorsement by the Department of Labor. This product is copyrighted by the institution that created it and is intended for individual organizational, non-commercial use only."

PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM

Green Generalist Workshop



Green 101

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Course Agenda

Welcome & Green Workforce Program Structure

What is “Green”?

Sustainability and Global Conditions

- Round 1 of Simulation

Solid Waste Generation / Material Use

Energy Management

- Round 2 of Simulation

Chemical Waste Generation / Green Chemistry

Climate / Air Emissions Management

Supply Water / Wastewater Management

- Round 3 of Simulation

Environmental Business Management

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Green Workforce Program Structure

- **Waste Stream Mapping (WSM)**
  - Audience: General Workforce, Green Project Teams
  - Duration: 2 days (Day 1 – “As Is” / Day 2 – “To Be”)
  - Approach: Training with Hands-on WSM Development
- **Green Specialist Training**
  - Audience: Plant Engineers, Environmental Managers, Green Team Participants, etc.
  - Duration: 1 day per module (6 modules)
  - Approach: Training with Hands-on Application / Simulation
- **Green Specialist Certificate Preparation**
  - Audience: Plant Engineers, Environmental Managers, etc.
  - Duration: 3 days
  - Approach: Training only for Certificate Exam with Accreditation through Society of Manufacturing Engineers (SME)

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What does being "Green" mean to you?





Green Concepts

- Healthier living
- Conserving natural resources
- Choosing non-toxic products
- Reducing your carbon footprint
- Recycling and reusing materials
- Buying local products
- Being socially responsible
- Reducing energy costs
- Being gentle to the Earth
- Investing in a better future



Going Green

Simply a matter of making different, better choices:

- Transportation alternatives
- Energy alternatives
- Refuse, Reduce, Reuse, Recycle
- Renewable vs. nonrenewable resources
- Buy local (groceries, building materials, services, etc.)
- Use natural alternatives (cleaning, weed control, fabric, etc.)
- Eco-friendly investments

Responsible Manufacturing

To be classified as a *Responsible Manufacturing or Clean Production* process, it should result in a significant benefit to the environment in one or more of these areas:

- Water usage
- Chemical usage
- Energy usage
- Emissions
- Heavy metals in products
- Hazardous and toxic waste releases
- Solid waste generation

Make it Real – Going Green

At Home:

- Buy local -- buy food (or any good or service) produced, grown, or raised as close to your home as possible.
- Look for electronics that are rechargeable. Lithium-ion (Li-Ion) and nickel metal hydride (NiMH) are cost-effective, green battery alternatives.

At Work:

- Recycle metal, glass, plastic and paper. Many companies make products from recycled materials now so help contribute. Also buy products with recycled content.

Globally:

- Adopt “Bring your own bag” around the world.

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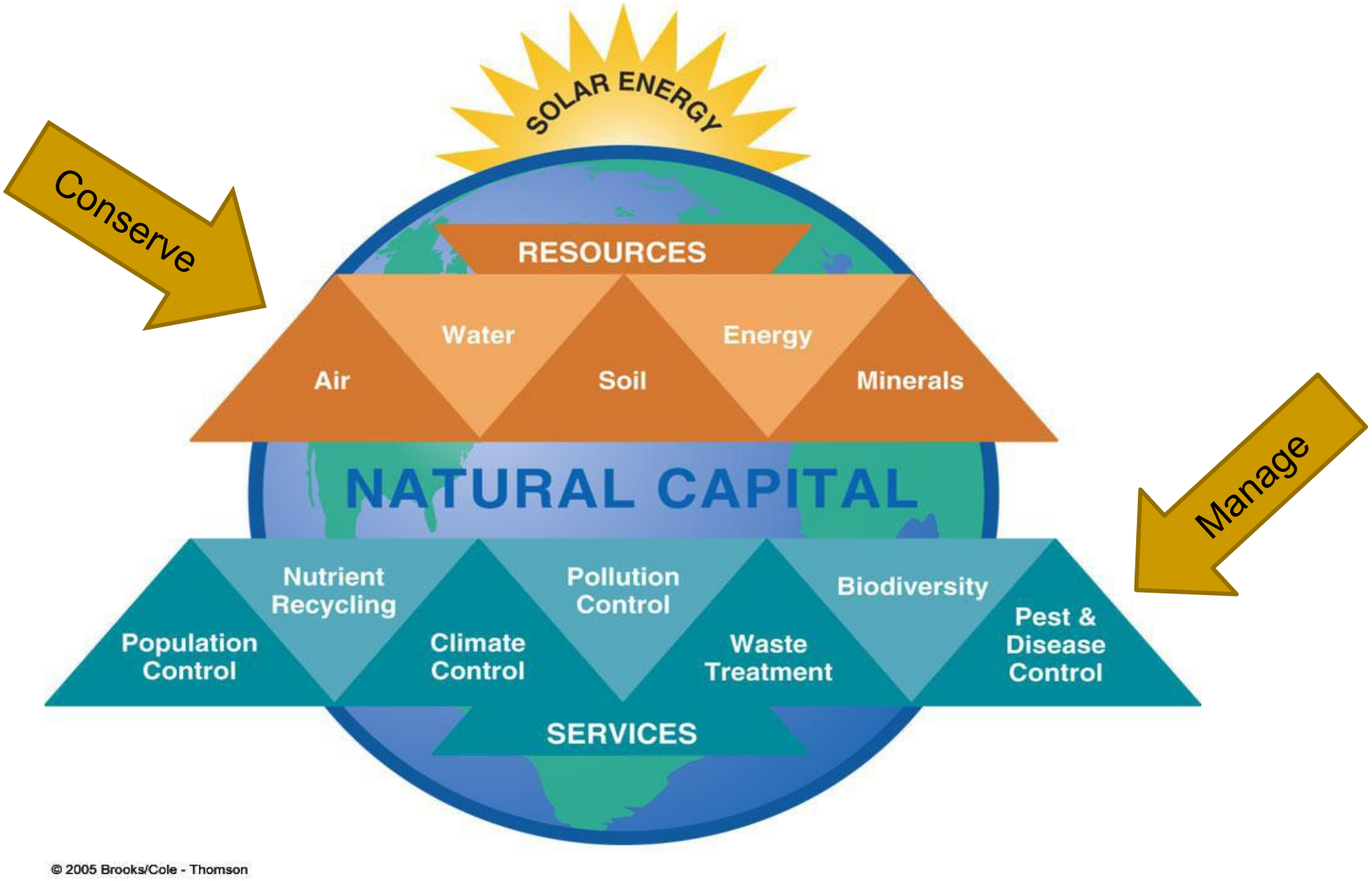
- Round 3 of Simulation

Environmental Business Management

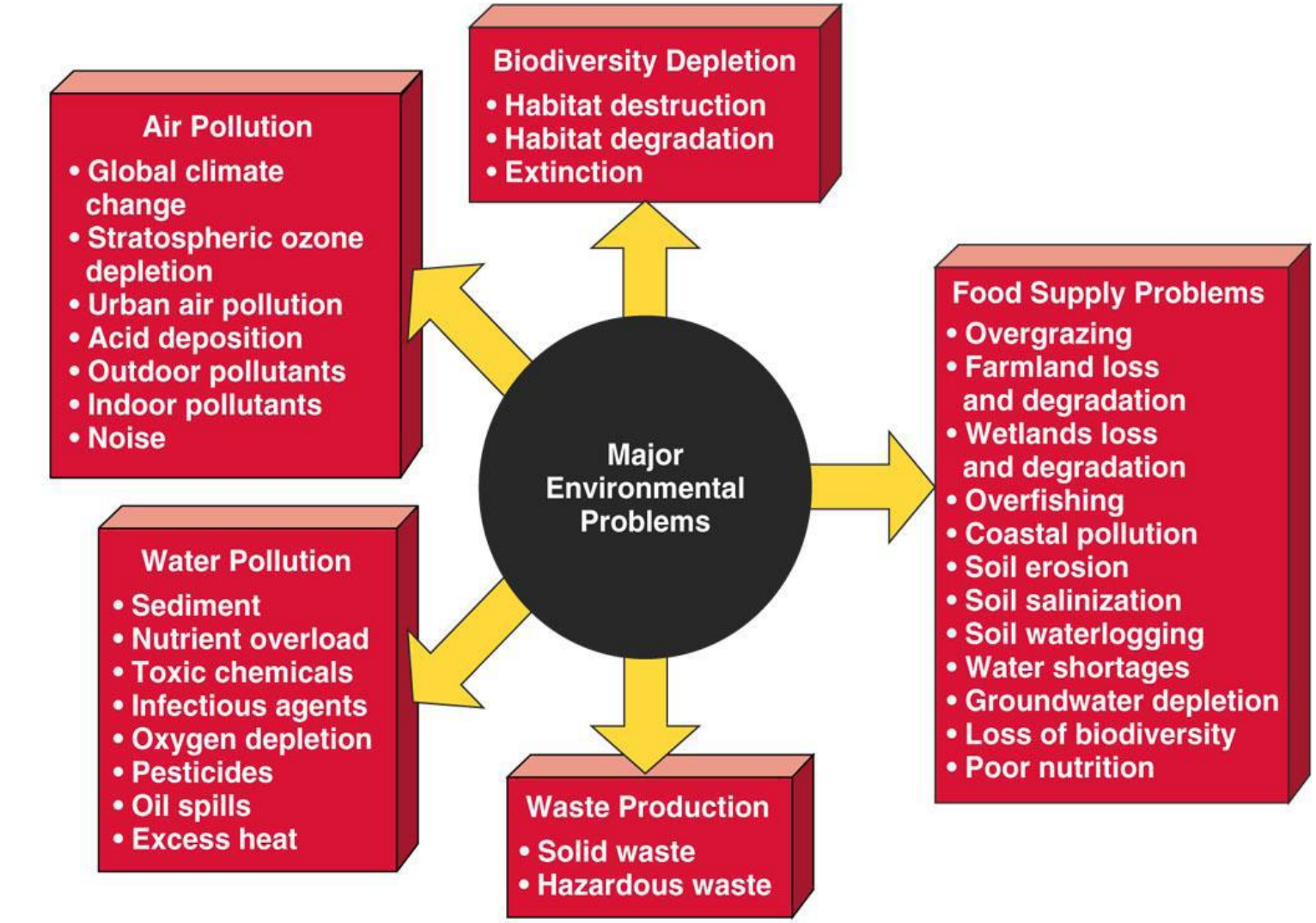
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Sustainability – Global Impact



Environmental Focus Areas



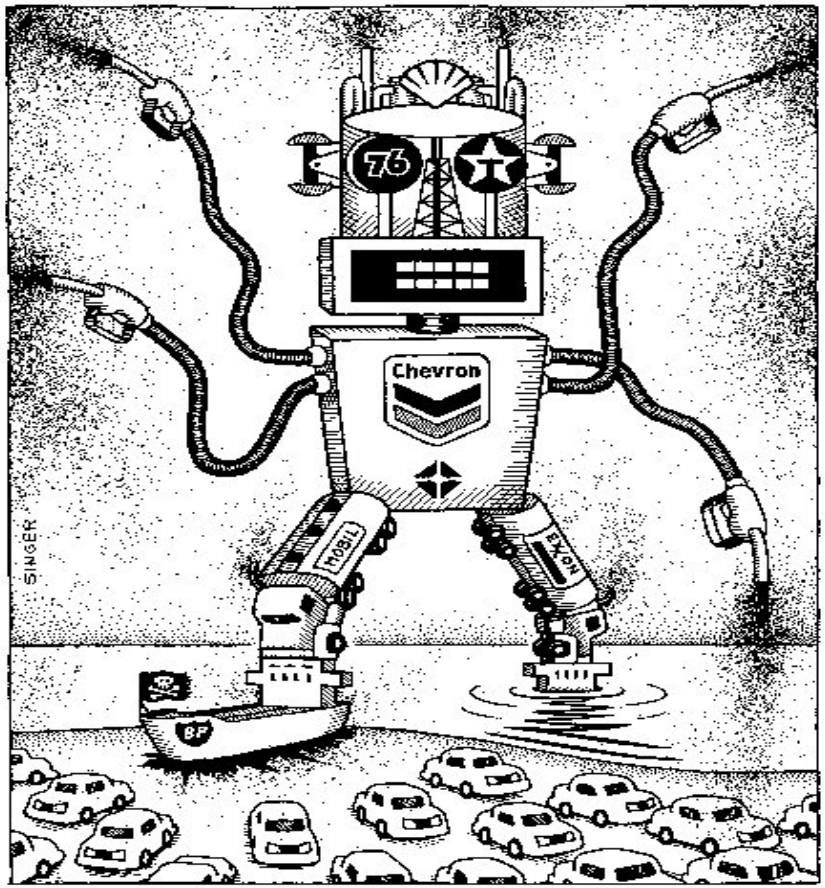
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Climate Change – Greenhouse Gases

Many greenhouse gases are created and emitted through human activities:

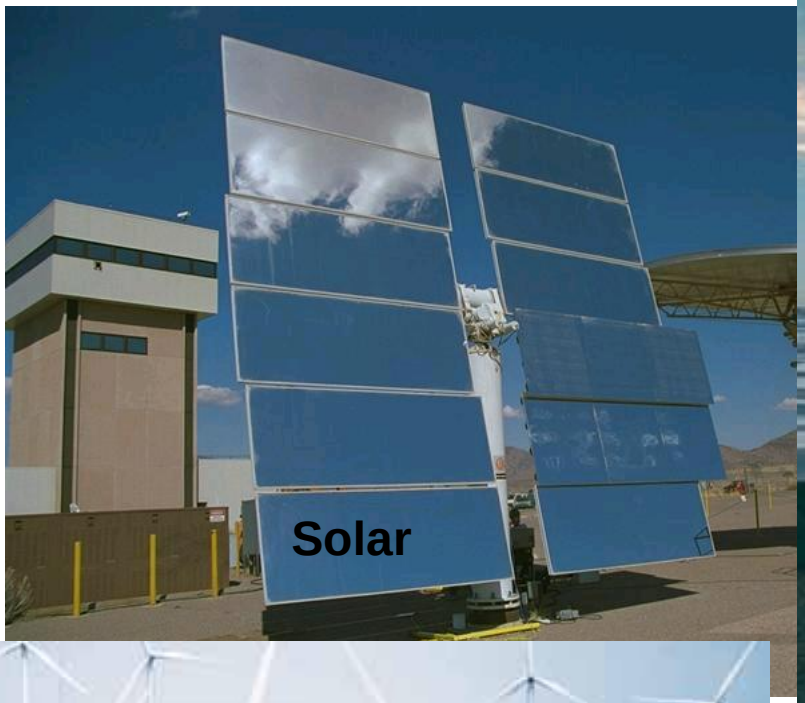
- Hydrofluorocarbons (HFCs)
- Electric energy production (fossil fuel combustion)
- Animal agriculture
- Deforestation
- Transportation emissions

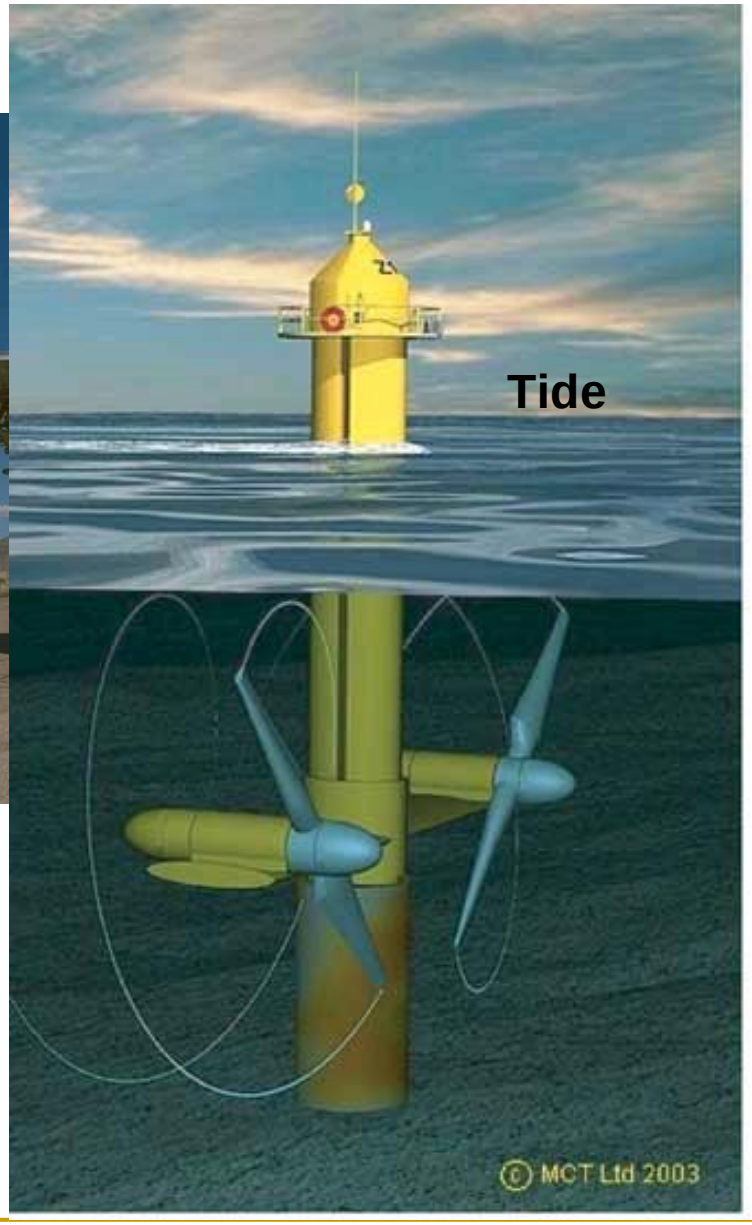
Unsustainable Energy Sources





Sustainable Alternative Energy







Natural Resource Protection

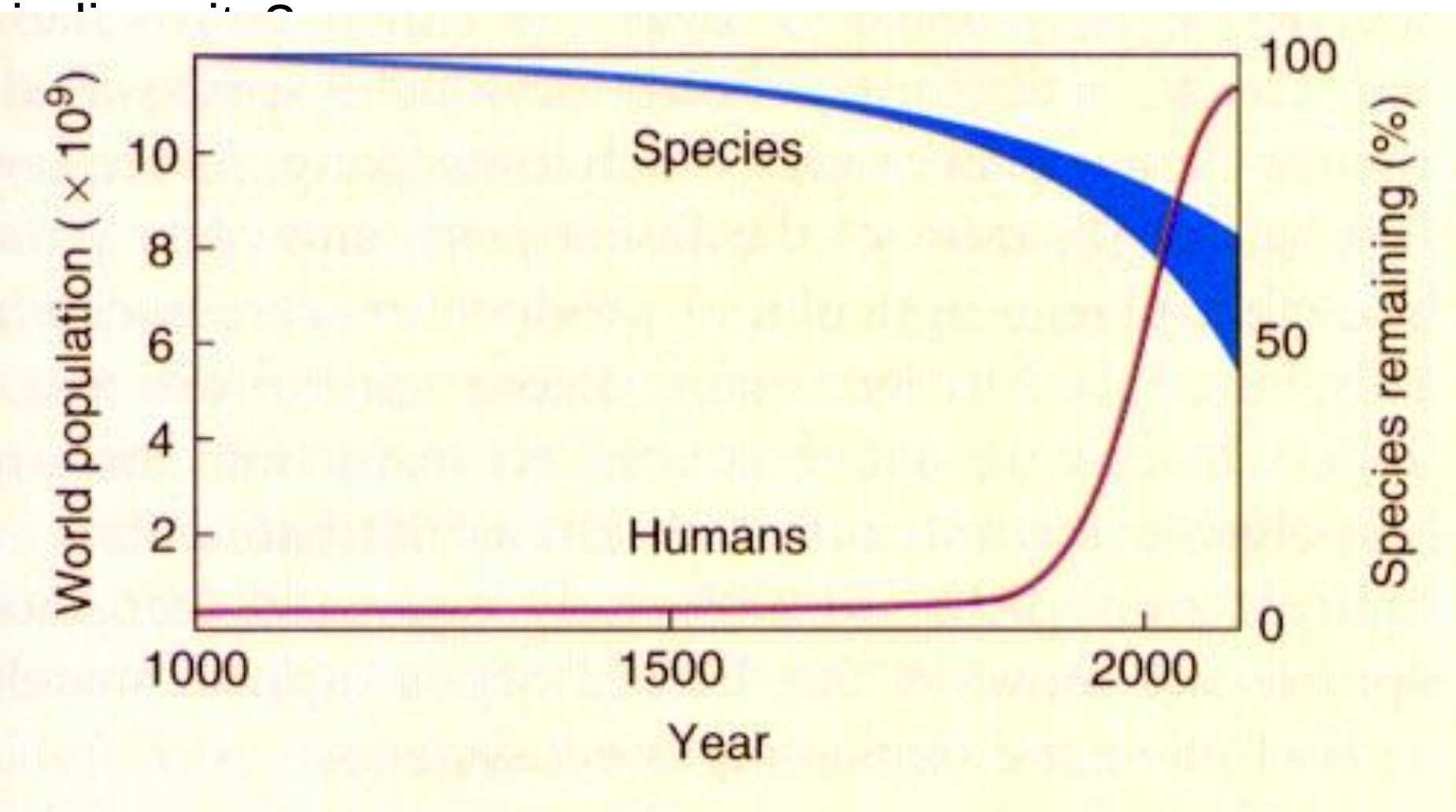
The largest spatial impact of human activity is ***land use to grow food.***



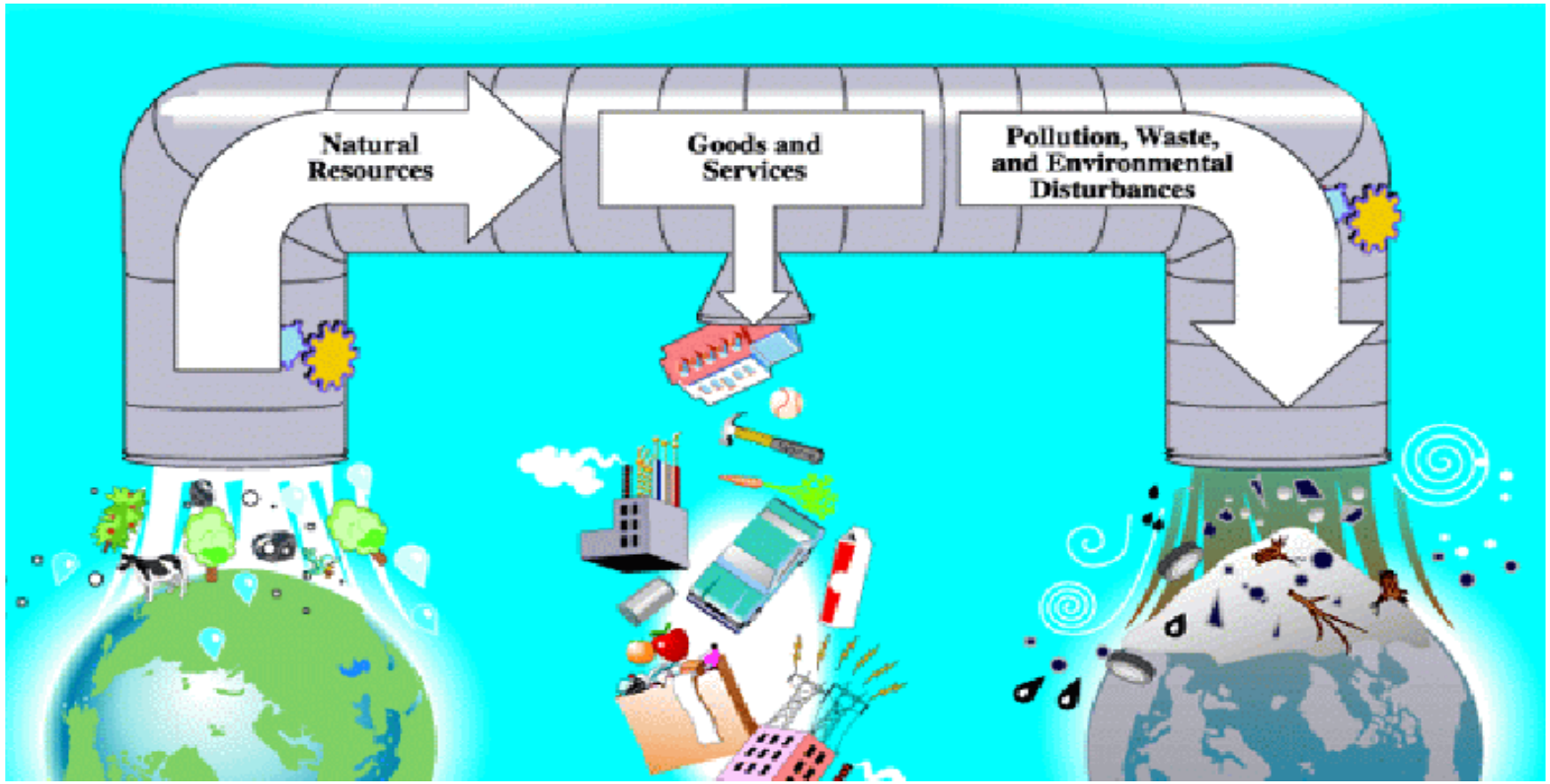


Ecosystem Biodiversity

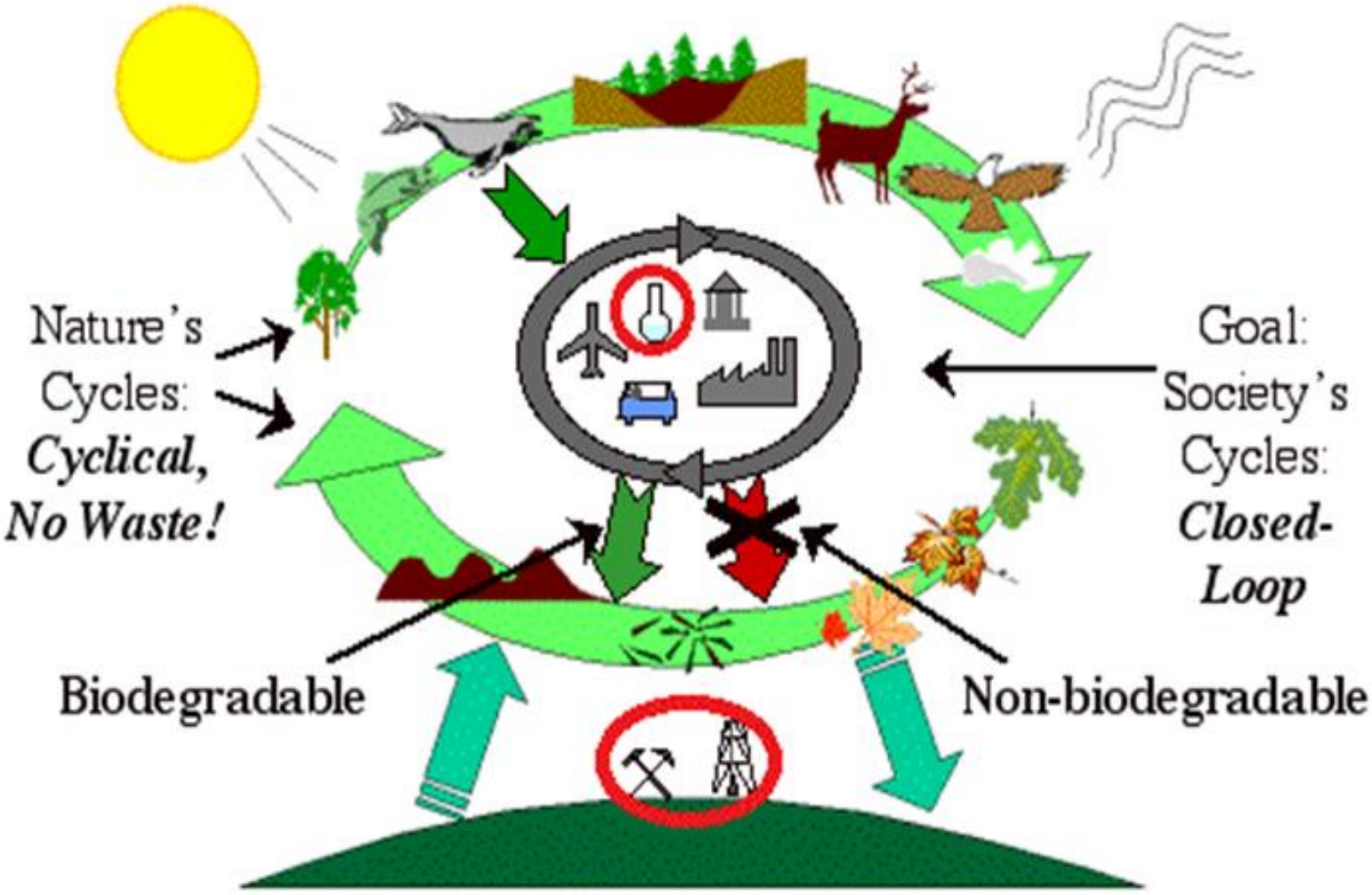
How does human population growth impact b



Current Industrial Cycle: Linear



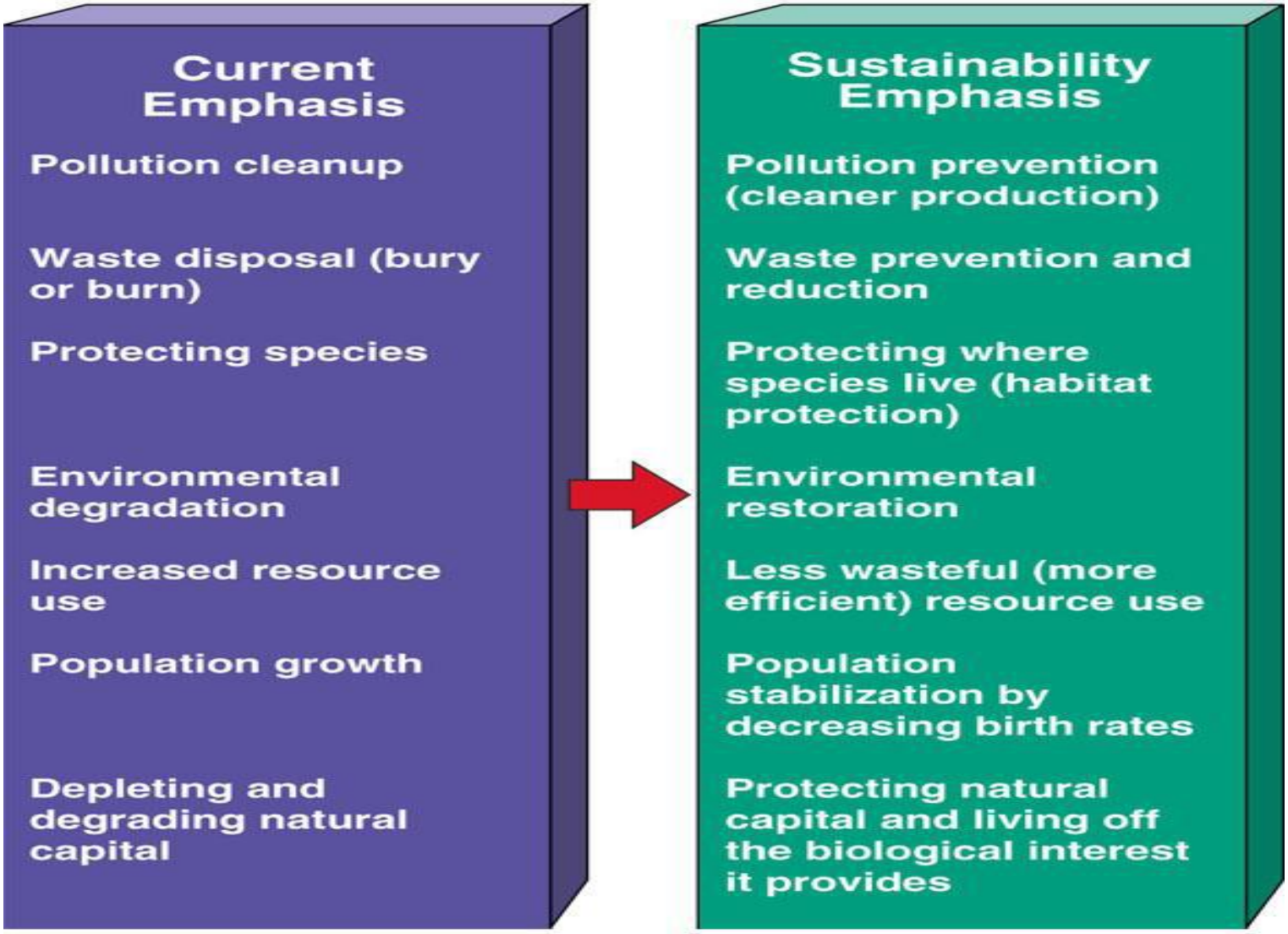
Sustainable Industrial Model: Nature's Cycle



Measure Your Sustainability

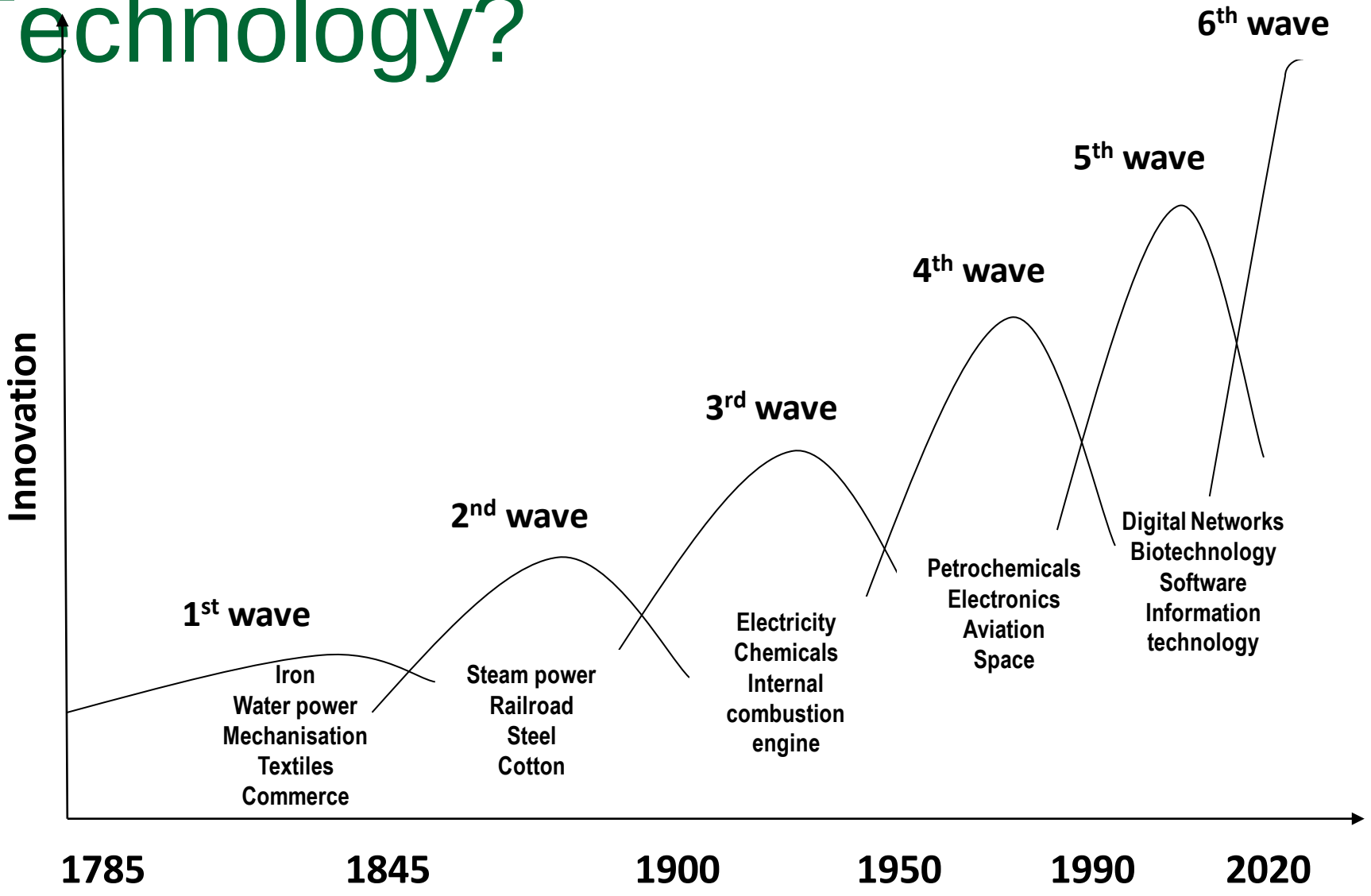
- Type and rate of material and water use
- Amount and type of energy consumption
- Amount and toxicity of waste and emissions
- Amount of land used or reused
- Development of workers

Move from Reactive to Proactive



© 2005 Brooks/Cole - Thomson

What is Next Leapfrog Technology?



Make it Real - Sustainability

At Home:

- Think about whether you really need something new before buying it and throwing away something old. Donate the old item if possible.
- Buy electricity from renewable energy sources like wind farms.

At Work:

- Switch company-owned vehicles to hybrids (may qualify for tax breaks.)
- Reduce printing and recycle all paper that must be used. Buy and use recycled paper whenever possible.

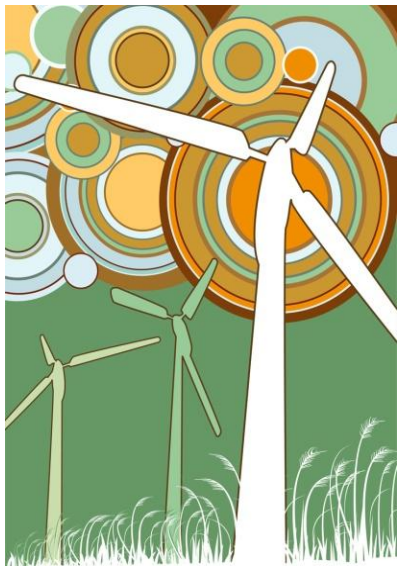
Globally:

- Save and restore rainforests to maintain proper biodiversity levels.

Course Agenda

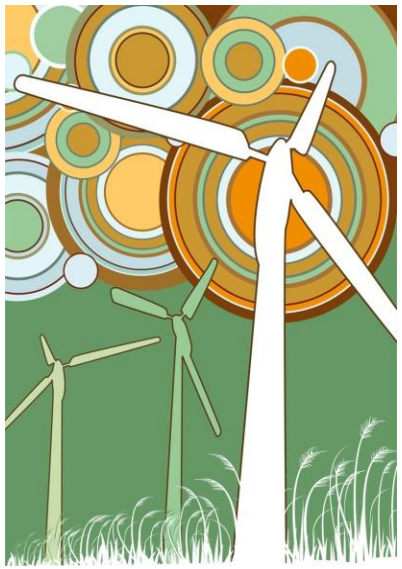
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Simulation Scenario – Round 1



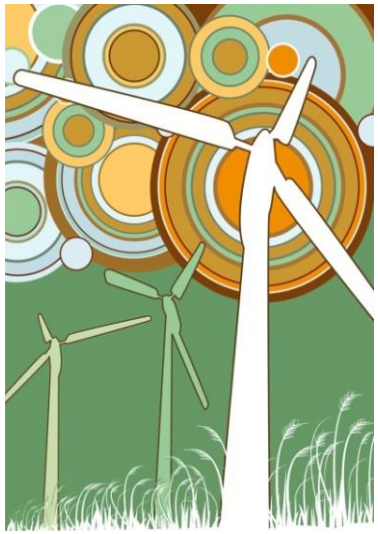
- New Wind Co. will be simulated involving many of the typical activities of a manufacturing business.
- New Wind Co. is a new start-up and produces micro wind turbines used to generate alternative energy.
- A “day” will be 20 minutes.

Simulation Scenario – Round 1



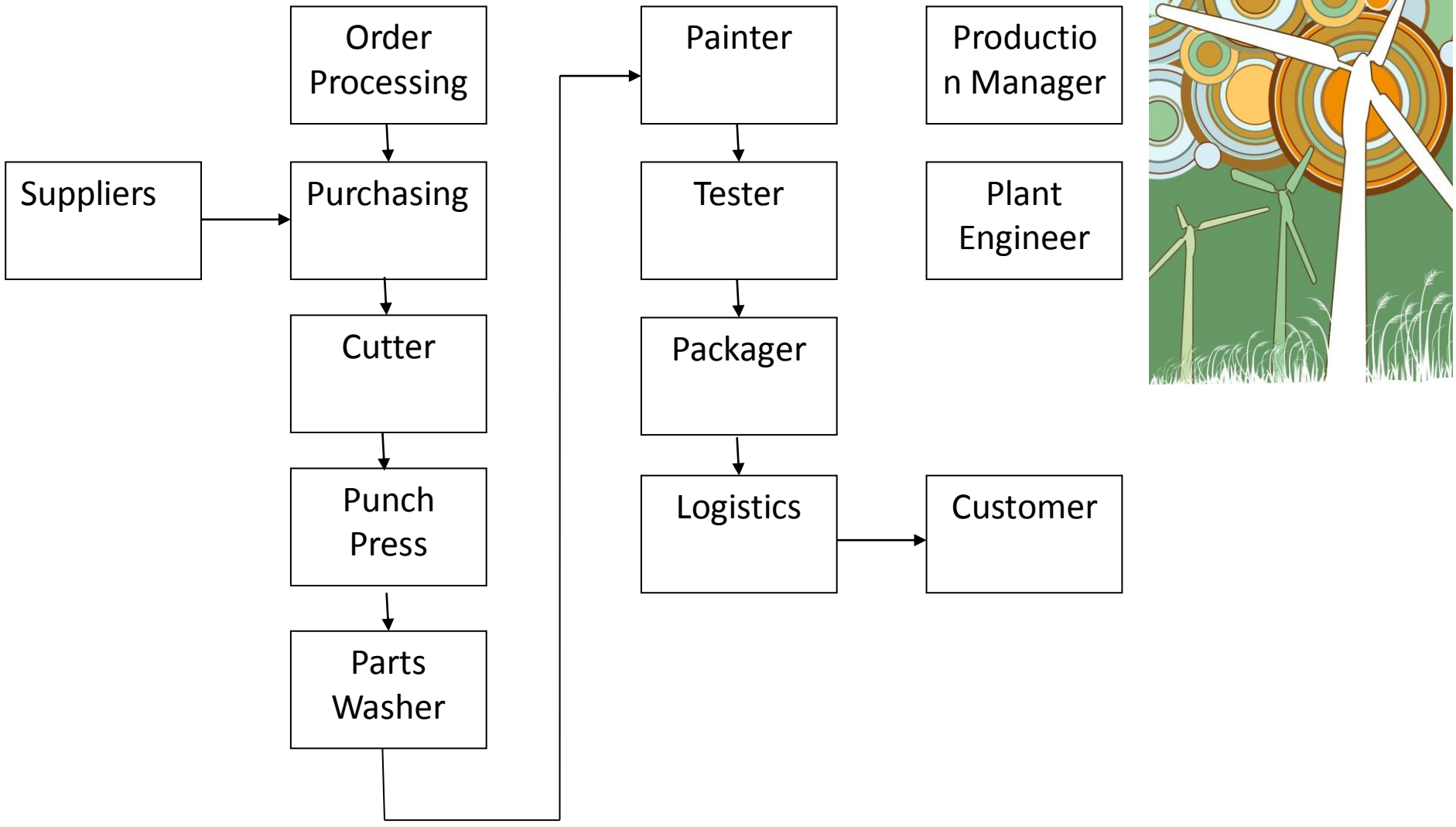
- New Wind Co. is getting pressure from their key customer to work toward a Zero Landfill goal which will also reduce their overall Carbon Footprint.
- New Wind Co. also has an interest in being good environmental stewards within their community since they are constructing products intended for generation of alternative energy.

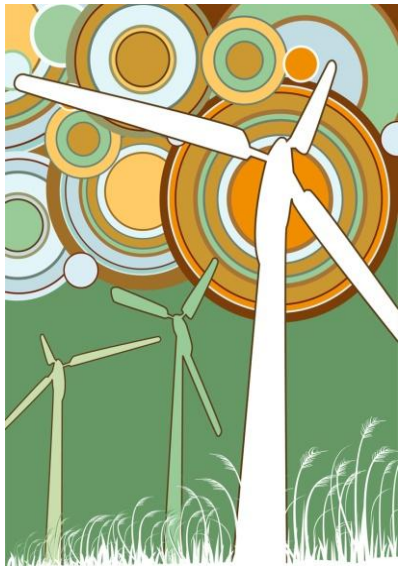
Simulation Scenario – Round 1



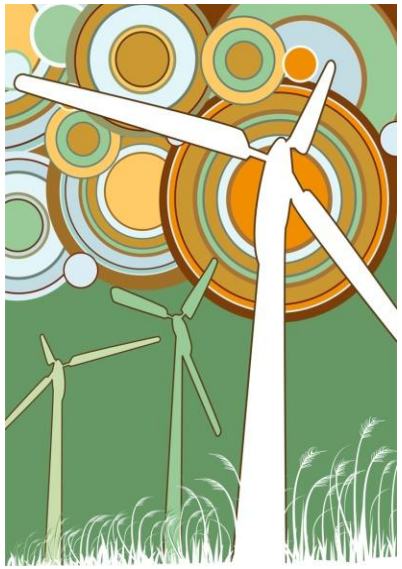
- Participants will assume the roles of:
  Purchasing, Order Processing, Supplier, Production Mgr, Cutter, Punch Press, Assembler, Parts Washer, Painter, Tester, Packager, Logistics, Customer, Plant Engineer.
- Other participants will serve as “Observers”.
- Performance will be measured at the end of each “shift” and at the end of the “day” including:
  - Material Wasted, Energy Used, Hazardous Waste Disposal Quantity, Number of Customer Orders Delivered, Product Quantity Delivered, Returns.

Simulation Scenario – Round 1





Simulation – Round 1 Lessons Learned



- What was the outcome of the process? (Report out all measurements.)
- What do the performance measures tell you?
- What did the Plant Engineer identify in the Audit Checklist?
- How does this relate to your actual experiences in your facility?

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Solid Waste Streams

- Paper
- Glass
- Metal
- Plastic
- Electronics
- Organic
- Construction/
  Demolition
- Hazardous
- Special/Universal
- Mixed Residue

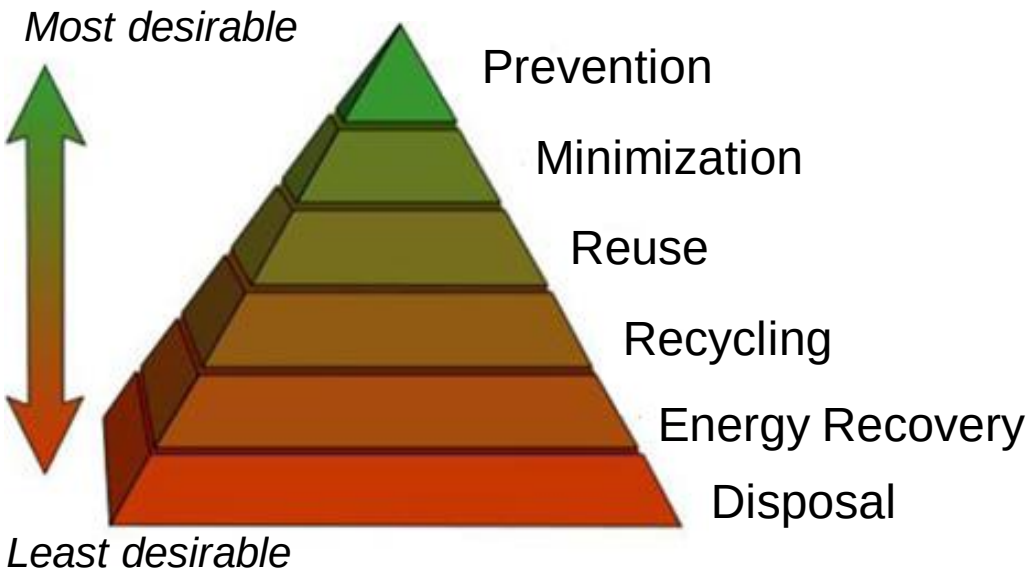


How is Solid Waste Managed?

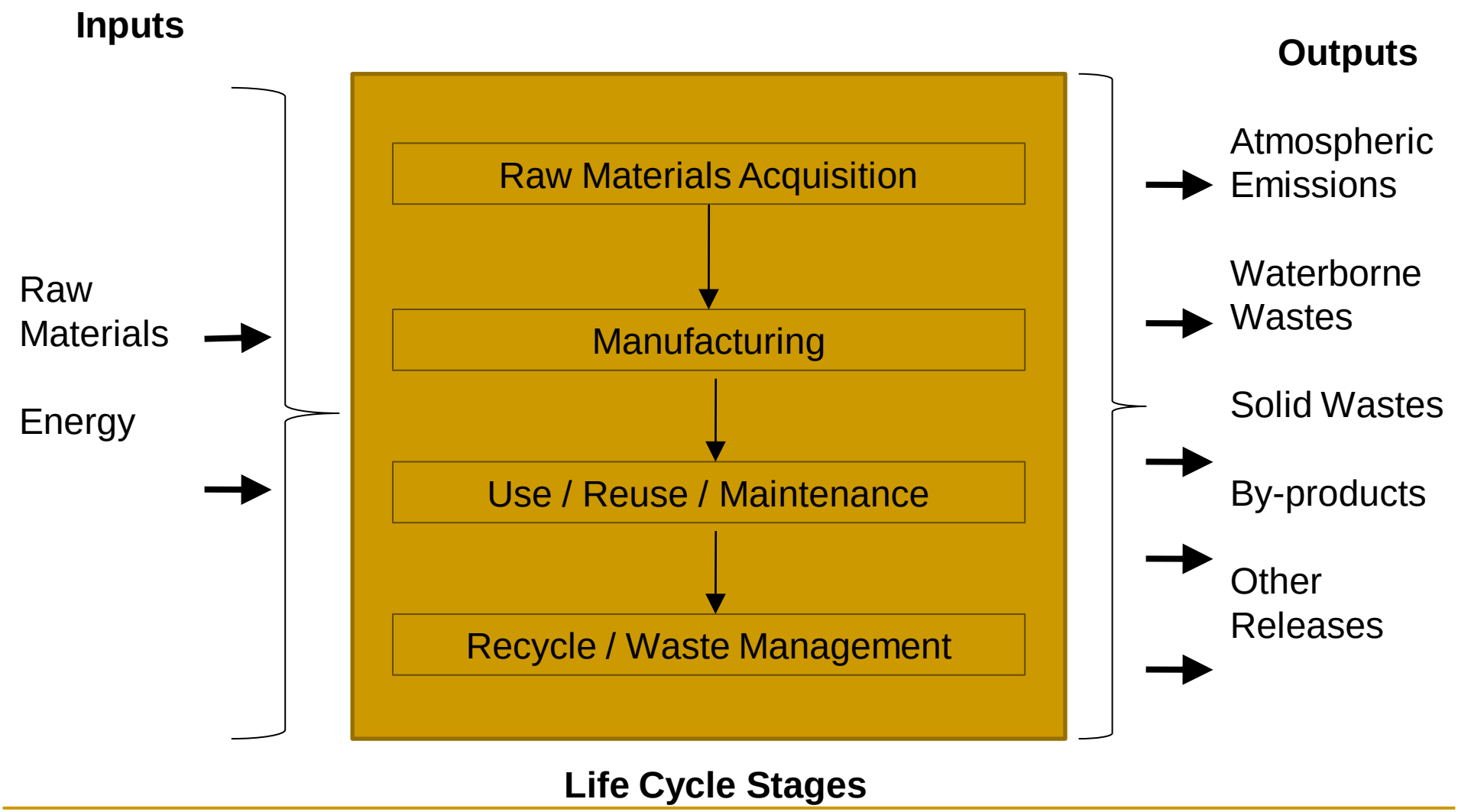
- **Landfill** - Burying waste which is normally compacted first.
- **Incineration -** Burning of waste material to convert waste materials into heat, gas, steam and ash.
- **Recycling -** Extracting resources or value from waste to recover or reuse the material.
- **Energy Recovery –** Harnessing the energy content of waste products directly by using them as a combustion fuel, or indirectly by processing them into another type of fuel.
- **Avoidance and Reduction Methods –** Includes:
  - reuse of second-hand products,
  - repairing broken items instead of buying new,
  - designing products to be refillable or reusable or use less material, and
  - avoiding use of disposable products.

Refuse, Reduce, Reuse, Recycle

- *Refuse* to buy new when current one is still usable.
- *Reduce* amount and toxicity of discarded trash.
- *Reuse* containers and products; repair what is broken.
- *Recycle* as much as possible; also buy products with recycled content.



Product Lifecycle Assessment



Alternative Materials Example

DuPont now produces high-performance thermoplastic resins and elastomer products made from *corn sugar* rather than petroleum.

- The products are targeted for automotive, electrical, electronic and other industrial markets.
- Offers their customers the benefits of renewably-sourced materials and reduced dependence on petrochemicals.
- Also requires approximately 40% less energy to manufacture than the earlier version.
- Contributes to the company's goal to drive 25% of its revenue from non-depletable resources by 2010.

Refuse

Waste Prevention means consuming and throwing away less by:



- If you don't need it, don't buy it.
- Refusing products with excessive or non-recyclable packaging.
- Refuse to purchase throw-away items or cheaply made items that need to be replaced quickly.
- Refuse materials that require extra processing or additional energy to process, whenever possible.

Reduce

Waste Reduction requires looking at the source of the waste to determine how it can be minimized by:

- Purchasing durable, long-lasting goods;
- Seeking products and packaging that are free of toxins;
- Using the minimum amount of energy required;
- Redesigning products to:
  - Use less raw material in production,
  - Have a longer life, or
  - Be used again after its original use is complete.



By-Product Reduction

- Design products for the environment.
- Restructure production and distribution systems to prevent waste from being created in the first place.
- Purchase products and materials that will result in fewer by-product outputs.
- Find internal uses for the waste that is generated.

By-Product Examples:

Absorbents	Batteries	Cardboard
Machining fluids	Grinding swarf	Metal scrap
Plastic strapping	Paper	Rubber tubing
Sludges	Solvents	Textiles (rags)
Pallet wood	Product lubricants	

Reuse - Benefits

- No reprocessing before it can be used again -- even better than recycling.

- Reduces waste - by repairing, donating to charity and community groups, or selling reusable items.







Reuse with Waste Exchange

Recovering the output of one Waste Stream to use as input for a manufacturing process.



Examples:

- Recovered glass in roadway asphalt (glassphalt).
- Recovered plastic in carpeting, park benches, and pedestrian bridges.

Recycling Process

- Collecting recyclable materials that would otherwise be considered waste;
- Sorting and processing recyclables into raw materials such as fibers;
- Manufacturing these raw materials into new products;
- Purchasing recycled products completes the recycling loop.



Reuse & Recycling Considerations

- Amount of material available for processing
- Concentration of collection sites
- Ease of separation of components
- Purity of materials / Mixed materials
- Consistency of waste stream quantity
- Proximity to the re-processing facility
- Inherent value of the waste stream output

Zero Waste / Zero Landfill



Results from Implementing 4Rs



- Increasing resource productivity/ eco-efficiency
- Stimulating development of greener technologies (New business = creation of jobs)
- Conservation of resources
- Supplying valuable raw materials to industry without harvesting them from Earth
- Reducing the need for new landfills and incinerators
- Preventing greenhouse gasses and water pollutants
- More profitability

4Rs in Manufacturing

4Rs can be used in all phases of manufacturing:

- *Purchasing* recycled-content materials and components wherever feasible;
- *Use and reuse* a variety of materials within production, test, assembly and packaging;
- *Produce* recyclable products for the customer with minimum materials;
- Supply secondary markets with *usable by-products* generated by waste streams.

Make it Real – Solid Waste

At Home:

- Select items wrapped in paper or cardboard, or not wrapped at all. Recycle the packaging (check plastic packaging for recyclability.)
- Take a reusable container for water, coffee, etc. rather than plastic water bottles or styrofoam drink cups.

At Work:

- Minimize waste – avoid surplus coating, cut-aways, trimming, by-products – in all production processes.
- Reduce the need for packaging; use packaging that contains recycled content or compostable material. Also consider reusable packaging.

Globally:

- Use appropriate waste, e.g., livestock waste, as a power source.
- Restrict purchases to recyclable or recycled materials and products to reduce the waste stream to zero.

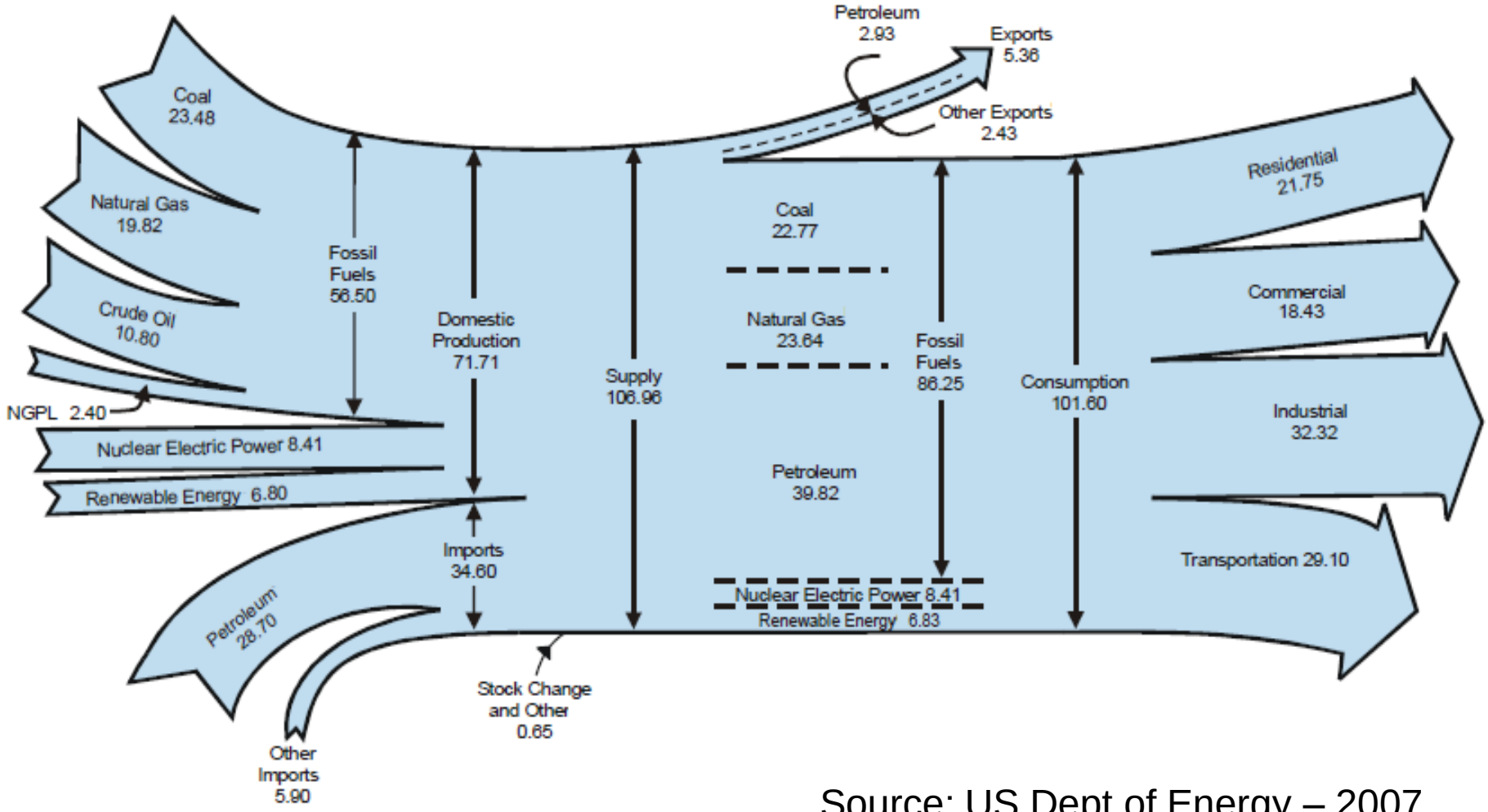
4Rs Exercise

- Think about your current work environment.
- Write down one example for each of the 4Rs (Refuse, Reduce, Reuse, Recycle) that could be implemented easily but has not been done yet.
- Also write down the names of other people in your company that would need to be involved if these changes are made.

Course Agenda

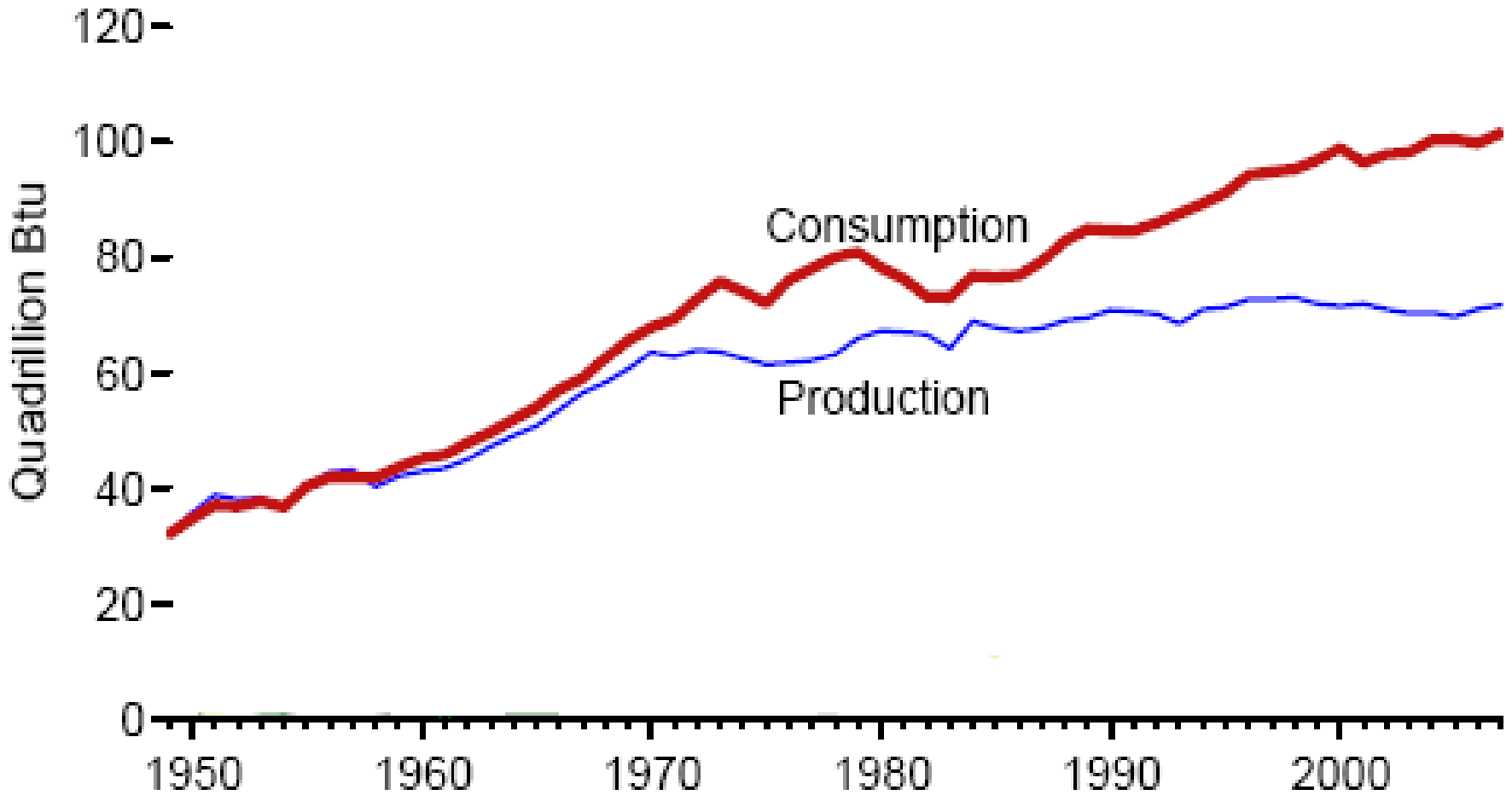
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U.S. Energy: Production & Consumption



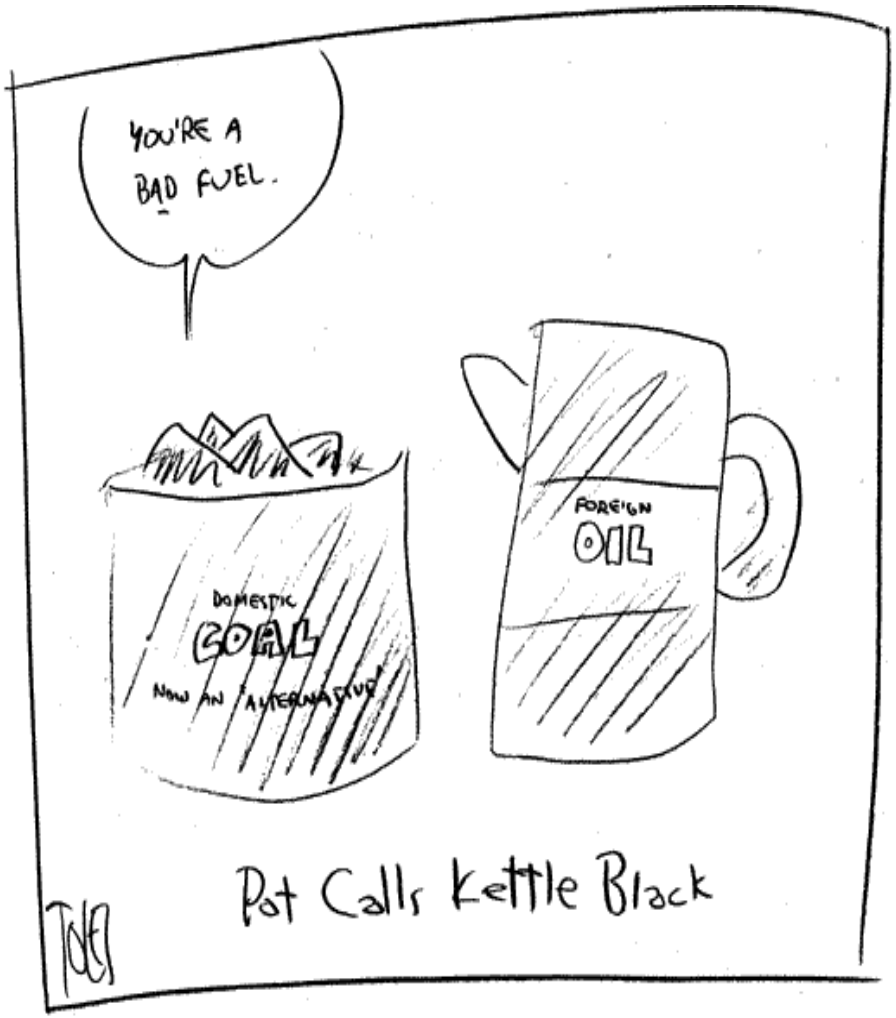
Source: US Dept of Energy – 2007

U.S. Energy Consumption Outpaces Production



Source: Energy Information Administration, June 2008

Facts: Energy Consumption



- Americans consume about 26% of the world's energy while accounting for only 5% of the world's population.
- Developing countries use 30% of global energy.
- Worldwide, about *2 billion* people are currently without electricity.

Primary Energy Sources

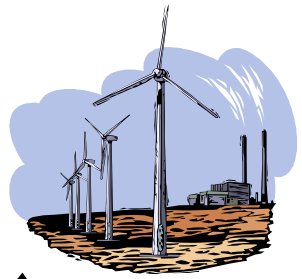
- Traditional Sources (Non-Renewable)
  - *Coal*
  - *Petroleum*
  - *Natural Gas*
  - *Uranium*







- Alternative Technology (Renewable)
  - *Wind Energy*
  - *Solar Power*
  - *Biomass*
  - *Geothermal*
  - *Hydropower*

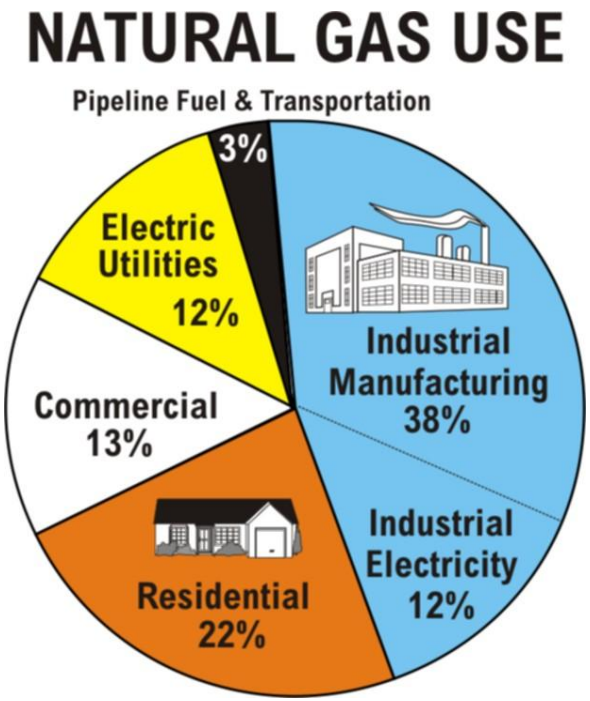


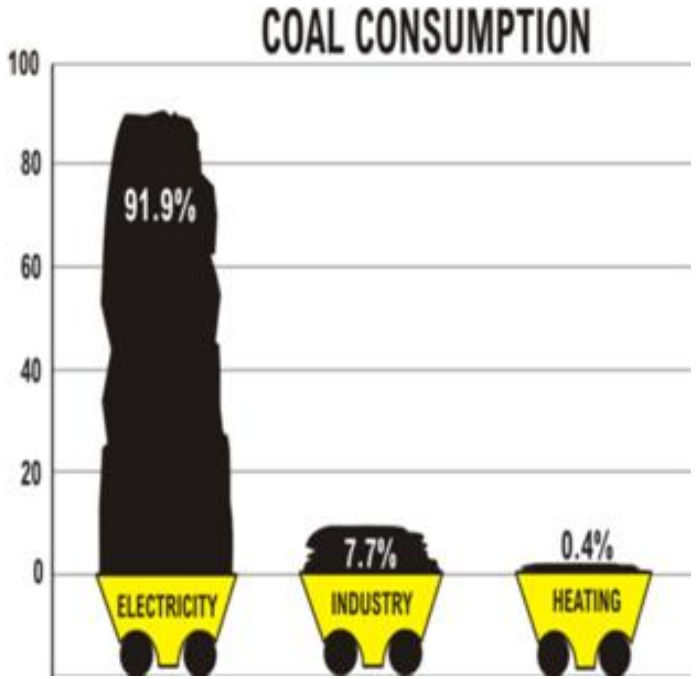


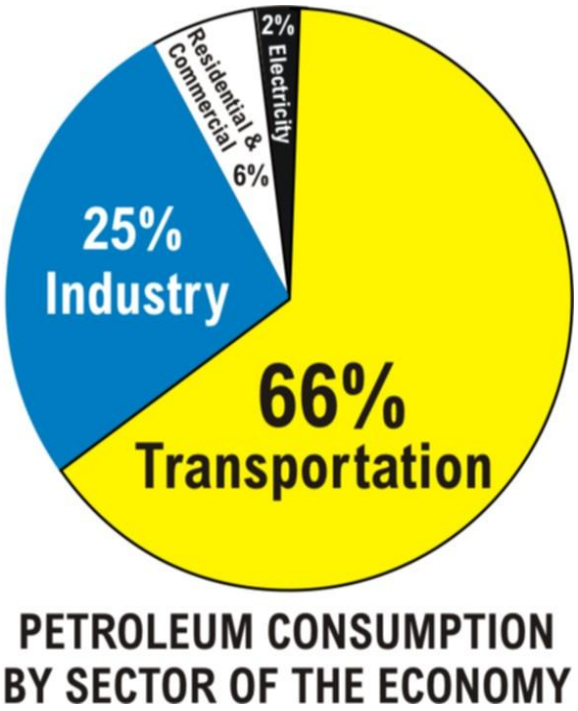




U.S. Energy Consumption





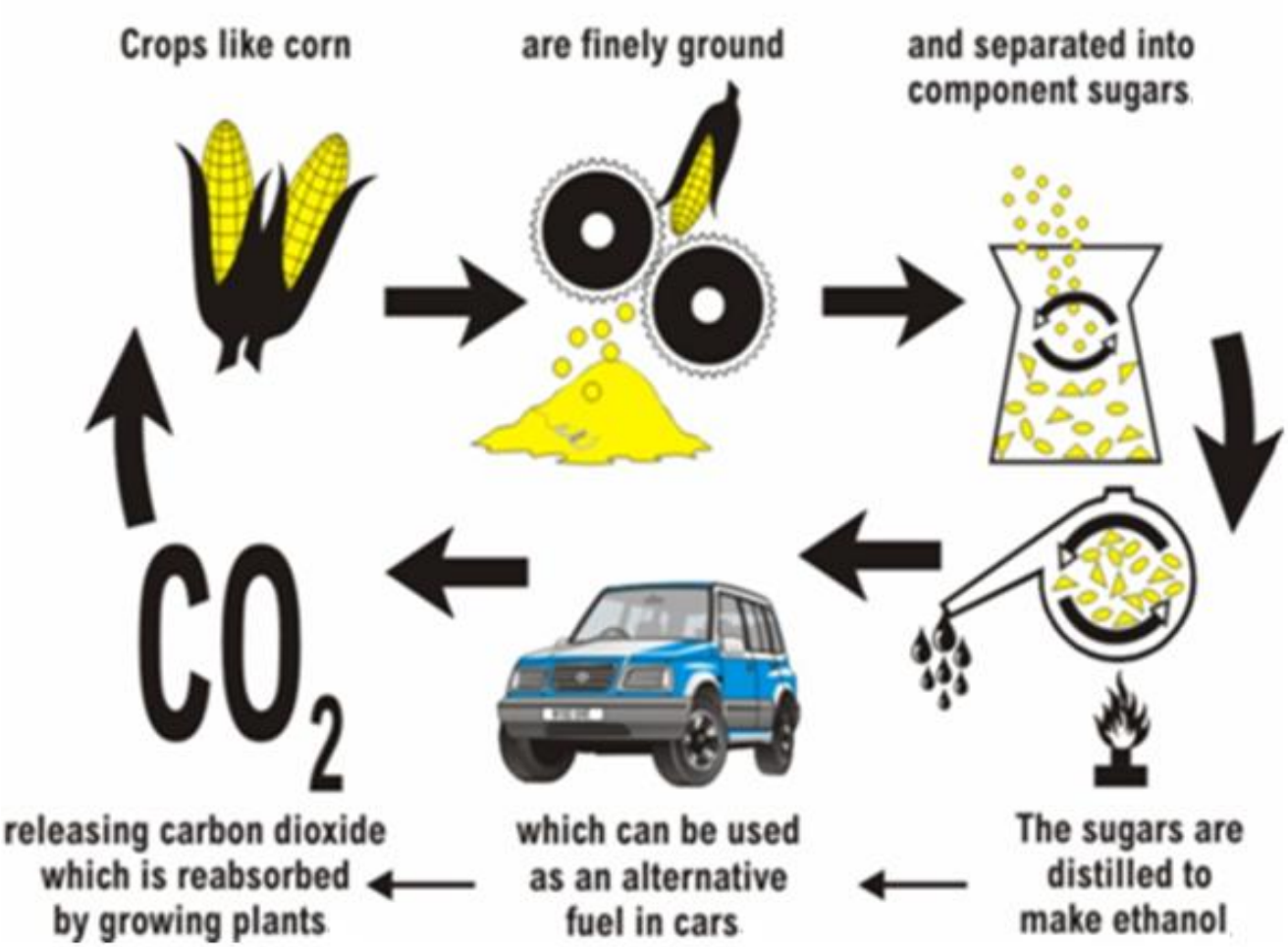


Source: Energy Information Administration

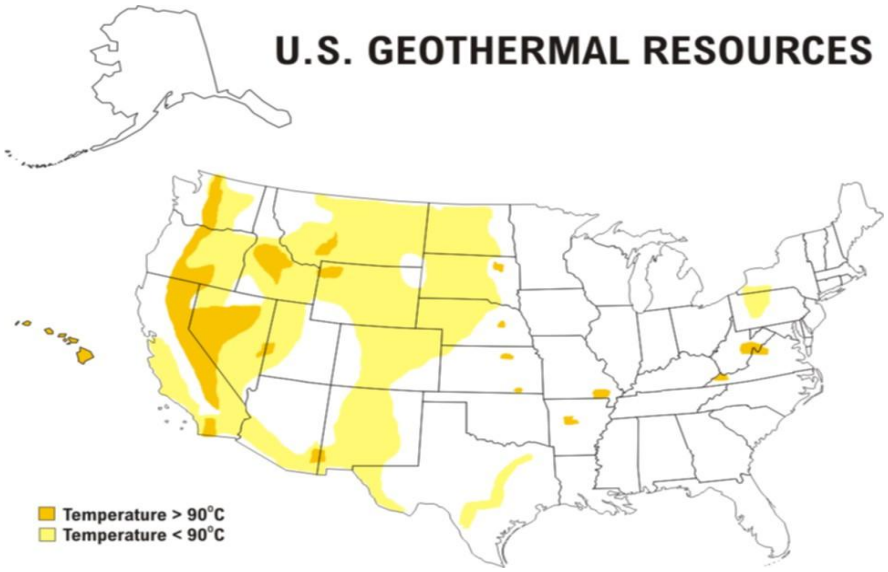
Alternative Renewable Energy

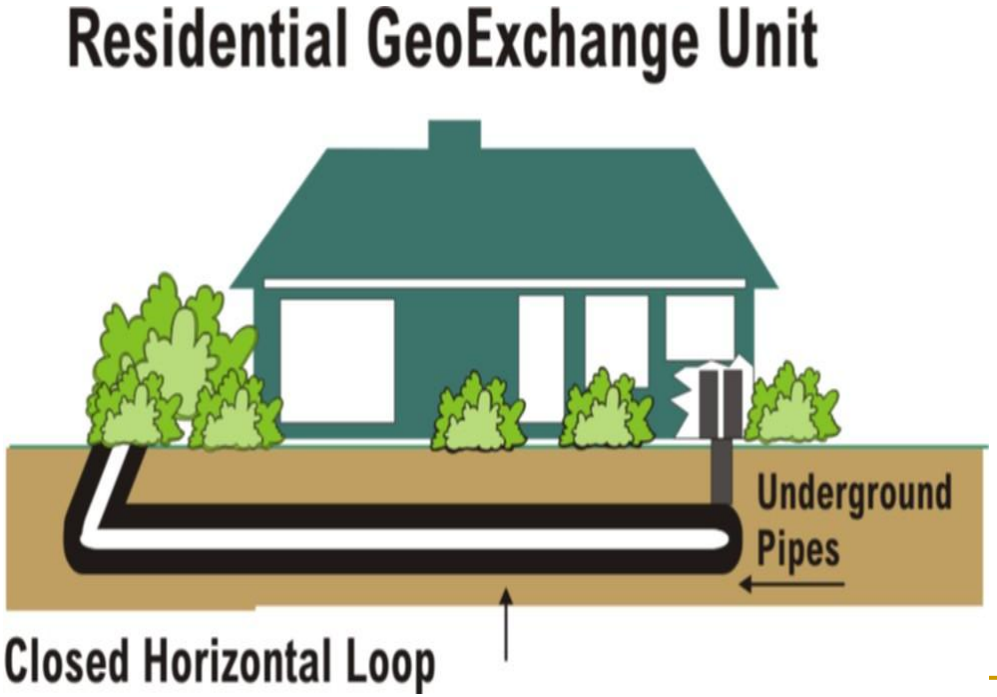
- Biomass energy is generated by the combustion of plant materials liquids produced from plants, sewage, landfills, or animal waste.
- Geothermal is energy collected form absorbed heat underground, in the atmosphere and oceans. Used to heat buildings.
- Hydropower is energy from moving water. Used to powers generators that can then provide electricity.
- Solar power is energy from the sun which can be converted to heat and other power outputs.
- Wind energy is formed by the movement of air through wind turbines that harness the wind power to generate electricity.

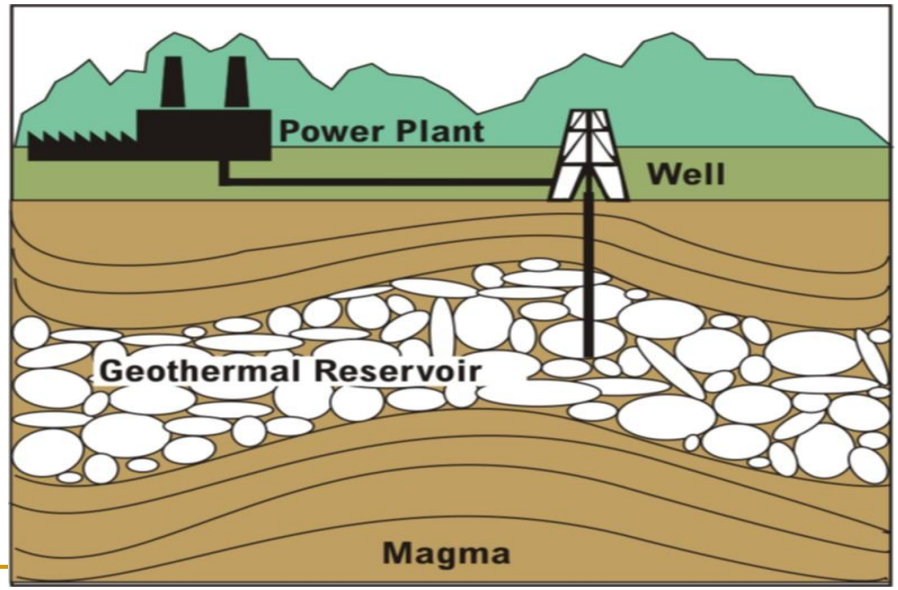
Renewable Energy - Biomass



Renewable Energy - Geothermal

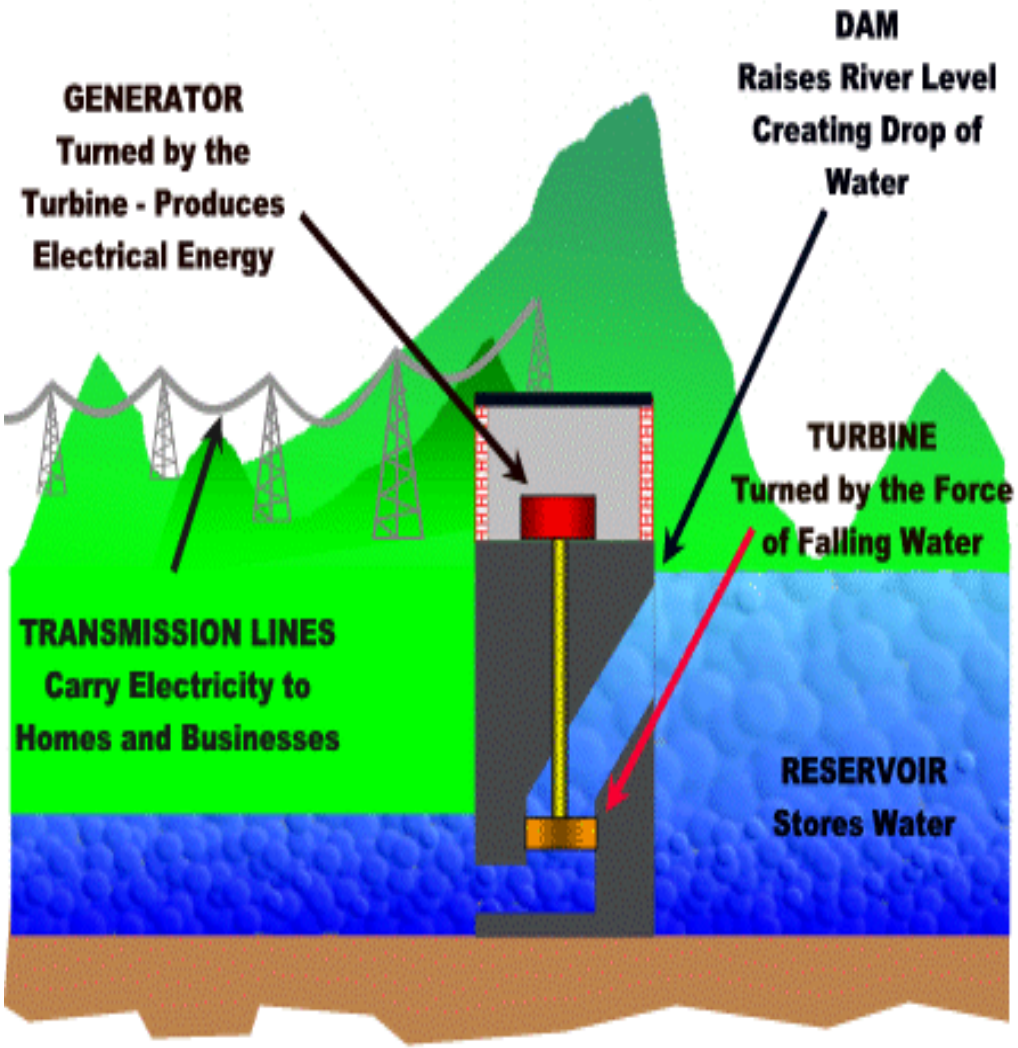






Renewable Energy - Hydropower

- Most comes from potential energy of dammed water driving a water turbine and generator.
- Energy extracted depends on volume and difference in height between the source and the water's outflow.



Renewable Energy - Solar



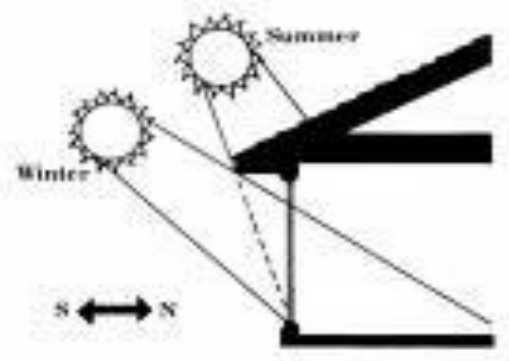
CSP (Concentrated Solar Power)



Photovoltaics



Solar Thermal



Passive Solar Design

Renewable Energy - Wind

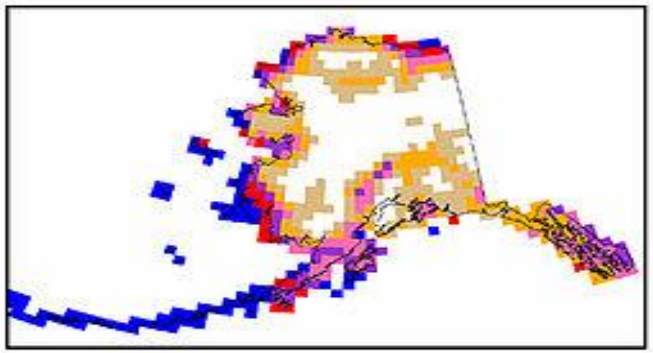


NREL Updated Maps:
Arizona (2003)
California (2002)
Colorado (2004)
Connecticut (2001)
Delaware (2002)
Hawaii (2004)
Idaho (2002)
Illinois (2001)
Indiana (2004)
Maine (2001)
Maryland (2002)
Massachusetts (2001)
Michigan (2004)
Missouri (2005)
Montana (2002)
Nebraska (2005)
Nevada (2003)
New Jersey (2002)
New Hampshire (2001)
New Mexico (2003)
North Carolina (2002)
North Dakota (2000)
Ohio (2004)
Oregon (2002)
Pennsylvania (2002)
Rhode Island (2001)
South Dakota (2001)
Texas mesas (2000)
Utah (2003)
Vermont (2001)
Virginia (2002)
Washington (2002)
West Virginia (2002)
Wyoming (2002)

Wind Resources and Transmission Lines



The remaining states use data from the 1987 "Wind Energy Atlas of the United States".



Transmission Lines
Voltage (kV)
345 - 499
500 - 699
700 - 799
1000 (DC)

Source: POWERmap, powermap.platts.com, ©2007 Platts, a division of the McGraw-Hill Companies

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed [a] at 50 m m/s	Wind Speed [a] at 50 m mph
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

[a] Wind speeds are based on a Weibull k value of 2.0

U.S. Department of Energy
National Renewable Energy Laboratory

NREL

19-APR-2007 1.5.9

Facts: Renewables

- Largest share of the renewable-generated electricity comes from hydroelectric energy (71%), followed by biomass (16%).
- Wind-generated electricity increased more than any other energy source -- almost 21% in 2007 over 2006.
- Followed closely by solar, which increased by over 19% in the same period.

Conservation is the Best Alternative Energy!

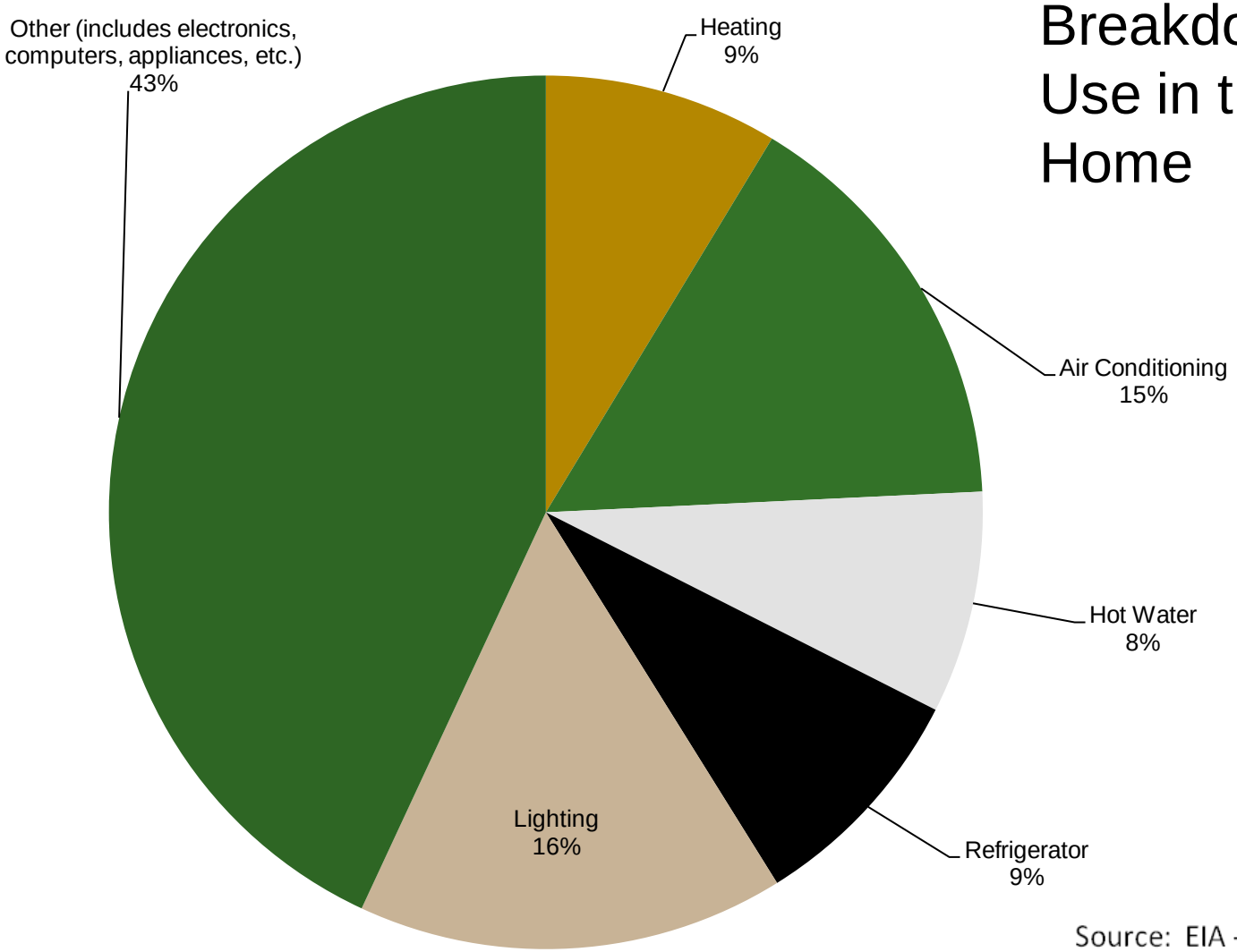
- Conservation programs are easier to implement than any other “alternative energy” technology.
- It is also much more cost effective.
- Conservation should always be first on a list of solutions!

Nine Major Energy Systems

- Building Envelope
- Heating, Ventilating, Air Conditioning (HVAC)
- Electrical Supply System
- Lighting
- Boiler and Steam System
- Hot Water System
- Compressed Air System
- Motors (pumps & fans)
- Special Purpose Process Equipment



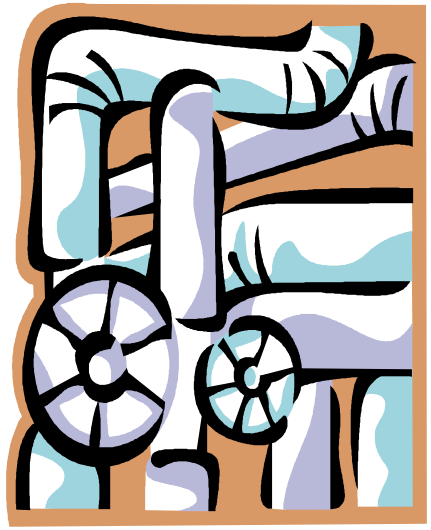
Energy Systems - Electrical



Breakdown of Electrical Use in the Average U.S. Home

Source: EIA - Energy Information Administration

Energy Systems - HVAC



- Programmable thermostats – temperature setbacks during unoccupied hours can save up to 10% of heating / cooling costs.
- Clean & replace air filters per schedule.
- Consider geothermal systems for new construction or replacement – typically saving 30 – 50% of heating & cooling costs.

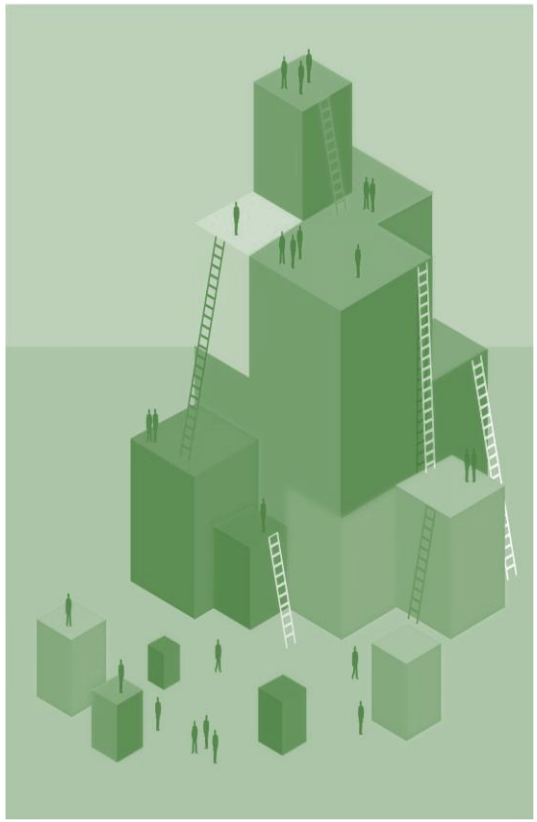
Energy Systems - Lighting



- Turn them off (motion detectors, photocell.)
- Compact fluorescents use ~25% of the energy to produce the same amount of light and last ~10 times longer than traditional incandescents.
- Light pipes or tubes offer tremendous daytime lighting savings.

Energy Systems - Building Envelope

- Thermal Scan to determine where major heat losses are occurring.
- Seal all gaps around doors and windows.
- Replace windows with high R-value, if possible.



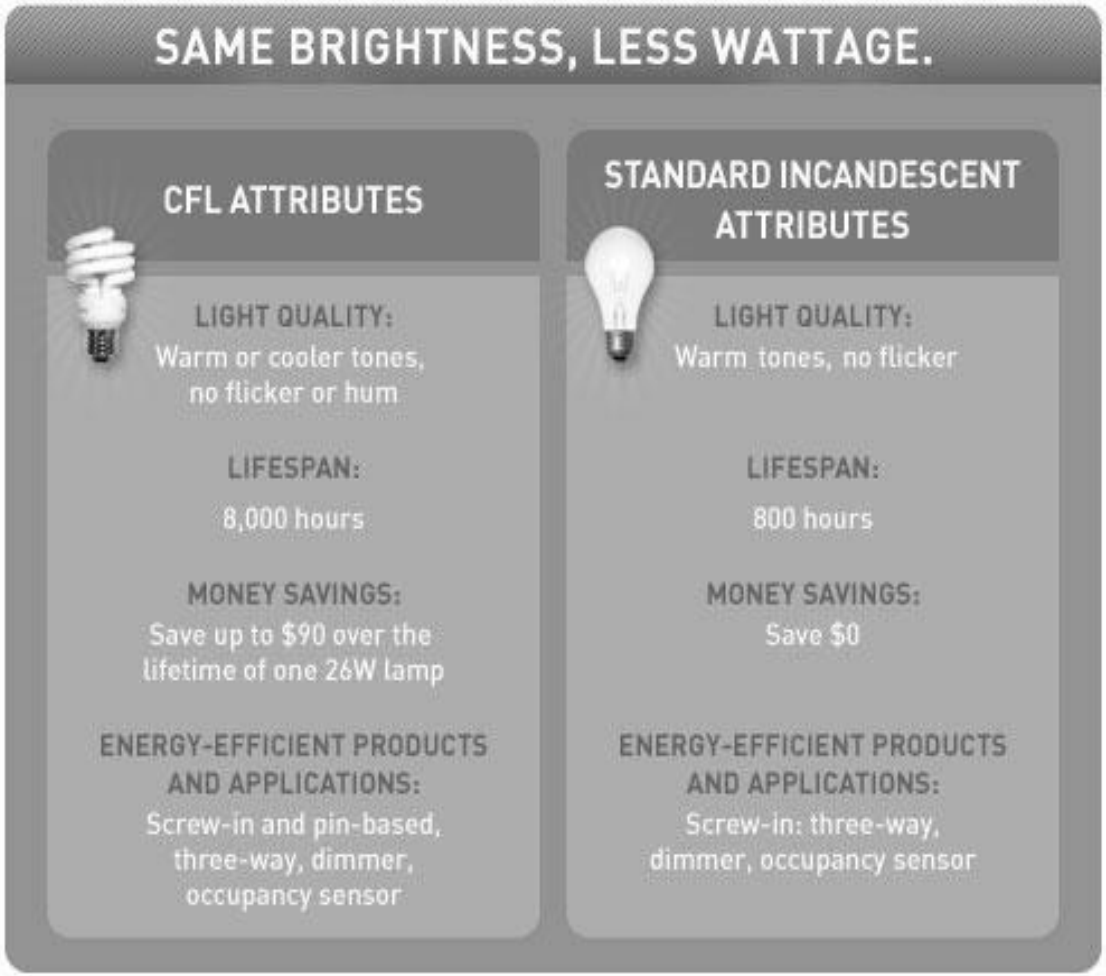
Energy Systems – Compressed Air

- All air systems leak - some substantially. It is not uncommon to have a 30% leak rate.
- Even the best air compressor is only around 12-15% efficient. Use electric motors and actuators rather than pneumatic whenever possible.
- Eliminate inappropriate uses of compressed air, e.g., panel cooling, sparging, positioning, etc.
- Consider recovering waste heat from air cooled compressors for facility heating during colder seasons.

Using an Energy Audit

- Identify types and costs of energy use.
- Understand how energy is being used & wasted.
- Identify and analyze more cost-effective ways of using energy with:
  - improved operational techniques
  - new equipment
- Perform an economic analysis on those alternatives to determine which are cost-effective.

Light Bulb Comparison





Make it Real - Energy

At Home:

- Choose Energy Star Appliances (gas is generally more cost effective than electric); adjust thermostats; switch to fluorescent bulbs.
- Consider Tankless Hot Water Heaters/Insulating blankets on older ones.
- Run full loads in Washer/Dryer/Dishwasher; vent Electric Dryers inside in winter.

At Work:

- Use laptop computers – they use 70 - 90% less energy than desktop models.
- Turn off equipment, table lamps, etc. when not in use.

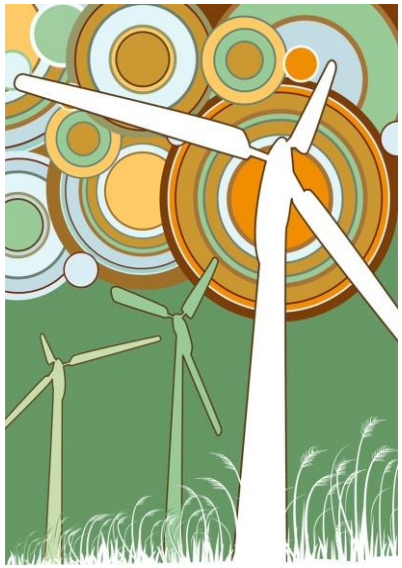
Globally:

- Support development of alternative energy technology through your investment dollars, political choices and selection of energy providers.

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Simulation Scenario – Round 2

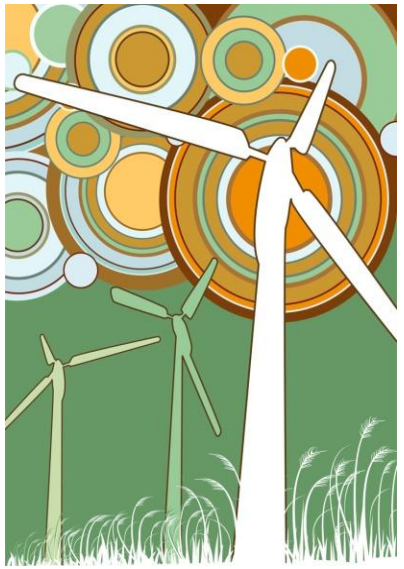


Develop ideas that can be implemented relating to the concepts covered:

- Refuse:
  - Materials requiring extra processing
- Reduce:
  - Material Use, Material Waste, Energy Use, Water Use, Transport
- Reuse:
  - Waste Materials, Returned Material, Packaging
- Recycle
  - Separation of Waste Materials, Waste Exchange, Purchase Recycled Products

No major Product Design changes will be permitted.

Simulation – Round 2 Lessons Learned



- What was the outcome of the process? Report out all measurements.
- What do the performance measures tell you?
- What did the Plant Engineer identify in the Audit Checklist?
- How does this relate to your actual experiences in your facility?

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Green Chemistry Philosophy

- Design products and processes to reduce use and generation of hazardous substances.
- Design processes to maximize raw material that ends up in the product;
- Use safe, environment-benign substances, including solvents;
- Design energy-efficient processes;
- Utilize the best form of waste disposal – do not create waste in the first place!



Typical Product R & D of Past



Often no toxicity screening until this point





Sustainable Futures Assessment

Risk = Hazard x Exposure

- Environmental Fate Hazard

  (If Hazard = 0, Low Toxicity Concern)
  - Aquatic Toxicity
  - Cancer Health Effects / Non-Cancer Health Effects

- Exposure Assessment

  (If Exposure = 0, Minimal Exposure Expected)
  - Occupational
  - Aquatic
  - General Population

Tackling the Issue of Solvents (Auxiliary Substances)

- Substitute with a less harmful solvent, such as water.
- Use Supercritical Carbon Dioxide as a solvent.
- Switch to another process that requires no solvent.
- Enclose the operation so that the solvent is not lost.
- Place something on the plant outlet to destroy or recover the solvent.

Re-engineering Processes



Switching from batch reactions to continuous processing:

- Is safer;
- Uses less energy;
- Uses fewer chemicals;
- Typically gives a higher purity product; and
- Allows more flexibility to prepare on demand rather than keeping inventory.

Green Chemistry Example



- Monsanto developed an alternative way of making the popular herbicide Roundup®.
- They now avoid the use of extremely toxic hydrogen cyanide, along with avoiding production of cyanide-containing waste.
- Risks to people working at the manufacturing plant, to those living nearby and to the environment, are greatly reduced.
- Much smaller amount of waste produced is also safer since it does not contain cyanide.

International Drivers for Green Chemistry

- Restriction of Hazardous Substances (ROHS)
  - Restricts use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs) (7/06)
  - Deca-bromodiphenylether (deca-BDE) (6/08)
- Waste Electrical/Electronic Equipment (WEEE) Directive
  - Requires producers of electrical/electronic equipment to finance collection arrangements for their products at the end-of-life (8/05)
- Registration, Evaluation, Authorization/restriction of Chemicals (REACH)
  - Requires all manufacturers and importers into the European Union (EU) to register all chemical substances into a database managed by the European Chemicals Agency in Helsinki (11/08)

Make it Real – Green Chemistry

At Home:

- Investigate your home or farm for potential hazardous chemicals and educate all the residents about proper disposal of these wastes.
- Organize a community paint exchange, or encourage your community to sponsor a household hazardous waste collection event (volunteer for it.)

At Work:

- Identify alternative chemicals for any products that you use that are currently not safe for the environment. Work with Engineering, Purchasing, Maintenance, etc. to use the eco-friendly alternatives.

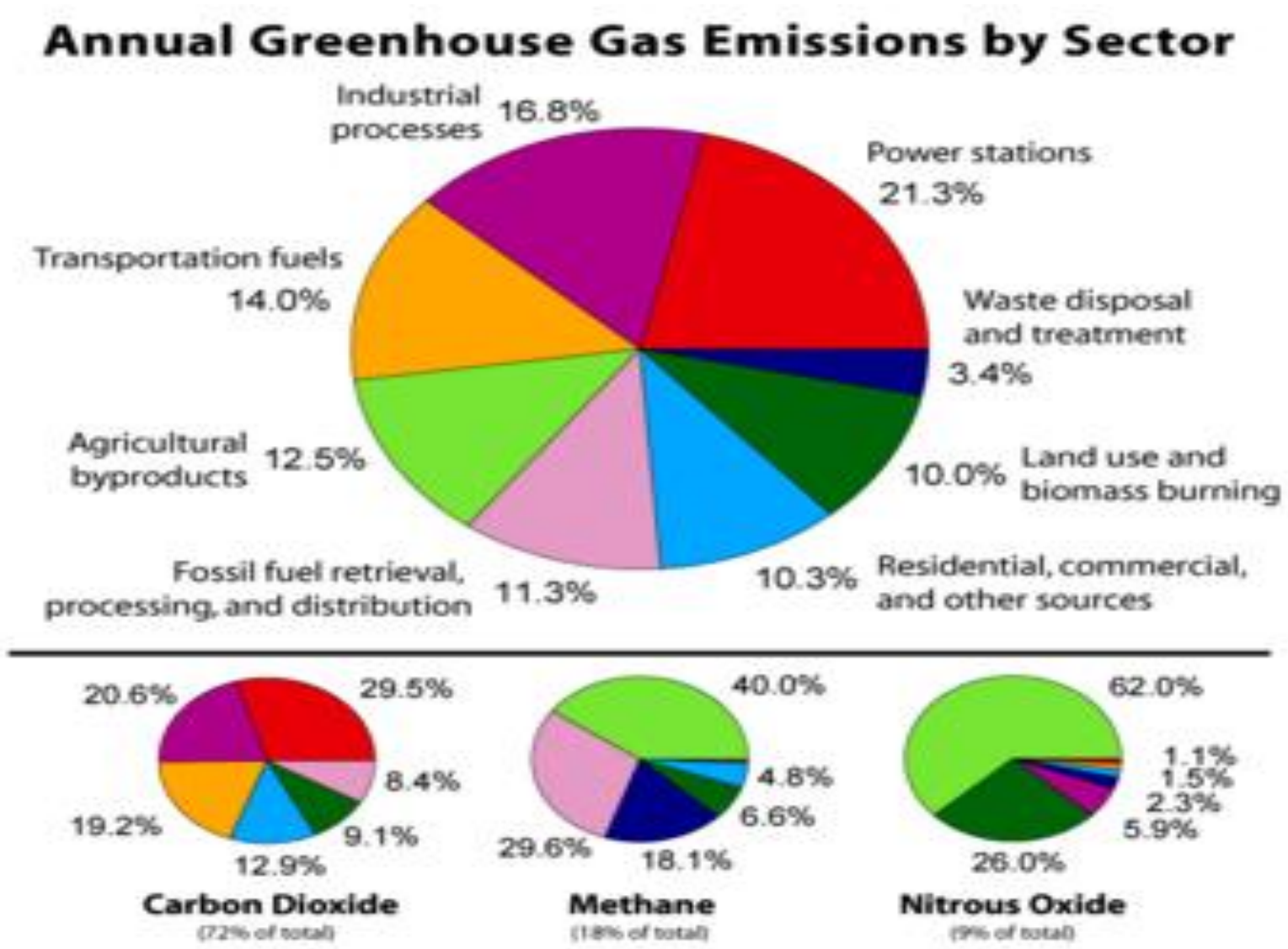
Globally:

- The best alternative for chemicals that are not safe for the environment are no chemicals at all. Find alternative methods to perform standard functions (cleaning, pest control, etc.) that eliminate chemical use.

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Greenhouse Gas Emissions



Carbon Dioxide (CO_2) Emissions



- On average, 16 million tons of CO_2 are emitted into the atmosphere every 24 hours by human use worldwide.
- Multiple methods will be needed to reduce the amount of CO_2 emissions including regulating output limits.

Effects of Ozone Depletion

- Ozone depletion can cause increased amounts of UV radiation to reach the Earth.
  - This can lead to more cases of skin cancer, cataracts, and weakened immune systems.
- UV can also damage sensitive crops, such as soybeans, and reduce crop yields.
  - This can have negative consequences for food supplies and crops for biofuels.

Air Quality Index

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 – 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 – 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 – 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 – 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 – 300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

Air Contaminants

- Gas Phase Contaminants
  - Gas
  - Vapor



- Aerosol Contaminants
  - Dust
  - Fume
  - Mist
  - Smog
  - Smoke

Industrial Air Sampling

- Personal
  - Sampling device is directly attached to the employee and worn continuously in the breathing zone during all work and rest operations.
- Breathing Zone
  - Sampling device remains in worker's breathing zone throughout workday.
- General Air (Area)
  - More appropriate for measuring source emissions rather than personal exposures.

Air Pollution Prevention

- Need to focus on both source and waste reduction – including reuse and recycling.
- Preventing air pollution remains the preferred approach.
- Indirect air pollution prevention measures by companies covers the entire product lifecycle, including *transportation*.

Make it Real – Air Emissions

At Home:

- Reduce your personal vehicle use. Combine trips, carpool.
- Eat less meat thereby reducing the overall agriculture byproduct production.

At Work:

- Have the air quality checked within your work facility. Identify potential air pollutants and work with necessary people to reduce the causes.

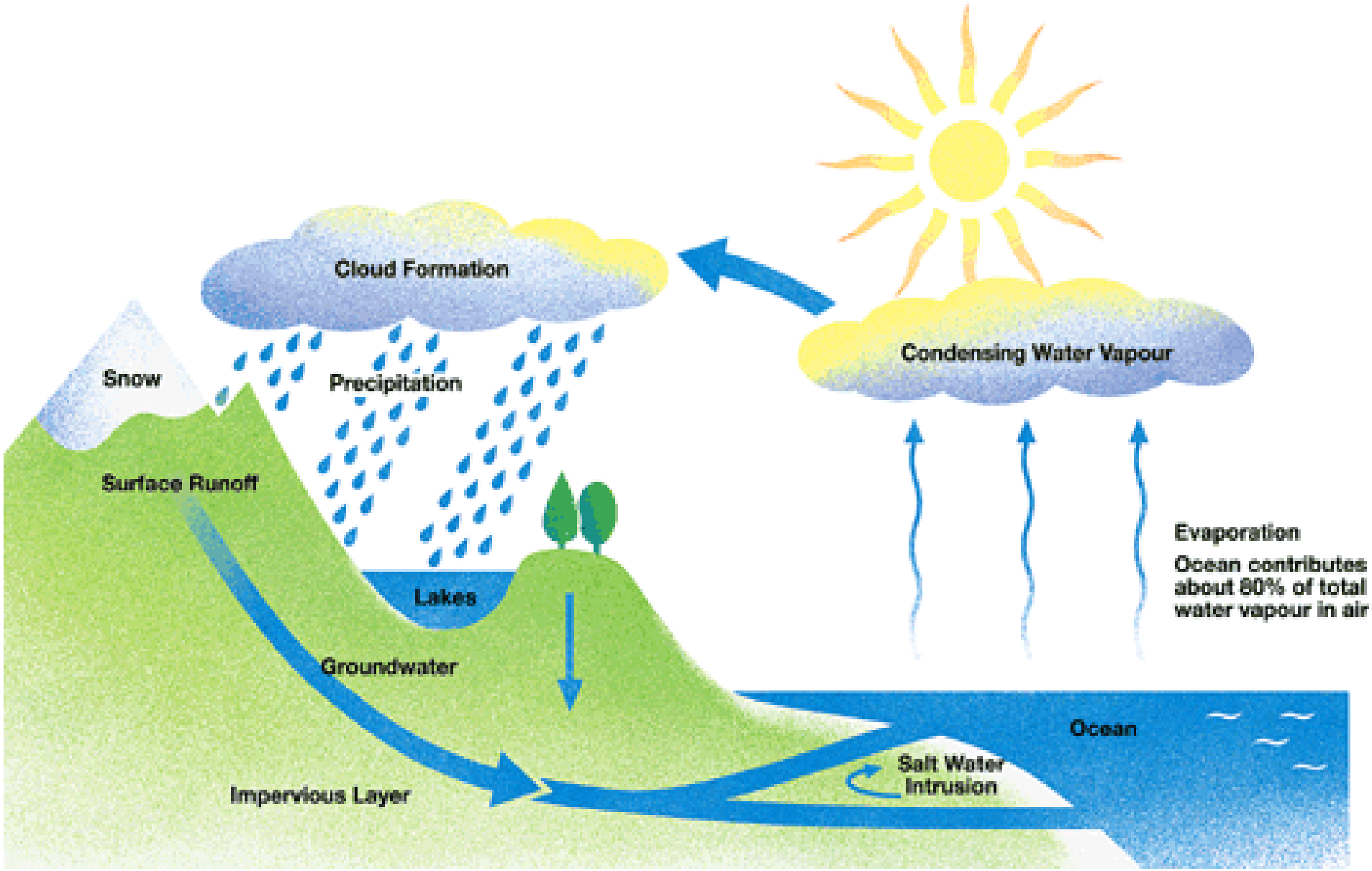
Globally:

- Choose clean energy sources whenever possible – whether for electricity, heat or transportation.
- Plant trees and vegetation (preferably native to the area) to improve the balance of carbon dioxide emissions and reduce pollution.

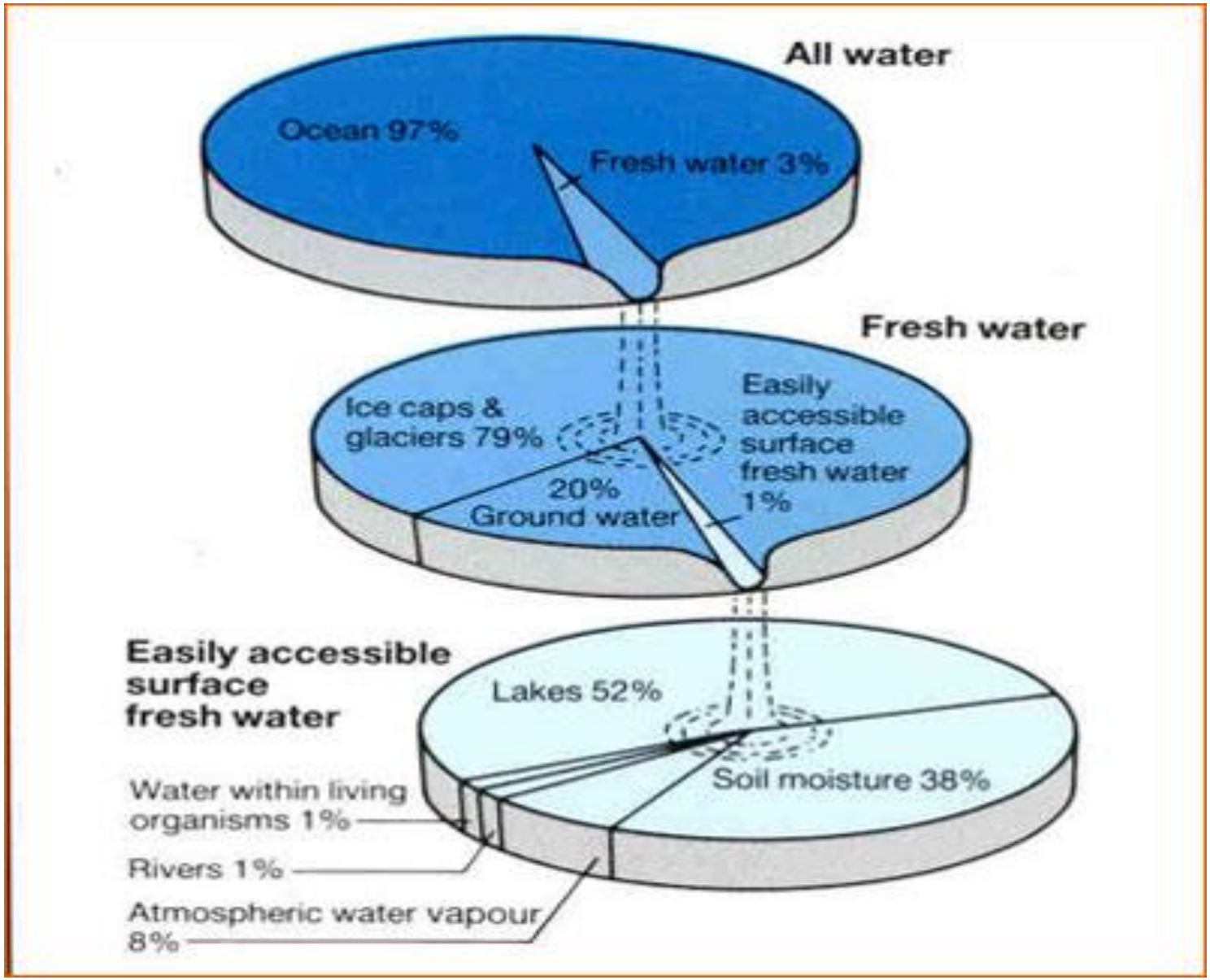
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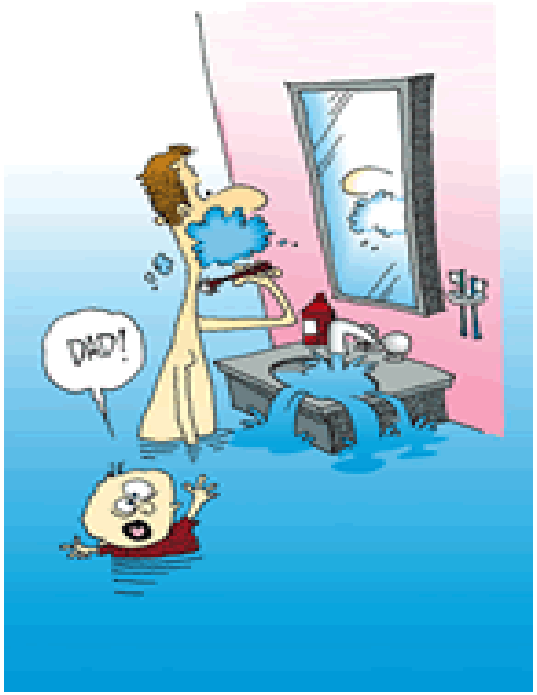
Water Cycle


Cloud Formation
Condensing Water Vapour
Snow
Precipitation
Surface Runoff
Lakes
Evaporation
Ocean contributes about 80% of total water vapour in air
Groundwater
Ocean
Salt Water Intrusion
Impervious Layer

Freshwater is a Finite Resource



Supply Water Quality



Human demands for water are increasing.

Water quality continues to degrade from:

- Industrial and agricultural pollution,
- raw sewage.

More people = More waste

But with the same percentage of freshwater as today.

Supply Water Considerations

Decisions relating to use of supply water resources and management are both political and economic.



For example:

250 million gallons of water will sustain 100,000 high tech jobs, but only 10 agricultural jobs.



If you are the decision maker, which do you choose?

Non-Point Source Water Pollution

Leading cause of water pollution in the U.S. today.

The pollutants include:



- Excess fertilizers, herbicides, insecticides, and animal wastes from agricultural lands and residential areas.
- Oil, grease, and toxic chemicals from urban runoff and energy production.
- Forestry activities including tree and vegetation removal, especially along stream and river beds, and road construction.

Keeping our Water Clean & Safe



Clean Water Act 1972

Goal: All surface waters to be swimmable & fishable. "Zero discharge" of pollutants into the nation's waters.

Status: ~40% in the U.S. are NOT!!

Safe Drinking Water Act 1974 (amended 1986 & 1996)

Goal: To protect the quality of both actual and potential drinking water through water quality standards.

Assess and protect drinking water sources; protect wells and collection systems; ensure water is treated by qualified operators; ensure the integrity of distribution systems.

Status: ~ 92% of the U.S water systems provide drinking water that meets all public health standards.

Water Conservation and Efficiency

Water Conservation Hierarchy follows the 4Rs:

- Refuse – Don’t Use!
- Reduce – Conserve
- Reuse/Recover – Divert, don’t discharge
- Recycle – Reuse directly or treat



Water Conservation Considerations

- Most water has only a single use. Increasing number of uses decreases demand.
- Wastewater can be treated to different qualities for industry, aquifer recharge, irrigation, and even to drinking water quality (psychological issues).
- Need to plan infrastructure along with new development and re-development to use best supply water and wastewater approaches.

Community Water Management

Local stewardship of water resources:

- Enhances economic development opportunities;
- Improves overall environmental quality;
- Builds community value.



Make it Real – Water Use

At Home:



- Check your home for leaky faucets, showerheads, and toilets; have the leaks repaired. Repair with water-saving options.
- Replace water-using appliances (washers, dishwashers, etc.) with environmentally friendly models when needed.
- Collect rainwater for use in gardens and lawn watering.



At Work:

- Ensure that no materials are flowing from your site into nearby storm drains streams or other water bodies.
- Develop a good leak and spill prevention program and have a plan of action for accidental spills.



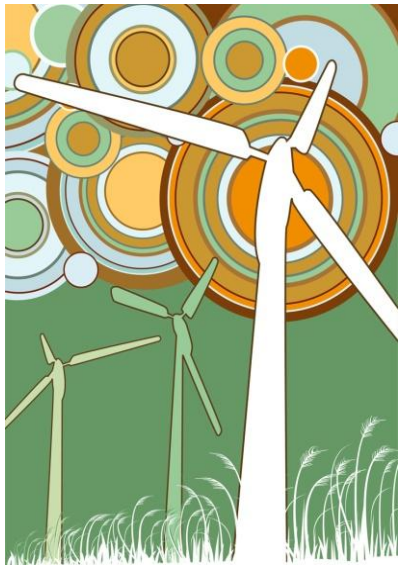
Globally:

- Improve technologies to encourage reuse of water, e.g., greywater.

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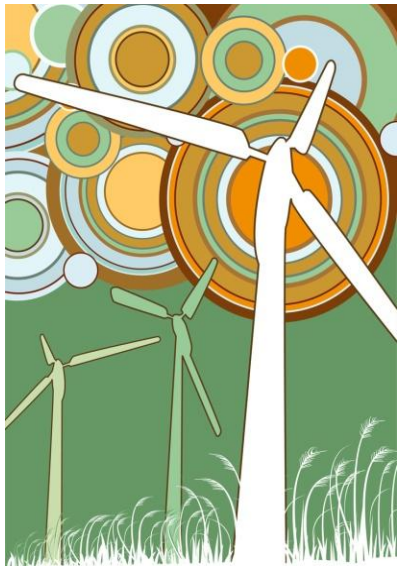
Simulation Scenario – Round 3



Develop ideas that can be implemented relating to the concepts covered:

- Refuse, Reduce, Reuse, Recycle
- Alternative Materials
- Green Supply Chain
- Air Emissions
- Product Lifecycle

Simulation – Round 3 Lessons Learned



- What was the outcome of the process? Report out all measurements.
- What do the performance measures tell you?
- What did the Plant Engineer identify in the Audit Checklist?
- How does this relate to your actual experiences in your facility?

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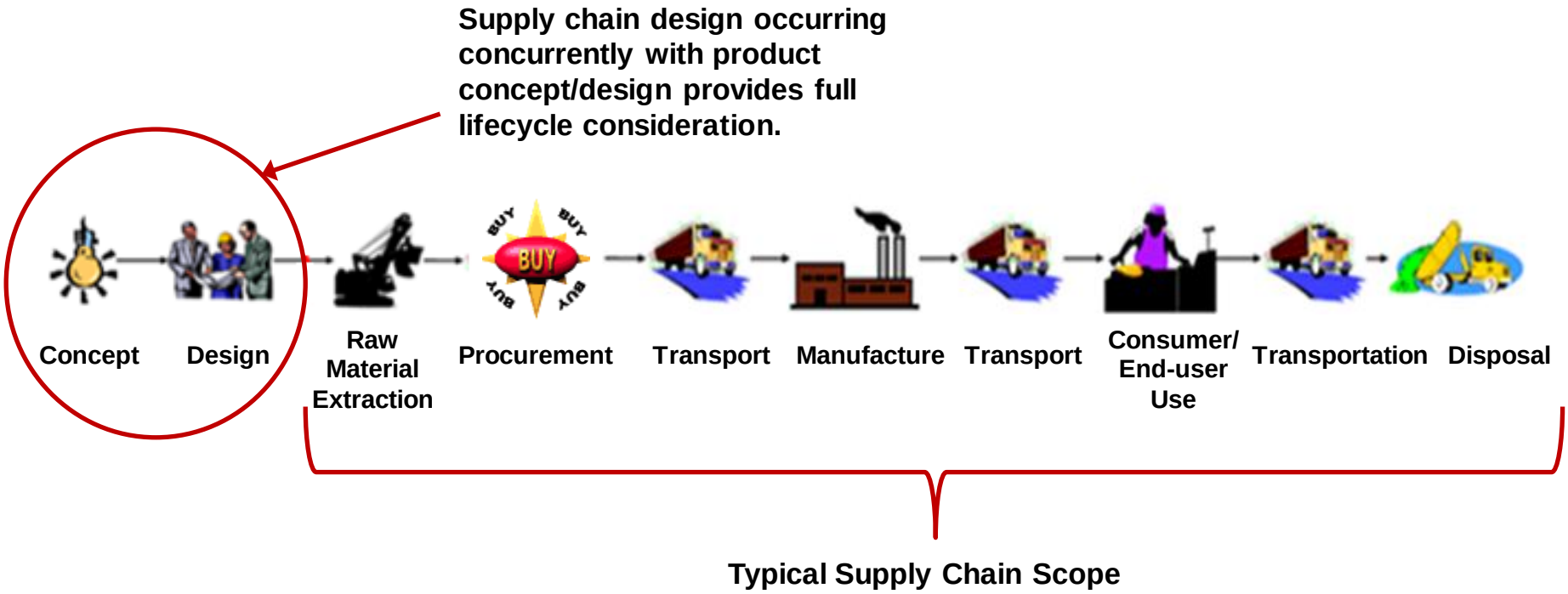
Environmental Management Success

- Cross-functional cooperation for environmental improvements.
- Environmental compliance and auditing programs.
- Cooperation with suppliers for environmental objectives.
- Cooperation with customer for eco-design, clean production and green packaging.



Green Supply Chain Management

Lifecycle Supply Chain:
All activities associated with the flow and production of goods -- from product concept through the end user.



Strategic Business Value

Determine the key driver(s) for making green improvements in your business:

- Cost Reduction
- Risk Management
- Regulatory Compliance
- Product Differentiation
- Managing Competitors
- Redefining Markets

What Makes a Product Green?

Some examples:



- Products with recycled content
- Products that reduce material use
- Products with exceptional durability or low maintenance requirements (good lifecycle)
- Natural, rapidly renewable, or minimally processed products
- Products used to reduce negative environmental impacts (pollution, energy waste, etc.)

LEED Certification



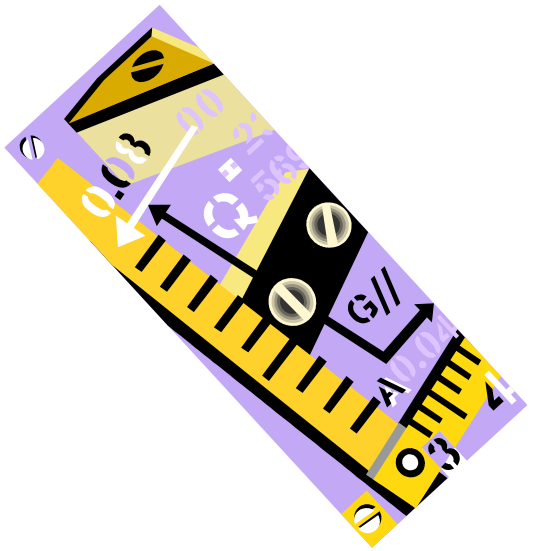
The Leadership in Energy and Environmental Design Green Building Rating System is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings.

Areas of focus:

- Sustainable site development
- Water savings
- Energy efficiency
- Materials and resources selection
- Indoor environmental quality

Environmental Metrics





- Energy Used
- Air Emissions
- Materials Use
- Hazardous Waste Generation
- Chemical Use
- Solid Waste Generation
- Water Use
- Wastewater Discharges

Why Measure Environmental Performance?

- Effective management and reduction of wastes, emissions, discharges, and accidents;
- Control environmental costs;
- Understand the effectiveness and environmental benefits of investments:
  - Choose wisely between alternative projects;
  - Justify capital requests and allocations.
- Easier environmental reporting (regulatory, stakeholder reports, etc.);
- Public relations and community/public image.

Carbon Footprint

- The amount of fossil carbon consumed by a facility, converted to metric tons of CO_2, is their *carbon footprint.*
- Movement is underway to cap carbon emissions with companies in different industries or geographical regions given *allowances*.

Carbon Offsets, Credits & Trading

- Carbon emissions can be “offset” by acquiring the rights to projects that reduce emissions, e.g., tree plantations, renewable energy.
- Carbon Credits can be earned by reducing emissions below your allowance.
- Credits (unused allowances) may be traded on the open market.

Make it Real - Environment

At Home:

- Calculate your personal or family Carbon Footprint. Set 1 goal to accomplish in the next month to reduce your Carbon Footprint.

At Work:

- Meet with customers and suppliers to determine what things can be changed cooperatively to provide your products with a more positive impact on the environment. Implement agreed changes immediately.

Globally:

- Make the best environmental choices whenever you have a purchasing decision, whether for products or services. Always choose the most “green” option when you can.

Course Agenda

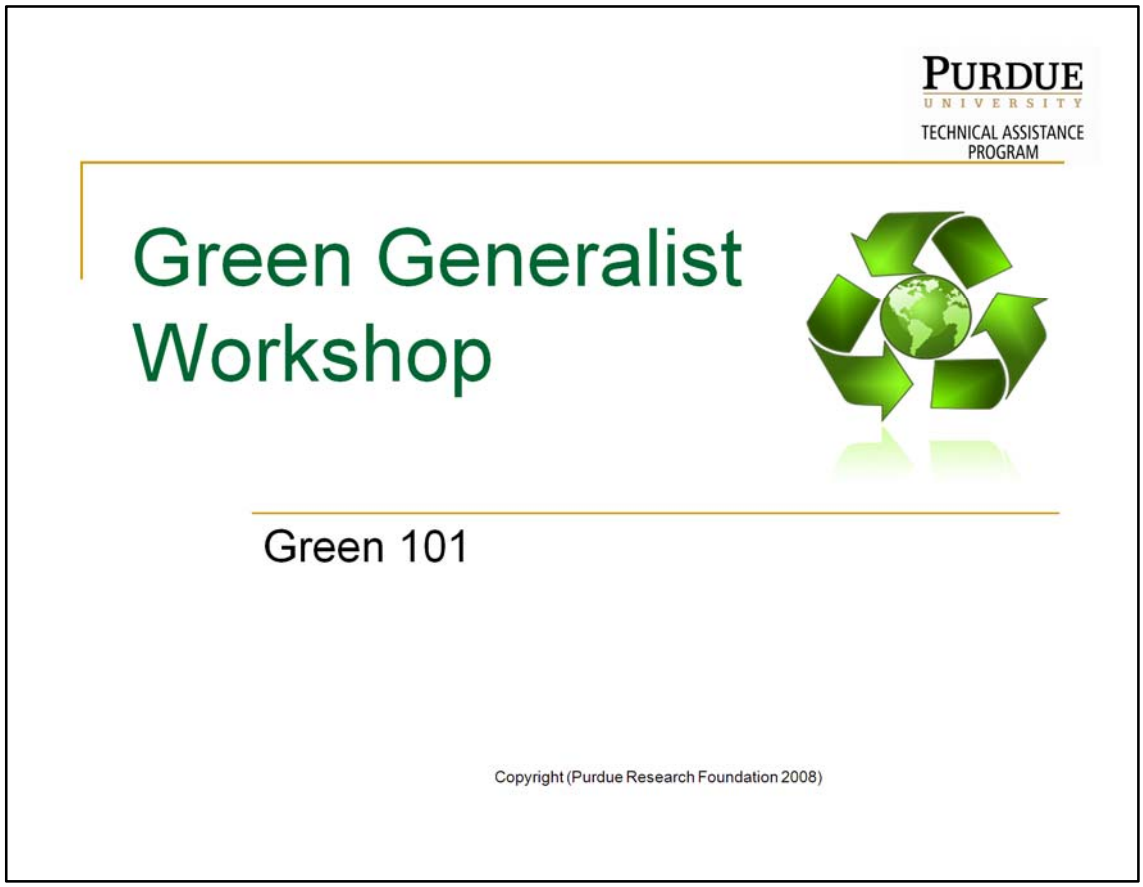
Welcome & Green Workforce Program Structure
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    Round 2 of Simulation
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Climate / Air Emissions Management
Supply Water / Wastewater Management
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Implementation Action Plan

- Team up with 1 or 2 others.
- Identify at least 1 idea from the concepts we've discussed that you can implement right away.
- Use the Environmental Waste Reduction Plan form in the Appendix to document this idea.
- Complete the data requested as best as you can – make an educated guess if you don't have exact information and complete in more detail later.

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Green Workforce Program Structure

- **Waste Stream Mapping (WSM)**
  - Audience: General Workforce, Green Project Teams
  - Duration: 2 days (Day 1 – "As Is" / Day 2 – "To Be")
  - Approach: Training with Hands-on WSM Development
- **Green Specialist Training**
  - Audience: Plant Engineers, Environmental Managers, Green Team Participants, etc.
  - Duration: 1 day per module (6 modules)
  - Approach: Training with Hands-on Application / Simulation
- **Green Specialist Certificate Preparation**
  - Audience: Plant Engineers, Environmental Managers, etc.
  - Duration: 3 days
  - Approach: Training only for Certificate Exam with Accreditation through Society of Manufacturing Engineers (SME)

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What does being "Green" mean to you?





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Green Concepts

- Healthier living
- Conserving natural resources
- Choosing non-toxic products
- Reducing your carbon footprint
- Recycling and reusing materials
- Buying local products
- Being socially responsible
- Reducing energy costs
- Being gentle to the Earth
- Investing in a better future



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Going Green

Simply a matter of making different, better choices:

- Transportation alternatives
- Energy alternatives
- Refuse, Reduce, Reuse, Recycle
- Renewable vs. nonrenewable resources
- Buy local (groceries, building materials, services, etc.)
- Use natural alternatives (cleaning, weed control, fabric, etc.)
- Eco-friendly investments

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Responsible Manufacturing

To be classified as a *Responsible Manufacturing or Clean Production* process, it should result in a significant benefit to the environment in one or more of these areas:

- Water usage
- Chemical usage
- Energy usage
- Emissions
- Heavy metals in products
- Hazardous and toxic waste releases
- Solid waste generation

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Make it Real – Going Green

At Home:

- Buy local -- buy food (or any good or service) produced, grown, or raised as close to your home as possible.
- Look for electronics that are rechargeable. Lithium-ion (Li-Ion) and nickel metal hydride (NiMH) are cost-effective, green battery alternatives.

At Work:

- Recycle metal, glass, plastic and paper. Many companies make products from recycled materials now so help contribute. Also buy products with recycled content.

Globally:

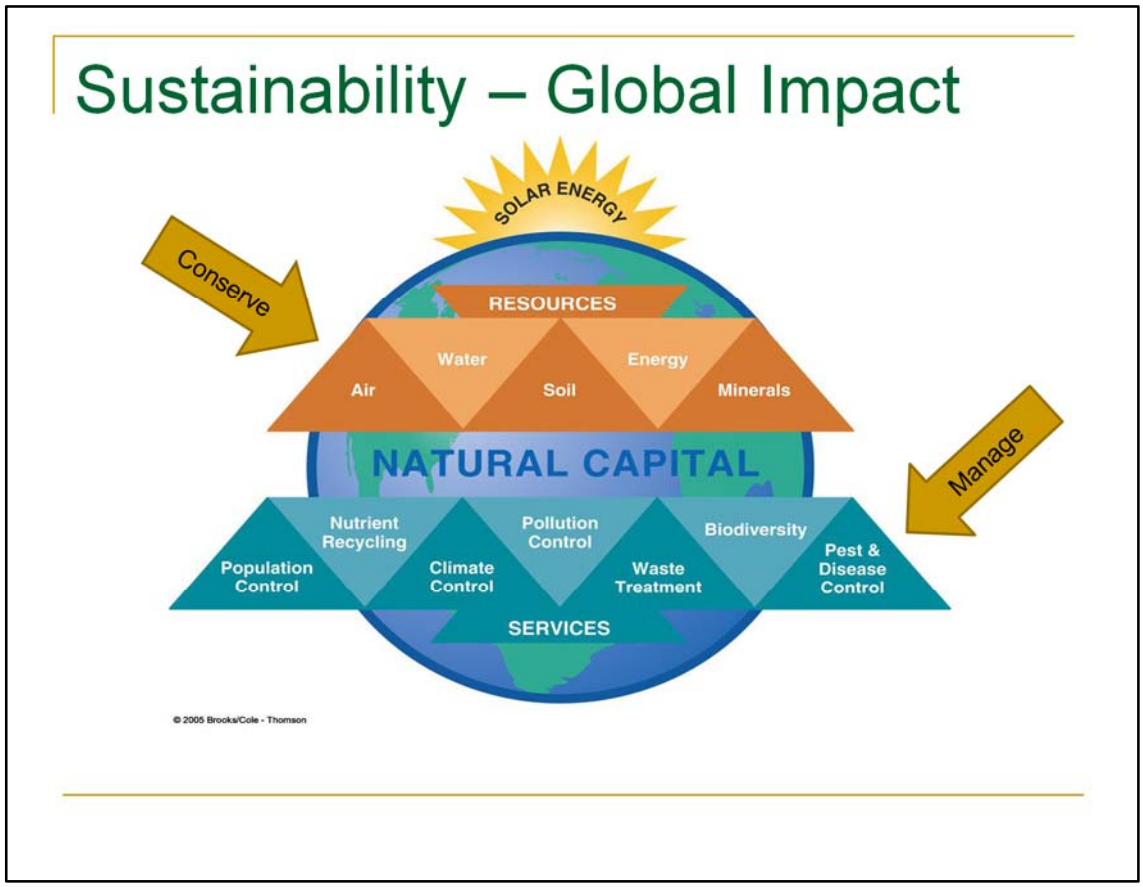
- Adopt "Bring your own bag" around the world.

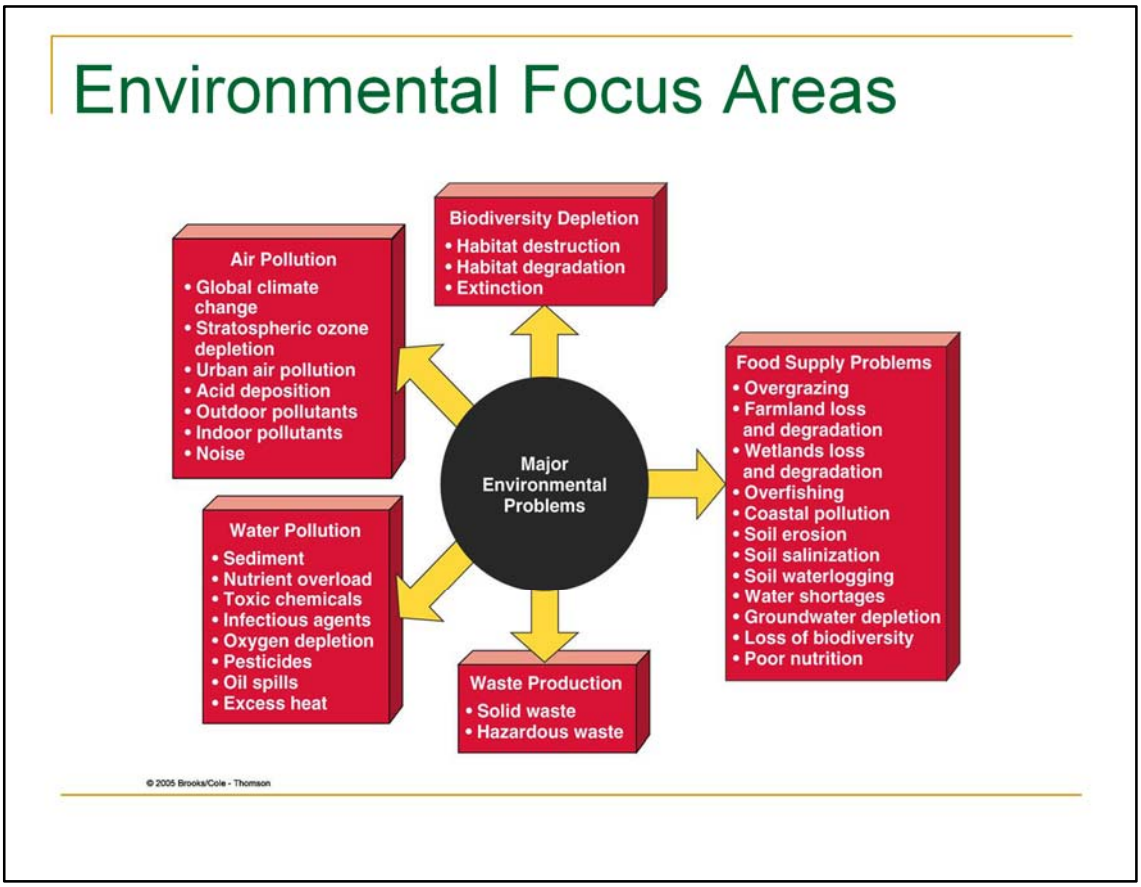
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Sustainability – Global Impact
SOLAR ENERGY
Conserve
RESOURCES
Water
Energy
Air
Soil
Minerals
NATURAL CAPITAL
Manage
Nutrient Recycling
Pollution Control
Biodiversity
Population Control
Climate Control
Waste Treatment
Pest & Disease Control
SERVICES
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Environmental Focus Areas
Air Pollution
• Global climate change
• Stratospheric ozone depletion
• Urban air pollution
• Acid deposition
• Outdoor pollutants
• Indoor pollutants
• Noise
Biodiversity Depletion
• Habitat destruction
• Habitat degradation
• Extinction
Food Supply Problems
• Overgrazing
• Farmland loss and degradation
• Wetlands loss and degradation
• Overfishing
• Coastal pollution
• Soil erosion
• Soil salinization
• Soil waterlogging
• Water shortages
• Groundwater depletion
• Loss of biodiversity
• Poor nutrition
Major Environmental Problems
Water Pollution
• Sediment
• Nutrient overload
• Toxic chemicals
• Infectious agents
• Oxygen depletion
• Pesticides
• Oil spills
• Excess heat
Waste Production
• Solid waste
• Hazardous waste
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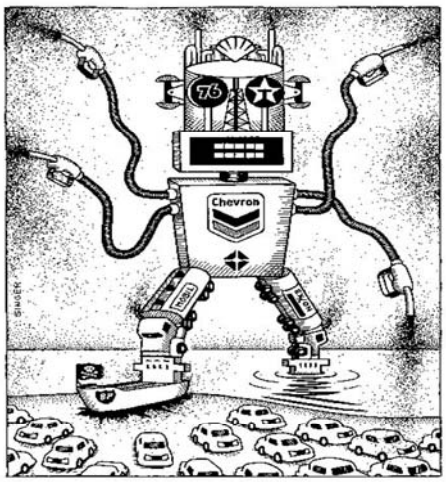
Climate Change – Greenhouse Gases

Many greenhouse gases are created and emitted through human activities:

- Hydrofluorocarbons (HFCs)
- Electric energy production (fossil fuel combustion)
- Animal agriculture
- Deforestation
- Transportation emissions

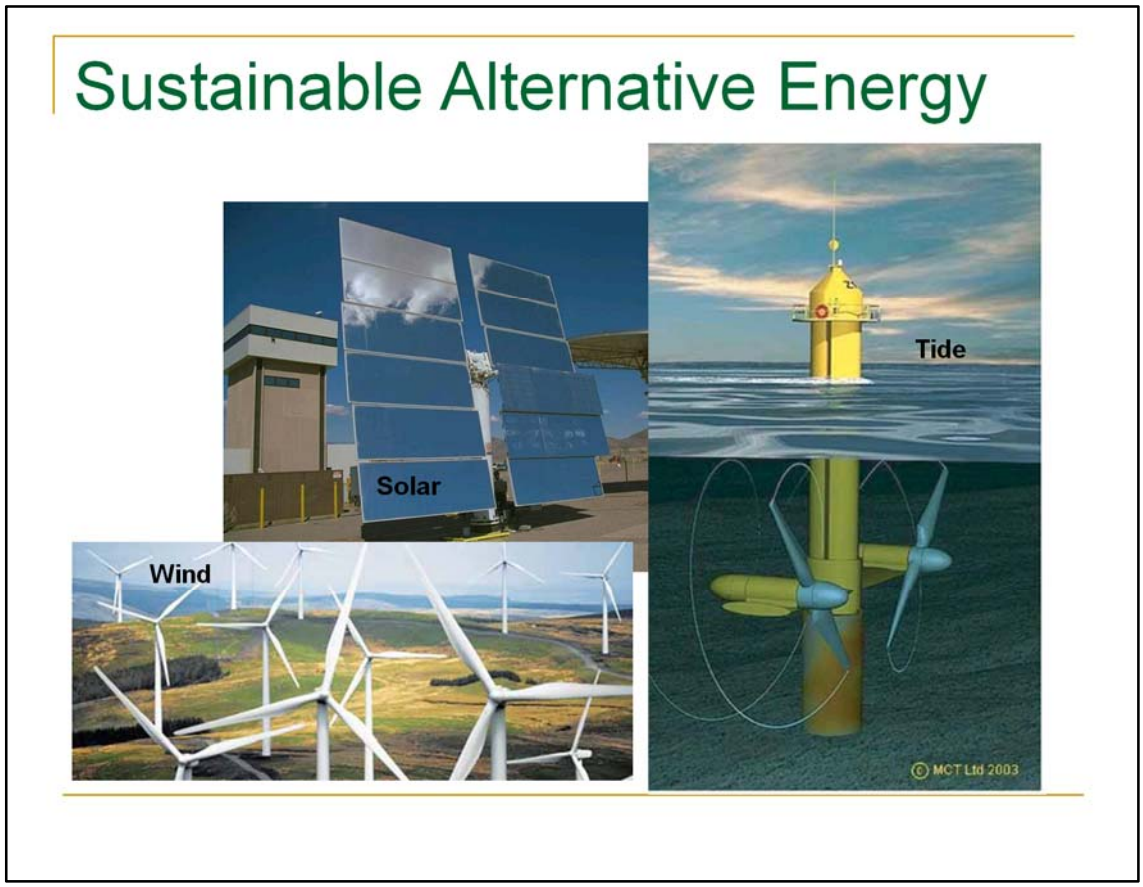
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Unsustainable Energy Sources





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Natural Resource Protection

The largest spatial impact of human activity is ***land use to grow food.***

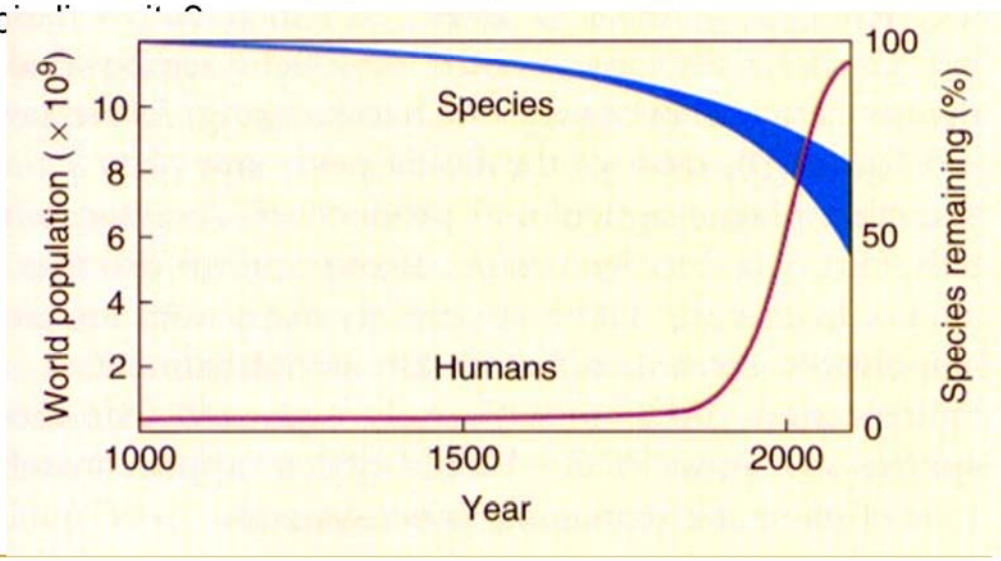




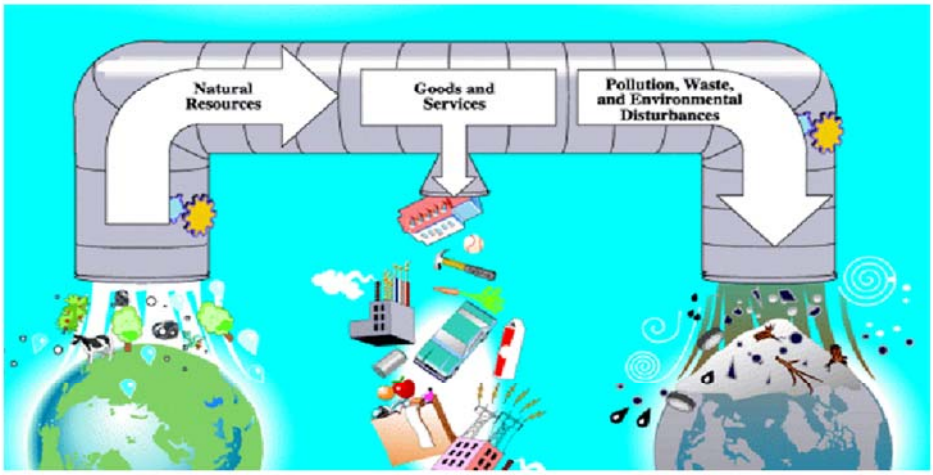
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Ecosystem Biodiversity

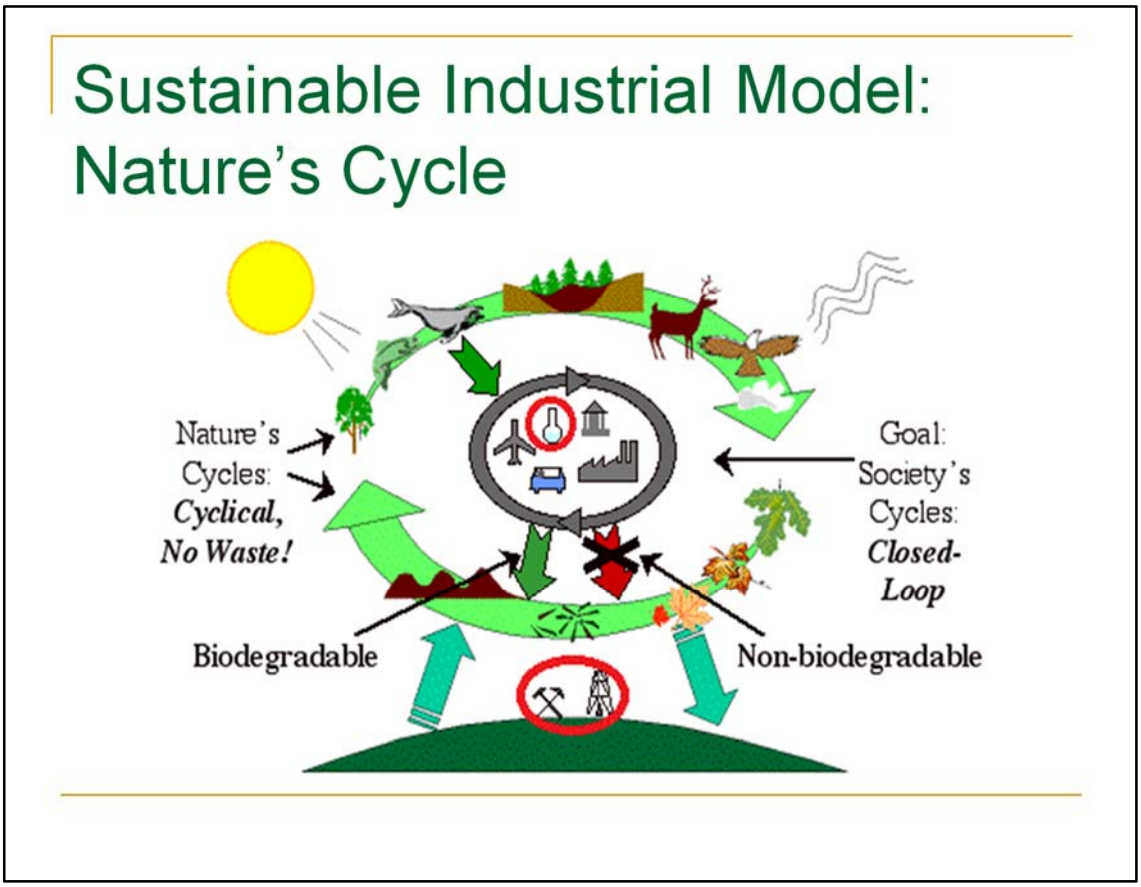
How does human population growth impact b



Current Industrial Cycle: Linear



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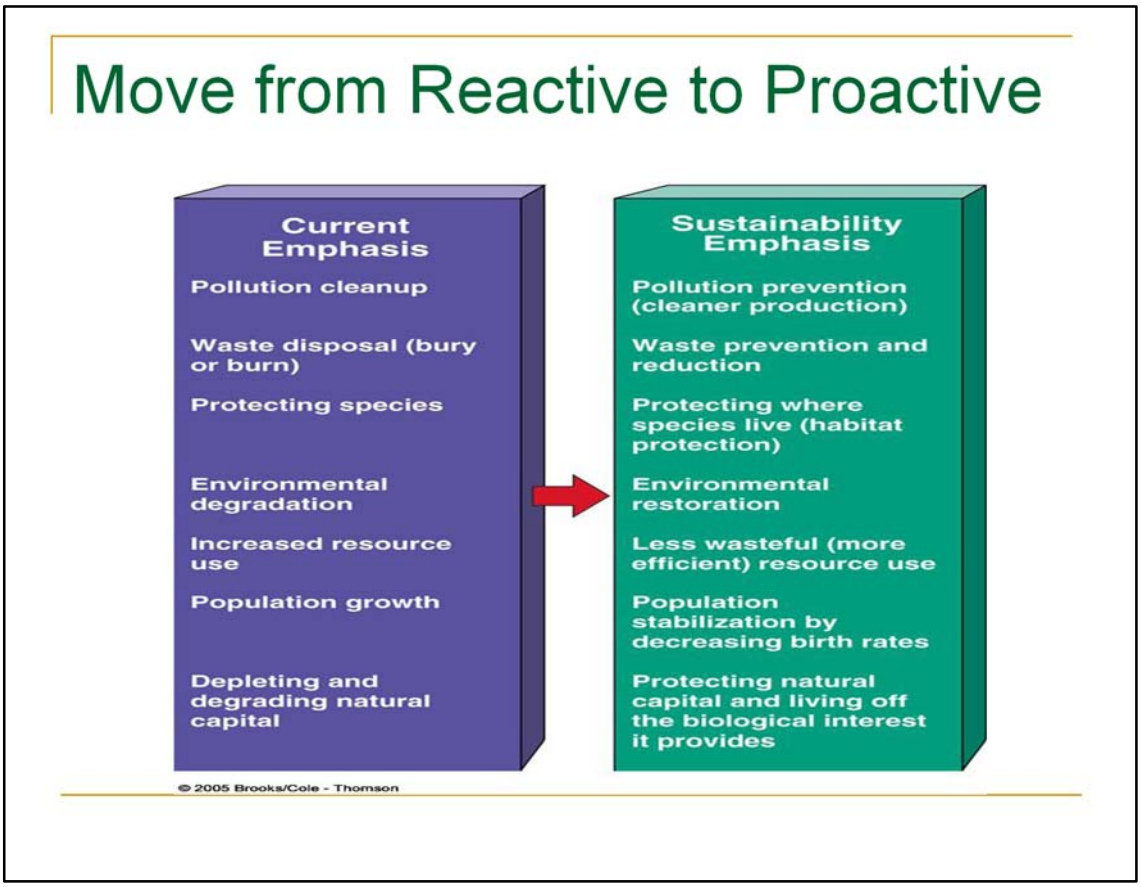


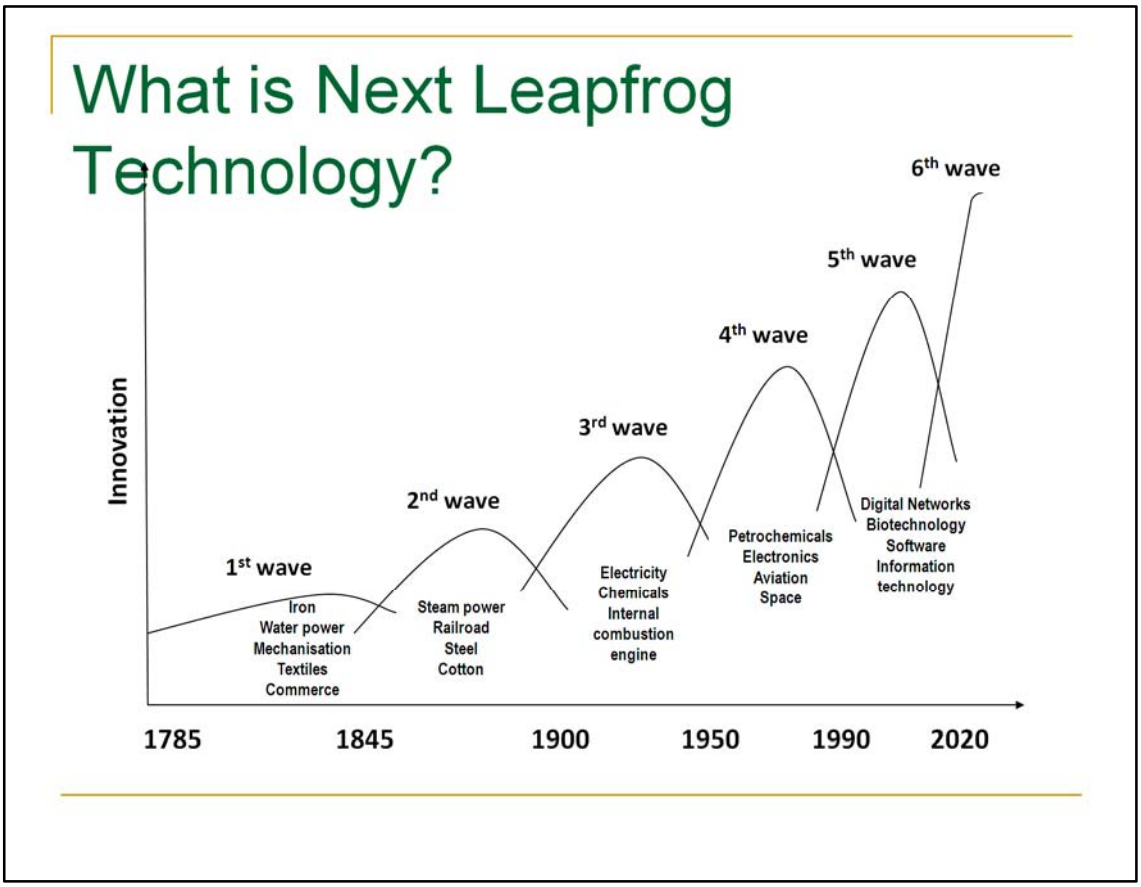
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Measure Your Sustainability

- Type and rate of material and water use
- Amount and type of energy consumption
- Amount and toxicity of waste and emissions
- Amount of land used or reused
- Development of workers

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Move from Reactive to Proactive
Current Emphasis
Pollution cleanup
Waste disposal (bury or burn)
Protecting species
Environmental degradation
Increased resource use
Population growth
Depleting and degrading natural capital
Sustainability Emphasis
Pollution prevention (cleaner production)
Waste prevention and reduction
Protecting where species live (habitat protection)
Environmental restoration
Less wasteful (more efficient) resource use
Population stabilization by decreasing birth rates
Protecting natural capital and living off the biological interest it provides
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What is Next Leapfrog Technology?
Innovation
1st wave
Iron
Water power
Mechanisation
Textiles
Commerce
2nd wave
Steam power
Railroad
Steel
Cotton
3rd wave
Electricity
Chemicals
Internal combustion engine
4th wave
Petrochemicals
Electronics
Aviation
Space
5th wave
Digital Networks
Biotechnology
Software
Information technology
6th wave
1785
1845
1900
1950
1990
2020

Make it Real - Sustainability

At Home:

- Think about whether you really need something new before buying it and throwing away something old. Donate the old item if possible.
- Buy electricity from renewable energy sources like wind farms.

At Work:

- Switch company-owned vehicles to hybrids (may qualify for tax breaks.)
- Reduce printing and recycle all paper that must be used. Buy and use recycled paper whenever possible.

Globally:

- Save and restore rainforests to maintain proper biodiversity levels.

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Simulation Scenario – Round 1



- New Wind Co. will be simulated involving many of the typical activities of a manufacturing business.
- New Wind Co. is a new start-up and produces micro wind turbines used to generate alternative energy.
- A “day” will be 20 minutes.

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Simulation Scenario – Round 1



- New Wind Co. is getting pressure from their key customer to work toward a Zero Landfill goal which will also reduce their overall Carbon Footprint.
- New Wind Co. also has an interest in being good environmental stewards within their community since they are constructing products intended for generation of alternative energy.

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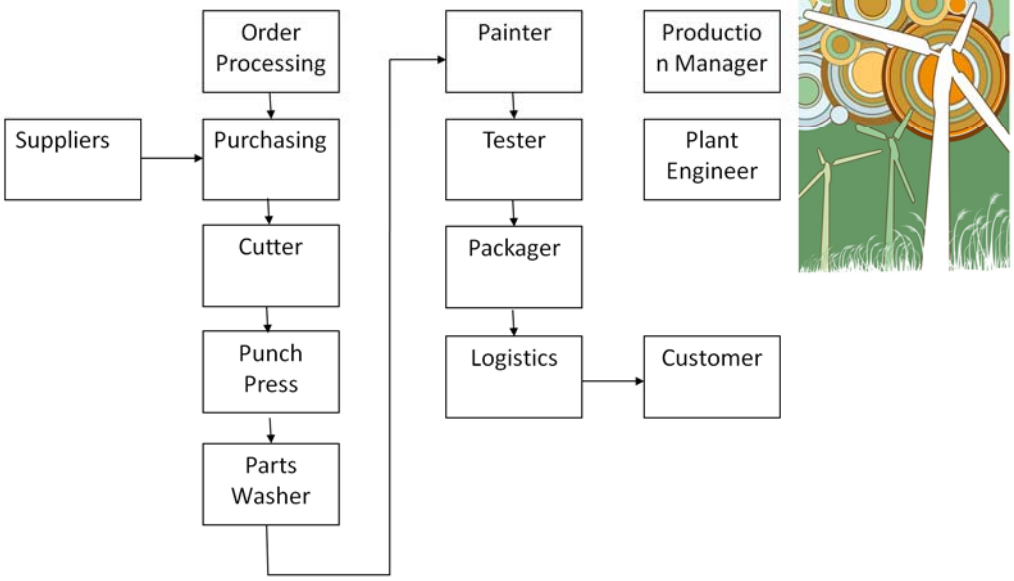
Simulation Scenario – Round 1



- Participants will assume the roles of:
  Purchasing, Order Processing, Supplier, Production Mgr, Cutter, Punch Press, Assembler, Parts Washer, Painter, Tester, Packager, Logistics, Customer, Plant Engineer.
- Other participants will serve as "Observers".
- Performance will be measured at the end of each "shift" and at the end of the "day" including:
  - Material Wasted, Energy Used, Hazardous Waste Disposal Quantity, Number of Customer Orders Delivered, Product Quantity Delivered, Returns.

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Simulation Scenario – Round 1



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Simulation – Round 1 Lessons Learned



- What was the outcome of the process? (Report out all measurements.)
- What do the performance measures tell you?
- What did the Plant Engineer identify in the Audit Checklist?
- How does this relate to your actual experiences in your facility?

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Solid Waste Streams

- Paper
- Glass
- Metal
- Plastic
- Electronics
- Organic
- Construction/ Demolition
- Hazardous
- Special/Universal
- Mixed Residue



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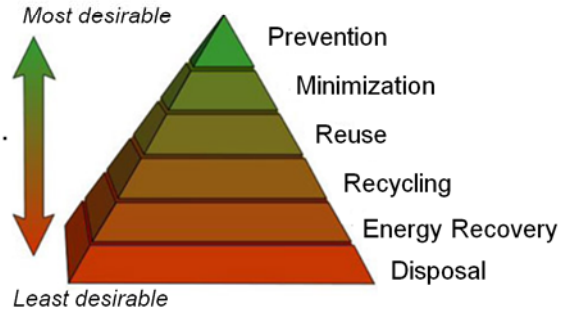
How is Solid Waste Managed?

- **Landfill** - Burying waste which is normally compacted first.
- **Incineration -** Burning of waste material to convert waste materials into heat, gas, steam and ash.
- **Recycling -** Extracting resources or value from waste to recover or reuse the material.
- **Energy Recovery** – Harnessing the energy content of waste products directly by using them as a combustion fuel, or indirectly by processing them into another type of fuel.
- **Avoidance and Reduction Methods –** Includes:
  - reuse of second-hand products,
  - repairing broken items instead of buying new,
  - designing products to be refillable or reusable or use less material, and
  - avoiding use of disposable products.

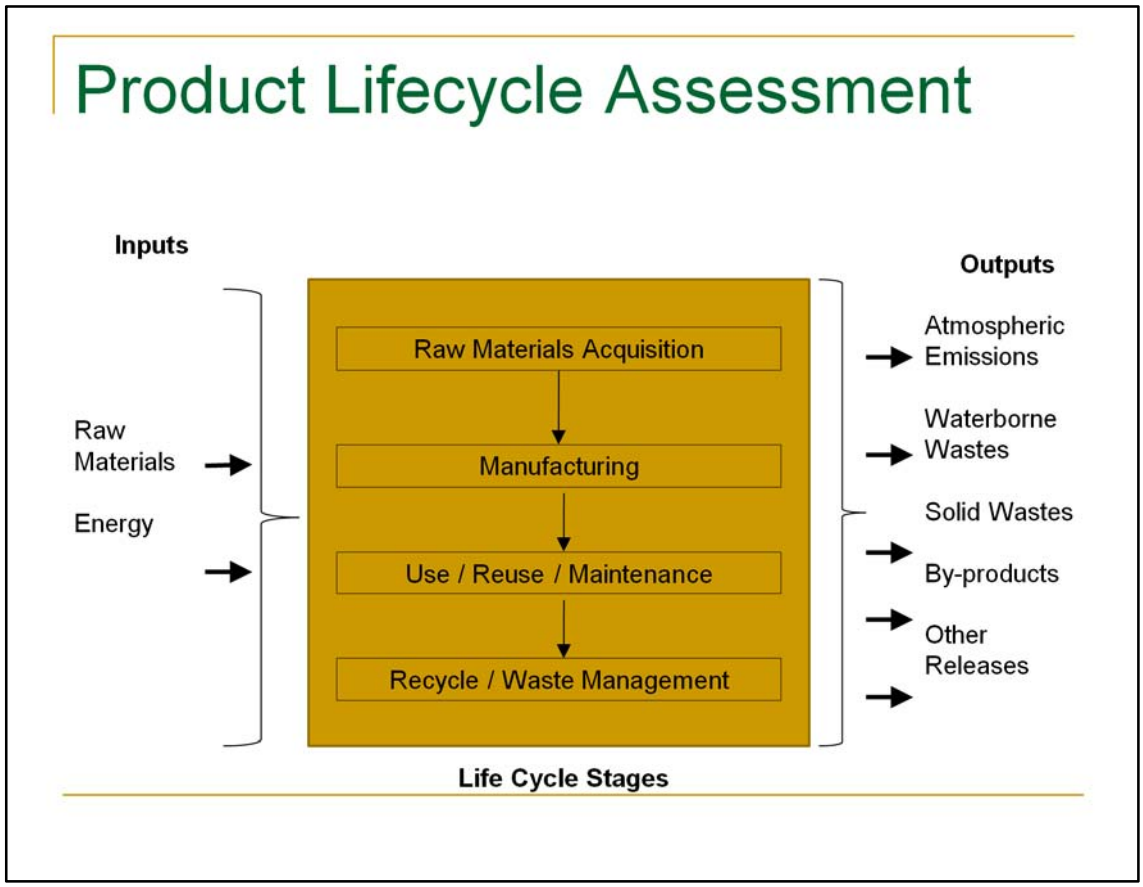
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Refuse, Reduce, Reuse, Recycle

- *Refuse* to buy new when current one is still usable.
- *Reduce* amount and toxicity of discarded trash.
- *Reuse* containers and products; repair what is broken.
- *Recycle* as much as possible; also buy products with recycled content.



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Alternative Materials Example

DuPont now produces high-performance thermoplastic resins and elastomer products made from *corn sugar* rather than petroleum.

- The products are targeted for automotive, electrical, electronic and other industrial markets.
- Offers their customers the benefits of renewably-sourced materials and reduced dependence on petrochemicals.
- Also requires approximately 40% less energy to manufacture than the earlier version.
- Contributes to the company's goal to drive 25% of its revenue from non-depletable resources by 2010.

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Refuse

Waste Prevention means consuming and throwing away less by:



- If you don't need it, don't buy it.
- Refusing products with excessive or non-recyclable packaging.
- Refuse to purchase throw-away items or cheaply made items that need to be replaced quickly.
- Refuse materials that require extra processing or additional energy to process, whenever possible.

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Reduce

Waste Reduction requires looking at the source of the waste to determine how it can be minimized by:

- Purchasing durable, long-lasting goods;
- Seeking products and packaging that are free of toxins;
- Using the minimum amount of energy required;
- Redesigning products to:
  - Use less raw material in production,
  - Have a longer life, or
  - Be used again after its original use is complete.



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By-Product Reduction

- Design products for the environment.
- Restructure production and distribution systems to prevent waste from being created in the first place.
- Purchase products and materials that will result in fewer by-product outputs.
- Find internal uses for the waste that is generated.

By-Product Examples:

Absorbents	Batteries	Cardboard
Machining fluids	Grinding swarf	Metal scrap
Plastic strapping	Paper	Rubber tubing
Sludges	Solvents	Textiles (rags)
Pallet wood	Product lubricants	

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Reuse - Benefits

- No reprocessing before it can be used again -- even better than recycling.
- Reduces waste - by repairing, donating to charity and community groups, or selling reusable items.



Reuse with Waste Exchange

Recovering the output of one Waste Stream to use as input for a manufacturing process.



Examples:

- Recovered glass in roadway asphalt (glassphalt).
- Recovered plastic in carpeting, park benches, and pedestrian bridges.

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Recycling Process

- Collecting recyclable materials that would otherwise be considered waste;
- Sorting and processing recyclables into raw materials such as fibers;
- Manufacturing these raw materials into new products;
- Purchasing recycled products completes the recycling loop.



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Reuse & Recycling Considerations

- Amount of material available for processing
- Concentration of collection sites
- Ease of separation of components
- Purity of materials / Mixed materials
- Consistency of waste stream quantity
- Proximity to the re-processing facility
- Inherent value of the waste stream output

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Results from Implementing 4Rs



- Increasing resource productivity/ eco-efficiency
- Stimulating development of greener technologies (New business = creation of jobs)
- Conservation of resources
- Supplying valuable raw materials to industry without harvesting them from Earth
- Reducing the need for new landfills and incinerators
- Preventing greenhouse gasses and water pollutants
- More profitability

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4Rs in Manufacturing

4Rs can be used in all phases of manufacturing:

- *Purchasing* recycled-content materials and components wherever feasible;
- *Use and reuse* a variety of materials within production, test, assembly and packaging;
- *Produce* recyclable products for the customer with minimum materials;
- Supply secondary markets with *usable by-products* generated by waste streams.

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Make it Real – Solid Waste

At Home:

- Select items wrapped in paper or cardboard, or not wrapped at all. Recycle the packaging (check plastic packaging for recyclability.)
- Take a reusable container for water, coffee, etc. rather than plastic water bottles or styrofoam drink cups.

At Work:

- Minimize waste – avoid surplus coating, cut-aways, trimming, by-products – in all production processes.
- Reduce the need for packaging; use packaging that contains recycled content or compostable material. Also consider reusable packaging.

Globally:

- Use appropriate waste, e.g., livestock waste, as a power source.
- Restrict purchases to recyclable or recycled materials and products to reduce the waste stream to zero.

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4Rs Exercise

- Think about your current work environment.
- Write down one example for each of the 4Rs (Refuse, Reduce, Reuse, Recycle) that could be implemented easily but has not been done yet.
- Also write down the names of other people in your company that would need to be involved if these changes are made.

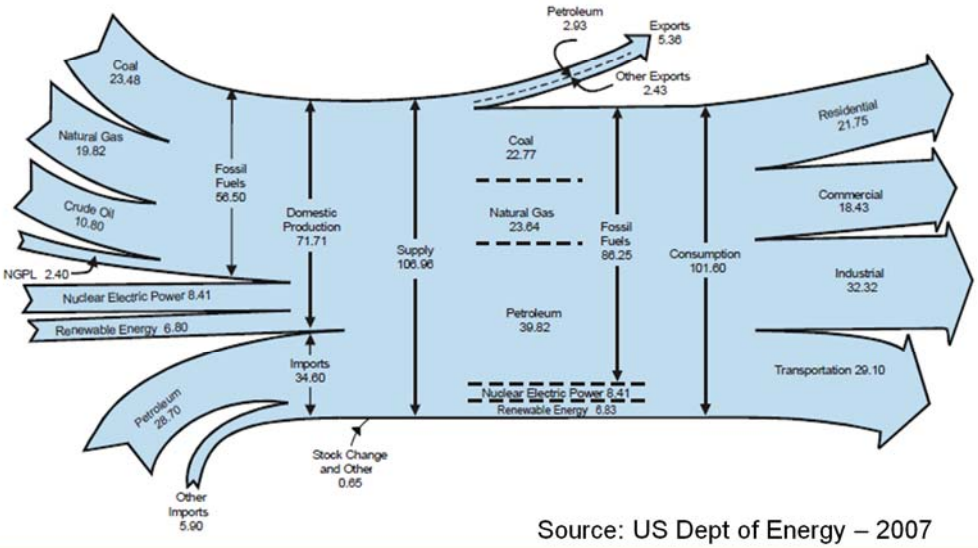
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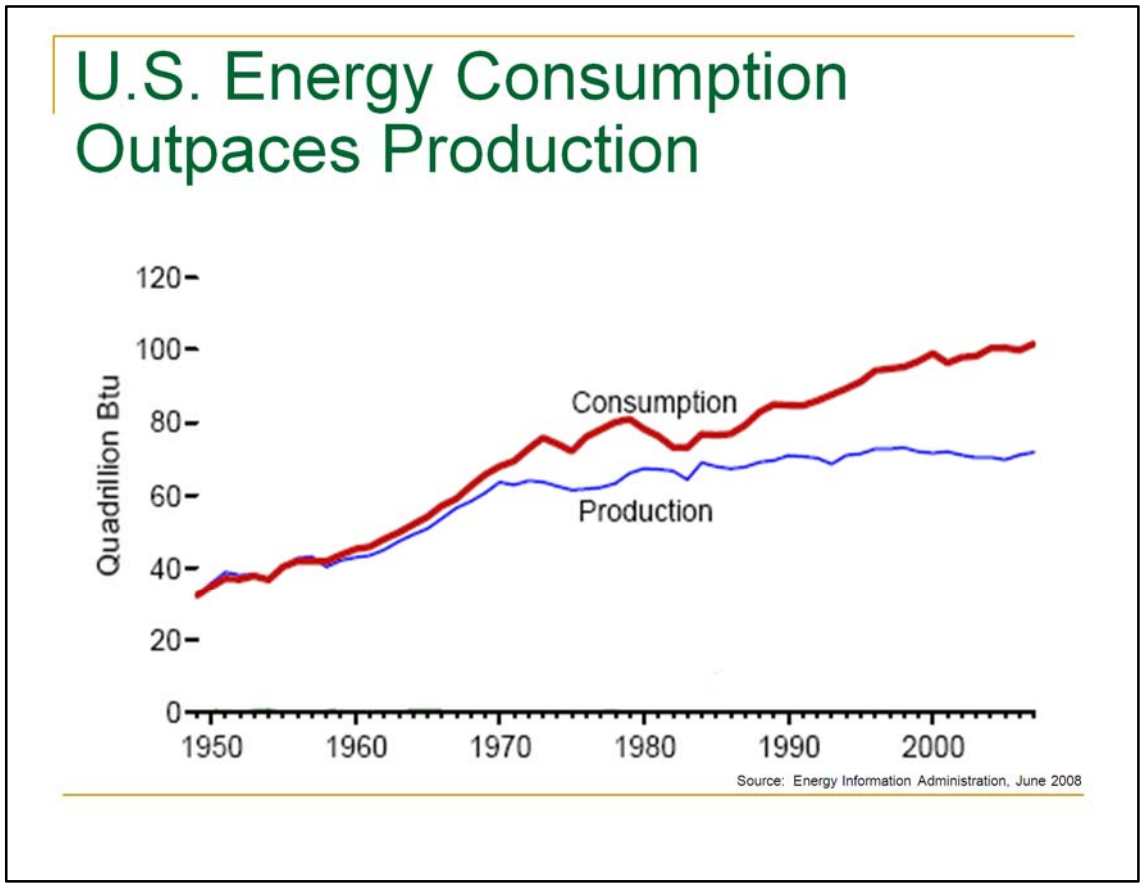
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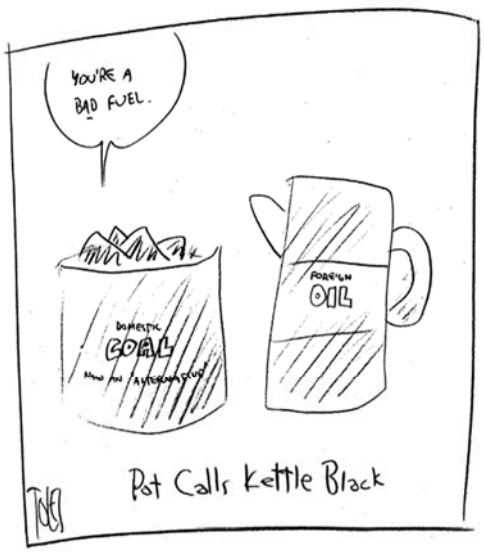
U.S. Energy: Production & Consumption



Source: US Dept of Energy – 2007


U.S. Energy Consumption Outpaces Production
Quadrillion Btu
120
100
80
60
40
20
0
1950
1960
1970
1980
1990
2000
Consumption
Production
Source: Energy Information Administration, June 2008

Facts: Energy Consumption

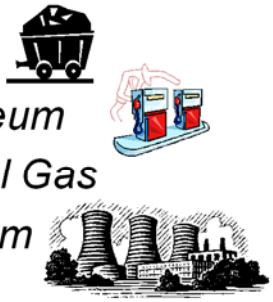


- Americans consume about 26% of the world's energy while accounting for only 5% of the world's population.
- Developing countries use 30% of global energy.
- Worldwide, about *2 billion* people are currently without electricity.

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Primary Energy Sources

- Traditional Sources (Non-Renewable)
  - *Coal*
  - *Petroleum*
  - *Natural Gas*
  - *Uranium*

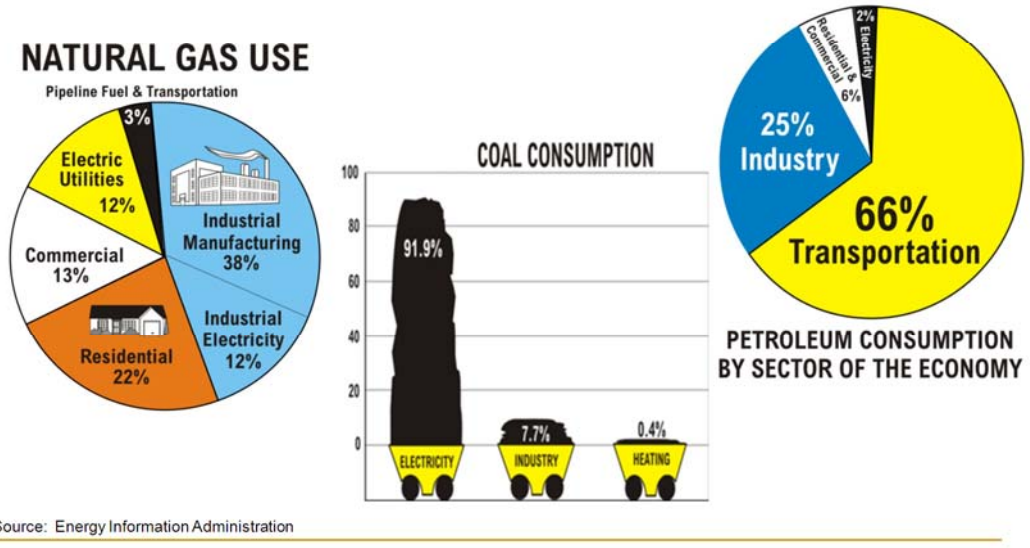


- Alternative Technology (Renewable)
  - *Wind Energy*
  - *Solar Power*
  - *Biomass*
  - *Geothermal*
  - *Hydropower*



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U.S. Energy Consumption



Source: Energy Information Administration

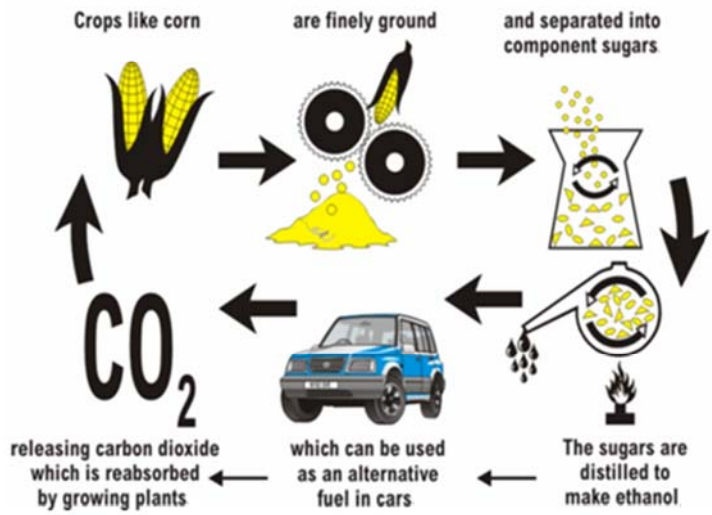
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Alternative Renewable Energy

- Biomass energy is generated by the combustion of plant materials liquids produced from plants, sewage, landfills, or animal waste.
- Geothermal is energy collected form absorbed heat underground, in the atmosphere and oceans. Used to heat buildings.
- Hydropower is energy from moving water. Used to powers generators that can then provide electricity.
- Solar power is energy from the sun which can be converted to heat and other power outputs.
- Wind energy is formed by the movement of air through wind turbines that harness the wind power to generate electricity.

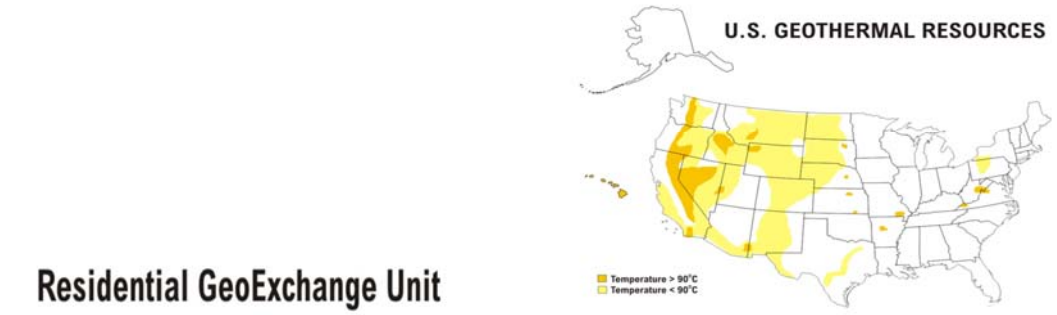
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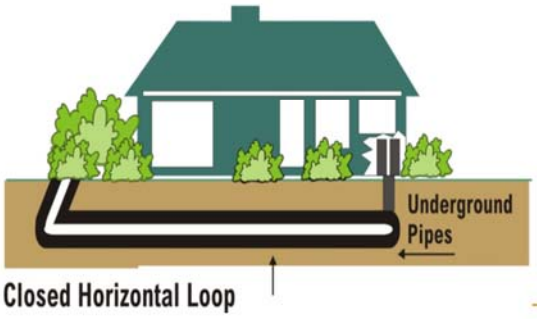
Renewable Energy - Biomass

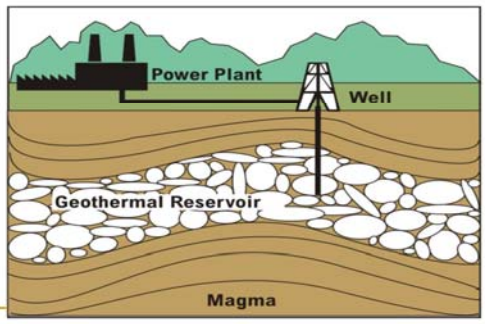


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Renewable Energy - Geothermal



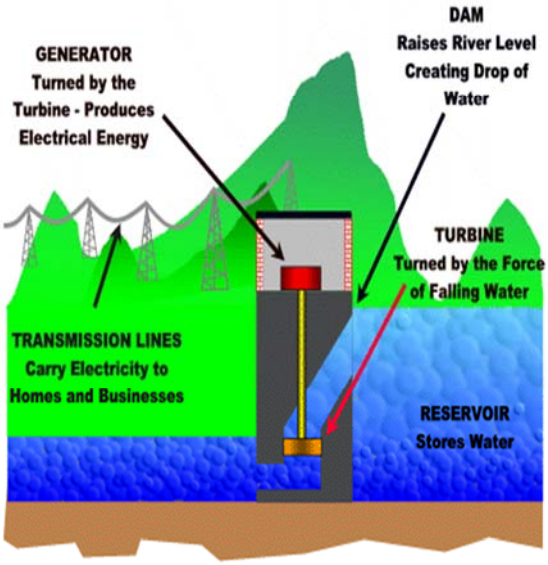




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Renewable Energy - Hydropower

- Most comes from potential energy of dammed water driving a water turbine and generator.
- Energy extracted depends on volume and difference in height between the source and the water's outflow.



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Renewable Energy - Solar



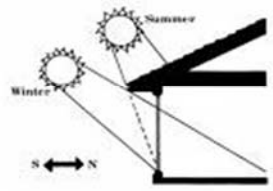
CSP (Concentrated Solar Power)



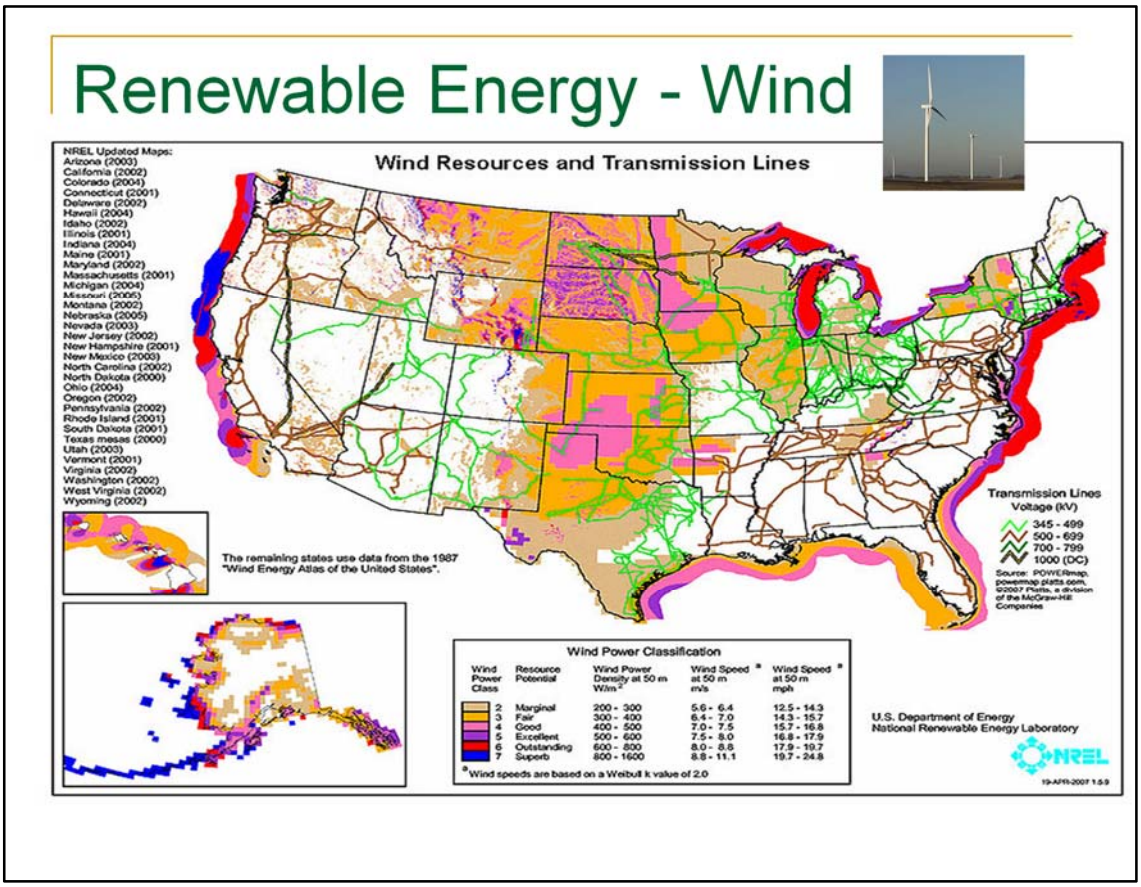
Solar Thermal



Photovoltaics



Passive Solar Design


Renewable Energy - Wind
Wind Resources and Transmission Lines
NREL Updated Maps:
Arizona (2003)
California (2002)
Colorado (2004)
Connecticut (2001)
Delaware (2002)
Hawaii (2004)
Idaho (2002)
Illinois (2001)
Indiana (2004)
Maine (2001)
Maryland (2002)
Massachusetts (2001)
Michigan (2004)
Missouri (2005)
Montana (2002)
Nebraska (2005)
Nevada (2003)
New Jersey (2002)
New Hampshire (2001)
New Mexico (2003)
North Carolina (2002)
North Dakota (2000)
Ohio (2004)
Oregon (2002)
Pennsylvania (2002)
Rhode Island (2001)
South Dakota (2001)
Texas mesas (2000)
Utah (2003)
Vermont (2001)
Virginia (2002)
Washington (2002)
West Virginia (2002)
Wyoming (2002)
The remaining states use data from the 1987 "Wind Energy Atlas of the United States".
Transmission Lines
Voltage (kV)
345 - 499
500 - 699
700 - 799
1000 (DC)
Source: POWERmap, powermap.platts.com, ©2007 Platts, a division of the McGraw-Hill Companies
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m²
Wind Speed at 50 m m/s
Wind Speed at 50 m mph
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb 800 - 1600 8.8 - 11.1 19.7 - 24.8
Wind speeds are based on a Weibull k value of 2.0
U.S. Department of Energy
National Renewable Energy Laboratory
NREL

Facts: Renewables

- Largest share of the renewable-generated electricity comes from hydroelectric energy (71%), followed by biomass (16%).
- Wind-generated electricity increased more than any other energy source -- almost 21% in 2007 over 2006.
- Followed closely by solar, which increased by over 19% in the same period.

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Conservation is the Best Alternative Energy!

- Conservation programs are easier to implement than any other "alternative energy" technology.
- It is also much more cost effective.
- Conservation should always be first on a list of solutions!

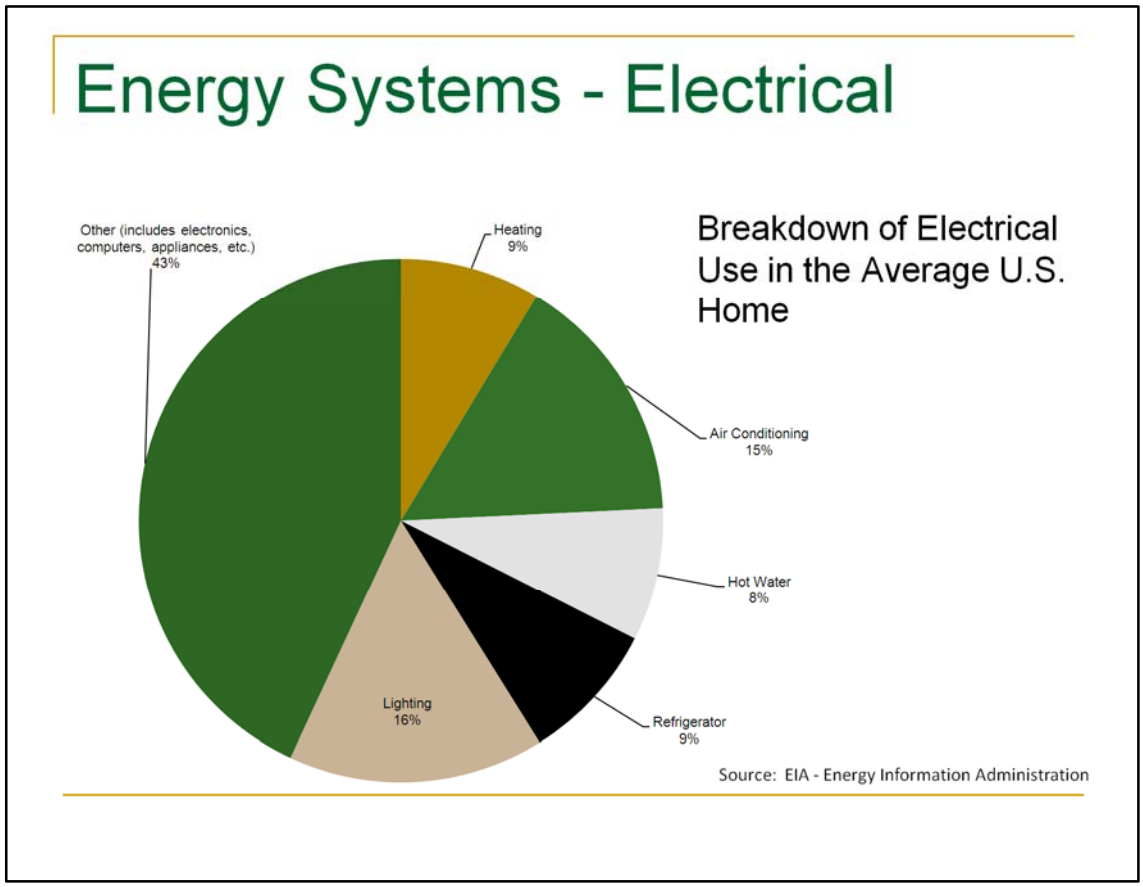
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Nine Major Energy Systems

- Building Envelope
- Heating, Ventilating, Air Conditioning (HVAC)
- Electrical Supply System
- Lighting
- Boiler and Steam System
- Hot Water System
- Compressed Air System
- Motors (pumps & fans)
- Special Purpose Process Equipment



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Energy Systems - HVAC



- Programmable thermostats – temperature setbacks during unoccupied hours can save up to 10% of heating / cooling costs.
- Clean & replace air filters per schedule.
- Consider geothermal systems for new construction or replacement – typically saving 30 – 50% of heating & cooling costs.

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Energy Systems - Lighting

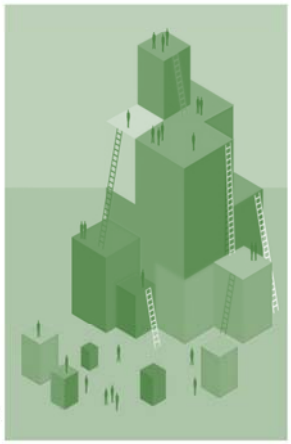


- Turn them off (motion detectors, photocell.)
- Compact fluorescents use ~25% of the energy to produce the same amount of light and last ~10 times longer than traditional incandescents.
- Light pipes or tubes offer tremendous daytime lighting savings.

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Energy Systems - Building Envelope

- Thermal Scan to determine where major heat losses are occurring.
- Seal all gaps around doors and windows.
- Replace windows with high R-value, if possible.



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Energy Systems – Compressed Air

- All air systems leak - some substantially. It is not uncommon to have a 30% leak rate.
- Even the best air compressor is only around 12-15% efficient. Use electric motors and actuators rather than pneumatic whenever possible.
- Eliminate inappropriate uses of compressed air, e.g., panel cooling, sparging, positioning, etc.
- Consider recovering waste heat from air cooled compressors for facility heating during colder seasons.

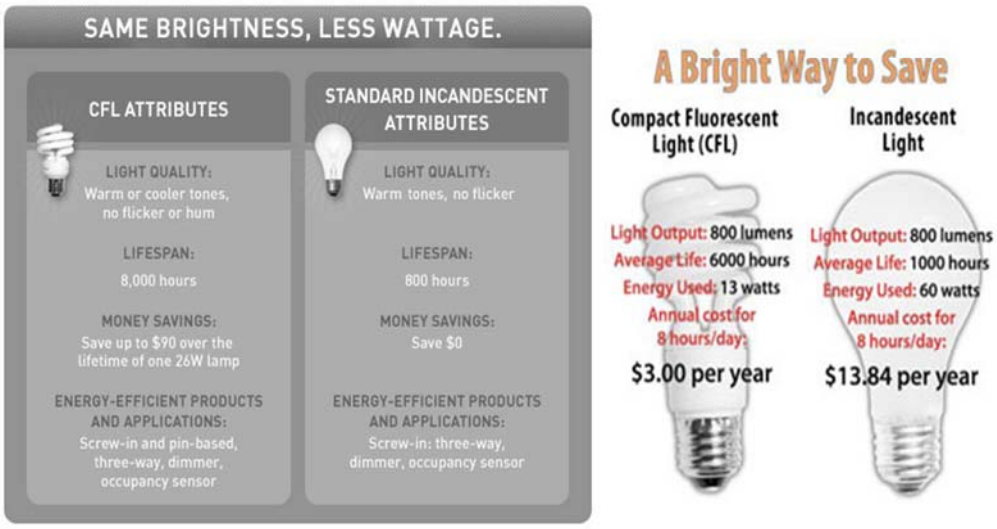
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Using an Energy Audit

- Identify types and costs of energy use.
- Understand how energy is being used & wasted.
- Identify and analyze more cost-effective ways of using energy with:
  - improved operational techniques
  - new equipment
- Perform an economic analysis on those alternatives to determine which are cost-effective.

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Light Bulb Comparison



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Make it Real - Energy

At Home:

- Choose Energy Star Appliances (gas is generally more cost effective than electric); adjust thermostats; switch to fluorescent bulbs.
- Consider Tankless Hot Water Heaters/Insulating blankets on older ones.
- Run full loads in Washer/Dryer/Dishwasher; vent Electric Dryers inside in winter.

At Work:

- Use laptop computers – they use 70 - 90% less energy than desktop models.
- Turn off equipment, table lamps, etc. when not in use.

Globally:

- Support development of alternative energy technology through your investment dollars, political choices and selection of energy providers.

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Simulation Scenario – Round 2



Develop ideas that can be implemented relating to the concepts covered:

- Refuse:
  - Materials requiring extra processing
- Reduce:
  - Material Use, Material Waste, Energy Use, Water Use, Transport
- Reuse:
  - Waste Materials, Returned Material, Packaging
- Recycle
  - Separation of Waste Materials, Waste Exchange, Purchase Recycled Products

No major Product Design changes will be permitted.

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Simulation – Round 2 Lessons Learned



- What was the outcome of the process? Report out all measurements.
- What do the performance measures tell you?
- What did the Plant Engineer identify in the Audit Checklist?
- How does this relate to your actual experiences in your facility?

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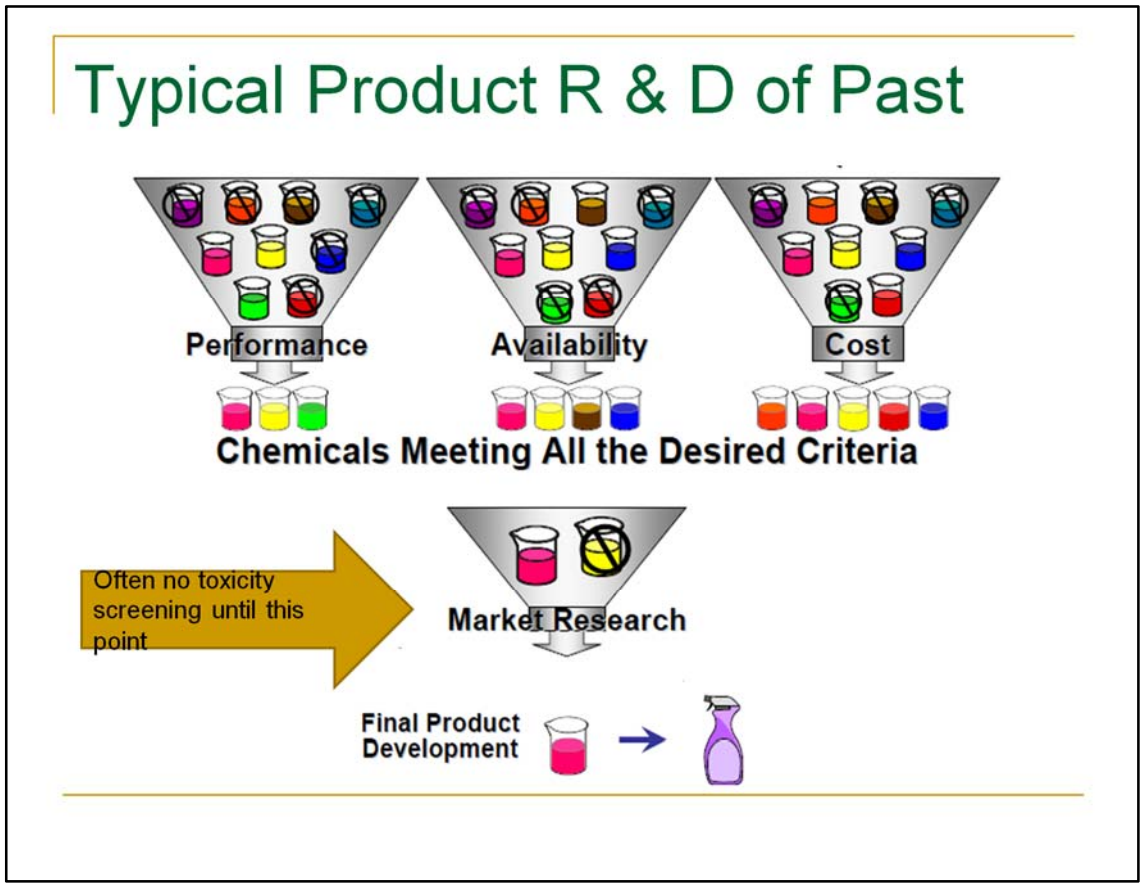
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Green Chemistry Philosophy

- Design products and processes to reduce use and generation of hazardous substances.
- Design processes to maximize raw material that ends up in the product;
- Use safe, environment-benign substances, including solvents;
- Design energy-efficient processes;
- Utilize the best form of waste disposal – do not create waste in the first place!



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Sustainable Futures Assessment

Risk = Hazard x Exposure

- Environmental Fate Hazard
  (If Hazard = 0, Low Toxicity Concern)
  - Aquatic Toxicity
  - Cancer Health Effects / Non-Cancer Health Effects
- Exposure Assessment
  (If Exposure = 0, Minimal Exposure Expected)
  - Occupational
  - Aquatic
  - General Population

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Tackling the Issue of Solvents (Auxiliary Substances)

- Substitute with a less harmful solvent, such as water.
- Use Supercritical Carbon Dioxide as a solvent.
- Switch to another process that requires no solvent.
- Enclose the operation so that the solvent is not lost.
- Place something on the plant outlet to destroy or recover the solvent.

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Re-engineering Processes



Switching from batch reactions to continuous processing:

- Is safer;
- Uses less energy;
- Uses fewer chemicals;
- Typically gives a higher purity product; and
- Allows more flexibility to prepare on demand rather than keeping inventory.

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Green Chemistry Example



- Monsanto developed an alternative way of making the popular herbicide Roundup®.
- They now avoid the use of extremely toxic hydrogen cyanide, along with avoiding production of cyanide-containing waste.
- Risks to people working at the manufacturing plant, to those living nearby and to the environment, are greatly reduced.
- Much smaller amount of waste produced is also safer since it does not contain cyanide.

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International Drivers for Green Chemistry

- Restriction of Hazardous Substances (ROHS)
  - Restricts use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs) (7/06)
  - Deca-bromodiphenylether (deca-BDE) (6/08)
- Waste Electrical/Electronic Equipment (WEEE) Directive
  - Requires producers of electrical/electronic equipment to finance collection arrangements for their products at the end-of-life (8/05)
- Registration, Evaluation, Authorization/restriction of Chemicals (REACH)
  - Requires all manufacturers and importers into the European Union (EU) to register all chemical substances into a database managed by the European Chemicals Agency in Helsinki (11/08)

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Make it Real – Green Chemistry

At Home:

- Investigate your home or farm for potential hazardous chemicals and educate all the residents about proper disposal of these wastes.
- Organize a community paint exchange, or encourage your community to sponsor a household hazardous waste collection event (volunteer for it.)

At Work:

- Identify alternative chemicals for any products that you use that are currently not safe for the environment. Work with Engineering, Purchasing, Maintenance, etc. to use the eco-friendly alternatives.

Globally:

- The best alternative for chemicals that are not safe for the environment are no chemicals at all. Find alternative methods to perform standard functions (cleaning, pest control, etc.) that eliminate chemical use.

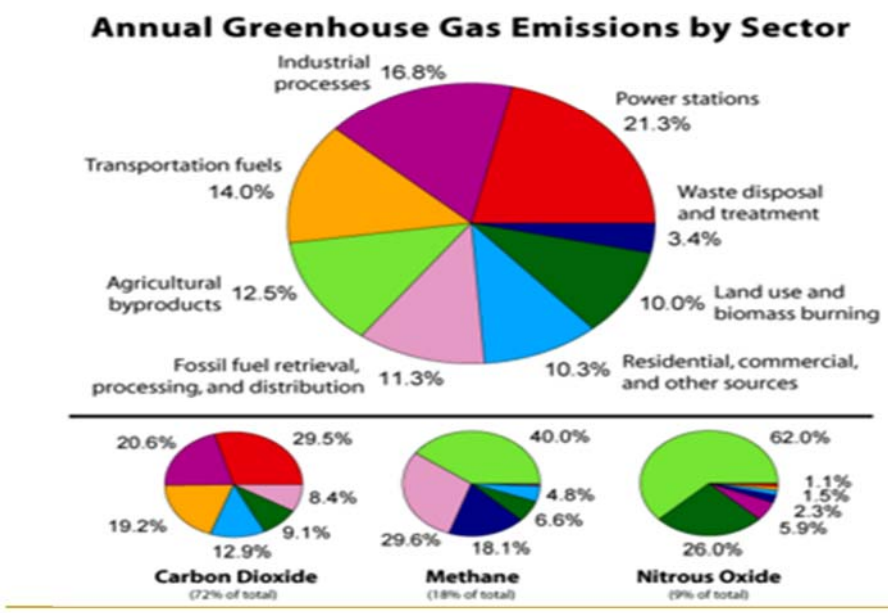
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Greenhouse Gas Emissions



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Carbon Dioxide (CO_2) Emissions



- On average, 16 million tons of CO_2 are emitted into the atmosphere every 24 hours by human use worldwide.
- Multiple methods will be needed to reduce the amount of CO_2 emissions including regulating output limits.

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Effects of Ozone Depletion

- Ozone depletion can cause increased amounts of UV radiation to reach the Earth.
  - This can lead to more cases of skin cancer, cataracts, and weakened immune systems.
- UV can also damage sensitive crops, such as soybeans, and reduce crop yields.
  - This can have negative consequences for food supplies and crops for biofuels.

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Air Quality Index

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 – 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 – 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 – 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 – 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 – 300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

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Air Contaminants

- Gas Phase Contaminants
  - Gas
  - Vapor



- Aerosol Contaminants
  - Dust
  - Fume
  - Mist
  - Smog
  - Smoke

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Industrial Air Sampling

- Personal
  - Sampling device is directly attached to the employee and worn continuously in the breathing zone during all work and rest operations.
- Breathing Zone
  - Sampling device remains in worker's breathing zone throughout workday.
- General Air (Area)
  - More appropriate for measuring source emissions rather than personal exposures.

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Air Pollution Prevention

- Need to focus on both source and waste reduction – including reuse and recycling.
- Preventing air pollution remains the preferred approach.
- Indirect air pollution prevention measures by companies covers the entire product lifecycle, including *transportation*.

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Make it Real – Air Emissions

At Home:

- Reduce your personal vehicle use. Combine trips, carpool.
- Eat less meat thereby reducing the overall agriculture byproduct production.

At Work:

- Have the air quality checked within your work facility. Identify potential air pollutants and work with necessary people to reduce the causes.

Globally:

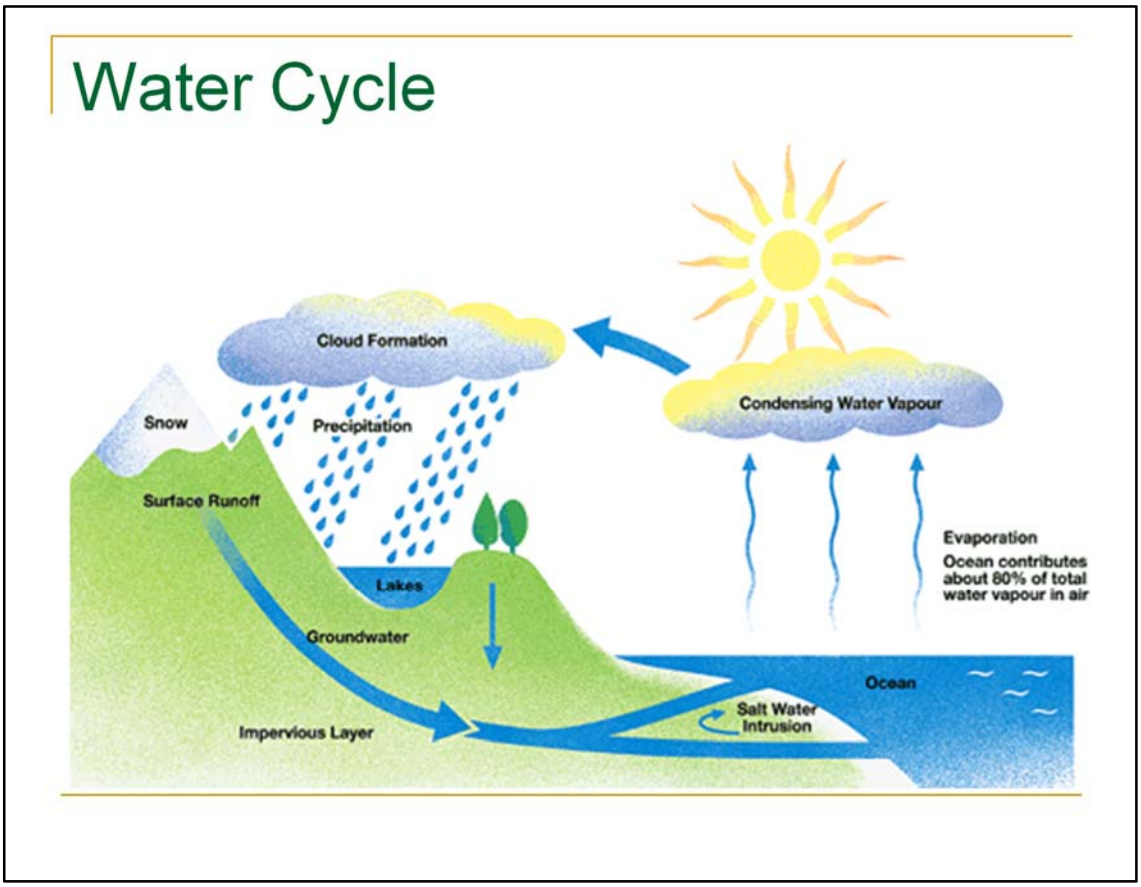
- Choose clean energy sources whenever possible – whether for electricity, heat or transportation.
- Plant trees and vegetation (preferably native to the area) to improve the balance of carbon dioxide emissions and reduce pollution.

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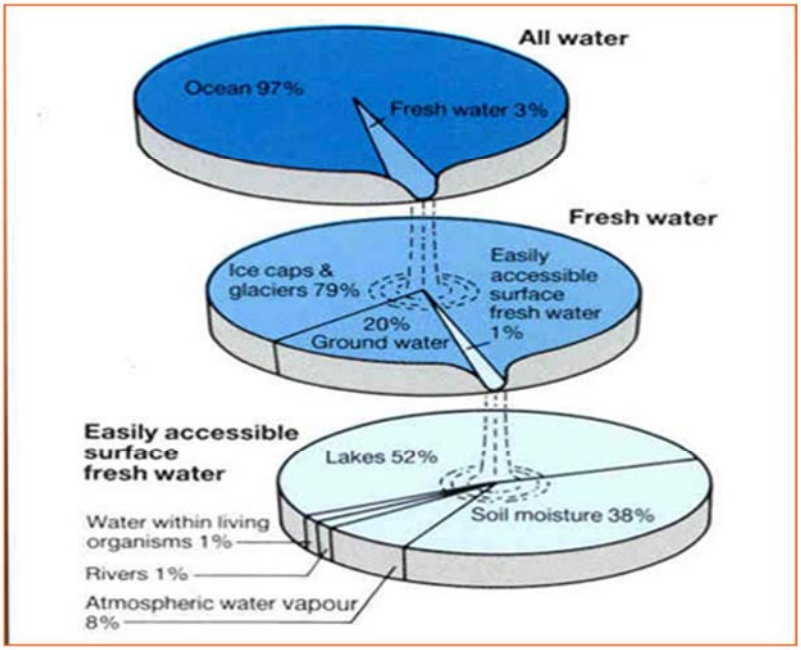
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Water Cycle
Cloud Formation
Condensing Water Vapour
Snow
Precipitation
Surface Runoff
Evaporation
Ocean contributes about 80% of total water vapour in air
Lakes
Groundwater
Ocean
Salt Water Intrusion
Impervious Layer

Freshwater is a Finite Resource



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Supply Water Quality



Human demands for water are increasing.

Water quality continues to degrade from:

- Industrial and agricultural pollution,
- raw sewage.

More people = More waste

But with the same percentage of freshwater as today.

Supply Water Considerations

Decisions relating to use of supply water resources and management are both political and economic.



For example:

250 million gallons of water will sustain 100,000 high tech jobs, but only 10 agricultural jobs.



If you are the decision maker, which do you choose?

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Non-Point Source Water Pollution

Leading cause of water pollution in the U.S. today.

The pollutants include:



- Excess fertilizers, herbicides, insecticides, and animal wastes from agricultural lands and residential areas.
- Oil, grease, and toxic chemicals from urban runoff and energy production.
- Forestry activities including tree and vegetation removal, especially along stream and river beds, and road construction.

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Keeping our Water Clean & Safe



Clean Water Act 1972

Goal: All surface waters to be swimmable & fishable. "Zero discharge" of pollutants into the nation's waters.

Status: ~40% in the U.S. are NOT!!

Safe Drinking Water Act 1974 (amended 1986 & 1996)

Goal: To protect the quality of both actual and potential drinking water through water quality standards.

Assess and protect drinking water sources; protect wells and collection systems; ensure water is treated by qualified operators; ensure the integrity of distribution systems.

Status: ~ 92% of the U.S water systems provide drinking water that meets all public health standards.

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Water Conservation and Efficiency

Water Conservation Hierarchy follows the 4Rs:

- Refuse – Don't Use!
- Reduce – Conserve
- Reuse/Recover – Divert, don't discharge
- Recycle – Reuse directly or treat



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Water Conservation Considerations

- Most water has only a single use. Increasing number of uses decreases demand.
- Wastewater can be treated to different qualities for industry, aquifer recharge, irrigation, and even to drinking water quality (psychological issues).
- Need to plan infrastructure along with new development and re-development to use best supply water and wastewater approaches.

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Community Water Management

Local stewardship of water resources:

- Enhances economic development opportunities;
- Improves overall environmental quality;
- Builds community value.



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Make it Real – Water Use

At Home:

- Check your home for leaky faucets, showerheads, and toilets; have the leaks repaired. Repair with water-saving options.



- Replace water-using appliances (washers, dishwashers, etc.) with environmentally friendly models when needed.
- Collect rainwater for use in gardens and lawn watering.



At Work:

- Ensure that no materials are flowing from your site into nearby storm drains streams or other water bodies.
- Develop a good leak and spill prevention program and have a plan of action for accidental spills.



Globally:

- Improve technologies to encourage reuse of water, e.g., greywater.

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Simulation Scenario – Round 3



Develop ideas that can be implemented relating to the concepts covered:

- Refuse, Reduce, Reuse, Recycle
- Alternative Materials
- Green Supply Chain
- Air Emissions
- Product Lifecycle

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Simulation – Round 3 Lessons Learned



- What was the outcome of the process? Report out all measurements.
- What do the performance measures tell you?
- What did the Plant Engineer identify in the Audit Checklist?
- How does this relate to your actual experiences in your facility?

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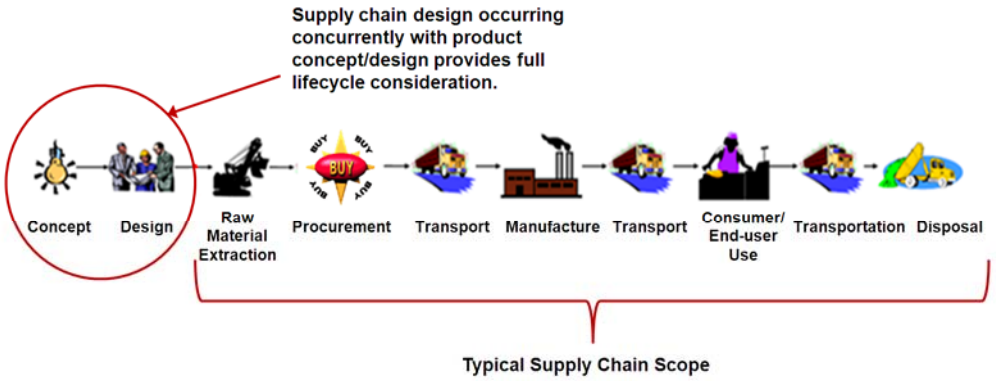
Environmental Management Success

- Cross-functional cooperation for environmental improvements.
- Environmental compliance and auditing programs.
- Cooperation with suppliers for environmental objectives.
- Cooperation with customer for eco-design, clean production and green packaging.



Green Supply Chain Management

Lifecycle Supply Chain:
All activities associated with the flow and production of goods -- from product concept through the end user.



Strategic Business Value

Determine the key driver(s) for making green improvements in your business:

- Cost Reduction
- Risk Management
- Regulatory Compliance
- Product Differentiation
- Managing Competitors
- Redefining Markets

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What Makes a Product Green?

Some examples:



- Products with recycled content
- Products that reduce material use
- Products with exceptional durability or low maintenance requirements (good lifecycle)
- Natural, rapidly renewable, or minimally processed products
- Products used to reduce negative environmental impacts (pollution, energy waste, etc.)

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LEED Certification



The Leadership in Energy and Environmental Design Green Building Rating System is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings.

Areas of focus:

- Sustainable site development
- Water savings
- Energy efficiency
- Materials and resources selection
- Indoor environmental quality

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Environmental Metrics





- Energy Used
- Air Emissions
- Materials Use
- Hazardous Waste Generation
- Chemical Use
- Solid Waste Generation
- Water Use
- Wastewater Discharges

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Why Measure Environmental Performance?

- Effective management and reduction of wastes, emissions, discharges, and accidents;
- Control environmental costs;
- Understand the effectiveness and environmental benefits of investments:
  - Choose wisely between alternative projects;
  - Justify capital requests and allocations.
- Easier environmental reporting (regulatory, stakeholder reports, etc.);
- Public relations and community/public image.

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Carbon Footprint

- The amount of fossil carbon consumed by a facility, converted to metric tons of CO_2, is their *carbon footprint.*
- Movement is underway to cap carbon emissions with companies in different industries or geographical regions given *allowances*.

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Carbon Offsets, Credits & Trading

- Carbon emissions can be “offset” by acquiring the rights to projects that reduce emissions, e.g., tree plantations, renewable energy.
- Carbon Credits can be earned by reducing emissions below your allowance.
- Credits (unused allowances) may be traded on the open market.

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Make it Real - Environment

At Home:

- Calculate your personal or family Carbon Footprint. Set 1 goal to accomplish in the next month to reduce your Carbon Footprint.

At Work:

- Meet with customers and suppliers to determine what things can be changed cooperatively to provide your products with a more positive impact on the environment. Implement agreed changes immediately.

Globally:

- Make the best environmental choices whenever you have a purchasing decision, whether for products or services. Always choose the most "green" option when you can.

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Implementation Action Plan

- Team up with 1 or 2 others.
- Identify at least 1 idea from the concepts we've discussed that you can implement right away.
- Use the Environmental Waste Reduction Plan form in the Appendix to document this idea.
- Complete the data requested as best as you can – make an educated guess if you don't have exact information and complete in more detail later.

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Appendix

Green Suppliers Network

The Green Suppliers Network is a collaborative venture among industry, the U.S. Environmental Protection Agency, and the U.S. Department of Commerce's National Institute of Standards and Technology's Manufacturing Extension Partnership (NIST MEP).

- Empowers companies to increase productivity, reduce waste and boost profitability.
- Combines Lean and Clean manufacturing methods by identifying opportunities to maximize return on investment and eliminate waste.

Lean and Clean

Using Lean and Clean manufacturing practices, the Green Suppliers Network review team will focus on incorporating process, energy, and material efficiencies into the supply chain, which can lead to substantial environmental benefits and reductions in labor and capital costs.

Improved Bottom Line

Green Suppliers Network reviewers work with suppliers to identify significant cost savings and environmental opportunities in their facilities.

Supply Chain Relationships

Through Green Suppliers, companies and their suppliers are able to work together to tackle common problems while building healthy collaborative relationships.

Metrics

NIST MEP centers will aggregate and quantify economic and environmental benefits identified during Green Suppliers Network Reviews.

Continuous improvement

The Green Suppliers Network establishes a delivery mechanism to engage manufacturers and their suppliers in continuous environmental/economic improvement.

Partnerships

The Green Suppliers Network partners with state, local and other federal agencies to bring the best technical, financial and research assistance to participating companies.

Successfully piloted in the automotive industry, this program is available to any manufacturing sector. Your company can be next!

Environmental Audit Checklist

Water Use

- ☐ How much water is used in the process and how is it used?
- ☐ How can you reuse water and/or reduce overall water use?
- ☐ Can you reduce contaminants in wastewater and discharges?

Energy Use

- ☐ How much energy is used in the process and how is it used?
- ☐ How can you reduce overall energy use?
- ☐ Is equipment running or are lights on when not being used?
- ☐ Are you using efficient light bulbs?
- ☐ Can you save energy by consolidating operations and/or storage space?
- ☐ Can you shift to a cleaner source of energy?

Chemicals and Materials Use

- ☐ What types and quantities of chemicals/materials are used in the process?
- ☐ How can you reduce the overall amount of chemicals and materials used?
- ☐ Can you switch to less harmful chemicals?
- ☐ Can you eliminate any non-value added use of chemicals or materials from the product or process (excess packaging, unneeded painting, etc.)?

Solid Waste

- ☐ What types and quantities of solid waste are generated by the process?
- ☐ How can you reduce the overall amount of solid waste generated?
- ☐ How can you reuse or recycle solid wastes?
- ☐ Is there a local composting facility that the waste can be taken to?

Hazardous Waste

- ☐ What types and quantities of hazardous waste are generated by the process?
- ☐ How can you reduce the amount or toxicity of hazardous waste generated?
- ☐ Can you better isolate and separate hazardous wastes from other wastes?

Air Emissions

- ☐ What types and amounts of air emissions are generated by the process?
- ☐ How can you reduce the overall amount or toxicity of air emissions?
- ☐ How far did vehicles travel to deliver parts and supplies?

Solid Waste Material Categories and Types

The list of material types is organized by category and type. Originally, the list included 57 types, but was expanded in 2004.

Paper

1. Uncoated Corrugated Cardboard
2. Paper Bags
3. Newspaper
4. White Ledger
5. Colored Ledger
6. Computer Paper
7. Other Office Paper
8. Magazines and Catalogs
9. Phone Books and Directories
10. Other Miscellaneous Paper
11. Remainder/Composite Paper

Glass

12. Clear Glass Bottles and Containers
13. Green Glass Bottles and Containers
14. Brown Glass Bottles and Containers
15. Other Colored Glass Bottles and Containers
16. Flat Glass
17. Remainder/Composite Glass

Metal

18. Tin/Steel Cans
19. Major Appliances
20. Used Oil Filters
21. Other Ferrous
22. Aluminum Cans
23. Other Nonferrous
24. Remainder/Composite Metal

Electronics

25. Brown Goods
26. Computer-related Electronics
27. Other Small Consumer Electronics
28. Televisions and Other Items with CRTs

Other Organic

39. Food
40. Leaves and Grass
41. Prunings and Trimmings
42. Branches and Stumps
43. Agricultural Crop Residues
44. Manures
45. Textiles
46. Carpet
47. Remainder/Composite Organic

Construction and Demolition

48. Concrete
49. Asphalt Paving
50. Asphalt Roofing
51. Lumber
52. Gypsum Board
53. Rock, Soil, and Fines
54. Remainder/Composite Construction and Demolition

Household Hazardous Waste

55. **Paint**
56. **Vehicle and Equipment Fluids**
57. **Used Oil**
58. **Batteries**
59. **Remainder/Composite Household Hazardous**

Special Waste

60. Ash
61. Sewage Solids
62. Industrial Sludge
63. Treated Medical Waste
64. Bulky Items
65. Tires
66. Remainder/Composite Special Waste

Solid Waste Material Categories and Types

Plastic

29. **PETE Containers**
30. **HDPE Containers**
31. **Miscellaneous Plastic Containers**
32. **Trash Bags**
33. **Grocer and Other Merchandise Bags**
34. **Non-Bag Commercial and Industrial Packaging Film**
35. **Film Products**
36. **Other Film**
37. **Durable Plastic Items**
38. **Remainder/Composite Plastic**

Mixed Residue

67. Mixed Residue

Sample Energy Saving Opportunities

Facility System	***Energy Saving Opportunity***
Pumps and fans	Replace on-off controllers with variable speed drives. By-pass any bends in the distribution system. Usage of premium energy efficient motors. Find locations to apply the Affinity Laws. Avoid using dampers and inlet vanes to control the flow. Use the fewest pumps to maintain flow when parallel pumps are installed.
Air Conditioning	Raise the room temperature seasonally to match the outside temperature. Consider night time temperature setback. Raise the chilled water temperature when the humidity is down. Use outside air when the conditions are right. Schedule pre-cooling time to match the occupation. Reduce hot deck temperature to match the minimum needs. Increase cold deck temperature to match the highest temperature needs. Damper operation and leaks, applicable to heating too. Replace dampers with variable speed drives, applicable to heating as well.
Heating	Reduce the hot water temperature to match the minimum comfort level. Remove heating units in corridors and lobbies. Avoid heating storerooms unless content requires certain temperature. Insulation on steam pipes. Lower turn on point of boilers in the spring and fall to reduce cycle time. Turn off boiler 30 minutes before the end of the occupied period. Check the operation of zone shut off valve. Verify the proper operation of steam traps. Examine the boiler or furnace efficiency, stack temperature, CO, and NO_x emission.
Electrical system	Conduct thermal imagery to identify lose connections and over-heated conductors. Correct for poor power factor. Check for presences of excessive harmonics & install filters as necessary. Examine ground wires and connections.

Sample Energy Saving Opportunities

Facility System	***Energy Saving Opportunity***
Building envelope	Raise R-Value of insulation of walls, attics, and roof. Keep positive inside air pressure. Proper use of skylight. Close leaks through overhead doors, foundation, and floor.
Process heat	Heat recovery through heat exchangers. Combined heat power-CHP.
Compressed Air	Fix leaks in pipes, fittings, and storage tanks. Drop air pressure to the lowest equipment specifications. Use heat recovery. Avoid improper use of compressed air.80-90% of energy used in producing compressed air is recoverable.
Lighting	Post reminders to turn off lights when not in use. Move work locations instead of moving or installing fixtures. Remove lights where too much light is available. Reduce high-bay lighting and use task lights. Arrange group-relamping (maintenance cost and morale). Replace with energy-efficient retrofits and lamps.

What Makes a Product Green?

- Salvaged products
- Products with post-consumer recycled content
- Products with pre-consumer recycled content
- Products made from agricultural waste material
- Products that reduce material use
- Products with exceptional durability or low maintenance requirements
- Certified wood products
- Rapidly renewable products
- Natural or minimally processed products
- Alternatives to ozone-depleting substances
- Alternatives to hazardous products
- Products that reduce or eliminate pesticide treatments
- Products that reduce stormwater pollution
- Products that reduce impacts from construction or demolition activities
- Products that reduce pollution or waste from operations
- Products that do not release significant pollutants into the building
- Products that block the introduction, development, or spread of indoor contaminants
- Building components that reduce heating and cooling loads
- Equipment that conserves energy and manages loads
- Renewable energy and fuel cell equipment
- Fixtures and equipment that conserve water
- Products that remove indoor pollutants
- Products that warn occupants of health hazards in the building
- Products that improve light quality
- Products that help control noise
- Products that enhance community well-being

BASIC ENVIRONMENTAL MEASURES

Category	Definition	Metric	Unit of Measure
Input Measures			
Energy Use	Any source providing usable power Transportation and non-transportation sources	Energy Used	Specific to energy source such as BTUs or kilowatt hours, % reduction, energy use/unit of product
Land Use	Land covered by buildings, parking lots, and other impervious surfaces Land/habitat conservation	Land Converted, Land Restored or Protected, Area of Impervious Surfaces	Square feet, acres
Materials Use	Materials used (total or specific), including: - Ozone depleting substances (e.g., CFC-11) - Packaging materials Proportion of input materials that were recycled or recovered (vs. virgin materials)	Materials Used, Percent Utilization of Materials, Post-Consumer Recycled Content	Tons/year, pounds/unit of product, % materials utilization
Toxic/Hazardous Chemicals Use	Use of hazardous and toxic chemicals that are regulated or otherwise of concern	Toxic/Hazardous Chemicals Used	Pounds/year, pounds/unit of product, % reduction
Water Use	Incoming raw water, from outside sources, e.g., from municipal water supply or wells, for operations, facility use, and grounds maintenance. NPDES	Volume of Water Used, P2 to reduce Priority Chemicals/Quality Standards/Pretreat Standards	Gallons/year, % reduction, % recycled Pounds Priority Chemicals/year, % reduced, % recycled

From “The Lean and Environment Toolkit” published by the US EPA

BASIC ENVIRONMENTAL MEASURES

Category	Definition	Metric	Unit of Measure
Non-Product Output Measures			
Air Emissions	The release of any of the following: Air toxics - CAA 112b HAPs (see attachment A) Carbon Monoxide Lead Ozone and its precursors, including: VOCs (volatile organic compounds) NOx (nitrogen oxides) Ozone-depleting substances PM10 (particulate matter) PM2.5 (fine particulate matter) Sulfur Dioxide Greenhouse gases, including Carbon Dioxide	Air Emissions Generated	Pounds/year, Tons/year % reduction
Water Pollution	Quantity of pollutant in wastewater that is discharged to water source. Should include any substances regulated in NPDES permit. May include: Heavy Metals - Cu, Pb, Hexavalent Chromium, Cadmium, Zn, Ni, Hg, Organic Pollutants and Pesticides, Conventional pollutants, e.g., oil and grease, BOD and suspended solids, and Nutrients - N, P Pathogens Sediment from runoff	Mass or Concentration of Regulated Pollutants Discharged	Pounds/year, mg/L or % reduction

From "The Lean and Environment Toolkit" published by the US EPA

BASIC ENVIRONMENTAL MEASURES

Category	Definition	Metric	Unit of Measure
Non-Product Output Measures (continued)			
Solid Waste	Wastes (liquid or solid) other than RCRA hazardous wastes.	Solid (Non-Hazardous) Waste Generated	Gallons or pounds/year, % reduction, % recycled
Downstream/Product Measures			
Product Impacts	Expected lifetime energy and water use Wastes (to air, water, & land) from product use and disposal or recovery	Energy and water used (over product's lifecycle) Waste generated (after the product is used)	Energy - Btu, kWh, MWh Water use - gallons Wastes - pounds, tons
Other Measures			
Money Saved	Money saved in the reduction of materials or other changes in processes (DfE/Clean Production) Savings from leaning out of permits	Dollars saved	Dollars saved

From "The Lean and Environment Toolkit" published by the US EPA

Principles of Green Chemistry PRODUCTIVELY

Paul Anastas, then of the United States Environmental Protection Agency, and John C. Warner developed 12 **principles of green chemistry**, (reference Green Chemistry: Theory and Practice.)

The 12 principles are:

*1) **P**revent waste:* Design chemical syntheses to prevent waste, leaving no waste to treat or clean up.

*2) **R**enewable feedstock:* Use raw materials and feedstock that are renewable (often made from agricultural products or wastes of other processes) rather than from fossil fuels (petroleum, natural gas, or coal).

*3) **O**mit chemical derivatives or derivation steps:* Derivatives use additional reagents and generate waste.

*4) **D**esign chemicals and products to degrade after use:* To break down after use so that they do not accumulate in the environment.

*5) **U**se less hazardous chemical syntheses:* Use and generate substances with little or no toxicity to humans or environment.

*6) **C**atalysts should be used, not stoichiometric reagents:* Catalysts are used in small amounts and can carry out a single reaction many times. They are preferable to stoichiometric reagents, which are used in excess and work only once.

*7) **T**emperature at ambient:* Run chemical reactions at ambient temperature and pressure whenever possible *to* increase energy efficiency.

*8) **I**n-process real-time monitoring and control:* Analyzing in real time to prevent pollution helps minimize or eliminate the formation of byproducts.

*9) **V**ery few auxiliary substances:* Avoid using solvents, separation agents, or other auxiliary chemicals. If a solvent is necessary, water is a good medium as well as certain eco-friendly solvents that do not contribute to smog formation or destroy the ozone.

*10) **E**-factor:* Maximize atom economy in the design so that the final product contains the maximum proportion of the starting materials.

*11) **L**ow toxicity:* Design safer chemicals and products to be fully effective, yet have little or no toxicity.

12) Yes, it is Safe!: Design chemicals and their forms (solid, liquid, or gas), along with their processes to minimize the potential for explosions, fires, and releases to the environment.

Environmental Waste Reduction Plan

(Copy this form and use one for each process, operation or activity)

DATE:_____ FACILITY: _____

PROCESS, OPERATION OR ACTIVITY: _____

For each waste stream generated, determine:

• Point of origin _____
• Subsequent handling/treatment/disposal _____
• Physical and chemical characteristics _____
• Quantity _____
• Rate of generation (i.e., lbs/unit of product) _____
• Variations in generation rate _____
• Potential for contamination or upset _____
• Cost to manage or dispose _____

List all toxic substances used in this process:

List reduction options for this process:

Which option is economically most feasible (list costs)? Explain:

Which option is technically most feasible? Explain:

How much reduction is realistic? Over what period of time? (This is your waste reduction goal for this waste stream.)

List positive and negative impacts on the environment or on employee health and safety.

Toxic substances affected:

Other waste streams affected:

Products affected:

Proposed Implementation Date:

Glossary

Glossary

Abatement – The reduction in landfill pollution by source reduction and waste recycling.

Acid Deposition – A complex chemical and atmospheric phenomenon that occurs when emissions of sulfur and nitrogen compounds and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on earth in either wet or dry form. The wet forms, popularly called "acid rain," can fall to earth as rain, snow, or fog. The dry forms are acidic gases or particulates.

Aerobic – with oxygen present.

Air Pollutant – Any substance in air that could, in high enough concentration, harm man, other animals, vegetation, or material. Pollutants may include almost any natural or artificial composition of airborne matter capable of being airborne. They may be in the form of solid particles, liquid droplets, gases, or in combination thereof. Generally, they fall into two main groups: (1) those emitted directly from identifiable sources and (2) those produced in the air by interaction between two or more primary pollutants, or by reaction with normal atmospheric constituents, with or without photoactivation. Exclusive of pollen, fog, and dust, which are of natural origin, about 100 contaminants have been identified. Air pollutants are often grouped in categories for ease in classification; some of he categories are: solids, sulfur compounds, volatile organic chemicals, particulate matter, nitrogen compounds, oxygen compounds, halogen compounds, radioactive compound, and odors.

Air Pollution Control Device – Mechanism or equipment that cleans emissions generated by a source (e.g. an incinerator, industrial smokestack, or an automobile exhaust system) by removing pollutants that would otherwise be released to the atmosphere.

Air Handling Unit (AHU) – Central unit consisting of a blower, heating and cooling elements, filter racks or chamber, dampers, humidifier, and other central equipment in direct contact with the airflow. This does not include the ductwork through the building.

Anaerobic – without oxygen present.

Anaerobic Digester – a wastewater treatment process that uses microbes to reduce the amount of solid sludge waste; generates methane and carbon dioxide gases as byproducts.

Aquifer – an underground geological formation able to store and yield water.

Aquifer Storage and Retrieval (ASR) – Use of a well or series of wells to inject surface water into an aquifer during wet weather or low demand periods for purposes of withdrawal and use during drought and/or high demand periods.

Artificial Recharge – Putting water back into groundwater storage from surface water supplies such as irrigation, or induced infiltration from streams or wells. Includes aquifer storage and retrieval (ASR).

BACT – Best Available Control Technology – An emission limitation based on the maximum degree of emission reduction (considering energy, environmental, and economic impacts) achievable through application of production processes and available methods, systems, and techniques. BACT does not permit emissions in excess of those allowed under any applicable Clean Air Act provisions. Use of the BACT concept is allowable on a case by case basis for major new or modified emissions sources in attainment areas and applies to each regulated pollutant.

Baseflow – Streamflow coming from groundwater seepage into a stream or river. Groundwater flows underground until the water table intersects the land surface and the flowing water becomes surface

water in the form of springs, streams/rivers, lakes and wetlands. Baseflow is the continual contribution of groundwater to rivers and is an important source of flow between rainstorms.

Benefit – Cost Analysis – An economic method for assessing the benefits and costs of achieving alternative health–based standards at given levels of health protection.

Best Management Practice (BMP) – Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non–point sources.

Brackish – Mixed fresh and salt water.

British Thermal Unit (BTU) – Any of several units of energy (heat) in the HVAC industry, each slightly more than 1 kJ. One BTU is the energy required to raise one pound of water one degree Fahrenheit, but the many different types of BTU are based on different interpretations of this "definition". In the United States the power of HVAC systems (the rate of cooling and dehumidifying or heating) is sometimes expressed in BTU/hour instead of watts.

Brown Goods – means generally larger, non–portable electronic goods that have some circuitry. Examples include microwaves, stereos, VCRs, DVD players, radios, audio/visual equipment, and non–CRT televisions (such as LCD televisions). **Note**: This type was classified under Remainder/Composite Metal in the original 57 standard material types used in the 1999 Statewide Study and the solid waste characterization database.

Bulk Sample – A small portion (usually thumbnail size) of a suspect asbestos–containing building material collected by an asbestos inspector for laboratory analysis to determine asbestos content.

Carrying Capacity - The maximum number of individuals that a given environment can support without detrimental effects.

Catalyst – a substance that helps chemical reactions to occur but is not changed in the reaction

Carbon Footprint – When used in Ecological Footprint studies, this term is synonymous with demand on CO_2 area. NOTE: The phrase "Carbon Footprint" or "carbon footprint" has been picked up in the climate change debate. There are several calculators that use the phrase "Carbon Footprint", but many just calculate tons of carbon, or tons of carbon per euro, rather than demand on bioproductive area.

Central Collection Point – Location were a generator of regulated medical waste consolidates wastes originally generated at various locations in his facility. The wastes are gathered together for treatment on–site or for transportation elsewhere for treatment and/or disposal. This term could also apply to community hazardous waste collections, industrial and other waste management systems.

Chiller – A device that removes heat from a liquid via a vapor–compression or absorption refrigeration cycle. This cooled liquid flows through pipes in a building and passes through coils in air handlers, fan–coil units, or other systems, cooling and usually dehumidifying the air in the building. Chillers are of two types; air–cooled or water–cooled. Air–cooled chillers are usually outside and consist of condenser coils cooled by fan–driven air. Water–cooled chillers are usually inside a building, and heat from these chillers is carried by recirculating water to outdoor cooling towers.

Glossary

Closed –Loop Recycling– Reclaiming or reusing wastewater for non–potable purposes in an enclosed process.

Closure – The procedure a landfill operator must follow when a landfill reaches its legal capacity for solid ceasing acceptance of solid waste and placing a cap on the landfill site.

Code of Federal Regulations (CFR) – Document that codifies all rules of the executive departments and agencies of the federal government. It is divided into fifty volumes, known as titles. Title 40 of the CFR (referenced as 40 CFR) lists all environmental regulations.

Coil – Equipment that performs heat transfer when mounted inside an Air Handling unit or ductwork. It is heated or cooled by electrical means or by circulating liquid or steam within it. Air flowing across it is heated or cooled.

Consumption Footprint – The most commonly reported type of Ecological Footprint. It is the area used to support a defined population's consumption. The consumption Footprint (in gha) includes the area needed to produce the materials consumed and the area needed to absorb the waste. The consumption Footprint of a nation is calculated in the National Footprint Accounts as a nation's primary production Footprint plus the Footprint of imports minus the Footprint of exports, and is thus, strictly speaking, a Footprint of apparent consumption. The national average or per capita Consumption Footprint is equal to a country's Consumption Footprint divided by its population.

Compliance Monitoring – Collection and evaluation of data, including self–monitoring reports, and verification to show whether pollutant concentrations and loads contained in permitted discharges are in compliance with the limits and conditions specified in the permit.

Composting – The controlled biological decomposition of organic material in the presence of air to form a humus–like material. Controlled methods of composting include mechanical mixing and aerating, ventilating the materials by dropping them through a vertical series of aerated chambers, or placing the compost in piles out in the open air and mixing it or turning it periodically.

Condensation – The process in the hydrologic cycle by which a vapor becomes a liquid; the opposite of evaporation.

Condenser – A component in the basic refrigeration cycle that ejects or removes heat from the system. The condenser is the hot side of an air conditioner or heat pump. Condensers are heat exchangers, and can transfer heat to air or to an intermediate fluid (such as water or an aqueous solution of ethylene glycol) to carry heat to a distant sink, such as ground (earth sink), a body of water, or air (as with cooling towers).

Conditionally Exempt Generators (CE) – Persons or enterprises which produce less than 220 pounds of hazardous waste per month. Exempt from most regulation, they are required merely to determine whether their waste is hazardous, notify appropriate state or local agencies, and ship it by an authorized transporter to a permitted facility for proper disposal.

Conservation – The use of methods to reduce the amount of resources needed for homes, farming, and industry, and thus increasing resource supplies for optimum long–term economic and social benefits.

Contaminant – Any substance that when added to water (or another substance) makes it impure and unfit for consumption or an intended use.

Glossary

Constant air volume (CAV) – A system designed to provide a constant air volume per unit time. This term is applied to HVAC systems that have variable supply–air temperature but constant air flow rates. Most residential forced–air systems are small CAV systems with on/off control.

Consumptive Use – The use of a resource that reduces the supply (removing water from a source like a river, lake or aquifer without returning an equal amount). Examples include the intake of water by plants, humans, and other animals and the incorporation of water into the products of industrial or food processing.

Conversion factor – A generic term for factors which are used to translate a material flow expressed within one measurement system into another one. For example, a combination of two conversion factors—"yield factors" and "equivalence factors"— translates hectares into global hectares. The extraction rate conversion factor translates a secondary product into primary product equivalents.

Cradle–to– Grave or Manifest System – A procedure in which hazardous materials are identified and followed as they are produced, treated, transported, and disposed of by a series of permanent, linkable, descriptive documents (e.g. manifests). Commonly referred to as the cradle–to–grave system.

Criteria Pollutants – The 1970 amendments to the Clean Air Act required EPA to set National Ambient Air Quality Standards for certain pollutants known to be hazardous to human health. EPA has identified and set standards to protect human health and welfare for six pollutants: ozone, carbon monoxide, total suspended particulates, sulfur dioxide, lead, and nitrogen oxide. The term, "criteria pollutants" derives from the requirement that EPA must describe the characteristics and potential health and welfare effects of these pollutants. It is on the basis of these criteria that standards are set or revised.

Cubic Feet Per Minute (CFM) – A measure of the volume of a substance flowing through air within a fixed period of time. With regard to indoor air, refers to the amount of air, in cubic feet, that is exchanged with outdoor air in a minute's time; i.e. the air exchange rate.

Controller – A device that controls the operation of part or all of a system. It may simply turn a device on and off, or it may more subtly modulate burners, compressors, pumps, valves, fans, dampers, and the like. Most controllers are automatic but have user input such as temperature set points, e.g. a thermostat. Controls may be analog, or digital, or pneumatic, or a combination of these.

Damper – A plate or gate placed in a duct to control air flow by introducing a constriction in the duct.

Daughter product – The product resulting from the processing of a parent product. For example wood pulp, a secondary product, is a daughter product of roundwood. Similarly, paper is a daughter product of wood pulp.

ΔT (delta T) – is a reference to a temperature difference. It is used to describe the difference in temperature of a heating or cooling fluid as it enters and as it leaves a heat transfer device. This term is used in the calculation of coil efficiency.

Depletion – The loss of resources from their various sources at a rate greater than that of recharge.

Diffusion – The movement of a substance from an area of high concentration to an area of low concentration.

Discharge – An outflow of water from a stream, pipe, groundwater aquifer, or watershed; the opposite of recharge.

Disposal – Final placement or destruction of toxic, radioactive, or other wastes; surplus or banned pesticides or other chemicals; polluted soils; and drums containing hazardous materials from removal actions or accidental releases. Disposal may be accomplished through use of approved secure landfills, surface impoundments, land farming, deep–well injection, ocean dumping, or incineration.

Drought – An extended period with little or no precipitation; often affects crop production and availability of water supplies.

Durable Plastic Items – means plastic items other than containers and film plastic that are made to last for more than one use. These items may bear the numbers 1 through 7 in the triangular recycling symbol. Examples include plastic outdoor furniture, plastic toys and sporting goods, CD's, and plastic housewares such as mop buckets, dishes, cups, and cutlery. This type also includes building materials such as house siding, window sashes and frames, housings for electronics such as computers, televisions and stereos, fan blades, impact–resistant cases such as tool boxes and first aid boxes, and plastic pipes and fittings.

Ecological Risk Assessment – The application of a formal framework, analytical process, or model to estimate the effects of human actions(s) on a natural resource and to interpret the significance of those effects in light of the uncertainties identified in each component of the assessment process. Such analysis includes initial hazard identification, exposure and dose–response assessments, and risk characterization.

Ecological Footprint – A measure of how much biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates using prevailing technology and resource management practices. The Ecological Footprint is usually measured in global hectares. Because trade is global, an individual or country's Footprint includes land or sea from all over the world. Ecological Footprint is often referred to in short form as Footprint (not footprint).

Ecological Footprint Standards – Specified criteria governing methods, data sources and reporting to be used in Footprint studies. Standards are established by the Global Footprint Network Standards Committee composed of scientists and Footprint practitioners from around the world. Standards serve to produce transparent, reliable and mutually comparable results in studies done throughout the Footprint Community. Where Standards are not appropriate, Footprint Guidelines should be consulted. For more information, consult www.footprintstandards.org.

Electrolysis – the use of electricity to cause a chemical reaction.

Embodied energy – Embodied energy is the energy used during a product's entire life cycle in order to manufacture, transport, use and dispose of the product. Footprint studies often use embodied energy when tracking trade of goods.

Emission – Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

Glossary

Emission Factor – The relationship between the amount of pollution produced and the amount of raw material processed. For example, an emission factor for a blast furnace making iron would be the number of pounds of particulates per ton of raw materials.

Energy Footprint – The sum of all areas used to provide non–food and non–feed energy. It is the sum of carbon uptake land, hydropower land, forest for fuelwood, and crop land for fuel crops.

Energy Recovery – Obtaining energy from waste through a variety of processes (e.g. combustion).

Environmental Fate – The destiny of a chemical or biological pollutant after release into the environment.

Erosion – The wearing down or washing away of the soil and land surface by the action of water, wind, or ice.

Evaporation – The conversion of a liquid (water) into a vapor (a gaseous state) usually through the application of heat energy during the hydrologic cycle; the opposite of condensation.

Evaporator – A component in the basic refrigeration cycle that absorbs or adds heat to the system. Evaporators can be used to absorb heat from air (by reducing temperature and by removing water) or from a liquid. The evaporator is the cold side of an air conditioner or heat pump.

Evapotranspiration –The loss water from the soil through both evaporation and transpiration from plants.

Exposure Assessment – Identifying the pathways by which toxicants may reach individuals, estimating how much of a chemical an individual is likely to be exposed to, and estimating the number likely to be exposed.

Extraction rate – A processing factor comparing the quantity of a parent product to the quantity of the resulting daughter product. When a parent product is processed its mass changes. For example, when wheat is processed into white flour, the bran and germ are stripped lessening its mass. Therefore, in order to calculate the number of hectares needed to produce a given mass of flour, an extraction rate is needed. This extraction rate in this example is the ratio of tonnes of flour divided by the tonnes of wheat processed to produce the flour.

Flash Point– The lowest temperature at which evaporation of a substance produces sufficient vapor to form an ignitable mixture with air.

Flue Gas – The air coming out of a chimney after combustion in the burner it is venting. It can include nitrogen oxides, carbon oxides, water vapor, sulfur oxides, particles and many chemical pollutants.

Fluorocarbons (FCs) – Any of a number of organic compounds analogous to hydrocarbons in which one or more hydrogen atoms are replaced by fluorine. Once used in the United States as a propellant for domestic aerosols, they are now found mainly in coolants and some industrial processes. FCs containing chlorine are called chlorofluorocarbons (CFCs). They are believed to be modifying the ozone layer in the stratosphere, thereby allowing more harmful solar radiation to reach the Earth's surface.

Formaldehyde – A colorless, pungent, and irritating gas, CH20, used chiefly as a disinfectant and preservative and in synthesizing other compounds like resins.

Fresh Air Intake (FAI) – An opening through which outside air is drawn into the building. This may be to replace air in the building that has been exhausted by the ventilation system, or to provide fresh air for combustion of fuel.

Fresh Water – Water with less than 0.5 parts per thousand dissolved salts.

Fossil Fuels – also known as mineral fuels, they are hydrocarbon containing natural resources such as coal, petroleum, and natural gas

Fuel Cell – a device that uses hydrogen (or hydrogen–rich fuel) and oxygen to create electricity by an electrochemical process. If pure hydrogen is used as a fuel, fuel cells emit only heat and water as byproducts.

Furnace – A component of an HVAC system that adds heat to air or an intermediate fluid by burning fuel (natural gas, oil, propane, butane, or other flammable substances) in a heat exchanger.

Geothermal Energy – electricity generated by utilizing naturally occurring geological heat sources

Global Warming – the average increase in the Earth's temperature. The greenhouse effect is the means by which global warming takes place. The greenhouse effect is produced when greenhouse gases, which include water vapor, methane (CH4), nitrous oxide (N2O), halogenated fluorocarbons (HCFCs) , ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs) and the most notorious greenhouse gas – carbon dioxide (CO2), allow incoming solar radiation to pass through the Earth's atmosphere, while blocking outgoing infrared radiation.

Green Chemistry – designing chemical products and processes to reduce or eliminate the use or generation of hazardous materials.

Greenhouse Effect – The warming of the Earth's atmosphere attributed to a buildup of carbon dioxide or other gases; some scientists think that this build–up allows the sun's rays to heat the Earth, while making the infra–red radiation atmosphere opaque to infra–red radiation, thereby preventing a counterbalancing loss of heat.

Greenhouse Gasses – gaseous components of the atmosphere including carbon dioxide and ozone, among others. They contribute to the greenhouse effect

Greenways – linear corridors of open space. They include natural corridors (e.g., along a stream, river, or ridge), canals, rail road rights of way converted to recreational use, and trails. They link places together, inviting city and community residents to experience a connection with the natural environment.

Gray Water (also Grey water) – Domestic wastewater composed of wash water from household sinks, tubs, and washers.

Groundwater – Water found in the spaces between soil particles and cracks in rocks underground (located in the saturation zone). Groundwater is a natural resource that is used for drinking, recreation, industry, and growing crops.

Half–Life – 1. The time required for a pollutant to lose one–half of its original concentration for example, the biochemical half–life of DDT in the environment is 15 years. 2. The time required for half of the atoms of a radioactive element to undergo self–transmutation or decay (half–life of radium is 1620 years). 3. The time required for the elimination of half a total dose from the body.

Hazardous Air Pollutants – Air pollutants which are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may present a threat of adverse human health effects or adverse environmental effects. Such pollutants include asbestos, beryllium, mercury, benzene, coke oven emissions, radionuclides, and vinyl chloride. EPA is required to control 188 hazardous air pollutants.

Hazardous Waste – By–products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appears on special EPA lists.

HDPE Containers – means natural and colored HDPE (high–density polyethylene) containers. This plastic is usually either cloudy white, allowing light to pass through it (natural) or a solid color, preventing light from passing through it (colored). When marked for identification, it bears the number 2 in the triangular recycling symbol and may also bear the letters HDPE. Examples include milk jugs, water jugs, detergent bottles, some hair–care bottles, empty motor oil, empty antifreeze, and other empty vehicle and equipment fluid containers.

Heat load, **heat loss**, or **heat gain** – Terms for the amount of heating (heat loss) or cooling (heat gain) needed to maintain desired temperatures and humidities in controlled air. Regardless of how well–insulated and sealed a building is, buildings gain heat from warm air or sunlight or lose heat to cold air and by radiation. Heat load calculations are used to determine the HVAC needs of the space being cooled or heated.

Heavy Metals – Metallic elements with high atomic weights; (e.g. mercury, chromium, cadmium, arsenic, and lead); can damage living things at low concentrations and tend to accumulate in the food chain.

Hydroelectricity – electricity produced by hydropower. Most hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator. The energy extracted from water depends on the volume and on the difference in height between the source and the water's outflow. Pumped storage hydroelectricity schemes currently provide the only commercially important means of grid energy storage.

Hydrogen Fuel Cells – electrochemical cell in which the energy of a reaction between fuel, such as liquid hydrogen, and an oxidant, such as liquid oxygen, is converted into electrical energy

Hydrophilic – Having a strong affinity for water.

Hydrophobic – Having a strong aversion for water.

Hydropower – energy obtained from flowing water

Hydrologic cycle (also known as the Water Cycle) – The paths water takes through its various states—vapor, liquid, solid—as it moves throughout the oceans, atmosphere, groundwater, streams, etc.

Hydrology – The study of the occurrence, distribution, and chemistry of all waters of the earth.

Glossary

Hydrolysis – The decomposition of organic compounds by interaction with water.

Hydronic – A ventilation system using heated or cooled water pumped through a building.

IO (Input–Output) analysis – Input–Output (IO, also I–O) analysis is a mathematical tool widely used in economics to analyze the flows of goods and services between sectors in an economy, using data from IO tables**.** IO analysis assumes that everything produced by one industry is consumed either by other industries or by final consumers, and that these consumption flows can be tracked. If the relevant data are available, IO analyses can be used to track both physical and financial flows. Combined economic–environment models use IO analysis to trace the direct and indirect environmental impacts of industrial activities along production chains, or to assign these impacts to final demand categories. In Footprint studies, IO analysis can be used to apportion Footprints among production activities, or among categories of final demand, as well as in developing Consumption Land Use Matrices .

In Situ – In its original place; unmoved unexcavated; remaining at the site or in the subsurface.

Indirect Discharge – Introduction of pollutants from a non–domestic source into a publicly owned waste–treatment system. Indirect dischargers can be commercial or industrial facilities whose wastes enter local sewers.

Industrial Source Reduction – Practices that reduce the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment. Also reduces the threat to public health and the environment associated with such releases. Term includes equipment or technology modifications, substitution of raw materials, and improvements in housekeeping, maintenance, training or inventory control.

Irrigation – The controlled application of water to cropland, hay fields, and/or pasture to supplement that supplied by nature.

Landfills – 1. Sanitary landfills are disposal sites for non–hazardous solid wastes spread in layers, compacted to the smallest practical volume, and covered by material applied at the end of each operating day. 2. Secure chemical landfills are disposal sites for hazardous waste, selected and designed to minimize the chance of release of hazardous substances into the environment.

Leaching – The process by which soluble materials in the soil, such as salts, nutrients, pesticide chemicals, or contaminants, are washed into a lower layer of soil or are dissolved and carried away by water.

LED – light emitting diodes: a semiconductor device that emits light using a variety of inorganic materials

Life cycle analysis (LCA) – A quantitative approach that assesses a product's impact on the environment throughout its life. LCA attempts to quantify what comes in and what goes out of a product from “cradle to grave,” including the energy and material associated with materials extraction, product manufacture and assembly, distribution, use and disposal and the environmental emissions that result. LCA applications are governed by the ISO 14040 series of standards (http://www.iso.org).

Life Cycle of a Product – All stages of a product's development, from extraction of fuel for power to production, marketing, use, and disposal.

Liquid – The part of the hydrologic cycle in which molecules move freely among themselves but do not separate like those in a vapor/gaseous state.

Lower Explosive Limit (LEL) – The concentration of a compound in air below which the mixture will not catch on fire.

Major Stationary Sources – Term used to determine the applicability of Prevention of Significant Deterioration and new source regulations. In a nonattainment area, any stationary pollutant source with potential to emit more than 100 tons per year is considered a major stationary source. In PSD areas the cutoff level may be either 100 or 250 tons, depending upon the source.

Material Safety Data Sheet (MSDS) – A compilation of information required under the OSHA Communication Standard on the identity of hazardous chemicals, health, and physical hazards, exposure limits, and precautions. Section 311 of SARA requires facilities to submit MSDSs under certain circumstances.

Maximum Contaminant Level (MCL): Designation given by the U.S. Environmental Protection Agency (EPA) to drinking water standards under the Safe Drinking Water Act. A MCL is the greatest amount of a contaminant allowed in drinking water without causing a risk to human health.

Miscellaneous Plastic Containers – means plastic containers made of types of plastic other than HDPE (high–density polyethylene) or PETE (polyethylene terephthalate). Items may be made of PVC (polyvinyl chloride), LDPE (low–density polyethylene), PP (polypropylene), PS (polystyrene), or mixed resins. When marked for identification, these items may bear the number 3, 4, 5, 6, or 7 in the triangular recycling symbol. Examples include food containers such as bottles for salad dressings and vegetable oils, flexible and brittle yogurt cups, syrup bottles, margarine tubs, microwave food trays, and clamshell–shaped fast food containers.

Multiple Chemical Sensitivity – A diagnostic label for people who suffer multi–system illnesses as a result of contact with, or proximity to, a variety of airborne agents and other substances.

Municipal Water System – A network of pipes, pumps, and storage and treatment facilities designed to deliver potable water to homes, schools, businesses, and other users in a city or town and to remove and treat waste materials.

National Ambient Air Quality Standards (NAAQS) – Standards established by EPA that apply for outdoor air throughout the country.

New Source Performance Standards (NSPS) – Uniform national EPA air emission and water effluent standards which limit the amount of pollution allowed from new sources or from modified existing sources.

Nitric Oxide (NO) – A gas formed by combustion under high temperature and high pressure in an internal combustion engine; it is converted by sunlight and photochemical processes in ambient air to nitrogen oxide. NO is a precursor of ground–level ozone pollution, or smog.

Nitrogen Dioxide (NO_2) – The result of nitric oxide combining with oxygen in the atmosphere; major component of photochemical smog.

Glossary

Nitrogen Oxide (NO_x) – The result of photochemical reactions of nitric oxide in ambient air; major component of photochemical smog. Product of combustion from transportation and stationary sources and a major contributor to the formation of ozone in the troposphere and to acid deposition.

Non– Ferrous Metals – Nonmagnetic metals such as aluminum, lead, and copper. Products made all or in part from such metals include containers, packaging, appliances, furniture, electronic equipment and aluminum foil.

Nonpoint Source (NPS) Pollution: Pollution discharged over a wide land area, not from one specific location. These are forms of diffuse pollution caused by sediment, nutrients, organic and toxic substances originating from land use activities which are carried to lakes and streams by surface runoff. Nonpoint source pollution is contamination that occurs when rainwater, snowmelt, or irrigation washes off plowed fields, city streets, or suburban backyards. As this runoff moves across the land surface, it picks up soil particles and pollutants, such as nutrients and pesticides.

Nonrenewable Resource – resources for which there are no ways to replenish the supply (i.e. fossil fuels)

Nuclear Energy – energy released from the nucleus of an atom creating an nuclear reaction

Oxidation – the loss of electrons, the gain of oxygen atoms, or the loss of hydrogen atoms.

Ozone (O_3) – Found in two layers of the atmosphere, the stratosphere and the troposphere. In the stratosphere (the atmospheric layer 7 to 10 miles or more above the earth's surface) ozone is a natural form of oxygen that provides a protective layer shielding the earth from ultraviolet radiation.In the troposphere (the layer extending up 7 to 10 miles from the earth's surface), ozone is a chemical oxidant and major component of photochemical smog. It can seriously impair the respiratory system and is one of the most wide– spread of all the criteria pollutants for which the Clean Air Act required EPA to set standards. Ozone in the troposphere is produced through complex chemical reactions of nitrogen oxides, which are among the primary pollutants emitted by combustion sources; hydrocarbons, released into the atmosphere through the combustion, handling and processing of petroleum products; and sunlight.

Parent product – The product processed to create a daughter product. For example wheat, a primary product, is a parent product of flour, a secondary product. Flour, in turn, is a parent product of bread.

Permeable/Permeability – Capable of transmitting water (porous rock, sediment, or soil); the rate at which water moves through rocks or soil.

Permeable layer – A layer of porous material (rock, soil, unconsolidated sediment); in an aquifer, the layer through which water freely passes as it moves through the ground.

Permissible Exposure Limit – Also referred to as PEL, federal limits for workplace exposure to contaminants as established by OSHA

Glossary

Personal Protective Equipment PPE – Clothing and equipment worn by pesticide mixers, loaders and applicators and re–entry workers, hazmat emergency responders, workers cleaning up Superfund sites, et. al., which is worn to reduce their exposure to potentially hazardous chemicals and other pollutants.

PETE Containers – means clear or colored PETE (polyethylene terephthalate) containers. When marked for identification, it bears the number 1 in the center of the triangular recycling symbol and may also bear the letters PETE or PET. The color is usually transparent green or clear. A PETE container usually has a small dot left from the manufacturing process, not a seam. It does not turn white when bent. Examples include soft drink and water bottles, some liquor bottles, cooking oil containers, and aspirin bottles.

pH – An expression of the intensity of the basic or acid condition of a liquid; may range from 0 to 14, where 0 is the most acid and 7 is neutral. Natural waters usually have a pH between 6.5 and 8.5.

PM–10/PM – 2.5 – PM 10 is measure of particles in the atmosphere with a diameter of less than ten or equal to a nominal 10 micrometers. PM–2.5 is a measure of smaller particles in the air. PM–10 has been the pollutant particulate level standard against which EPA has been measuring Clean Air Act compliance. On the basis of newer scientific findings, the Agency is considering regulations that will make PM–2.5 the new "standard".

Point Source Pollution – Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers of various types.

Pollution – An alteration in the character or quality of the environment, or any of its components, that renders it less suited for certain uses. The alteration of the physical, chemical, or biological properties of water by the introduction of any substance that renders the water harmful to use.

Porosity – The ratio of the volume of void or air spaces in a rock or sediment to the total volume of the rock or sediment. The capacity of rock or soil to hold water varies with the material. For example, saturated small grain sand contains less water than coarse gravel.

Potable water – Water of a quality suitable for drinking.

Precipitation – The part of the hydrologic cycle when water falls, in a liquid or solid state, from the atmosphere to Earth (rain, snow, sleet).

Prevention of Significant Deterioration (PSD) – EPA program in which state and/or federal permits are required in order to restrict emissions from new or modified sources in places where air quality already meets or exceeds primary and secondary ambient air quality standards.

Primary product – In Footprint Studies a primary product is the least processed form of a biological material that humans harvest for use. There is a difference between the raw product, which is all the biomass produced in a given area, and the primary product, which is the biological material humans will harvest and use. For example, a fallen tree is a raw product that, when stripped of its leaves and bark, results in the primary product of roundwood. Primary products are then processed to produce secondary products like wood pulp, paper, and so on. Other examples of primary products are potatoes, cereals, cotton, or forage. Examples of secondary products are kWh of electricity, bread, clothes, beef, or appliances.

Glossary

Productivity – The amount of biological material useful to humans that is generated in a given area. In agriculture, productivity is called yield.

Recharge – Water added to an aquifer. For example, when rainwater seeps into the ground. Recharge may occur artificially through injection wells or by spreading water over groundwater reservoirs.

Recharge Rate – The quantity of water per unit of time that replenishes or refills an aquifer.

Reclaimed Wastewater – Treated wastewater that can be used for beneficial purposes, such as irrigating certain plants.

Recycled Water – Water that is used more than one time before it passes back into the natural hydrologic system.

Remainder/Composite Household Hazardous – means household hazardous material that cannot be put in any other type. This type also includes household hazardous material that is mixed. Examples include household hazardous waste which if improperly put in the solid waste stream may present handling problems or other hazards, such as pesticides, caustic cleaners, and fluorescent light bulbs.

Remainder/Composite Metal – means metal that cannot be put in any other type. This type includes items made mostly of metal but combined with other materials and items made of both ferrous metal and non–ferrous metal combined. Examples include small non–electronic appliances such as toasters and hair dryers, motors, insulated wire, and finished products that contain a mixture of metals, or metals and other materials, whose weight is derived significantly from the metal portion of its construction.

Remainder/Composite Organic – means organic material that cannot be put in any other type. This type includes items made mostly of organic materials, but combined with other material types. Examples include leather items, cork, hemp rope, garden hoses, rubber items, hair, carpet padding, cigarette butts, diapers, feminine hygiene products, small wood products (such as Popsicle sticks and tooth picks), sawdust, and animal feces.

Remainder/Composite Paper – means items made mostly of paper but combined with large amounts of other materials such as wax, plastic, glues, foil, food, and moisture. Examples include waxed corrugated cardboard, aseptic packages, plastic–coated paper milk cartons, waxed paper, tissue, paper towels, blueprints, sepia, onion skin, fast food wrappers, carbon paper, self adhesive notes, and photographs.

Remainder/Composite Plastic – means plastic that cannot be put in any other type. These items are usually recognized by their optical opacity. This type includes items made mostly of plastic but combined with other materials. Examples include auto parts made of plastic attached to metal, plastic drinking straws, foam drinking cups, produce trays, egg cartons, foam packing blocks, packing peanuts, cookie trays found in cookie packages, plastic strapping, foam plates/bowls, and new Formica, vinyl, or linoleum.

Remainder/Composite Special Waste – means special waste that cannot be put in any other type. Examples include asbestos–containing materials such as certain types of pipe insulation and floor tiles, auto fluff, auto bodies, trucks, trailers, truck cabs, untreated medical waste/pills/hypodermic needles, and artificial fireplace logs.

Renewable Resource – natural resource that is depleted at a rate slower than the rate at which it regenerates (i.e. solar energy)

Glossary

Risk Factor – Characteristics (e.g., race, sex, age, obesity) or variables (e.g., smoking, occupational exposure level) associated with increased probability of a toxic effect.

Risk Management– The process of evaluating and selecting alternative regulatory and non–regulatory responses to risk. The selection process necessarily requires the consideration of legal, economic, and behavioral factors.

Runoff –Precipitation that flows over land to surface streams, rivers, and lakes.

R-Value - A measure of the capacity of a material, such as insulation, to impede heat flow, with increasing values indicating a greater capacity.

Salt Water – Water that contains a relatively high percentage (over 0.5 parts per thousand) of salt minerals.

Scrap – Materials discarded from manufacturing operations that may be suitable for reprocessing.

Scrap Metal Processor – Intermediate operating facility where recovered metal is sorted, cleaned of contaminants, and prepared for recycling

Small Quantity Generator (SQG–sometimes referred to as "Squeegee") – Persons or enterprises that produce 220–2200 pounds per month of hazardous waste; they are required to keep more records than conditionally exempt generators. The largest category of hazardous waste generators, SQGs, include automotive shops, dry cleaners, photographic developers, and many other small businesses.

Solar Energy – harnessing the energy produced by sunlight

Source Water Protection – Voluntary action taken to prevent the pollution of drinking water sources, including groundwater, lakes, rivers, and streams.

Stationary Source – A fixed–site producer of pollution, mainly power plants and other facilities using industrial combustion processes.

Surface Water – Water above the surface of the land, including lakes, rivers, streams, ponds, floodwater, and runoff.

Sustainable Streets – multimodal rights–of–way designed and operated to create benefits to mobility, community and ecology. They are streets that use sustainable design principles that promote safe, least–polluting ways to connect people and incorporate natural, landscape–based methods that infiltrate, reuse, or allow water to evaporate back into the air, stormwater runoff, and mitigate the "urban heat island effect".

Thermal zone – A single or group of neighboring indoor spaces that the HVAC designer expects will have similar thermal loads. Building codes may require zoning to save energy in commercial buildings. Zones are defined in the building to reduce the number of HVAC subsystems, and thus initial cost.

Third–party logistics – (abbreviated 3PL) describes businesses that provide one or many of a variety of logistics–related services. Types of services would include public warehousing, contract warehousing, transportation management, distribution management, freight consolidation.

Threshold Level – Time–weighted average pollutant concentration values, exposure beyond which is likely to adversely affect human health.

Threshold Limit Value (TLV) – The concentration of an airborne substance to which an average person can be repeatedly exposed without adverse effects. TLVs may be expressed in three ways: (1) TLV–TWA—Time weighted average, based on an allowable exposure averaged over a normal 8–hour workday or 40–hour work– week; (2) TLV–STEL—Short–term exposure limit or maximum concentration for a brief specified period of time, depending on a specific chemical (TWA must still be met); and (3) TLV–C—Ceiling Exposure Limit or maximum exposure concentration not to be exceeded under any circumstances. (TWA must still be met.)

Transpiration – The process by which water absorbed by plants (usually through the roots) is evaporated into the atmosphere from the plant surface (principally from the leaves).

Vapor – The state of water in the hydrologic cycle in which individual molecules are highly energized and move about freely; also known as gas/gaseous.

Variable Air Volume (VAV) System – An HVAC system that has a stable supply–air temperature, and varies the air flow rate to meet the temperature requirements. Compared to CAV systems, these systems waste less energy through unnecessarily–high fan speeds. Most new commercial buildings have VAV systems.

Volatile Organic Compound (VOC) – Any organic compound that participates in atmospheric photochemical reactions except those designated by EPA as having negligible photochemical reactivity.

Waste–Heat Recovery – Recovering heat discharged as a byproduct of one process to provide heat needed by a second process.

Wastewater – Water that contains unwanted materials from homes, businesses, and industries; a mixture of water and dissolved or suspended substances.

Wastewater Treatment – Any of the mechanical or chemical processes used to modify the quality of wastewater in order to make it more compatible or acceptable to humans and the environment.

Wind Power – using the kinetic energy of the wind or wind turbines to extract the wind's energy.

TECHNICAL ASSISTANCE PROGRAM

Green Enterprise Development

LEVEL 1

Green Generalist Training (Green 101)

Join us for the Green 101 Workshop!

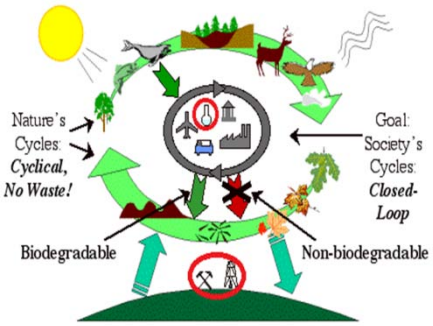
Learn green concepts, key environmental issues and the components of sustainability.

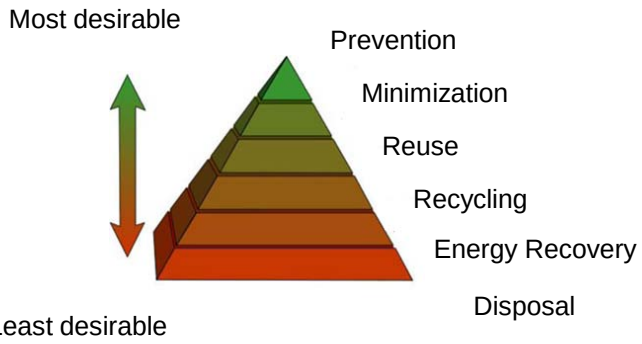
One-Day Workshop • Appropriate for the entire workforce

Green Generalist (Green101) was designed by Purdue's Technical Assistance Program for manufacturers and others interested in learning how to apply sustainable, environmentally friendly practices in the workplace. Expect a fun, fast-paced workshop that combines classroom-style learning with interactive "live" simulations.

Green 101 will provide a general awareness on:

- What is "Green"?
- Sustainability and Global Conditions
- Material & Solid Waste Management
- Energy Management
- Chemical Waste Generation / Green Chemistry
- Climate / Air Emissions Management
- Supply Water / Wastewater Management
- Environmental Business Management
- Develop an Implementation Action Plan





Green Enterprise Development



Visit www.tap.purdue.edu/green to learn how to take the green movement to the next level.

How We Can Work With You: In addition to Green Enterprise Development, Purdue's Technical Assistance Program offers on-site public workshops and provides implementation and consulting services.

For workshop dates or to register: Visit www.tap.purdue.edu/green under "Register for Events."

For more information: Contact Abbey Maddy via phone at (800) 877-5182 ext. 620 or email amaddy@purdue.edu.

Black & Gold & Green Enterprise Development

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TECHNICAL ASSISTANCE PROGRAM



Dumpster Dive

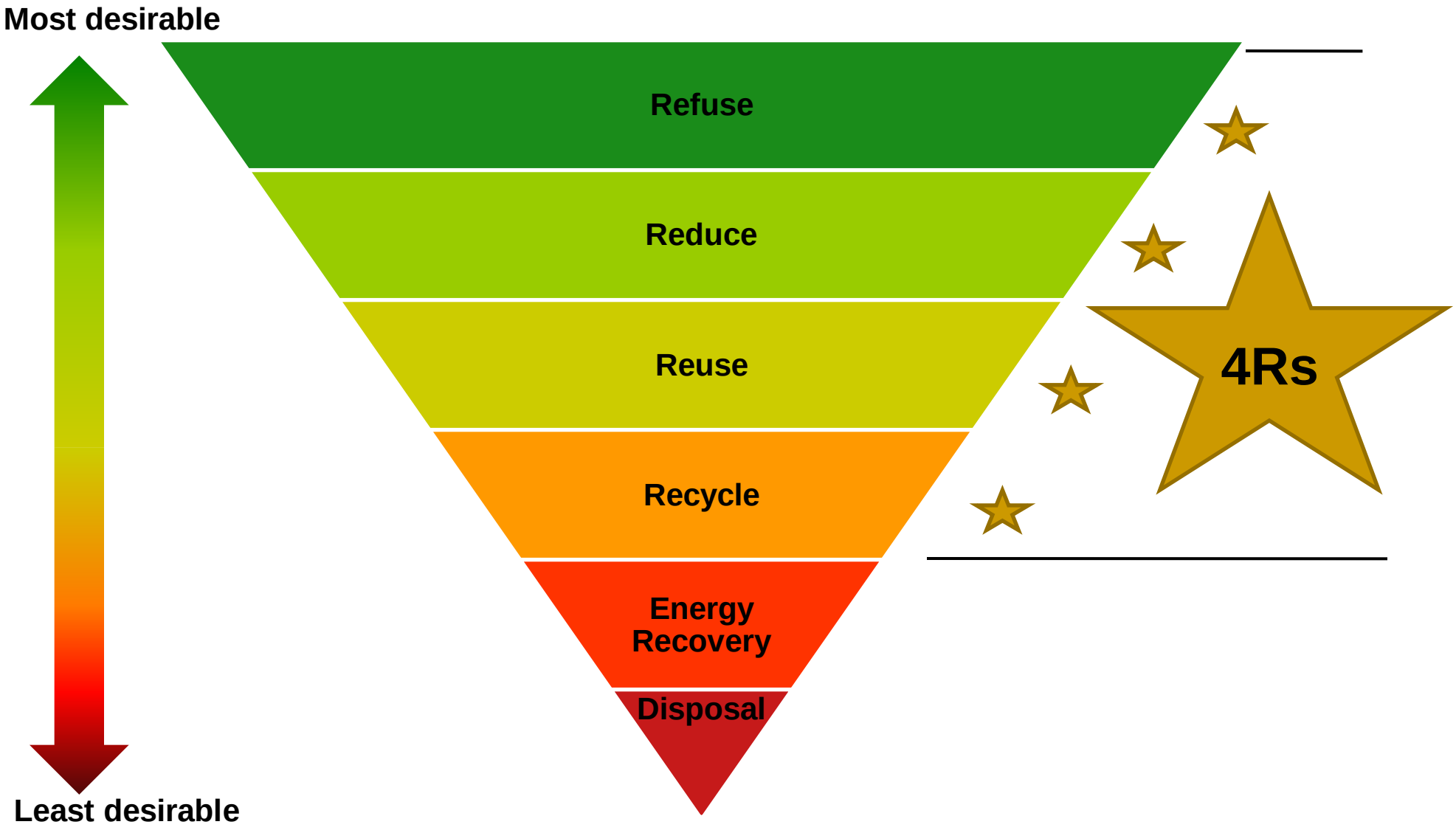
Materials Use &

Solid Waste Management

Purpose of This Module

- To provide an understanding of solid waste streams.
- To identify methods that can be implemented to reduce material use and the resulting solid waste.
- To provide strategies for incorporating material and solid waste reduction into an overall sustainability approach.

Waste Hierarchy



Zero Landfill – A Worthwhile Goal

- 100% of the waste output is going somewhere other than a landfill.
- Pursuing waste prevention, reuse, repair, recycling and composting.
- Harnessing the forces of the marketplace, e.g., selling valuable by-products, to achieve this goal.



Zero Waste – The Ultimate Goal

- Emphasis on waste *prevention*.
- Doing more with less - refusing extra materials in products and processes.
- Focusing on renewable resources.
- Defining economic success as delivering more services with fewer energy and material resources.
- Moving from a linear consumption-driven economy to a cyclical service-oriented economy.

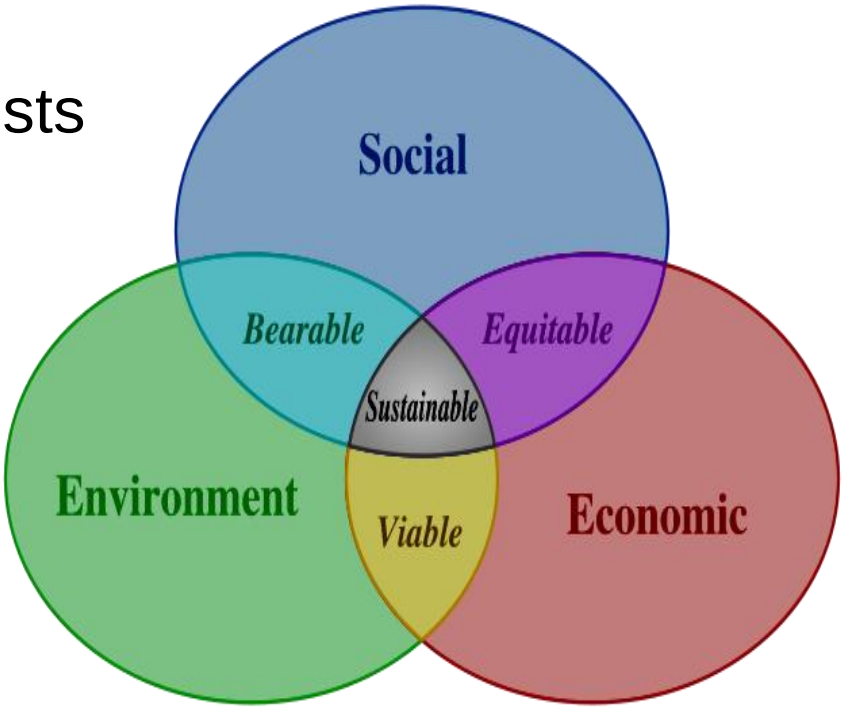
Zero Waste Supports Sustainability

Profit

- Improves efficiency & lowers costs
- Reduces regulatory compliance costs

Planet

- Reduces demand for resources and energy *from* nature
- Reduces waste *to* nature



People

- More resources and energy become available for others
- Closing the loop (cradle-to-cradle) generates new jobs

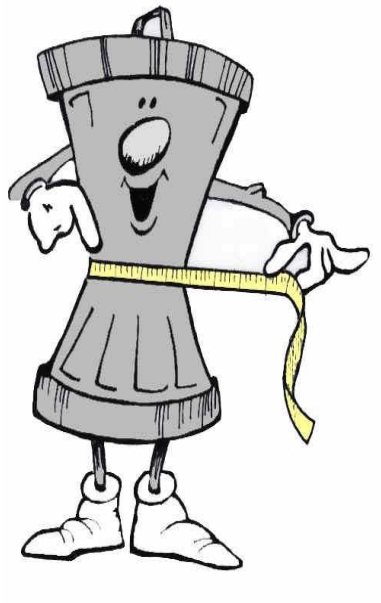
Business Case for Waste Minimization

Cost *reductions* can be found in:

- Waste treatment & disposal;
- Energy use;
- Materials and supplies – purchasing & storage:
- Regulatory compliance.

Cost *recovery* can be realized from:

- Sale of recyclable materials;
- Sale of 4Rs technologies.



Course Agenda

Solid Waste Streams

Managing Solid Waste

Dumpster Dive / Waste Sort

4Rs – Refuse, Reduce, Reuse, Recycle

Considering the Entire Lifecycle

Putting Waste Minimization in Practice

Course Evaluation

Solid Waste Streams

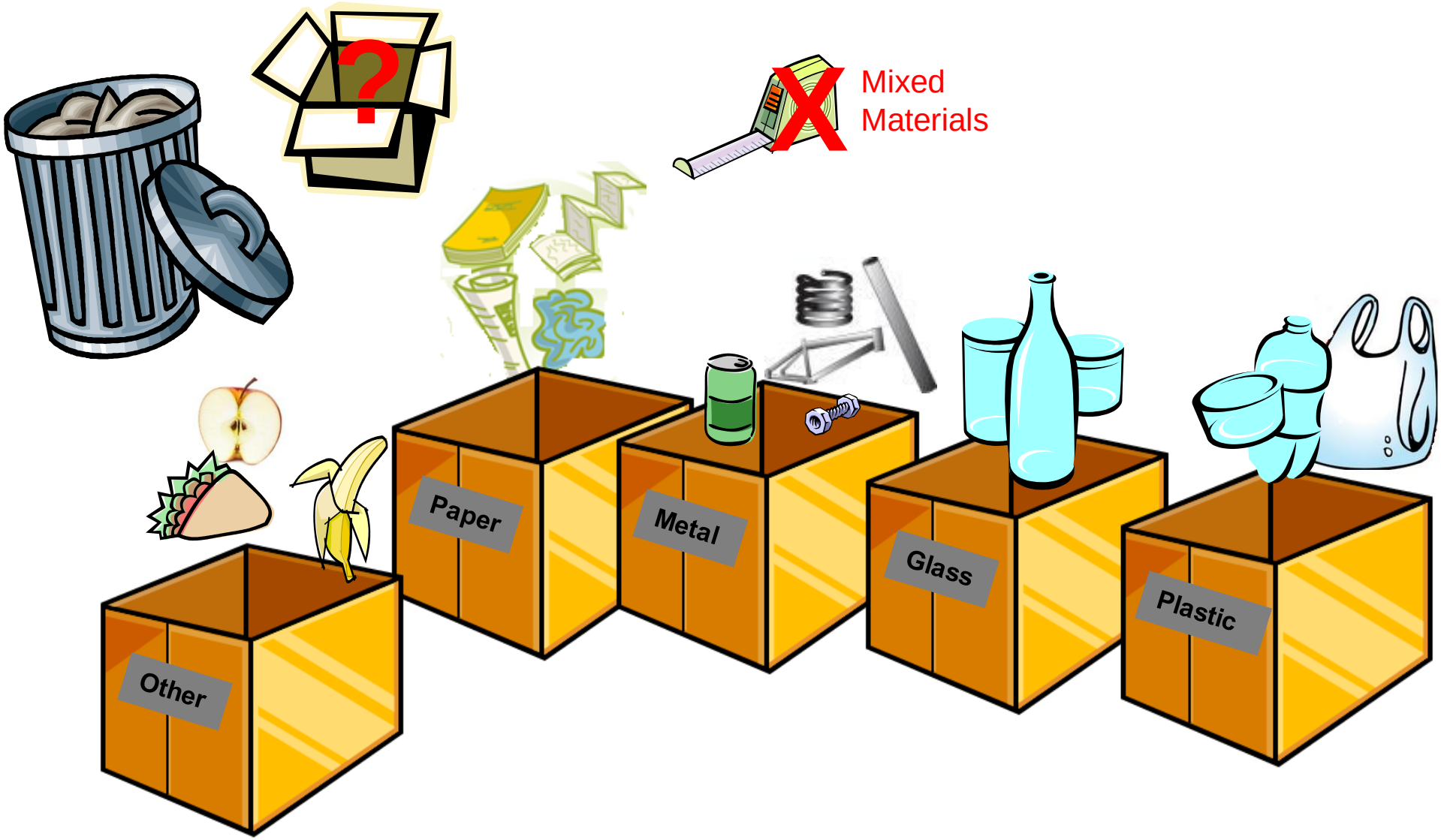
- Paper
- Glass
- Metal
- Plastic
- Electronics
- Organic
- Construction/ Demolition
- Hazardous
- Special/Universal
- Mixed Residue



Steps to Reduce Solid Waste

- Identify and sort the Solid Waste Streams.
- Start at the **top** of the Waste Hierarchy to evaluate new methods for managing each waste category.
- Reduce waste at the *source* wherever feasible.
- Establish synergies for waste exchange, resource management, etc.
- Measure improvements to the environment and bottom line.

Sorting by Material Category



Contaminants are a Problem

Materials contaminated with non-compatible elements get handled at a *lesser level* in the Waste Hierarchy.



Contaminant examples:

- Foreign material that makes a recyclable or compostable material impure, e.g., food residue in containers;
- Material that does not belong in a specific category, type, or grade of waste, e.g., mixed plastics.

Paper



- Paper is the most prevalent material in municipal solid waste streams.
- Americans recycle more than 50% of the paper we use – more is recycled than landfilled!
- By weight, more paper is recovered in America for recycling than all other materials combined except steel.
- Paper packaging is a success story for *lightweighting* – reductions in the weight and/or volume of material.

Paper Recycling

According to U.S. EPA, recycling one ton of paper:

- Saves enough energy to power the average American home for 6 months.
- Saves 7,000 gallons of water.
- Saves 3.3 cubic yards of landfill space.
- Reduces greenhouse gas emissions by one metric ton of carbon equivalent (MTCE.)



Glass



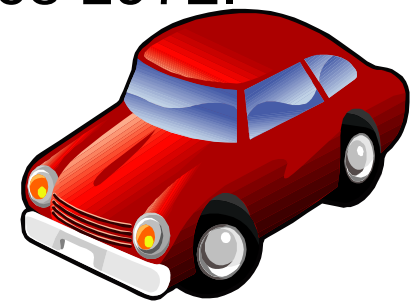
- About 24% of post-consumer glass is recovered for recycling.
- 90% of recycled glass is crushed into cullet to make new containers, which:
  - Costs less than raw materials,
  - Prolongs furnace life, and
  - Demands less energy since it melts at a lower temperature.
- Demand for high-quality cullet is currently greater than supply.
- High-quality cullet is also used in abrasives, aggregate substitute, decorative applications, fiberglass, frictionators, and fluxes in metal foundry work.

Metal – Aluminum

- Manufacturers make 99% of all beer cans and 97% of all soft drink cans from aluminum.



- Aluminum beer and soft drink containers were recovered at a rate of about 45%.
- The average aluminum can contains 40% post-consumer recycled aluminum, saving 95% of the energy to produce it from bauxite ore.
- Weight of aluminum cans has decreased by 52% since 1972.
- Diecasts, used by the automotive industry, constitute the second largest portion of recovered aluminum.



Metal – Steel / Ferrous

- The steel industry recovered and recycled 95% shredded steel scrap from automobiles.
- Automotive fenders, refrigerator encasements, soup cans, pails, and industrial drums are made with 25 – 35% recycled steel *content*.
- Products such as structural beams, steel plates, and reinforcement bars are made with 100% recycled steel.
- Recovering steel dramatically reduces energy consumption, compared to making steel from virgin materials.
- Over the past 25 years, the thickness of steel containers has been reduced by 30%.

Plastics

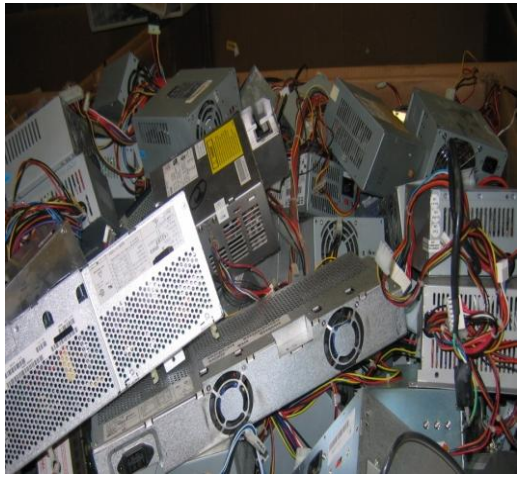


- About 12% of total municipal solid waste generation is plastics.
- Recovered plastics are sorted by type, processed to remove all contaminants, ground into small flakes, then melted and filtered to form pellets for manufacture into new plastic products.
- Demand for recovered plastic resin exceeds the amount available.
- Primary market for recycled PET bottles is fiber for carpet and textiles. Primary market for recycled HDPE is bottles, but also recycled-content landscape and garden products.
- *Lightweighting* has occurred in most plastic packaging for consumer products, including 30% weight reduction for plastic milk jugs.

E-Waste



- Americans discard between 300 and 400 million electronic items per year.
- Electronic waste represents 2% of America's trash in landfills. Less than 20% of all electronic waste is recycled.



- Some e-waste recyclers separate glass, metal and plastics, so that most reusable materials find their way into new products.
- If not treated properly, e-waste is a major source of toxins (lead, mercury, cadmium) and carcinogens (PCBs), constituting 70% of overall toxic waste.

Miscellaneous

- *Organic material* (yard trimmings, food wastes) make up 24% of the municipal solid waste in the U.S.



- *Recovered wood* can be used for mulch, fuel applications, and to manufacturer value-added products such as medium density fiberboard and particleboard.



- *Batteries* contain heavy metals such as mercury, lead, cadmium, and nickel, which can contaminate the environment if not properly disposed.

Course Agenda

Solid Waste Streams

Managing Solid Waste

Dumpster Dive (Waste Sort)

4Rs – Refuse, Reduce, Reuse, Recycle

Considering the Entire Lifecycle

Putting Waste Minimization in Practice

Course Evaluation

Solid Waste Management

- **Landfill –** Burying waste which is normally compacted first.
- **Incineration –** Burning waste to convert into heat, gas, steam and ash.
- **Recycling –** Extracting resources or value from waste to recover or reuse the material.
- **Energy Recovery –** Harnessing energy content of waste directly by using it as combustion fuel, or indirectly by processing it into another type of fuel.
- **Avoidance and Reduction Methods –**
  - reuse of second-hand products;
  - repairing broken items instead of buying new;
  - designing products to be refillable, reusable or use less material;
  - avoiding use of disposable products.

Landfill



Advantages:

- Relatively inexpensive.
- Landfill gas is collected and utilized for heat and fuel for energy generation.

Disadvantages:

- Produces toxic gases and volatile organic compounds, as well as greenhouse gases.
- Can leak and cause groundwater contamination.
- Long-term management due to slow waste decomposition.
- Encourages waste production.

Incineration

Advantages:

- Minimal land required for generation site/disposal area.
- Immediate waste reduction.
- Cost can be offset by heat recovery or sale of energy.

Disadvantages:

- Expensive to build and operate.
- High energy requirement.
- Requires skilled personnel and continuous maintenance.

Recycling

Advantages:

- Slows the consumption of natural resources.
- Promotes advancements in recyclable/biodegradable materials.
- Keeps costs from escalating for waste collection/disposal.

Disadvantages:

- Collection and processing is still relatively expensive.
- Contamination, lack of sources for certain materials, and material separation difficulties causes limitations.



Commonly Recycled Materials



Source: US EPA, 2007

Energy Recovery



Advantages:

- Reduces reliance on conventional fossil fuels.
- Diverts biodegradable waste from landfill which also reduces greenhouse gas emissions.
- Provides security and diversity of fuel supply.



Disadvantages:

- Quality of energy produced may not be high enough for all potential applications.
- Must expend energy to remove moisture from the refuse and scrub pollutants from flue gasses.

Avoidance and Reduction

Advantages:

- Most cost-effective.
- Saves energy and natural resources.
- Eliminates or reduces waste stream volume rather than just diverting it.

Disadvantages:

- Requires a new mindset that ***less is better***, along with the associated behavioral changes

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Dumpster Dive / Waste Sort

- Collect, sort and measure/weigh a representative sample of the company's waste.
- Identify each waste component and calculate as precisely as possible its percentage of the waste generated.
- Evaluate options to move waste management practices up the Waste Hierarchy.

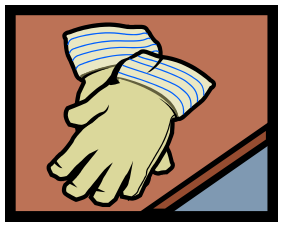


Objectives of Waste Sorting

- Determine composition and quantities of waste being generated.
- Measure effectiveness of existing waste management practices.
- Collect baseline data for measuring the effectiveness of new waste minimization efforts.
- Identify opportunities to improve waste management strategies and systems.

Preparing for the Waste Sort

- Select the area(s) / waste container(s) to sort.
- Decide whether to include recycle containers in the sort.
- Determine which waste categories to quantify.
- Put on protective gear – gloves, goggles, aprons.



SAFETY is a top priority!



Gathering Trash Data

- Sort the trash/recycle receptacles into the agreed categories.
- After sorting, weigh each type of waste.
  Note: Visual inspection or volume could be used instead of weight as long as same method is used for all categories.
- Record information on the *Waste Sort Worksheet*.



Remember that SAFETY is a top priority!

Proper Handling of Sorted Waste

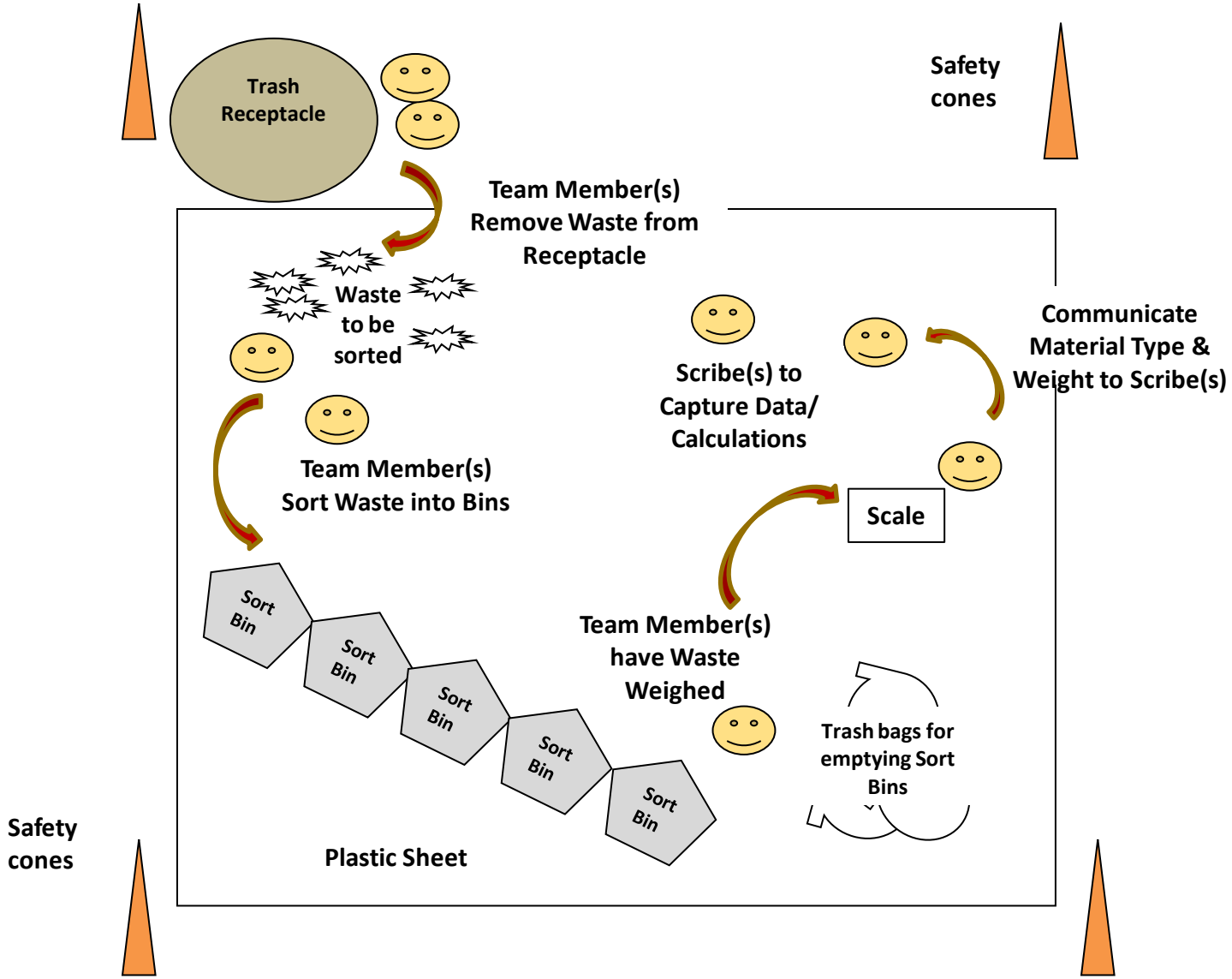


- The confidentiality and privacy of documents or personal items found in the waste stream must be assured.
- There is no need to read the contents of any documents that are found.
- If waste is to be transported to another location to be sorted then it must be stored and disposed of securely.
- Customer requirements must also be considered and adhered to, e.g., destruction of nonconforming product, control of documents.

Waste Sort Considerations

- Space on loading docks, dumpster areas, and interior storage may not be ideal for sorting dumpster contents.
- Minimize the traffic flow around the sorting/weighing area as much as possible.
- It may be difficult to get a representative sample since different materials are often collected throughout the operation.
- Make sure that containers are not too large to remove contents from, or too heavy to move safely if needed.

Waste Sort Logistics



Simulation Scenario



- Furniture ‘R’ Us has been in the upholstered furniture manufacturing business for over 50 years.
- Implemented Continuous Improvement tools such as: 5S, Kanban and Total Productive Maintenance.
- Reduced energy costs by turning off unnecessary lights and adjusting heating/cooling temperatures for off-hours.

Simulation Scenario

Furniture R US

- Started implementing additional “Green” approaches last year.
- Completed *Waste Stream Mapping* of some solid wastes – wood, sawdust and fabric.
- Successfully found sources for scrap wood – the largest percentage of their solid waste – and also for sawdust.





Simulation Scenario

Furniture R US

- Fabric scraps are the 2nd largest component of their solid waste.
- No reliable, consistent source for fabric scraps.



- The new Sustainability Manager is leading their effort to identify, justify and implement methods to further reduce the solid waste – with a goal of Zero Landfill!

Simulation Scenario

Furniture R Us



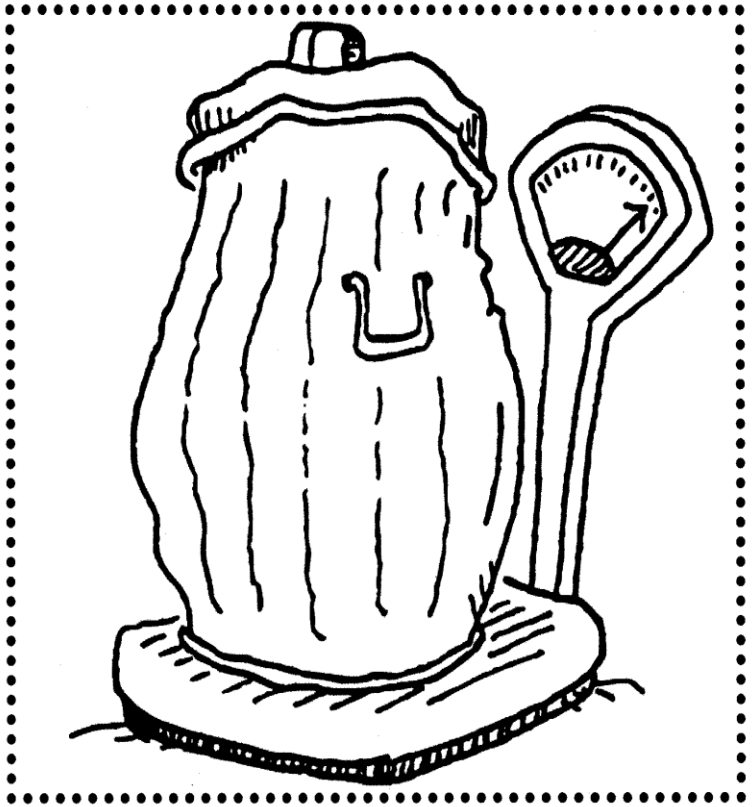
They've asked for our assistance in a Dumpster Dive!

Dumpster Dive

Assignments

&

Gear



Lessons Learned - Simulation

- What was the outcome of the waste sort process? Report out all measurements.
- What do these measurements tell us?
- Were there any surprises or unexpected items in the dumpster?

Course Agenda

Solid Waste Streams

Managing Solid Waste

Dumpster Dive (Waste Sort)

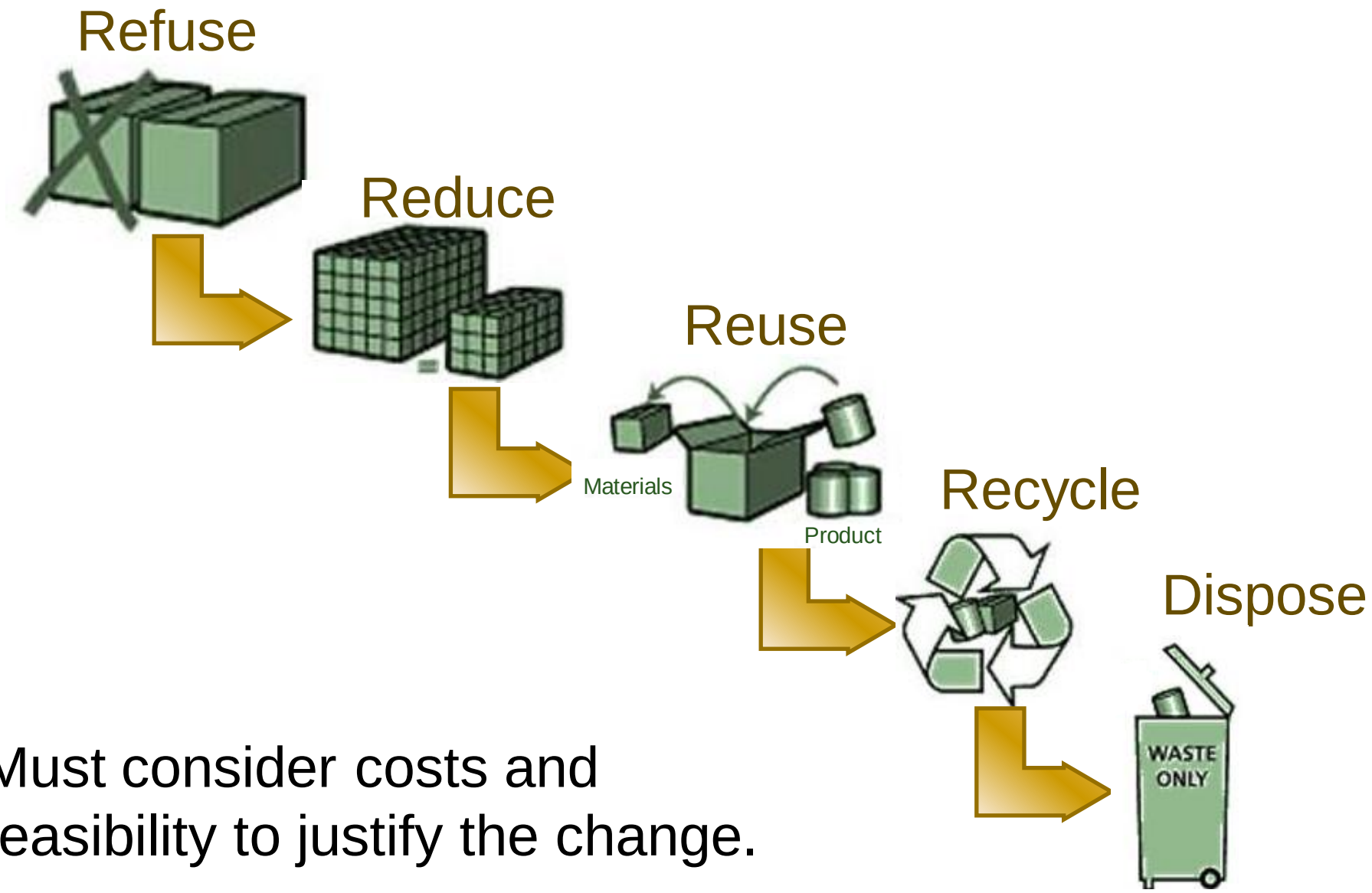
4Rs – Refuse, Reduce, Reuse, Recycle

Considering the Entire Lifecycle

Putting Waste Minimization in Practice

Course Evaluation

Start at the TOP of the Hierarchy

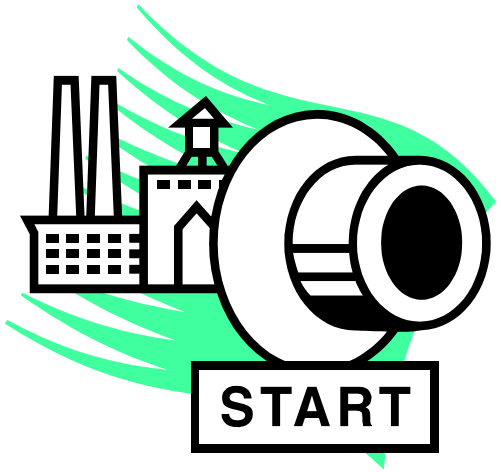


Must consider costs and feasibility to justify the change.

Find the Source of the Waste

For the cause/source analysis, consider how each of the following affect *material use*, *waste generation* and overall *environmental impact* of the business:

- Product specifications,
- Choice and quality of input materials,
- Selection of technology,
- Equipment operation and maintenance.



Determine Waste Sources/Causes

Consider for each waste:

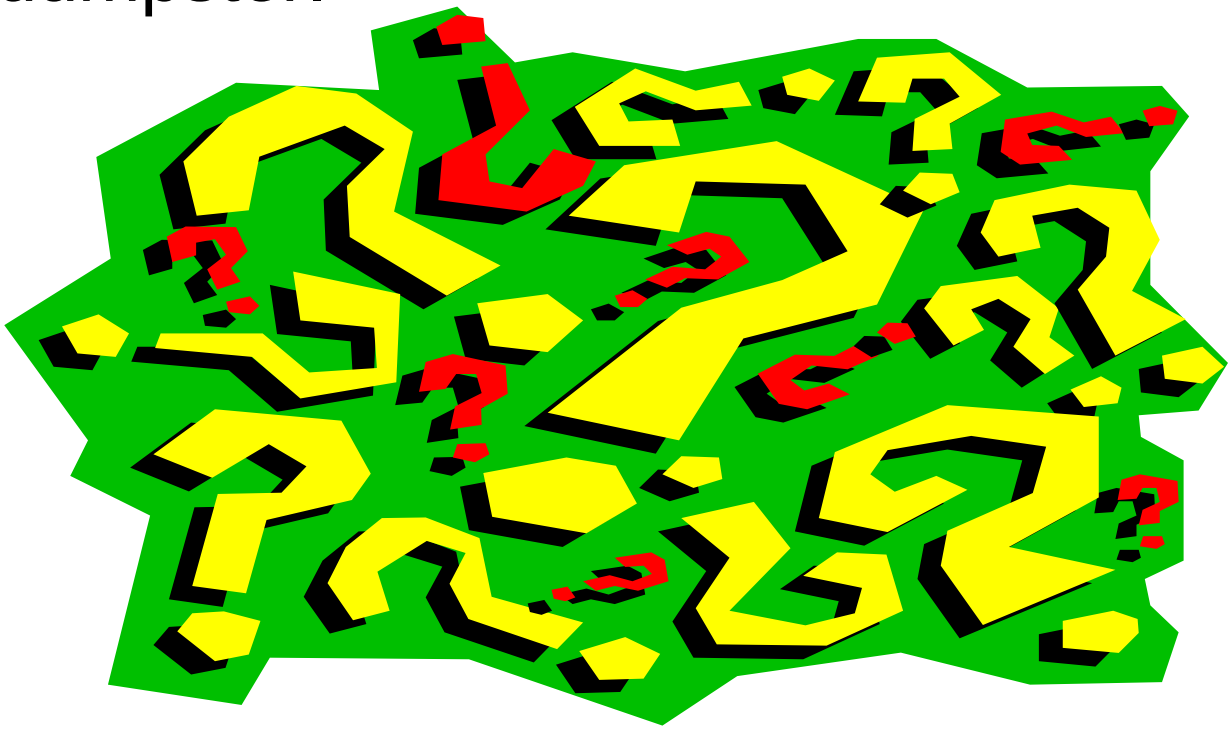
- Why do you have the waste in the first place?
- Where/how does it get generated?
- When is there more/less waste generated?
- Why are current waste management practices ineffective for this waste?
- What process(es) produce the waste?



Group Activity - Possible Causes



Using the questions from the previous page, let's brainstorm some reasons that a company might have packaging waste in their dumpster.



Where Does the Waste Come From?



Material Use/Waste

Corrugated Cardboard Packaging

Product Specifications

- Customer requires packaging
- Multiple sizes needed

Technology

- Suppliers ship materials in corr. pkg. – multiple sizes
- More larger than smaller
- Larger boxes need reinforcement for heavier items
- Boxes cut into pieces with remainder to recycle

Input Materials

- "Peanuts" needed for filler in oversize boxes
- Larger sizes only used when smaller ones not available
- Smaller sizes needed more often so space for large fills up

Operating Practices

- Overflow of storage space for larger sizes
- Recycling bundles take up too much space/fall over
- Inventory of corr. pkg. not always accurate/timely
- Different sizes needed than available

Ishakawa Fishbone Diagram

4Rs Example – Packaging

- Sustainable Packaging Coalition launched in 2005 to promote packaging sustainability and develop new packaging approaches.
- Made up of consumer products companies supporting sustainability, as well as companies who make packaging.
- Turn to page 10 in your *Appendix* and let's look at some of the methods that are recommended there.



Any other ideas for implementing the 4Rs with Packaging?

Exercise – Waste Sources

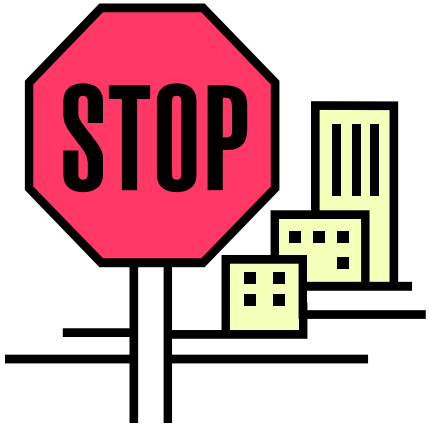
- Split into your Dumpster Dive teams.
- Consider one of the top waste categories (largest percentages) found during the Dumpster Dive.
- Brainstorm where this waste originates from (use the 5W1H questions from the Group Exercise.)
- Use the fishbone diagram to categorize the causes/sources you identify.
- Is there a specific category that most of the source answers fall into?
- Capture this information in your *Waste Sort Worksheet* (Appendix page 17.)

Determine Best Options

Consider for each waste:

- Are there different methods/technology to eliminate it?
- How can it be minimized?
- Would different materials be acceptable?
- How can it be reused, even as a lower value by-product?
- What type of recovery – on-site or off-site – is feasible?
- Are there more environmentally-acceptable options?

Dematerialization / Source Reduction



Stopping waste before it starts.

- Design the product and its processing and packaging to minimize waste, including techniques like *lightweighting*.
- Reduce scrap or product defects through reduction in set-ups and improved equipment maintenance.
- Decrease the amount of materials or energy used during the manufacturing, distribution and packaging of products.

By-Product Reduction & Reuse

- The first step is to determine ways to reduce or eliminate specific by-products completely.
- If they cannot be eliminated, identify internal uses or “synergies” with a waste exchange to reuse by-products.

Solid By-Product Examples:

Absorbents	Shrink Wrap	Cardboard
Grinding swarf	Metal scrap	Paper
Plastic strapping	Rubber tubing	
Textiles	Pallet wood	

Waste Exchange

One company's waste can be a valuable resource to another.

Examples include:

- Process by-products;
- Reusable industrial materials;
- Off-spec items;
- Overstock, and damaged or unwanted materials.

Federal, state and local level act as information clearinghouses, directories, and marketing facilitators for reusable industrial materials.

Reuse – Where to Look

- Scrap or defective products - internal and supply chain.
- Provide take-back programs for your customers.
- Product returns disassembled for reuse and/or repair.
- Reusable packaging for your products.
- Choose suppliers who have take-back programs.



4Rs Considerations

Consider these when determining feasibility of options:

- Amount of material available for processing;
- Concentration of collection sites;
- Ease of separation of components;
- Purity of materials / Mixed materials;
- Consistency of waste stream quantity;
- Proximity to the waste exchange or other re-processing facility;
- Inherent value of the waste stream output.

Exercise – Applying the 4Rs

For the waste category just analyzed, Dumpster Dive Team members identify on *Waste Sort Worksheet* pages 19 & 20:

- What can be done to **REFUSE** the waste?
  How much of the waste will be eliminated this way?
- What can be done to **REDUCE** the remainder of this waste?
  How much more of the waste will be reduced this way?
- Finally, if any of this waste remains, what can be done to **REUSE/RECYCLE** this waste?
  Will this keep all of this type of waste from going to the landfill?

Course Agenda

Solid Waste Streams

Managing Solid Waste

Dumpster Dive (Waste Sort)

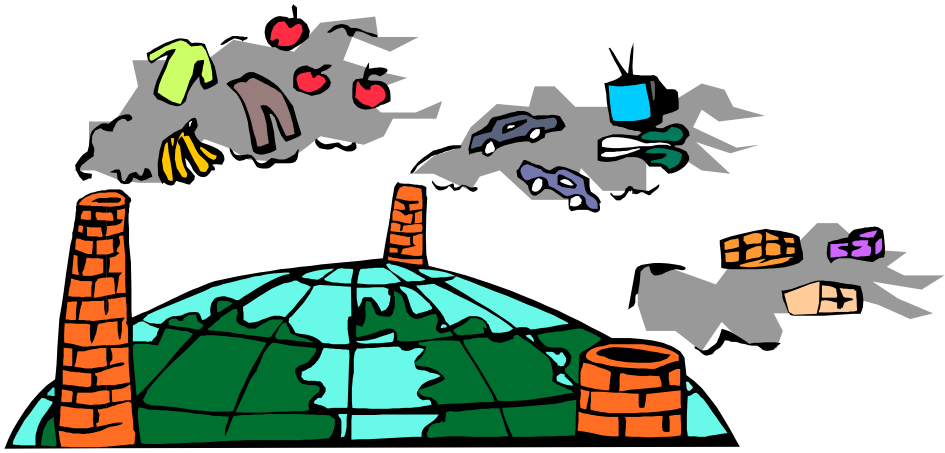
4Rs – Refuse, Reduce, Reuse, Recycle

Considering the Entire Lifecycle

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Course Evaluation

Cleaner Production



Reduce environmental impact of production processes with continual product, service and process improvement.

- Reduces pollution and waste at source;
- Simultaneously improves efficiency and reduces costs;
- Can often be achieved through basic housekeeping methods, without the need for additional costs or high technology solutions.

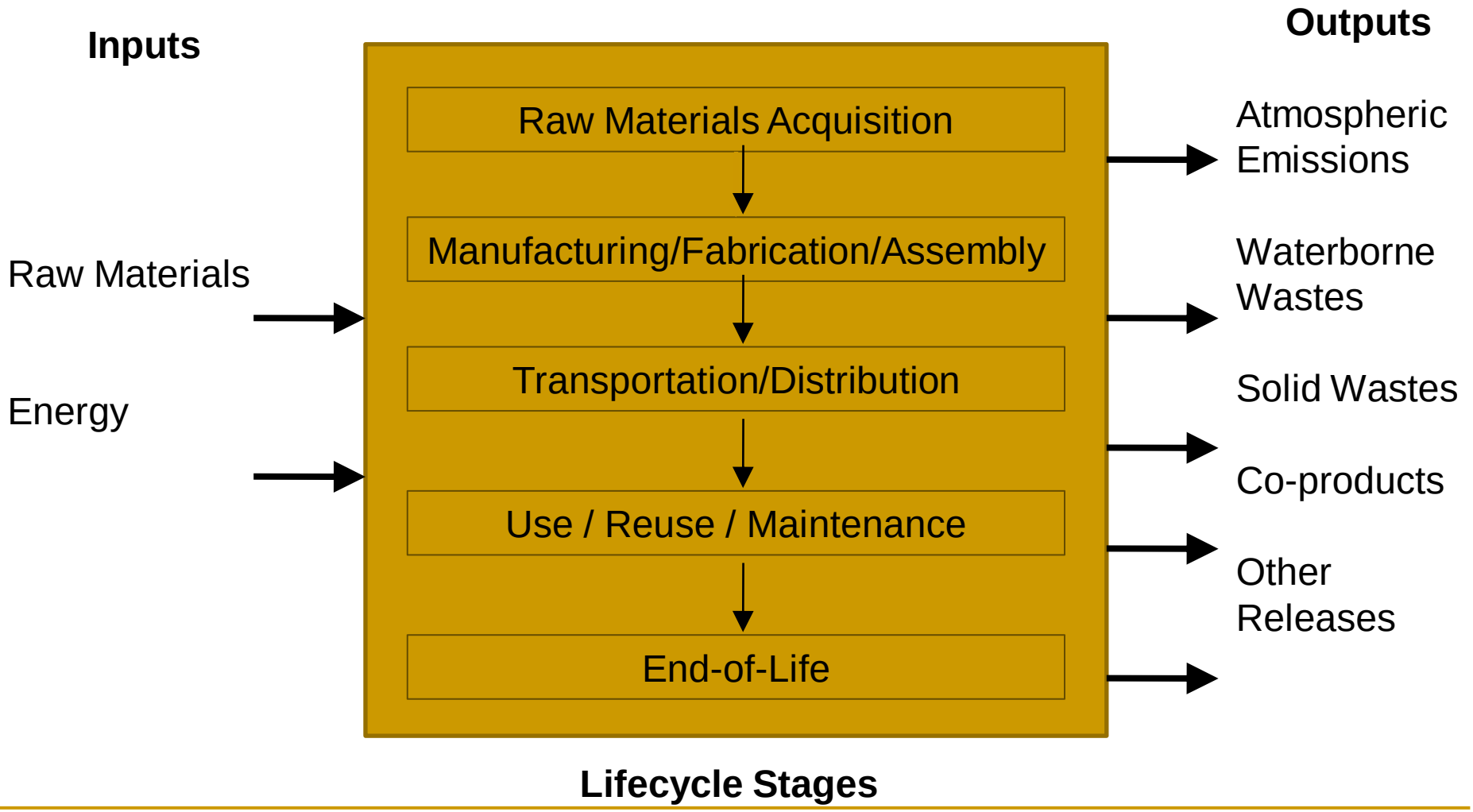
Lifecycle Assessment (LCA)



Evaluate the environmental burdens associated with a product, process, or activity.

- Identifying and quantifying energy and materials used and wastes released to the environment;
- Assessing the impact of the energy and materials used and released to the environment;
- Identifying and evaluating opportunities to affect environmental improvements.

LCA Inputs / Outputs / Stages



Lifecycle of an Aluminum Can



Lifecycle Assessment Questions

- Where will the raw materials come from?
- Which manufacturing processes will be needed?
- What types of waste will be created during product manufacture?
- Who will use the product?
- What type of maintenance and cleaning might be required?
- What types of waste will be created in the use of the product?
- Where will the product go when it is no longer useful?

LCA Potential Outcomes

Raw Material Procurement
- Product downsizing (lightweighting)
- Source reduction
- Recycled materials
- Alternative materials

Manufacturing/Assembly
- Conservation & recycling of raw materials
- Energy conservation
- Prevention of air & water pollution
- Reduction of hazardous materials for processing

Distribution/Transportation
- Simplified packaging
- Reusable packaging
- Efficient distribution
- Use of low-pollution delivery vehicles

Consumer Use
- Products that are more durable with longer lifespan
- Reduced use of auxiliary materials (products that require less water, energy, detergent, etc.)

Post-Consumer Use
- Products designed for easier disassembly, recycling, reuse
- Lower amounts of environmentally harmful substances when disposed of

Environmentally Responsible Product Assessment Matrix (ERPA)

Lifecycle Stage \ Environmental Concern	1.Material Choice	2.Energy Use	3. Solid Residue	4. Liquid Residue	5.Gaseous Residue
1. Pre-Manufacture	1,1	1,2	1,3	1,4	1,5
2. Product Manufacture	2,1	2,2	2,3	2,4	2,5
3. Product Packaging	3,1	3,2	3,3	3,4	3,5
4. Product Use	4,1	4,2	4,3	4,4	4,5
5. End-of-Life	5,1	5,2	5,3	5,4	5,5

Value Assignments in the Matrix

4 = No environmental impact

3 = Minimal environmental impact (less than the expected average)

2 = Moderate environmental impact (about the expected average)

1 = Substantial environmental impact (more than the expected average)

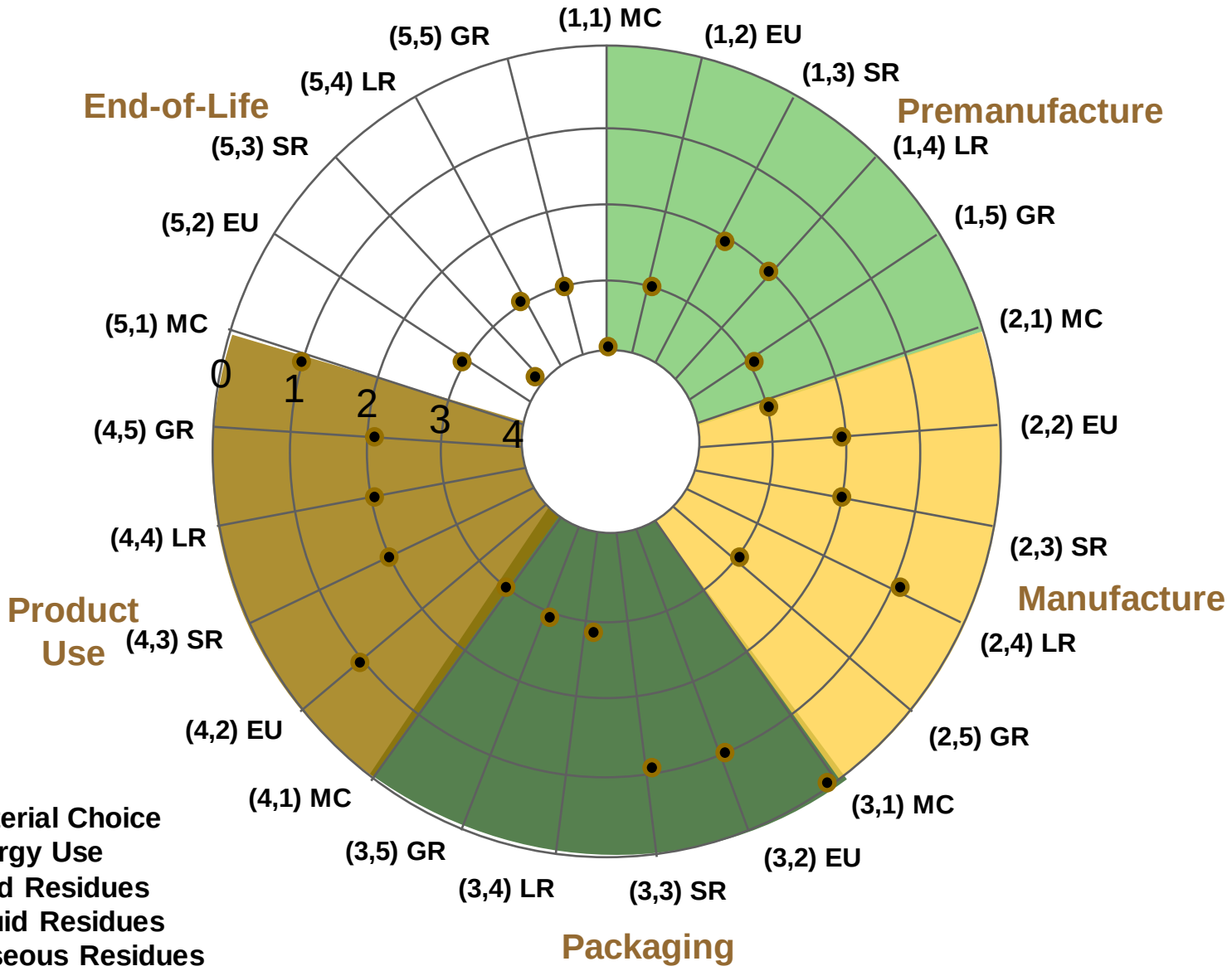
0 = Very high environmental impact

Assigning Matrix Values

Example: Product Packaging/Materials Choice (3,1)

- Score 4 if no packaging is used
- Score 3, 2, or 1 depending on
  - use of recycled packaging materials
  - minimization of materials diversity
  - existence of recycling infrastructure
  - involvement of packaging engineer on product team
- Score 0 if packaging is not marked for recycling and contains three or more materials

Target Plot



MC = Material Choice
EU = Energy Use
SR = Solid Residues
LR = Liquid Residues
GR = Gaseous Residues

Exercise – ERPA Matrix

- Choose a partner.
- Turn to page 35 in your Appendix.
- We're going to complete the ERPA Matrix by analyzing a product we are all familiar with. Then we will compare results and see if everyone agrees!

 Premanufacture	2

Premanufacture / Raw Materials (1, 1) Materials choice	Yes, or no impact = 1 No/Not applicable = 0
Does the program promote use of resources or raw materials that can be easily regenerated (sustainable crops for paper products, etc.)?	1
Does the program promote the use of materials that are less toxic for the function to be performed?	1
Does the program promote utilizing recycled materials or material minimization (minimize number of different materials used) wherever possible?	0
Does the program address obtaining environmental information about suppliers (where they get their raw materials)?	0
(1, 1) Total	2

Pre-Manufacture

- Design for the Environment (DfE)
  - Innovative, optimized product design (Eco-Design, Lightweighting);
  - Minimize number and types of materials contained in the product.
- Material Selection – Product & Process
  - Use recycled, recyclable, or compostable materials, e.g., green plastics;
  - Avoid or minimize use of restricted or hazardous materials.

Are Bioplastics a Viable Solution?

Advantages:

- Plant-based plastics (bioplastics) degrade very readily – some are even compostable.
- Bioplastics lack toxins like polyvinyl chloride that have raised health concerns.

Disadvantages:

- Biopolymers are typically more expensive than synthetic polymers.
- Processing requires more energy, as well as water, than traditional thermoplastics.

DfE Example - Bioplastics

- Toyota uses bioplastics for car floormats and the spare tire cover in some of its cars.



- The Toyota biotechnology division works with numerous companies, including office equipment makers such as Fujitsu and NEC, to supply them with bioplastics.

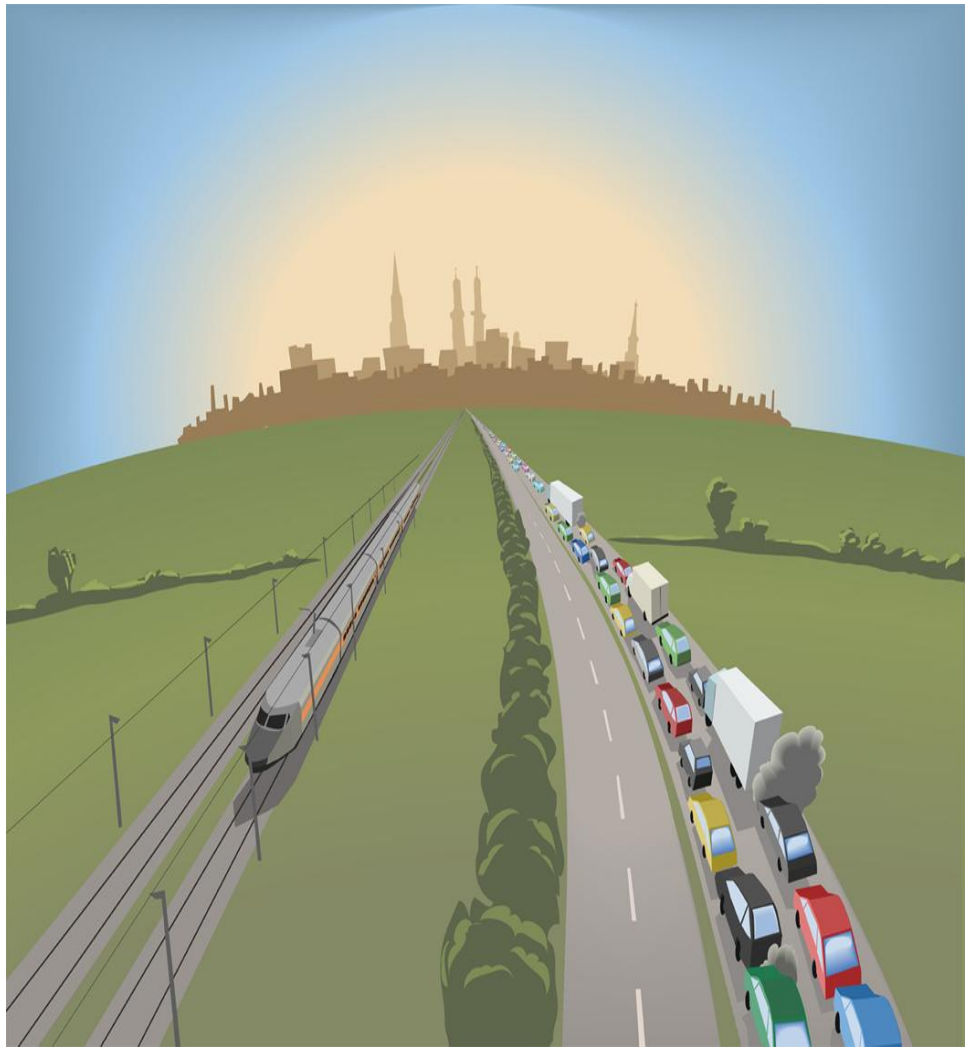
Manufacture

Design the product and production processes to:

- Avoid energy-intensive processes during manufacture, e.g., multiple heating or cooling cycles
- Use alternative processes to avoid surplus coating, cut-aways, trimming, by-products, etc.
- Implement best practices for process control and error reduction.
- Optimize assembly, disassembly, testing to avoid scrap and product defects.

Manufacturing Best Practices

- Standardize process steps/ components.
- Eliminate process variability.
- Perform preventive maintenance.
- Error-proof (poka-yoke) processes.
- Right the first time.
- Minimize resource inputs.



Transport & Packaging

Product, packaging and transport can be improved to:

- Reduce packaging materials, including eliminating the need for packaging protection.
- Use recycled-content packaging and reusable transport packaging.
- Avoid hazardous or restricted materials used for labeling the product/packaging.



Product Use / End of Product Life

Product design should ensure:

- Easy to identify material types – also easy to separate.
- Reusable components rather than one-time use, e.g., cartridges, containers, batteries, etc.
- Easy disassembly for repair, upgrade, reuse
- Products requiring a power source use electric power efficiently or use renewable energy.

Design for Disassembly Example

- The Think® chair manufactured by Steelcase is 99% recyclable. Disassembly with hand tools takes only 5 minutes.
- Anticipate 20-year life expectancy, potentially lengthened by office donations of the chairs to nonprofits and schools for a second life.
- The 14 raw materials used to manufacture the Think® chairs were selected due to their low or moderate risk to humans and the environment.
- Also contain 41% recycled-content materials and are often shipped to customers in reusable totes.



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Course Evaluation

Waste Management

- Communicate clear procedures for waste segregation to site personnel.
- Reinforce the segregation scheme using appropriate personnel to carry out waste audits.
- Use incentives/penalties to encourage segregation.
- Encourage ideas from site personnel through a suggestion scheme.
- Provide regular feedback on the success of the waste minimization efforts.

Waste Handling

- Delivery, storage and transportation of waste needs to be planned carefully. Look at movement of waste at every point:
  - Are containers positioned both for ease of access to fill, but also for emptying & removal?
  - How can you minimize the number of times it is handled?
  - How can collection be integrated into other functions?
  - How can waste be safely moved around site, e.g., forklift, carts?



- Consider using balers or compaction systems when there are space constraints – can reduce space requirements up to 40%.

Source Reduction – 1st Priority

- Good housekeeping (5S)
- Product modification
  - Alternative material selection
  - Lightweighting
- Process changes
  - Input material change
  - Better process control
  - Equipment modification / maintenance
  - Technology change
- Reuse / Recycling
  - On-site recovery and reuse
  - Production of useful by-products



Collection at the Source



- Prevents recoverable materials from being contaminated.
- Also prevents double handling of materials – saving time and effort.
- Encourages employees who generate the waste to make suggestions for reducing or reusing.



- Waste Stream Mapping identifies waste production points and convenient places to locate segregated collection containers.

Make it Visual and Obvious

- Labeling is important to identify which areas or containers are used for particular wastes.
- Signs should also specify what *not* to put into containers.
- Attach the signs directly to receptacles, where possible, or to an adjacent wall hanging above the receptacle.



Green Purchasing

Procurement process and supply chain are part of the Waste Minimization process:

- Specify products that create less waste and are not hazardous if they enter the waste stream;
- Get supplier agreements to take back excess materials and packaging,
- Use Just-in-Time procurement and delivery;
- Specify reusable and recyclable packaging;
- Reuse waste rather than purchasing new;
- Use materials and products with recycled content;
- Buy products designed for reuse.



Greenhouse Gas Emissions (GHGs)

Solid waste management decisions can reduce GHGs by affecting one or more of the following:

- Energy consumption, e.g., *combustion of fossil fuels*;
- Non-energy-related manufacturing *emissions*;
- Methane (CH_4) emissions from *waste disposal landfills*;
- Carbon dioxide (CO_2) from *raw material extraction*;
- Nitrous oxide (N_2O) and CO_2 emissions from *waste combustion*;
- Carbon sequestration.

How Much Does Your Waste Cost?

Understanding the costs help justify changes.



- Look at invoices from waste contractors to calculate weight and cost of all your waste.
- Determine from purchase orders how much raw material ends up as product versus leaving the site as waste.
- Do you track how much reject/off-spec products are recycled or reused rather than simply disposed of?

Finding Hidden Costs

If a product is broken in the shipping department:

True cost of waste =

Cost of wasted raw materials +
cost of utilities used + lost time +
waste treatment/handling + disposal costs

The total cost of waste is generally around *20 times* the first estimate that a company makes.

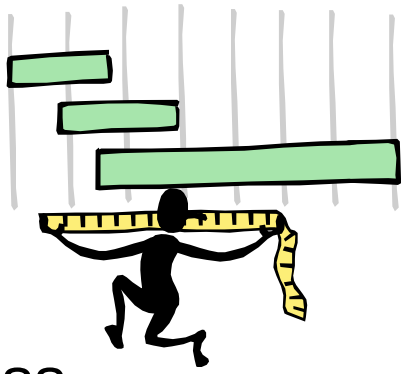
Economic Viability

- Capital Costs
- Annual Operating Costs
- Avoided Waste Removal Costs
- Avoided Purchase Costs
- Potential Annual Revenues

Exercise – Economic Analysis

- With your Dumpster Dive Team, choose 1 of the *REFUSE* solutions you identified.
- Complete the *Economic Feasibility* section of your *Waste Sort Worksheet (Appendix* pages 22 - 25.)
- Estimate costs, savings and revenue potential for those categories where actual data isn't available.
- Be prepared to present your Economic Justification to the class.

Measurements for Managing



- *Report waste as % of effectiveness.*

  Relating waste to throughput helps monitor progress over time even when other business variables change.

- *Don't keep costs secret.*

  People often don't appreciate the value of the materials they are handling. Share the dollars saved and how that impacts the business environment.

- *Make the producer pay.*

  Detailed monitoring of waste streams provides a means to charge waste generators for the disposal.

Next Steps

Based on what you learned in the Dumpster Dive today:

- What are the “Just Do It” changes you are going to implement right away?
- Which potential solutions need to have further analysis and justification before implementing?

Course Agenda

Solid Waste Streams

Managing Solid Waste

Dumpster Dive (Waste Sort)

4Rs – Refuse, Reduce, Reuse, Recycle

Considering the Entire Lifecycle

Putting Waste Minimization in Practice

Course Evaluation



This product was funded by a grant awarded under the Workforce Innovation in Regional Economic Development (WIRED) Initiative as implemented by the U.S. Department of Labor's Employment & Training Administration. The information contained in this product was created by a grantee organization and does not necessarily reflect the official position of the U.S. Department of Labor. All references to non-governmental companies or organizations, their services, products, or resources are offered for informational purposes and should not be construed as an endorsement by the Department of Labor. This product is copyrighted by the institution that created it and is intended for individual organizational, non-commercial use only.

TECHNICAL ASSISTANCE PROGRAM

Green Enterprise Development

LEVEL **2**

Green Specialist Certificate Series

Join us for the "Dumpster Dive" Workshop!

Understand the importance of the entire product lifestyle and its impact on your bottom line.

One-Day Workshop • Appropriate for engineers, green team participants and environmental managers

The Green Specialist: "Dumpster Dive" Workshop was designed by Purdue's Technical Assistance Program for manufacturers and others interested in learning the fundamentals of solid waste streams and their sources by focusing on the leading methods of waste reduction. Expect a fun, fast-paced workshop with simulations and case studies for in-depth instruction in applying green concepts and techniques.

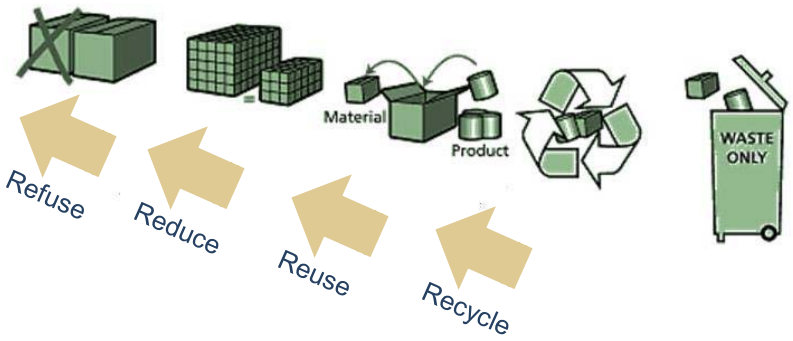
Participants will learn:

- Fundamentals of solid waste streams
- Methods to evaluate materials used in products and processes
- Concepts relating to life cycle analysis
- How to reduce or eliminate the solid waste stream
- How to apply the 4Rs – Refuse, Reduce, Reuse, Recycle



Take part in a live "Dumpster Dive" activity:

Sort through a simulated company's trash, calculate the costs associated with managing this waste, and generate ideas for saving money and improving the environment.



Green Enterprise Development



Visit www.tap.purdue.edu/green to learn how to take the green movement to the next level.

How We Can Work With You: In addition to Green Enterprise Development, Purdue's Technical Assistance Program offers on-site public workshops and provides implementation and consulting services.

For workshop dates or to register: Visit www.tap.purdue.edu/green under "Register for Events." Cost is $395/per person.

For more information: Contact Abbey Maddy via phone at (800) 877-5182 ext. 620 or email amaddy@purdue.edu.

Black & Gold & Green Enterprise Development

Technical Assistance Program
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PURDUE UNIVERSITY

PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM



Sustainability in Practice

Environmental Business Management

Purpose of This Module

- To provide an understanding of what it means to be a sustainable business and why it is important.
- To provide strategies for incorporating an overall sustainability mindset throughout your business.
- To identify implementable methods for your company to build a sustainability program and use it to drive business improvements.

Course Agenda

Sustainability & Business Strategy

Sustainability Scope

Economic Sustainability

Environmental Footprint Exercise #1

Environmental Stewardship

Environmental Footprint Exercise #2

Social Responsibility

Environmental Footprint Exercise #3

Innovation as a Bridge to Sustainability

Environmental Footprint Exercise #4

Course Evaluation

Green Business – All the Rage



Countless Case Studies

- Staples added $4.2 million to annual bottom line by changing light bulbs.
  - April, 2009 CFO.com

- Lockheed Martin switched to smart water management on its two 500-acre campuses in California's Silicon Valley, saving an annual estimated 126 million gallons of water, $1 million in water cost and avoiding property damage.
  - January, 2009 HydroPoint

- Subaru is one of a growing number of companies claiming or working toward "zero landfill" status. While success earns environmental bragging rights, reuse and recycling also cuts costs to the tune of millions of dollars a year.
  - February, 2008 USA Today

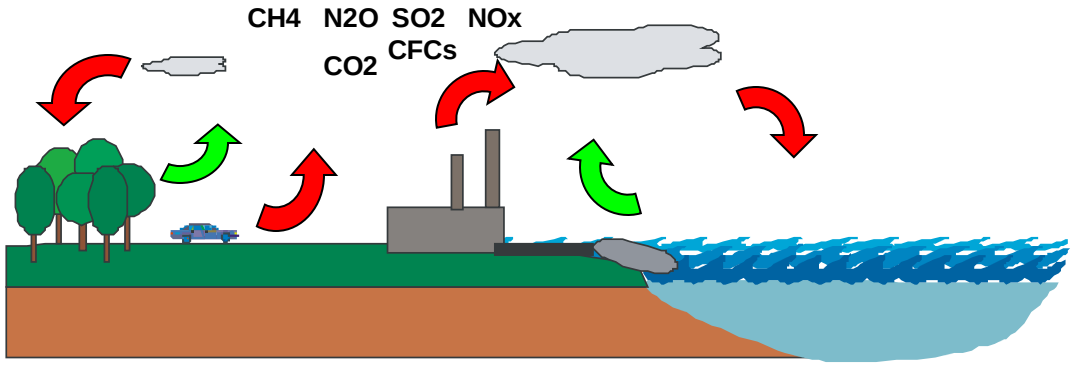
- Kohlberg Kravis Roberts & Co reduced 25,000 metric tons of greenhouse gas emission reductions and 650 tons of solid waste, which generated a $16 million reduction in operating costs.
  - April, 2009 CFO.com

Human Impact on Natural Capital

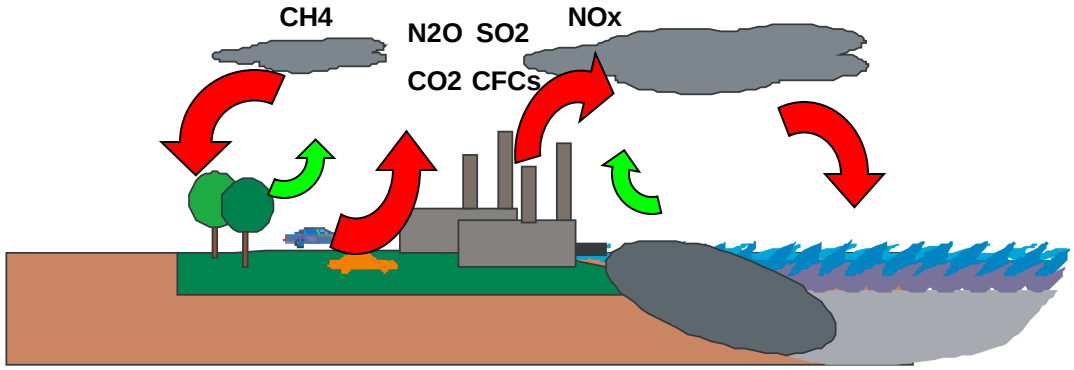


Environmental Damage

Past



Present



Natural processes can absorb some of the wastes generated by humans, but not all.

Carrying Capacity

- Number of living things that can exist for long periods in a given area without damaging the environment.
- Different for each species in a habitat because of their particular food, shelter, and social requirements.



Resource Scarcity

According to a 2008 *McKinsey Global Survey of Corporate Executives-*

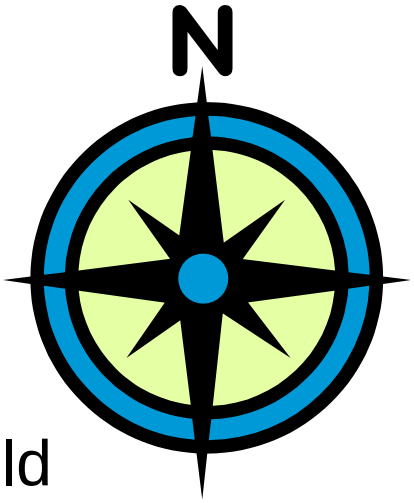
- "increasing constraints on supply or usage of natural resources" jumped from 7th to 2nd on list of important trends.
- 34% of CEOs believe resource constraints will affect profits in the next 5 years yet…
- Only 1/3 of those companies have taken action!

Sustainability



Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Strategic Planning



Stable companies have Strategic Plans spanning 1- 5 years.

A company with a vision of Sustainability should develop strategies extending *at least* 25 years into the future.

Why not 50 or 100 years?



How does Sustainability fit into your company's strategy?

Triple Bottom Line

Profit (Economic)

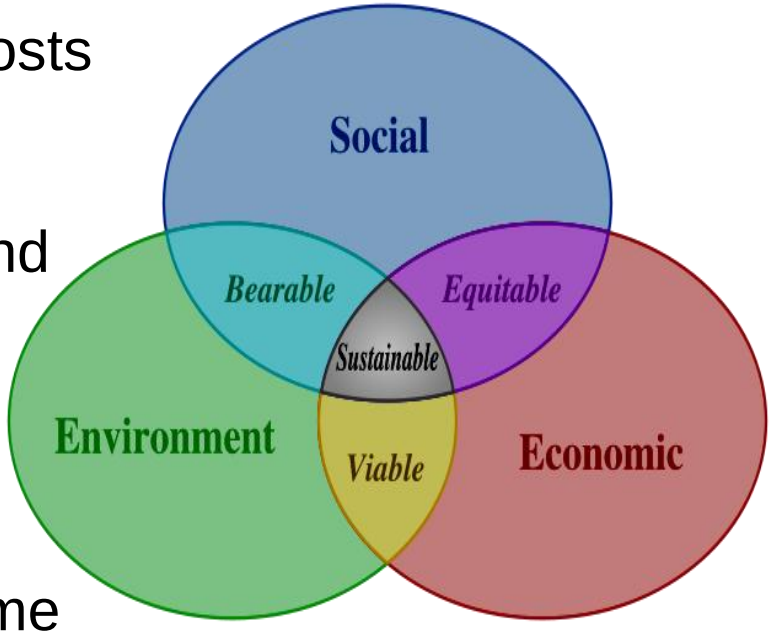
- Improves efficiency & lowers costs
- Reduces regulatory compliance costs

Planet (Environmental)

- Reduces demand for resources and energy *from* nature
- Reduces waste *to* nature

People (Social)

- More resources and energy become available for others
- Closing the loop (cradle-to-cradle) generates new jobs



Executive Level Objectives

While our primary drivers may be Economic, Sustainability efforts must evaluate Environmental & Social impact as well.



Profit

- Resource Costs
- Waste Management Costs
- Operational Costs
- Employee Effectiveness
- Product/Service Repositioning
- Customer Satisfaction



Planet

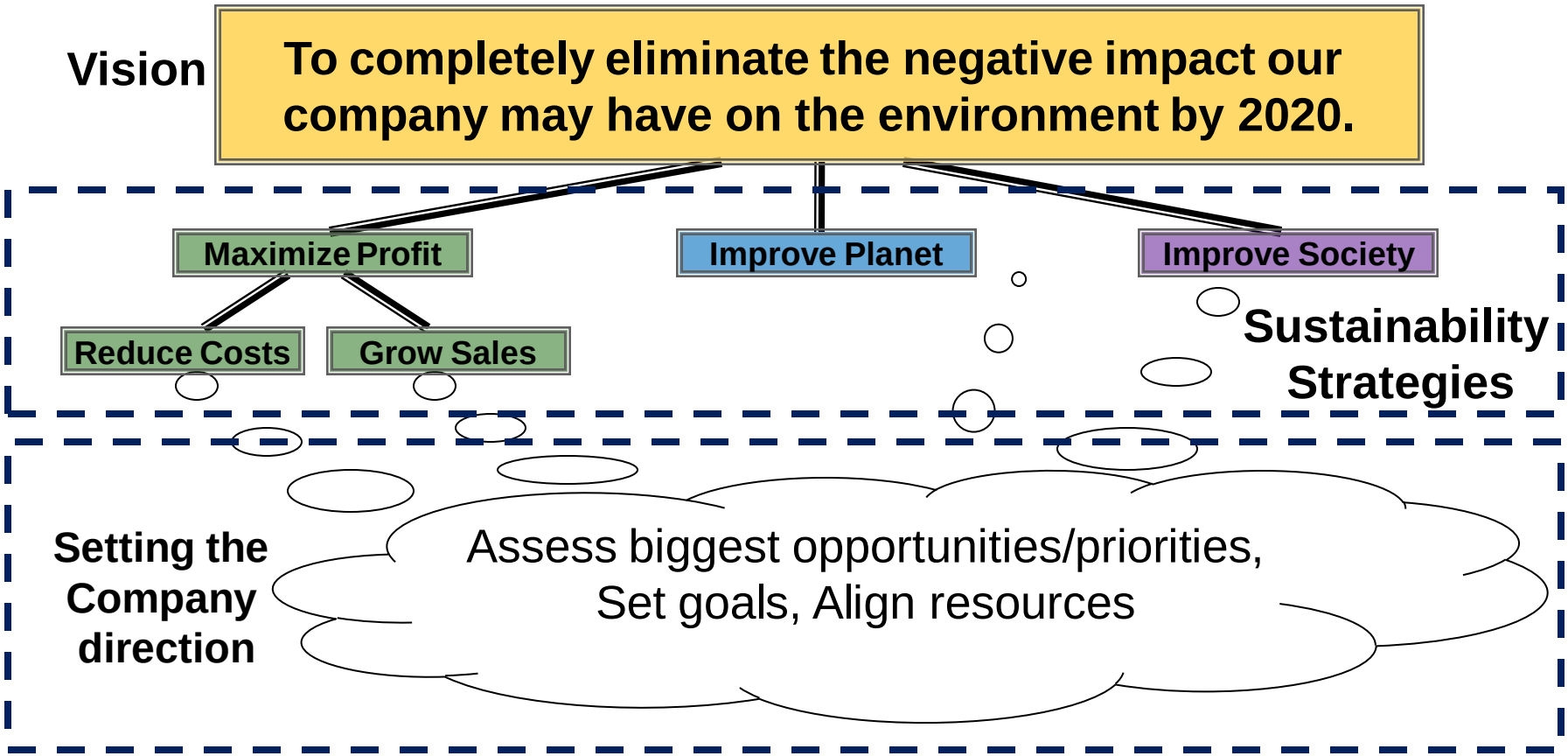
- Emissions/Pollution
- Alternative Energy
- Land/Natural Resources
- Waste Exchange
- Biodiversity



People

- Trusted Advocate
- Quality of Life
- Future Generations
- Global Citizen

Sustainability Vision



Vision links to specific Strategies.
Then define priorities and goals for all organizational areas.

Starbucks Environmental Goals

- Ethical Sourcing
- Environmental Stewardship
- Community Involvement





Making Choices

- Assess technical feasibility
  - Get input from people who operate & maintain equipment
  - Availability of equipment / maintenance requirements
  - Necessary operating skills
  - Space availability
  - Impact on production / operational flexibility
  - Effect on product quality
- Analyze economic viability and payback
- Evaluate environmental advantage / consequences
- Consideration for safety & ergonomics
- Review impact on the community

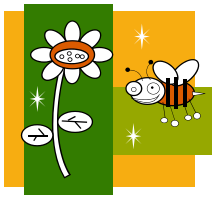
EnVi

Environmental Footprint



Get
Real
Effective
Environmental
Nu-Metrics

BE GREEN



- Get Real Effective Environmental Nu-Metrics (*GREEN*), a division of Buzz Electronics (*BE GREEN*!) produces solar-powered calculators for determining *Environmental Footprint*.

- Problem: Customers are requiring that *BE GREEN*, along with their entire supply chain, reduce their Environmental Footprint.

Environmental Footprint Calculator

- Triple Bottom Line Sustainability impact:

  Economic (Profit) Social (People) Environmental (Planet)





- Considering the five key resource/waste streams:

Solids **Energy** **Air** **Water** **Chemicals**







Footprint Calculator Challenges

GREEN believes a simplified tracking method for Sustainability progress is important.

Challenges:

- What matters? What doesn't?
- How to measure?
- Are there any standards?
- Just one number?



EnVi Baseline



Start with a baseline of 500:

- uses resources without concern about replenishment or alternatives;
- generates waste streams that end up in landfills, waterways, and the ozone; and
- no focus on nature's cycle as part of standard operating practices.

Calculates in **IITE**s (**I**nvesting **I**n **T**he **E**nvironment)

Mission: “Countdown to Zero”



Our promise:

To completely eliminate the negative impact our company may have on the environment by 2020.

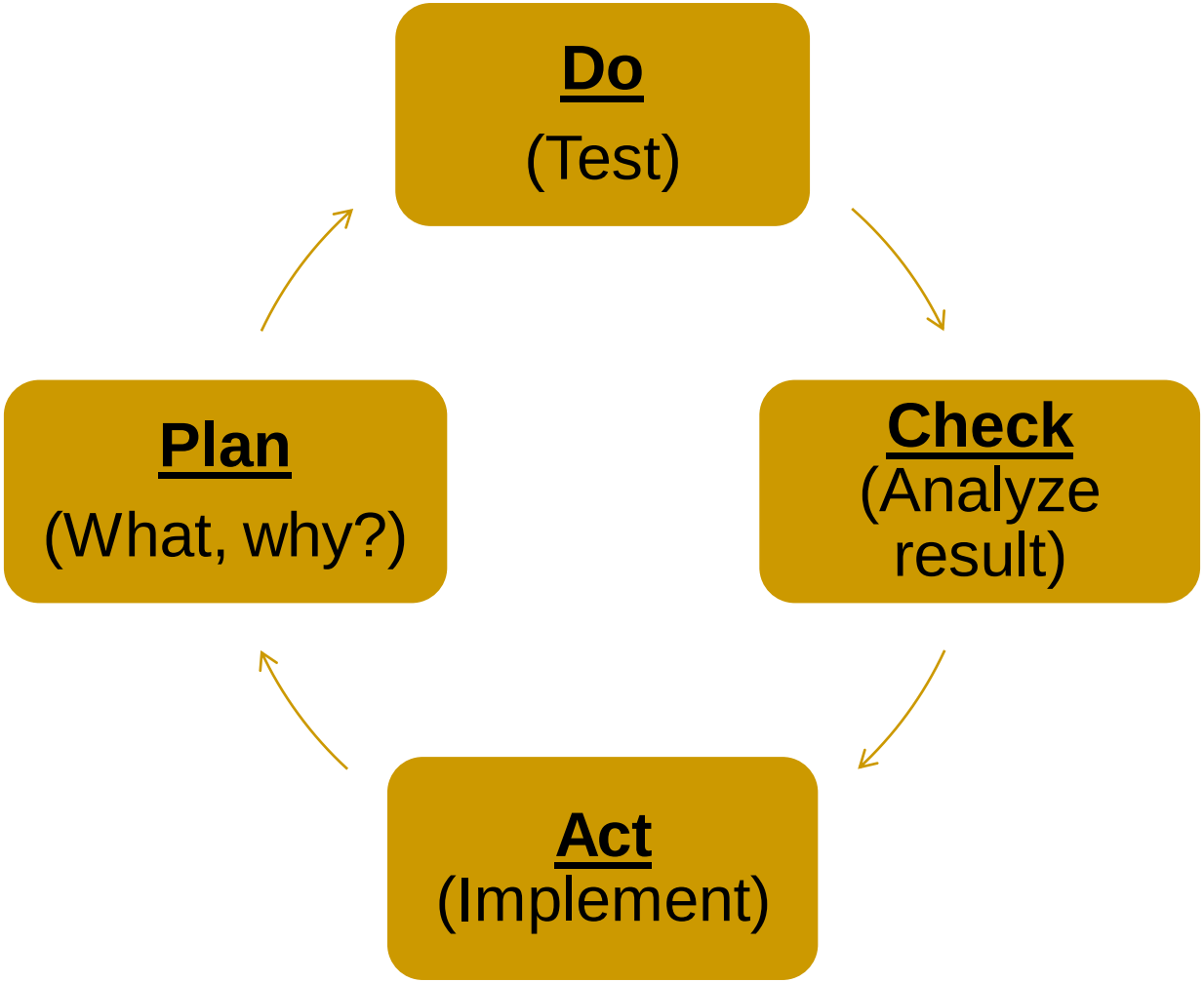
Sustainability Effort at *GREEN*

- Company recycling program for plastic, paper and aluminum, with color-coded recycling containers;
- E-waste recycling program;
- Energy-savings
  - light fixture and bulb replacement;
  - programmable thermostats and motion sensors, and
  - equipment power downs during unmanned periods.

Countdown to Zero

Project	IITEs Credit	EnVi Footprint
BASELINE		**500**
Recycling program	- 6 (2 per mat'l)	**= 494**
E-waste collection	- 6	**= 488**
Lighting improvements (new fixtures/bulbs)	- 12	**= 476**
Programmable thermostats/motion sensors	- 6	**= 470**
Motion sensors for lighting control	- 5	**= 465**
Powering down equipment	- 4	**= 461**
ANTICIPATED 1ST YEAR SAVINGS = $39,000		

Plan – Do – Check – Act (PDCA)



Problem Solving A3 Report

Date:

Theme:

Team Members:

Background:

Current Condition:

Goal/Target Conditon:

Root Cause:

Describe the problem-
Why?
Why?
Why?
Why?
Why?

Countermeasures:

Achieve Target Condition

Follow Up Actions:

Plan

Do

Check

Act

Course Agenda

Sustainability & Business Strategy

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Social Responsibility

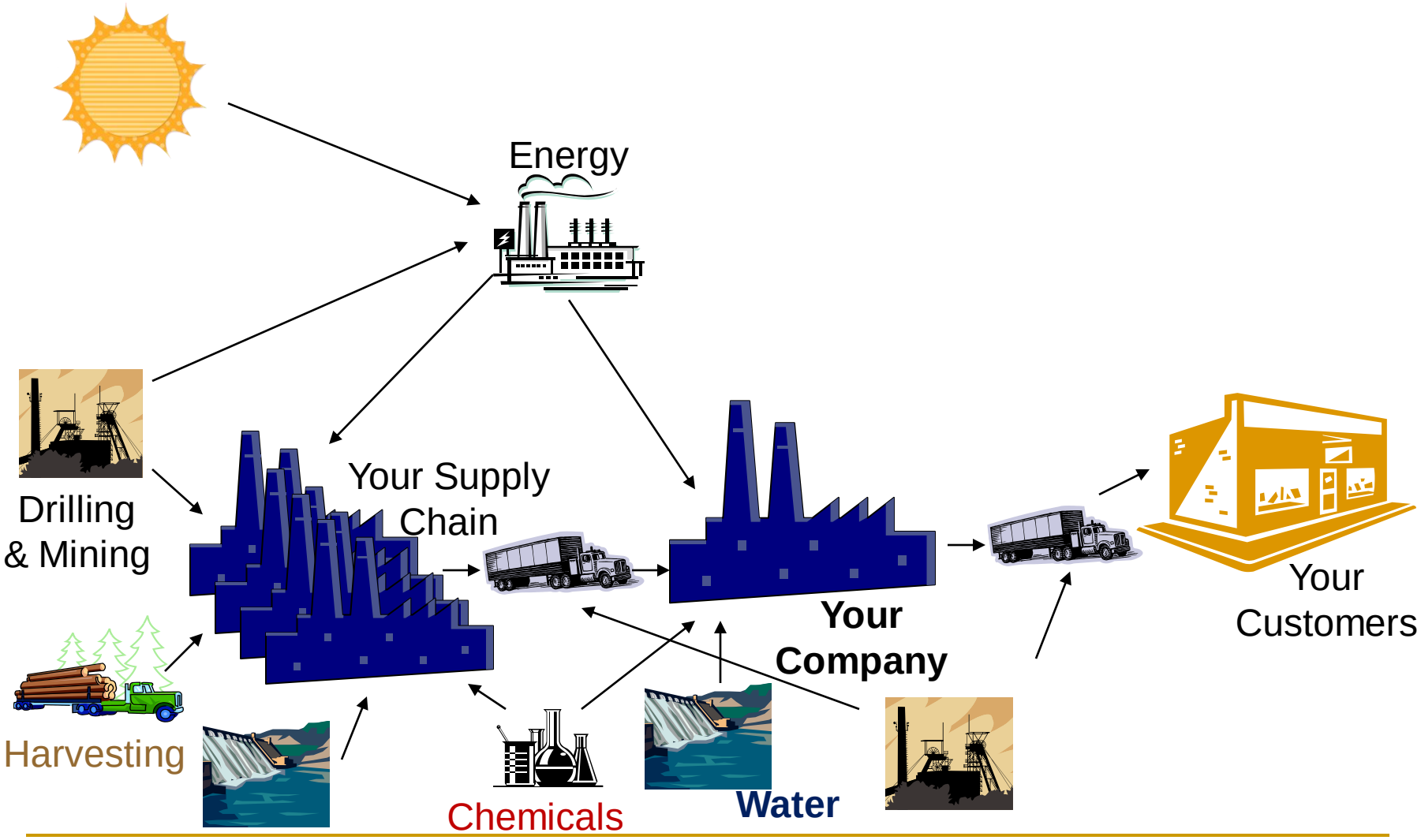
Environmental Footprint Exercise #3

Innovation as a Bridge to Sustainability

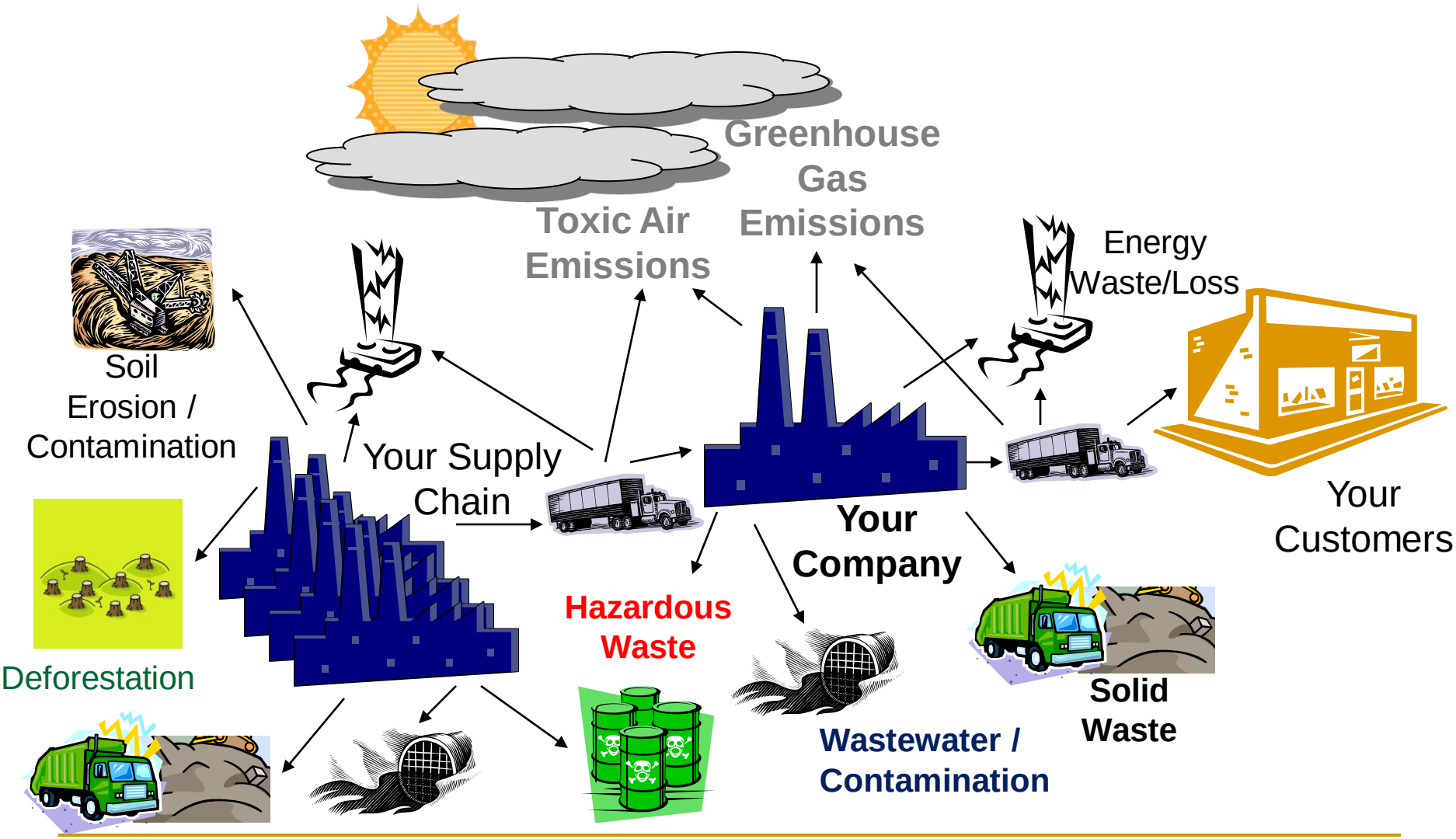
Environmental Footprint Exercise #4

Course Evaluation

System Inputs: Leading Indicators



System Outputs: Lagging Indicators



Leading & Lagging Indicators

Inputs

Leading Indicators

- Soil/Minerals
- Hazardous Chemicals
- Water
- Energy Resources
- Air Quality

Processes



Valued Output

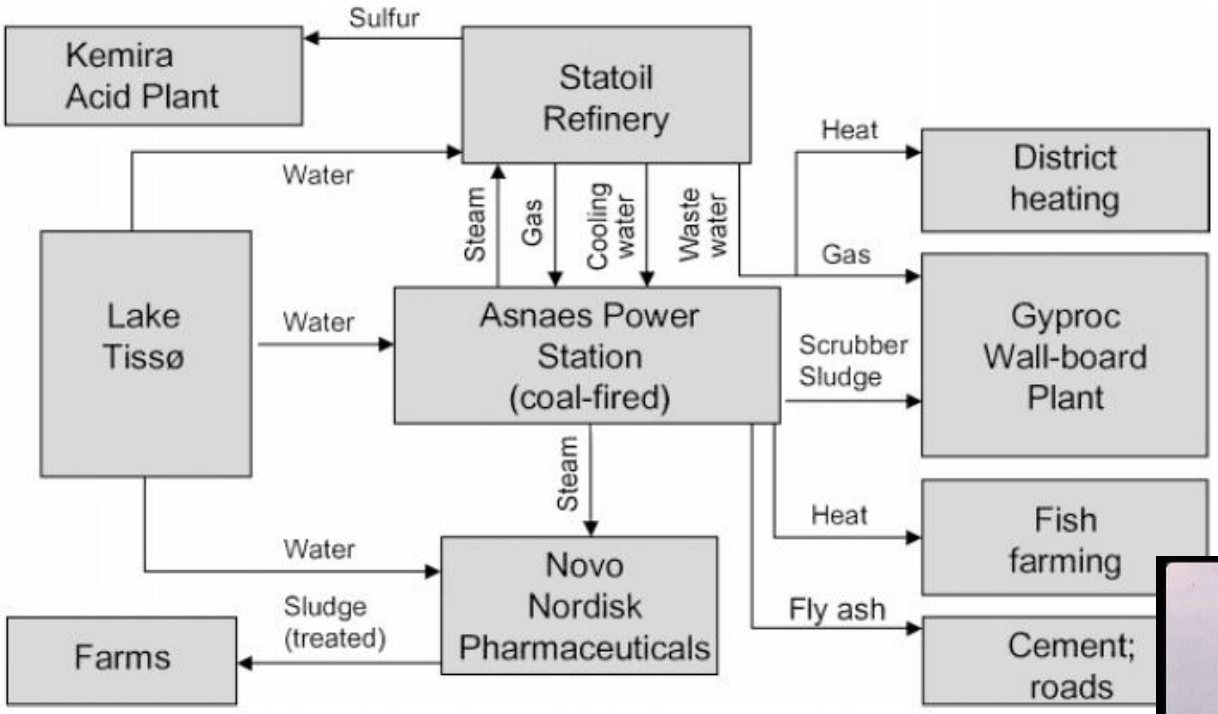
By-products

Lagging Indicators

- Wastewater
- Solid Waste
- Air Emissions
- Hazardous Waste
- Energy Waste

Prioritize improvement plans by measuring and evaluating Leading and Lagging Indicators.

Pursuing Zero Net Waste

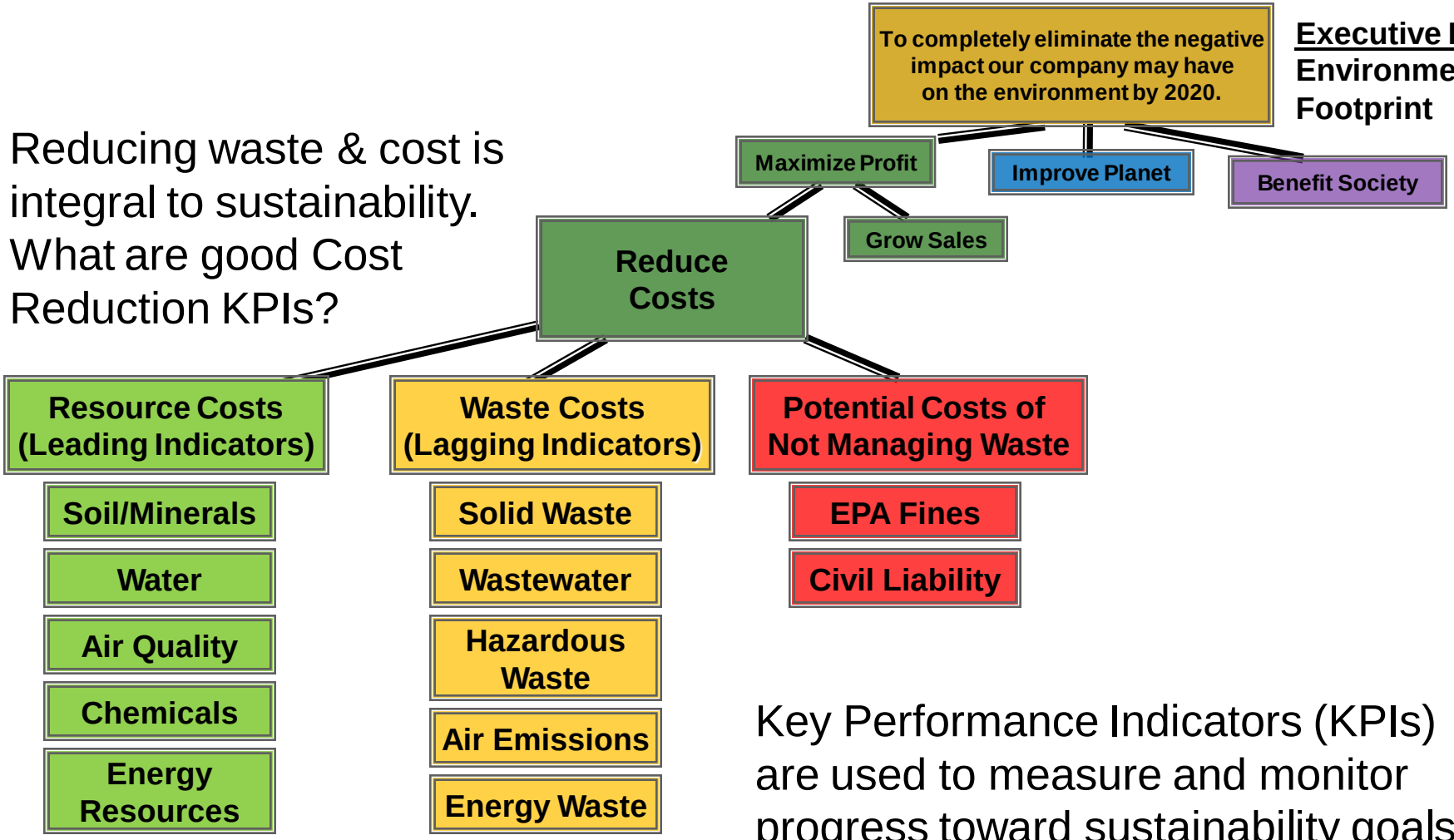


Industrial symbiosis at Kalundborg



Is there waste generated by your company that could be a valuable resource to another organization?

Key Performance Indicators (KPIs)

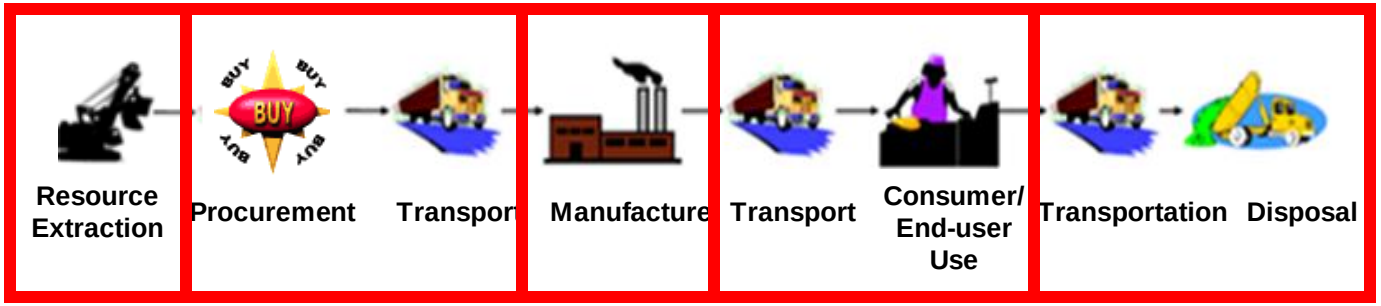


Reducing waste & cost is integral to sustainability. What are good Cost Reduction KPIs?

Key Performance Indicators (KPIs) are used to measure and monitor progress toward sustainability goals.

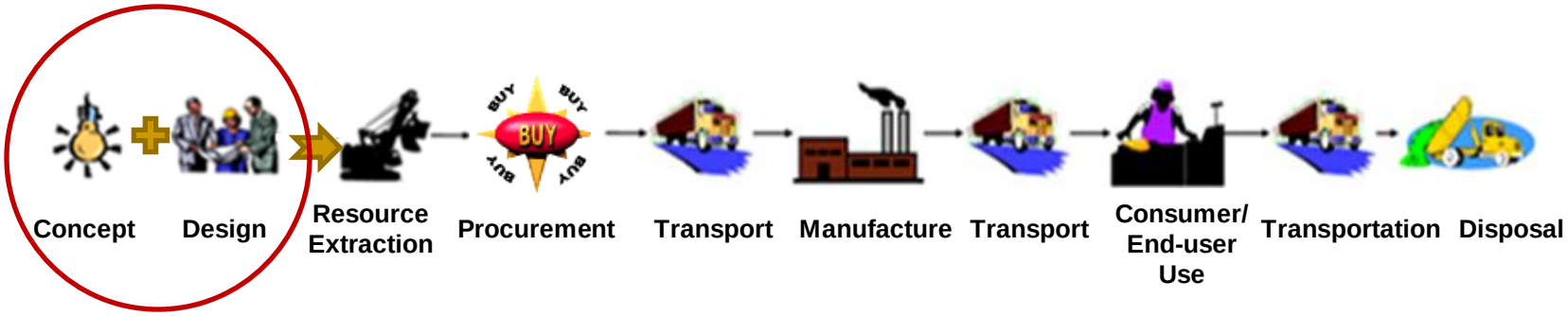
Sustainability Scope

How much control or influence do we have in regard to environmental costs – especially beyond our walls?



- Lifecycle supply chain: from resource extraction through end-of-life disposal.
- Looking for a win-win throughout the supply chain.

Begins with Concept & Design



Lifecycle considerations begin during the Concept and Design stages for both *products* and *processes*.

Sustainability Standards



Standards are needed to evaluate:

- Product Design
  - Durability / Reliability
  - Selection of materials / chemicals
  - Repair ease and feasibility
  - Disassembly / Disposal / End-of-life alternatives
- Production/Processing options
- Supplier selection and management
- Packaging design
- Logistics

Product Design



Design products that are optimally:

- Durable and difficult to damage;
- Lightweight / minimal materials;
- Made of recyclable or biodegradable materials;
- Modular / Standardized;
- Easily reconditioned, repaired and/or reused;
- Made of recycled or environmentally-benign materials.

Potential KPIs:

- % Recycled material
- % Recyclable material
- % of Product that can be reused / reconditioned
- % Product weight reduction
- Durability test results

Production Options



Production considerations:

- Resource needs
- Waste produced
- Reclamation and reuse
- Process / Equipment reliability
- Proven existing technology vs. Innovation needs
- Lower cost & impact to make internal vs. outsource
- Repair / Recondition preference

Potential KPIs:

- Total Carbon Footprint per unit of finished goods (f/g)
- Solid and/or Hazardous Waste weight per unit of f/g
- Waste treatment per unit of f/g
- Operating Equipment Effectiveness (OEE)
- % Material reclaimed/reused

Green Packaging



Key considerations:

- Materials, adhesives, fasteners & inks
- Minimize material used in design
- Recycled, recyclable, non-toxic & biodegradable
- Returnable, reusable, nesting design when empty
- Minimize overall volume to reduce transportation weight

Potential KPIs:

- Product to Packaging ratio
- % of Recycled Content
- % Recyclable Content
- % Returned / Reused
- % Packaging weight reduction

Green Transport



Key factors:

- Maintain equipment
- Driver/Dispatcher education
- Avoid rush hour scheduling/routing
- Transport alternatives, e.g., rail
- Maximize volume / minimize empty miles – consider partnerships
- Hybrids / right-sizing
- Revised incentives
  - less miles with higher MPG
  - shut-down vs. engine idling

Potential KPIs:

- Miles per gallon
- Miles logged per pounds of freight
- Empty miles logged per sales dollar

Green Supplier Management

Evaluating current / potential suppliers:

- Environmental Management System (EMS) review / certification
- Appropriate licensing / permitting
- Recognized achievements
- Sustainability culture
- Measurement of Environmental Footprint
- Distance to minimize transportation



Potential KPIs:

- % of Suppliers with verified EMS
- % of Suppliers who are local
- Average Supplier Environmental Footprint

Green Buildings

The U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) certification program promotes making buildings as Green as they can be.

The USGBC's members include practitioners along every point of the architectural and construction value chain – from designers and furniture makers to architects and raw material suppliers – all providing specific areas of expertise.



Regulatory & Litigation Risks

APRIL 23, 2009

EPA Reinstates Stricter Toxic Substances Reporting Requirements

The U.S. Environmental Protection Agency (EPA) has reinstated stricter reporting requirements, under the directi President Obama, for industria facilities that release toxic subs threaten human health and the

Press Release

Groups Plan Lawsuit to Force Cleanup of Air Pollution in National Parks

Legal notice charges illegal delays in cleaning up parks' haze pollution

June 25, 2008

Washington, DC -- As summer vacation season enters full swing, clean air advocates are fighting to make sure visitors to national parks can enjoy scenic vistas free of the yellowish haze caused by industrial pollution.

The 1977 Clean Air Act set a national goal of cleaning up dirty air in major national parks and wilderness areas. Decades later, only a small handful of states have submitted legally required plans to comply. The result: power plant and factory emissions continue to obscure views of beloved landmarks in national parks across the country including Shenandoah, Great Smoky Mountains, Glacier, Big Bend, Acadia, Sequoia, and Yosemite.

The nonprofit environmental law firm Earthjustice today filed formal legal notice of intent to sue on behalf of Environmental Defense Fund and National Parks Conservation Association over the U.S. Environmental Protection Agency's failure to enforce deadlines for the states to adopt these clean air plans.

EPA Levies $3.1 million In Fines In Northwest For 2008

BY ROB MANNING

Portland, OR December 5, 2008 11:25 a.m.

The federal government levied more than $3 million in fines on Northwest companies, state agencies, and cities over the past year. Pete Springer reports. Region ten of the Environmental Protection Agency covers Oregon, Washington, Idaho, and Alaska. EPA compliance and enforcement director Mike Bussell says the EPA worked closely with agencies in those states to inspect a number of sectors. Mike Bussell: "Everything from mining operations all the way to municipalities that are struggling to keep their sewage treatment facilities in compliance. So it's a broad range."

Environmental Management System

- Environmental Management Systems (EMS) provide a foundation for compliance and continuous improvement.
- ISO 14001 and other standards / guidelines are available from government agencies and industry groups.
- Potential benefits of implementation:
  - Drive improvements;
  - Opportunities for new customers & markets;
  - Enhance public image
  - Managing risk of non-compliance and/or litigation.

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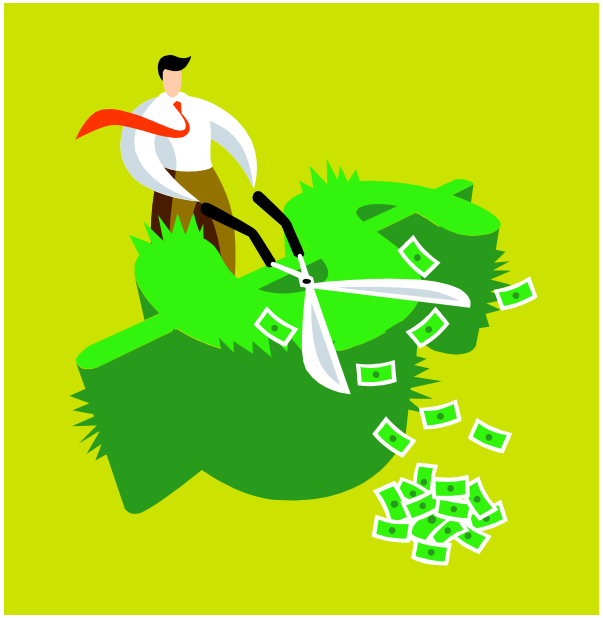
Environmental Footprint Exercise #3

Innovation as a Bridge to Sustainability

Environmental Footprint Exercise #4

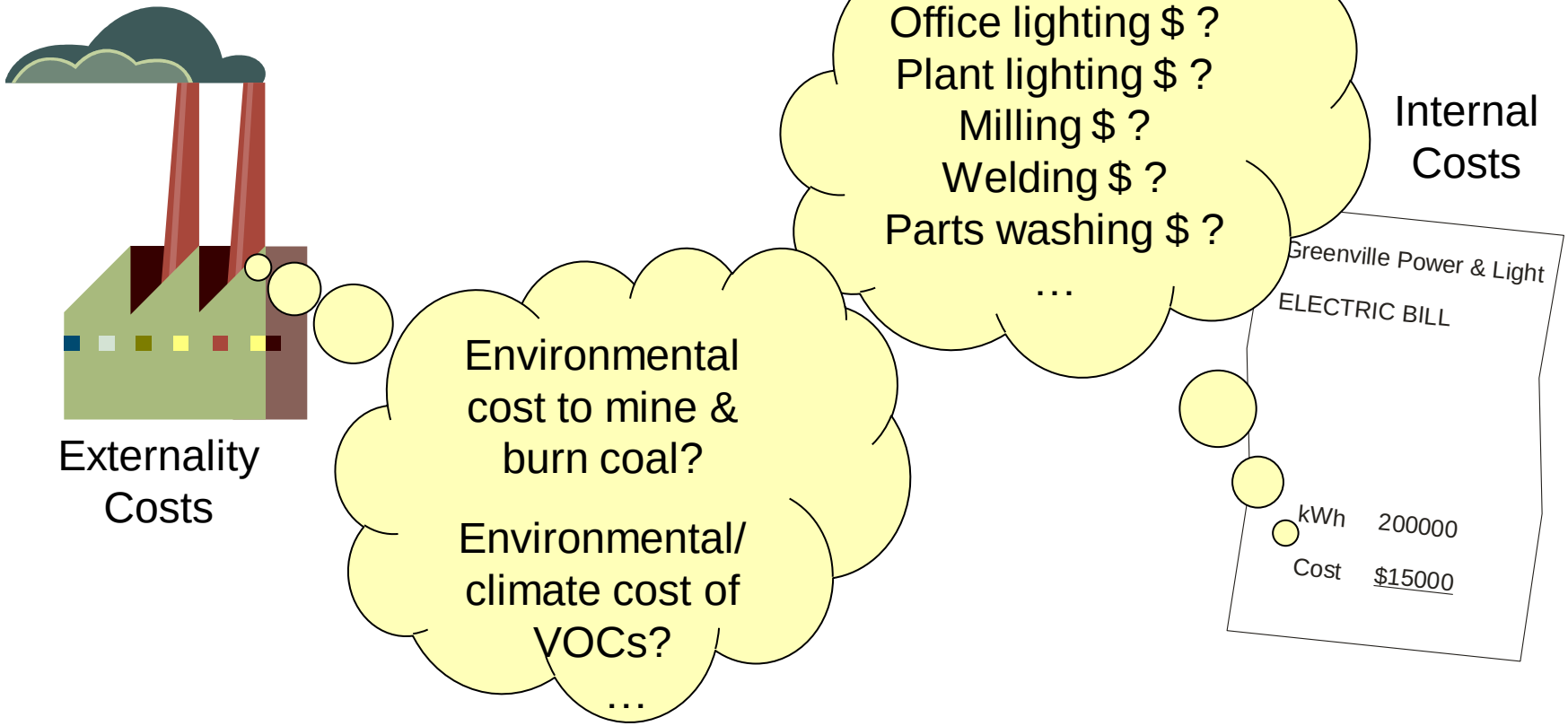
Course Evaluation

Bottom Line Impact



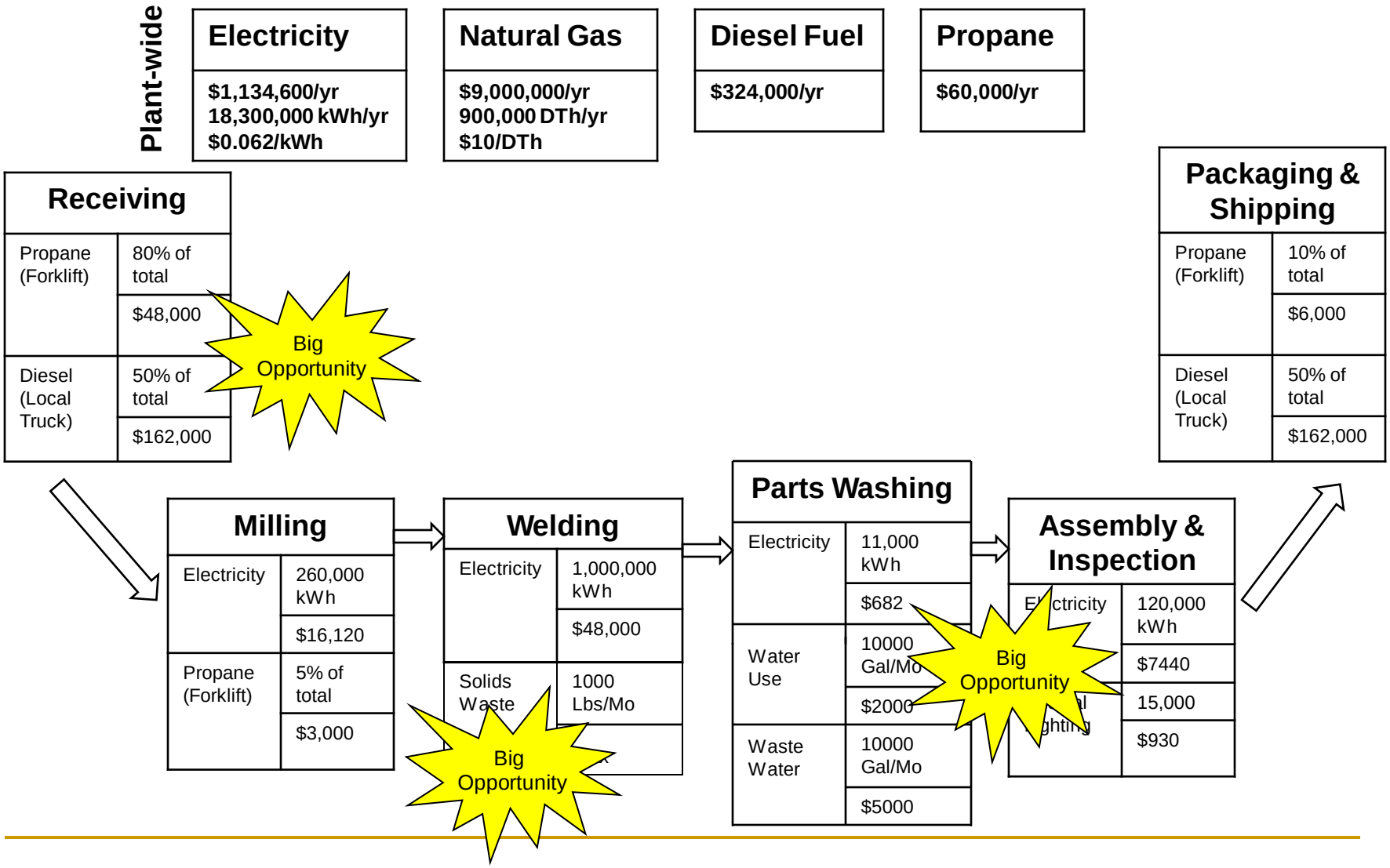
- Eliminate waste disposal costs;
- Decrease waste treatment costs;
- Lower energy costs;
- Reduce storage costs;
- Save on materials, chemicals and supplies;
- Improve transportation efficiencies and costs;
- Cut regulatory compliance costs;
- People costs, e.g., turnover, exposure.

Accounting Cost Picture



Standard accounting reports do not capture all details related to sustainability costs – especially externality costs.

Seeing Costs - Waste Stream Map



Product Certifications



Founded in 1989, Green Seal is one of the most recognized certifications in the consumer marketplace.

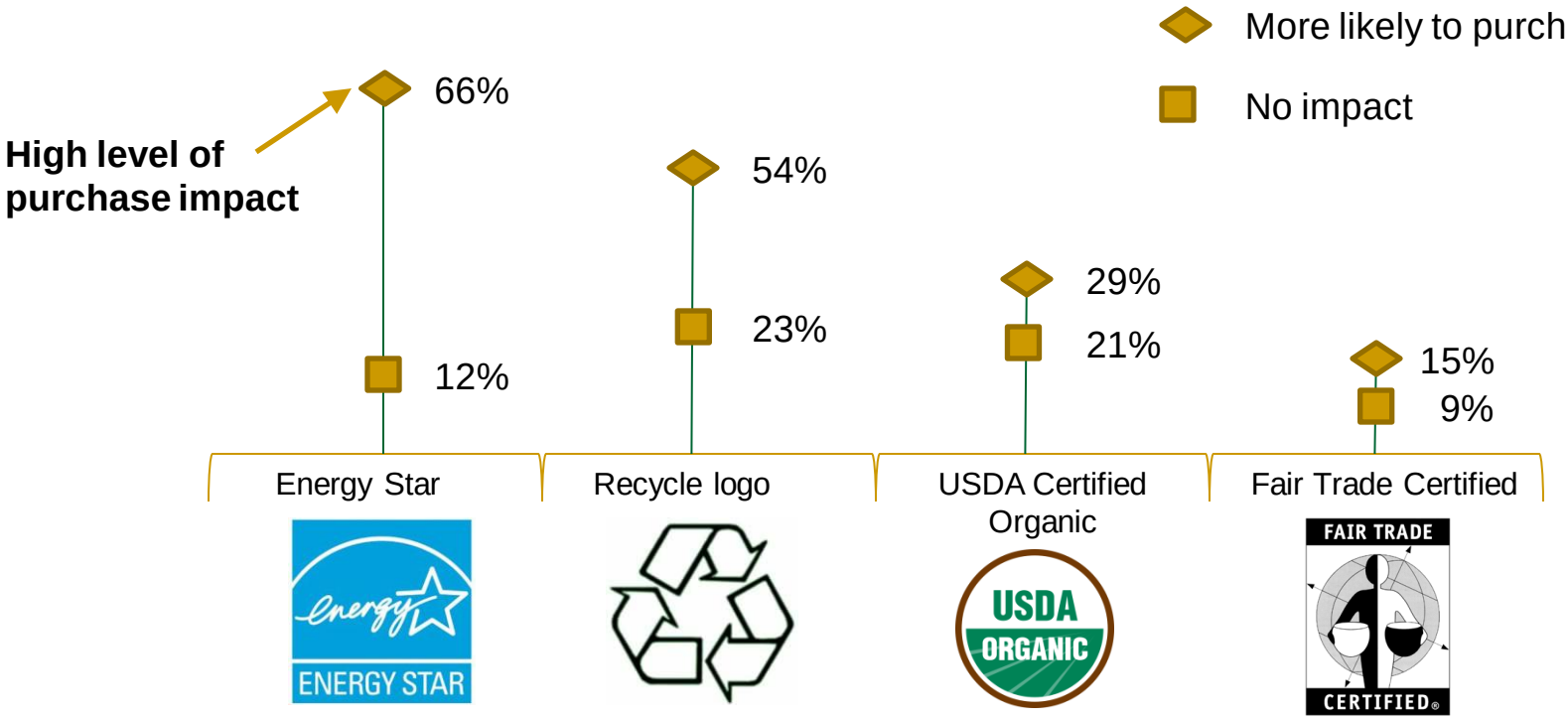
FSC coordinates development of forest management standards. Products bearing the FSC logo guarantee that the wood it is made from came from a certified well-managed forest.



Green Recognition

Green labels positively impact purchase behavior.

% General population indicating the impact of label/certifications on product/service choices



Source: National Marketing Institute

Consumer Behavior is Changing

82 Percent of Consumers Buying Green Despite Battered Economy

Green Seal and EnviroMedia Social Marketing release 2009 National Green Buying research

(PORTLAND, Ore.)—Four out of five people say they are still buying green products and services today—which sometimes cost more—even in the midst of a U.S. recession.

A new study commissioned by Green Seal and EnviroMedia Social Marketing and conducted by Opinion Research Corporation reveals peoples' opinions and behaviors about products that claim to be environmentally friendly.

Addressing consumer concerns about climate change

Businesses must act on global warming and other issues to narrow a general trust gap between them and the public.

MARCH 2008 • Sheila M. J. Bonini, Greg Hintz, and Lenny T. Mendonca



In This Article

Business executives are catching up with consumers in expressing concern about global warming and other environmental issues, two global surveys indicate. [1] In a sea change over the past 12 months, executives now regard the environment as the sociopolitical issue that will attract the most attention, by far, from the public and politicians over the next five years.

CONSUMER INTEREST IN ENVIRONMENTAL PURCHASING NOT ECLIPSED BY POOR ECONOMY

More than one-third of consumers more likely to buy environmentally responsible products today

BOSTON (February 18, 2009) – Despite the dire state of the economy, 34 percent of American consumers indicate they are *more likely* to buy environmentally responsible products today, and another 44 percent indicate their environmental shopping habits *have not changed* as a result of the economy. Fewer than one-in-10 (8 percent) say they are *less likely* to buy. This is according to the results of the **2009 Cone Consumer Environmental Survey** released today.

Even amid the recession, American interest in the environment has not waned, and as a result, many consumers are inclined to hold companies accountable for their environmental commitments today and in the future:

· 35 percent of Americans have higher interest in the environment today than they did one year ago;

· 35 percent of Americans have higher expectations for companies to make and sell environmentally responsible products and services during the economic downturn; and,

· 70 percent of Americans indicate that they are paying attention to what companies are doing with regard to the environment today, even if they cannot buy until the future.

Consumer Actions & Indicators

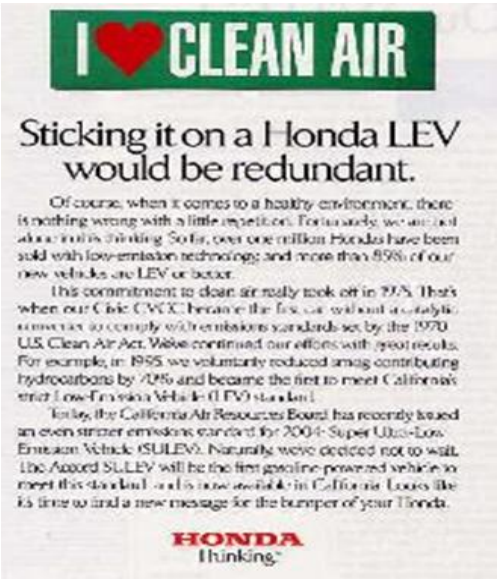


Source: BCG Global Green Consumer Survey, 2008

Green Marketing











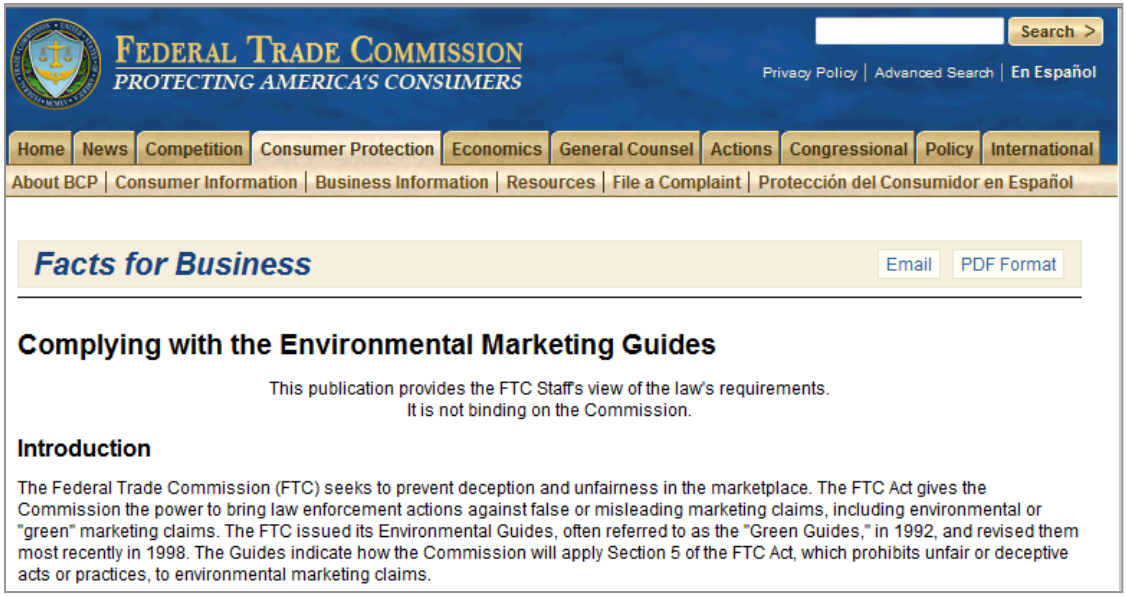




Green Marketing vs. Greenwashing

The Federal Trade Commission (FTC) enforces Environmental Marketing Guides:

- Biodegradable
- Recycled content
- Recycled
- Refillable
- Source reduction
- Ozone-friendly
- Non-toxic



Scientific evidence from objective, competent parties is requirement for proof of marketing claims.

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Course Evaluation

Exercise 1: “Countdown to Zero”



- *BE GREEN* wants the best EnVi score they can get!
- We’re going to help *BE GREEN* to improve their Environmental Footprint by recommending which suggestions to implement!
- Each team will report on their:
  - Decision-making process,
  - Selections, and
  - Results (IITEs and Anticipated Savings)

Course Agenda

Sustainability & Business Strategy

Sustainability Scope

Economic Sustainability

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Environmental Footprint Exercise #4

Course Evaluation

Ecosystem Services



An intact ecosystem provides for our economy with:

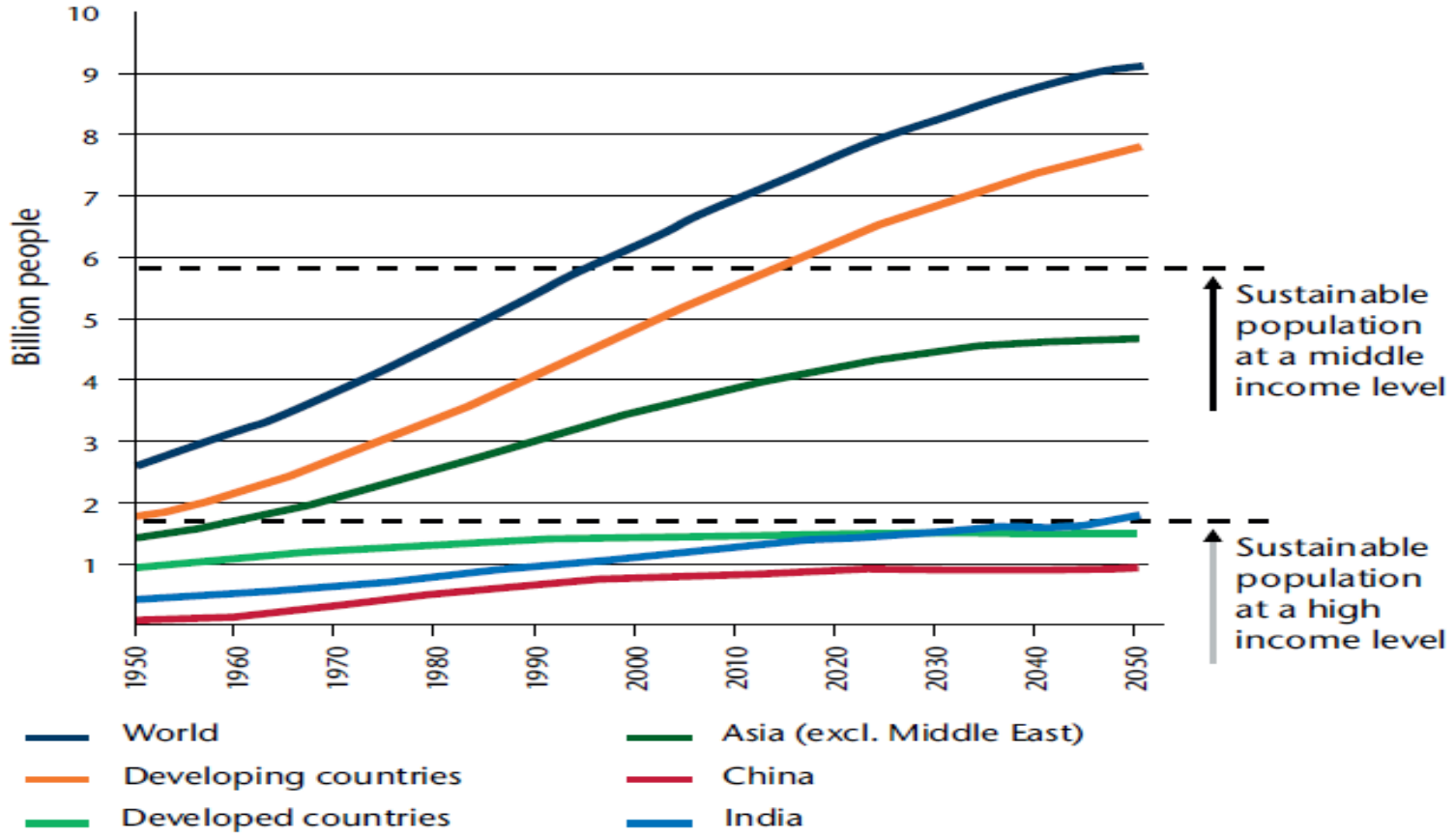
- Climate regulation
- Incubation of new life
- Nutrient cycling
- Waste management
- Erosion control
- Pest control
- Water and air purification
- Temperature moderation
- Noise reduction
- Economical landscaping
- Stormwater retention
- Tourist attractions

Global Consumption

Global consumption levels and patterns are driven at the most fundamental level by:

- Rapid global population growth;
- The rise in global affluence – middle- and lower-income consumers;
- A culture of “consumerism” among higher income groups.

Unsustainable Consumption



Up to 5 times the Earth's resources would be required if U.S. consumption was copied by the rest of the world.

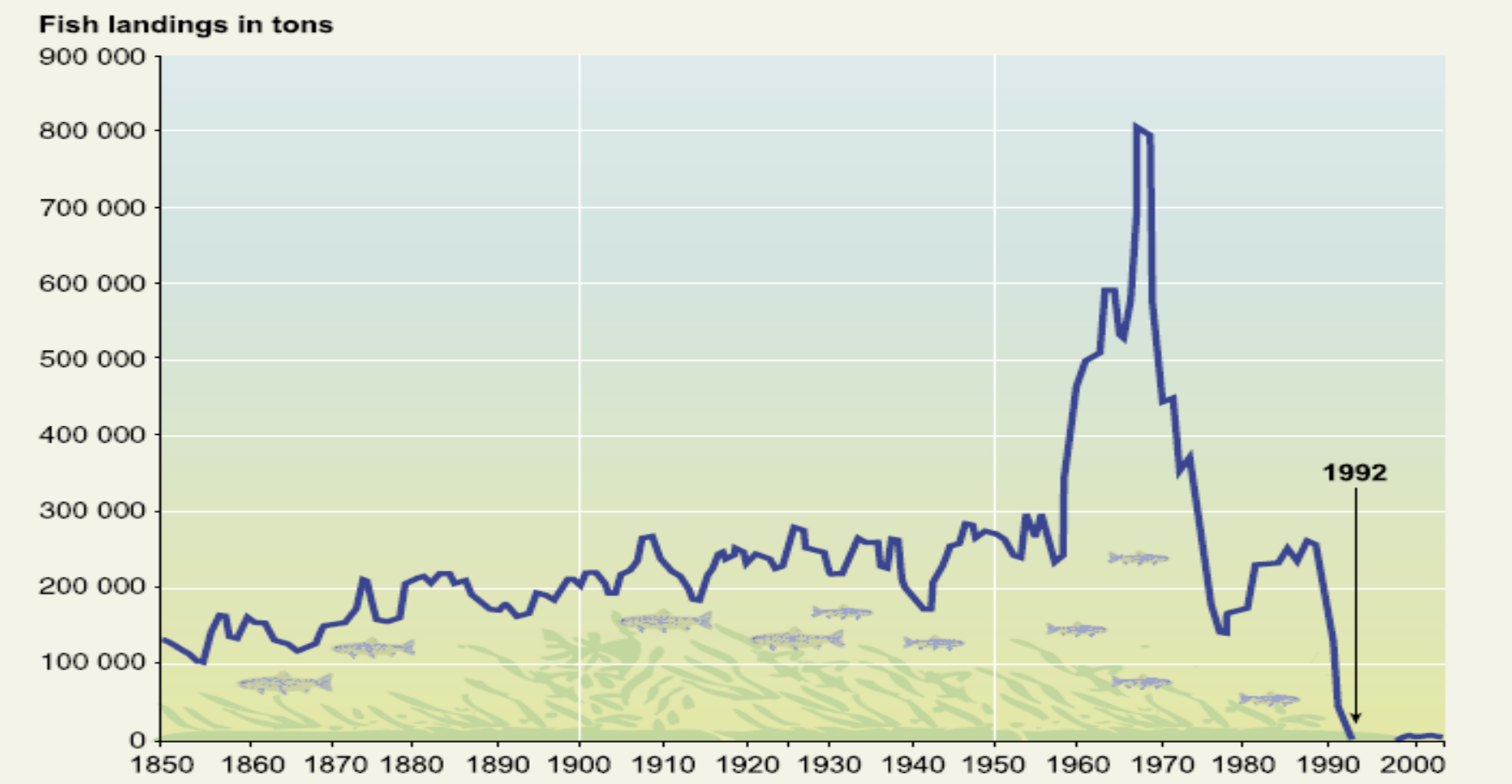
Source: United Nations Environment Program, UN Global Compact and Utopies, 2005
also, World Resources Institute (WRI)/Earthtrends, 2008

Biodiversity Loss Drivers

Economic activity and population density tend to be correlated with biodiversity loss and changes in ecosystem services specifically resulting in:

- Habitat change,
- Climate change,
- Invasive alien species,
- Overexploitation, and
- Pollution.

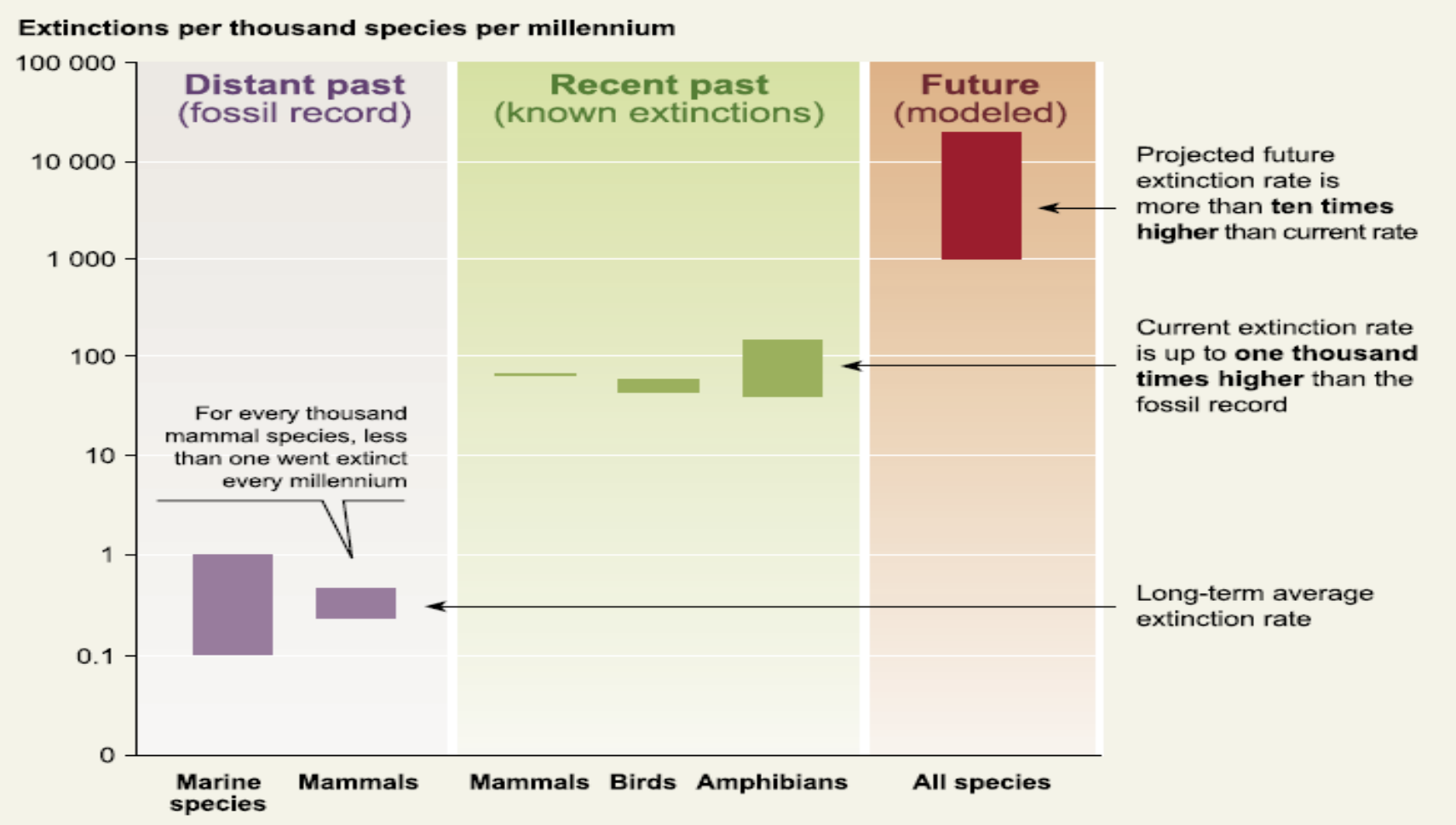
Overexploitation



Harvest of Atlantic Cod (1850-2003)

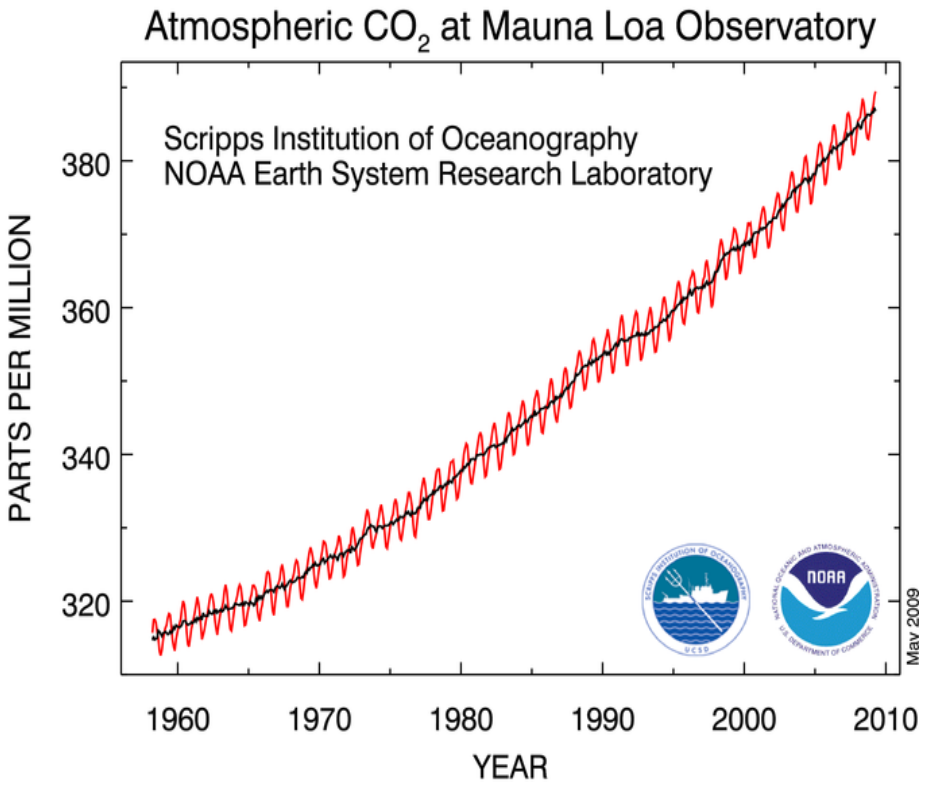
Source: Millennium Ecosystem Assessment

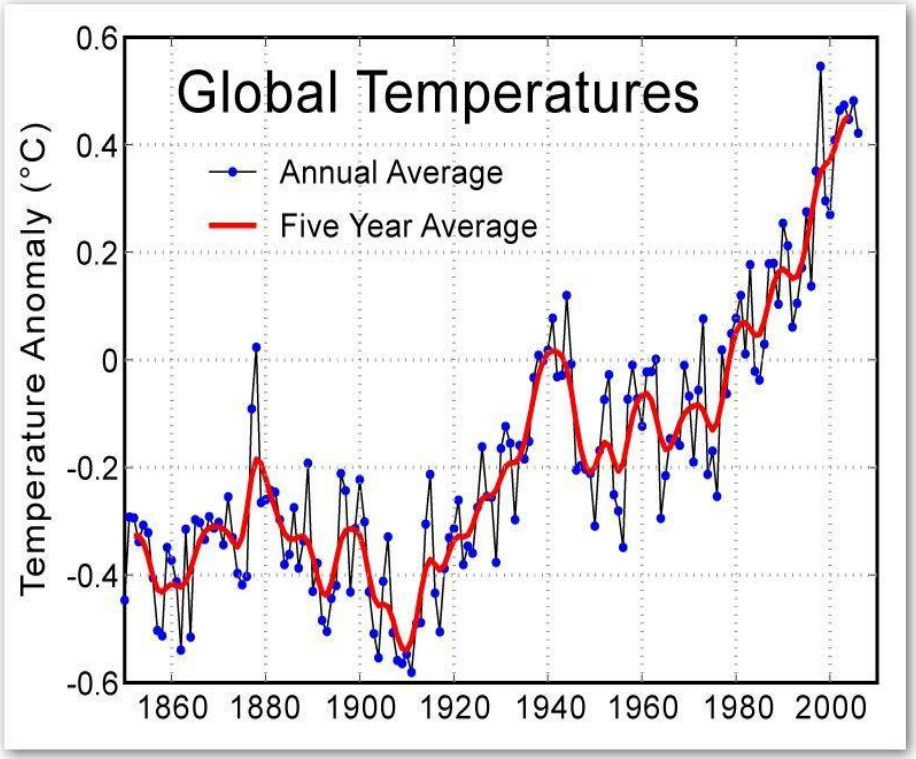
Unprecedented Extinction Rates



Source: Millennium Ecosystem Assessment

Climate Change

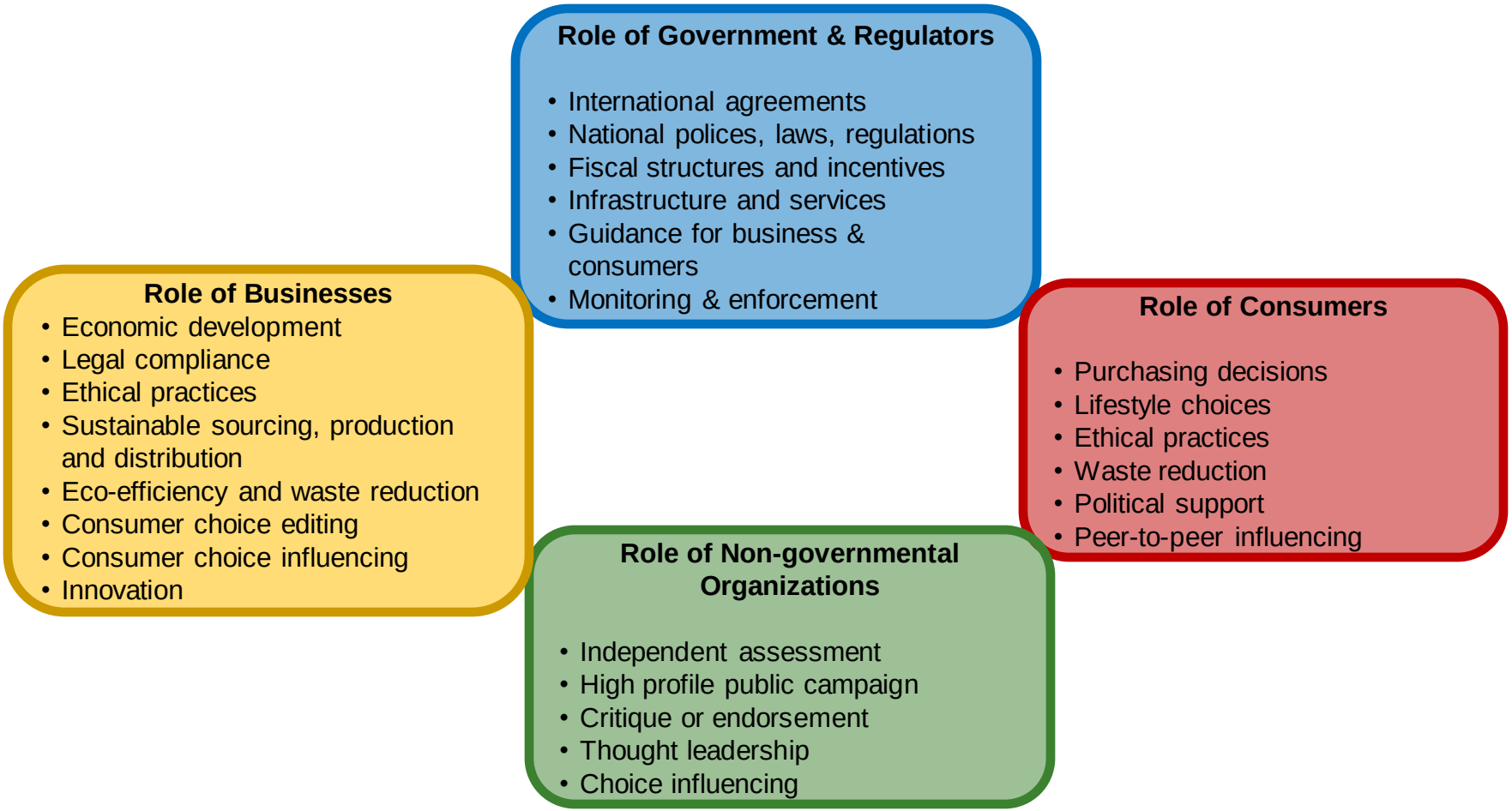




Coincidence or Correlation?

Source: http://www.theglobalwarmingoverview.com/index.php

Roles in Sustainable Consumption



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Course Evaluation

Exercise 2: “Countdown to Zero”



- The employee suggestions keep coming!
- Let’s help BE GREEN to continue to improve their Environmental Footprint by recommending which suggestions to implement!
- Each team will report on their:
  - Decision-making process,
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Social Responsibility



Providing for human well-being:

- Secure and adequate livelihoods;
- Health - feeling well; healthy physical environment;
- Social cohesion and ability to help others;
- Secure access to natural and other resources,
- Personal safety and security from natural and human-made disasters; and
- Freedom of choice and action.

Ecosystem Impact on Well-being

Changes to ecosystem services - Provisioning, Regulating, Cultural and Support - directly impact human well-being.

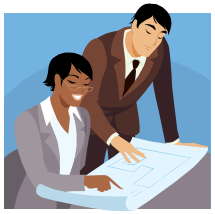


Direct change drivers include:

- Changes in local land use/cover;
- Species introduction or removal;
- Technology adaptation and use;
- External additives and inputs;
- Resource consumption;
- Climate change; and
- Natural, physical & biological events.

Value & Job Creation

- Leading companies rigorously pursue innovation to provide unique value to their customers.
- Harnessing knowledge and creativity of all employees means staying ahead of competition - growing and adding new, rewarding jobs.
- Suppliers and local community benefit as well.



Market & Product Requirement Analysis



Maintenance Refurbishment Reclamation

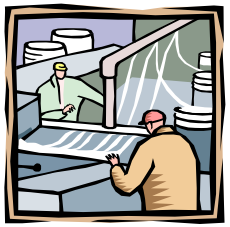


Distribution & Installation

Innovative Value Creation



Research, Development & Design

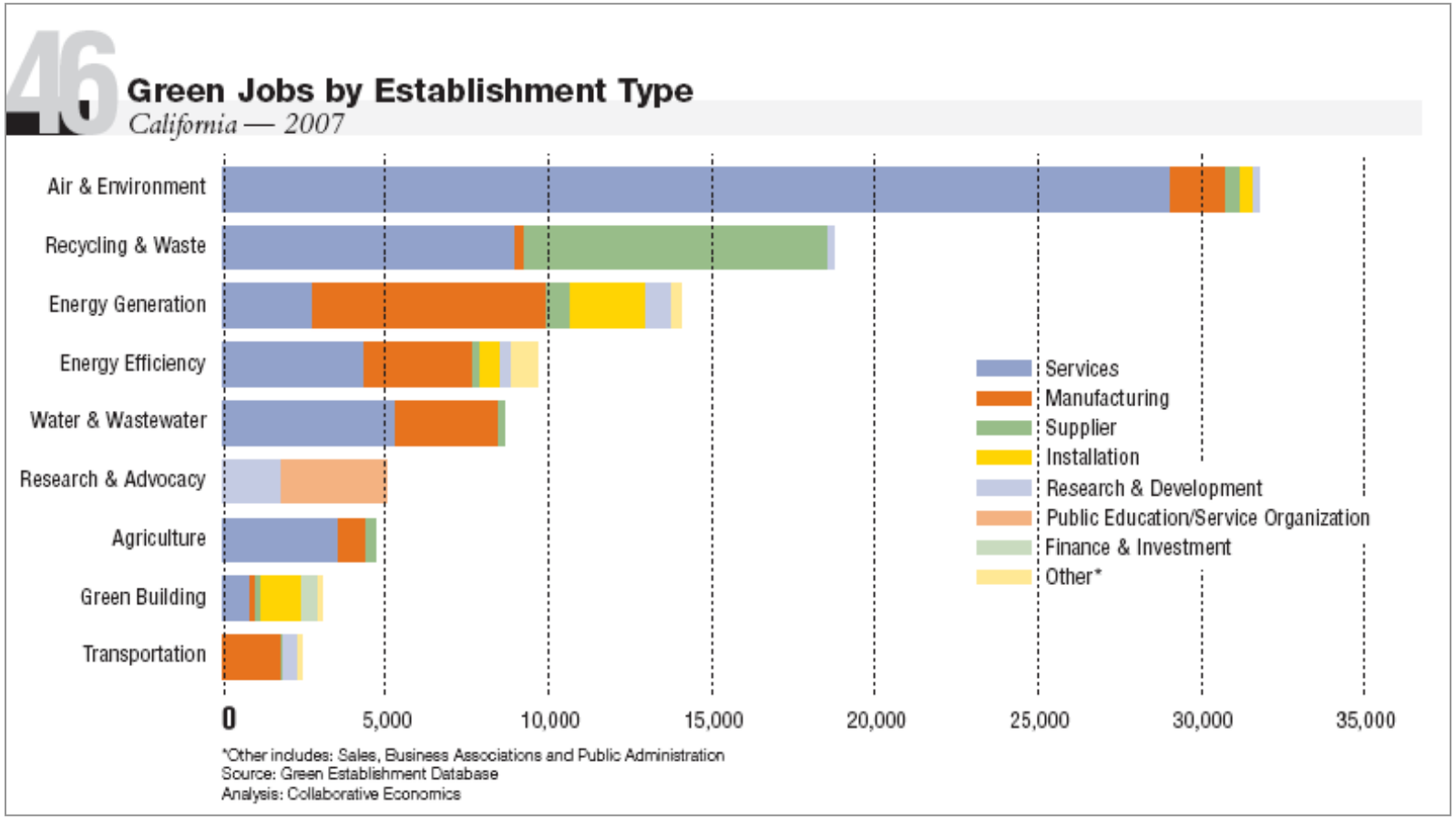


Production



Marketing & Sales

Green Jobs



As a sustainability leader, California's annual "green job" growth rate was 10% from 2005-2009. Total job growth was only 1% during same period.

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Course Evaluation

Exercise 3: “Countdown to Zero”



- The suggestions just get better and better!
- BE GREEN wants our input on which suggestions to continue their Countdown to Zero efforts!
- Each team will report on their:
  - Decision-making process,
  - Selections, and
  - Results (IITEs and Anticipated Savings)

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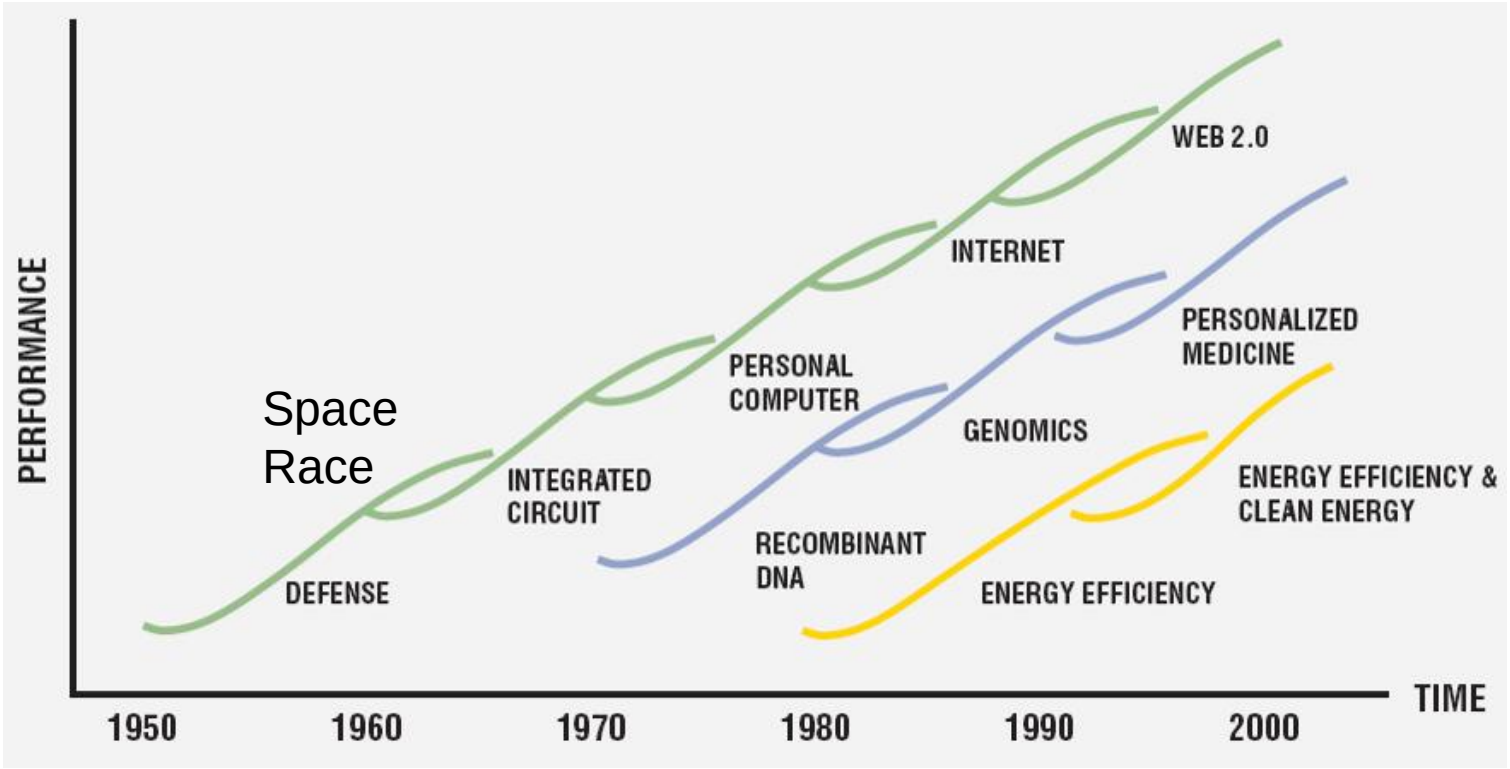
Innovation



Necessity is the mother of invention.

- Plato 360 BC

Waves of Innovation



- Beginning with the Space Race, we see 3 recent of waves of technology.
- What will the Sustainability wave include?

Next Wave: Sustainability

Some companies start small:

Whole Foods banning plastic shopping bags.



While other companies have their sights on much bigger things:

Honda's development of hydrogen-powered, zero-emissions vehicles.



Green Seeds of Innovation

- Green has become a platform for creating value around:



  - New product concepts,
  - Service strategies, and
  - Business models.

- Represents disruptive change in the marketplace.
- Referred to as “Green Hat” thinking!

Paradigm Shift

Old



Corporate Resident

- Me
- More
- Materialism
- Quantity
- Greed
- Short-term
- Rights



New

Corporate Community Partner

- We
- Enough
- Holism
- Quality
- Need
- Long-term
- Responsibilities



Innovation Investment & Returns

GE's 2008 Ecomagination Revenues to Rise 21 percent, Cross $17 Billion

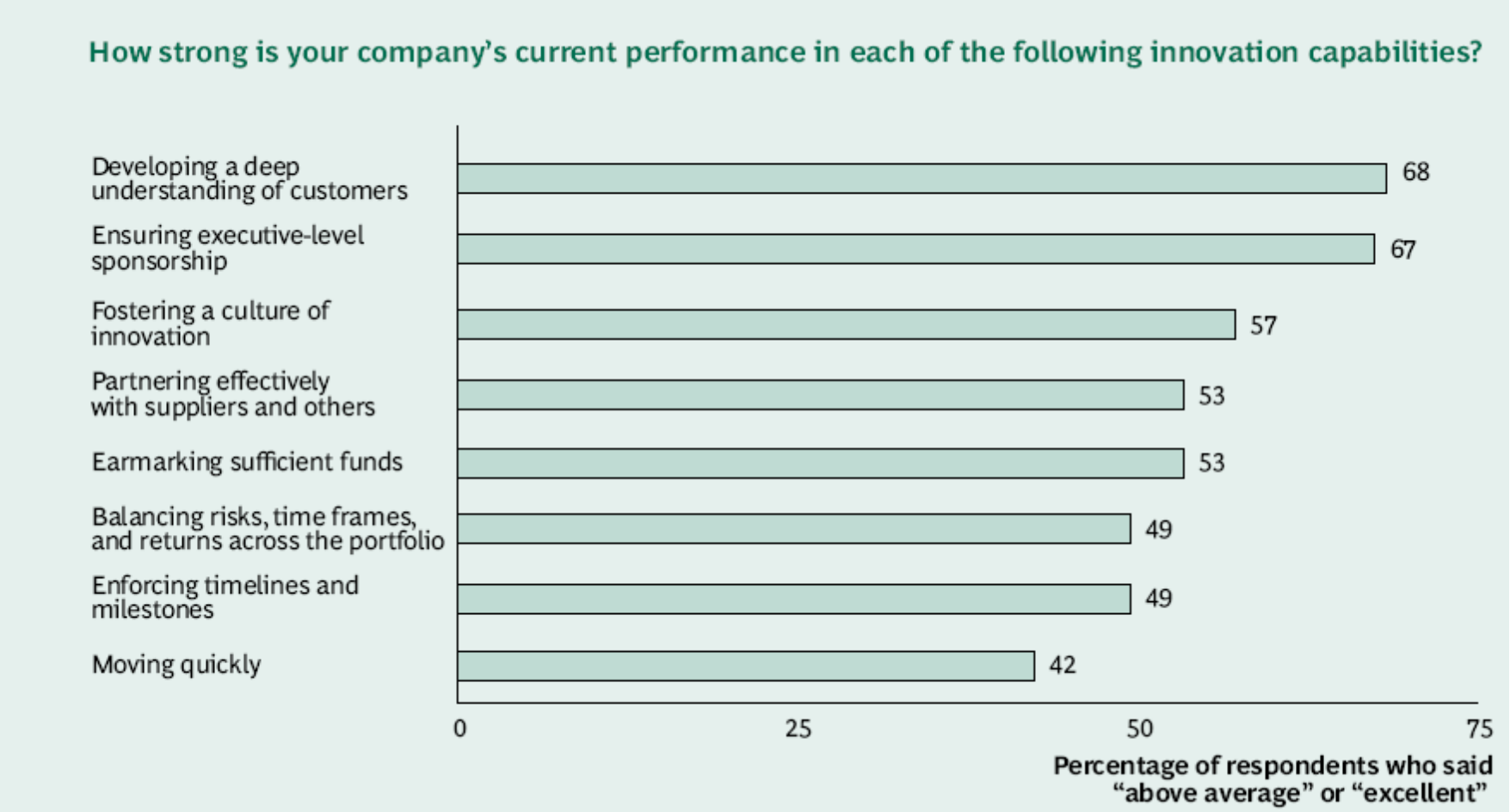
Annual Cleaner R&D Grows to $1.4 Billion
Total Energy Savings to Company of $100 Million

Fairfield, CT, October 21, 2008. GE today affirmed that, amidst global economic turbulence, revenues from its range of energy efficient and environmentally advantageous products and services will surge 21 percent to $17 billion in 2008, while GE's annual investment in cleaner research and development will pass $1.4 billion.



Why do you think GE invests so much in R & D?

Innovation Capabilities



Results from 2500 of the largest companies worldwide.

Source: BCG 2008 Senior Executive Innovation Survey

Course Agenda

Sustainability & Business Strategy

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Course Evaluation

Exercise 4: “Countdown to Zero”

You are all hired!!

- You’ve done such a great job advising BE GREEN on projects to implement, we’re making you official members of the BE GREEN Team!
- Independently, identify 1 or 2 innovative project ideas and the associated ROI and impacts.
- Share your ideas with the group.
- Let’s see what other ideas are triggered when we start thinking outside the box!

Integrated Resource Management

To transition to sustainable societies requires eco-design and eco-efficiency in all business aspects.



- Products
- Services
- Processes
- Materials and energy flows
- Facilities
- Business organizations/missions/strategies
- Non-governmental organization and grassroots strategies
- Inter-company and inter-stakeholder relations
- Community and regional planning and infrastructure
- Societal institutions and policies

Sustainable Thinking



- How can we act with creativity and rigor to design effective environmental, technical, economic, and social solutions at all of these levels?
- How do we know the right level of design for approaching a particular issue?
- How do we resolve conflicts across levels of design?
- How can we best evaluate alternative solutions?
- How do we maintain a coherent view of the whole system in order to manage design decisions well at any level?

Rethinking Your Business



- How could your organization go beyond improving efficiency to start to design with ecology in mind?

- If you were to redefine your business as one that provides services in closed-loop systems rather than a provider of products, what would that look like?
  - What would the costs and benefits be?
  - What would be the process for exploring this with some seriousness and who should be involved?

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Course Evaluation

PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM



Sustainability in Practice

Environmental Business Management

Purpose of This Module

- To provide an understanding of what it means to be a sustainable business and why it is important.
- To provide strategies for incorporating an overall sustainability mindset throughout your business.
- To identify implementable methods for your company to build a sustainability program and use it to drive business improvements.

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Course Evaluation

Green Business – All the Rage



Countless Case Studies

- Staples added $4.2 million to annual bottom line by changing light bulbs.
  - April, 2009 CFO.com

- Lockheed Martin switched to smart water management on its two 500-acre campuses in California's Silicon Valley, saving an annual estimated 126 million gallons of water, $1 million in water cost and avoiding property damage.
  - January, 2009 HydroPoint

- Subaru is one of a growing number of companies claiming or working toward "zero landfill" status. While success earns environmental bragging rights, reuse and recycling also cuts costs to the tune of millions of dollars a year.
  - February, 2008 USA Today

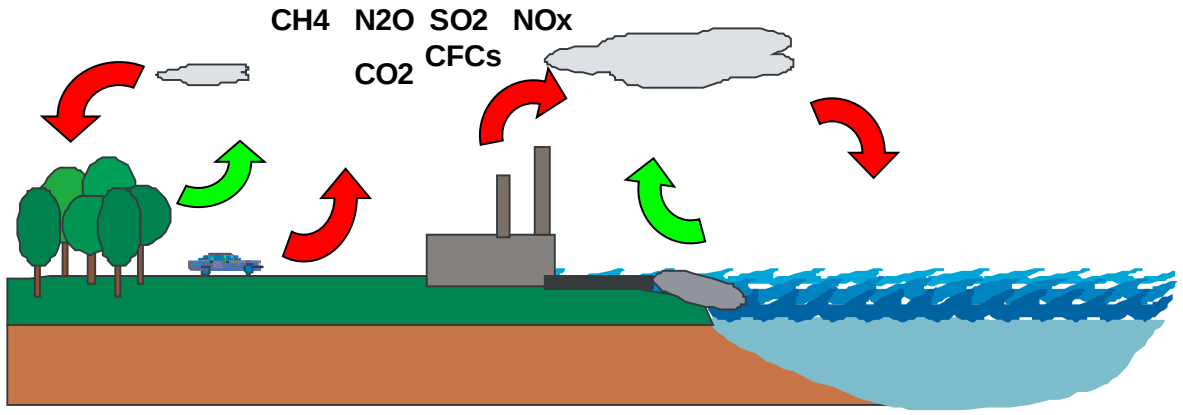
- Kohlberg Kravis Roberts & Co reduced 25,000 metric tons of greenhouse gas emission reductions and 650 tons of solid waste, which generated a $16 million reduction in operating costs.
  - April, 2009 CFO.com

Human Impact on Natural Capital

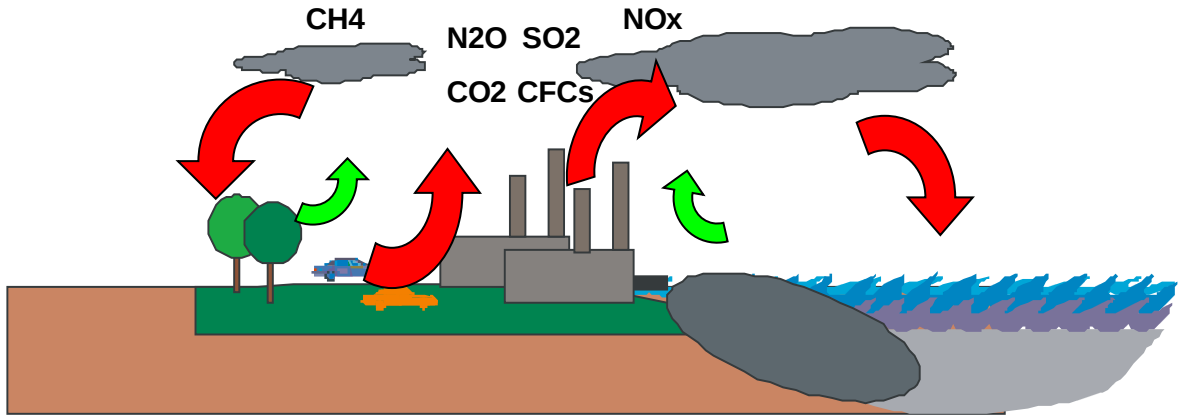


Environmental Damage

Past



Present



Natural processes can absorb some of the wastes generated by humans, but not all.

Carrying Capacity

- Number of living things that can exist for long periods in a given area without damaging the environment.
- Different for each species in a habitat because of their particular food, shelter, and social requirements.



Resource Scarcity

According to a 2008 *McKinsey Global Survey of Corporate Executives-*

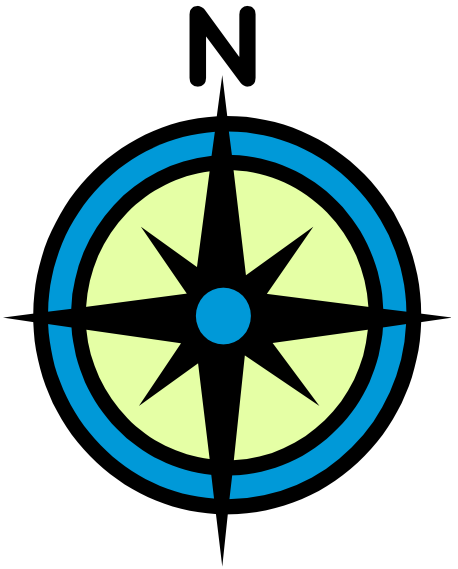
- "increasing constraints on supply or usage of natural resources" jumped from 7th to 2nd on list of important trends.
- 34% of CEOs believe resource constraints will affect profits in the next 5 years yet…
- Only 1/3 of those companies have taken action!

Sustainability



Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

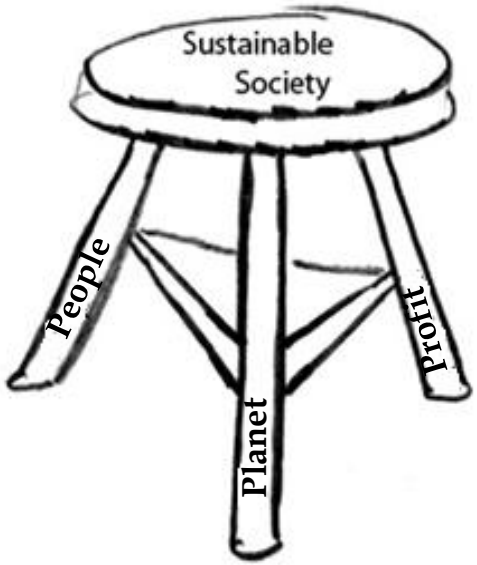
Strategic Planning



Stable companies have Strategic Plans spanning 1- 5 years.

A company with a vision of Sustainability should develop strategies extending *at least* 25 years into the future.

Why not 50 or 100 ye



How does Sustainability fit into your company's strategy?

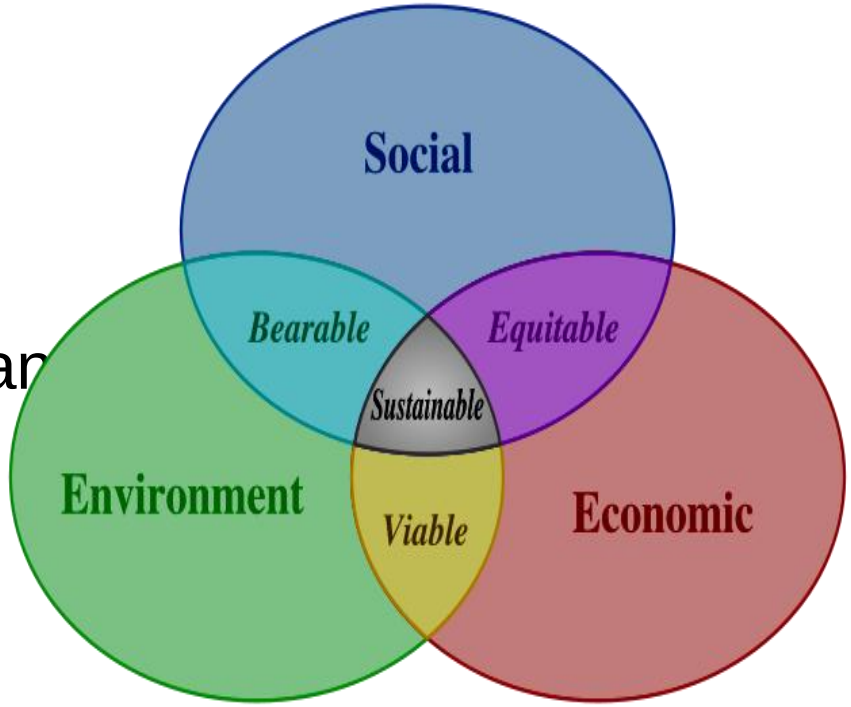
Triple Bottom Line

Profit (Economic)

- Improves efficiency & lowers costs
- Reduces regulatory compliance costs

Planet (Environmental)

- Reduces demand for resources an energy *from* nature
- Reduces waste *to* nature



People (Social)

- More resources and energy become available for others
- Closing the loop (cradle-to-cradle) generates new jobs

Executive Level Objectives

While our primary drivers may be Economic, Sustainability efforts must evaluate Environmental & Social impact as well.



Profit

Pe e

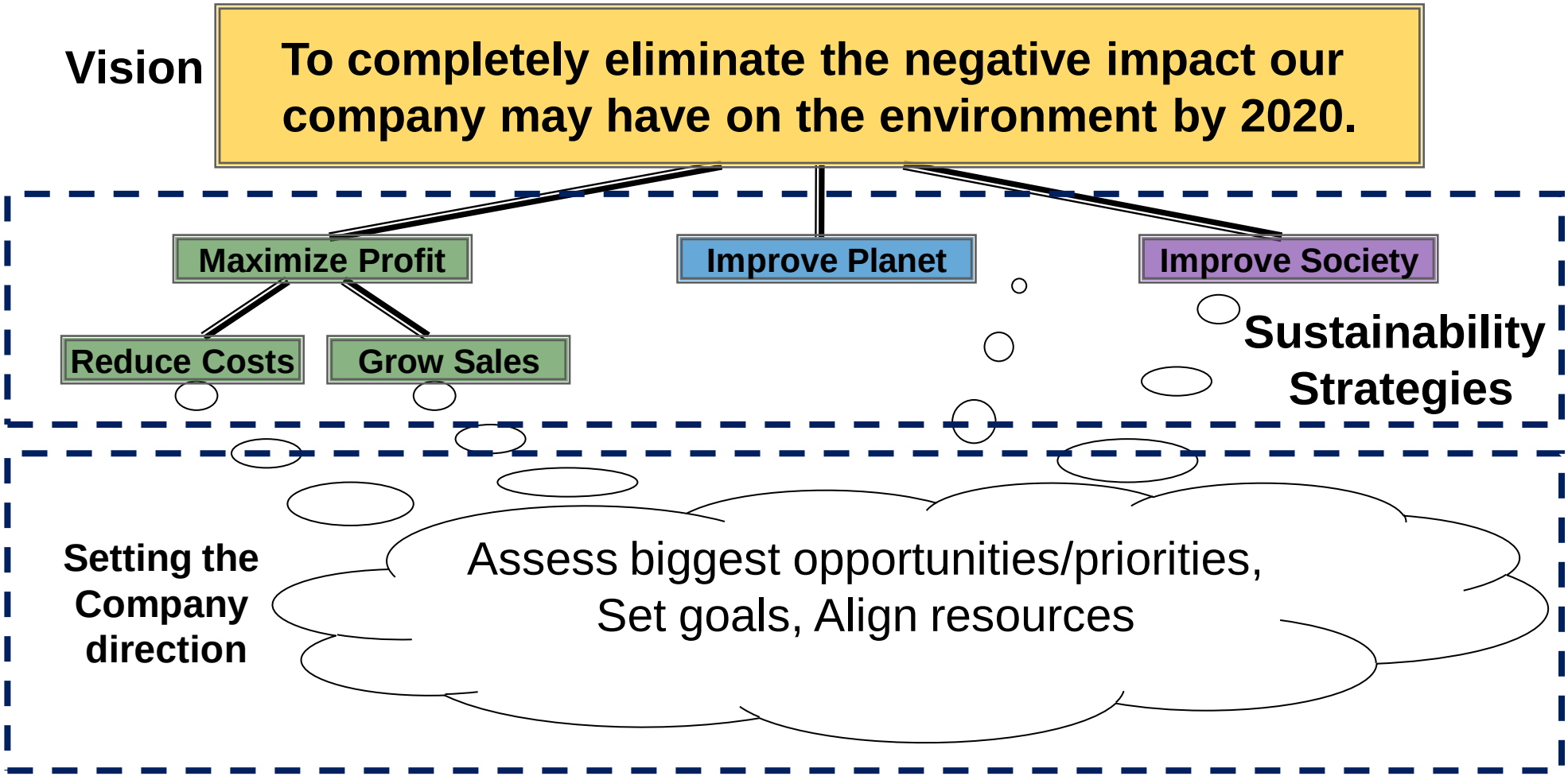


Planet



Resource Costs	Emissions/Pollution	Trusted Advocate
Waste Management Costs	Alternative Energy	Quality of Life
Operational Costs	Land/Natural Resources	Future Generations
Employee Effectiveness	Waste Exchange	Global Citizen
Product/Service Repositioning	Biodiversity	
Customer Satisfaction		

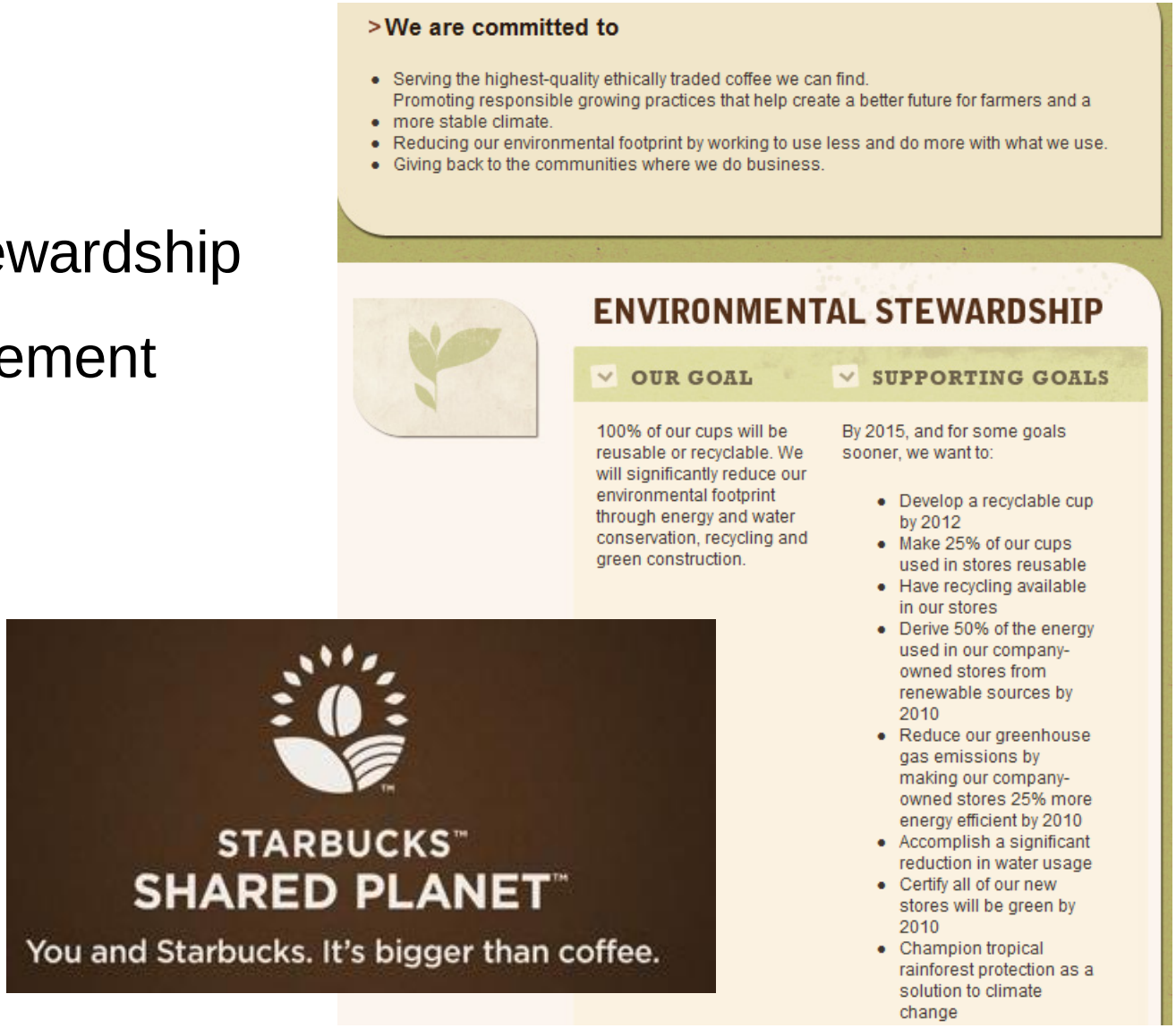
Sustainability Vision



Vision links to specific Strategies.
Then define priorities and goals for all organizational areas.

Starbucks Environmental Goals

- Ethical Sourcing
- Environmental Stewardship
- Community Involvement



Making Choices

- Assess technical feasibility
  - Get input from people who operate & maintain equipment
  - Availability of equipment / maintenance requirements
  - Necessary operating skills
  - Space availability
  - Impact on production / operational flexibility
  - Effect on product quality
- Analyze economic viability and payback
- Evaluate environmental advantage / consequences
- Consideration for safety & ergonomics
- Review impact on the community

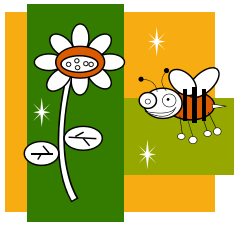
EnVi

Environmental Footprint



Get
Real
Effective
Environmental
Nu-Metrics

BE GREEN



- Get Real Effective Environmental Nu-Metrics (*GREEN*), a division of Buzz Electronics (*BE GREEN*!) produces solar-powered calculators for determining *Environmental Footprint*.

- Problem: Customers are requiring that *BE GREEN*, along with their entire supply chain, reduce their Environmental Footprint.

Environmental Footprint Calculator

- Triple Bottom Line Sustainability impact:

  Economic (Profit) Social (People) Environmental (Planet)





- Considering the five key resource/waste streams:

  Solids **Energy** **Air** **Water** **Chemicals**







Footprint Calculator Challenges

GREEN believes a simplified tracking method for Sustainability progress is important.

Challenges:

- What matters? What doesn't?
- How to measure?
- Are there any standards?
- Just one number?



EnVi Baseline



Start with a baseline of 500:

- uses resources without concern about replenishment or alternatives;
- generates waste streams that end up in landfills, waterways, and the ozone; and
- no focus on nature's cycle as part of standard operating practices.

Calculates in **IITE**s (**I**nvesting **I**n **T**he **E**nvironment)

Mission: “Countdown to Zero”



Our promise:

To completely eliminate the negative impact our company may have on the environment by 2020.

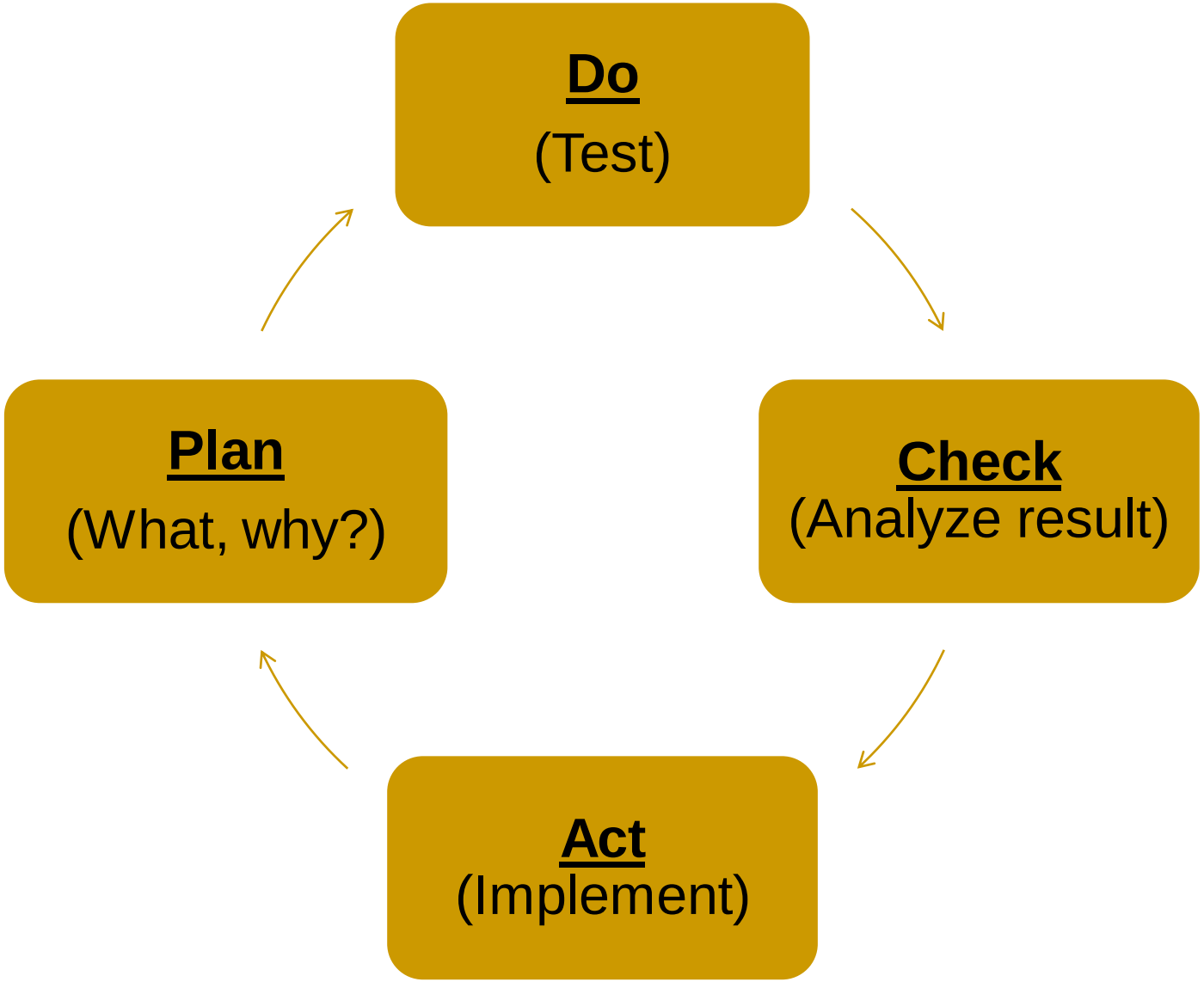
Sustainability Effort at *GREEN*

- Company recycling program for plastic, paper and aluminum, with color-coded recycling containers;
- E-waste recycling program;
- Energy-savings
  - light fixture and bulb replacement;
  - programmable thermostats and motion sensors, and
  - equipment power downs during unmanned periods.

Countdown to Zero

Project	IITEs Credit	EnVi Footprint
BASELINE		**500**
Recycling program	- 6 (2 per mat'l)	**= 494**
E-waste collection	- 6	**= 488**
Lighting improvements (new fixtures/bulbs)	- 12	**= 476**
Programmable thermostats/motion sensors	- 6	**= 470**
Motion sensors for lighting control	- 5	**= 465**
Powering down equipment	- 4	**= 461**
ANTICIPATED 1ST YEAR SAVINGS = $39,000		

Plan – Do – Check – Act (PDCA)



Problem Solving A3 Report

Date:

Theme:

Team Members:

Background:

Current Condition:

Goal/Target Conditon:

Root Cause:

Describe the problem-
Why?
Why?
Why?
Why?
Why?

Countermeasures:

Achieve Target Condition

Follow Up Actions:

Plan

Do

Check

Act

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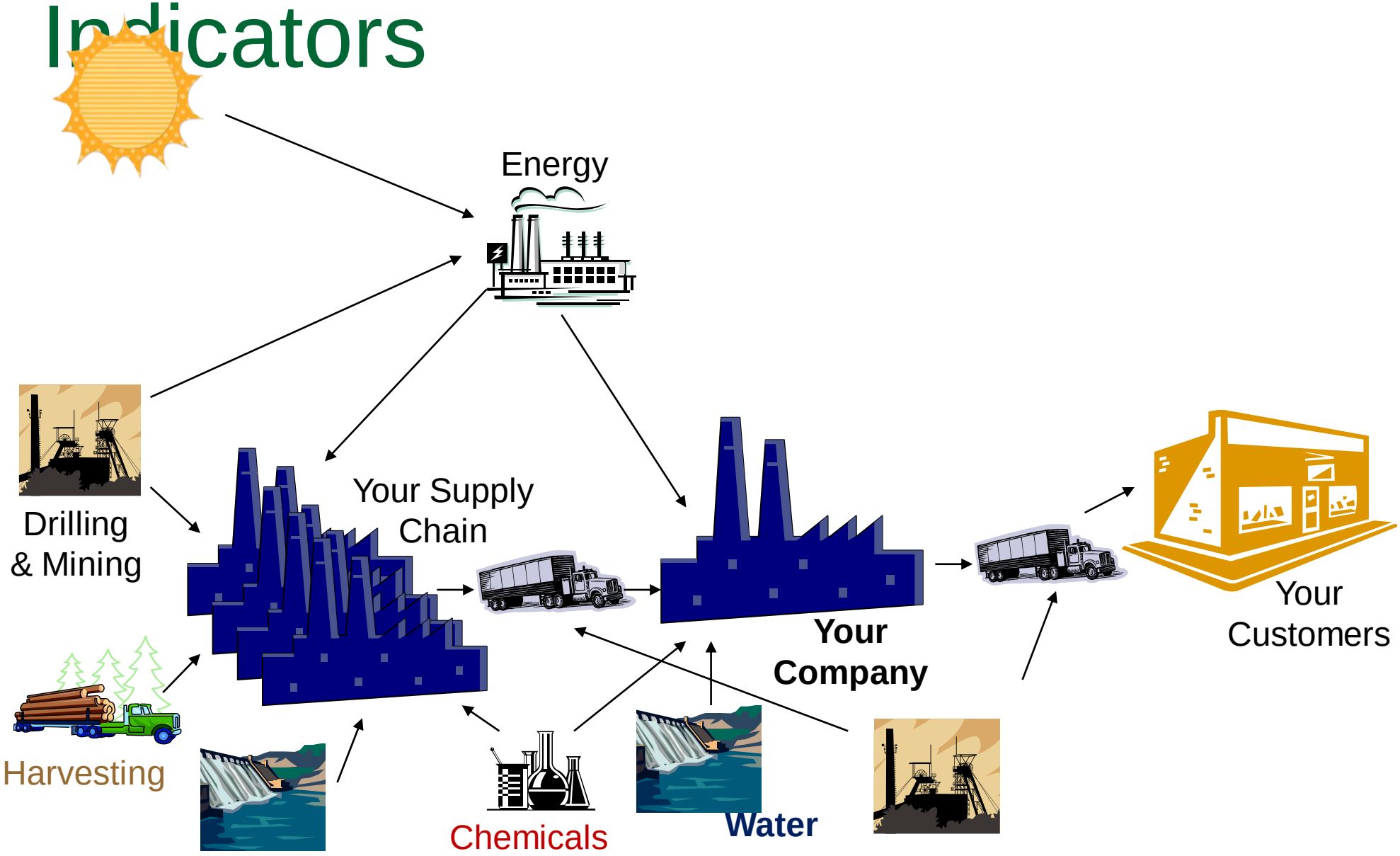
Environmental Footprint Exercise #3

Innovation as a Bridge to Sustainability

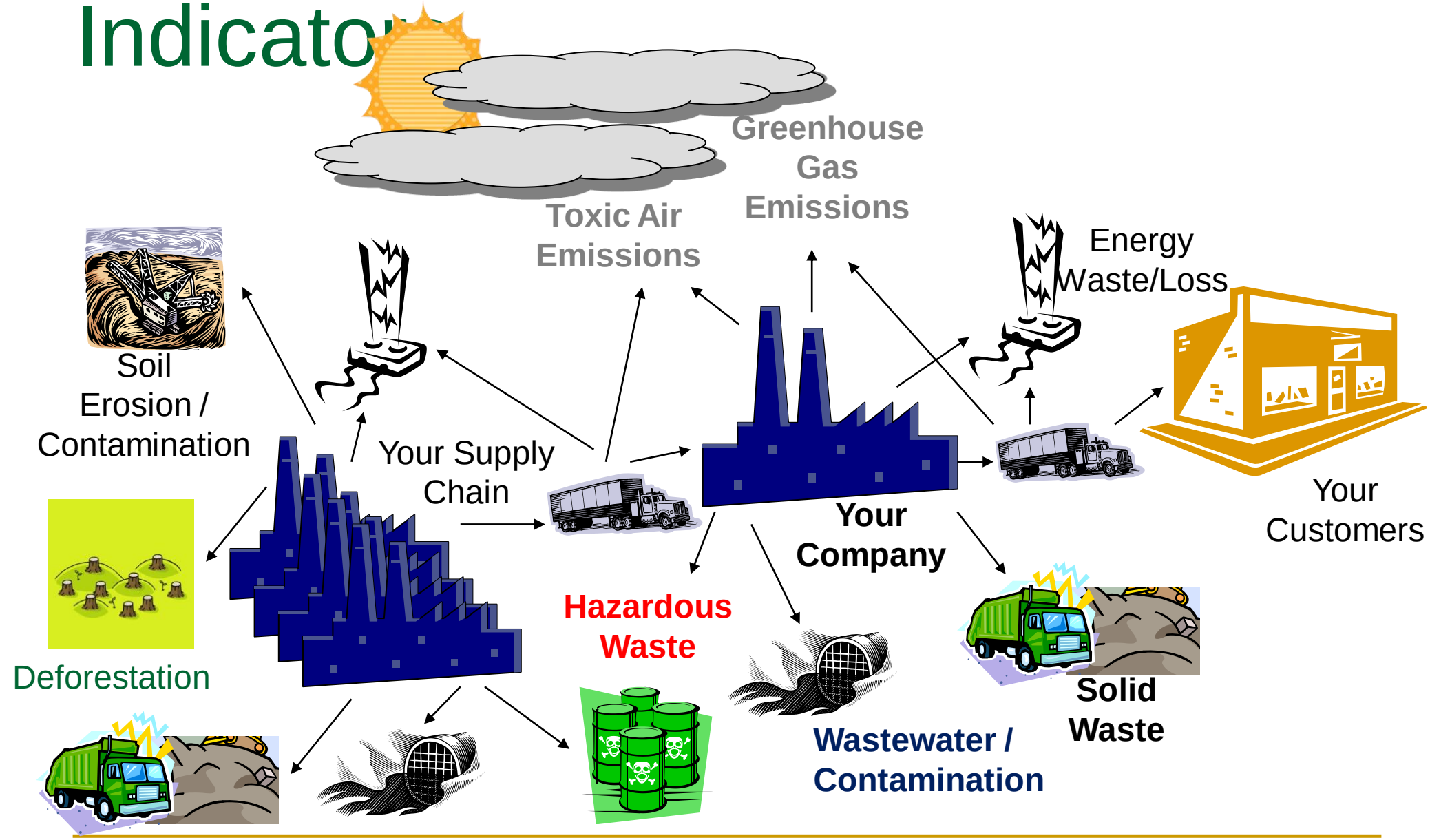
Environmental Footprint Exercise #4

Course Evaluation

System Inputs: Leading Indicators



System Outputs: Lagging Indicators



Leading & Lagging Indicators

Inputs

Leading Indicators

- Soil/Minerals
- Hazardous Chemicals
- Water
- Energy Resources
- Air Quality

Processes



Valued Output

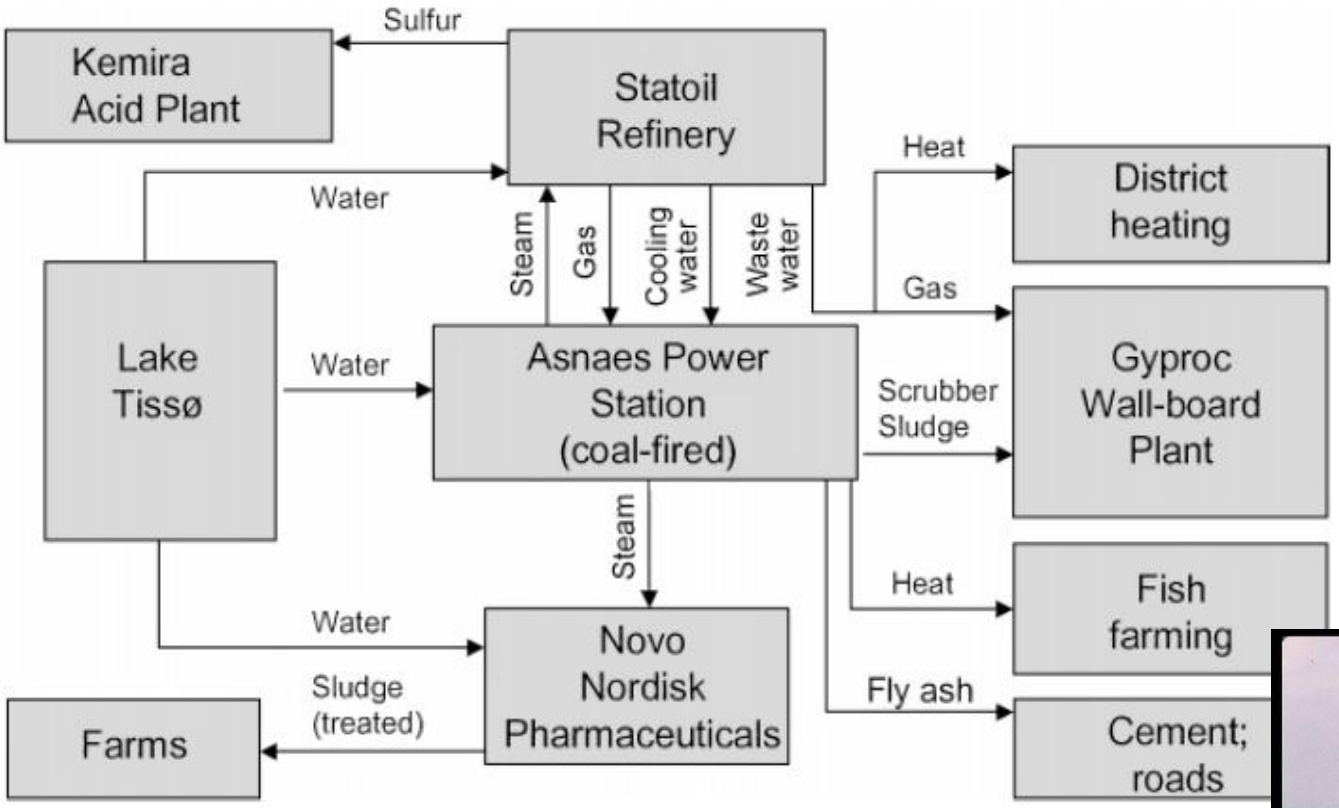
By-products

Lagging Indicators

- Wastewater
- Solid Waste
- Air Emissions
- Hazardous Waste
- Energy Waste

Prioritize improvement plans by measuring and evaluating Leading and Lagging Indicators.

Pursuing Zero Net Waste



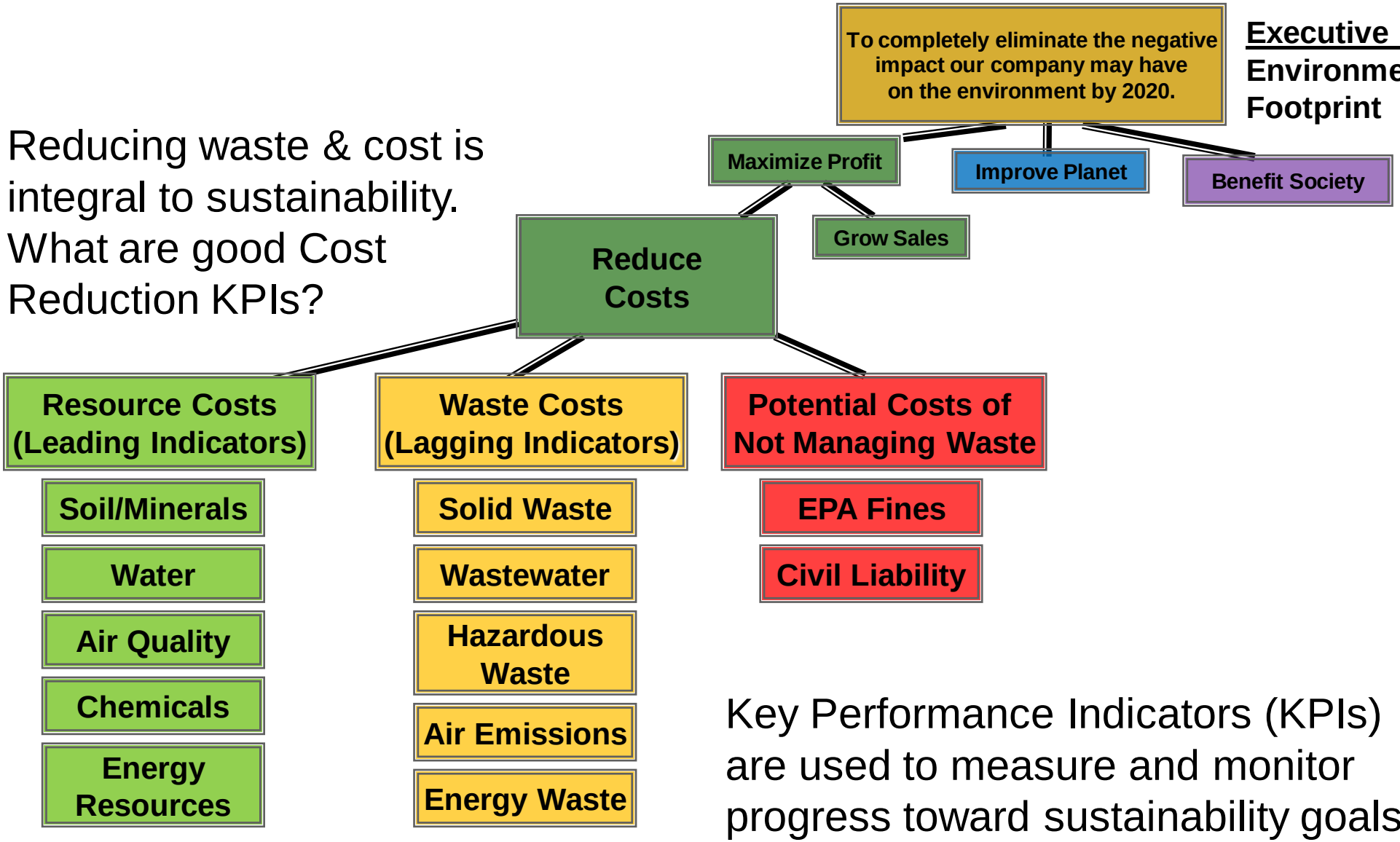
Industrial symbiosis at Kalundborg



Is there waste generated by your company that could be a valuable resource to another organization?

Key Performance Indicators (KPIs)

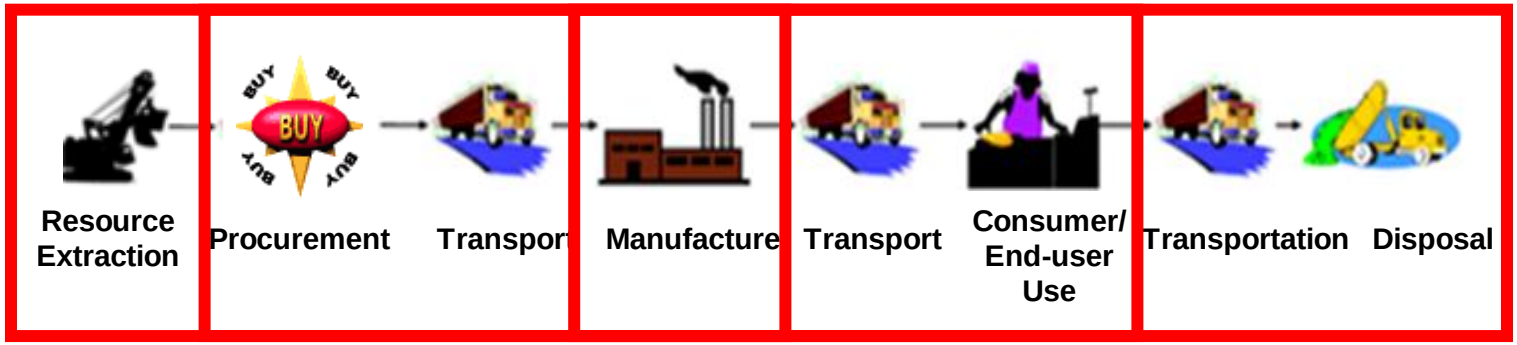
Reducing waste & cost is integral to sustainability. What are good Cost Reduction KPIs?



Key Performance Indicators (KPIs) are used to measure and monitor progress toward sustainability goals.

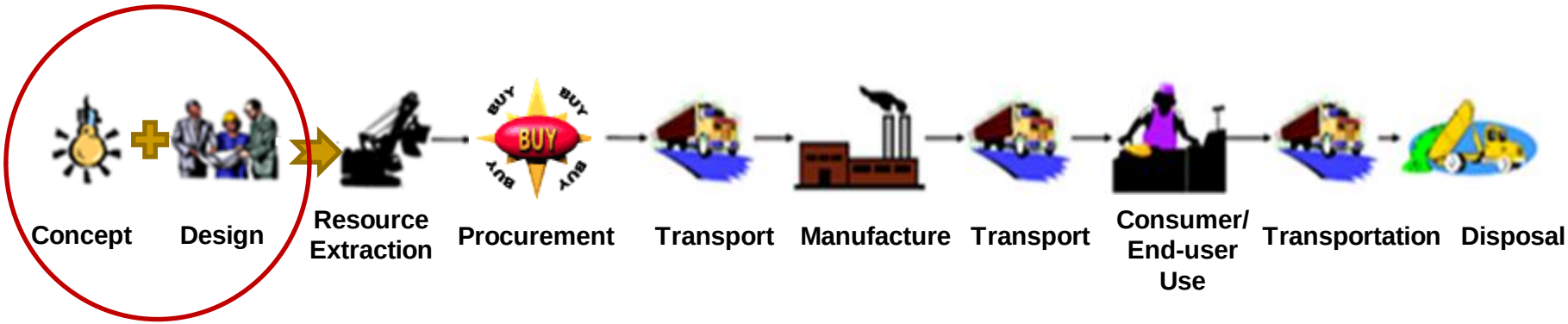
Sustainability Scope

How much control or influence do we have in regard to environmental costs – especially beyond our walls?



- Lifecycle supply chain: from resource extraction through end-of-life disposal.
- Looking for a win-win throughout the supply chain.

Begins with Concept & Design



Lifecycle considerations begin during the Concept and Design stages for both *products* and *processes*.

Sustainability Standards



Standards are needed to evaluate:

- Product Design
  - Durability / Reliability
  - Selection of materials / chemicals
  - Repair ease and feasibility
  - Disassembly / Disposal / End-of-life alternatives
- Production/Processing options
- Supplier selection and management
- Packaging design
- Logistics

Product Design



Design products that are optimally:

- Durable and difficult to damage;
- Lightweight / minimal materials;
- Made of recyclable or biodegradable materials;
- Modular / Standardized;
- Easily reconditioned, repaired and/or reused;
- Made of recycled or environmentally-benign materials.

Potential KPIs:

- % Recycled material
- % Recyclable material
- % of Product that can be reused / reconditioned
- % Product weight reduction
- Durability test results

Production Options



Production considerations:

- Resource needs
- Waste produced
- Reclamation and reuse
- Process / Equipment reliability
- Proven existing technology vs. Innovation needs
- Lower cost & impact to make internal vs. outsource
- Repair / Recondition preference

Potential KPIs:

- Total Carbon Footprint per unit of finished goods (f/g)
- Solid and/or Hazardous Waste weight per unit of f/g
- Waste treatment per unit of f/g
- Operating Equipment Effectiveness (OEE)
- % Material reclaimed/reused

Green Packaging



Key considerations:

- Materials, adhesives, fasteners & inks
- Minimize material used in design
- Recycled, recyclable, non-toxic & biodegradable
- Returnable, reusable, nesting design when empty
- Minimize overall volume to reduce transportation weight

Potential KPIs:

- Product to Packaging ratio
- % of Recycled Content
- % Recyclable Content
- % Returned / Reused
- % Packaging weight reduction

Green Transport



Key factors:

- Maintain equipment
- Driver/Dispatcher education
- Avoid rush hour scheduling/routing
- Transport alternatives, e.g., rail
- Maximize volume / minimize empty miles – consider partnerships
- Hybrids / right-sizing
- Revised incentives
  - less miles with higher MPG
  - shut-down vs. engine idling

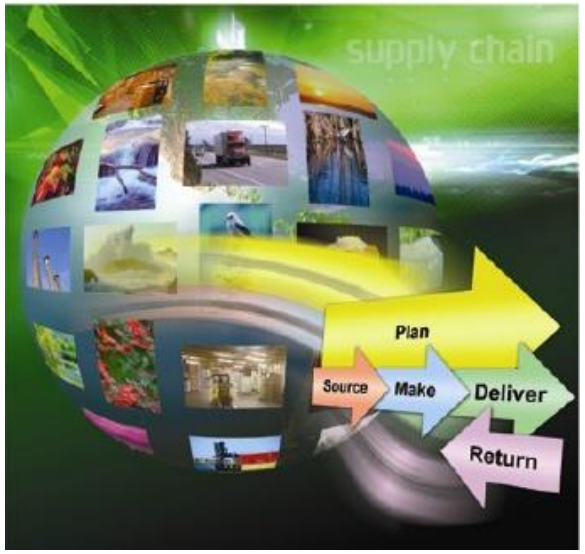
Potential KPIs:

- Miles per gallon
- Miles logged per pounds of freight
- Empty miles logged per sales dollar

Green Supplier Management

Evaluating current / potential suppliers:

- Environmental Management System (EMS) review / certification
- Appropriate licensing / permitting
- Recognized achievements
- Sustainability culture
- Measurement of Environmental Footprint
- Distance to minimize transportation



Potential KPIs:

- % of Suppliers with verified EMS
- % of Suppliers who are local
- Average Supplier Environmental Footprint

Green Buildings

The U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) certification program promotes making buildings as Green as they can be.

The USGBC's members include practitioners along every point of the architectural and construction value chain – from designers and furniture makers to architects and raw material suppliers – all providing specific areas of expertise.



Regulatory & Litigation Risks

APRIL 23, 2009

EPA Reinstates Stricter Toxic Substances Reporting Requirements

The U.S. Environmental Protection Agency (EPA) has reinstated stricter reporting requirements, under the directi President Obama, for industria facilities that release toxic subs threaten human health and the

Press Release

Groups Plan Lawsuit to Force Cleanup of Air Pollution in National Parks

Legal notice charges illegal delays in cleaning up parks' haze pollution

June 25, 2008

Washington, DC -- As summer vacation season enters full swing, clean air advocates are fighting to make sure visitors to national parks can enjoy scenic vistas free of the yellowish haze caused by industrial pollution.

The 1977 Clean Air Act set a national goal of cleaning up dirty air in major national parks and wilderness areas. Decades later, only a small handful of states have submitted legally required plans to comply. The result: power plant and factory emissions continue to obscure views of beloved landmarks in national parks across the country including Shenandoah, Great Smoky Mountains, Glacier, Big Bend, Acadia, Sequoia, and Yosemite.

The nonprofit environmental law firm Earthjustice today filed formal legal notice of intent to sue on behalf of Environmental Defense Fund and National Parks Conservation Association over the U.S. Environmental Protection Agency's failure to enforce deadlines for the states to adopt these clean air plans.

EPA Levies $3.1 million In Fines In Northwest For 2008

BY ROB MANNING

Portland, OR December 5, 2008 11:25 a.m.

The federal government levied more than $3 million in fines on Northwest companies, state agencies, and cities over the past year. Pete Springer reports. Region ten of the Environmental Protection Agency covers Oregon, Washington, Idaho, and Alaska. EPA compliance and enforcement director Mike Bussell says the EPA worked closely with agencies in those states to inspect a number of sectors. Mike Bussell: "Everything from mining operations all the way to municipalities that are struggling to keep their sewage treatment facilities in compliance. So it's a broad range."

Environmental Management System

- Environmental Management Systems (EMS) provide a foundation for compliance and continuous improvement.
- ISO 14001 and other standards / guidelines are available from government agencies and industry groups.
- Potential benefits of implementation:
  - Drive improvements;
  - Opportunities for new customers & markets;
  - Enhance public image
  - Managing risk of non-compliance and/or litigation.

Course Agenda

Sustainability & Business Strategy

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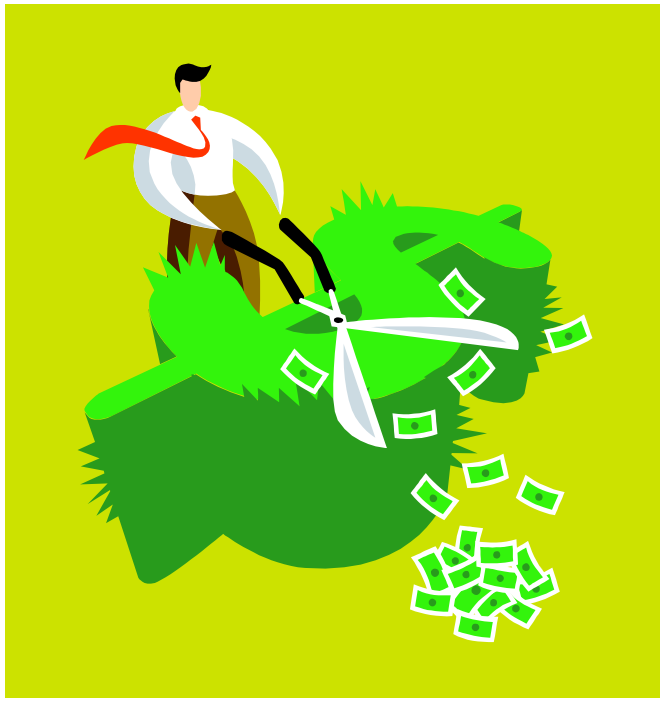
Environmental Footprint Exercise #3

Innovation as a Bridge to Sustainability

Environmental Footprint Exercise #4

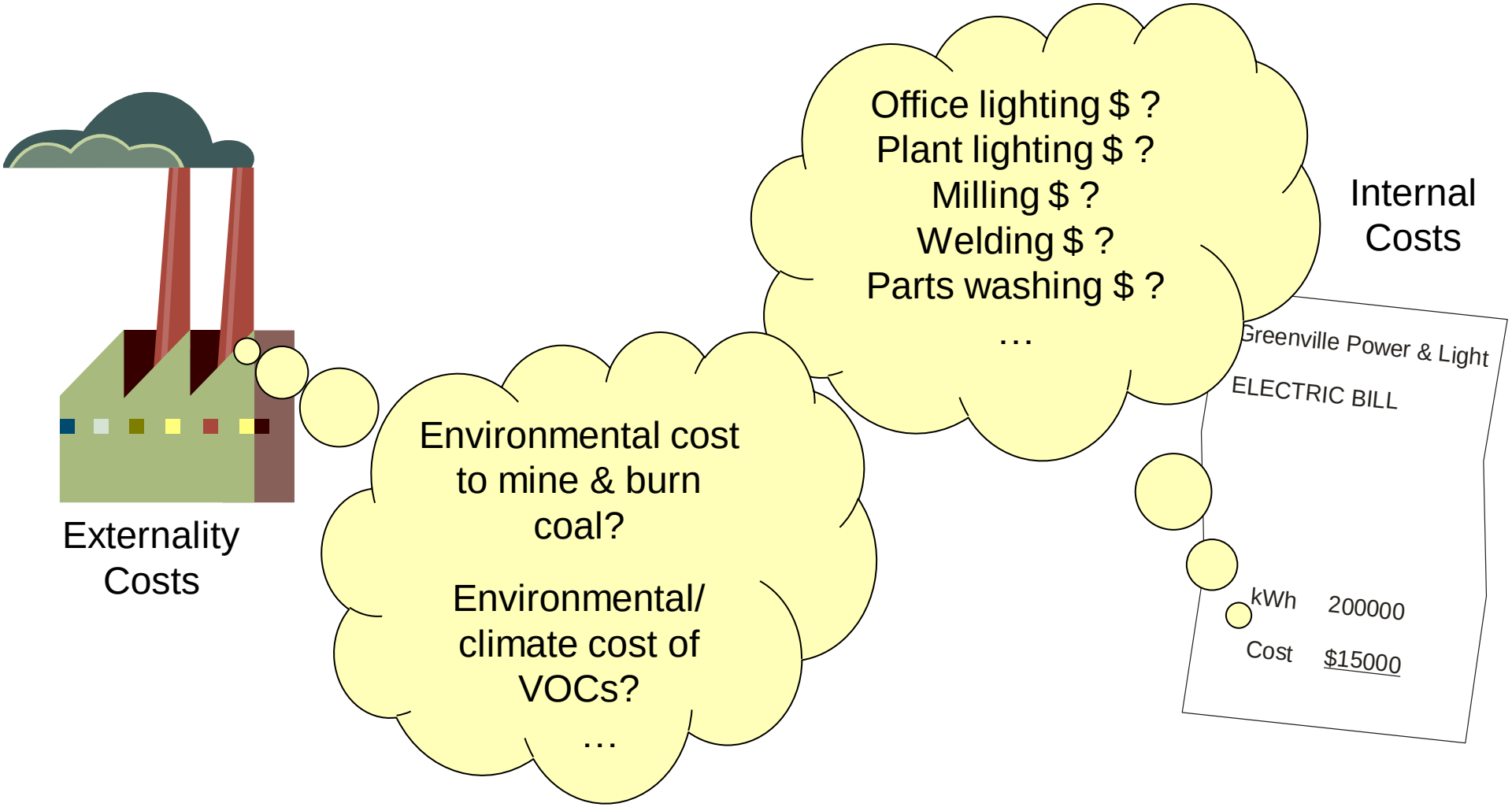
Course Evaluation

Bottom Line Impact



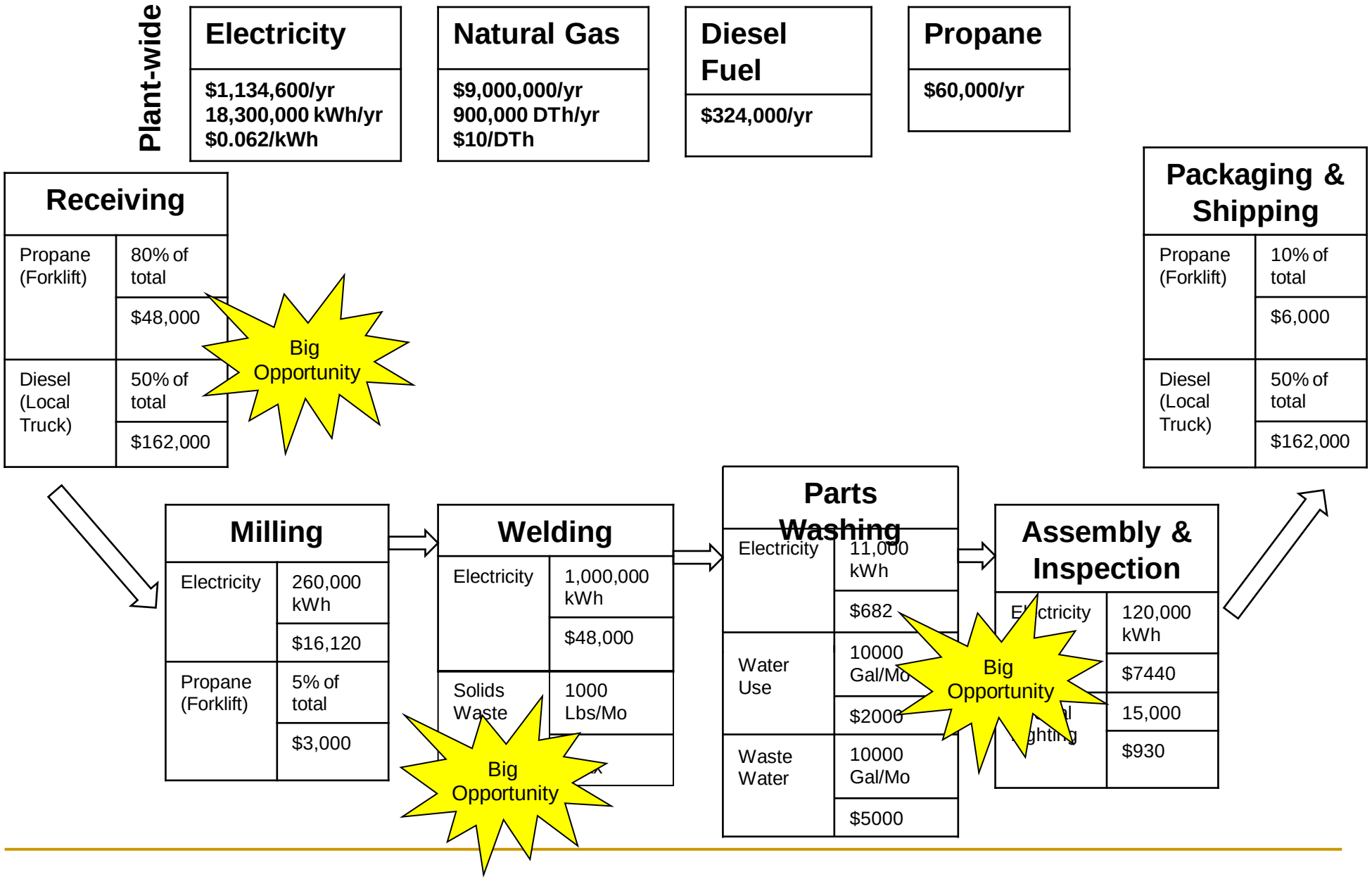
- Eliminate waste disposal costs;
- Decrease waste treatment costs;
- Lower energy costs;
- Reduce storage costs;
- Save on materials, chemicals and supplies;
- Improve transportation efficiencies and costs;
- Cut regulatory compliance costs;
- People costs, e.g., turnover, exposure.

Accounting Cost Picture



Standard accounting reports do not capture all details related to sustainability costs – especially externality costs.

Seeing Costs - Waste Stream Map



Product Certifications



Founded in 1989, Green Seal is one of the most recognized certifications in the consumer marketplace.

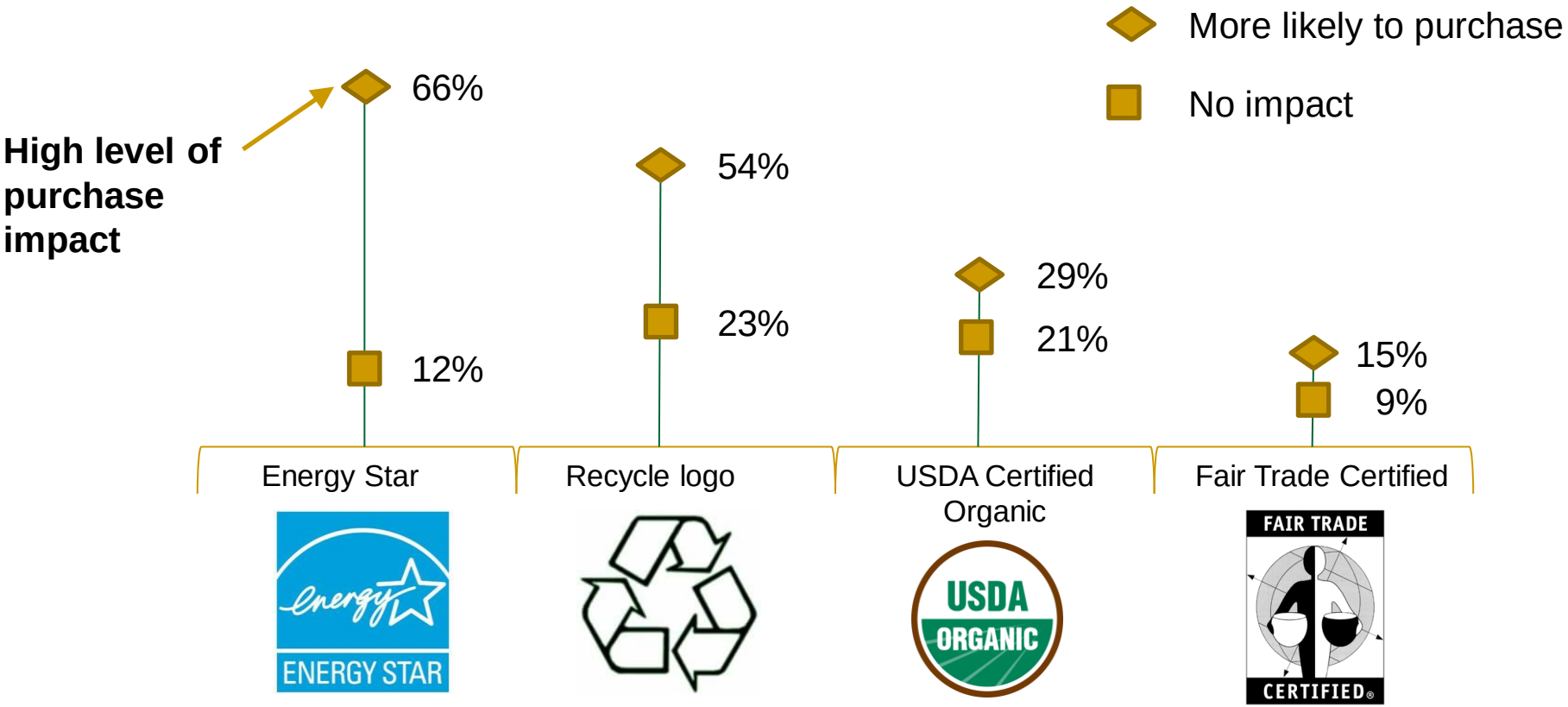
FSC coordinates development of forest management standards. Products bearing the FSC logo guarantee that the wood it is made from came from a certified well-managed forest.



Green Recognition

Green labels positively impact purchase behavior.

% General population indicating the impact of label/certifications on product/service choices



Source: National Marketing Institute

Consumer Behavior is Changing

82 Percent of Consumers Buying Green Despite Battered Economy

Green Seal and EnviroMedia Social Marketing release 2009 National Green Buying research

(PORTLAND, Ore.)—Four out of five people say they are still buying green products and services today—which sometimes cost more—even in the midst of a U.S. recession.

A new study commissioned by Green Seal and EnviroMedia Social Marketing and conducted by Opinion Research Corporation reveals peoples' opinions and behaviors about products that claim to be environmentally friendly.

Addressing consumer concerns about climate change

Businesses must act on global warming and other issues to narrow a general trust gap between them and the public.

MARCH 2008 • Sheila M. J. Bonini, Greg Hintz, and Lenny T. Mendonca



In This Article

Business executives are catching up with consumers in expressing concern about global warming and other environmental issues, two global surveys indicate. [1] In a sea change over the past 12 months, executives now regard the environment as the sociopolitical issue that will attract the most attention, by far, from the public and politicians over the next five years.

CONSUMER INTEREST IN ENVIRONMENTAL PURCHASING NOT ECLIPSED BY POOR ECONOMY

More than one-third of consumers more likely to buy environmentally responsible products today

BOSTON (February 18, 2009) – Despite the dire state of the economy, 34 percent of American consumers indicate they are *more likely* to buy environmentally responsible products today, and another 44 percent indicate their environmental shopping habits *have not changed* as a result of the economy. Fewer than one-in-10 (8 percent) say they are *less likely* to buy. This is according to the results of the **2009 Cone Consumer Environmental Survey** released today.

Even amid the recession, American interest in the environment has not waned, and as a result, many consumers are inclined to hold companies accountable for their environmental commitments today and in the future:

· 35 percent of Americans have higher interest in the environment today than they did one year ago;

· 35 percent of Americans have higher expectations for companies to make and sell environmentally responsible products and services during the economic downturn; and,

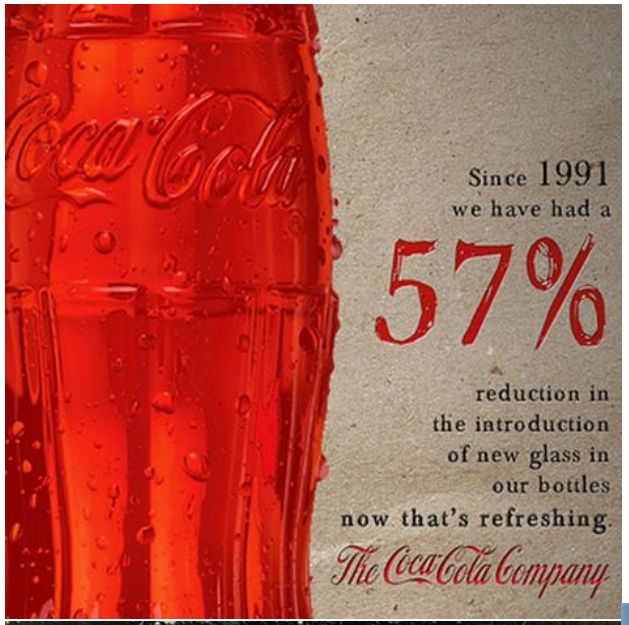
· 70 percent of Americans indicate that they are paying attention to what companies are doing with regard to the environment today, even if they cannot buy until the future.

Consumer Actions & Indicators



Source: BCG Global Green Consumer Survey, 2008

Green Marketing











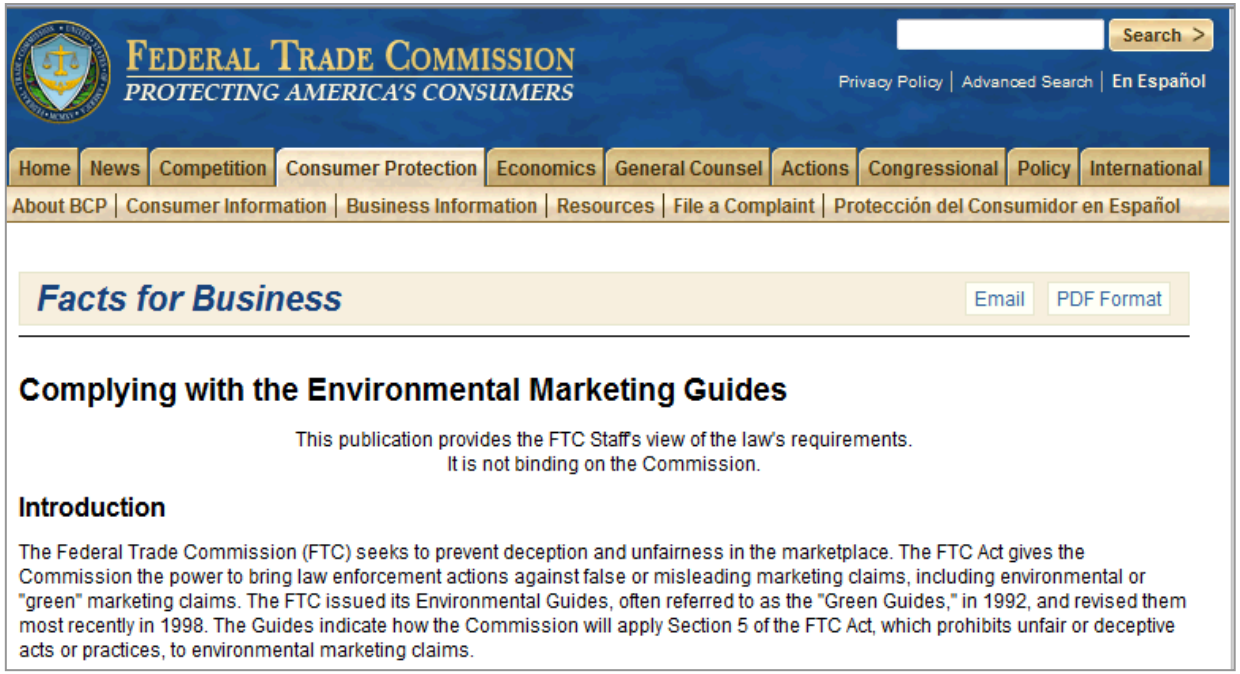




Green Marketing vs. Greenwashing

The Federal Trade Commission (FTC) enforces Environmental Marketing Guides:

- Biodegradable
- Recycled content
- Recyclable
- Refillable
- Source reduction
- Ozone-friendly
- Non-toxic



Scientific evidence from objective, competent parties is requirement for proof of marketing claims.

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Environmental Footprint Exercise #4

Course Evaluation

Exercise 1: “Countdown to Zero”



- *BE GREEN* wants the best EnVi score they can get!
- We’re going to help *BE GREEN* to improve their Environmental Footprint by recommending which suggestions to implement!
- Each team will report on their:
  - Decision-making process,
  - Selections, and
  - Results (IITEs and Anticipated Savings)

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Ecosystem Services



An intact ecosystem provides for our economy with:

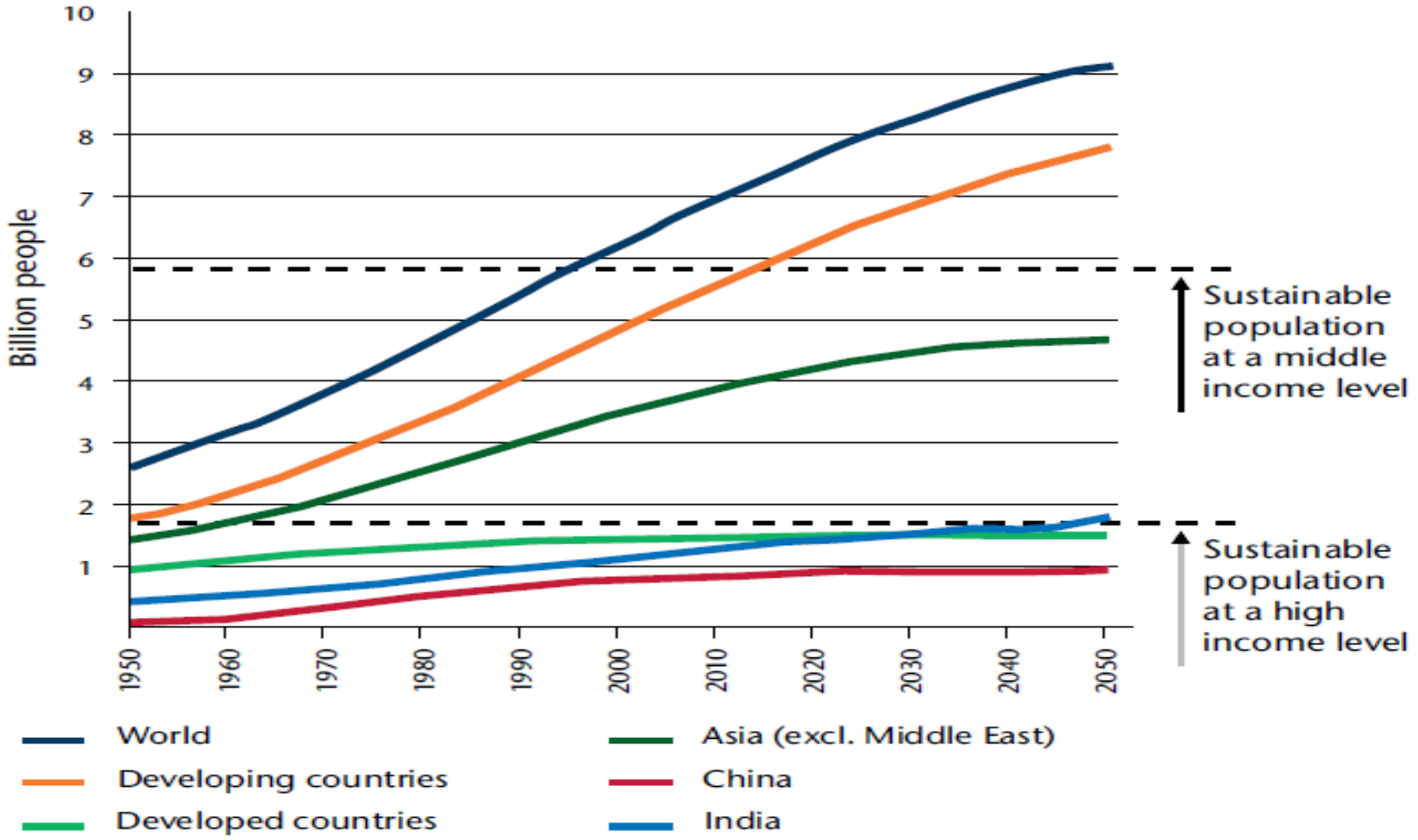
- Climate regulation
- Incubation of new life
- Nutrient cycling
- Waste management
- Erosion control
- Pest control
- Water and air purification
- Temperature moderation
- Noise reduction
- Economical landscaping
- Stormwater retention
- Tourist attractions

Global Consumption

Global consumption levels and patterns are driven at the most fundamental level by:

- Rapid global population growth;
- The rise in global affluence – middle- and lower-income consumers;
- A culture of “consumerism” among higher income groups.

Unsustainable Consumption



Up to 5 times the Earth's resources would be required if U.S. consumption was copied by the rest of the world.

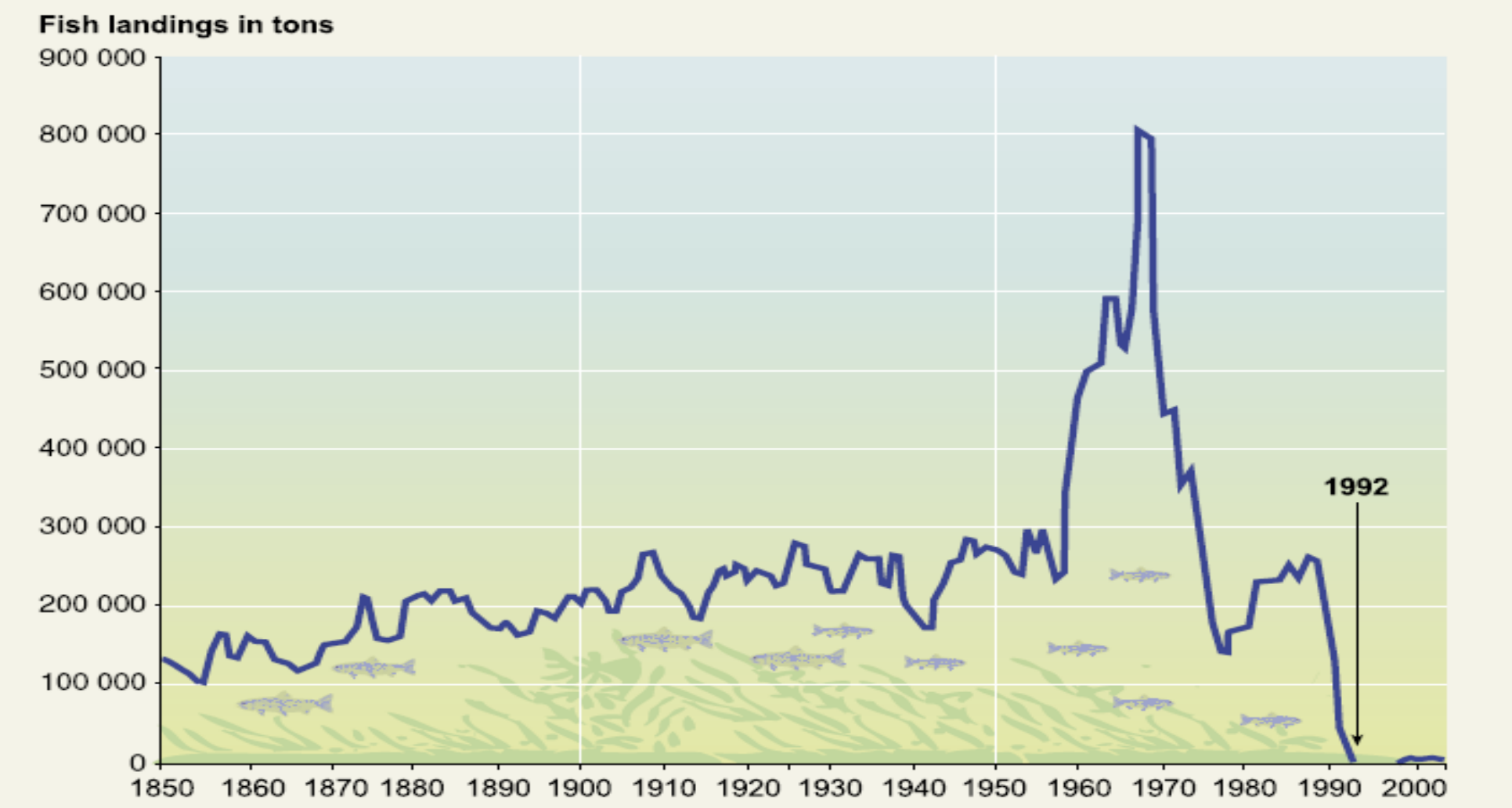
Source: United Nations Environment Program, UN Global Compact and Utopies, 2005
also, World Resources Institute (WRI)/Earthtrends, 2008

Biodiversity Loss Drivers

Economic activity and population density tend to be correlated with biodiversity loss and changes in ecosystem services specifically resulting in:

- Habitat change,
- Climate change,
- Invasive alien species,
- Overexploitation, and
- Pollution.

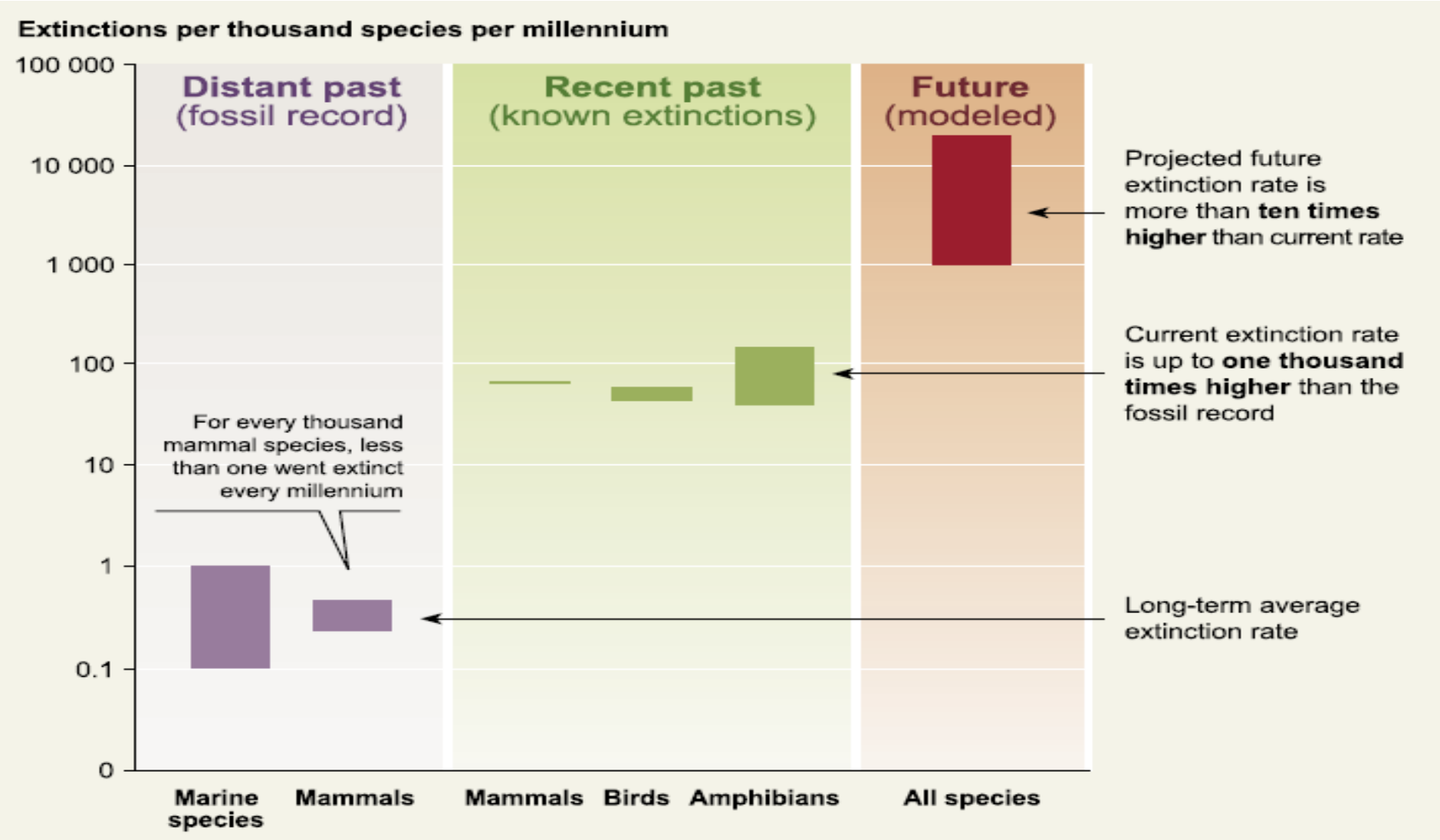
Overexploitation



Harvest of Atlantic Cod (1850-2003)

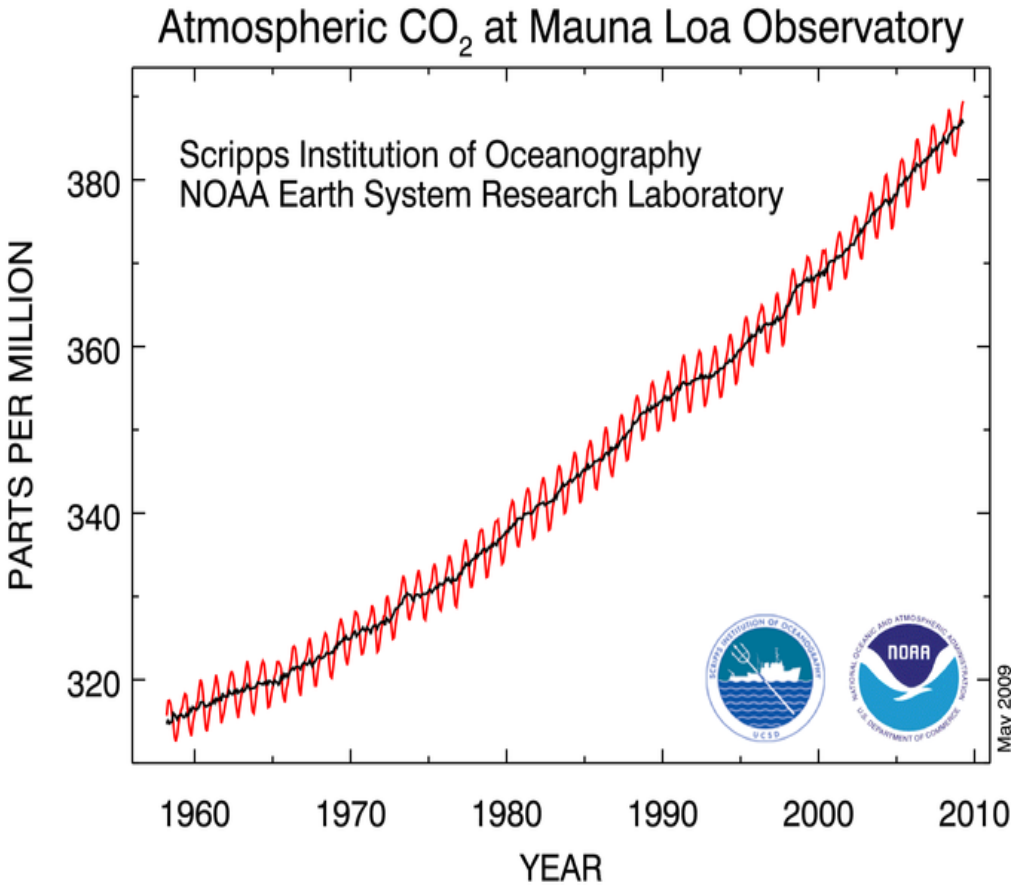
Source: Millennium Ecosystem Assessment

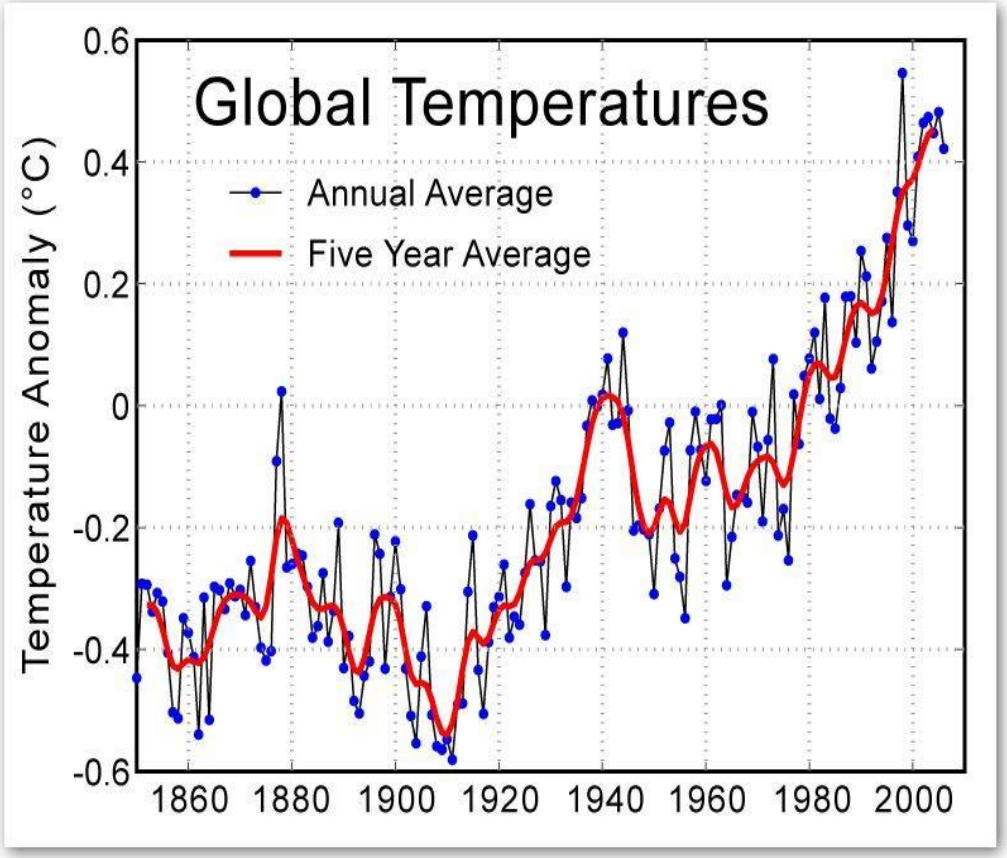
Unprecedented Extinction Rates



Source: Millennium Ecosystem Assessment

Climate Change





Coincidence or Correlation?

Source: http://www.theglobalwarmingoverview.com/index.php

Roles in Sustainable Consumption

Role of Government & Regulators

- International agreements
- National polices, laws, regulations
- Fiscal structures and incentives
- Infrastructure and services
- Guidance for business & consumers
- Monitoring & enforcement

Role of Businesses

- Economic development
- Legal compliance
- Ethical practices
- Sustainable sourcing, production and distribution
- Eco-efficiency and waste reduction
- Consumer choice editing
- Consumer choice influencing
- Innovation

Role of Consumers

- Purchasing decisions
- Lifestyle choices
- Ethical practices
- Waste reduction
- Political support
- Peer-to-peer influencing

Role of Non-governmental Organizations

- Independent assessment
- High profile public campaign
- Critique or endorsement
- Thought leadership
- Choice influencing

Course Agenda

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Social Responsibility

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Environmental Footprint Exercise #4

Course Evaluation

Exercise 2: “Countdown to Zero”



- The employee suggestions keep coming!
- Let’s help BE GREEN to continue to improve their Environmental Footprint by recommending which suggestions to implement!
- Each team will report on their:
  - Decision-making process,
  - Selections, and
  - Results (IITEs and Anticipated Savings)

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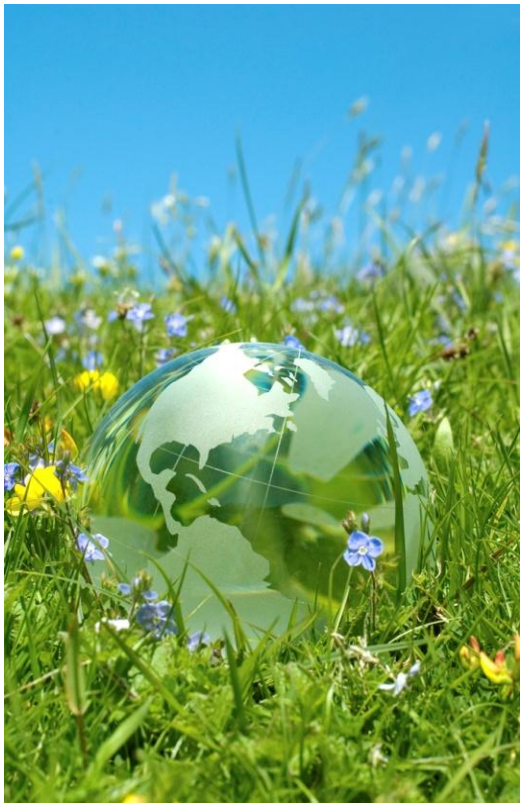
Environmental Footprint Exercise #3

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Social Responsibility



Providing for human well-being:

- Secure and adequate livelihoods;
- Health - feeling well; healthy physical environment;
- Social cohesion and ability to help others;
- Secure access to natural and other resources,
- Personal safety and security from natural and human-made disasters; and
- Freedom of choice and action.

Ecosystem Impact on Well-being

Changes to ecosystem services - Provisioning, Regulating, Cultural and Support - directly impact human well-being.

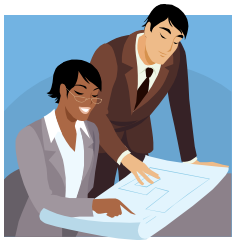


Direct change drivers include:

- Changes in local land use/cover;
- Species introduction or removal;
- Technology adaptation and use;
- External additives and inputs;
- Resource consumption;
- Climate change; and
- Natural, physical & biological events.

Value & Job Creation

- Leading companies rigorously pursue innovation to provide unique value to their customers.
- Harnessing knowledge and creativity of all employees means staying ahead of competition - growing and adding new, rewarding jobs.
- Suppliers and local community benefit as well.



Market & Product Requirement Analysis



Maintenance Refurbishment Reclamation

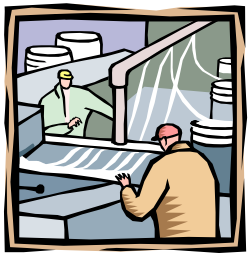


Distribution & Installation

Innovative Value Creation



Research, Development & Design

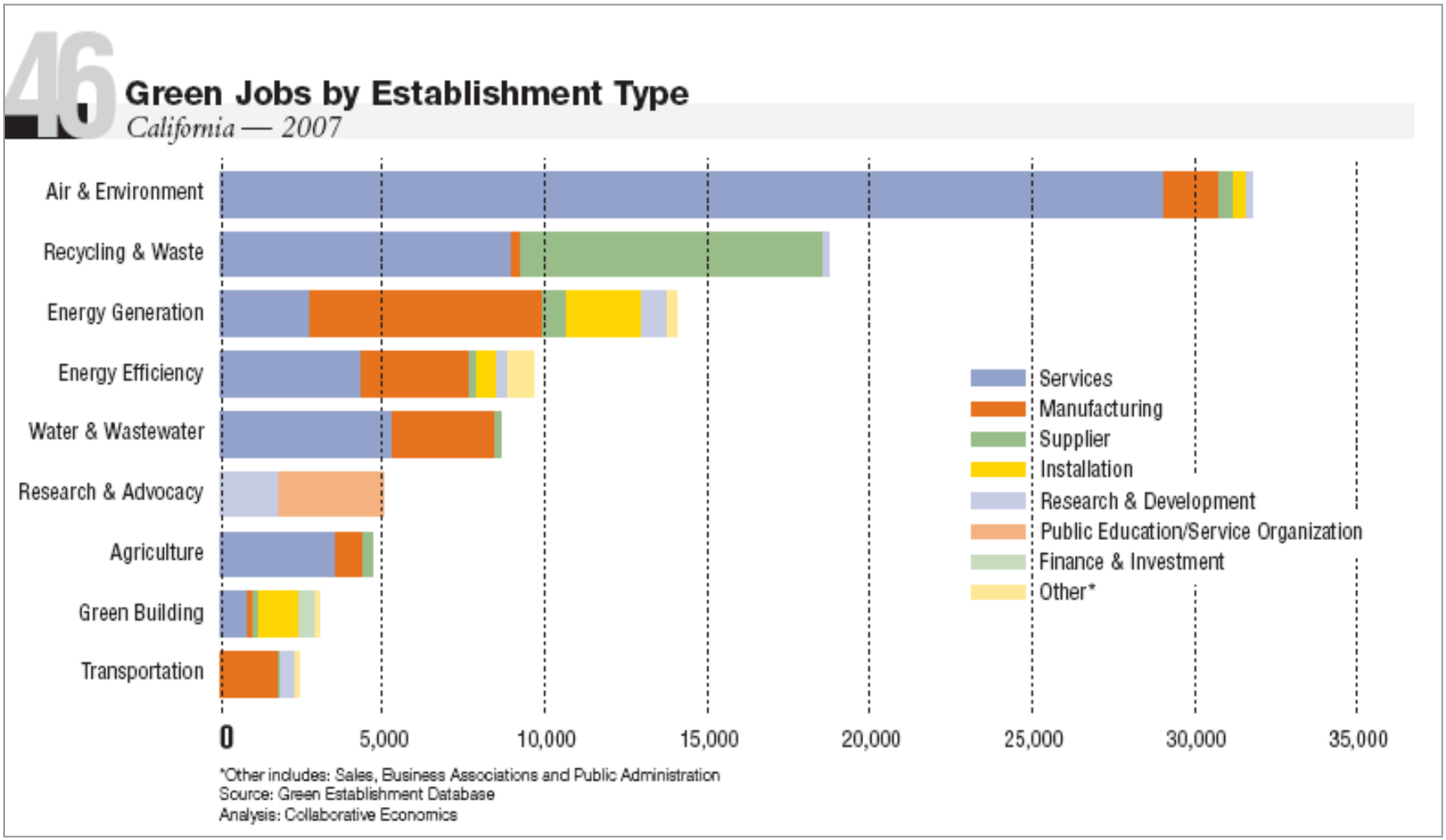


Production



Marketing & Sales

Green Jobs



As a sustainability leader, California's annual "green job" growth rate was 10% from 2005-2009. Total job growth was only 1% during same period.

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Course Evaluation

Exercise 3: “Countdown to Zero”



- The suggestions just get better and better!
- BE GREEN wants our input on which suggestions to continue their Countdown to Zero efforts!
- Each team will report on their:
  - Decision-making process,
  - Selections, and
  - Results (IITEs and Anticipated Savings)

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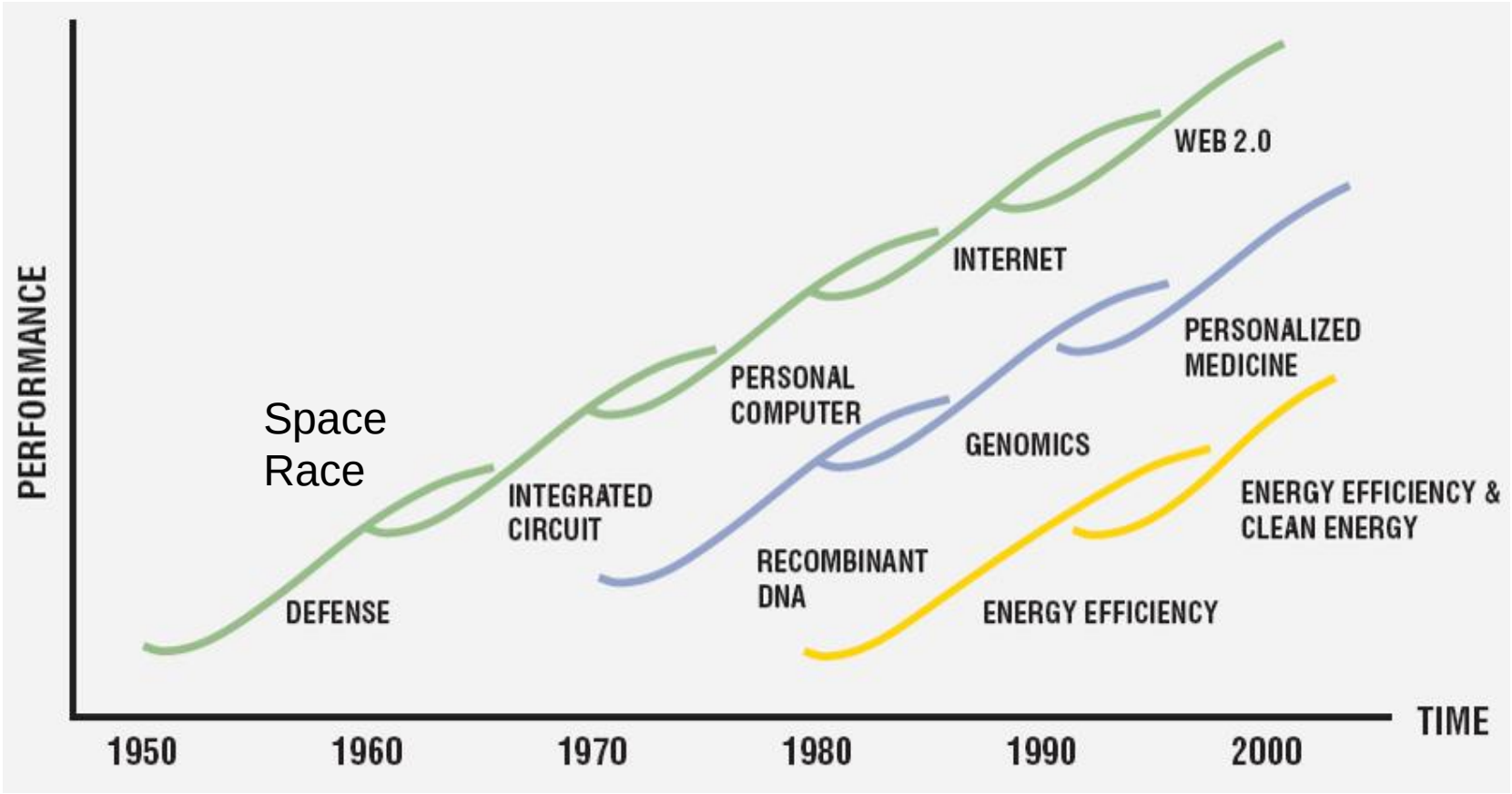
Innovation



Necessity is the mother of invention.

- Plato 360 BC

Waves of Innovation



- Beginning with the Space Race, we see 3 recent of waves of technology.
- What will the Sustainability wave include?

Next Wave: Sustainability

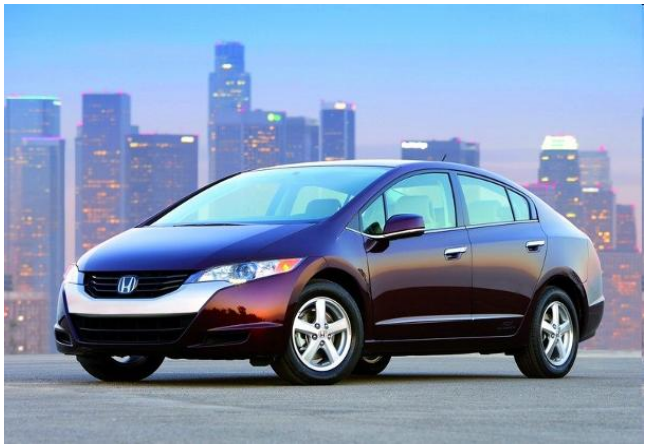
Some companies start small:

Whole Foods banning plastic shopping bags.



While other companies have their sights on much bigger things:

Honda's development of hydrogen-powered, zero-emissions vehicles.



Green Seeds of Innovation

- Green has become a platform for creating value around:



  - New product concepts,
  - Service strategies, and
  - Business models.

- Represents disruptive change in the marketplace.
- Referred to as “Green Hat” thinking!

Paradigm Shift

Old



Corporate Resident

- Me
- More
- Materialism
- Quantity
- Greed
- Short-term
- Rights



New

Corporate Community Partner

- We
- Enough
- Holism
- Quality
- Need
- Long-term
- Responsibilities



Innovation Investment & Returns

GE's 2008 Ecomagination Revenues to Rise 21 percent, Cross $17 Billion

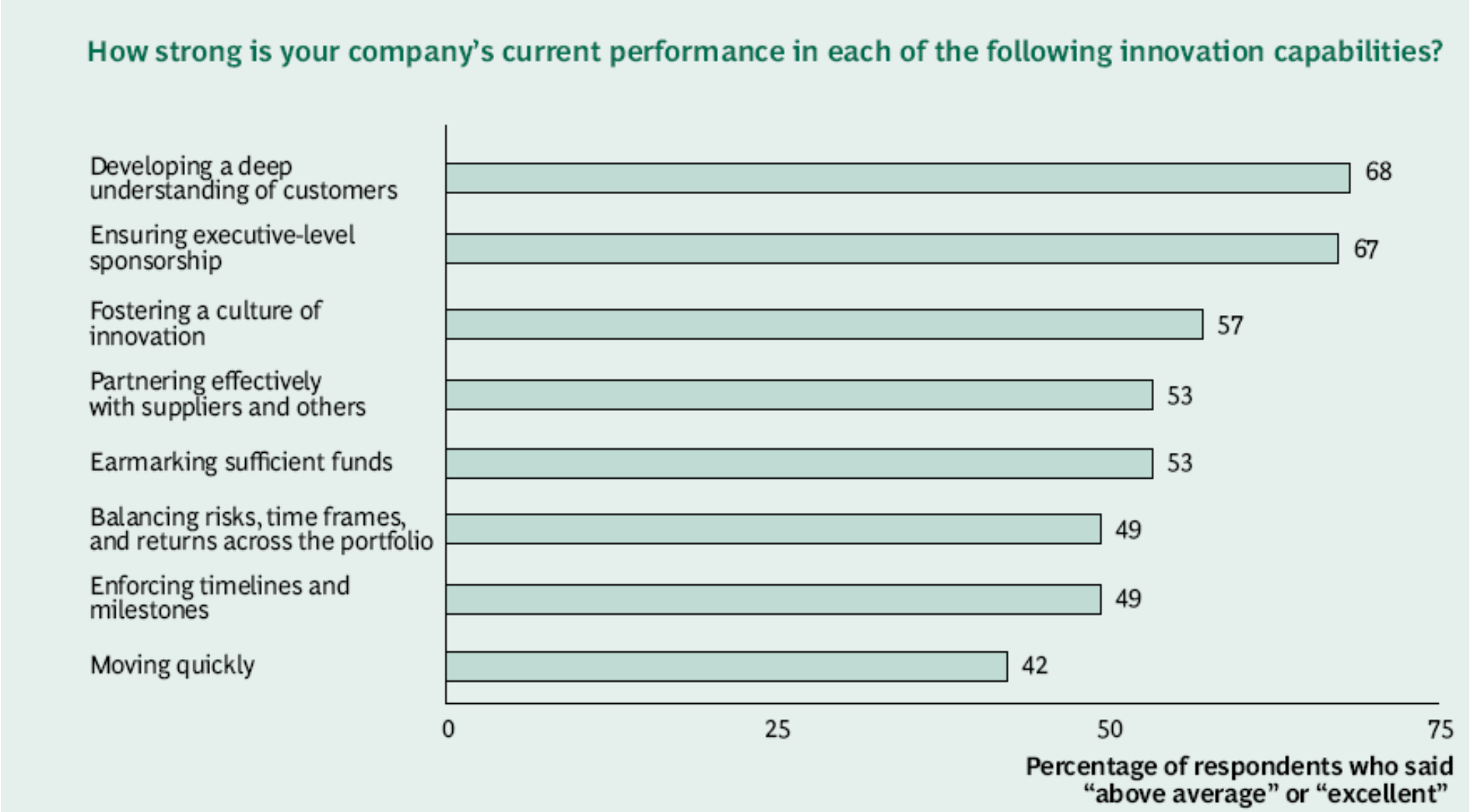
Annual Cleaner R&D Grows to $1.4 Billion
Total Energy Savings to Company of $100 Million

Fairfield, CT, October 21, 2008. GE today affirmed that, amidst global economic turbulence, revenues from its range of energy efficient and environmentally advantageous products and services will surge 21 percent to $17 billion in 2008, while GE's annual investment in cleaner research and development will pass $1.4 billion.



Why do you think GE invests so much in R & D?

Innovation Capabilities



Results from 2500 of the largest companies worldwide.

Source: BCG 2008 Senior Executive Innovation Survey

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Course Evaluation

Exercise 4: “Countdown to Zero”

You are all hired!!

- You’ve done such a great job advising BE GREEN on projects to implement, we’re making you official members of the BE GREEN Team!
- Independently, identify 1 or 2 innovative project ideas and the associated ROI and impacts.
- Share your ideas with the group.
- Let’s see what other ideas are triggered when we start thinking outside the box!

Integrated Resource Management

To transition to sustainable societies requires eco-design and eco-efficiency in all business aspects.



- Products
- Services
- Processes
- Materials and energy flows
- Facilities
- Business organizations/missions/strategies
- Non-governmental organization and grassroots strategies
- Inter-company and inter-stakeholder relations
- Community and regional planning and infrastructure
- Societal institutions and policies

Sustainable Thinking



- How can we act with creativity and rigor to design effective environmental, technical, economic, and social solutions at all of these levels?
- How do we know the right level of design for approaching a particular issue?
- How do we resolve conflicts across levels of design?
- How can we best evaluate alternative solutions?
- How do we maintain a coherent view of the whole system in order to manage design decisions well at any level?

Rethinking Your Business



- How could your organization go beyond improving efficiency to start to design with ecology in mind?

- If you were to redefine your business as one that provides services in closed-loop systems rather than a provider of products, what would that look like?
  - What would the costs and benefits be?
  - What would be the process for exploring this with some seriousness and who should be involved?

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Environmental Footprint Exercise #4

Course Evaluation

TECHNICAL ASSISTANCE PROGRAM

Green Enterprise Development

LEVEL **2**

Green Specialist Certificate Series

Join us for the Sustainability in Practice Workshop!

Develop a business case for implementing a sustainability program.

One-Day Workshop • Appropriate for engineers, green team participants and environmental managers

The Green Specialist: Sustainability in Practice Workshop was designed by Purdue's Technical Assistance Program for manufacturers and others interested in learning how to develop a business case for implementing a comprehensive environmental management or sustainability program. Expect a fun, fast-paced workshop with simulations and case studies for in-depth instruction in applying green concepts and techniques.

Participants will learn:

- Benefits of using Triple Bottom Line as a sustainability framework
- How to save money with a positive environmental impact
- The impact of regulations and standards
- Values of green certifications and marketing practices
- The importance of including green supply chain in your sustainability scope
- Typical measures for monitoring a successful program



Green Enterprise Development

Visit www.tap.purdue.edu/green to learn how to take the green movement to the next level.





How We Can Work With You: In addition to Green Enterprise Development, Purdue's Technical Assistance Program offers on-site public workshops and provides implementation and consulting services.

For workshop dates or to register: Visit www.tap.purdue.edu/green under "Register for Events." Cost is $395/per person.

For more information: Contact Abbey Maddy via phone at (800) 877-5182 ext. 620 or email amaddy@purdue.edu.

Black & Gold & Green Enterprise Development

Technical Assistance Program
6640 Intech Blvd., Suite 120
Indianapolis, IN 46278-2012
(800) 877-5182 or (317) 275-6810 Fax (317) 275-2375
www.tap.purdue.edu/green

PURDUE UNIVERSITY

PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM

Energy Management



Efficient Energy Use

Purpose of This Module

- To provide an understanding of traditional and alternative energy sources.
- To identify methods that can be implemented to reduce energy use.
- To provide strategies for incorporating effective energy management concepts into your business practices.

Course Agenda

Energy Consumption & Sources

Energy Audit Prep

Energy Audit In Practice

- Utility Bill Analysis
- Fueled Systems: Process Heating, Steam
- Electric Systems: Compressed Air, Fans & Pumps, HVAC, Lighting
- Transportation
- Co-Generation

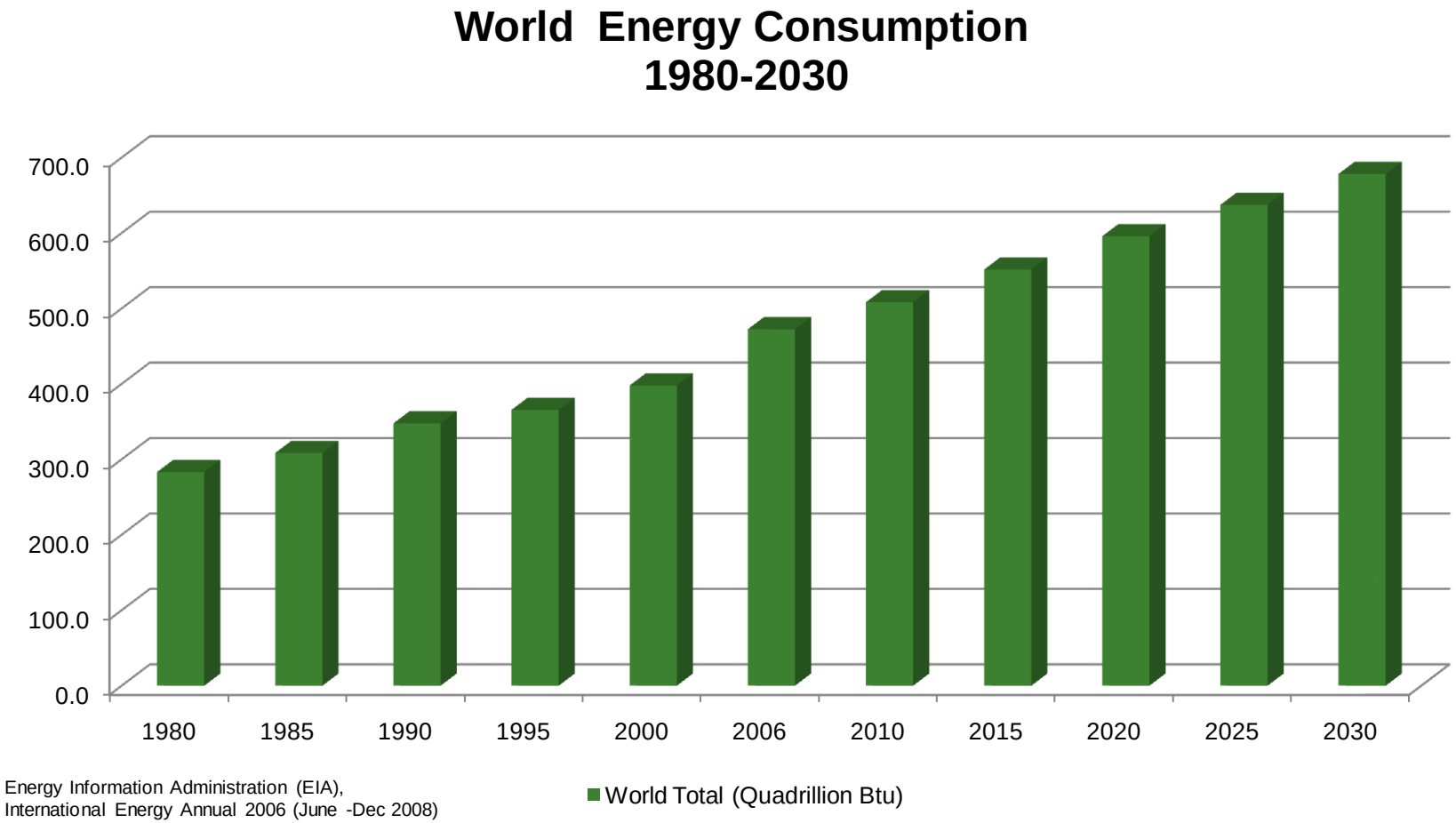
Carbon Footprint

Alternative / Renewable Energy Sources

Systems Approach

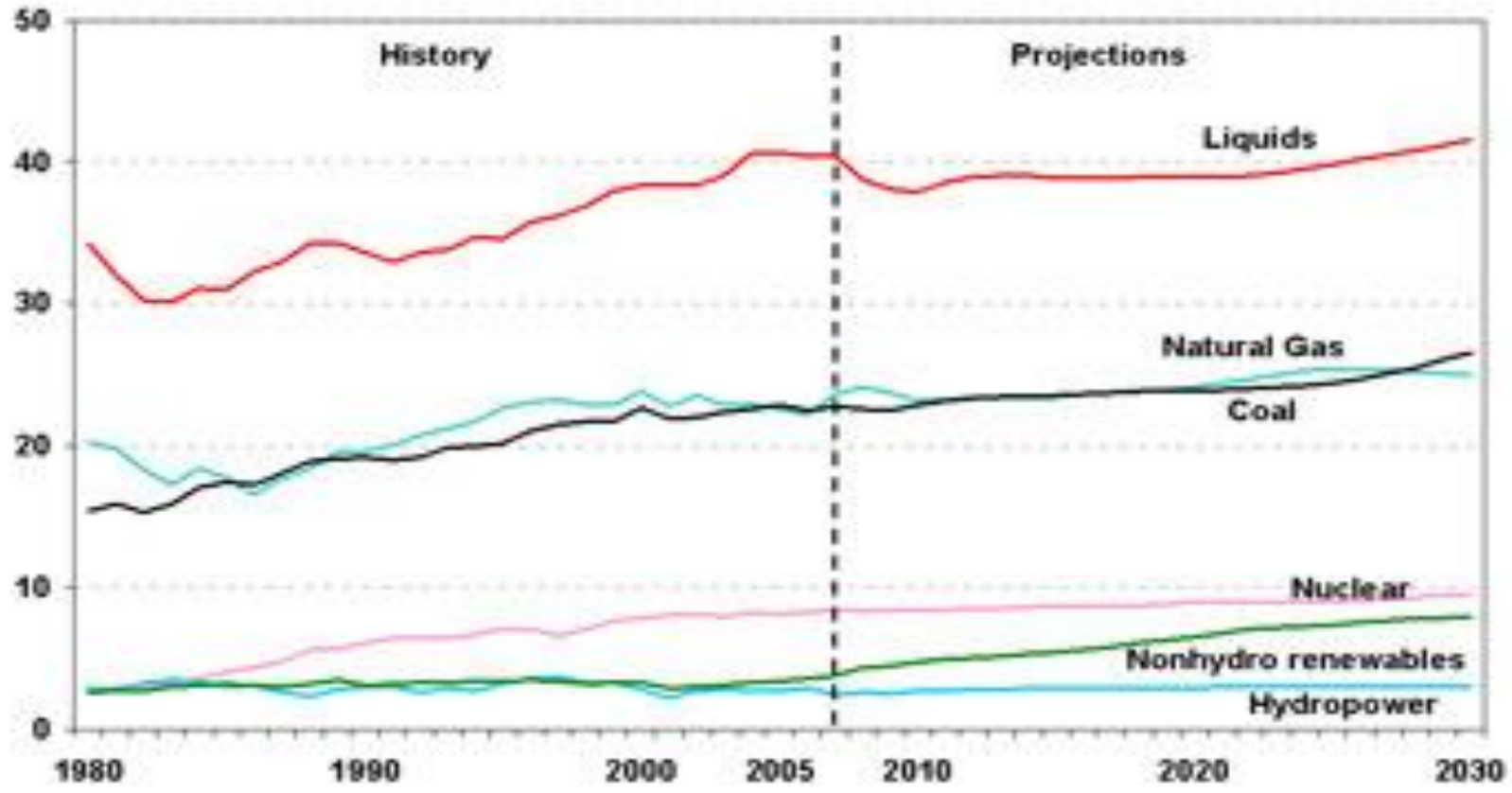
Course Evaluation

Energy Demands Increasing

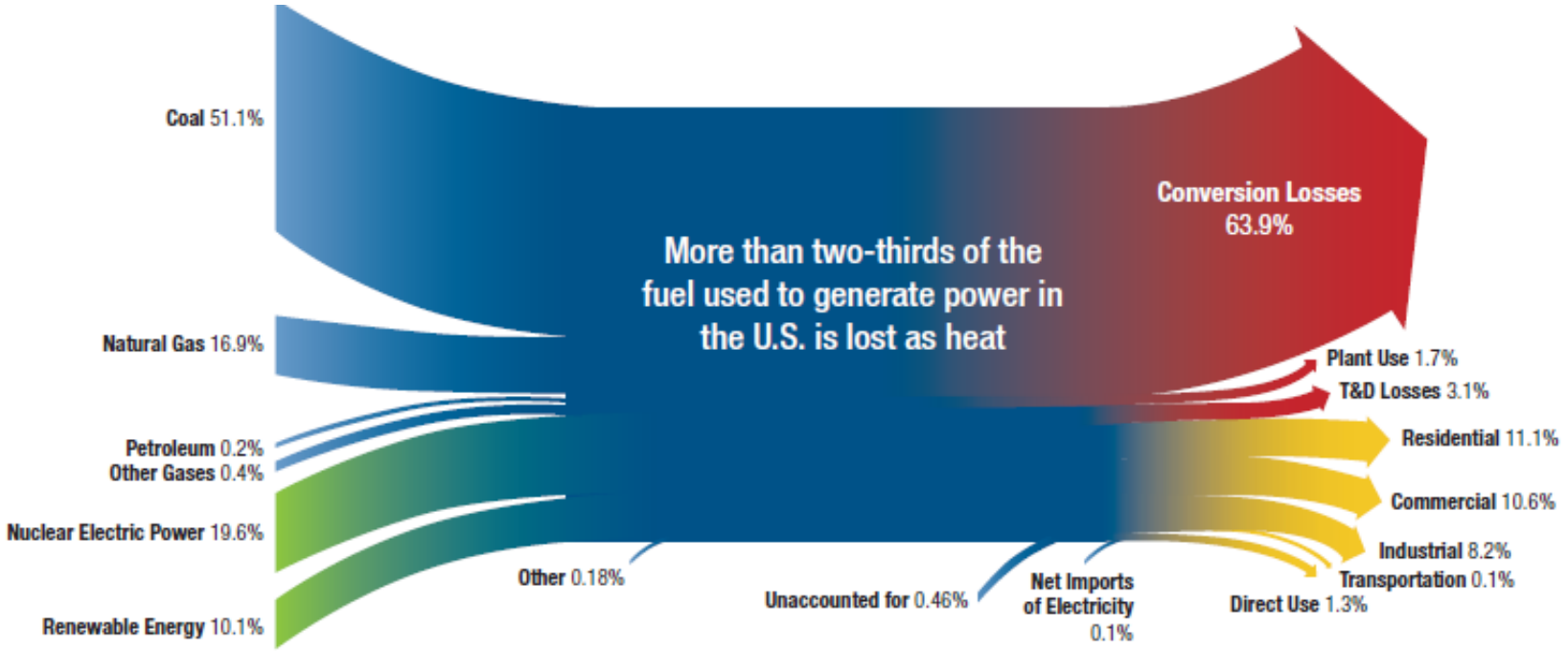


Energy Information Administration (EIA),
International Energy Annual 2006 (June -Dec 2008)

U.S. Energy: Production & Consumption



Inefficiency of Consumption



Source: DOE Energy Information Administration Annual Energy Review 2007

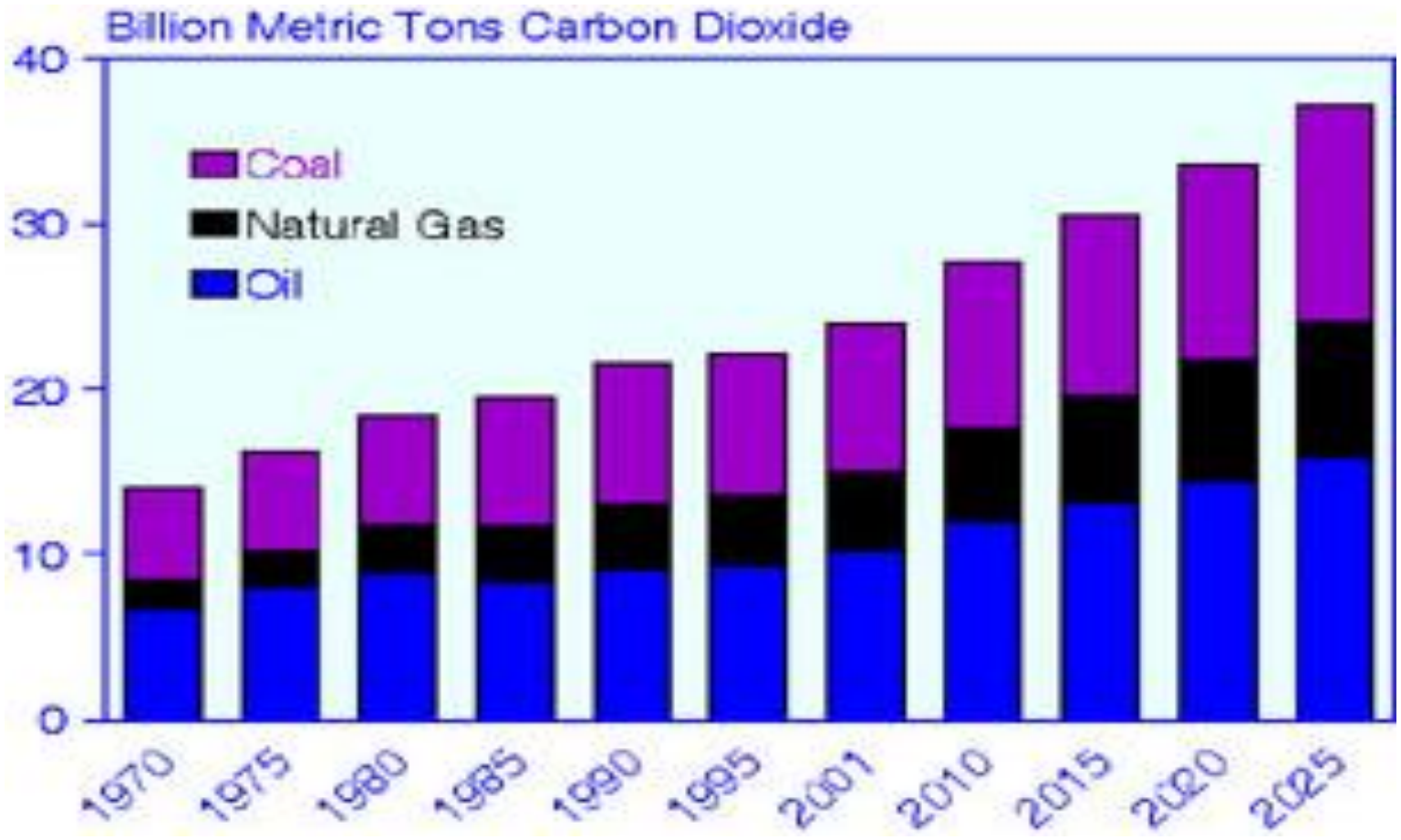
Impact of Unsustainable Energy Use

- Worldwide military engagement to protect petroleum supply chain
- Greenhouse gases
- Habitat destruction
- Water pollution
- Air pollution
- Solid waste generation

Facts: Energy Consumption

- Americans consume about 26% of the world's energy while accounting for only 5% of the world's population.
- Developing countries use 30% of global energy.
- Worldwide, about *2 billion* people are currently without electricity. This is over 30% of the current estimated global population of 6.5 billion.

Environmental Impacts



Source: U.S. Department of Energy

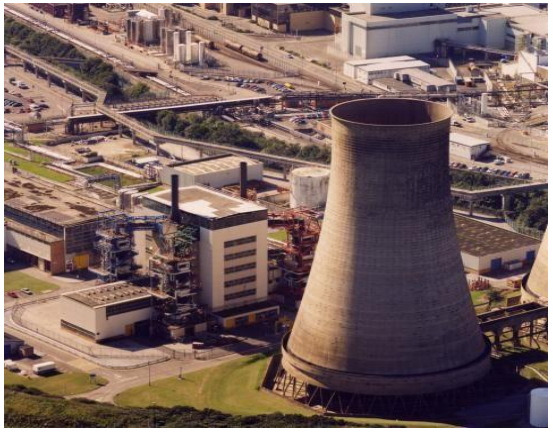
Traditional Energy Sources

- Coal
- Petroleum
- Natural Gas
- Uranium



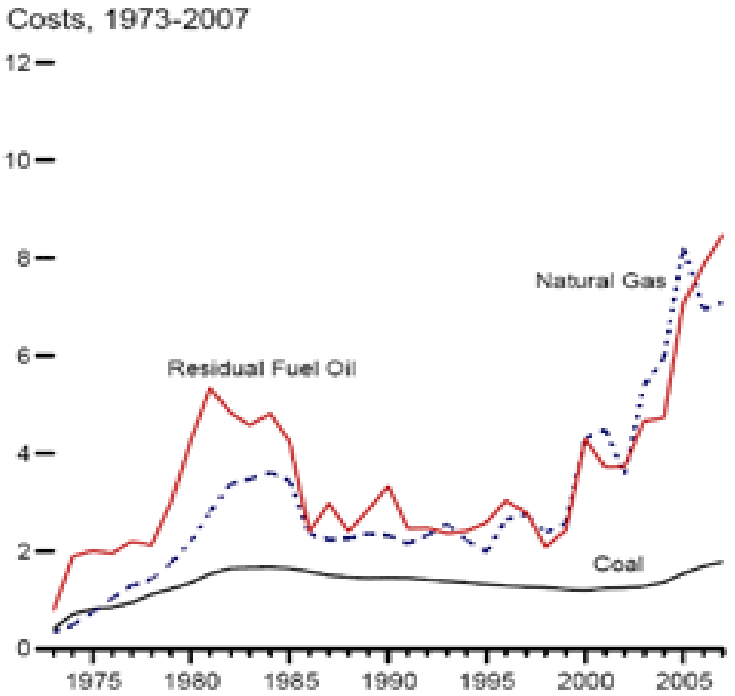


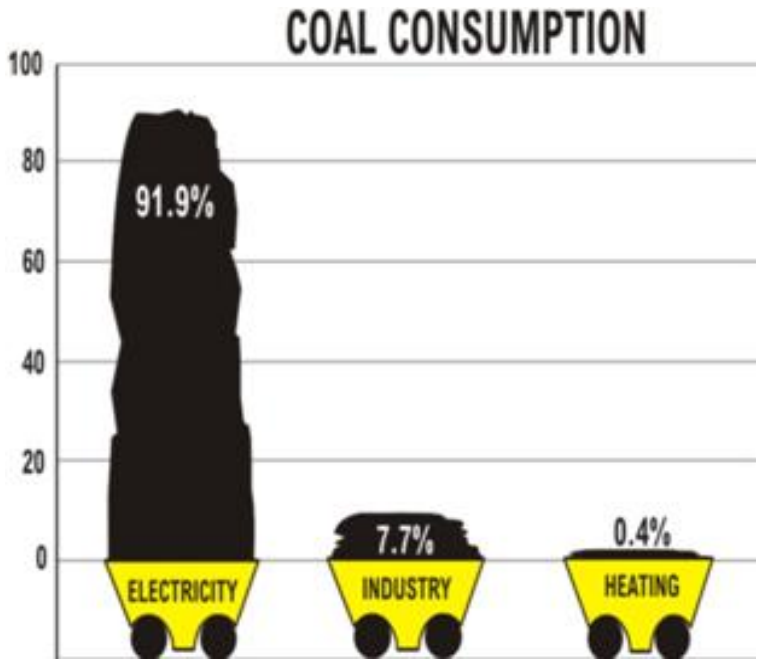




Coal

- US Coal Consumption is ~1.1 Billion Short Tons Annually
- World Consumption is ~6.7 Billion Short Tons Annually
- US Recoverable Coal Reserves are ~262 Billion Tons & World Reserves are ~930 Billion Tons (A 130+ year supply at current consumption levels.)

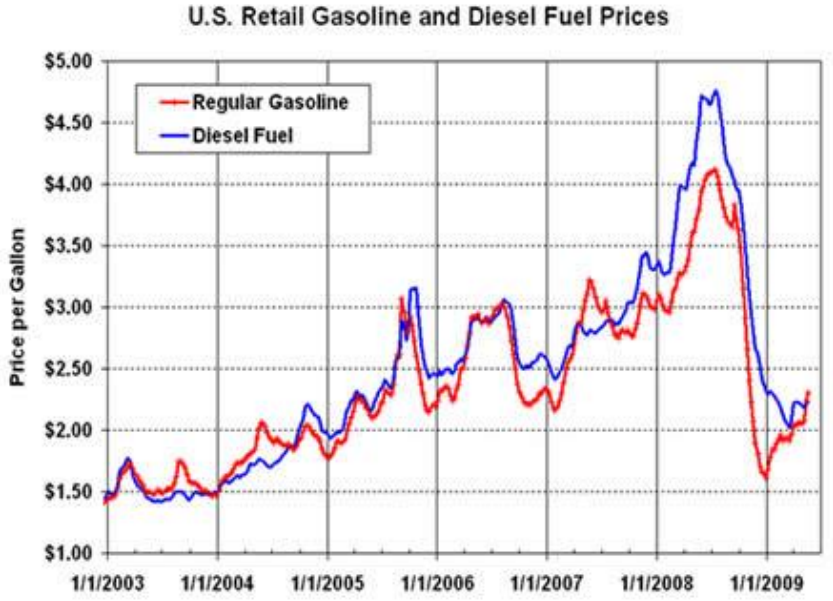


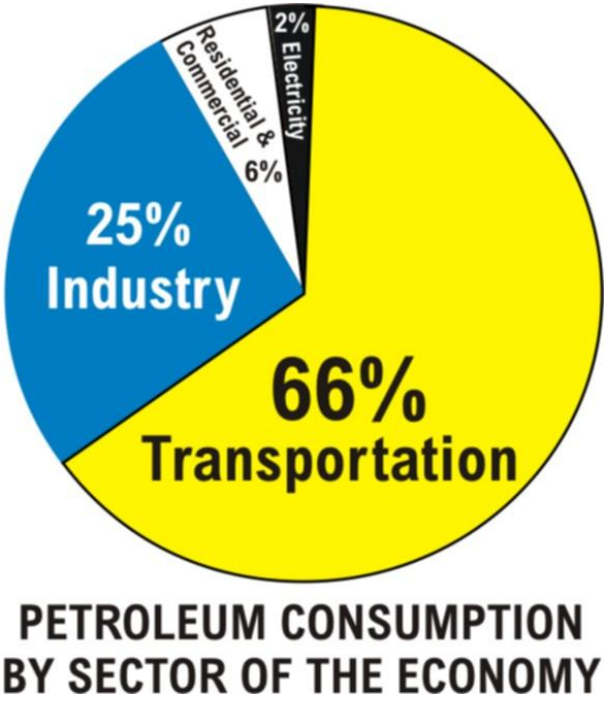


Source: Energy Information Administration (EIA); Monthly Energy Review, May 2009

Petroleum

- US Petroleum Consumption is 21 Million Barrels/day or 7.67 Billion Barrels Annually
- Current US Proven Reserves is 21.3 Billion Barrels…
- Current World Petroleum Consumption is 85.9 Million Barrels/day or 31.35 Billion Barrels Annually
- Current World Proven Reserves is 1,342 Billion Barrels; ~ 42 years at current consumption rates…



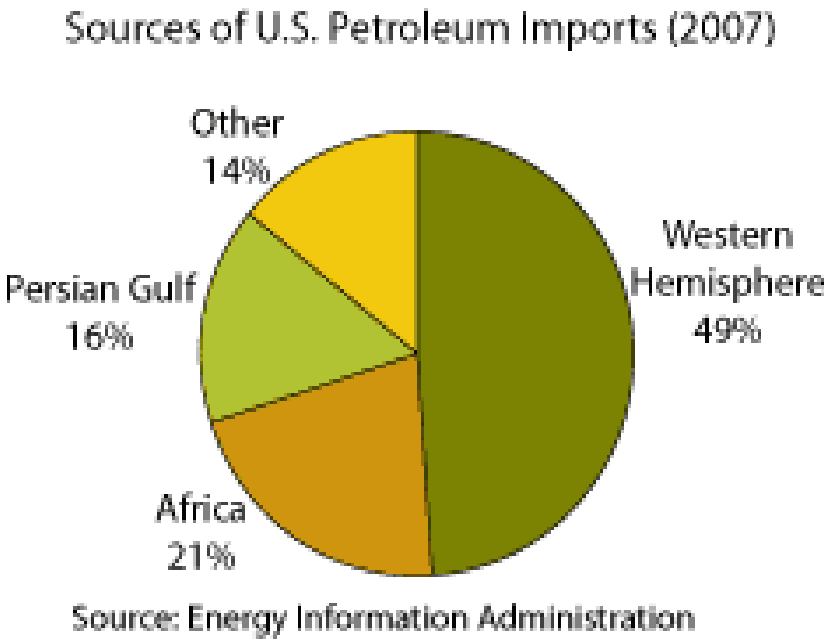


Petroleum

- The US provides 42% of its petroleum from domestic sources importing the remaining 58%.
- About half the imported petroleum comes from the Western Hemisphere.

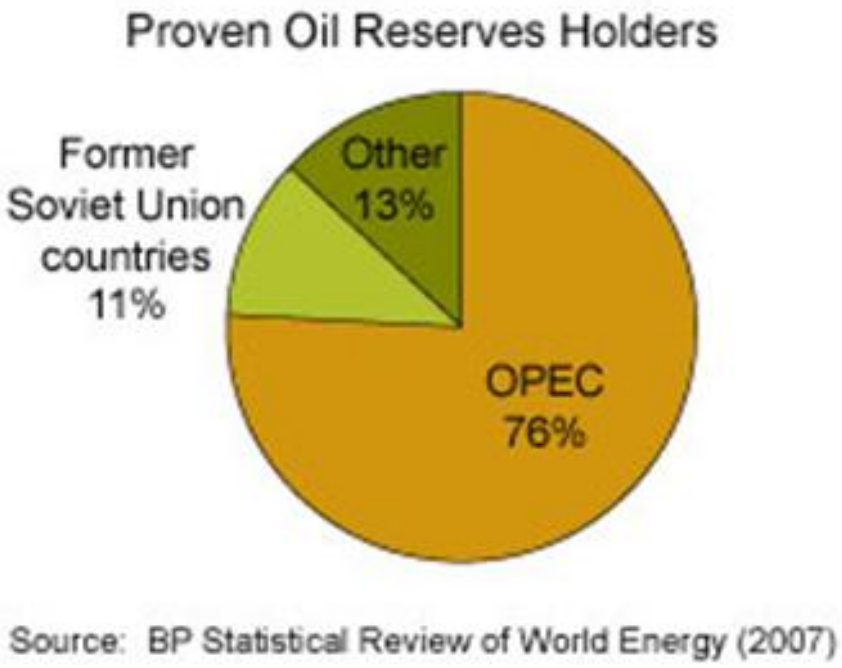
1. Canada (18.2%)
2. Mexico (11.4%)
3. Saudi Arabia (11.0%)
4. Venezuela (10.1%)
5. Nigeria (8.4%)

Next 10: Includes Angola, Iraq, Brazil, Columbia, Russia, Algeria, Ecuador, Kuwait, Gabon, & Norway (~28.2%)

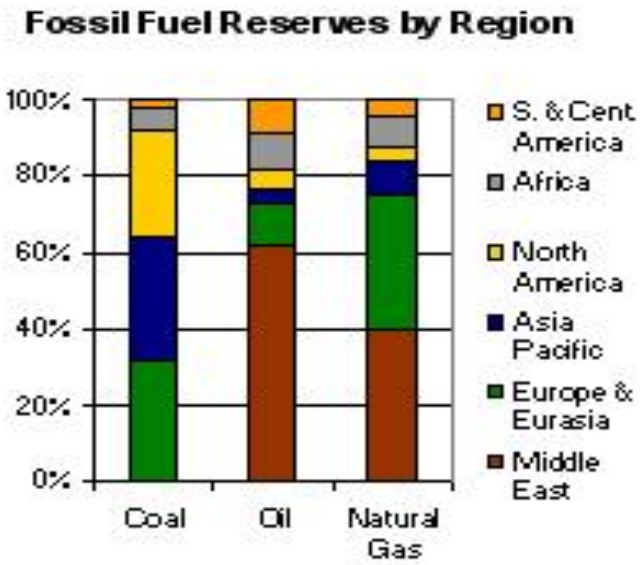


Traditional Energy Reserves

• OPEC member countries held over 75% of the world's proven oil reserves at the end of 2006.

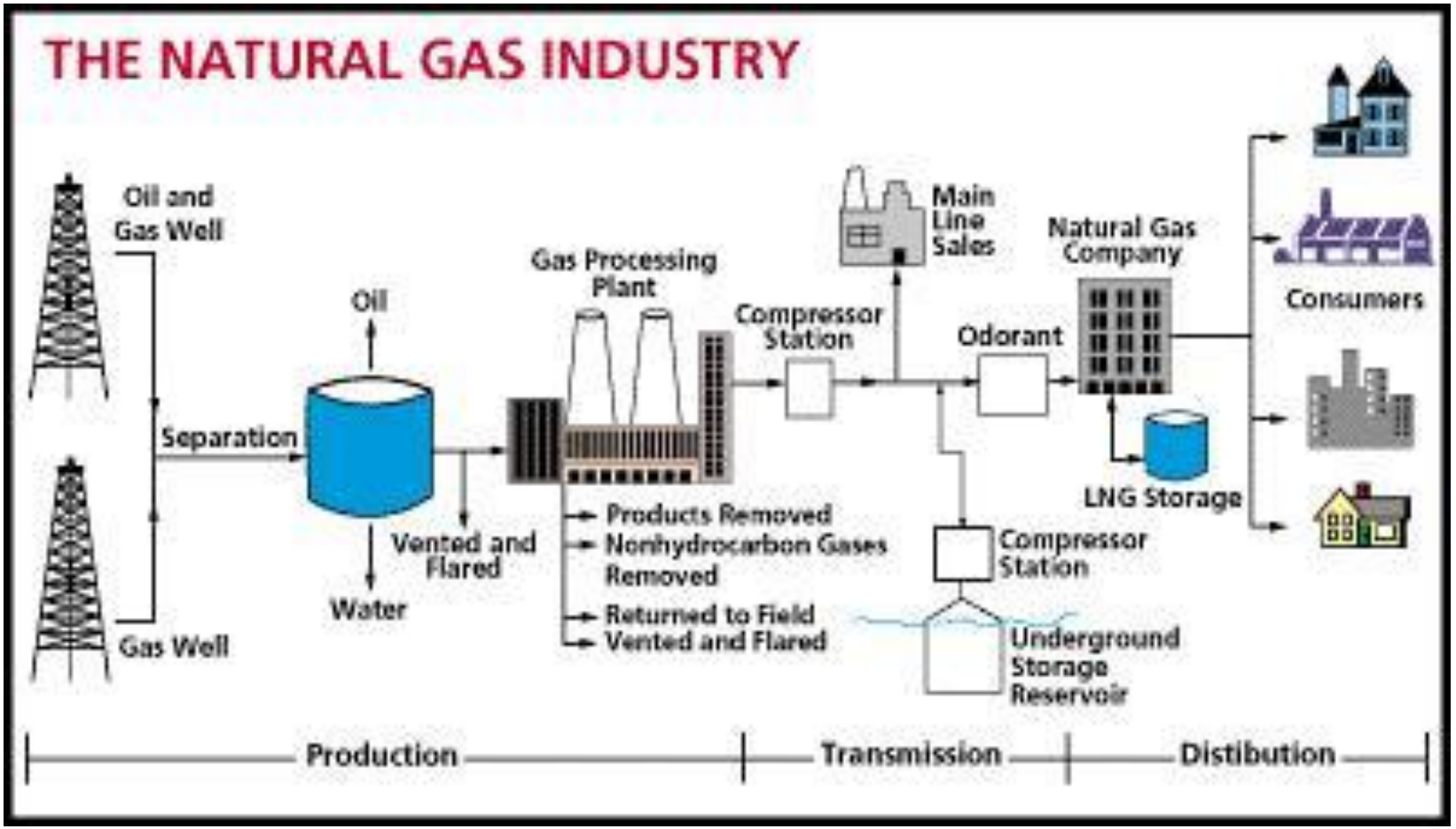


Source: BP Statistical Review of World Energy (2007)



Source: BP, p.l.c., 2006

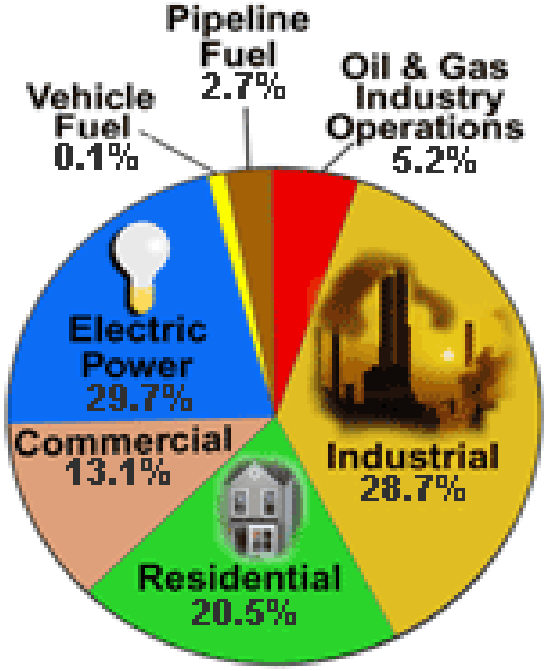
Natural Gas

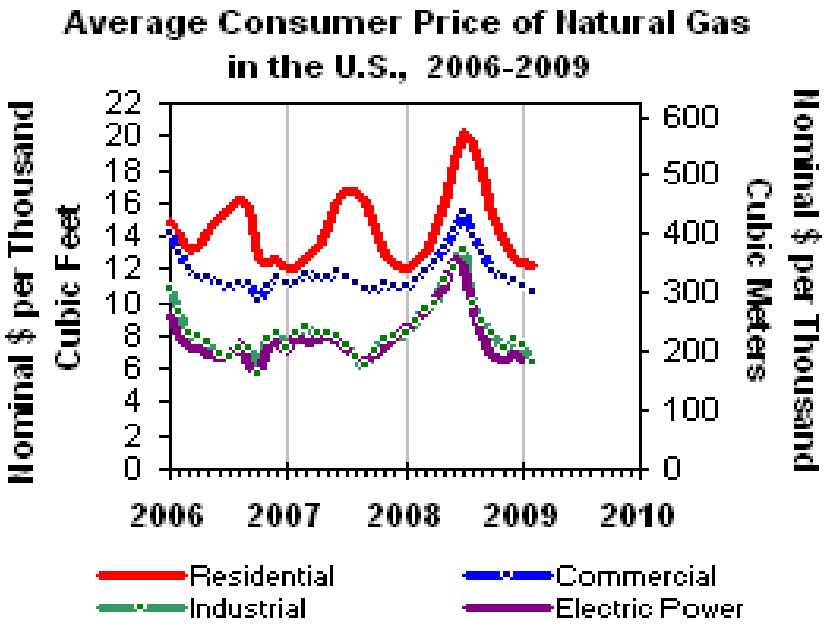


Source: EIA

Natural Gas

- The US consumes roughly 18.5 trillion cubic feet of natural gas annually. This is about 18% of the annual world consumption of 104 trillion cubic feet.
- US Natural Gas reserves are estimated at 237.7 trillion cubic feet. International reserves are reported as 6290 trillion cubic feet representing a 60+ year supply at current consumption rates.





Source: EIA 2009

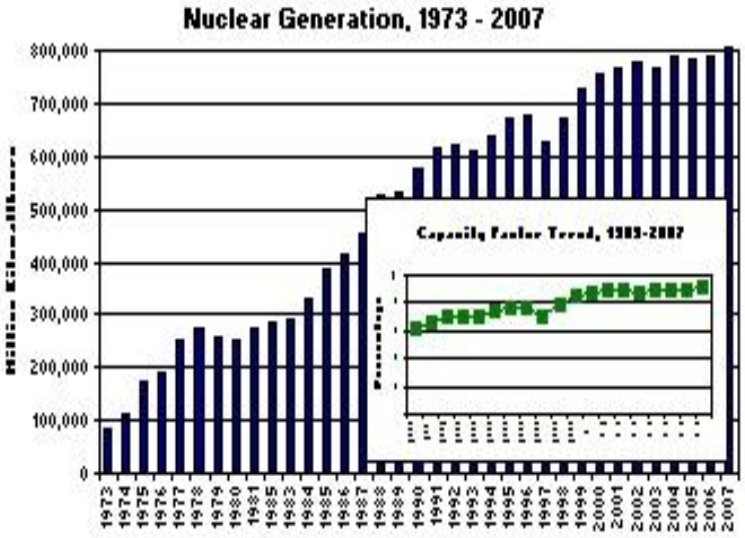
World Natural Gas Reserves



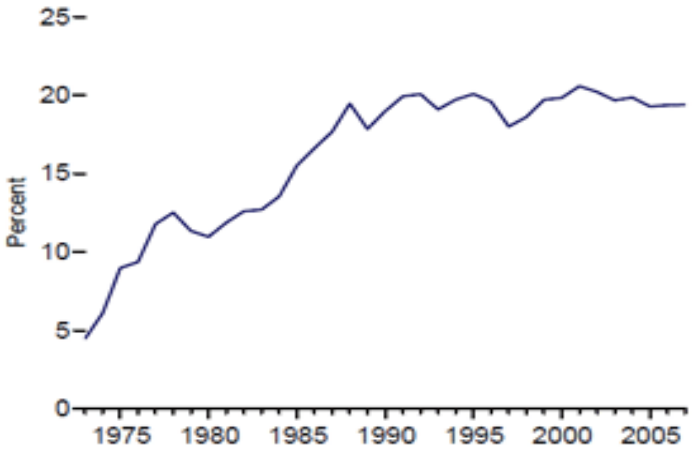
1988 1998 2008

Source: BP Statistical Review of World Energy, 2009

Nuclear



US Nuclear Electricity Generation
as a percentage of Overall (US)

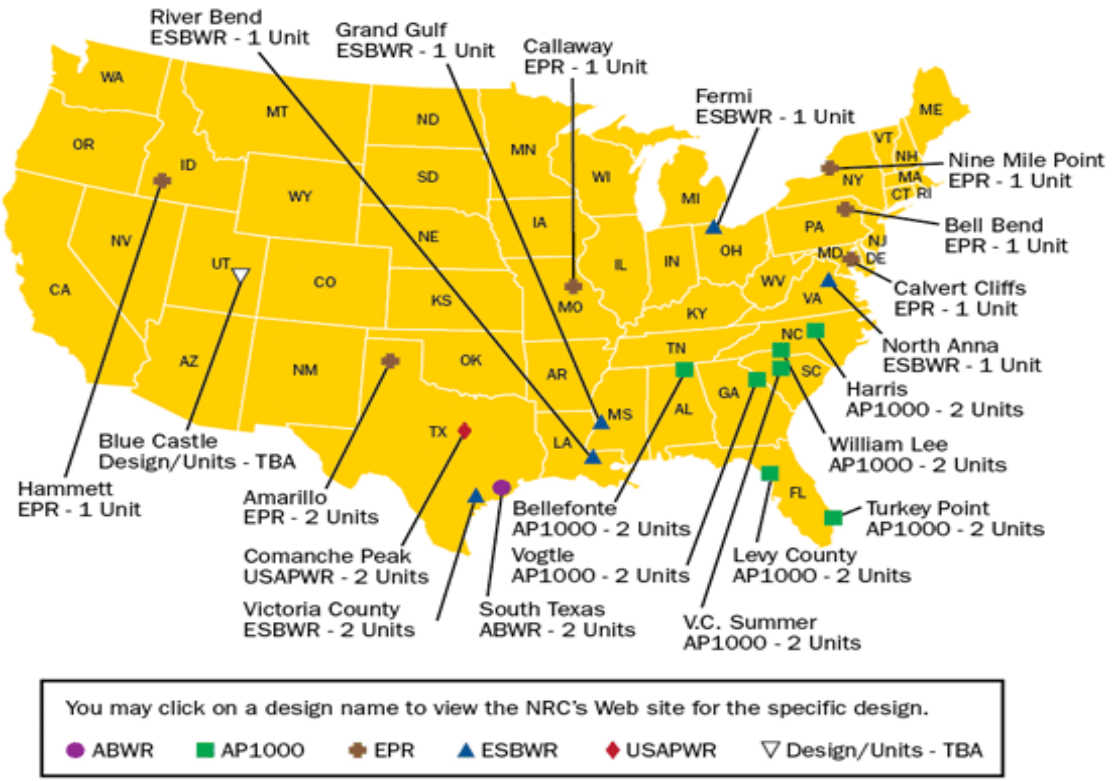


- Nuclear power, used commercially in the US since 1957, effectively produces electricity with zero carbon emissions.
- Estimated world reserves are adequate for about the next 85 years.
- Fly Ash from Coal burning power plants carries up to 100 times more radiation into the environment than a comparable nuclear plant.

Source: EIA; International Atomic Energy Agency

Potential Growth of Nuclear Power

- It is expected that the US will add up to 30 additional reactors to its existing “fleet” of 104 over the next several decades
- China plans to quadruple its nuclear energy production by 2020.



Source: NRC 2009

Course Agenda

- Energy Consumption & Sources
- Energy Audit Prep
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  - Co-Generation
- Carbon Footprint
- Alternative / Renewable Energy Sources
- Systems Approach
- Course Evaluation

Energy Audit Purpose



- Identify types and costs of energy use.
- Understand how the energy is being used & wasted.
- Identify and analyze more cost-effective ways of using energy with:
  - improved operational techniques
  - new equipment
- Perform an economic analysis on those alternatives to determine which are cost-effective.

Other Questions to Ask



- Who will the auditor(s) report findings to?
- Who will implement the recommendations?
- Is money available for capital projects?
- Is time available for staff to implement?
- What is the level of management involvement, commitment?

Gathering Data

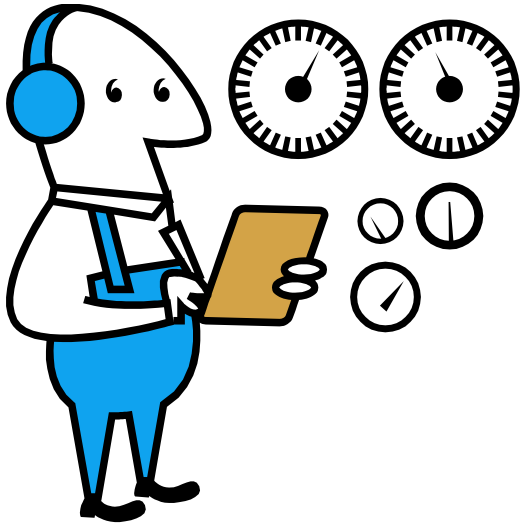
- Collect the following:
  - “Typical” electric bill.
  - “Typical” natural gas bill.
  - “Typical” transport fuel costs.

- To be used to determine:
  - Electrical Demand
  - Electrical and Natural Gas Usage
  - Electrical Power Factor
  - Transport and Elecrical Fuel Charges

Energy Sources & Costs

Energy Sources:	Electricity	Nat Gas	Other Fuel (propane)	Steam	Chilled Water	Co-Generation
Units (kWh, MMBtu, etc)	kWh, kW	therms	gallons			
Cost per unit ($)	$0.034	$9.00				
Average Volume	50,397,696	5,040,000				
Period (hour, day, week, month, or annually)	Year	Year				
Average Cost/Period - include demand charges, etc.	$1,713,522	$4,536,000				

Breaking Down Energy Costs



Utility Analysis:

- Consumption
- Demand Charge
- Power Factor
- Monthly Charges

Utility Analysis Comparison

- Energy Intensity
  - How much energy is used per unit of production or provision of service
  - Similar to Raw Materials/Unit of Production or;
  - Labor input/volume of sales

- Why calculate Energy Intensity?
  - Energy is a cost-of-goods sold
  - Better mechanism to track costs year-to-year

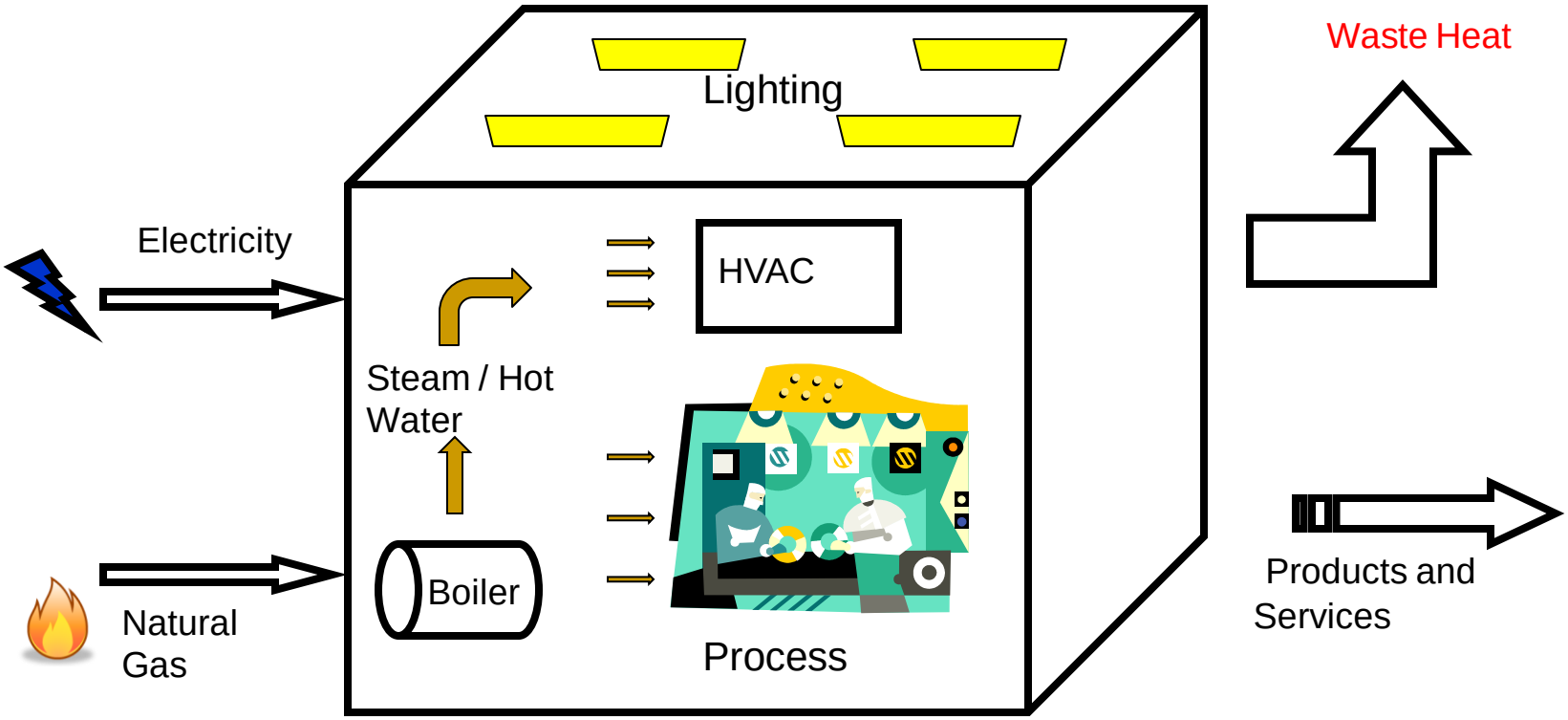
Energy Cost per Unit

Performance Measure:				
	How would you like to measure performance? (Examples: Energy use per ton, or per case, or per employee. Energy cost per $million in sales)			
	Example	Option 1	Option 2	Option 3
Product Name	Pencils	Quantity	Weight	
Units	cases	Reels	Tons	
Average Volume	100,000	45,000	275,000	
Period	Month	Year	Year	
Energy Intensity	1 kWh/Case of Pencils	1 MMBtu/reel	10,000 Btu/ton	
Energy Cost Index	$0.01/Pencil	$10.00/reel	$1.00/ton	

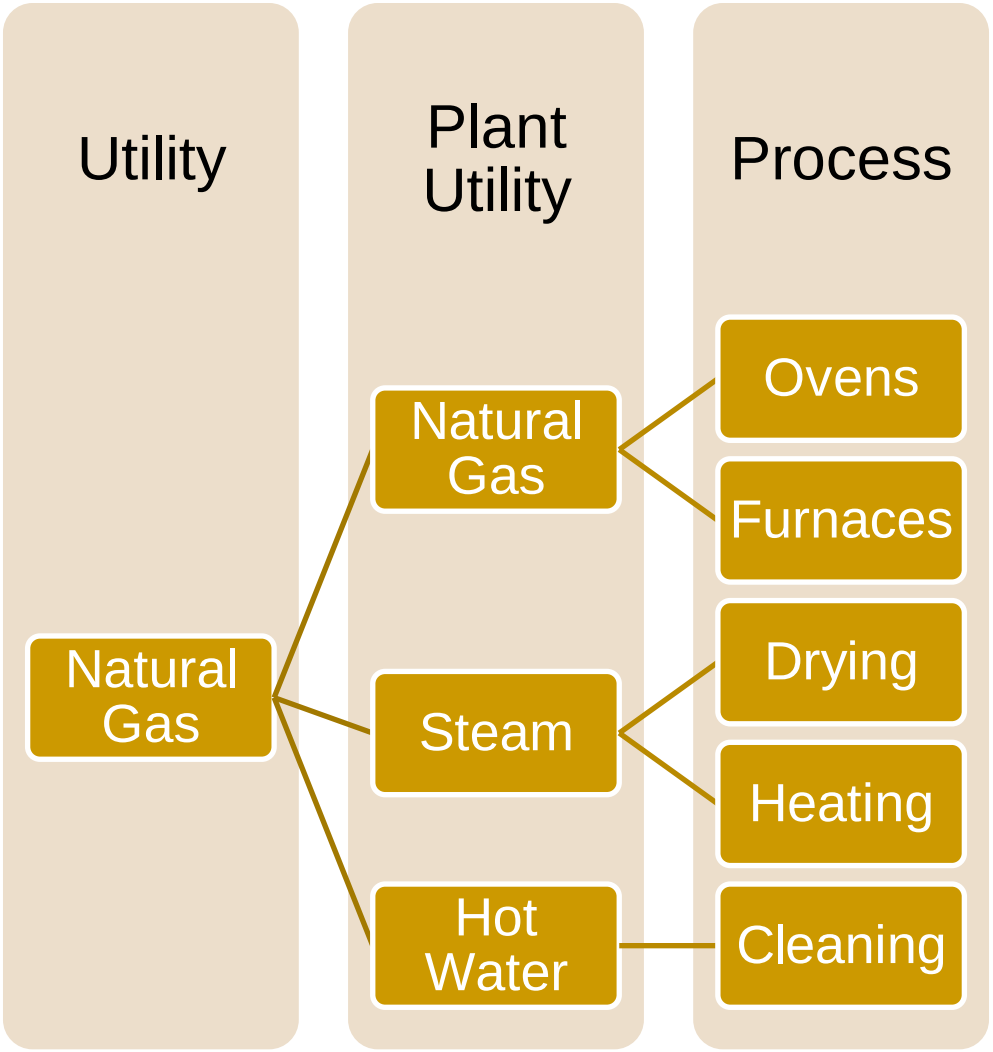
Getting Started

- What are your base utilities?
  - Electricity, natural gas, water, __?____, _____
- What conversions happen on site?
  - Steam (y/n), compressed air (y/n), _____, _____
- What are your end uses?
  - Building heating and cooling
  - Lighting
  - Processes:____, _____, _____, _____

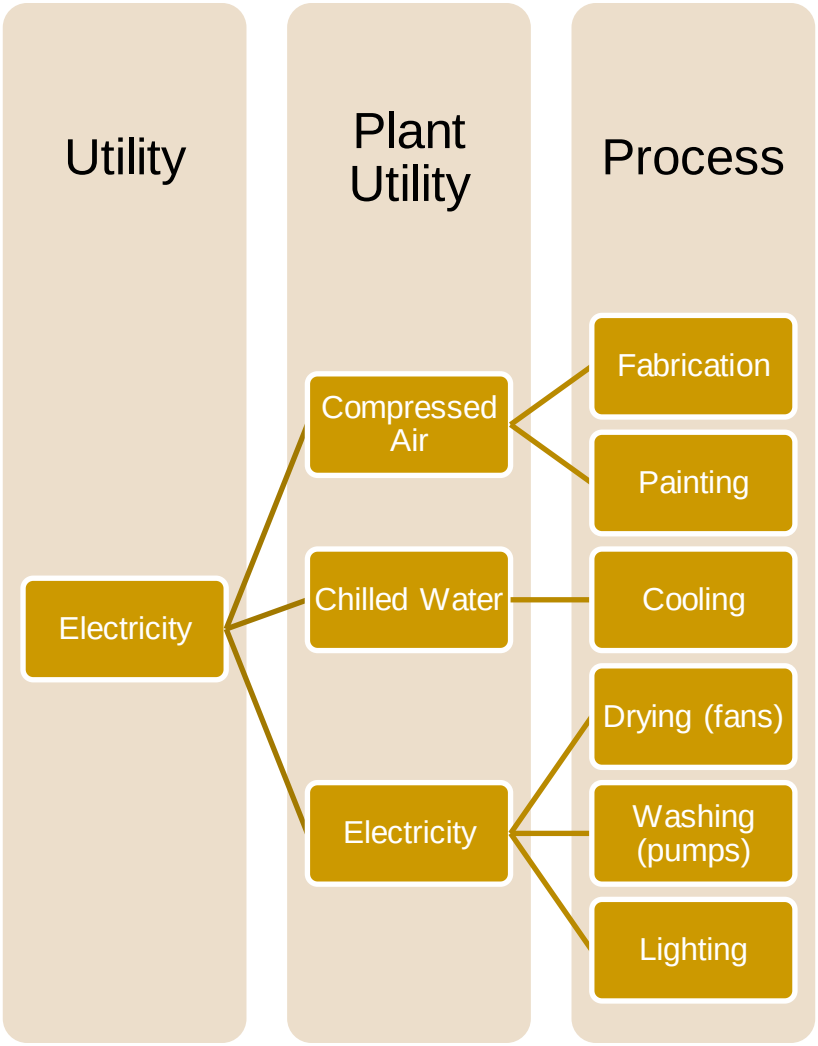
Energy System Flow



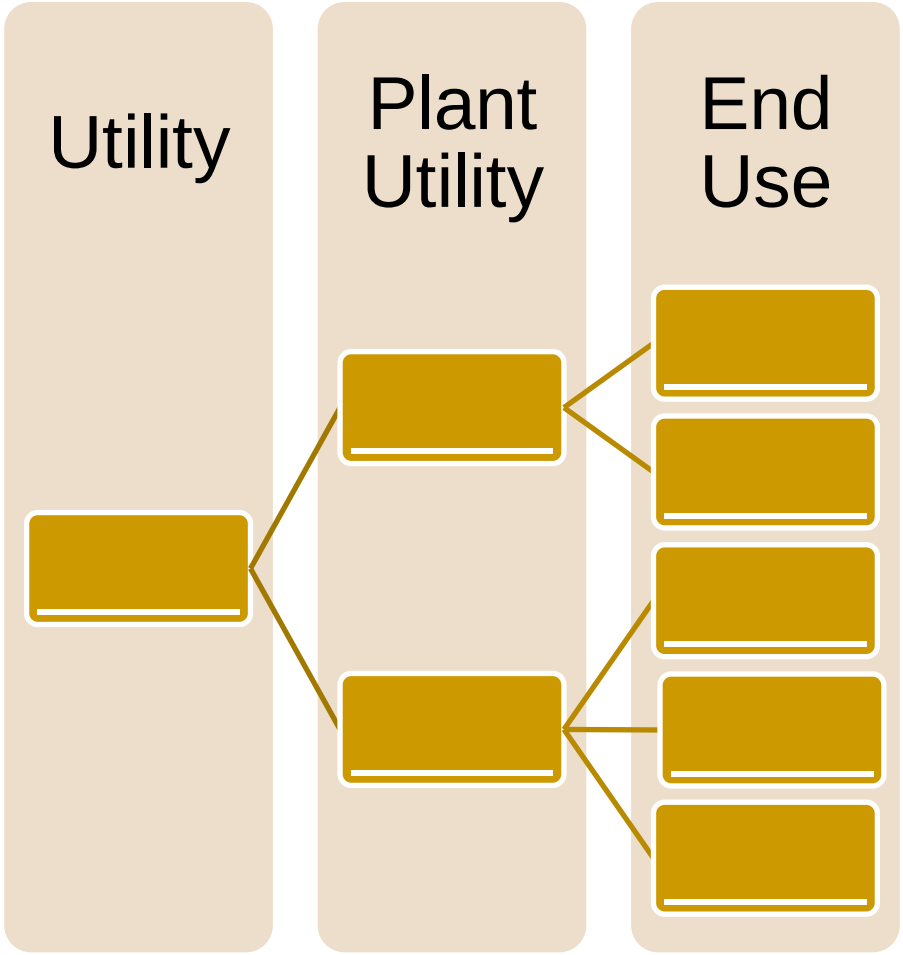
Natural Gas Use & Conversion



Electricity Use & Conversion



Exercise: Draw Your Facility's Natural Gas Use



Data collection

Energy Use Distribution:	Electricity	Natural Gas	Propane	Steam
Compressed Air (_____psi)	10			
Chemical Processing				
Facility - lights, HVAC	10	10		10
Fans & Blowers	20			
Material Handling	1		100	
Material Processing - grinding, mixing, screening	10			10
Process Cooling				
Process Heating	10	10		80
Pumps	38			
Boilers / Steam Production Temp: Pressure:	1	80		
Other				
Totals (100% or N/A):	100.00	100.00	100.00	100.00

Interview of Plant Personnel

- Number of employees
- Operating Hours of facility and major equipment
- Square footage of facility
- Copies of Utility Bills, check rate structure
- Copy of Motor Inventory (if available)
- Suspected High Energy Users
- Problem areas, Maintenance problems, etc.

Building the Audit Scenario

- Powerhouse
  - Production Processes
  - Special Purpose Equipment
  - Warehouse
- Building Envelope
- Lighting
- Transportation
  - Shipping / Receiving,
  - Warehouse,
  - Internal vs. External

Course Agenda

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Rite Stuff Paper Mill



Rite Stuff was founded by Jim Rite in the late 1960s. They are one of the few remaining stand-alone paper mills. Most of their competitors have added pulp mill capabilities, as well, but the community that Rite Stuff resides in is opposed to the smell that the pulp mill would bring with it.

Their facility has remained in the same location since inception, although they added some more warehouse space in the 70s to store all of the inventory they were stocking.



Some of their equipment dates back to the start of their business, as well. Joe Rite, Jim's brother and chief maintenance operator, is especially proud of how they've been able to keep the old boiler running all this time.

Rite Stuff Paper Mill



Jim Rite recently brought his granddaughter, Sally Rite, into the business as the chief accountant. Sally's first task was to calculate the Carbon Footprint of Rite Stuff in response to a customer request for this information.

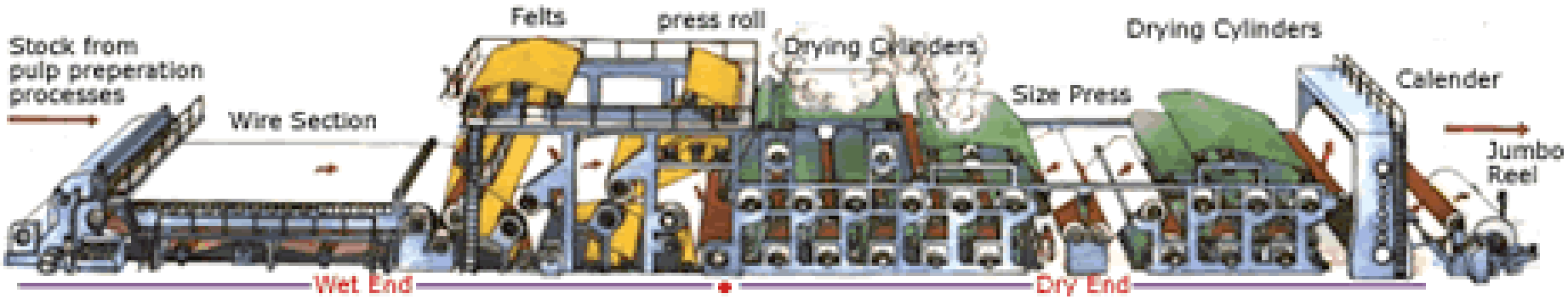
As Sally was gathering info for this calculation, she looked at the utility bills and thought they seemed really high. The Carbon Footprint calculator also indicated there is plenty of room for improvement in the way energy is used at Rite Stuff.

Sally Rite has asked for our help to audit their Energy systems and see if we can find some ways for them to save some money and reduce their Carbon Footprint.

Rite Stuff Paper Mill



Key Process Equipment:
Fourdrinier Machine



Key Personnel:



Owner
Jim Rite



Plant Engineer
“Big Joe” Rite



Maintenance Manager
“Junior”



Office Manager
Thelma Rite



Accountant
Sally Rite

Rite Stuff Processes



- **Headbox** – Clean pulp, called stock, is mixed with water to form a "furnish." Furnish is 99.5% water and .5% stock.
- **Presses** – A series of heavy, rotating cylinders press water from the paper, compacting it and reducing its moisture content to 60%.
- **Dryers** - Steam-heated cylinders contact both sides of the paper, evaporating the water to a 5% content level.
- **Size Press/Dryers** – Paper passes through a sizing liquid to make it less porous, then through additional dryers that evaporate the liquid from the sizing.
- **Calendars** – The paper rolls through polished steel rolls that make it even smoother and more compact.
- **Reel** – Paper is wound around a reel and removed from the machine.
- **Shipping** – Paper is then shipped around the world for many uses.

Sally Rite



Getting Started

- Contacted local resources
- Gathered industry baseline information
- Collected annual energy use data

Sally Rite Baseline Research



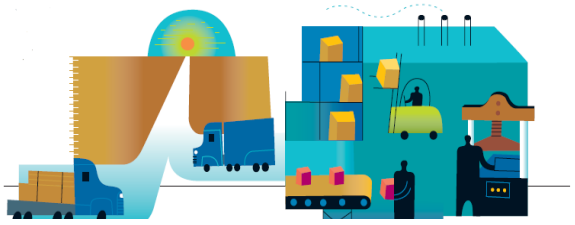


Table 7-3. Energy Consumption in Papermaking (Million Btu per Ton of Finished Paper)

Process	Steam	Electricity	Fuel	TOTAL
Paper Refining and Screening		0.84		0.84
Newspaper Forming, Pressing and Finishing		1.44		1.44
Newsprint Drying	4.07	0.10		4.17
Tissue Forming, Pressing, Finishing		1.82		1.82
Tissue Paper Drying	4.0	0.45	3.50	7.85
Uncoated Paper Forming, Pressing, Finishing		1.80		1.80
Uncoated Paper Drying	5.0	0.10		5.10
Coated Paper Forming, Pressing, Finishing		1.80		1.80
Coated Paper Drying	5.2	0.10		5.30
Linerboard Forming, Pressing, Finishing		0.92		0.92
Linerboard Drying	4.0	0.05		4.05
Papermaking Average (5.26 10^6 Btu/ton) Total Papermaking Energy Use/Yr: 554 10^{12} Btu (based on annual paper production of 85.4 million tons of paper and paperboard)[a]				

a Linerboard energy averages are assumed to be representative of the paperboard sector.

Sources: Jaccard 1996; AF&PA 2004a; Thorp 2006.

Energy Used Within Paper Manufacturing

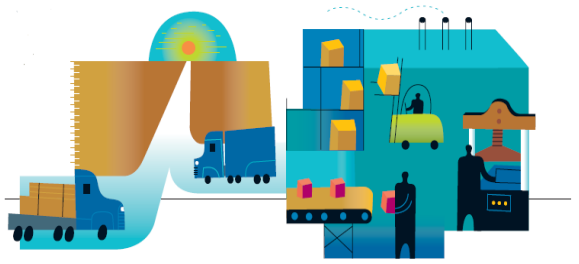
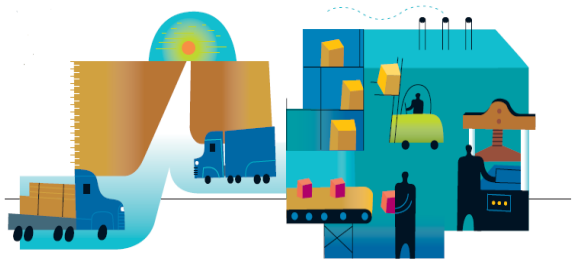


Table 4.4 Energy Used within Paper Manufacturing						
	Electrical Energy		Steam Energy		Direct Fuel Energy	
	TBtu	%[c]	TBtu	%[c]	TBtu	%[c]
Wet End[a]	103.2	49.9	107.8	20.0	0.0	0.0
Pressing	36.5	17.7	0.0	0.0	0.0	0.0
Drying	45.0	21.7	422.3	78.5	13.4	42.7
Dry End[b]	18.4	8.9	0.0	0.0	0.0	0.0
Coating Preparation	1.2	0.6	2.5	0.5	0.0	0.0
Coating Drying	0.0	0.0	0.0	0.0	17.9	57.3
Super Calendering	2.7	1.3	5.3	1.0	0.0	0.0
Total	**206.9** (26.7%)	100.0	**542.3** (69.3%)	100.0	**31.3** (4.0%)	100.0
Grand Total				**776.0** (100.0%)		

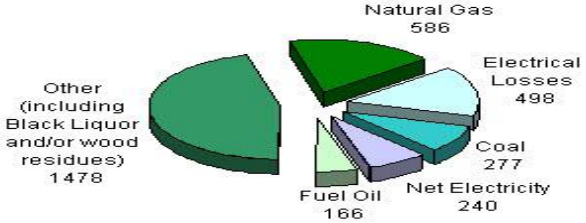
a. Wet End includes stock preparation through forming
b. Dry End includes calendering through winding
The percentages above represent an overall average for all papermaking processes and vary for individual processes (e.g., liner, uncoated freesheet, tissue, etc.)



Paper Demographics



Energy Consumption by Fuel – 1998 (NAICS 322 Pulp & Paper)



Total Energy Consumed
3245 trillion Btu (with electrical losses*)

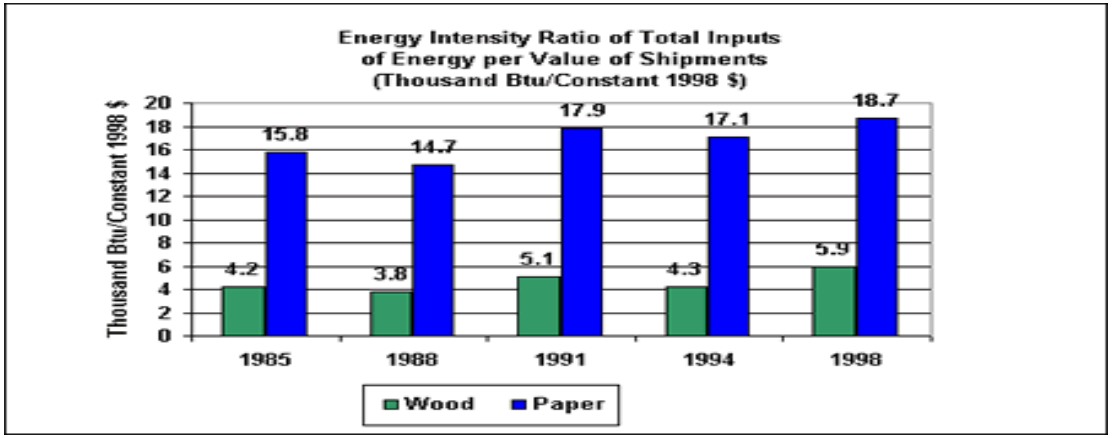
Source: MECS 1998

* Losses incurred during the generation and transmission of electricity

http://www.eia.doe.gov/emeu/mecs/iab98/forest/expenditures.html



Energy-Intensity: Ratio of Total Inputs of Energy per Value of Shipments



Source: MECS 1985, 1988, 1991, 1994, 1998, DOC 2001

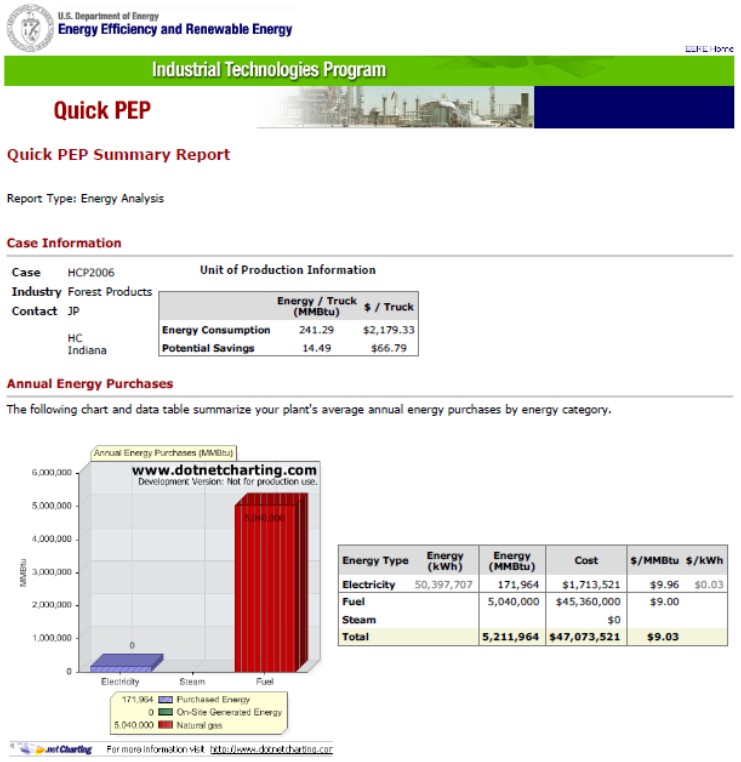
http://www.eia.doe.gov/emeu/mecs/iab98/forest/intensity.html

Baseline Comparison



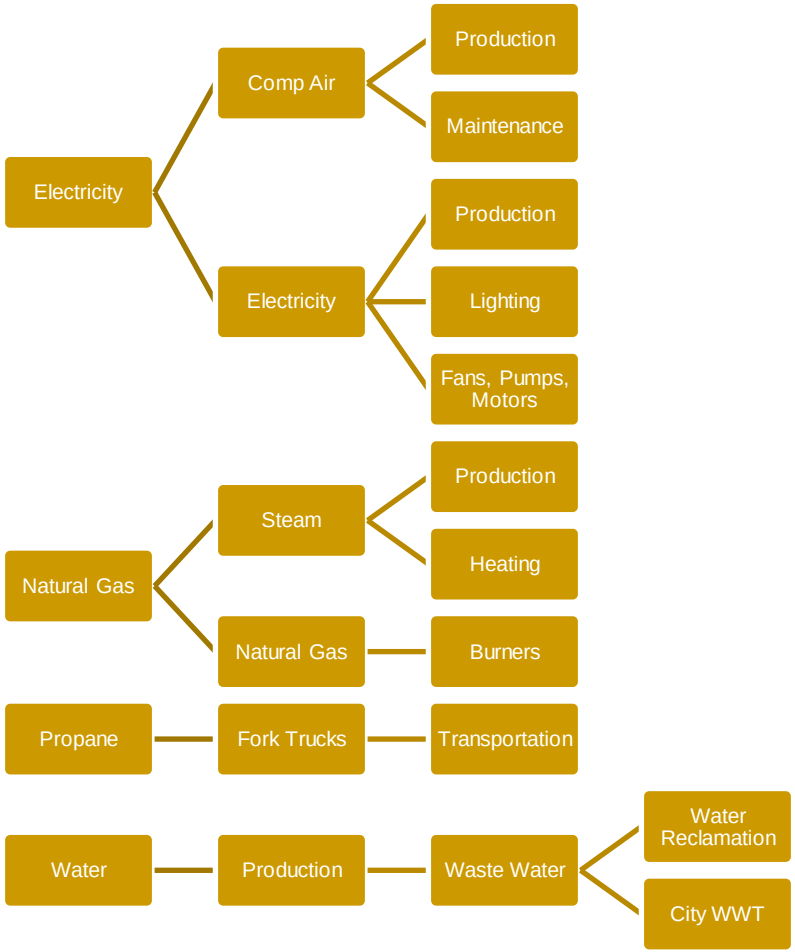
- U.S. Department of Energy
  - Quick Plant Energy Profiler on-line survey tool
    - Energy Intensity
    - Potential Energy Savings
    - Recommendations





Rite Stuff Energy Map





Initial Carbon Footprint at Rite Stuff

Reference Information for CO2 Emission Factors

	CO2 Emissions	
Energy Source or Fuel	lbs./MM Btu	kg/MM Btu
Electricity* (see note below)	142.5	64.626
Natural gas	117.1	53.098
Residual Fuel Oil - #6	173.9	78.869
Coal (Bituminous)	215.2	97.596
Kerosene	159.5	72.351
LPG	139.0	63.056
Distillate fuel (Diesel)	161.4	73.191
Black Liquor	221.6	100.501
Blast Furnace Gas	604.6	274.190
Butane	141.8	64.309
Coke	225.1	102.100
Coke Oven Gas	103.2	46.823
Crude Petroleum	170.4	77.300
Distillate Fuel (Light Fuel Oil)	161.4	73.191
Ethane	130.0	58.970
Gasoline	156.4	70.941
Isobutane	142.0	64.419
Methane / Landfill Gas	115.3	52.271
Municipal refuse (Dry)	145.9	66.157
Peat	246.5	111.785
Propane	139.2	63.119
Wood Waste (Hog Fuel)	195.0	88.435
Other 1	162.0	73.469
Other 2	210.0	95.238



Baseline Comparison

- Energy comparison

Energy Source	Potential Savings	Energy Saving/Reel	Total Cost Savings	Cost Savings/Reel
kWh	5,333,894	118 kWh	$180,800	$4.02
Nat Gas	441,000 dt	9.8 dt	$3,969,000	$88.20
Totals: (Savings in MMBtu)	459,200.00 MMBtu	10.204 MMBtu	$4,149,800	$92.22

- CO2 Comparison

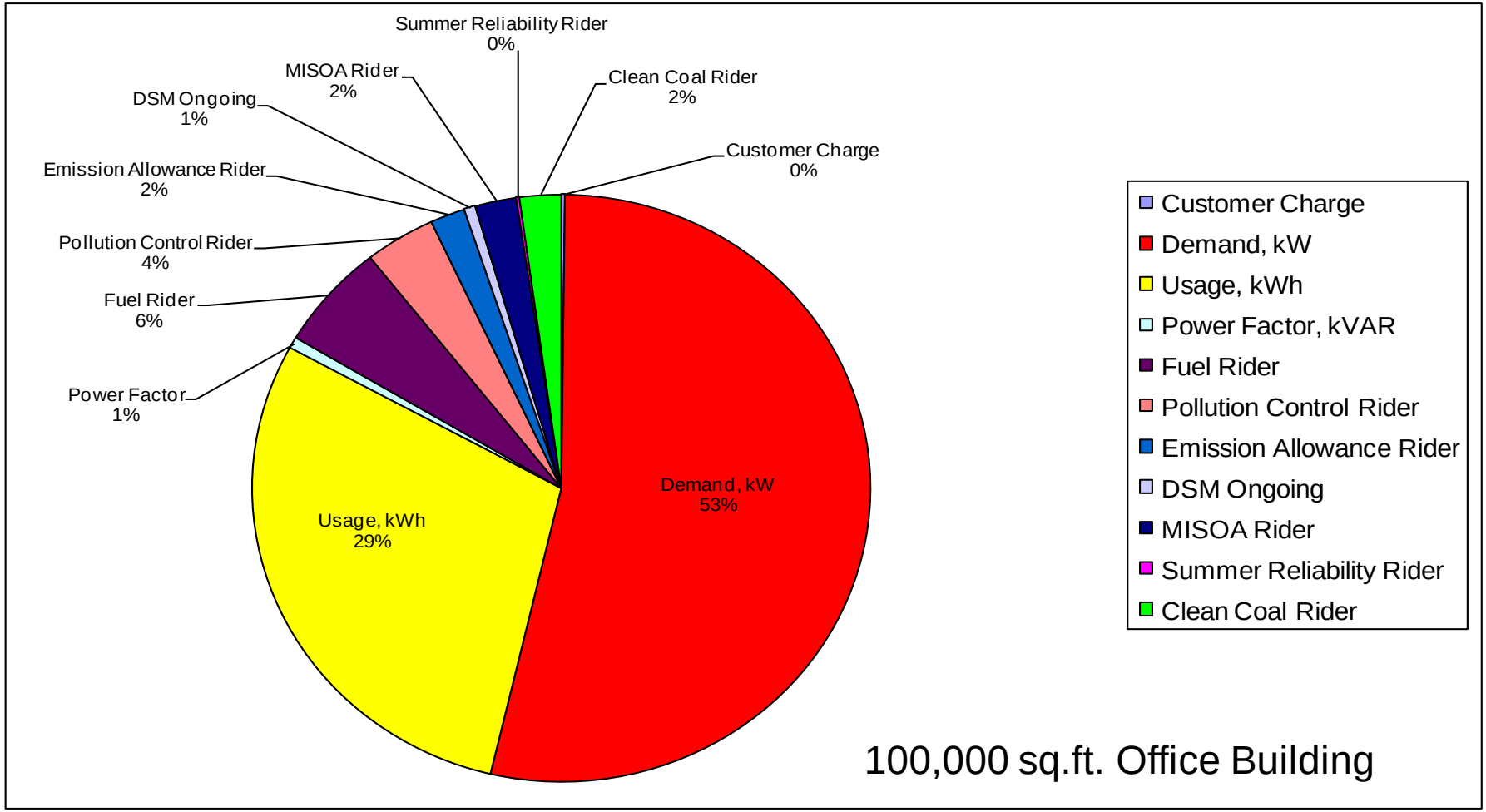


Potential CO_2 Savings From Electricity 3573 tons/yr.
Potential CO_2 Savings From Fuel/Steam 25,816 tons/yr.

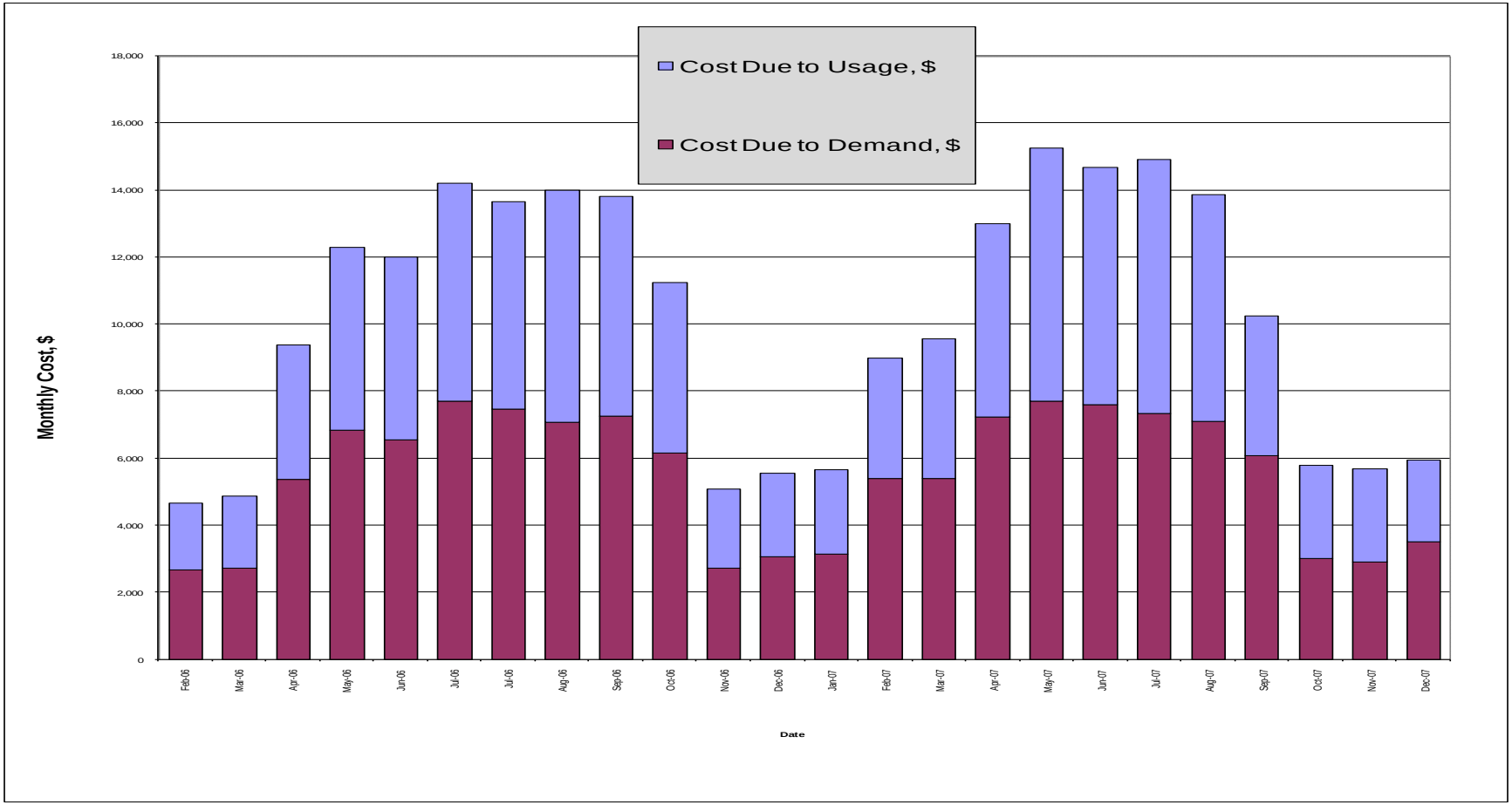
Course Agenda

- Energy Consumption & Sources
- Energy Audit Prep
- Energy Audit In Practice
  - Utility Bill Analysis
  - Fueled Systems: Process Heating, Steam
  - Electric Systems: Compressed Air, Fans & Pumps, HVAC, Lighting
  - Transportation
  - Co-Generation
- Carbon Footprint
- Alternative / Renewable Energy Sources
- Systems Approach
- Course Evaluation

Electrical Cost Breakdown



Seasonal Electrical Cost Variations



Electric Bill Variables

- Power Factor Penalty
- Sales Tax (5-10% Additional depending on location)
  Note: May be sales tax exempt if energy use is primarily for manufacturing
- Load Factors
- Peak rates / Off Peak Rates
- Time of Day / Seasonal Peaks
- Option to purchase renewable energy
- Participation in Demand Side Management (DSM) programs

Natural Gas

Measured in: volume or heat content
Volume: Cubic Feet (cu.ft or cf),
100 cf = ccf
1000 cf = tcf
1,000,000 cf = mcf
Heat Content: British thermal units (Btu)
1000 Btu = Mbtu
1,000,000 Btu = MMBtu

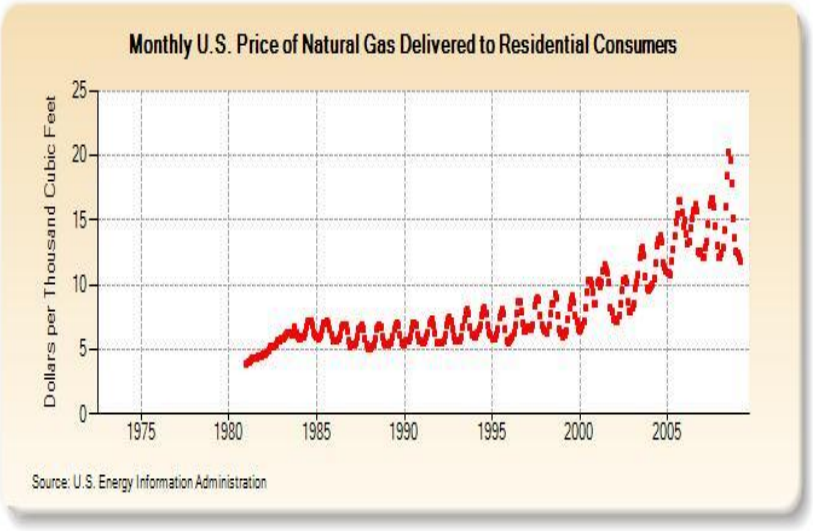


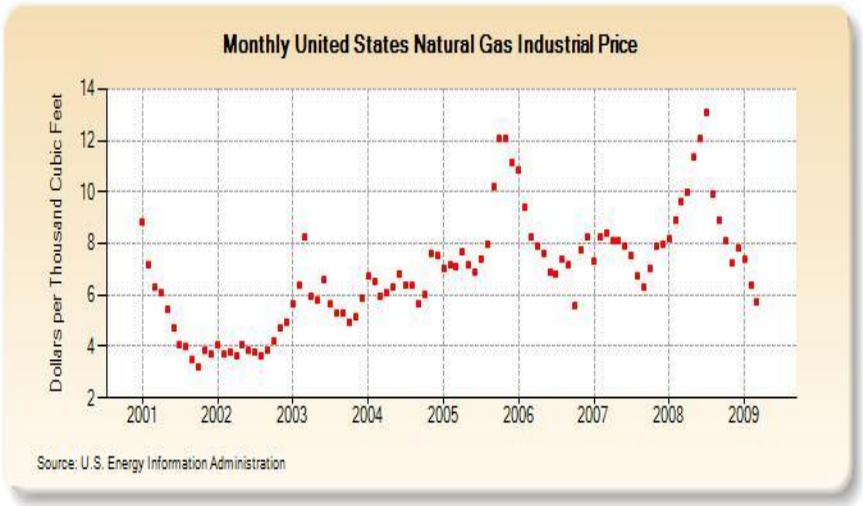
Efficiency = Energy Out / Energy In

For a 90% efficient Water Heater,
where does the other 10% go?

Natural Gas Prices



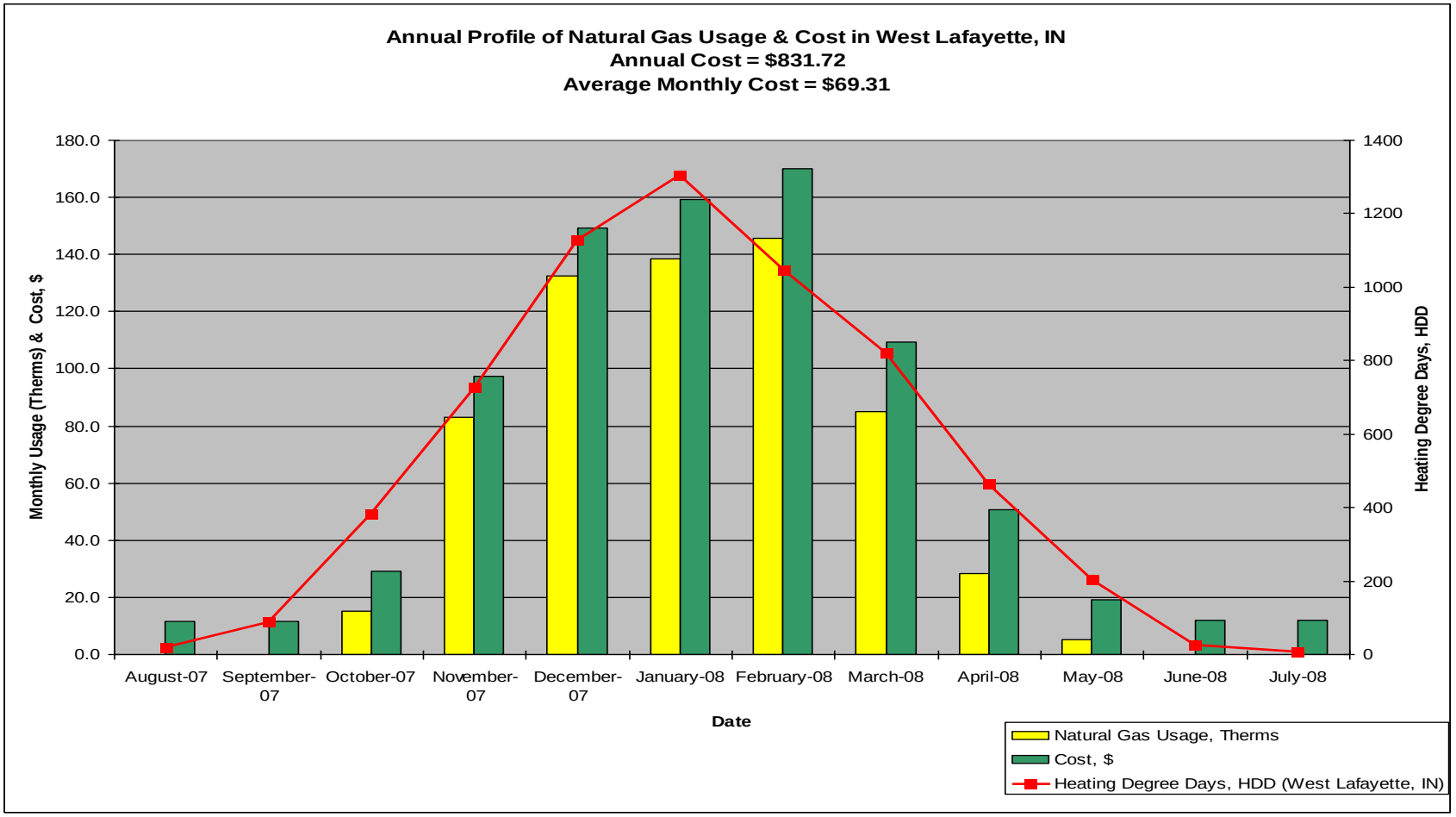




As natural gas usage becomes more prevalent for electricity production, the volatility and cost has been increasing!

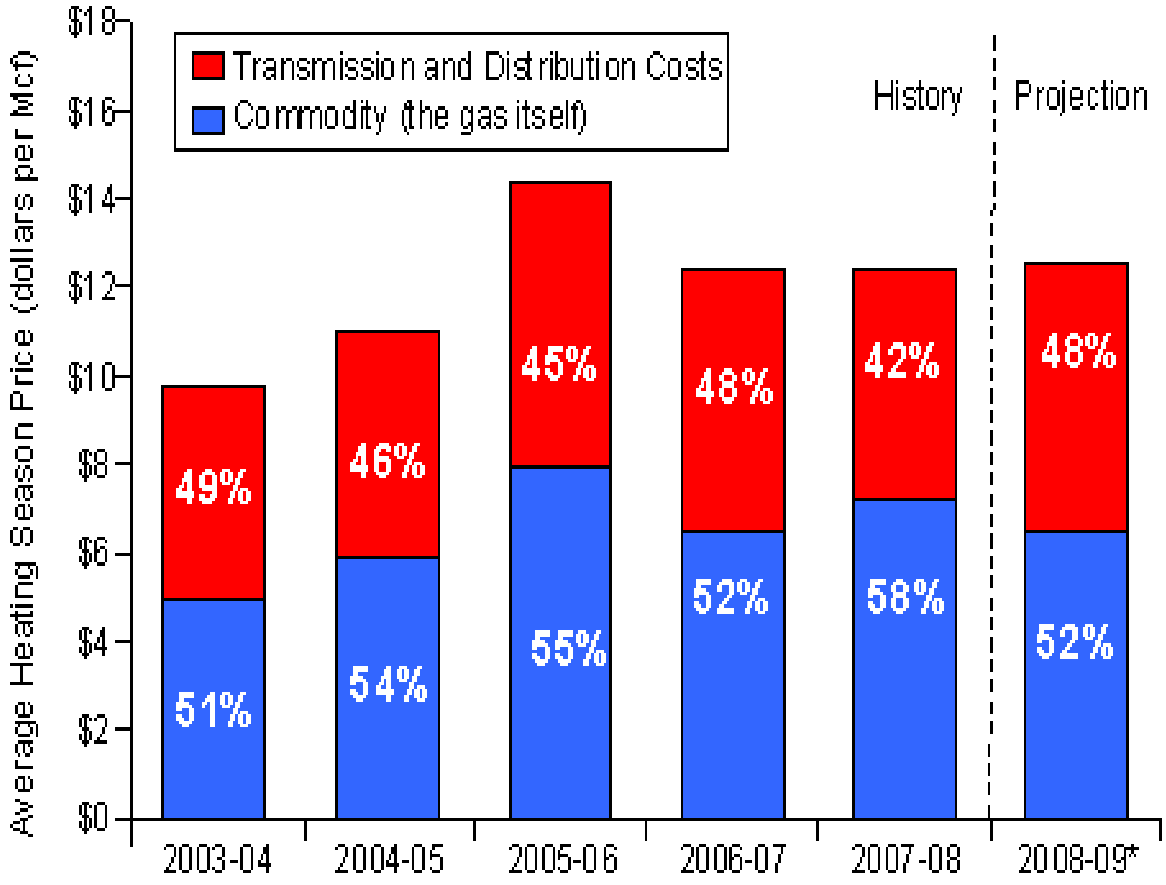
Source: EIA 2009

Seasonal Natural Gas Load



Natural Gas Bill Variables

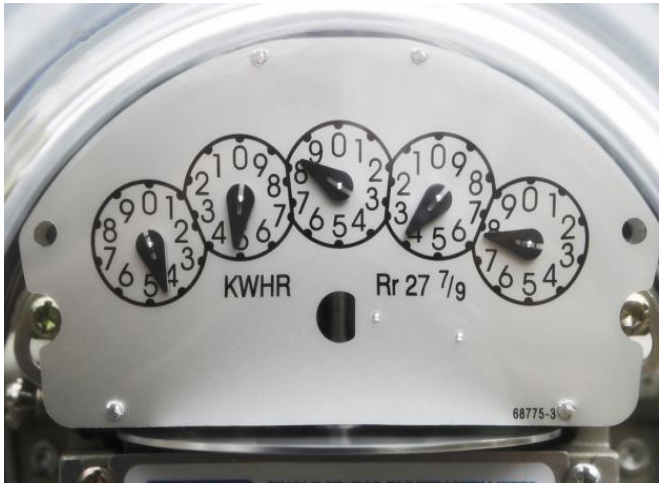
- Quantity Consumed
- Transmission /Distribution Charges
- Sales Taxes (if applicable)



Source: Energy Information Administration, Short Term Energy Outlook (November 2008)

Utility Analysis at Rite Stuff

- What is Rite Stuff paying for?
- Are they are the correct tariff?
- What is the utility encouraging & discouraging?
- Where can they save?





Utility Analysis at Rite Stuff



Gotham County Municipal Utilities
Calculation of LP Rate Charges

Bill To: Rite Stuff Paper Co, Inc.
100 Backwater Road
Happy Hollow GO, 46205

Date 09/24/2007
Acct#: 555-12345
Site: 100 Backwater Rd

Electric Service Rendered from 08/20/07 to 09/26/07 — Schedule LP

Meter Number:	901080595		Demand (KVA)
Pres Reading:	5282893920	Demand Reading	5565.31
Prev Reading:	5285417460	X Meter Multiplier	1.025
Diff:	2523540	= Metered	5704.44
Meter Multiplier:	1.0	/ Power Factor	0.84
Consumption:	2523540	= Act-Demand	6791

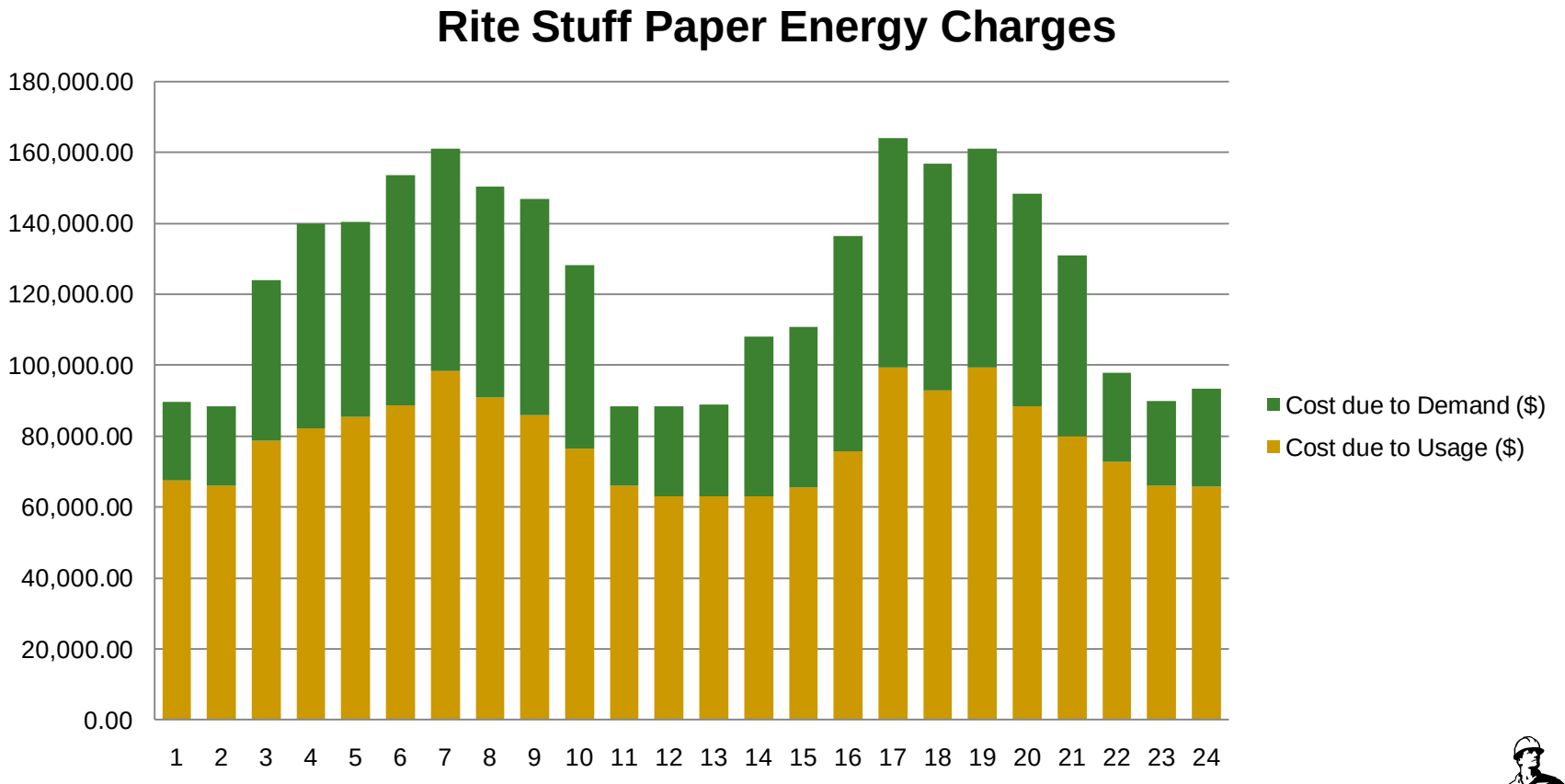
Calculation of Bill

Facility Charge:				150.00
Demand Charge:	Rate LP Regular	6791 kVA x $9.00		61,118.82
Energy Charge				
0 to 100,000 kWh		100000 X 0.041		4100.00
100,001 to 250,000 kWh		150000 x 0.039	5850.00	
250,001 to 500,000 kWh		250000 x 0.034	8500.00	
500,001 to 1,000,000 kWh		500000 x 0.030	15000.00	
1,000,000 to 10,000,000 kWh		1523540 x 0.028		42659.12
Total				76,109.12
Fuel Cost Adjustment	$0.00384 x 2523540 kWh			9,690.88
Total Billing for Electric Service	>>>>>			146,918.82



Energy Charges





Utility Bill Analysis

- Paying for low power factor
- Encouraged to use more power,
- But penalized for higher demand

- Opportunities
  - Demand reduction
  - Power factor correction
  - Consumption reduction



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Natural Gas Systems at Rite Stuff

- Process Heating in paper making
- Boilers / Steam System
- Space Heating





Process Heating

- Direct Fired Gas Furnaces





- Electric Arc Furnaces (Typically very efficient)



STEEL BEING POURED IN AN ELECTRIC FURNACE

Causes of Inefficiency - Process Heating (with Natural Gas)

- Excess Combustion Air
- Air Leakage / Air Infiltration
- Radiation Losses
- Insulation Failures
- Fouled heat transfer surfaces (scale, soot, sludge, or slag)
- Lack of Waste Heat Recovery

Process Heating – Best Practices

- Tune Burner Air-to-Fuel Ratios
- Waste Heat Recovery
- Preheat Combustion Air
- Reduce Air Infiltration & Radiation Losses
- Reuse Waste Heat in External Processes
- Consider Load Pre-heating and/or Oxygen Enrichment

Process Heating -Low-Cost & No-Cost Actions

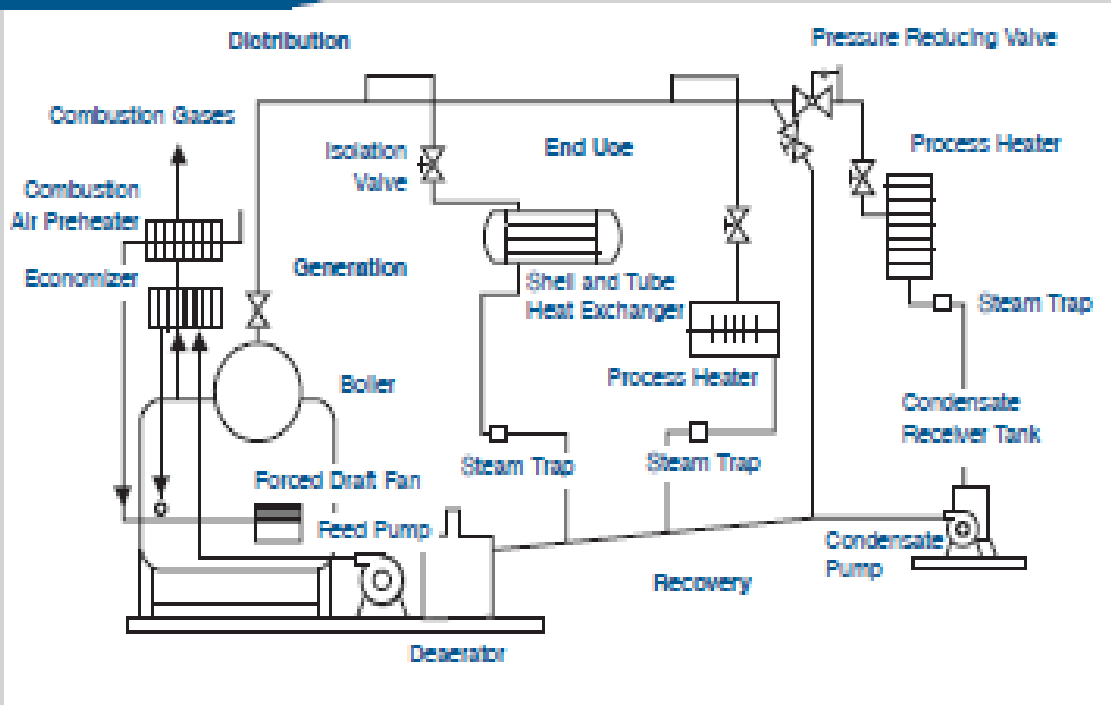
- Measure & Maintain proper air/fuel combustion ratios.
- Control furnace pressure to minimize air infiltration
- Replace/repair failed insulation & door seals to minimize radiation losses
- Minimize time doors are open
- Install radiation shields on permanent openings

Powerhouse / Power Systems

- Boilers
- Steam / Hot water heaters
- Process heating
- Special Purpose Process Equipment
- Compressed Air
- Motors / Rotating Equipment

Steam/Hot Water

Steam System Schematic



Running a steam system efficiently requires much more than tuning boilers because many cost-saving opportunities exist downstream from the boiler.

Causes of Inefficiencies – Boilers

- Pressure too high
- Poor system controls - too much combustion air
- Steam leaks - traps blowing through
- Maintenance Issues:
  - Adjust damper linkages
  - Insulation damage
  - Leaks, steam traps
  - Lubricate fans and pumps
  - Clean tubes
  - Water quality

Best Practices - Boilers

- Review for leaks, check traps
- Maintain air/fuel ratio
- Stack economizers
- In systems with more than one boiler, rather than operate both at medium fire, operate one at high fire and idle the other.
- Regularly clean & inspect tubes

US DOE Tip Sheets can be found at:

http://www1.eere.energy.gov/industry/bestpractices/tip_sheets_steam.html

Initial Interview - Joe Rite



Potential Projects



Questions:

1. List three projects that Joe Rite has already considered:
   a. Buy a new 10,000 lb/hour boiler
   b. Install economizers and optimize the existing steam system
   c. Peak shaving
   d. Switching to transmission (69 kV) power from 4160W
   e. Burning paper waste in the boilers
2. Discuss these the pros and cons of these projects

Rite Stuff Powerhouse



Option 1: continue to do minimal rebuilds and buy a trim unit – this will provide more capacity but not address demand side inefficiencies. Cost: $100,000

Option 2: Optimize existing units including installation of recuperators, insulating piping, fix steam trap leaks and optimize demand side use. Cost $250,000

The existing boilers used $3,628,800 last year (at this year's prices). The two boilers required $75,000 in annual maintenance and water treatment.



The Boiler at Rite Stuff

- What are the advantages of option #1?
- Are there any disadvantages?

- What are the advantages of option #2?
- What long-term issues must be considered?



A Simple System Cost Analysis

System Costs		Baseline	Option 1	Option 2
Installation Costs (occurs in Year 1)	A			
1. Preventative Maintenance (recurring costs)	1			
2. Predictive Maintenance (recurring costs)	2			
3. Energy (recurring costs)	3			
4. Lost Production	4			
Annual Cost	B = (1+2+3+4)			
Cumulative Outlay end Year 1	=A+B			
Cumulative Outlay end Year 2	= A+B+B			



Rite Stuff Powerhouse



	Option 1	Option 2
A. Installation Costs (occurs in Year 1)	$100,000	$250,000
1. Maintenance (recurring costs)	$ 5,000	$ 70,000
2. Energy Costs (recurring cost)	$ 3,628,800 (450,000) $3,178,800	$3,628,800 (650,000) $2,978,800
B. Annual Costs = Maint. + Energy	$3,183,800	$3,048,800
Cumulative Outlay at End of Year 1 = A + B	$3,283,800	$3,298,800
Cumulative Outlay at End of Year 2 = A + B + B	$6,462,600	$6,347,600

Course Agenda

- Energy Consumption & Sources
- Energy Audit Prep
- Energy Audit In Practice
  - Utility Bill Analysis
  - Fueled Systems: Process Heating, Steam
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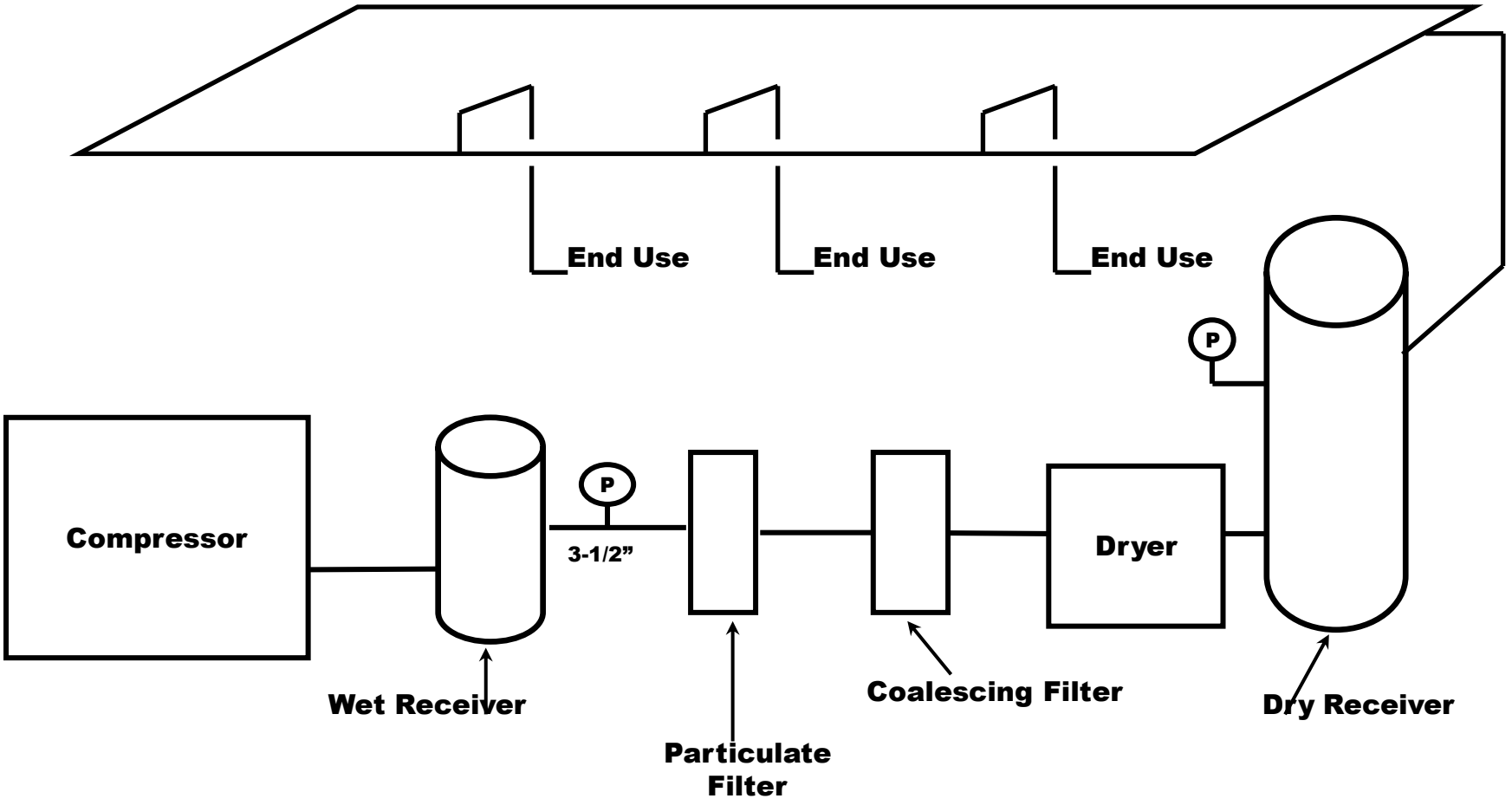
Electric Systems: Motors

- Motor Driven Systems
  - Fans & Blowers
  - Pumps
  - Air Compressors
  - Chillers





Compressed Air



Causes of Inefficiency - Air Compressor

- Poor System Controls
- Inefficient Air Dryers
- Inappropriate uses of air
- Inadequate Air Supply
- Inefficient Air Filters

Air Compressors – Best Practices

- Adjust supply pressure to meet demand needs
- Air leaks can eat up 30 to 50%. An aggressive leak control strategy can reduce this to 10-15%
- Clean and dry the air only as necessary for the end uses
- Optimize controls
- Use large diameter piping. Avoid “T” piping between compressors
- Have adequate storage

Initial Interview with Junior
The Air Compressor



Compressed Air at Rite Stuff

- Compressed air is used for the following
  - Paper making process
  - Maintenance equipment
  - Cabinet cooling
  - Cleaning
- Costs associated with their compressed air system
  - Approximately 100hp of leaks



Air Compressors at Rite Stuff

- Cost of leaks:
  - 100 hp = 100 hp x 0.746 hp/kW
  - Compressors are loaded approximately 70%
  - Efficiency of motor is 90%
  - Marginal cost of electricity is $0.034/kWh
  - Plant is in operation 8000hr/year
- Cost of leaks = $15,782/year



Air Compressors: Rules of Thumb

- Most compressors deliver 4-5 cfm per 1 hp at 100 psi
- Every 2 psig of pressure increases or decreases the power draw by 1%
- Every 10 deg F change in inlet air temp affects efficiency about 1%
- Power costs for 1hp x 3 shifts at $0.10/kWh = $750/year
- A 50 hp Compressor rejects 126,000 Btu/hr



Motors / Rotating Equipment

Causes of Inefficiency

- Poorly / Improperly rewound motor
- Inadequate maintenance
- Pump or fan oversized to load
- Partially closed dampers or valves
- Loose belts, poorly aligned pulleys

Motors / Rotating Equipment

Best Practices

- Proper motor sizing.
- Implementing a Preventive and Predictive Maintenance
- Variable speed drive (where appropriate)
- Pump impeller or fan blade optimized to load
- Operating equipment on fan-curve or pump curve

Good Maintenance = Energy Savings

- Aligning shaft and pulleys
- Cleaning impellers and heat exchangers
- Replacing filters
- Adjusting linkages of valves/dampers
- Oil analysis on compressors
- Vibration monitoring of bearings
- Infrared thermography of fan or motor bearings

Interview with Sally
Rotating Equipment



Story Problem: A Really Big Fan

Situation: A new dust collector is needed



Which is More Cost Effective?

Option #1: A 200 hp radial bladed fan. The fan efficiency is 55%.

It costs **$70,000**.

Option #2: An airfoil fan. The fan efficiency is 85%.

It costs **$105,000**.



A Simple System Cost Analysis

System Costs		Baseline	Option 1	Option 2
Installation Costs (occurs in Year 1)	A			
1. Preventative Maintenance (recurring costs)	1			
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4. Lost Production	4			
Annual Cost	B = (1+2+3+4)			
Cumulative Outlay end Year 1	=A+B			
Cumulative Outlay end Year 2	= A+B+B			

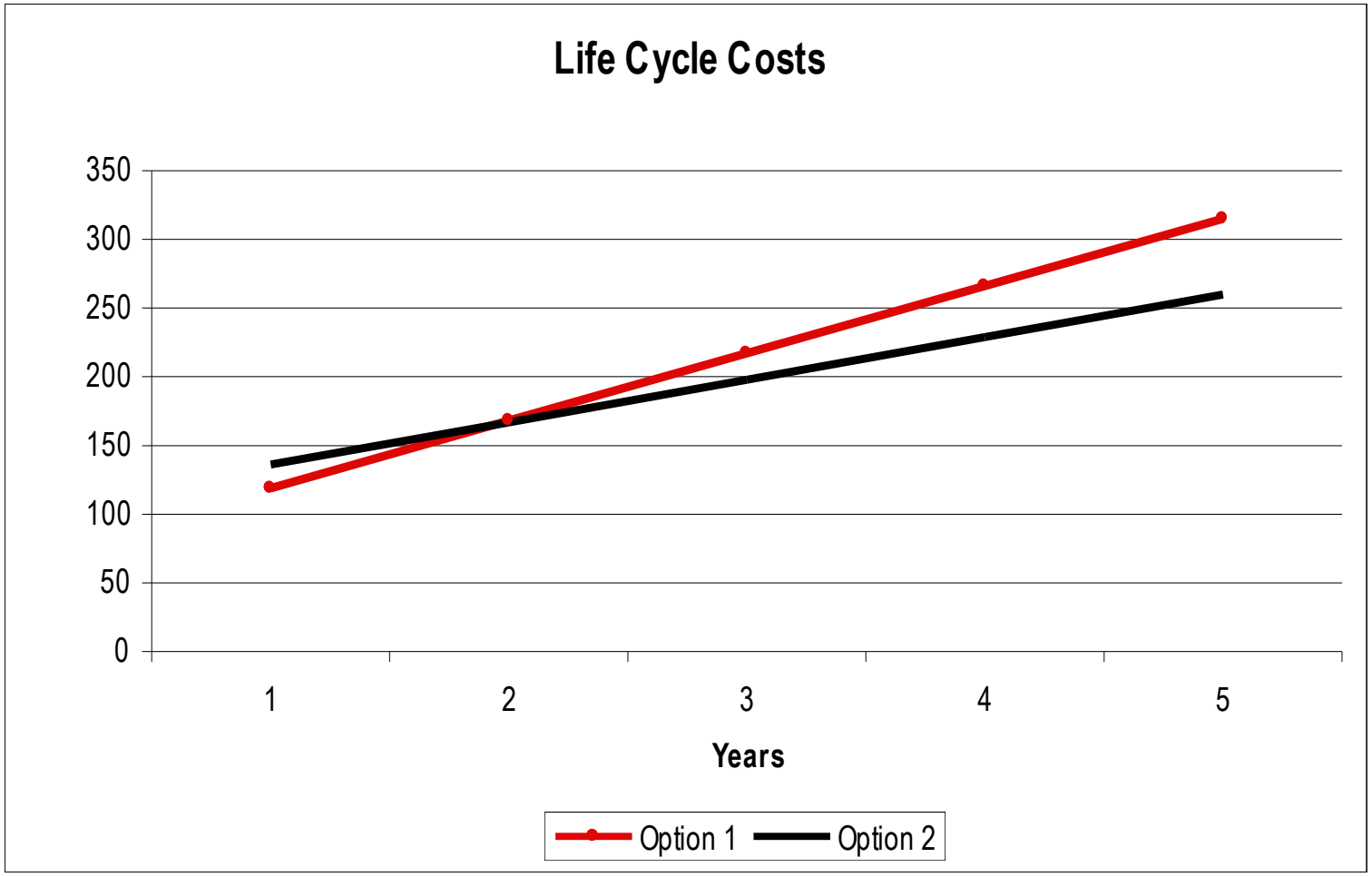


System Cost Analysis

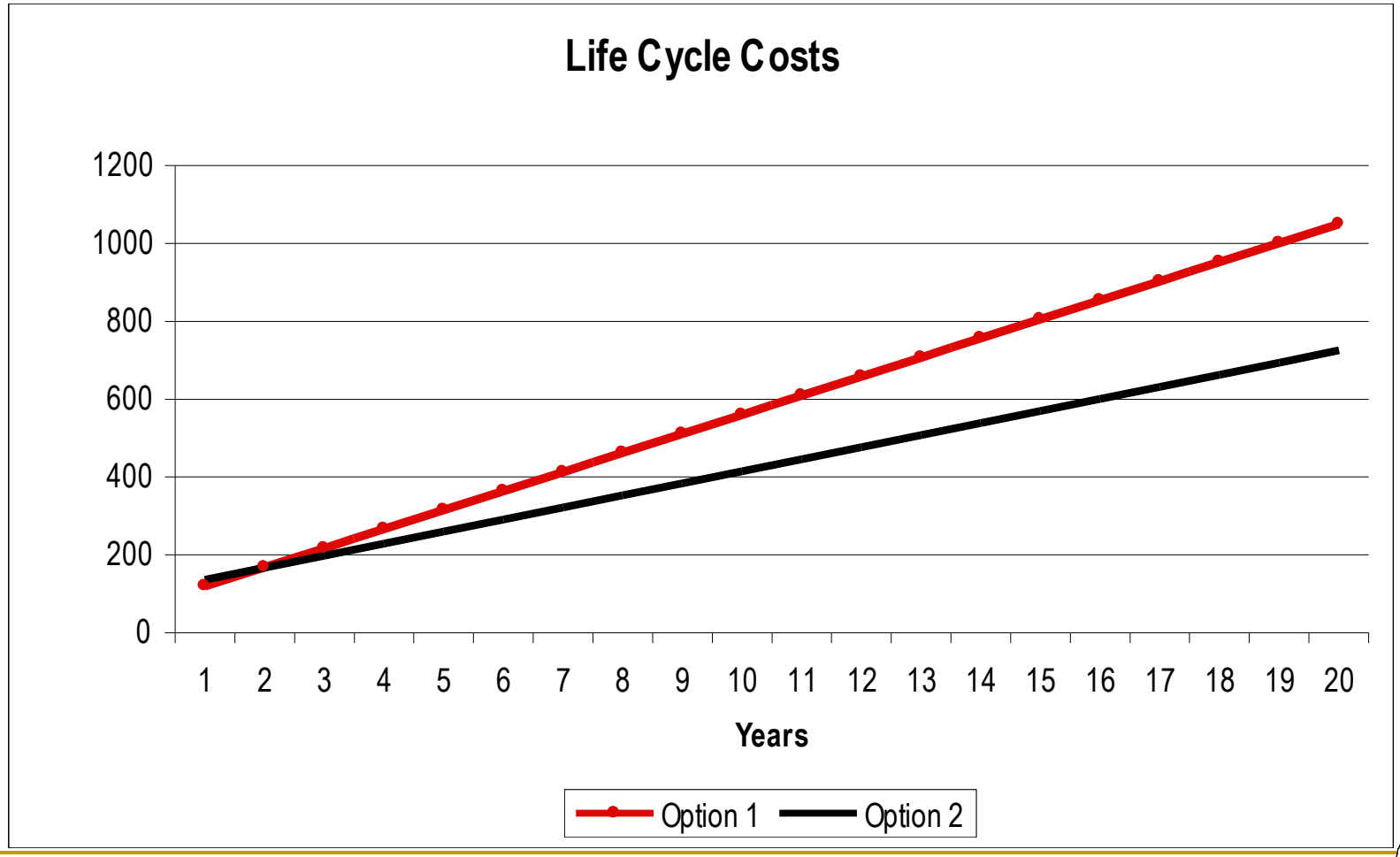
	Option 1	Option 2
Installation Cost (Year 1)	**A.** $70,000	**A.** $105,000
1. Maintenance Cost (R)	$1,000/yr	$1,000/yr
2. Energy Cost (R)	$48,000/yr	$30,000/yr
3. Lost Production Cost	NA	NA
Annual Recurring Cost [Total 1 + 2 + 3]	**B.**	**B.**
Cumulative Outlay at End of Year 1 [Total A + B]		
Cumulative Outlay at End of Year 2 [Total A + B + B]		



Cash Flow Graph Years 1-5

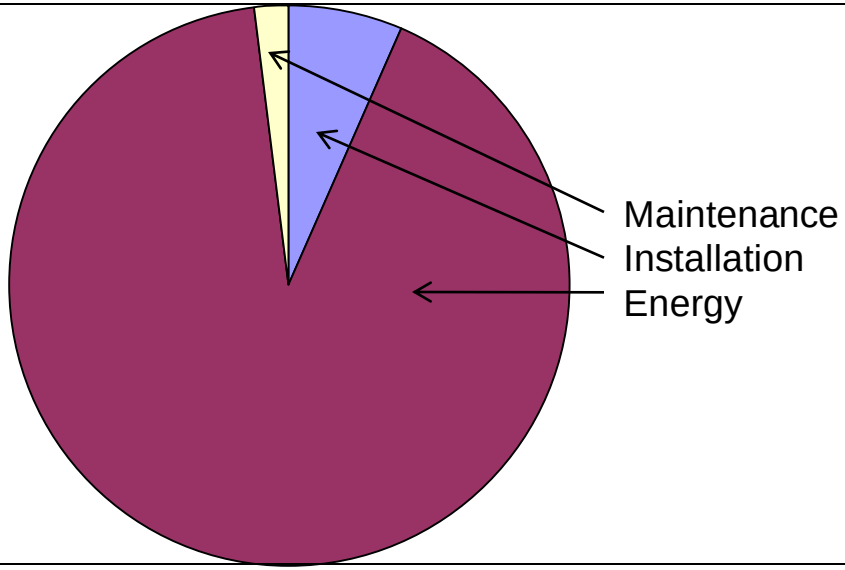


Cumulative Cash Flow Graph



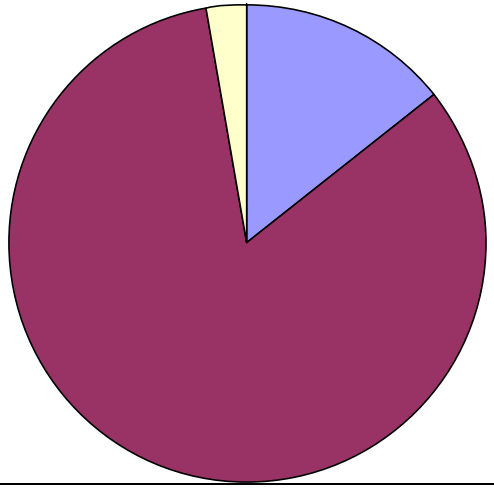
Overall System Costs of Options

Option 1 Radial Fan



Lifetime Cost
$1,050,000

Option 2 Airfoil Fan



Lifetime Cost
$725,000

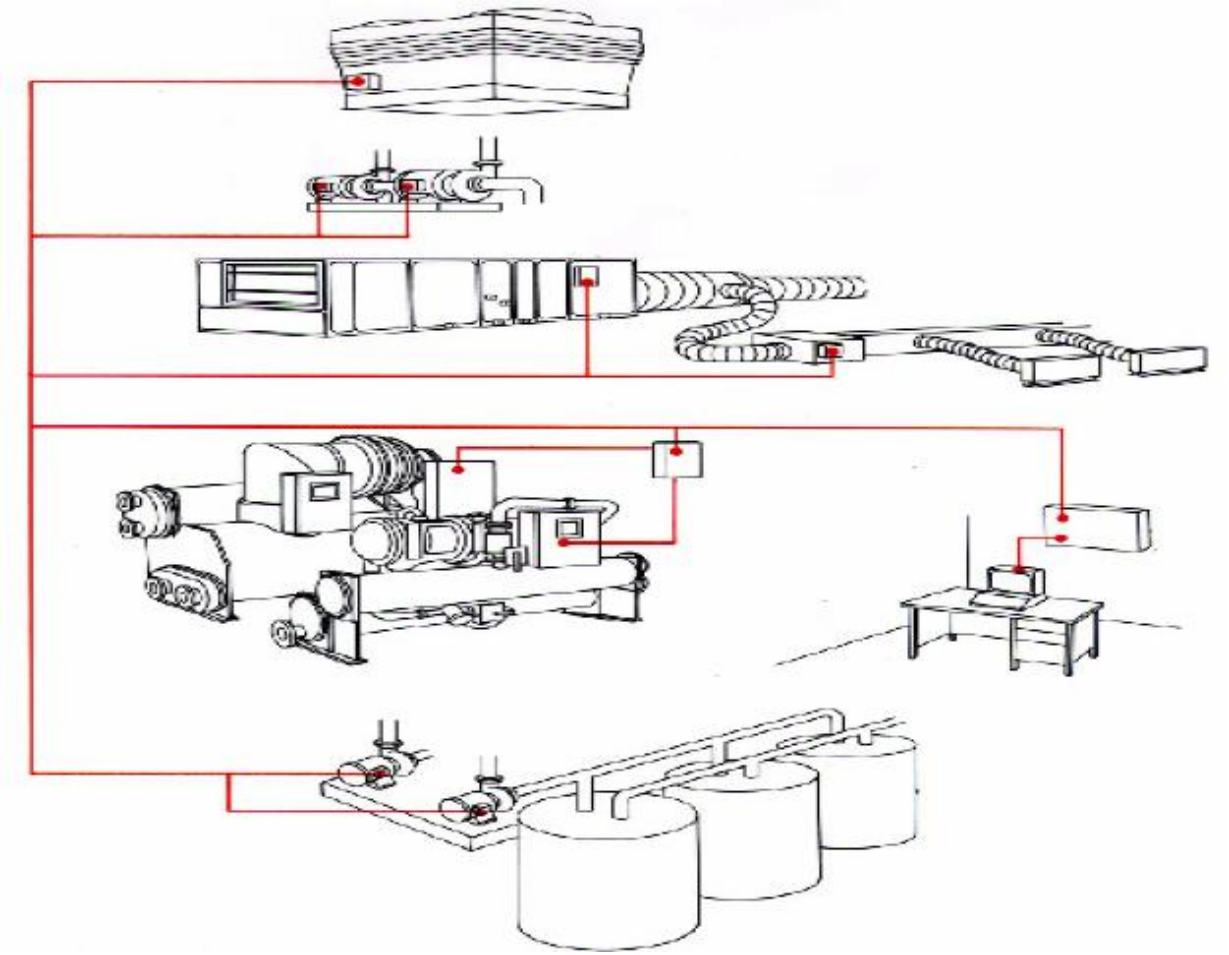
Facilities

- HVAC System
  - Chillers
  - Cooling towers
  - Duct work
  - Vents and returns
  - Fans
  - Pumps
- Lighting
- Building Envelope
- Electrical Supply System (Co-Gen)

Course Agenda

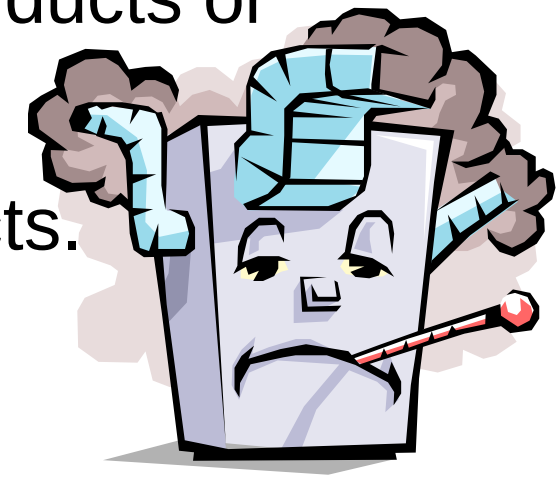
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HVAC



Causes of Inefficiency - HVAC

- Improper sizing. Oversized systems do not properly dehumidify; undersized systems can not maintain temperature.
- Poor system design. Undersized ducts or unnecessary elbows & offsets
- Leaky ductwork. Uninsulated ducts.
- Undersized fans



Best Practices - HVAC

- Variable Frequency Drives (VFD's) for Air handler fan drives can substantially reduce energy consumption on a Variable Air Volume (VAV) system.
- Economizers to make use of "free cooling" during the spring/fall months.
- Cogged V-belts to reduce friction losses.
- Install occupancy sensors/programmable thermostats

Preventive Maintenance – HVAC

- Review and/or re-commission control logic to ensure that system is operating as designed
- Maintain / lubricate damper controls
- Clean heat transfer coils & fans regularly
- Replace damaged/missing insulation
- Replace air filters regularly

Low-Cost & No-Cost Actions HVAC

Better Operation

- Verify proper control settings on HVAC
- Seasonal Setbacks



Benefit

- Increase Comfort
- Reduce energy use 1% for every 1 deg F

Building Envelope

- Walls
- Roof/Ceiling
- Windows and doors
- Land use



Causes of Inefficiency - Building Envelope

- Poor design / building age
- Lack of insulation / deterioration of insulation
- Metal framed / single pane windows
- Gaps in exterior openings (overhead doors, man doors, ventilation systems, wall penetrations, etc.)

Preventive Maintenance – Building Envelope

- Insulation, Insulation, Insulation!
- Weather stripping, caulking
- Repair / replace windows
- Roof repair (wet insulation does a poor job of insulating)
- Replace / repair damaged doors (forklifts!)

Low-Cost & No-Cost Actions
Building Envelope

- Keep the doors closed
- Programmable Thermostats (Can save 10-30% of heating/cooling costs)
- Occupancy sensors
- Plug holes and cracks in exterior doors, windows, and walls
- Insulate, insulate, insulate!

Low-Cost & No-Cost Actions
Hot Water Heaters

Better Operation

- Install timers
- Set at 110º F instead of 120º F
- Make seasonal adjustments

Benefit

- Each 10 degree Fahrenheit reduction in water temperature will generally save 3 – 5 % on water heating costs.

LEED: Leadership in Energy & Environmental Design

- U.S. Green Building Council
  - An internationally recognized certification system that measures how well a building performs across several metrics:
  - Energy, Water, CO_2, Indoor Air Quality, Environmental Quality, Stewardship of Resources and Sensitivity to Impacts



Auditing in the Office
Interview with Thelma





Office Environment at Rite Stuff

- 10,000 sq. ft.
- Monday-Friday
- 70 computers & office machines
- 100 4-bulb T-12 fluorescent fixtures
- Roof-top A/C
- Heating via steam loop



Office Energy Efficiency



70 computers, copiers and other office equipment are drawing 2200 watts when not in use, a total of 6500 hours a year.

How much energy and cost is being wasted?

HVAC Case Study

- The office is often too cold in the central area, but too hot in some of the offices and meeting rooms.
- There is only one thermostat
- Heating is supplied by the plant steam system
- Air conditioning is supplied by a roof-top condenser unit
- Estimated costs are $25,000/year

HVAC Case Study

- Recommendation:
  - Install programmable thermostat
  - Modify air handler to allow free cooling
  - Install more terminal reheat units
  - Raise temperature of air from condenser units
- Cost $10,000
- Estimated annual savings $3,000



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Lighting

- Incandescent
- Fluorescent
- High-intensity discharge
  - High-pressure sodium
  - Low-pressure sodium
  - Metal halide
  - Mercury Vapor, Halogen, Quartz, other
- Light emitting diode (LED)

Causes of Inefficiency - Lighting

- Old, inefficient fixtures
- Improper lamp (bulb) selection
- Poor maintenance
- Poor design / layout of fixtures

Preventive Maintenance – Lighting

- Group relamping at 80% of estimated bulb life saves money and maintains appropriate light levels.
- Replacement of lamps with more efficient newer designs
- Cleaning fixtures and reflectors

Low-Cost & No-Cost Actions
Lighting

Better Technology

- Compact Fluorescents
- High-Bay Fluorescents
- Automated/Programmable Controls
- Motion Sensors



Auditing in the Warehouse





Replace Metal Halides with Fluorescents



Analysis

The warehouse has 100 metal halide lights that use 400-W lamps. The ballasts for these lights draw about 65 W each.

New high-bay fluorescent lights that use four 8-ft T8 lamps in specially-designed high-efficiency fixtures are available. The high-bay fluorescents lights draw about 227 W per.

Fluorescent Fixtures





Estimated Savings



The electricity savings from replacing the current fixtures with the proposed fixtures would be about:

Assume $0.034 kWh and $10.00 / kW during peak hours

100 fix x [(460-227W)/1000 W/kW] x 8000 hours/year x $0.034/kWh =
$6337.60 usage savings

100 fix x [(460-227W)/1000 W/kW] x $10/kW x 12 month/year =
$2796 demand savings

Total **$9133.60 cost savings**

Maintenance Costs



T8 life = 15,000 hours x 1.25 = 18,750 hours

MH: [100 fix x (8,000 hours/year / 20,000 hours)] x 1 lamps/fix = 40 lamps/year

T8: [100 fix x (8,000 hours/year / 18,750 hours)] x 4 lamps/fix = 171 lamps/year

Metal Halides cost about $23/each while T8 lamps cost about $6 each.

MH: $920 /year

T8: $1026 /year

Thus, annual maintenance costs could increase by: = $106 /year

The net savings would be about: $9,133.60 + (106.00) = $9,027.60 /year

Estimated Implementation Cost



Cost of a new high-bay fluorescent fixture is about $185. Assuming $25 per fixture installation costs, the total implementation cost :

100 fixtures x ($185 /fixture + (60/60 hours/fixture x $25 /hour)) =
$21,000

Estimated Simple Payback:

($21,000 installation costs) / ($9,027.60/year cost savings) x 12 months/year = 27.9 months

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Transportation Metrics

- Overall Road Miles
- Average mileage of fleet vehicles
- Fuel use per $ revenue
- Carbon (CO_2) generated per $ revenue/profit
- Maintenance/Operating Costs of internal (lift truck) operations

Causes of Inefficiency - Transportation



- Idling
- Inefficient routes
- Oversized vehicles for the job
- Inefficient motors
- Inefficient packaging
- Shipping partial loads
- Just-in-Time delivery

Transportation Considerations

- Alternative Transportation Fuels
- Hybrid Vehicles for fleet (tax incentives)
- Plug-In Electric Vehicles for local errands (tax incentives)
- Electric vs. LP vs. Diesel (Biodiesel?) for lift trucks

Low-Cost & No-Cost Actions
Transportation

- Optimize logistics of product flow (Get Lean!)
- Specify / demand fuel efficiency when purchasing new equipment (look at life cycle cost rather than just first cost)
- Off-peak rates for recharging fork lifts (if available)
- Consider Smartway vehicles for transportation/shipping needs

Interview with “Big Joe” Transportation Projects







Transportation Case Study

- Each shift, the fork trucks were making on average 12 trips of 1000 ft carrying waste paper to the dumpster each shift.
- The company pulling the dumpster is charging $25/ton and $200 for each pull of the dumpster.



Transportation Case Study

- Install a bailer near the dry end of the papermaking machine where most of the waste is generated.
- Reduce trips to dumpster from 12 to 1 per shift. Reduces the number of pulls from 1/day to 1 per week.



Transportation Case Study

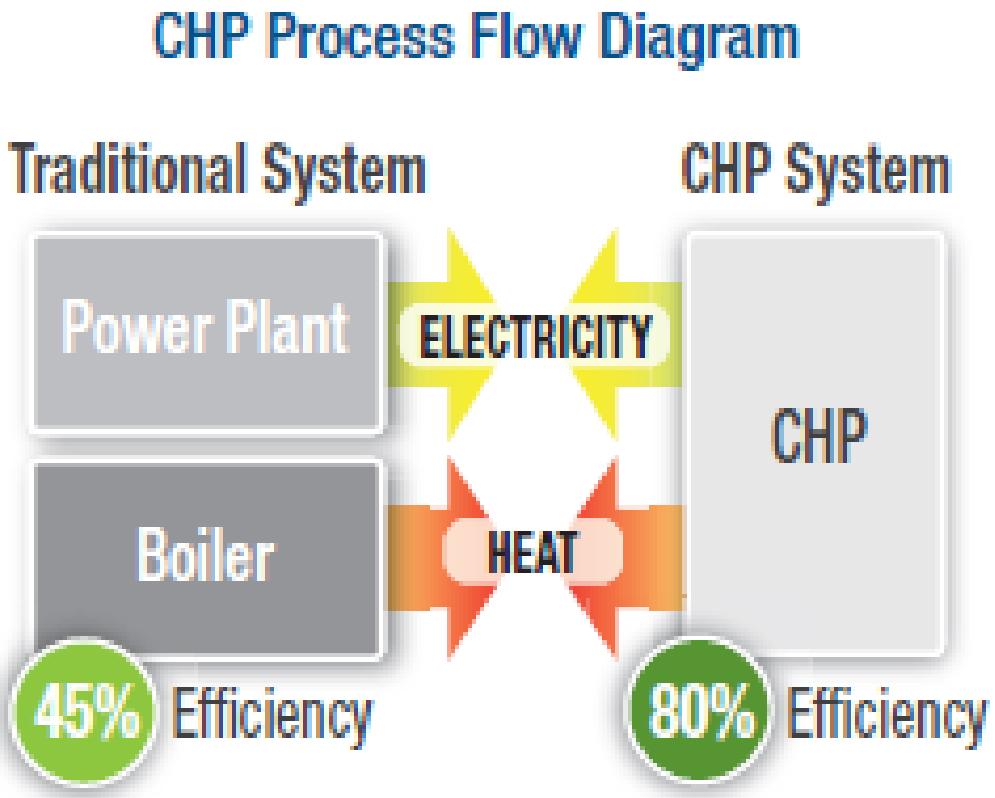
Cost	Frequency	Cost	Before	After	Savings
Dumpster Pull	7/week	$200/pull	7 = $1400	1 = $200	$1200.00
Tons Shipped	14 tons/week	$25/ton	$350	$350	0
Fork Trucks Propane Worker time	180 trips/week 5 min/trip = 15 hrs/week	$3.00/gallon $10.00/hour	$6.9/week $150/week	$0.57 $12.50	$ 6.33 $137.50
TOTAL					$1343.83/wk
Total/Year	50wks/year	$1343.83/wk			**$67,191.50**



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Co-Generation - Combined Heat & Power (CHP)



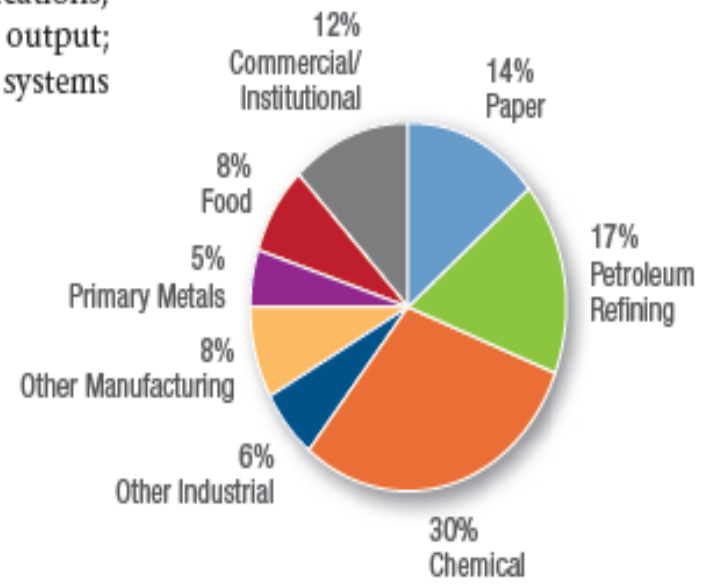
Market Sector Potential

What Does a CHP System Produce?

CHP is unique among electricity-producing technologies and methods because it generates more than one output. For most industrial applications, the thermal energy produced by the systems is the most valued output; electricity is considered a secondary, yet beneficial, by-product. CHP systems can provide the following products:

- Electricity
- Direct mechanical drive
- Steam or hot water
- Process heating
- Cooling and refrigeration
- Dehumidification

Existing CHP Capacity by Application



Source: EEA, Inc. CHP Installation Database.

CHP Systems

Potential Savings Nationwide

Proposition: What If 20% of US Electricity Generation Came From CHP?

CHP currently comprises 12.6 percent of US electricity generation (i.e. MWh) and 8.6 percent of total generating capacity (i.e. MW). Achieving 20 percent generation capacity by 2030 would result in 1.16 billion MWh of generation (or 240.9 GW of capacity). Increasing CHP capacity to 20 percent, while an aggressive target, can be accomplished given the proper technical and policy circumstances.

2030 CHP – Proposition: 20% of U.S. Capacity	240,900 MW
Reduced Annual Energy Consumption with CHP	5.3 Quads
Total Annual CO_2 Reduction	848 MMT
Total Annual Carbon Reduction	231 MMT
Number of Car Equivalents Taken Off Road	154 million

CHP Case Study



Should Rite Stuff invest in co-generation?

Jim Rite and Joe Rite have looked into using waste paper as a secondary fuel for one of their boilers and wondered if it might help them achieve LEED (Leadership in Energy & Environmental Design).

They also asked the engineer what he thought of putting solar panels on the warehouse or maybe even a wind turbine.

What are the merits of these ideas? What other types of CHP should they consider?





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Carbon Footprint

- The amount of fossil carbon consumed by a facility, converted to metric tons of CO_2, is their *carbon footprint.*
- Movement is underway to cap carbon emissions with companies in different industries or geographical regions given *allowances*.

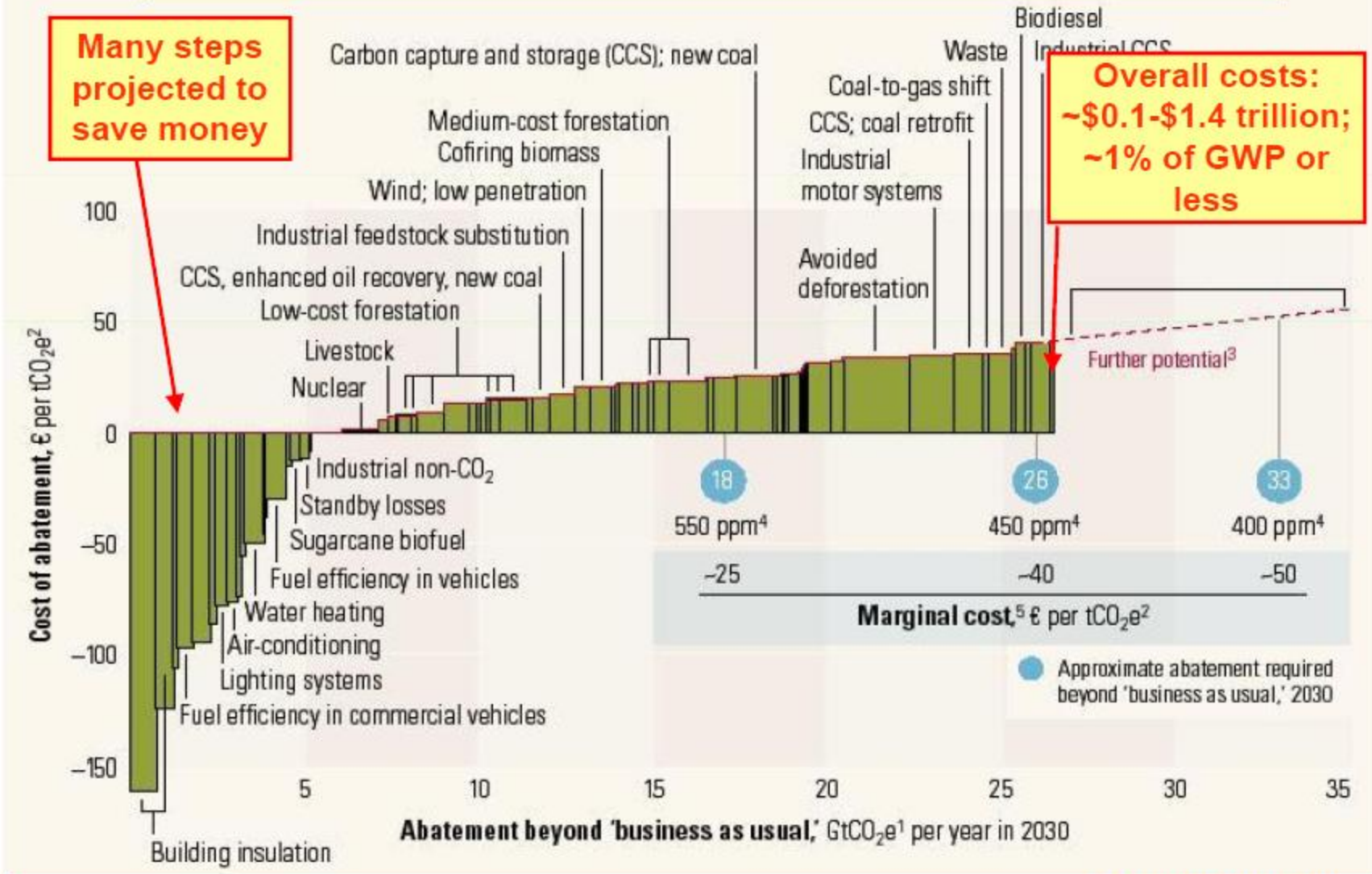
Carbon Footprint

- The cost of a product or service is usually directly related to the amount of energy invested in its creation.
- If that energy is created through combustion of fuels, then the lower the production costs, the less carbon emissions
- Not the case if the energy is created through renewable sources.

Carbon Offsets, Credits & Trading

- Carbon emissions can be “offset” by acquiring the rights to projects that reduce emissions, e.g., tree plantations, renewable energy.
- Carbon Credits can be earned by reducing emissions below your allowance.
- Credits (unused allowances) may be traded on the open market.

WHAT WOULD IT COST?



Source: McKinsey & Co.

New Carbon Footprint at Rite Stuff

Project	Electricity Savings (kWh)	Natural Gas Savings (MMBtu)	Propane (gallons)	Cost Savings
Steam		72,222.00		$ 580,000.00
Fan	529,411.00			$ 18,000.00
HVAC		277.00		$ 3,000.00
Lighting (warehouse)	816,400.00			$ 9,027.60
Fork Trucks			105.50	$ 67,191.50
Compressed Air				$ 15,782.00
Lighting (office)	14,300.00			$ 486.20
Total	1,360,111.00	72,499.00	105.50	**$ 692,987.30**
Total MMBtu	4,640.70	72,499.00	10.08	**77,149.77**
Total CO2 reduction	976.56	3,625	0.06	**4,601.57**



Carbon Footprint

- Calculating carbon footprint
- Decide what to include:
  - Direct
  - Indirect
  - Plant
  - Transportation
  - Sales & Administration

- Websites
  - US EPA Climate Change
  - http://www.epa.gov/climatechange/
  - **eGRID2007 Version 1.1 annual non-baseload CO_2 output emission rates (year 2005 data)**



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Sustainable Alternative Energy

Solar

Wind

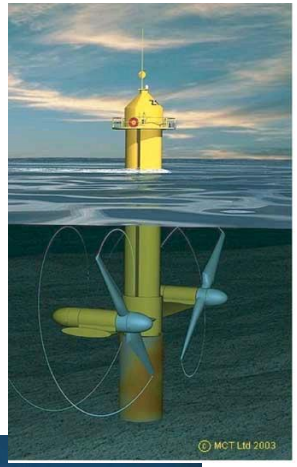
Hydroelectric

Biomass

Geothermal

Hydrogen













Solar

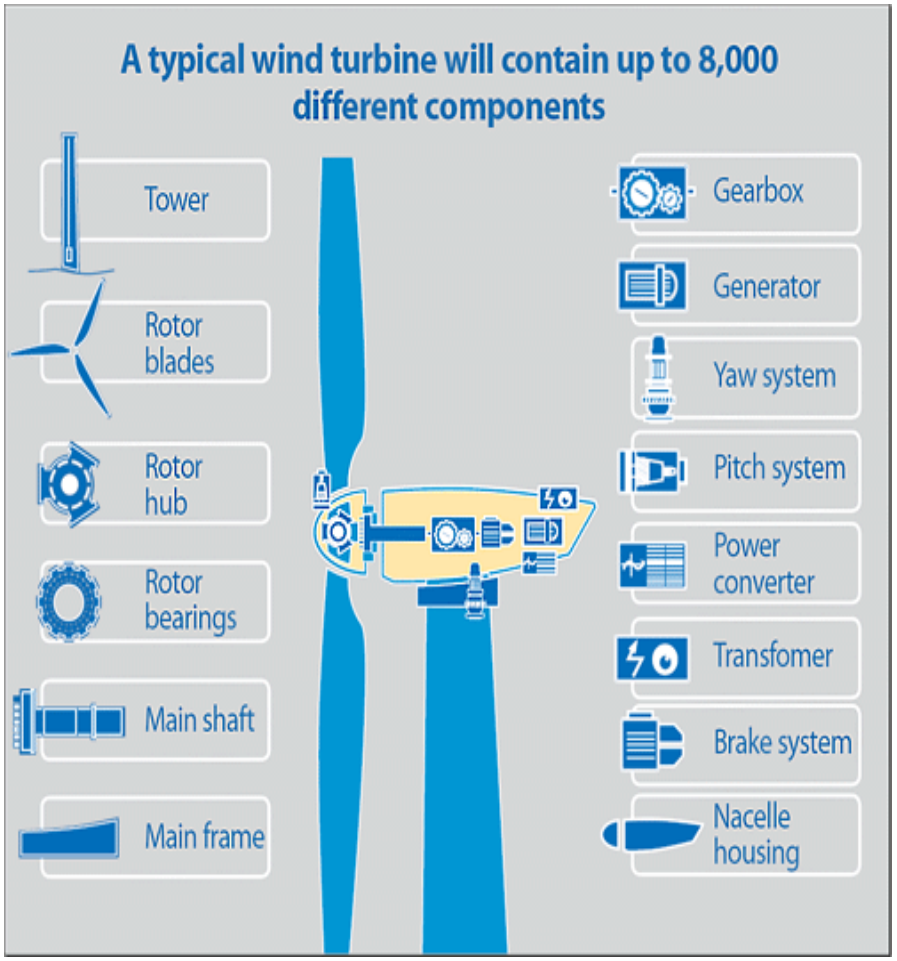


The 14 MW Nellis Solar Power Plant is the largest solar photovoltaic system in North America, and is located within Nellis Air Force Base in Clark County, Nevada.



A section of the parabolic troughs from the Nevada Solar One project near Boulder City, Nevada. The site covers about 300 acres and contains 760 mirror arrays.

Wind


A typical wind turbine will contain up to 8,000 different components
Tower
Rotor blades
Rotor hub
Rotor bearings
Main shaft
Main frame
Gearbox
Generator
Yaw system
Pitch system
Power converter
Transfomer
Brake system
Nacelle housing

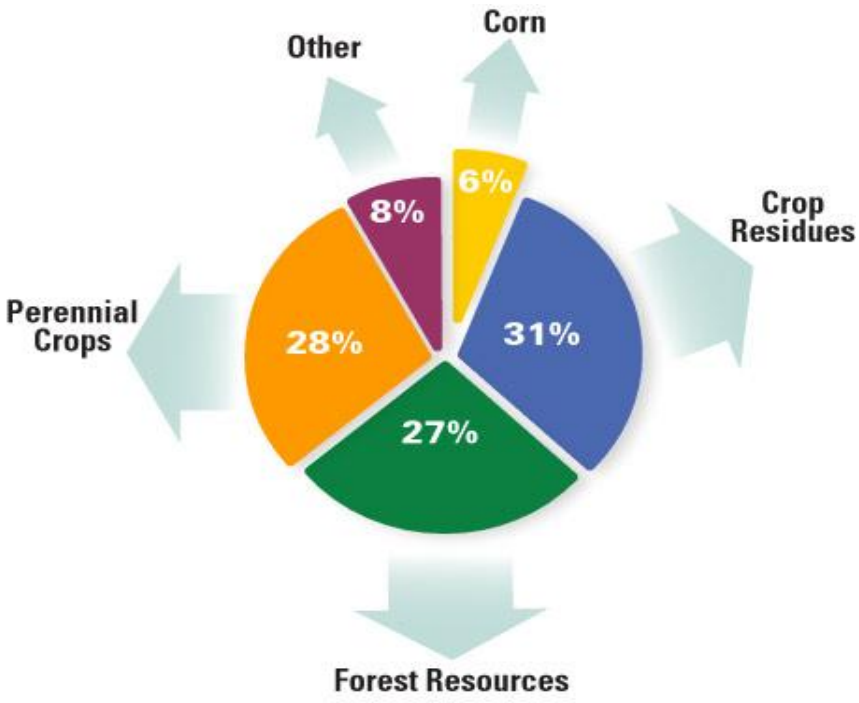




Hydropower

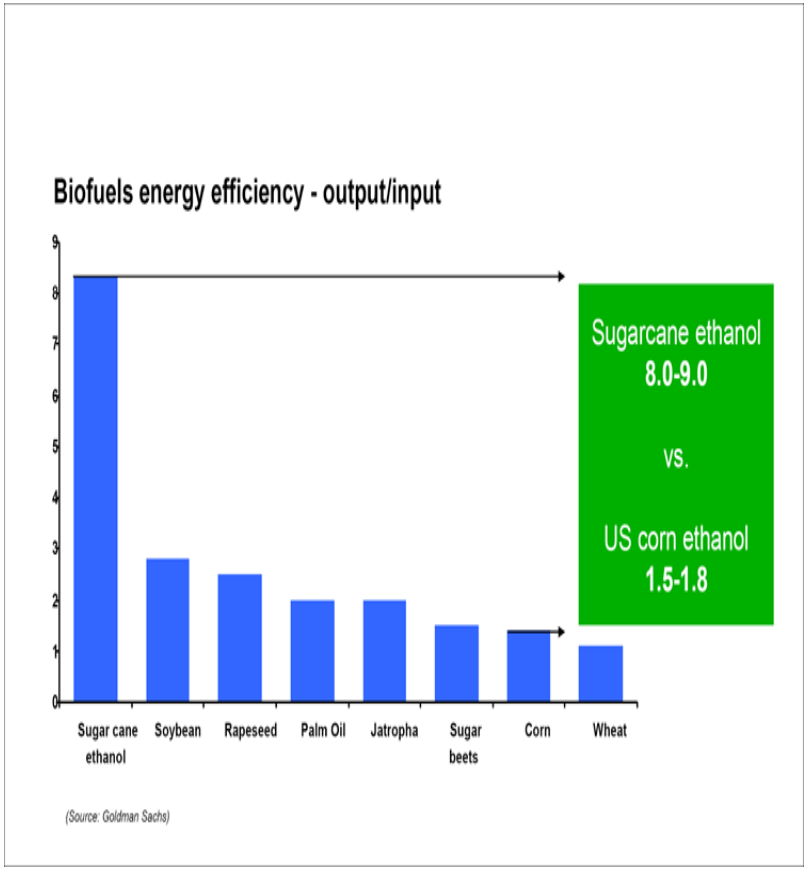
- Hydroelectric dams / watermills
- Damless hydro systems which derive energy from rivers and oceans without using a dam.
- Wave power which uses the energy in waves. Wave power has now reached commercialization.
- Tidal power captures energy from the tides.
- Ocean thermal energy conversion and Deep lake water cooling use the temperature difference between the warmer surface of the water and the colder lower recesses.

Biomass



Projected U.S. Biofuel Sources

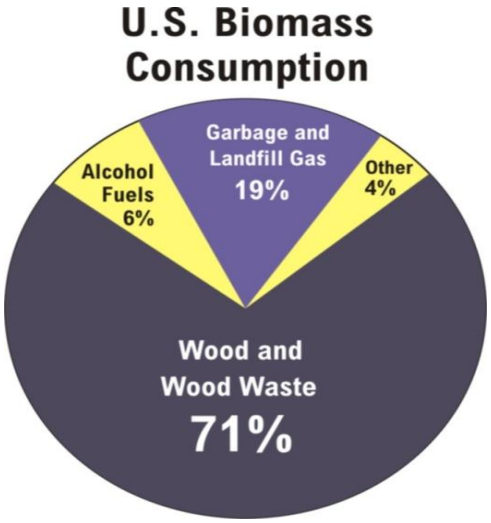
Source: Biomass as Feedstock for a Bioenergy and Bioproducts Industry: Technical Feasibility of a Billion Ton Annual Supply. 2005. DOE and USDA.

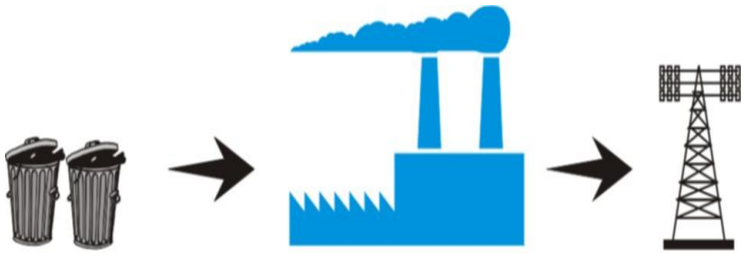


- Cellulosic ethanol (from switchgrass and other perennial crops) is expected to increase the energy output of ethanol production to ~20 units of energy output for every unit input.

Source: DOE

Biomass



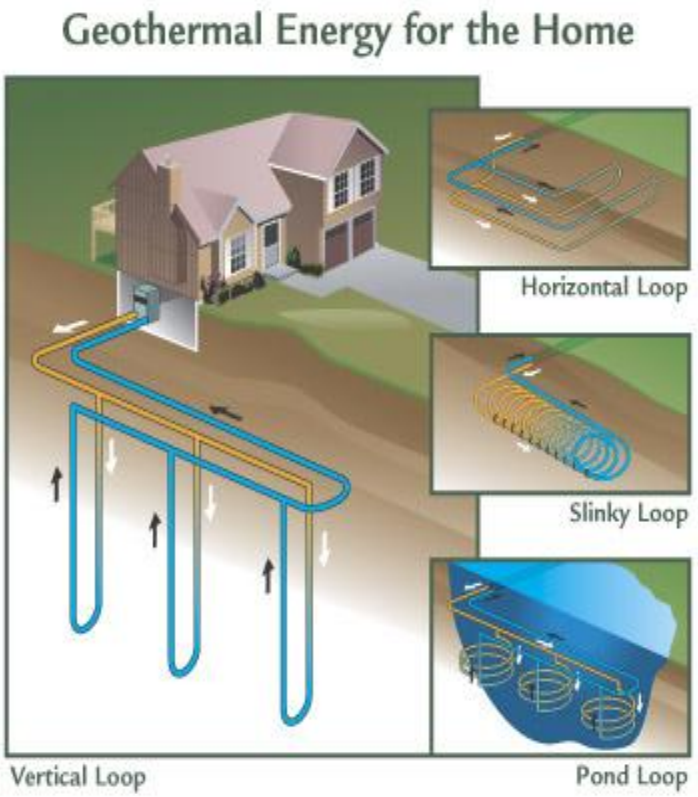


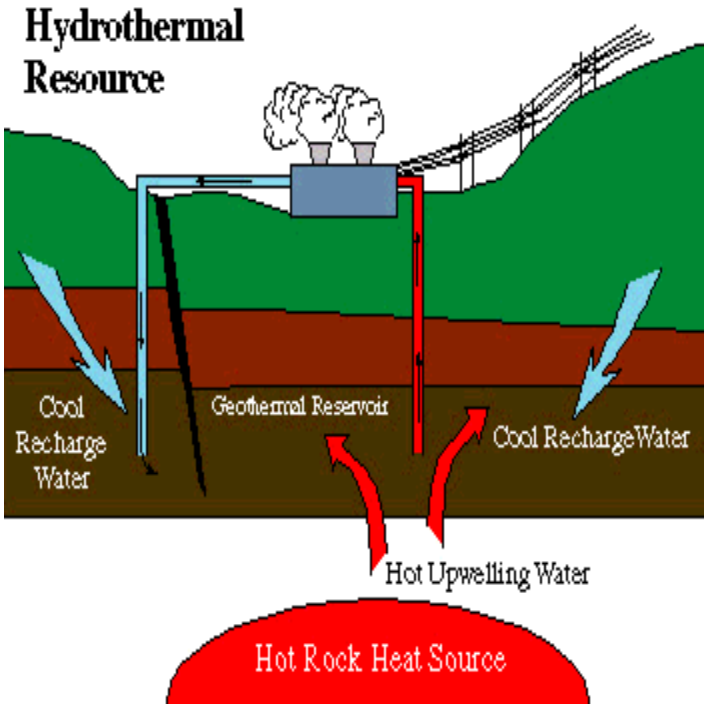
Waste-to-Energy plants convert garbage into steam and electricity.

- The vast majority of biomass heating in the US is burning wood for facility or home heating.
- Waste Incineration can be an alternative to landfills.

Source: DOE

Geothermal

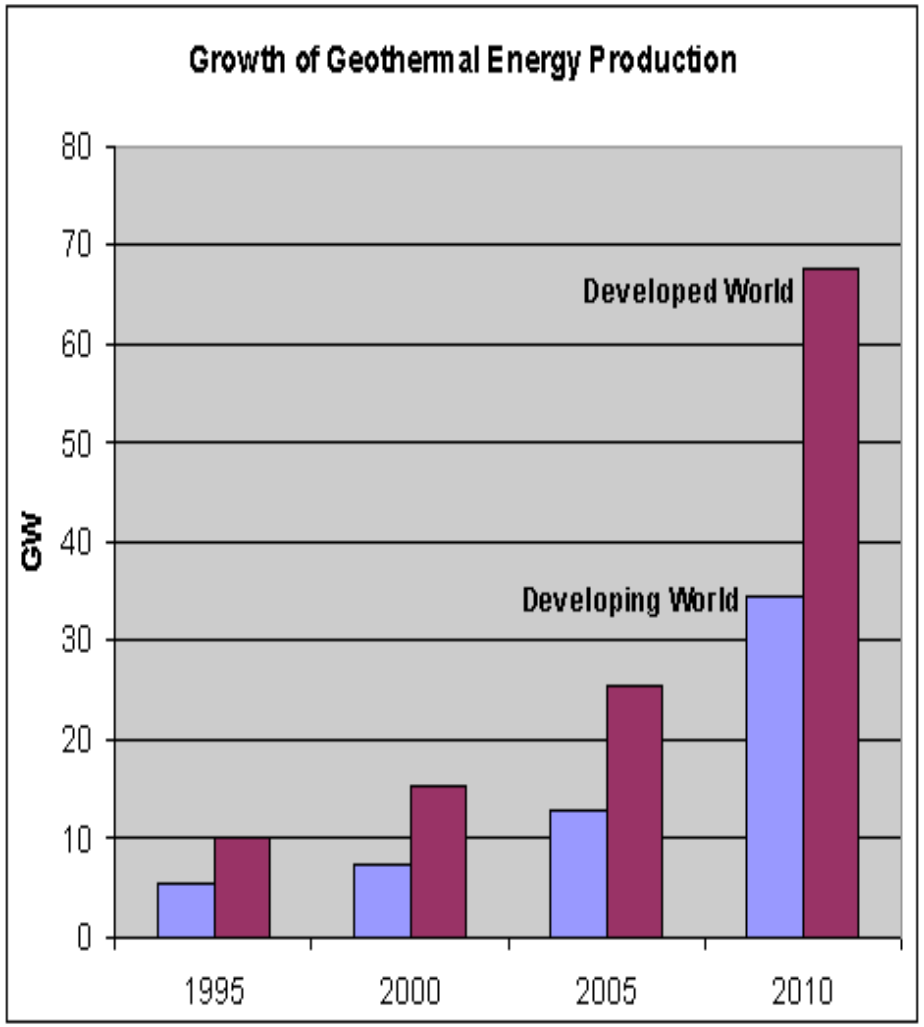




Source: International Geothermal Association

Geothermal

- Paybacks for home / small commercial geothermal installations vary based on climate; however in general range from 5-10 years. Additionally, they are very low maintenance.
- Larger commercial systems have been installed at colleges and other institutions with similar payback periods.
- Utility scale geothermal energy is inexpensive; usually about $0.05/kWh.

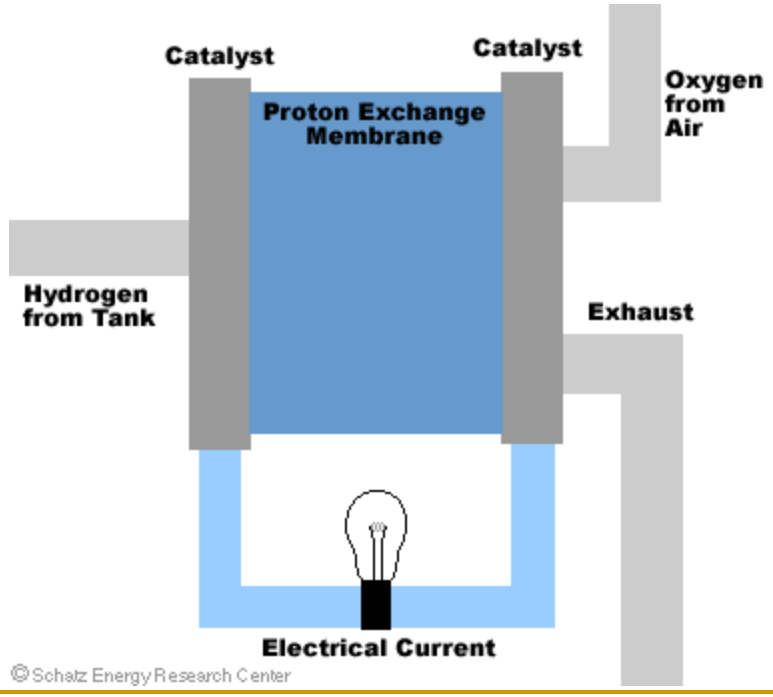


Source: International Geothermal Association

Fuel Cells

Fuel cells are typically named for the type of electrolyte they use:

PEMFC
(proton exchange membrane fuel cell)
uses a proton exchange membrane electrolyte to split hydrogen



Other fuel cells:

AFC – Alkaline

DMFC – Direct Methane

PAFC – Phosphoric Acid

MCFC – Molten Carbonate

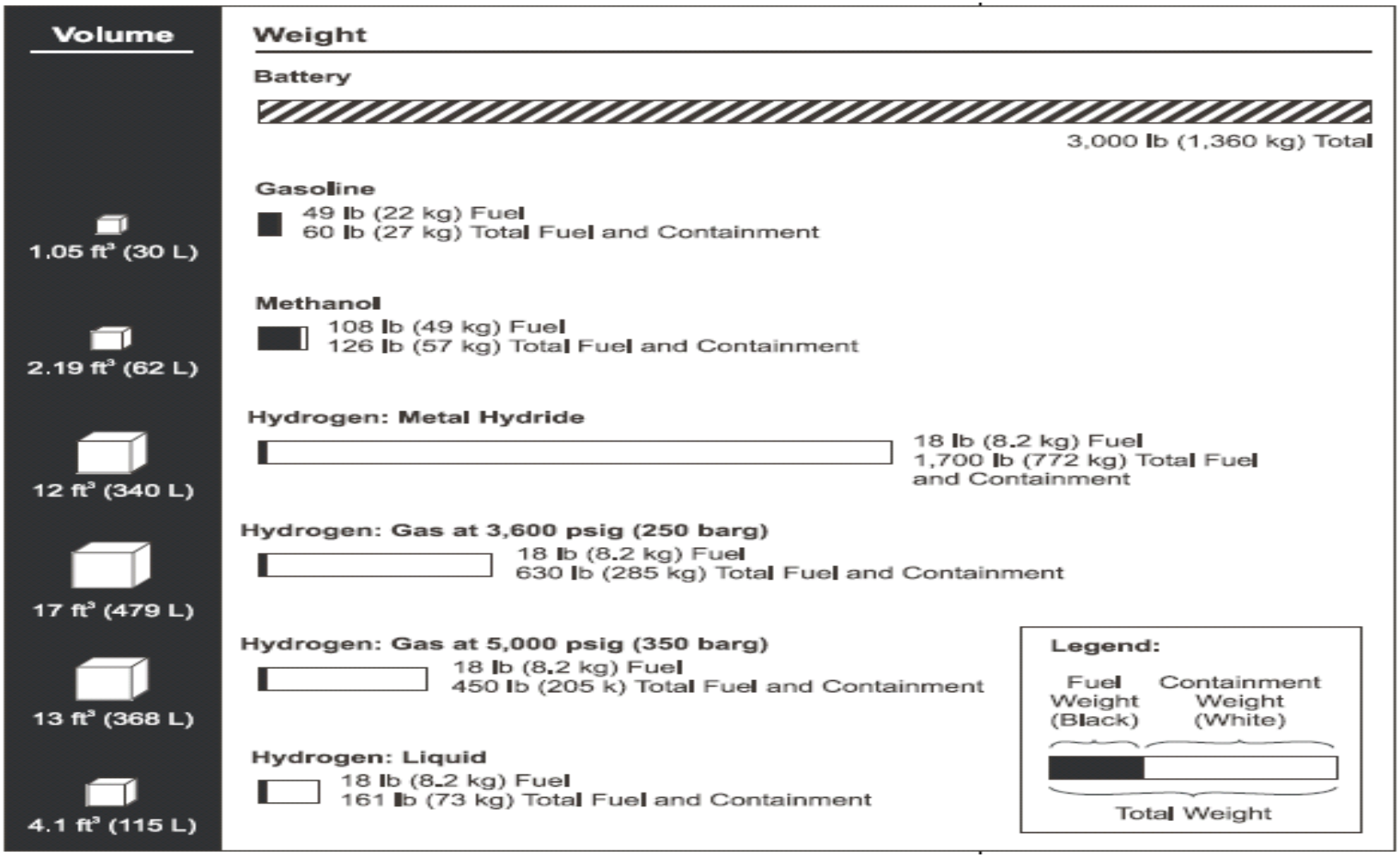
SOFC – Solid Oxide

Hydrogen



- Safety – Hydrogen vs. Gasoline
- Less flammable
- Disperses quickly
- Nontoxic, nonpolluting, clean burning
- Stronger than Gasoline tanks

Hydrogen


Volume
Weight
Battery
3,000 lb (1,360 kg) Total
Gasoline
49 lb (22 kg) Fuel
60 lb (27 kg) Total Fuel and Containment
1.05 ft³ (30 L)
Methanol
108 lb (49 kg) Fuel
126 lb (57 kg) Total Fuel and Containment
2.19 ft³ (62 L)
Hydrogen: Metal Hydride
18 lb (8.2 kg) Fuel
1,700 lb (772 kg) Total Fuel and Containment
12 ft³ (340 L)
Hydrogen: Gas at 3,600 psig (250 barg)
18 lb (8.2 kg) Fuel
630 lb (285 kg) Total Fuel and Containment
17 ft³ (479 L)
Hydrogen: Gas at 5,000 psig (350 barg)
18 lb (8.2 kg) Fuel
450 lb (205 k) Total Fuel and Containment
13 ft³ (368 L)
Hydrogen: Liquid
18 lb (8.2 kg) Fuel
161 lb (73 kg) Total Fuel and Containment
4.1 ft³ (115 L)
Legend:
Fuel Weight (Black)
Containment Weight (White)
Total Weight

Fuel Cell Energy Potential



A 210 kWh Molten Carbonate Fuel Cell Plant that also produces 350 lbs of steam per hour



5 kW unit that could be used to power a home or small business







Utility Scale Alternative Energy Costs

	Current		Future
Wind	4–8 ¢/kWh	➔	3–10 ¢/kWh
Solar (PV)	25–160 ¢/kWh	➔	5–25 ¢/kWh
Solar Thermal	12–34 ¢/kWh	➔	4–20 ¢/kWh
Hydro (Large)	2–10 ¢/kWh	➔	2–10 ¢/kWh
Hydro (Small)	2–12 ¢/kWh	➔	2–10 ¢/kWh
Geothermal	2–10 ¢/kWh	➔	1–8 ¢/kWh
Biomass	3–12 ¢/kWh	➔	4–10 ¢/kWh
Coal	4 ¢/kWh		???
Geothermal Heat Pump	0.5–5 ¢/kWh	➔	0.5–5 ¢/kWh
Biomass (Heat)	1–6 ¢/kWh	➔	1–5 ¢/kWh

Source: World Energy Assessment, 2004 update

Conservation is the Best Alternative Energy!

- Conservation programs are easier to implement and much more cost effective than any other “alternative energy” technology.
- Conservation should always be first on a list of solutions!

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Systems Approach

- Prioritize
- Analyze entire system
- Optimize System
- Implement Best Practices
- Good Maintenance = Energy Savings



Quantifying Potential Benefits

- Energy saved (kWh or ccf)
- Demand reduction (kW)
- Energy Use Index / Energy Cost Index
- Carbon Footprint
- Other utility savings
- Reduced maintenance
- Increased production capacity
- Less down time



Justifying Changes at Rite Stuff



- Energy cost savings
- Demand reduction
- Material savings
- Labor savings
- Increased production capacity
- Decreased compliance costs

Improvement Opportunities at Rite Stuff



- Steam System capacity improvement
- Compressed Air leak reduction
- HVAC Optimization
- Warehouse Lighting
- Dust Collector fan improvement
- Waste paper compactor

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PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM

Energy Management



Efficient Energy Use

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Purpose of This Module

- To provide an understanding of traditional and alternative energy sources.
- To identify methods that can be implemented to reduce energy use.
- To provide strategies for incorporating effective energy management concepts into your business practices.

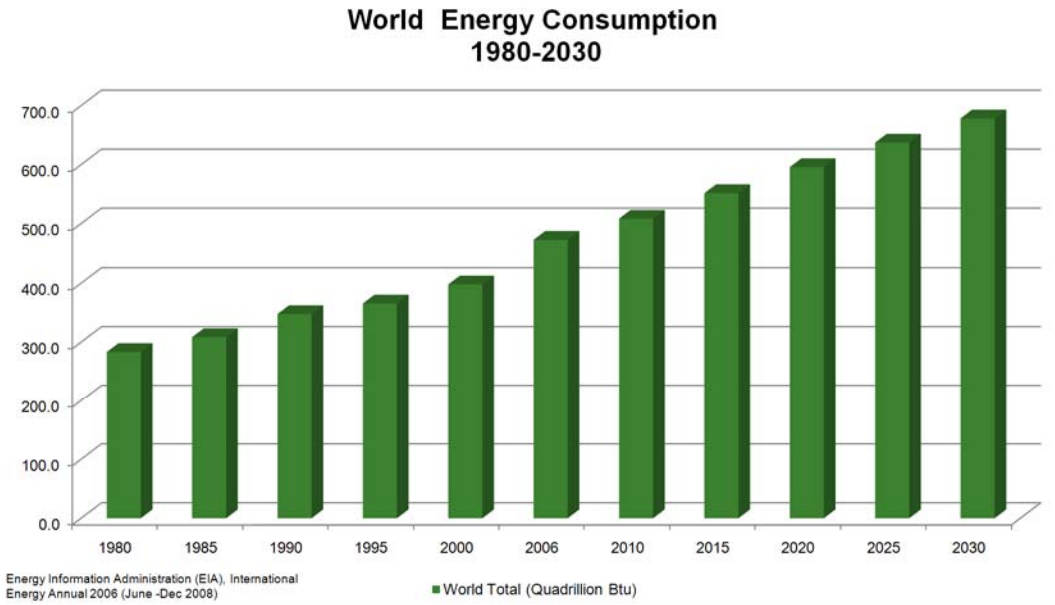
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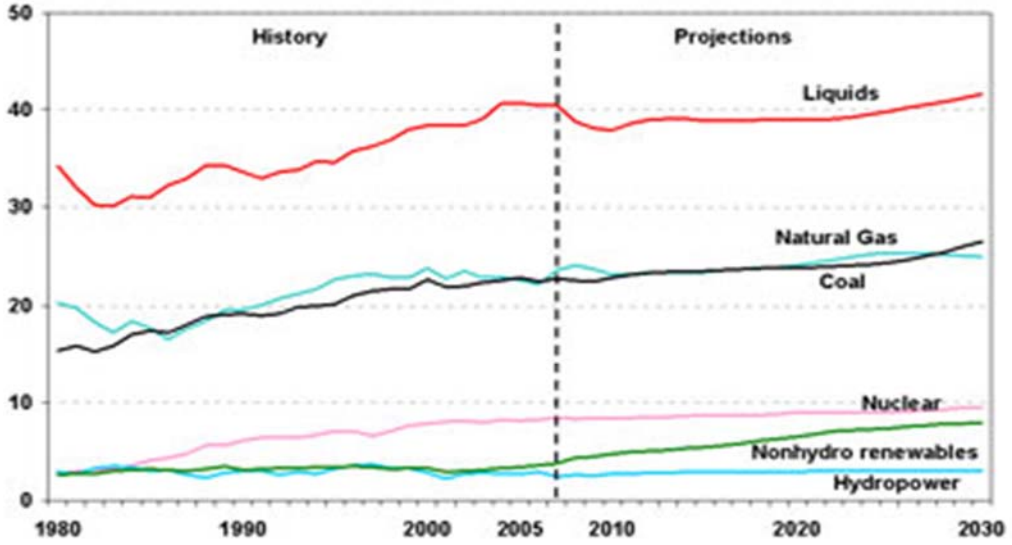
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Energy Demands Increasing



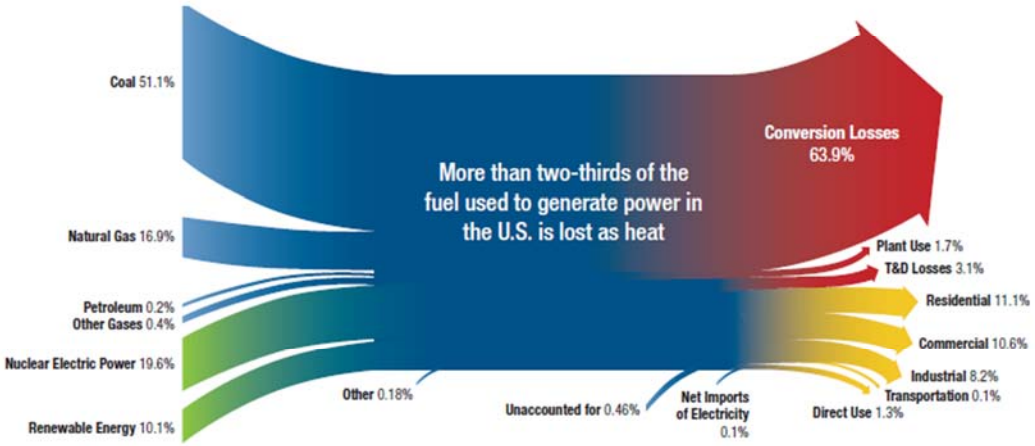
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U.S. Energy: Production & Consumption



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Inefficiency of Consumption



Source: DOE Energy Information Administration Annual Energy Review 2007

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Unsustainable Energy Use Impact

- Worldwide military engagement to protect petroleum supply chain (engaged in ~130 countries)
- Greenhouse gases (atmospheric CO_2 levels increasing quickly)
- Habitat destruction (rainforest, crop monocultures, species extinction, etc.)
- Water pollution (Sediment, mercury, heavy metals, pesticides, herbicides, etc.)
- Air pollution (NO_x, SO_x, Hg, Ozone)
- Solid waste generation (radioactive, fly ash, mining debris, etc.)

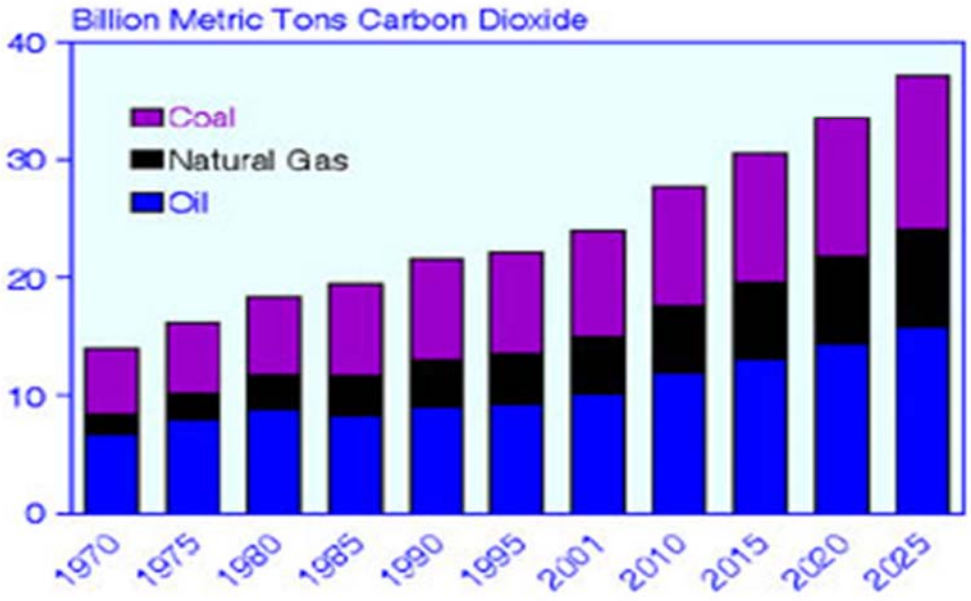
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Facts: Energy Consumption

- Americans consume about 26% of the world's energy while accounting for only 5% of the world's population.
- Developing countries use 30% of global energy.
- Worldwide, about *2 billion* people are currently without electricity.

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Environmental Impacts



Source: U.S. Department of Energy

Traditional Energy Sources

- Coal
- Petroleum
- Natural Gas
- Uranium



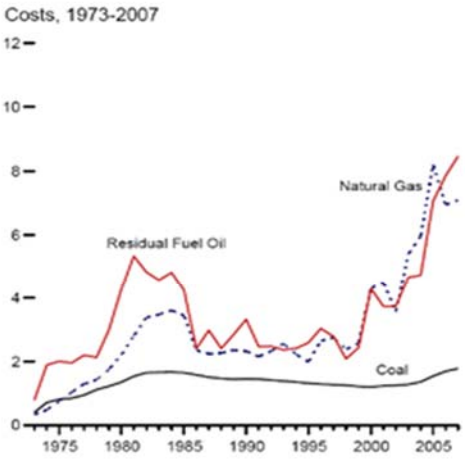


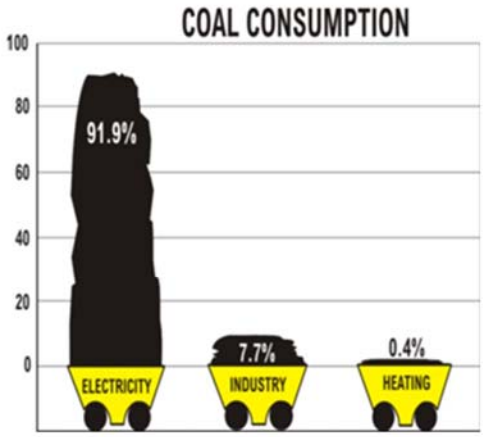




Coal

- US Coal Consumption is ~1.1 Billion Short Tons Annually
- World Consumption is ~6.7 Billion Short Tons Annually
- US Recoverable Coal Reserves are ~262 Billion Tons & World Reserves are ~930 Billion Tons (A 130+ year supply at current consumption levels.)

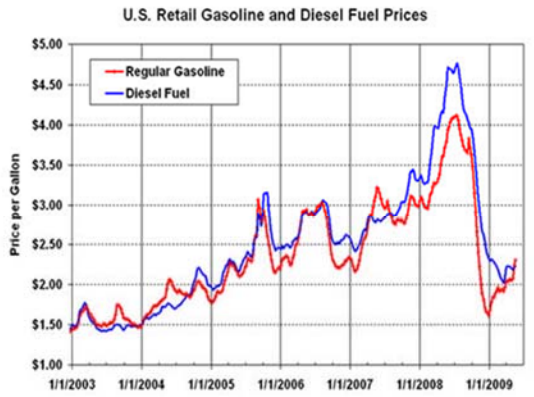


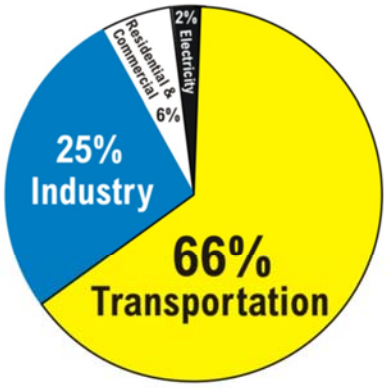


Source: Energy Information Administration (EIA); Monthly Energy Review, May 2009

Petroleum

- US Petroleum Consumption is 21 Million Barrels/day or 7.67 Billion Barrels Annually
- Current US Proven Reserves is 21.3 Billion Barrels…
- Current World Petroleum Consumption is 85.9 Million Barrels/day or 31.35 Billion Barrels Annually
- Current World Proven Reserves is 1,342 Billion Barrels; ~ 42 years at current consumption rates…





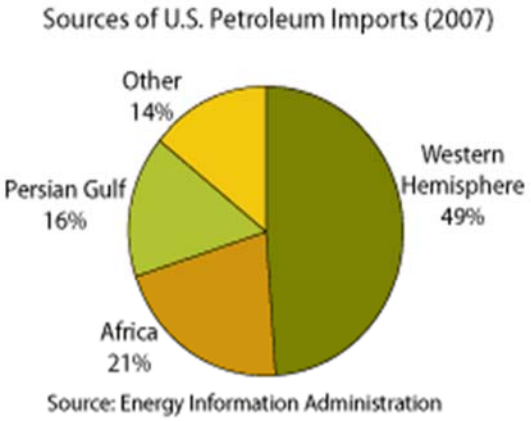
PETROLEUM CONSUMPTION BY SECTOR OF THE ECONOMY

Petroleum

- The US provides 42% of its petroleum from domestic sources importing the remaining 58%.
- About half the imported petroleum comes from the Western Hemisphere.

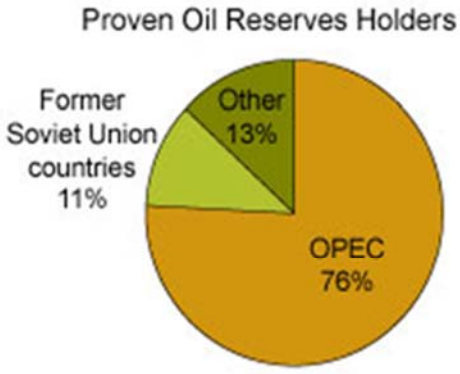
1. Canada (18.2%)
2. Mexico (11.4%)
3. Saudi Arabia (11.0%)
4. Venezuela (10.1%)
5. Nigeria (8.4%)

Next 10: Includes Angola, Iraq, Brazil, Columbia, Russia, Algeria, Ecuador, Kuwait, Gabon, & Norway (~28.2%)

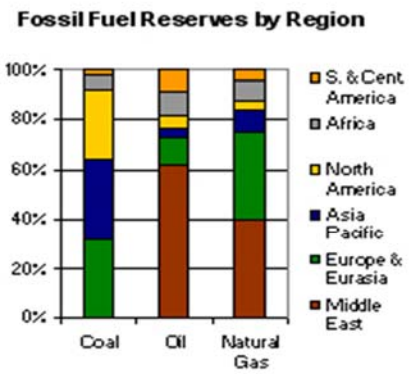


Traditional Energy Reserves

• OPEC member countries held over 75% of the world's proven oil reserves at the end of 2006.

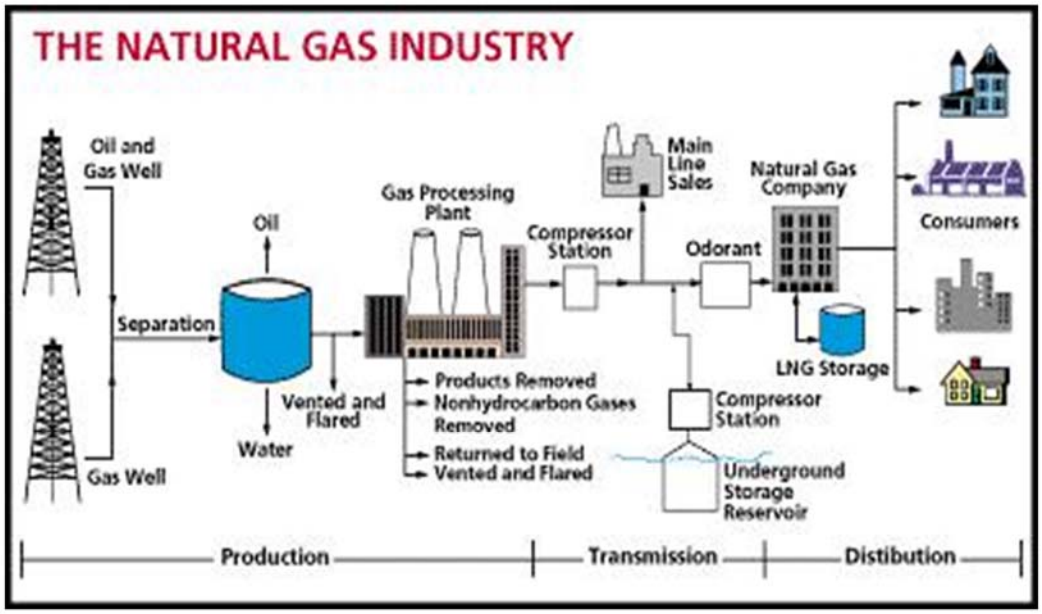


Source: BP Statistical Review of World Energy (2007)



Source: BP, p.l.c., 2006

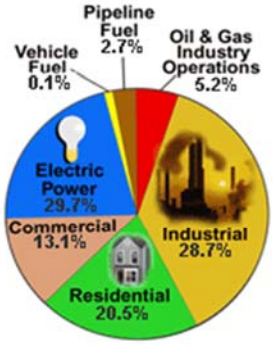
Natural Gas



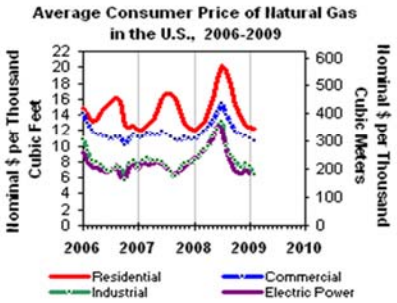
Source: EIA

Natural Gas

The US consumes roughly 18.5 trillion cubic feet of natural gas annually. This is about 18% of the annual world consumption of 104 trillion cubic feet.



US Natural Gas reserves are estimated at 237.7 trillion cubic feet. International reserves are reported as 6290 trillion cubic feet representing a 60+ year supply at current consumption rates.



Source: EIA 2005

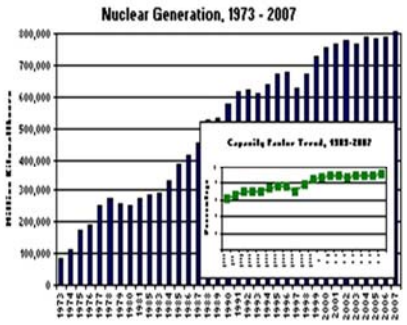
Traditional Energy Reserves

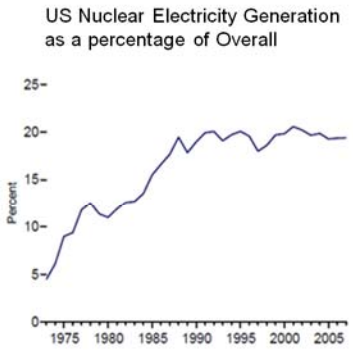
World Natural Gas Reserves in 1988, 1998, and 2008.



Source: BP Statistical Review of World Energy, 2009

Nuclear





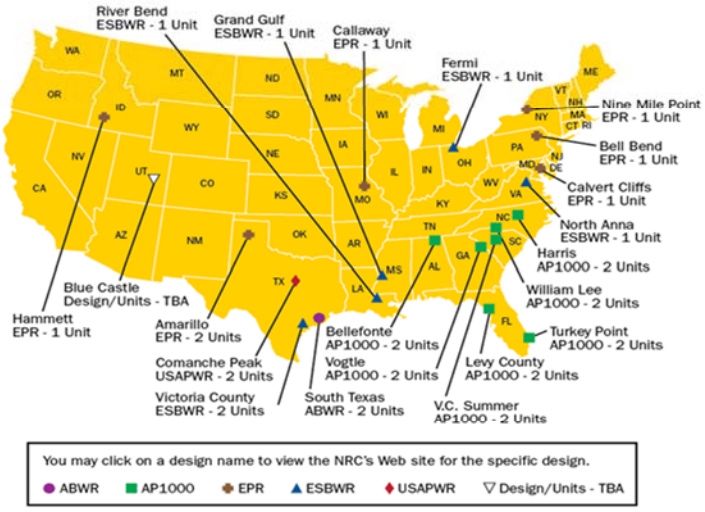
- Nuclear power, used commercially in the US since 1957, has 0 carbon emissions.
- It is estimated that world reserves are adequate for at least the next 85 years.
- Fly Ash from Coal burning power plants carries up to 100 times more radiation into the environment than a comparable nuclear plant.

Source: EIA; International Atomic Energy Agency

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Potential Growth of Nuclear Power

- It is expected that the US will add up to 30 additional reactors to its existing "fleet" of 104 over the next several decades
- China plans to quadruple its nuclear energy production by 2020.



Source: NRC 2009

Course Agenda

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Sustainable Alternative Energy

Solar

Wind

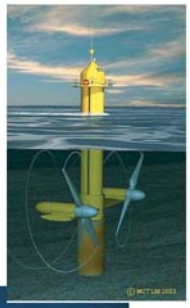
Ocean / Hydropower

Biomass / Biofuels

Geothermal resources

Hydrogen













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Solar



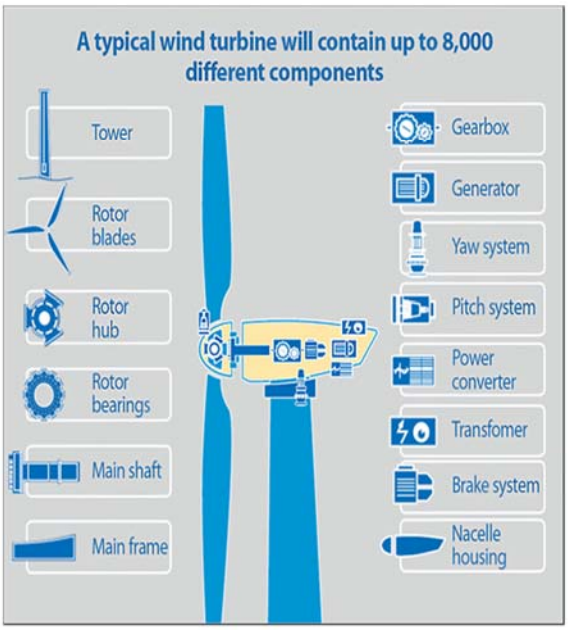
The 14 MW Nellis Solar Power Plant is the largest solar photovoltaic system in North America, and is located within Nellis Air Force Base in Clark County, Nevada.



A section of the parabolic troughs from the Nevada Solar One project near Boulder City, Nevada. The site covers about 300 acres and contains 760 mirror arRites.

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Wind







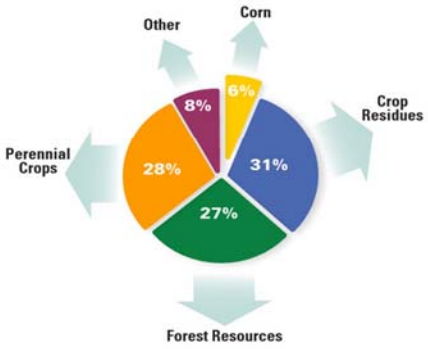
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Hydropower

- Hydroelectric dams / watermills
- Damless hydro systems which derive energy from rivers and oceans without using a dam.
- Wave power which uses the energy in waves. Wave power has now reached commercialization.
- Tidal power captures energy from the tides.
- Ocean thermal energy conversion and Deep lake water cooling use the temperature difference between the warmer surface of the water and the colder lower recesses.

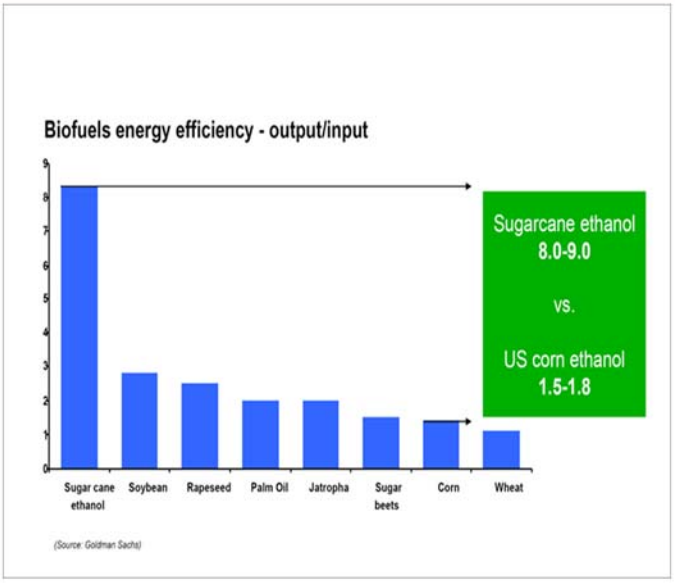
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Biomass



Projected U.S. Biofuel Sources

Source: Biomass as Feedstock for a Bioenergy and Bioproducts Industry: Technical Feasibility of a Billion Ton Annual Supply. 2005. DOE and USDA.

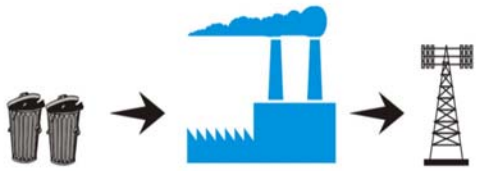


- Cellulosic ethanol (from switchgrass and other perennial crops) is expected to increase the energy output of ethanol production up to 20 units of energy output for every unit input.

Source: DOE

Biomass



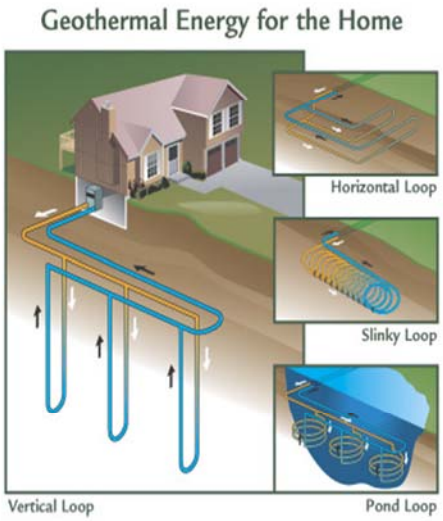


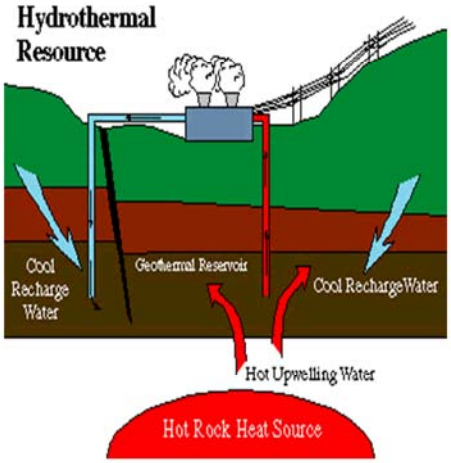
Waste-to-Energy plants convert garbage into steam and electricity.

- The vast majority of biomass heating in the US is burning wood for facility or home heating.
- Waste Incineration can be an alternative to landfills.

Source: DOE

Geothermal

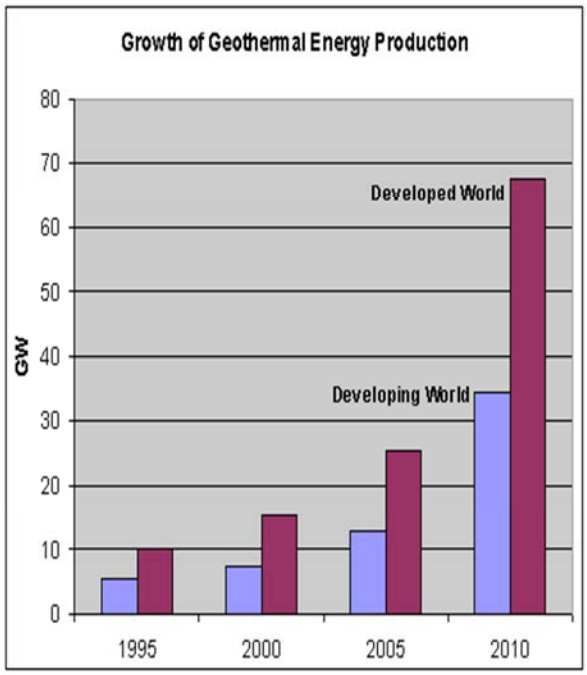




Source: International Geothermal Association

Geothermal

- Paybacks for home / small commercial geothermal installations vary based on climate; however in general range from 5-10 years. Additionally, they are very low maintenance.
- Larger commercial systems have been installed at colleges and other institutions with similar payback periods.
- Utility scale geothermal energy is inexpensive; usually about $0.05/kWh.

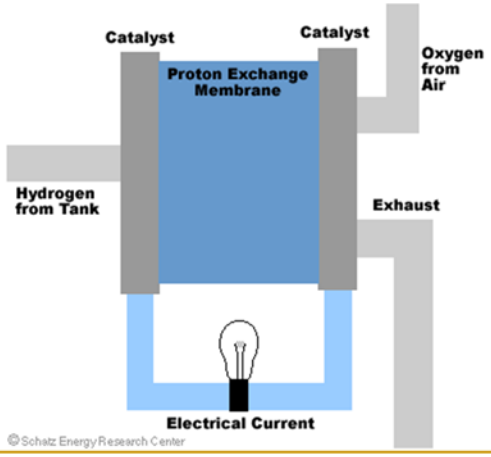


Source: International Geothermal Association

Fuel Cells

Fuel cells are typically named for the type of electrolyte they use:

PEMFC
(proton exchange membrane fuel cell)
uses a proton exchange membrane electrolyte to split hydrogen



Other fuel cells:

AFC – Alkaline

DMFC – Direct Methane

PAFC – Phosphoric Acid

MCFC – Molten Carbonate

SOFC – Solid Oxide

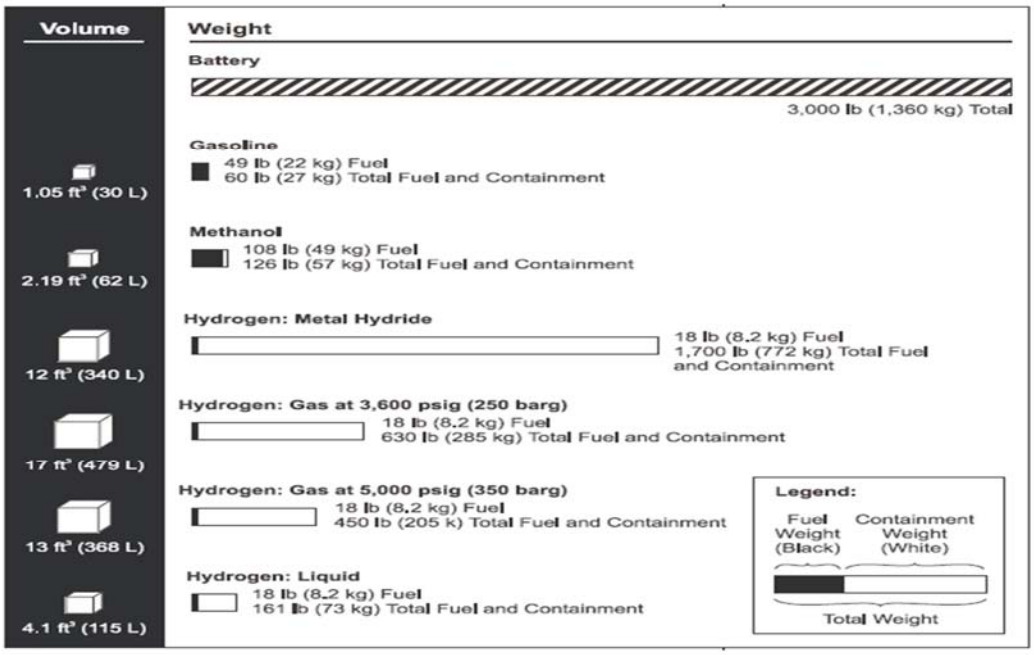
Hydrogen



- Safety – Hydrogen vs. Gasoline
- Less flammable
- Disperses quickly
- Nontoxic, nonpolluting, clean burning
- Stronger than Gasoline tanks

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Hydrogen



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Fuel Cell Energy Potential



A 210 kWh Molten Carbonate Fuel Cell Plant that also produces 350 lbs of steam per hour



5 kW unit that could be used to power a home or small business







Utility Scale Alternative Energy Costs

	Current		Future
Wind	4–8 ¢/kWh	→	3–10 ¢/kWh
Solar (PV)	25–160 ¢/kWh	→	5–25 ¢/kWh
Solar Thermal	12–34 ¢/kWh	→	4–20 ¢/kWh
Hydro (Large)	2–10 ¢/kWh	→	2–10 ¢/kWh
Hydro (Small)	2–12 ¢/kWh	→	2–10 ¢/kWh
Geothermal	2–10 ¢/kWh	→	1–8 ¢/kWh
Biomass	3–12 ¢/kWh	→	4–10 ¢/kWh
Coal	4 ¢/kWh		???
Geothermal Heat Pump	0.5–5 ¢/kWh	→	0.5–5 ¢/kWh
Biomass (Heat)	1–6 ¢/kWh	→	1–5 ¢/kWh

Source: World Energy Assessment, 2004 update

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Conservation is the Best Alternative Energy!

- Conservation programs are easier to implement and much more cost effective than any other “alternative energy” technology.
- Conservation should always be first on a list of solutions!

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Course Agenda

- Energy Consumption & Sources
- Alternative / Renewable Energy Sources
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- Energy Audit In Practice
  - Utility Bill Analysis
  - Fueled Systems: Process Heating, Steam
  - Electric Systems: Compressed Air, Fans & Pumps, HVAC, Lighting
  - Transportation
  - Co-Generation
- Carbon Footprint
- Systems Approach
- Course Evaluation

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Energy Audit Purpose



- Identify types and costs of energy use.
- Understand how the energy is being used & wasted.
- Identify and analyze more cost-effective ways of using energy with:
  - improved operational techniques
  - new equipment
- Perform an economic analysis on those alternatives to determine which are cost-effective.

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Other Questions to Ask



- Who will the auditor(s) report findings to?
- Who will implement the recommendations?
- Is money available for capital projects?
- Is time available for staff to implement?
- What is the level of management involvement, commitment?

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Gathering Data

- Collect the following:
  - "Typical" electric bill.
  - "Typical" natural gas bill.
  - "Typical" transport fuel costs.
- To be used to determine:
  - Electrical Demand
  - Electrical and Natural Gas Usage
  - Electrical Power Factor
  - Transport and Elecrical Fuel Charges

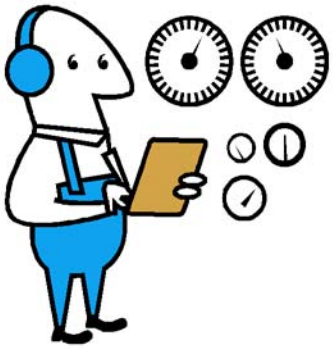
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Energy Sources & Costs

Energy Sources:	Electricity	Nat Gas	Other Fuel (propane)	Steam	Chilled Water	Co-Generation
Units (kWh, MMBtu, etc)	kWh, kW	therms	gallons			
Cost per unit ($)	$0.034	$9.00				
Average Volume	50,397,696	5,040,000				
Period (hour, day, week, month, or annually)	Year	Year				
Average Cost/Period - include demand charges, etc.	$1,713,522	$4,536,000				

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Breaking Down Energy Costs



Utility Analysis:

- Consumption
- Demand Charge
- Power Factor
- Monthly Charges

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Utility Analysis Comparison

- Energy Intensity
  - How much energy is used per unit of production or provision of service
  - Similar to Raw Materials/Unit of Production or;
  - Labor input/volume of sales
- Why calculate Energy Intensity?
  - Energy is a cost-of-goods sold
  - Better mechanism to track costs year-to-year

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Energy Cost per Unit

Performance Measure:				
	How would you like to measure performance? (Examples: Energy use per ton, or per case, or per employee. Energy cost per $million in sales)			
	Example	Option 1	Option 2	Option 3
Product Name	Pencils	Quantity	Weight	
Units	cases	Reels	Tons	
Average Volume	100,000	45,000	275,000	
Period	Month	Year	Year	
Energy Intensity	1 kWh/Case of Pencils	1 MMBtu/reel	10,000 Btu/ton	
Energy Cost Index	$0.01/Pencil	$10.00/reel	$1.00/ton	

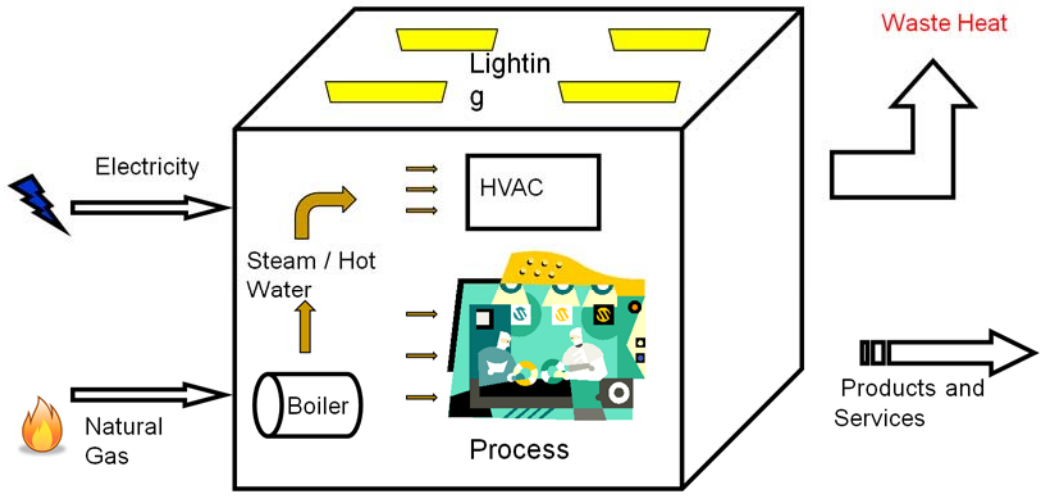
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Getting Started

- What are your base utilities?
  - Electricity, natural gas, water, __?____, _____
- What conversions happen on site?
  - Steam (y/n), compressed air (y/n), _____, _____
- What are your end uses?
  - Building heating and cooling
  - Lighting
  - Processes:____, _____, _____, _____

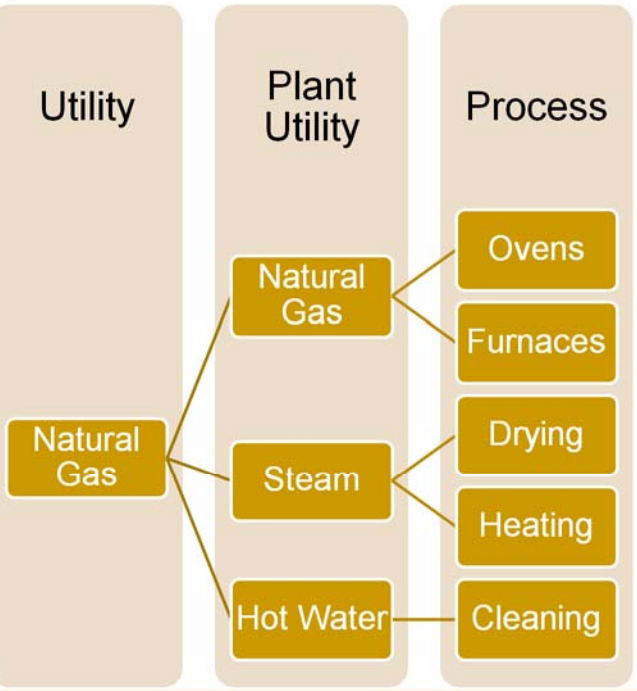
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Energy System Flow



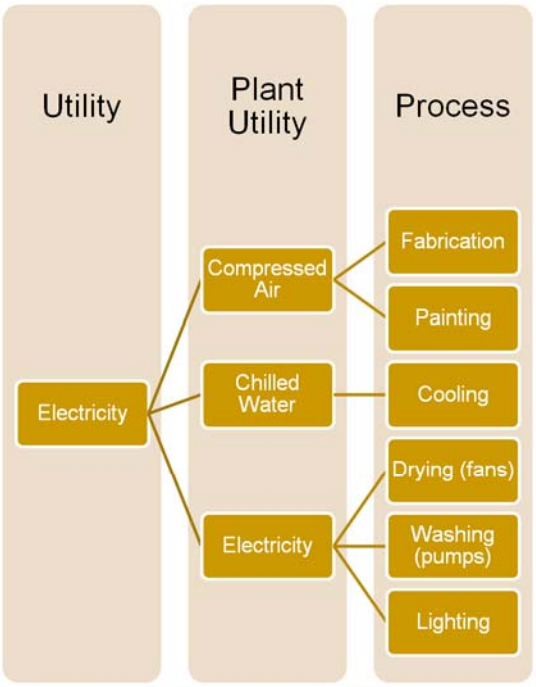
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Natural Gas Use & Conversion



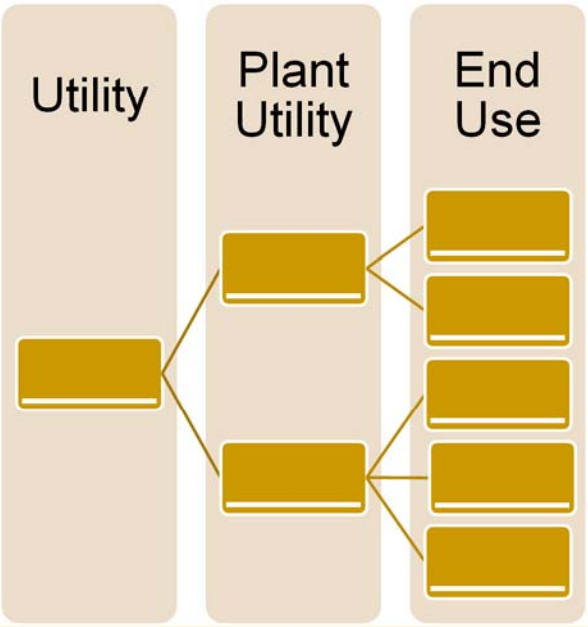
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Electricity Use & Conversion



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Exercise: Draw Your Facility's Natural Gas Use



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Data collection

Energy Use Distribution:	Electricity	Natural Gas	Propane	Steam
Compressed Air (_____psi)	10			
Chemical Processing				
Facility - lights, HVAC	10	10		10
Fans & Blowers	20			
Material Handling	1		100	
Material Processing - grinding, mixing, screening	10			10
Process Cooling				
Process Heating	10	10		80
Pumps	38			
Boilers / Steam Production Temp: Pressure:	1	80		
Other				
Totals (100% or N/A):	100.00	100.00	100.00	100.00

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Interview of Plant Personnel

- Number of employees
- Operating Hours of facility and major equipment
- Square footage of facility
- Copies of Utility Bills, check rate structure
- Copy of Motor Inventory (if available)
- Suspected High Energy Users
- Problem areas, Maintenance problems, etc.

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Building the Audit Scenario

- Powerhouse
  - Production Processes
  - Special Purpose Equipment
  - Warehouse
- Building Envelope
- Lighting
- Transportation
  - Shipping / Receiving,
  - Warehouse,
  - Internal vs. External

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Rite Stuff Paper Mill



Rite Stuff was founded by Jim Rite in the late 1960s. They are one of the few remaining stand-alone paper mills. Most of their competitors have added pulp mill capabilities, as well, but the community that Rite Stuff resides in is opposed to the smell that the pulp mill would bring with it.

Their facility has remained in the same location since inception, although they added some more warehouse space in the 70s to store all of the inventory they were stocking.



Some of their equipment dates back to the start of their business, as well. Joe Rite, Jim's brother and chief maintenance operator, is especially proud of how they've been able to keep the old boiler running all this time.

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Rite Stuff Paper Mill



Jim Rite recently brought his granddaughter, Sally Rite, into the business as the chief accountant. Sally's first task was to calculate the Carbon Footprint of Rite Stuff in response to a customer request for this information.

As Sally was gathering info for this calculation, she looked at the utility bills and thought they seemed really high. The Carbon Footprint calculator also indicated there is plenty of room for improvement in the way energy is used at Rite Stuff.

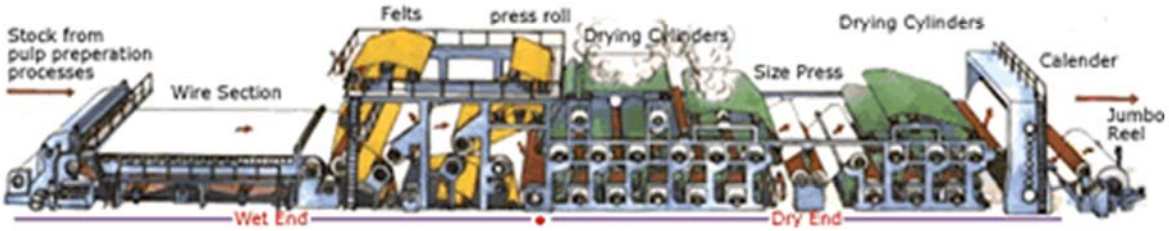
Sally Rite has asked for our help to audit their Energy systems and see if we can find some ways for them to save some money and reduce their Carbon Footprint.

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Rite Stuff Paper Mill



Key Process Equipment:
Fourdrinier Machine



Key Personnel:



Owner
Jim Rite

Plant Engineer
"Big Joe" Rite

Maintenance Manager
"Junior"

Office Manager
Thelma Rite

Accountant
Sally Rite

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Rite Stuff Processes



- **Headbox** – Clean pulp, called stock, is mixed with water to form a "furnish." Furnish is 99.5% water and .5% stock.
- **Presses** – A series of heavy, rotating cylinders press water from the paper, compacting it and reducing its moisture content to 60%.
- **Dryers** - Steam-heated cylinders contact both sides of the paper, evaporating the water to a 5% content level.
- **Size Press/Dryers** – Paper passes through a sizing liquid to make it less porous, then through additional dryers that evaporate the liquid from the sizing.
- **Calendars** – The paper rolls through polished steel rolls that make it even smoother and more compact.
- **Reel** – Paper is wound around a reel and removed from the machine.
- **Shipping** – Paper is then shipped around the world for many uses.

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Sally Rite



Getting Started

- Contacted local resources
- Gathered industry baseline information
- Collected annual energy use data

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Sally Rite Baseline Research





Table 7-3. Energy Consumption in Papermaking (Million Btu per Ton of Finished Paper)

Process	Steam	Electricity	Fuel	TOTAL
Paper Refining and Screening		0.84		0.84
Newspaper Forming, Pressing and Finishing		1.44		1.44
Newsprint Drying	4.07	0.10		4.17
Tissue Forming, Pressing, Finishing		1.82		1.82
Tissue Paper Drying	4.0	0.45	3.50	7.95
Uncoated Paper Forming, Pressing, Finishing		1.80		1.80
Uncoated Paper Drying	5.0	0.10		5.10
Coated Paper Forming, Pressing, Finishing		1.80		1.80
Coated Paper Drying	5.2	0.10		5.30
Linerboard Forming, Pressing, Finishing		0.92		0.92
Linerboard Drying	4.0	0.05		4.05
Papermaking Average (5.26 10^6 Btu/ton) Total Papermaking Energy Use/Yr: 554 10^{12} Btu (based on annual paper production of 85.4 million tons of paper and paperboard)[a]				

a Linerboard energy averages are assumed to be representative of the paperboard sector.
Sources: Jaccard 1996; AF&PA 2004a; Thorp 2005.

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Energy Used Within Paper Manufacturing



Table 4.4
Energy Used within Paper Manufacturing

	Electrical Energy		Steam Energy		Direct Fuel Energy	
	TBtu	%[c]	TBtu	%[c]	TBtu	%[c]
Wet End[a]	103.2	49.9	107.8	20.0	0.0	0.0
Pressing	36.5	17.7	0.0	0.0	0.0	0.0
Drying	45.0	21.7	422.3	78.5	13.4	42.7
Dry End[b]	18.4	8.9	0.0	0.0	0.0	0.0
Coating Preparation	1.2	0.6	2.5	0.5	0.0	0.0
Coating Drying	0.0	0.0	0.0	0.0	17.9	57.3
Super Calendering	2.7	1.3	5.3	1.0	0.0	0.0
Total	**206.9** (26.7%)	100.0	**542.3** (69.3%)	100.0	**31.3** (4.0%)	100.0
Grand Total					**776.0** (100.0%)	

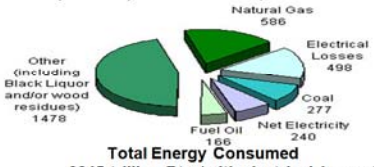
[a] Wet End includes stock preparation through forming
[b] Dry End includes calendering through winding
The percentages above represent an overall average for all papermaking processes and vary for individual processes (e.g., liner, uncoated freesheet, tissue, etc.)



Paper Demographics



Energy Consumption by Fuel – 1998 (NAICS 322 Pulp & Paper)



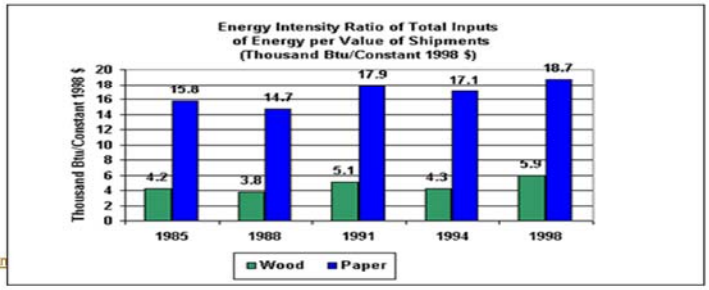
Total Energy Consumed
3245 trillion Btu (with electrical losses*)

Source: MECS 1998
* Losses incurred during the generation and transmission of electricity
http://www.eia.doe.gov/emeu/mecs/iab98/forest/expenditures.html

Energy-Intensity: Ratio of Total Inputs of Energy per Value of Shipments



Source: MECS 1985, 1988, 1991, 1994, 1998, DOC 2001
http://www.eia.doe.gov/emeu/mecs/iab98/forest/intensity.htm

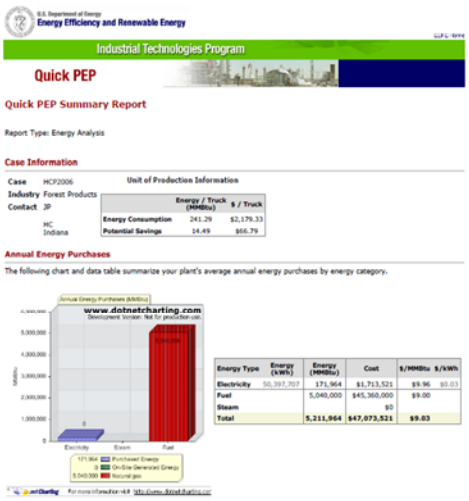


Baseline Comparisor



- U.S. Department of Energy
  - Quick Plant Energy Profiler on-line survey tool
    - Energy Intensity
    - Potential Energy Savings
    - Recommendations





Rite Stuff Energy Map





Initial Carbon Footprint at Rite Stuff



Reference Information for CO2 Emission Factors

	CO2 Emissions	
Energy Source or Fuel	lbs./MM Btu	kg/MM Btu
Electricity* (see note below)	142.5	64.626
Natural gas	117.1	53.098
Residual Fuel Oil - #6	173.9	78.869
Coal (Bituminous)	215.2	97.596
Kerosene	159.5	72.351
LPG	139.0	63.056
Distillate fuel (Diesel)	161.4	73.191
Black Liquor	221.6	100.501
Blast Furnace Gas	604.6	274.190
Butane	141.8	64.309
Coke	225.1	102.100
Coke Oven Gas	103.2	46.823
Crude Petroleum	170.4	77.300
Distillate Fuel (Light Fuel Oil)	161.4	73.191
Ethane	130.0	58.970
Gasoline	156.4	70.941
Isobutane	142.0	64.419
Methane / Landfill Gas	115.3	52.271
Municipal refuse (Dry)	145.9	66.157
Peat	246.5	111.785
Propane	139.2	63.119
Wood Waste (Hog Fuel)	195.0	88.435
Other 1	162.0	73.469
Other 2	210.0	95.238

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Baseline Comparison

- Energy comparison

Energy Source	Potential Savings	Energy Saving/Reel	Total Cost Savings	Cost Savings/Reel
kWh	5,333,894	118 kWh	$180,800	$4.02
Nat Gas	441,000 dt	9.8 dt	$3,969,000	$88.20
Totals: (Savings in MMBtu)	459,200.00 MMBtu	10.204 MMBtu	$4,149,800	$92.22

- CO_2 Comparison



Potential CO_2 Savings From Electricity 3573 tons/yr.
Potential CO_2 Savings From Fuel/Steam 25,816 tons/yr.

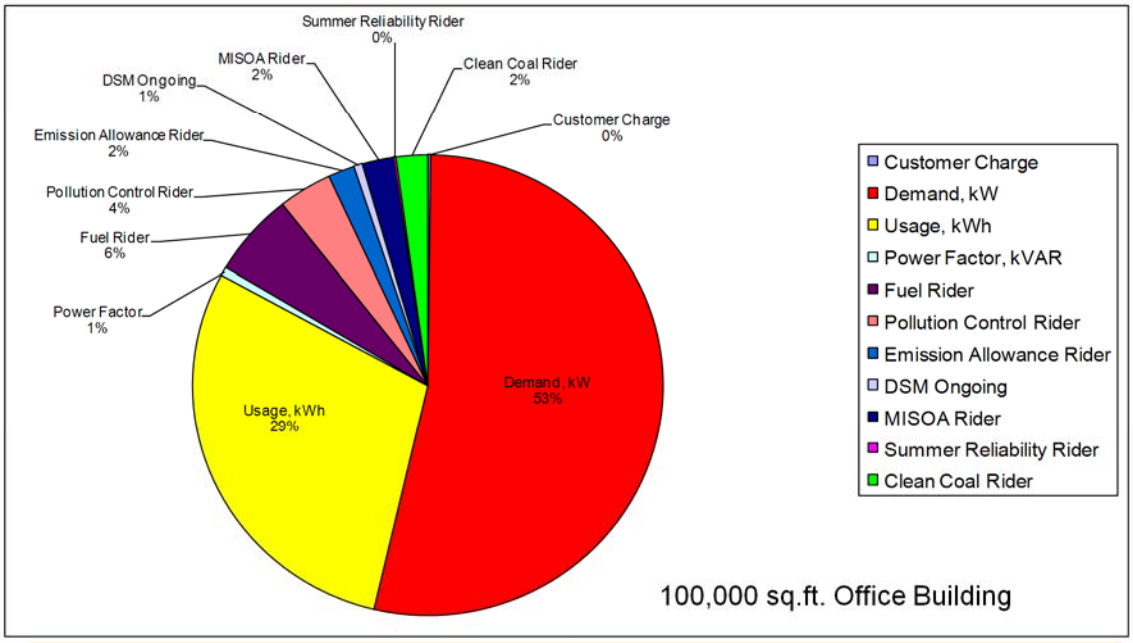
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Course Agenda

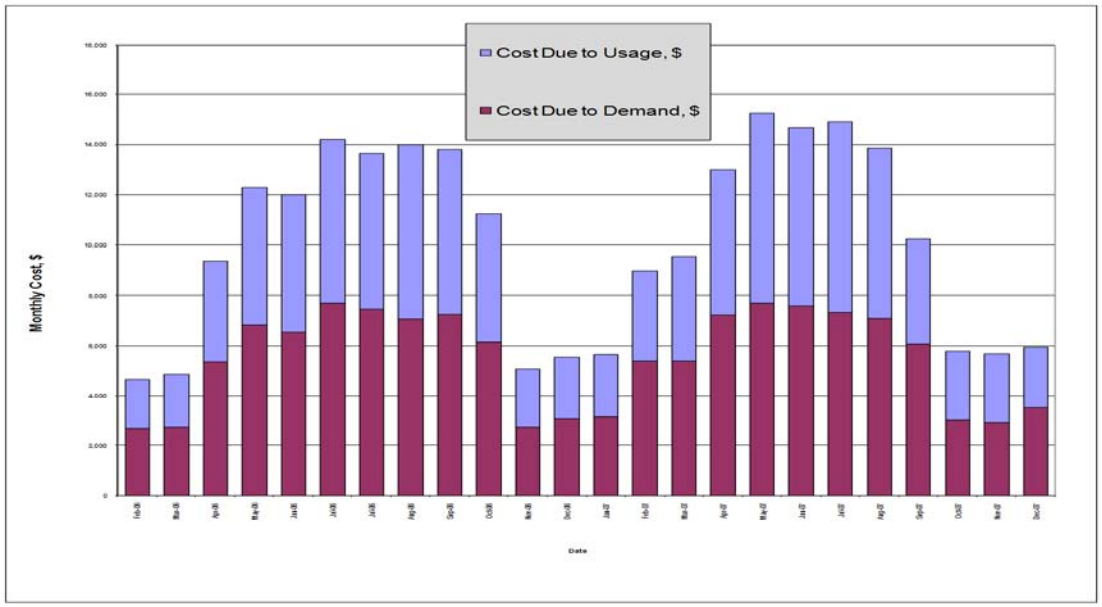
- Energy Consumption & Sources
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Electrical Cost Breakdown



Seasonal Electrical Cost Variations



Electric Bill Variables

- Power Factor Penalty
- Sales Tax (5-10% Additional depending on location)
  Note: May be sales tax exempt if energy use is primarily for manufacturing
- Load Factors
- Peak rates / Off Peak Rates
- Time of Day / Seasonal Peaks
- Option to purchase renewable energy
- Participation in Demand Side Management (DSM) programs

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Natural Gas

Measured in: volume or heat content
Volume: Cubic Feet (cu.ft or cf),
- 100 cf = ccf
- 1000 cf = tcf
- 1,000,000 cf = mcf

Heat Content: British thermal units (Btu)
- 1000 Btu = Mbtu
- 1,000,000 Btu = MMBtu

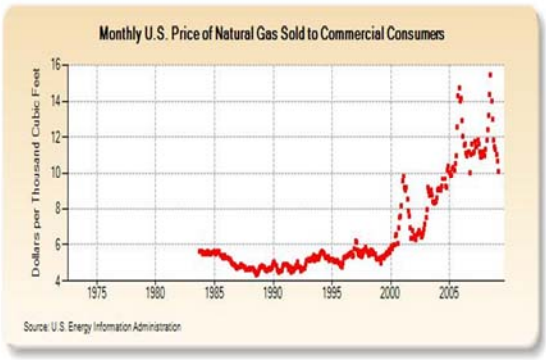


Efficiency = Energy Out / Energy In

For a 90% efficient Water Heater,
where does the other 10% go?

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Natural Gas Prices



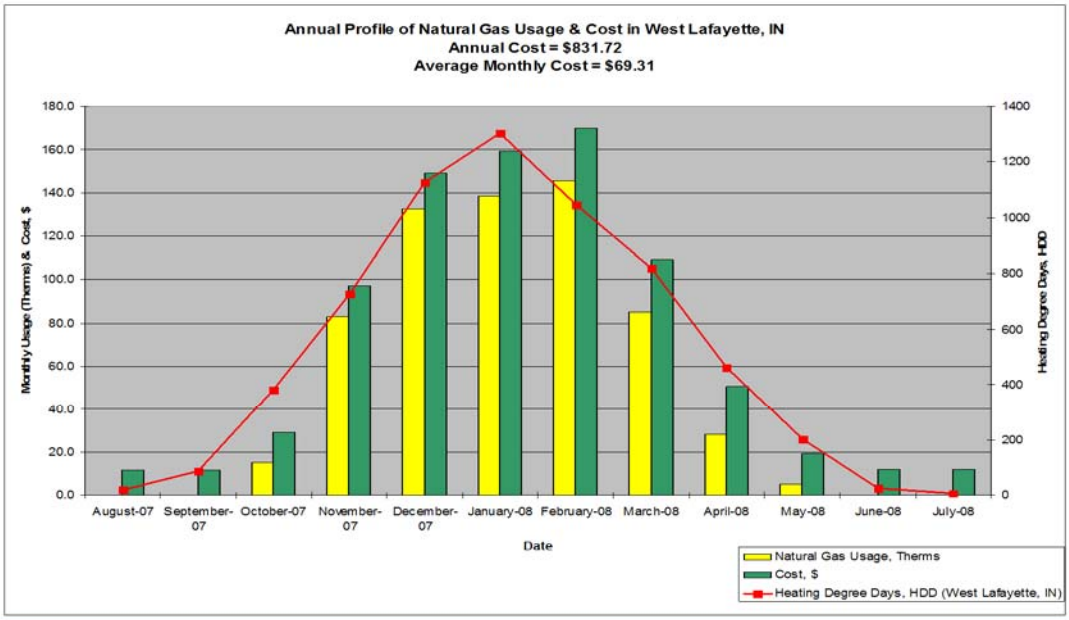




As natural gas usage becomes more prevalent for electricity production, the volatility and cost has been increasing!

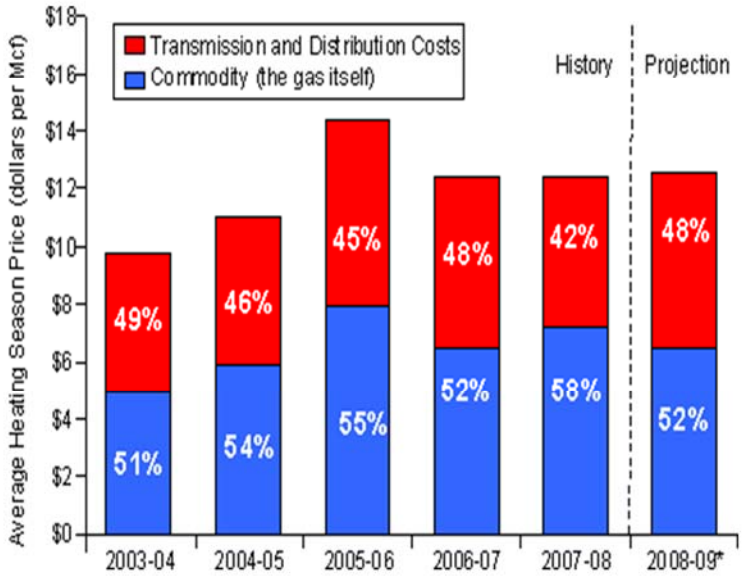
Source: EIA 2009

Seasonal Natural Gas Load



Natural Gas Bill Variables

- Quantity Consumed
- Transmission /Distribution Charges
- Sales Taxes (if applicable)



Source: Energy Information Administration, Short Term Energy Outlook (November 2008)

Utility Analysis at Rite Stuff



Gotham County Municipal Utilities
Calculation of LP Rate Charges

Bill To: Rite Stuff Paper Co, Inc.
100 Backwater Road
Happy Hollow GO, 46205

Date 09/24/2007
Acct#: 555-12345
Site: 100 Backwater Rd

Electric Service Rendered from 08/20/07 to 09/26/07 — Schedule LP

		Demand (KVA)		
Meter Number:	901080595			
Pres Reading:	5282893920	Demand Reading 5565.31		
Prev Reading:	5285417460	X Meter Multiplier		1.025
Diff:	2523540	= Metered	5704.44	
Meter Multiplier:	1.0	/ Power Factor	0.84	
Consumption:	2523540	= Act-Demand	6791	

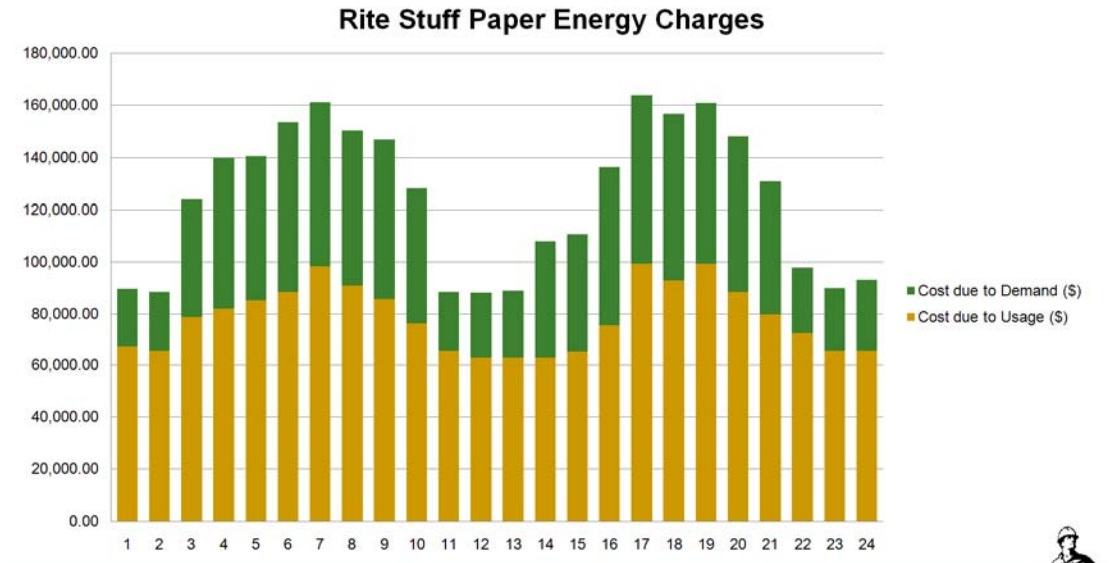
Calculation of Bill

Facility Charge:		150.00	
Demand Charge: Rate LP Regular	6791 kVA x $9.00		61,118.82
Energy Charge			
0 to 100,000 kWh	100000 X 0.041	4100.00	
100,001 to 250,000 kWh	150000 x 0.039	5850.00	
250,001 to 500,000 kWh	250000 x 0.034	8500.00	
500,001 to 1,000,000 kWh	500000 x 0.030	15000.00	
1,000,000 to 10,000,000 kWh	1523540 x 0.028		42659.12
Total		76,109.12	
Fuel Cost Adjustment	$0.00384 x 2523540 kWh	9,690.88	
Total Billing for Electric Service >>>>>		146,918.82	



Paper Energy Charges







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Utility Bill Analysis

- Paying for low power factor
- Encouraged to use more power,
- But penalized for higher demand

- Opportunities
  - Demand reduction
  - Power factor correction
  - Consumption reduction



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Natural Gas Systems at Rite Stuff

- Process Heating in paper making
- Boilers / Steam System
- Space Heating





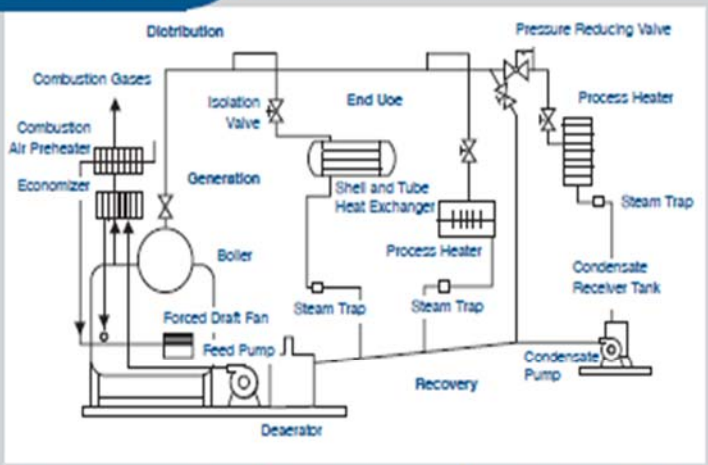
Powerhouse / Power Systems

- Boilers
- Steam / Hot water heaters
- Process heating
- Special Purpose Process Equipment
- Compressed Air
- Motors / Rotating Equipment

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Steam/Hot Water

STEAM SYSTEM SCHEMATIC



Running a steam system efficiently requires much more than tuning boilers because many cost-saving opportunities exist downstream from the boiler.

Causes of Inefficiencies – Boilers

- Pressure too high
- Poor system controls - too much combustion air
- Steam leaks - traps blowing through
- Maintenance Issues:
  - Adjust damper linkages
  - Insulation damage
  - Leaks, steam traps
  - Lubricate fans and pumps
  - Clean tubes
  - Water quality

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Best Practices - Boilers

- Review for leaks, check traps
- Maintain air/fuel ratio
- Stack economizers
- In systems with more than one boiler, rather than operate both at medium fire, operate one at high fire and idle the other.
- Regularly clean & inspect tubes

US DOE Tip Sheets can be found at:

http://www1.eere.energy.gov/industry/bestpractices/tip_sheets_steam.html

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Initial Interview - Joe Rite



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Potential Projects



Questions:

1. List three projects that Joe Rite has already considered:
   a. Buy a new 10,000 lb/hour boiler
   b. Install economizers and optimize the existing steam system
   c. Peak shaving
   d. Switching to transmission (69 kV) power from 4160W
   e. Burning paper waste in the boilers
2. Discuss these the pros and cons of these projects



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Rite Stuff Powerhouse



Option 1: continue to do minimal rebuilds and buy a trim unit – this will provide more capacity but not address demand side inefficiencies. Cost: $100,000

Option 2: Optimize existing units including installation of recuperators, insulating piping, fix steam trap leaks and optimize demand side use. Cost $250,000

The existing boilers used $3,628,800 last year (at this year's prices). The two boilers required $75,000 in annual maintenance and water treatment.



The Boiler at Rite Stuff

- What are the advantages of option #1?
- Are there any disadvantages?

- What are the advantages of option #2?
- What long-term issues must be considered?



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A Simple System Cost Analysis

System Costs	Baseline	Option 1	Option 2
Installation Costs (occurs in Year 1) A			
1. Preventative Maintenance (recurring costs) 1			
2. Predictive Maintenance (recurring costs) 2			
3. Energy (recurring costs) 3			
4. Lost Production 4			
Annual Cost B = (1+2+3+4)			
Cumulative Outlay end Year 1 =A+B			
Cumulative Outlay end Year 2 = A+B+B			



Rite Stuff Powerhouse



	Option 1	Option 2
A. Installation Costs (occurs in Year 1)	$100,000	$250,000
1. Maintenance (recurring costs)	$ 5,000	$ 70,000
2. Energy Costs (recurring cost)	$ 3,628,800 (450,000) $3,178,800	$3,628,800 (650,000) $2,978,800
B. Annual Costs = Maint. + Energy	$3,183,800	$3,048,800
Cumulative Outlay at End of Year 1 = A + B	$3,283,800	$3,298,800
Cumulative Outlay at End of Year 2 = A + B + B	$6,462,600	$6,347,600



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Electric Systems: Motors

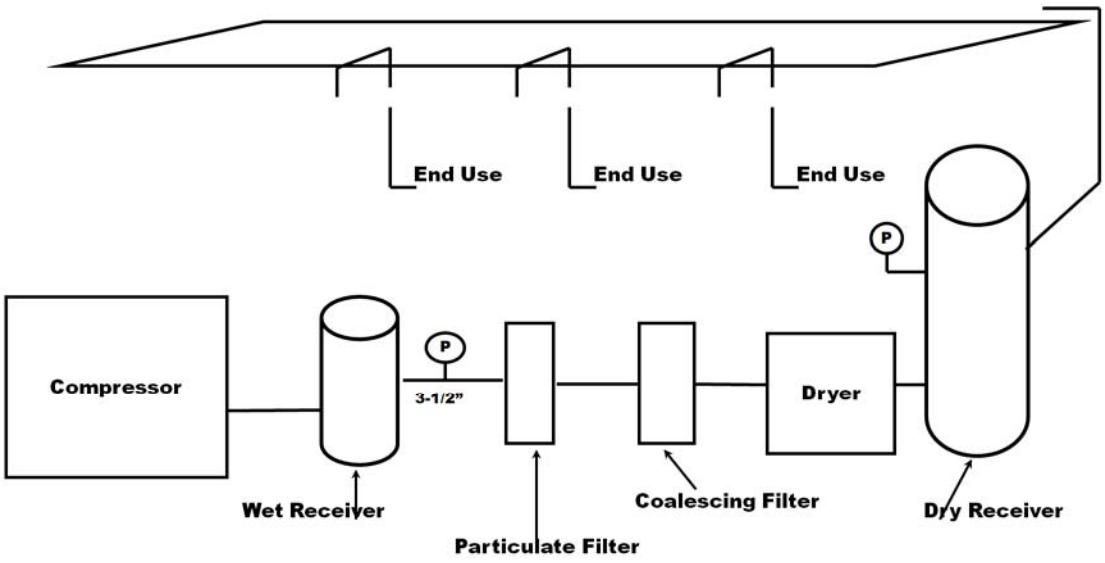
- Motor Driven Systems
  - Fans & Blowers
  - Pumps
  - Air Compressors
  - Chillers





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Compressed Air



Causes of Inefficiency - Air Compressor

- Poor System Controls
- Inefficient Air Dryers
- Inappropriate uses of air
- Inadequate Air Supply
- Inefficient Air Filters

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Air Compressors – Best Practices

- Adjust supply pressure to meet demand needs
- Air leaks can eat up 30 to 50%. An aggressive leak control strategy can reduce this to 10-15%
- Clean and dry the air only as necessary for the end uses
- Optimize controls
- Use large diameter piping. Avoid “T” piping between compressors
- Have adequate storage

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Initial Interview with Junior
The Air Compressor



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Motors / Rotating Equipment

Causes of Inefficiency

- Poorly / Improperly rewound motor
- Inadequate maintenance
- Pump or fan oversized to load
- Partially closed dampers or valves
- Loose belts, poorly aligned pulleys

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Motors / Rotating Equipment

Best Practices

- Proper motor sizing.
- Implementing a Preventive and Predictive Maintenance
- Variable speed drive (where appropriate)
- Pump impeller or fan blade optimized to load
- Operating equipment on fan-curve or pump curve

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Good Maintenance = Energy Savings

- Aligning shaft and pulleys
- Cleaning impellers and heat exchangers
- Replacing filters
- Adjusting linkages of valves/dampers
- Oil analysis on compressors
- Vibration monitoring of bearings
- Infrared thermography of fan or motor bearings

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Interview with Sally
Rotating Equipment



Story Problem: A Really Big Fan

Situation: A new dust collector is needed



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Which is More Cost Effective?

Option #1: A 200 hp radial bladed fan. The fan efficiency is 55%.

It costs **$70,000**.

Option #2: An airfoil fan. The fan efficiency is 85%.

It costs **$105,000**.



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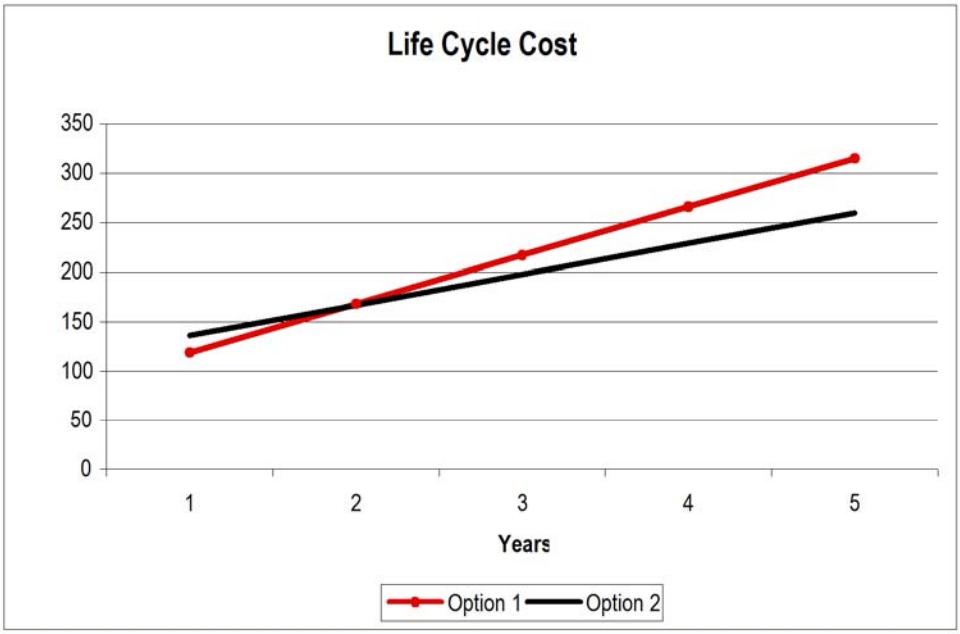


System Cost Analysis

	Option 1	Option 2
Installation Cost (Year 1)	**A.** $70,000	**A.** $105,000
1. Maintenance Cost (R)	$1,000/yr	$1,000/yr
2. Energy Cost (R)	$48,000/yr	$30,000/yr
3. Lost Production Cost	NA	NA
Annual Recurring Cost [Total 1 + 2 + 3]	**B.**	**B.**
Cumulative Outlay at End of Year 1 [Total A + B]		
Cumulative Outlay at End of Year 2 [Total A + B + B]		

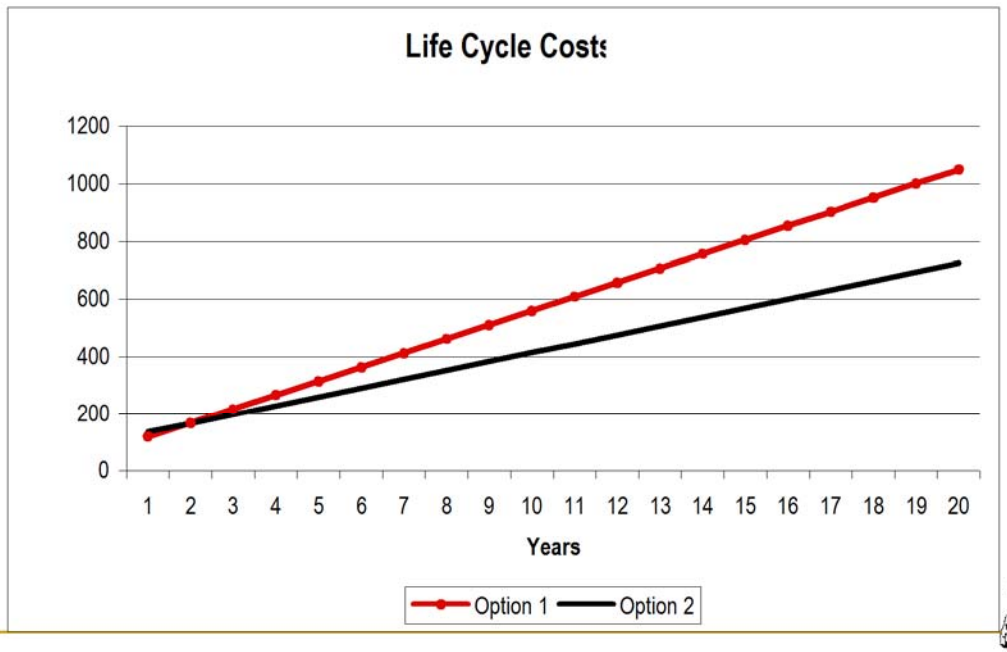


Cash Flow Graph Years 1-5



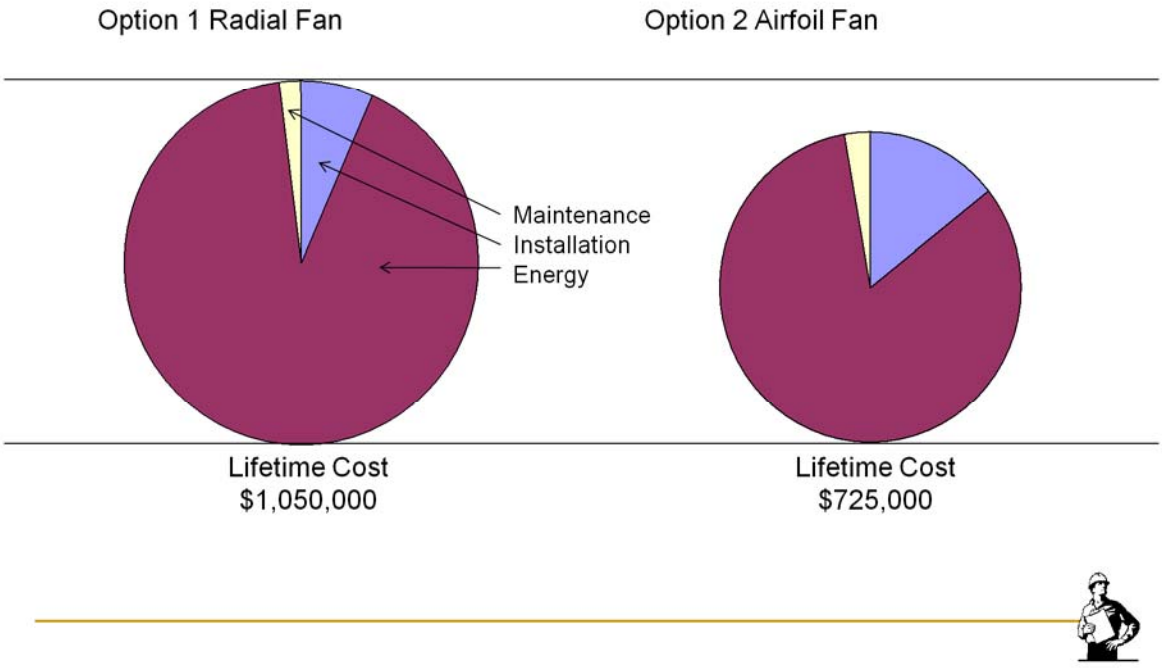
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Cumulative Cash Flow Graph



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Overall System Costs of Options



Facilities

- HVAC System
  - Chillers
  - Cooling towers
  - Duct work
  - Vents and returns
  - Fans
  - Pumps
- Lighting
- Building Envelope
- Electrical Supply System (Co-Gen)

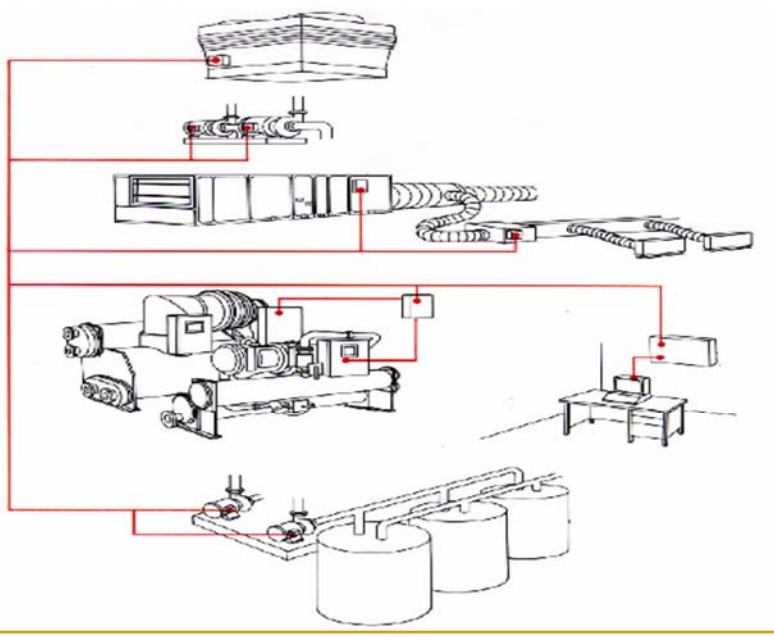
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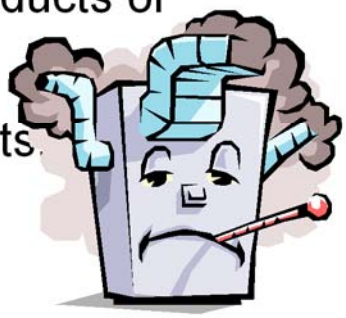
HVAC



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Causes of Inefficiency - HVAC

- Improper sizing. Oversized systems do not properly dehumidify; undersized systems can not maintain temperature.
- Poor system design. Undersized ducts or unnecessary elbows & offsets
- Leaky ductwork. Uninsulated ducts.
- Undersized fans



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Best Practices - HVAC

- Variable Frequency Drives (VFD's) for Air handler fan drives can substantially reduce energy consumption on a Variable Air Volume (VAV) system.
- Economizers to make use of "free cooling" during the spring/fall months.
- Cogged V-belts to reduce friction losses.
- Install occupancy sensors/programmable thermostats

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Preventive Maintenance – HVAC

- Review and/or re-commission control logic to ensure that system is operating as designed
- Maintain / lubricate damper controls
- Clean heat transfer coils & fans regularly
- Replace damaged/missing insulation
- Replace air filters regularly

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Low-Cost & No-Cost Actions HVAC

Better Operation

- Verify proper control settings on HVAC
- Seasonal Setbacks



Benefit

- Increase Comfort
- Reduce energy use 1% for every 1 deg F

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Building Envelope

- Walls
- Roof/Ceiling
- Windows and doors
- Land use



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Causes of Inefficiency - Building Envelope

- Poor design / building age
- Lack of insulation / deterioration of insulation
- Metal framed / single pane windows
- Gaps in exterior openings (overhead doors, man doors, ventilation systems, wall penetrations, etc.)

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Preventive Maintenance – Building Envelope

- Insulation, Insulation, Insulation!
- Weather stripping, caulking
- Repair / replace windows
- Roof repair (wet insulation does a poor job of insulating)
- Replace / repair damaged doors (forklifts!)

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Low-Cost & No-Cost Actions Building Envelope

- Keep the doors closed
- Programmable Thermostats (Can save 10-30% of heating/cooling costs)
- Occupancy sensors
- Plug holes and cracks in exterior doors, windows, and walls
- Insulate, insulate, insulate!

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Low-Cost & No-Cost Actions
Hot Water Heaters

Better Operation	Benefit
▪ Install timers ▪ Set at 110º F instead of 120º F ▪ Make seasonal adjustments	▪ Each 10 degree Fahrenheit reduction in water temperature will generally save 3 – 5 % on water heating costs.

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LEED: Leadership in Energy & Environmental Design

- U.S. Green Building Council
  - An internationally recognized certification system that measures how well a building performs across several metrics:
  - Energy, Water, CO_2, Indoor Air Quality, Environmental Quality, Stewardship of Resources and Sensitivity to Impacts



Auditing in the Office
Interview with Thelma





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Office Energy Efficiency



70 computers, copiers and other office equipment are drawing 2200 watts when not in use, a total of 6500 hours a year.

How much energy and cost is being wasted?



HVAC Case Study

- The office is often too cold in the central area, but too hot in some of the offices and meeting rooms.
- There is only one thermostat
- Heating is supplied by the plant steam system
- Air conditioning is supplied by a roof-top condenser unit
- Estimated costs are $25,000/year

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HVAC Case Study

- Recommendation:
  - Install programmable thermostat
  - Modify air handler to allow free cooling
  - Install more terminal reheat units
  - Raise temperature of air from condenser units
- Cost $10,000
- Estimated annual savings $3,000



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Lighting

- Incandescent
- Fluorescent
- High-intensity discharge
  - High-pressure sodium
  - Low-pressure sodium
  - Metal halide
  - Mercury Vapor, Halogen, Quartz, other
- Light emitting diode (LED)

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Causes of Inefficiency - Lighting

- Old, inefficient fixtures
- Improper lamp (bulb) selection
- Poor maintenance
- Poor design / layout of fixtures

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Preventive Maintenance – Lighting

- Group relamping at 80% of estimated bulb life saves money and maintains appropriate light levels.
- Replacement of lamps with more efficient newer designs
- Cleaning fixtures and reflectors

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Low-Cost & No-Cost Actions
Lighting

Better Technology

- Compact Fluorescents
- High-Bay Fluorescents
- Automated/Programmable Controls
- Motion Sensors



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Replace Metal Halides with Fluorescents



Analysis

The warehouse has 100 metal halide lights that use 400-W lamps. The ballasts for these lights draw about 65 W each.

New high-bay fluorescent lights that use four 8-ft T8 lamps in specially-designed high-efficiency fixtures are available. The high-bay fluorescents lights draw about 227 W per.



Fluorescent Fixtures





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Estimated Savings



The electricity savings from replacing the current fixtures with the proposed fixtures would be about:

Assume $0.034 kWh and $10.00 / kW during peak hours

100 fix x [(460-227W)/1000 W/kW] x 8000 hours/year x $0.034/kWh =
$6337.60 usage savings

100 fix x [(460-227W)/1000 W/kW] x $10/kW x 12 month/year =
$2796 demand savings

Total **$9133.60 cost savings**



Maintenance Costs



T8 life = 15,000 hours x 1.25 = 18,750 hours

MH: [100 fix x (8,000 hours/year / 20,000 hours)] x 1 lamps/fix = 40 lamps/year

T8: [100 fix x (8,000 hours/year / 18,750 hours)] x 4 lamps/fix = 171 lamps/year

Metal Halides cost about $23/each while T8 lamps cost about $6 each.

MH: $920 /year T8: $1026 /year

Thus, annual maintenance costs could increase by: = $106 /year

The net savings would be about: $9,133.60 + (106.00) = $9,027.60 /year



Estimated Implementation Cost



Cost of a new high-bay fluorescent fixture is about $185. Assuming $25 per fixture installation costs, the total implementation cost :

100 fixtures x ($185 /fixture + (60/60 hours/fixture x $25 /hour)) =
$21,000

Estimated Simple Payback:

($21,000 installation costs) / ($9,027.60/year cost savings) x 12 months/year = 27.9 months



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  - Transportation
  - Co-Generation
- Carbon Footprint
- Systems Approach
- Course Evaluation

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Transportation Metrics

- Overall Road Miles
- Average mileage of fleet vehicles
- Fuel use per $ revenue
- Carbon (CO_2) generated per $ revenue/profit
- Maintenance/Operating Costs of internal (lift truck) operations

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Transportation Considerations

- Alternative Transportation Fuels
- Hybrid Vehicles for fleet (tax incentives)
- Plug-In Electric Vehicles for local errands (tax incentives)
- Electric vs. LP vs. Diesel (Biodiesel?) for lift trucks

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Low-Cost & No-Cost Actions Transportation

- Optimize logistics of product flow (Get Lean!)
- Specify / demand fuel efficiency when purchasing new equipment (look at life cycle cost rather than just first cost)
- Off-peak rates for recharging fork lifts (if available)
- Consider Smartway vehicles for transportation/shipping needs

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Interview with "Big Joe" Transportation Projects









Transportation Case Study

- Each shift, the fork trucks were making on average 12 trips of 1000 ft carrying waste paper to the dumpster each shift.
- The company pulling the dumpster is charging $25/ton and $200 for each pull of the dumpster.



Transportation Case Study

- Install a bailer near the dry end of the papermaking machine where most of the waste is generated.
- Reduce trips to dumpster from 12 to 1 per shift. Reduces the number of pulls from 1/day to 1 per week.





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Transportation Case Study

Cost	Frequency	Cost	Before	After	Savings
Dumpster Pull	7/week	$200/pull	7 = $1400	1 = $200	$1200.00
Tons Shipped	14 tons/week	$25/ton	$350	$350	0
Fork Trucks Propane Worker time	180 trips/week 5 min/trip = 15 hrs/week	$3.00/gallon $10.00/hour	$6.9/week $150/week	$0.57 $12.50	$ 6.33 $137.50
TOTAL					$1343.83/wk
Total/Year	50wks/year	$1343.83/wk			**$67,191.5**



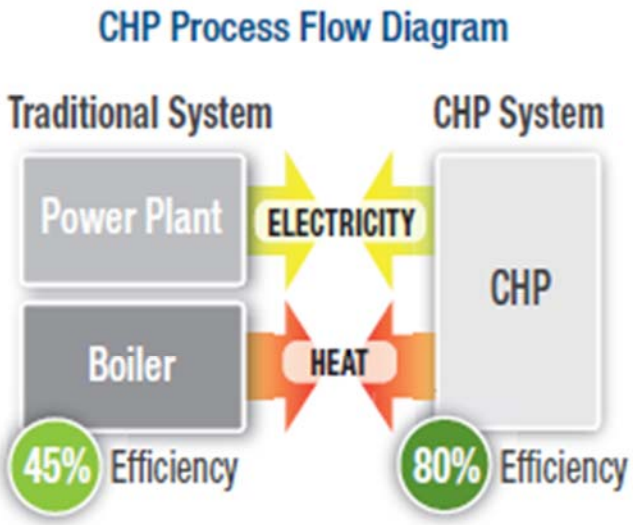
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Course Agenda

- Energy Consumption & Sources
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Co-Generation - Combined Heat & Power (CHP)



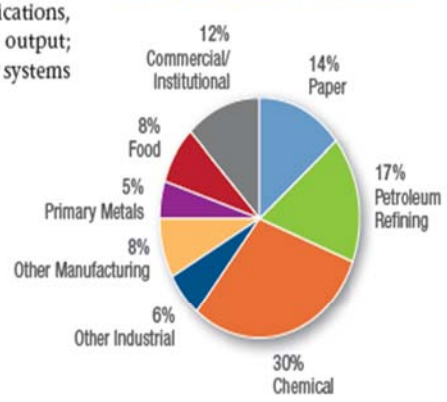
Market Sector Potential

What Does a CHP System Produce?

CHP is unique among electricity-producing technologies and methods because it generates more than one output. For most industrial applications, the thermal energy produced by the systems is the most valued output; electricity is considered a secondary, yet beneficial, by-product. CHP systems can provide the following products:

- Electricity
- Direct mechanical drive
- Steam or hot water
- Process heating
- Cooling and refrigeration
- Dehumidification

Existing CHP Capacity by Application



Source: EEA, Inc. CHP Installation Database.

CHP Systems

Potential Savings Nationwide

Proposition: What If 20% of US Electricity Generation Came From CHP?

CHP currently comprises 12.6 percent of US electricity generation (i.e. MWh) and 8.6 percent of total generating capacity (i.e. MW). Achieving 20 percent generation capacity by 2030 would result in 1.16 billion MWh of generation (or 240.9 GW of capacity). Increasing CHP capacity to 20 percent, while an aggressive target, can be accomplished given the proper technical and policy circumstances.

2030 CHP – Proposition: 20% of U.S. Capacity	240,900 MW
Reduced Annual Energy Consumption with CHP	5.3 Quads
Total Annual CO_2 Reduction	848 MMT
Total Annual Carbon Reduction	231 MMT
Number of Car Equivalents Taken Off Road	154 million

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CHP Case Study



Should Rite Stuff invest in co-generation?

Jim Rite and Joe Rite have looked into using waste paper as a secondary fuel for one of their boilers and wondered if it might help them achieve LEED (Leadership in Energy & Environmental Design).

They also asked the engineer what he thought of putting solar panels on the warehouse or maybe even a wind turbine.

What are the merits of these ideas? What other types of CHP should they consider?





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Carbon Footprint

- The amount of fossil carbon consumed by a facility, converted to metric tons of CO_2, is their *carbon footprint.*
- Movement is underway to cap carbon emissions with companies in different industries or geographical regions given *allowances*.

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Carbon Footprint

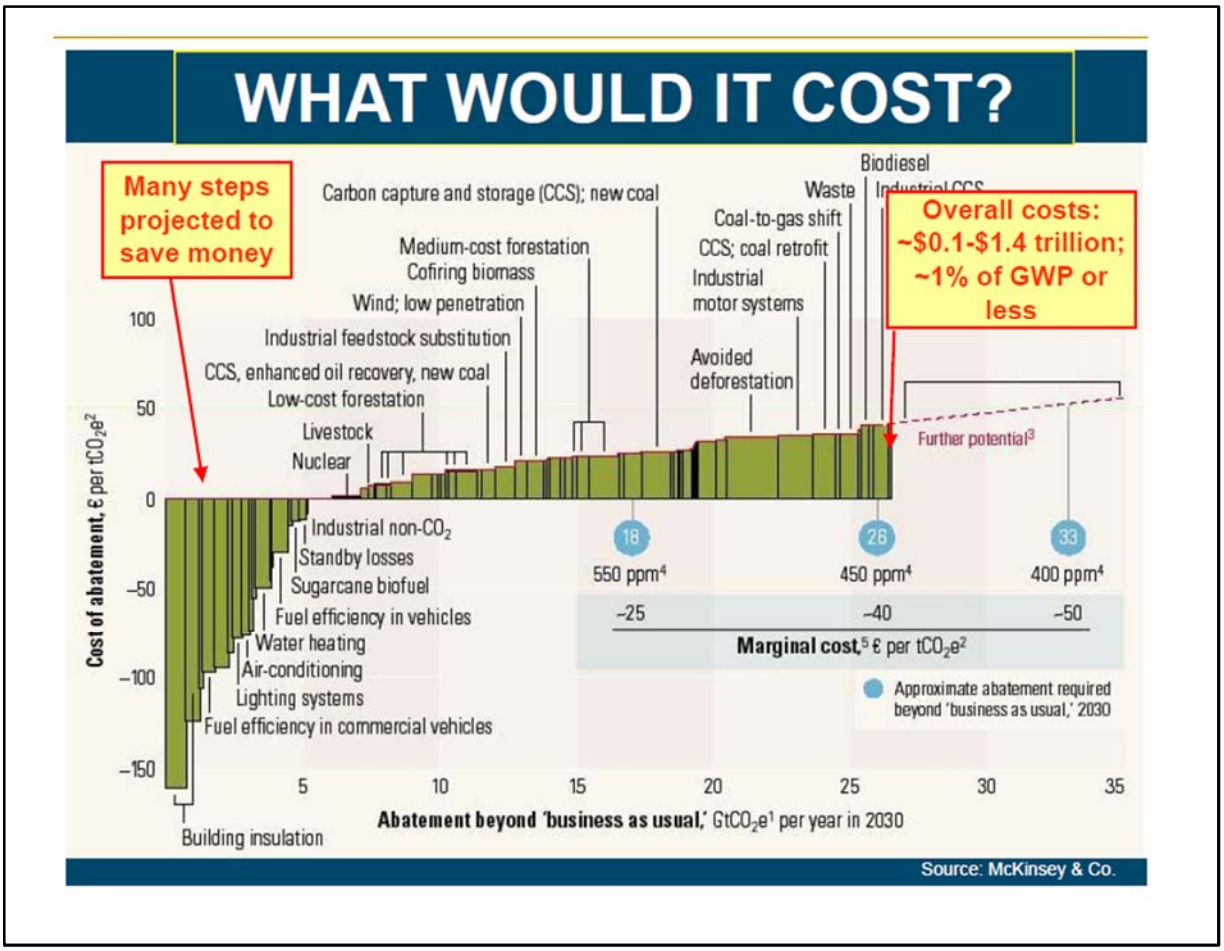
- The cost of a product or service is usually directly related to the amount of energy invested in its creation.
- If that energy is created through combustion of fuels, then the lower the production costs, the less carbon emissions
- Not the case if the energy is created through renewable sources.

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Carbon Offsets, Credits & Trading

- Carbon emissions can be “offset” by acquiring the rights to projects that reduce emissions, e.g., tree plantations, renewable energy.
- Carbon Credits can be earned by reducing emissions below your allowance.
- Credits (unused allowances) may be traded on the open market.

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WHAT WOULD IT COST?
Many steps projected to save money
Overall costs: ~$0.1-$1.4 trillion; ~1% of GWP or less
Carbon capture and storage (CCS); new coal
Biodiesel
Waste
Coal-to-gas shift
CCS; coal retrofit
Industrial motor systems
Medium-cost forestation
Cofiring biomass
Wind; low penetration
Industrial feedstock substitution
CCS, enhanced oil recovery, new coal
Low-cost forestation
Livestock
Nuclear
Avoided deforestation
Further potential[3]
Industrial non-CO2
Standby losses
Sugarcane biofuel
Fuel efficiency in vehicles
Water heating
Air-conditioning
Lighting systems
Fuel efficiency in commercial vehicles
Building insulation
Cost of abatement, € per tCO2e2
100
50
0
–50
–100
–150
5
10
15
20
25
30
35
Abatement beyond 'business as usual,' GtCO2e1 per year in 2030
18
26
33
550 ppm4
450 ppm4
400 ppm4
–25
–40
–50
Marginal cost,5 € per tCO2e2
Approximate abatement required beyond 'business as usual,' 2030
Source: McKinsey & Co.

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Systems Approach

- Prioritize
- Analyze entire system
- Optimize System
- Implement Best Practices
- Good Maintenance = Energy Savings



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Quantifying Potential Benefits

- Energy saved (kWh or ccf)
- Demand reduction (kW)
- Energy Use Index / Energy Cost Index
- Carbon Footprint
- Other utility savings
- Reduced maintenance
- Increased production capacity
- Less down time



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Justifying Changes at Rite Stuff



- Energy cost savings
- Demand reduction
- Material savings
- Labor savings
- Increased production capacity
- Decreased compliance costs

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Improvement Opportunities at Rite Stuff



- Steam System capacity improvement
- Compressed Air leak reduction
- HVAC Optimization
- Warehouse Lighting
- Dust Collector fan improvement
- Waste paper compactor

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New Carbon Footprint at Rite Stuff

Project	Electricity Savings (kWh)	Natural Gas Savings (MMBtu)	Propane (gallons)	Cost Savings
Steam		72,222.00		$ 580,000.00
Fan	529,411.00			$ 18,000.00
HVAC		277.00		$ 3,000.00
Lighting (warehouse)	816,400.00			$ 9,027.60
Fork Trucks			105.50	$ 67,191.50
Compressed Air				$ 15,782.00
Lighting (office)	14,300.00			$ 486.20
Total	1,360,111.00	72,499.00	105.50	**$ 692,987.30**
Total MMBtu	4,640.70	72,499.00	10.08	**77,149.77**
Total CO2 reduction	976.56	3,625	0.06	**4,601.57**



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Appendix

Purdue Technical Assistance Program
Energy Efficiency Services
Energy Audit Workbook

Table of Contents

Audit Forms

1. **Building Information**
2. **Building Occupancy Profile**
3. **Building Characteristics**
4. **Annual Energy Use and Cost**
5. **Heating Ventilating & Cooling System (HVAC)**
   - a) **Cooling System**
   - b) **Steam System**
6. **Domestic Hot Water**
7. **Lighting**
8. **Special Systems**
   - a) **Ovens & Furnaces**
   - b) **Compressed Air**
   - c) **Fans & Pumps**

References

Much of this workbook is based on the “Washington State University Energy Program Energy Audit Workbook” developed by Washington State University Cooperative Extension Program and published in May 2003: WSUCEEP2003-049

The data collection sheet for motor driven systems was created for Purdue TAP by Productive Energy Solutions, LLC; 2229 Eton Ridge; Madison, WI 53726-5303

The compressed air data collection sheet is based in part on materials created by Air Power USA, Inc., P.O. Box 292, Pickerington, OH 43147

1. Building Information

Date _____ Auditor & Organization _____

Name of Facility _____ Address _____

City, State, Zip _____

Mailing Address _____

Owner of facility _____Address _____

Name of Building_____ Building # ___ of ____

Building Use_____ Building Type _____

Date of Construction (approximate if needed) _____ Remaining useful life _____

Original Architects (if knows) _____ Additions _____

Original Engineers (if Known) _____ Additions _____

Does the building have an energy management system? _____ Date of last service _____

Previous energy audits completed _____ (if yes, give dates & auditors below)

_____

Utilities: (y/n) Electricity ___ Natural Gas ____ Water ____ Fuel Oil ____ Other _____

Metering: is this building individually metered for:
electricity (y/n) ___ gas ___ steam ___ compressed air ___

Energy Utilization Index for this type of building _____
Can look up at: http://www.eia.doe.gov/emeu/efficiency/cbecstrends/cbecs_tables_list.htm
Use Table 5b. U.S. Commercial Buildings Energy Intensity Using Site Energy by Census Region and Principal Building Activity, 1992-2003

Notes:

2. Building Occupancy Profile

Daily Profile

100%									
0%									

12 mid 6 am 12 noon 6 pm 12 mid

Fill in blocks or draw line to indicate normal daily occupancy profile

Weekly Profile

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
100%						
0%						

Fill in blocks or draw line to indicate normal weekly occupancy profile

Annual Profile

Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
100%											
50%											
0%											

Fill in blocks or draw line to indicate normal annual occupancy profile

Occupancy Schedule

Description of Shifts (Number and duration) _____

_____

3. Building Characteristics

Gross Floor area _____ Gross sq.ft. x ceiling height ___ ft = volume _____ cu.ft.

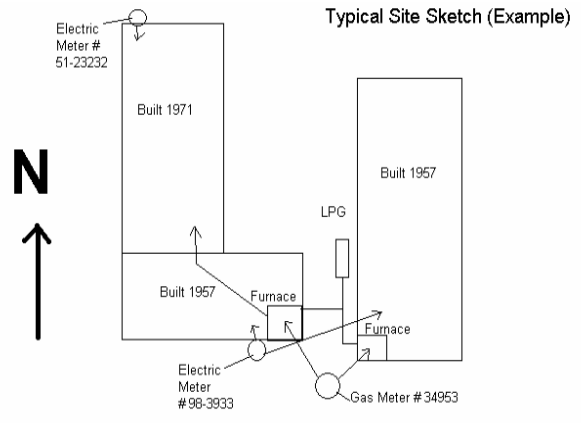
Air conditioned floor area (if different than Gross) _____

Doors			**Windows**			**Walls**		
Type	**Number**	**Area**	**Type**	**Number**	**Area**	**Type**	**Number**	**Area**
Totals:								

Insulation
Describe insulation in walls, ceilings, roofs and doors:

Describe general building condition:

In the space below, sketch the building or building complex. Include the following information: Relative location and outline of building(s), building age, building name or number, dimensions, utility meters and inputs, location of heating and cooling units, and north orientation arrow.



4. Annual Energy Usage and Cost

Electricity

Building _____ Power Input _____(eg: 480, 240V)
Utility _____ Tariff _____

Month	kWh	Usage charge	kW	Demand Charge	PF	Power Factor Charge	Other Charge	Other Charge	Total Charges
Totals									

Natural Gas or other Fuel

Building _____ Delivery Utility _____

Meter Number _____ Transport Utility _____

Building Size (sq.ft) _____ Fuel Type _____

Month	Volume	Conversion Factor	MMBtu	Annual EUI (Btu/sq.ft)	Fuel Cost
Total					

5 Heating Ventilating & Air Conditioning System

System	Primary	Secondary 1	Secondary 2	Other
Type of System				
Area Served (sq.ft.)				
Location / Building				
Condition of System				
Maintenance Program				
Control System				
Hours/Week Operation				
Weeks / Year Operation				
System Demand (kW)				

System Diagram:

5a: COOLING SYSTEM

Cooling System	Primary	Secondary #1	Secondary #2
Type of System			
Energy Source			
Condition			
Maintenance			
Control System			
Voltage			
Full load amps			
Hours of operation per week			
Weeks per year			

Primary use of cooling:

Secondary use of cooling:

System Diagram:

5b: Steam System

Boiler	Primary	Secondary #1	Secondary #2
Type of Boiler			
Rated input			
Rated output			
Energy Source			
Condition			
Maintenance			
Controls			

Boiler Operation Profile

Hours per weekday _____

Hours per Saturday _____
Hours per Sunday _____

Total per Week _____

Weeks per year _____

Total per year _____

Steam Demand Profile

Primary Use _____

Hours per day _____

Secondary Use _____

Hours per day _____

Other uses _____
_____

Hours per day _____

System Diagram:

6 Domestic Hot Water

Domestic hot water is heated by _____ Daily usage (gal) _____

Number of units _____ Types _____ General location _____

Is there a recirculation loop? _____ Temperature of city water _____

Hot water temperature at point of use _____ at heater _____

Is tank wrapped _____ Distance from point of nearest use_____ farthest _____

Is hot water uses other than lavatories_____

7 Lighting

Building Area	Type of Fixture	Approximate Number of Fixtures	Average Watts/Fixture	Operating Hours/Day	Average Foot candles

8 Special Systems

Motor Driven Systems (Pumps, Fans, Blowers)

Use the attached spreadsheet to record all or at least the largest motors in your plant. Be sure to record the horsepower and estimated hours of operation for each. These numbers can be used to determine which motor driven systems are using the most power.

Make note of older motors that have lower name plate efficiencies or that may have been rewound more than once.

Fans & Blower systems:

Is a fan curve available for this system?

Make not of fan systems with partially closed dampers, especially if they are on the suction side of the fan.

Look for sharp turns in duct work that restrict flow. Is duct work of sufficient size?

If the fan is oversized for the load, can it be optimized with a different fan blade? Is this a good application for a variable speed drive?

Are there filters? How often are the cleaned/replaced?

Pumping Systems:

Is a pump curve available for this system?

Make not of any partially closed valves and any recirculation loops that enable a pump to operate under full load even though there is not sufficient liquid under normal circumstances to provide this load.

Look for sharp turns in piping that restrict flow. Is piping of sufficient size?

If the pump is oversized for the load, can it be optimized through a trimmed impeller? Is this a good application for a variable speed drive?

Are there filters? How often are they cleaned or replaced?

Furnaces and Ovens

Unit Name/No.	Fuel	Rate	Fuel-Air Mixture	Excess Oxygen

Do units have heat exchangers?____ If so, how efficient? _____

Describe control systems:

Make a rough diagram of each of the major ovens and furnaces. Include location of burners, controls, gas and air lines, exhaust flues, heat recuperators, and flow of material.

COMPRESSED AIR SYSTEM

DATA COLLECTION FORM

Company Name: _____ Plant Products: _____ # of Employees: ____

Address: _____ City/State/Zip: _____

Contact: _____ Telephone: _____ E-Mail: _____

Average Compressor Discharge: _____ (psig) Loaded
_____ (psig) Unloaded

System Pressure: _____ Minimum
_____ Maximum

Number of separate systems: _____
Number of compressor areas: _____
Air System Operation: _____ hrs/wk _____ wks/yr

Primary air use: _____
Secondary use: _____
Other uses: _____

Air Compressors:

#	Make/Type	Model	Hp	Type of Control	Use (hrs/yr)	Comments & Problems

Dryers:

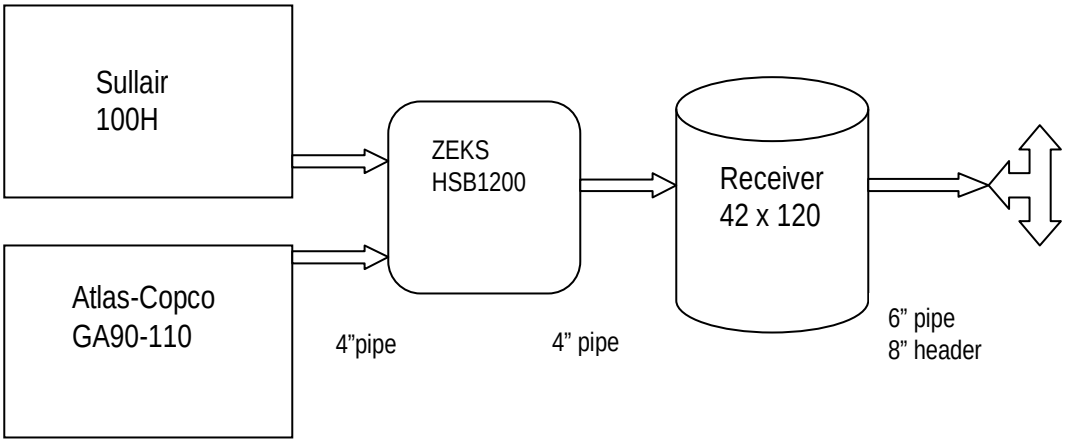
#	Make/Type	Model	Cfm	Dew Point Control	Use (hrs/yr)	Comments & Problems

Describe any problems you are experiencing with system flow, pressure, reliability or maintenance:

Air System Diagram

Make a rough diagram of compressor, dyers and other system components. Include the model numbers of the components and pipe diameters. Make a separate diagram for each system.

Example:



Fan System Data Sheet

Thank you for registering for the Fan System Assessment Training. Before the training please:

(1) Identify one **large fan** that has **long operating hours and is either**: (a) controlled with dampers, and/or (b) experiencing operating problems. (Preferably without an adjustable speed drive.)
(2) Have a qualified electrician or your local utility take the measurements necessary to **complete the Required Data** section below.
(3) **Gather the Optional Data.** You will need this information to use FSAT after the training.
(4) **Bring this data form and a calculator** to the training. You will use this data during the training session to calculate your fan operation costs.

Required Data:

1. Name of Fan System _____

2. (a) Motor Nameplate HP _____ hp and (b) Motor Efficiency _____

3. (a) Measured Power Draw _____-_____ kW (if power meter available)
   OR
   (b) Motor Voltage and Amperes:

Phase	VOLTS	AMPS
AB		
BC		
AC		
Average		

4. Operating Hours _____ hr/yr

5. Electric Rate _____ $/kWh (Calculate this by dividing the total bill amount by the total kilowatt hours.)

Optional Data:

6. Type of Fan Impeller _____ (if known)
7. (a) Fan Pressure Rise ____ in. H_2O (if known)
   (b) Damper Pressure Drop _____ in. H_2O (if known)
   (c) Pressure Required for Process _____ in. H_2O (if known)
8. Fan Flow _____cfm (if known)
9. Fan Speed _____rpm (if known)
10. Fan Impeller Size _____ inches (if known)
11. Air Stream Temperature _____ °F
12. Gas Other Than Air _____

Energy use data collection sheet
Industrial Motor systems

			Fans				Pumps		Measured						
Tag	System Description	HP	VIV	IBD	ASD	System Damper	Throttle valve	Bypass valve	Volts	Amps	kW	Hours	Annual kWh	Annual energy Cost	Remarks

COMPRESSED AIR SYSTEM
DATA COLLECTION FORM

Company Name: _____ Plant Products: _____ # of Employees: ____

Address: _____ City/State/Zip: _____

Contact: _____ Telephone: _____ E-Mail: _____

Average Compressor Discharge: _____ (psig) Loaded
_____ (psig) Unloaded

System Pressure: _____ Minimum
_____ Maximum

Number of separate systems: _____
Number of compressor areas: _____
Air System Operation: _____ hrs/wk _____ wks/yr

Primary air use: _____
Secondary use: _____
Other uses: _____

Air Compressors:

#	Make/Type	Model	Hp	Type of Control	Use (hrs/yr)	Comments & Problems

Dryers:

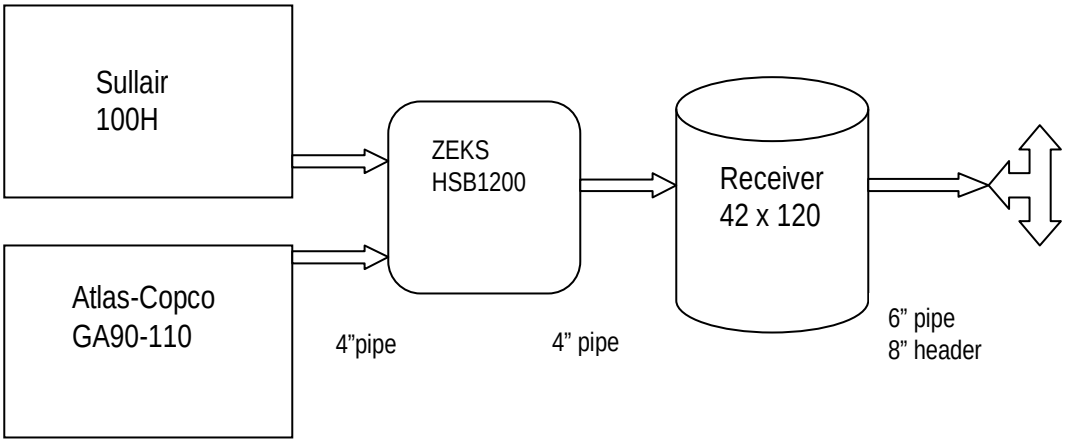
#	Make/Type	Model	Cfm	Dew Point Control	Use (hrs/yr)	Comments & Problems

Describe any problems you are experiencing with system flow, pressure, reliability or maintenance:

Air System Diagram

Make a rough diagram of compressor, dyers and other system components. Include the model numbers of the components and pipe diameters. Make a separate diagram for each system.

Example:



System Cost of a Light Bulb

- Problem: the light in the hall has burned out and must be replace.



Solution Options:

- A: 60W 4/$3.29
  - 2000 hours/bulb
- B: 60W 4/$2.49
  - 1000 hours/bulb
- C: 13W 1/$2.00
  - 8000 hours/bulb
- D: 13W 1/$2.50
  - 10,000 hours/bulb

System Cost of a Light Bulb

A: 60 Watt, 4pack / $3.29, 2000 hours

- (8760 hours/year)/2000 hours = 4.38 bulbs/year
- 4.38 bulbs/year x $3.29/ 4 bulbs = $3.60/year
- (60W x 8760hr/year x $0.07/kWh) /1000W/kWh = $36.79/year in electricity
- = $40.39 total

System Cost of a Light Bulb

- Option A:
  $3.60 bulbs
  $36.79 power
  $40.39 Total
- Option B:
  $5.45 bulbs
  $36.79 power
  $42.24 Total
- Option C:
  $2.19 bulb
  $7.97 power
  $10.16 Total
- Option D:
  $2.19 bulb
  $7.97 power
  $10.16 Total

Other Costs to Consider

- Time
- Disposal
- Standardizing of supplies



Helpful Websites

- U.S. Department of Energy http://www.energy.gov/
  - Energy Efficiency & Renewable Energy http://www.eere.energy.gov/
    - Industrial Technology Program: http://www1.eere.energy.gov/industry/
      - Save Energy Now: http://www1.eere.energy.gov/industry/saveenergynow/
      - Energy Savings Assessments http://www1.eere.energy.gov/industry/saveenergynow/assessments.html
      - BestPractices Program: http://www1.eere.energy.gov/industry/bestpractices/
  - EnergyStar http://www.energystar.gov/
  - EPAct 2005 http://www.energy.gov/taxbreaks.htm
  - Energy Information Agency http://www.eia.doe.gov/
    - State Profiles http://www.eia.doe.gov/emeu/states/_states.html
- Financial Assistance http://grants.pr.doe.gov/
- U.S. Department of Agriculture – Energy
  - http://www.nrcs.usda.gov/technical/energy/
  - http://www.rurdev.usda.gov/rd/energy/
- Indiana office of the Lieutenant Governor
  - Office of Energy Development http://www.state.in.us/energy/
  - http://www.state.in.us/energy/programs/current.html
  - Indiana State Department of Agriculture: http://www.in.gov/isda/
- Indiana Utility Regulatory Commission http://www.state.in.us/iurc/
- Indiana Office of the Utility Consumer Counselor http://www.in.gov/oucc/
- Indiana Department of Environmental Management – Recycling Program
  - http://www.in.gov/recycle/topics/grants/
- Purdue University –
  - Technical Assistance Program (TAP) http://www.tap.purdue.edu/html/about_tap/index.html
  - Purdue Calumet Center for Energy Efficiency and Reliability
  - http://www.calumet.purdue.edu/energycenter/
  - Purdue Energy Experts list http://news.uns.purdue.edu/html3month/2006/060815.E-Energy.html
- Indiana Industrial Energy Consumers, Inc. http://www.indiec.com/
- Indiana Society of Healthcare Engineers http://www.isheweb.org/

PURDUE UNIVERSITY
Technical Assistance Program

TAP Energy Efficiency Services
Opportunity Assessment Form

Quick PEP Worksheet

Please fill out One sheet per facility

Sheet for Facility # 1

Company Name: Rite Stuff Paper Mill

Street: 100 High Energy Avenue

Telephone: 555-1234

City: Renewables

Fax:

State: IN

E-Mail:

Zip Code: 46205

Company Contact: Sally Rite

Number of Buildings: 3

TAP-IES Project Manager:

Employees at this plant: 74

Energy Sources:

List for each utility, the average amount of energy consumed for given period. For example: National Electric; 100,000 kWh at $0.045 per month. Total monthly charges $4650.00

Utilities	Electricity	Nat Gas	Other Fuel (propane)	Steam	Chilled Water	Co-Generation
Company						
Units (kWh, MMBtu, etc)	kWh, kW	therms	gallons			
Cost per unit ($)	$0.034	$9.00				
Average Volume	50,397,696	5,040,000				
Period (hour, day, week, month, or annually)	Year	Year				
Average Cost/Perioc - include demand charges, etc.	$1,713,522	$4,536,000				

Energy Use Distribution:

Provide best estimates of the distribution of each energy source. If steam is used for process heating and natural gas is used for creating steam, record the percentage for Process Heating in the Steam column and the Boiler/Steam Production in the Natural Gas Column. Include steam temp.& pressure.

End Use	Percent of Energy Source or units/period					
	Electricity	Nat Gas	Other Fuel (propane)	Steam	Chilled Water	Co-Generation
Co-Generation						
Compressed Air (_____psi)	10					
Chemical Processing						
Facility - lights, HVAC	10	10		10		
Fans & Blowers	20					
Material Handling	1		100			
Material Processing - grinding, mixing, screening	10			10		
Process Cooling						
Process Heating	10	10		80		
Pumps	38					
Boilers / Steam Production Temp: Pressure:	1	80				
Other						
Totals (100% or N/A):	100.00	100.00	100.00	100.00	-	-

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Performance Measure:

	How would you like to measure performance? (Examples: Energy use per ton, or per case, or per employee. Energy cost per $million in sales)			
	Example	Option 1	Option 2	Option 3
Product Name	Pencils	Quantity	Weight	
Units	cases	Reels	Tons	
Average Volume	100,000	45,000	275,000	
Period	Month	Year	Year	

Activities To-Date:

	What activities have you undertaken to-date? Please list which systems have been analyzed for effciency and which systems you have begun or completed efficiency upgrades.		
	No Activity	**Assessment Done**	**Implementation (Begun/Finished)**
Compressed Air	**X**		
Facility Energy Use: Lighting, HVAC	**X**		
Fans & Blowers	**X**		
Material Handling	**X**		
Material Processing			**X**
Process Cooling		**X**	
Process Heating		**X**	
Pumping Systems	**X**		
Power Factor Correction	PF No: 85		New PF No.:

Do you have in place:	**Y/N**
A practice of using life-cycle cost analysis to evaluate larger energy efficiency projects?	N
A practice of encourageing employees to identify potential energy savings projects?	N
An Energy Management Team?	N
An Energy Management Plan?	N
A practice of requiring a specific payback period for energy savings projects?	Y

Future Activities:

What are your top energy efficiency improvement priorities?

1. Reducing steam usage and thereby reducing natural gas costs 2. reduce compressed air costs 3. reduce electricity usage

With which one do you feel you need the most help?

Reducing steam usage

How soon do you plan to implement efficiency improvements?

This year

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TAP Energy Efficiency Services

Manufacturing Processes:

Please provide a general discription of your facility, the manufacturing process(s): what raw materials are brought in, how they are processed, and what final producs are shipped out:

Pulp slurry is brought in from one of two vendors. Additives are added and then the "stock" is heated and feed into the papermaking machine. The slurry is formed into a sheet and subjected to pressing and drying before it is trimmed and collected on reels that are shipped to customers.

Energy Use in Manufacturing:

Please provide a short narrative of how energy is used in the manufacturing process(s). Examples: natural gas is used in the boiler, in the furnace to melt the raw material and provide space heating in the warehouse. Electricity is used to machine and assemble product, provide lighting and air conditioning. Steam is used to heat chemicals and and create chilled water which is used for the solvent condensing process.

Electricity is used to power motors that drive pumps, fans and the rollers of the papermaking machine. The pumps pump water, slurry, and effluent. The fans provide drying and carry off humidity. Natural gas is used to create steam and provide direct heating. Evaporation is accomplished by pressing the sheet agains hot, steam-filler dryer drums. Three drying processes occur at the same time: (1) flow of heat from the surface of the drying cyclinder to the paper (contact drying), (2) cooling of the paper as heat is used to evaoporate the water in it (flash drying), and (3) flow of heat from the surrounding air to the paper (convection drying).

General Information:

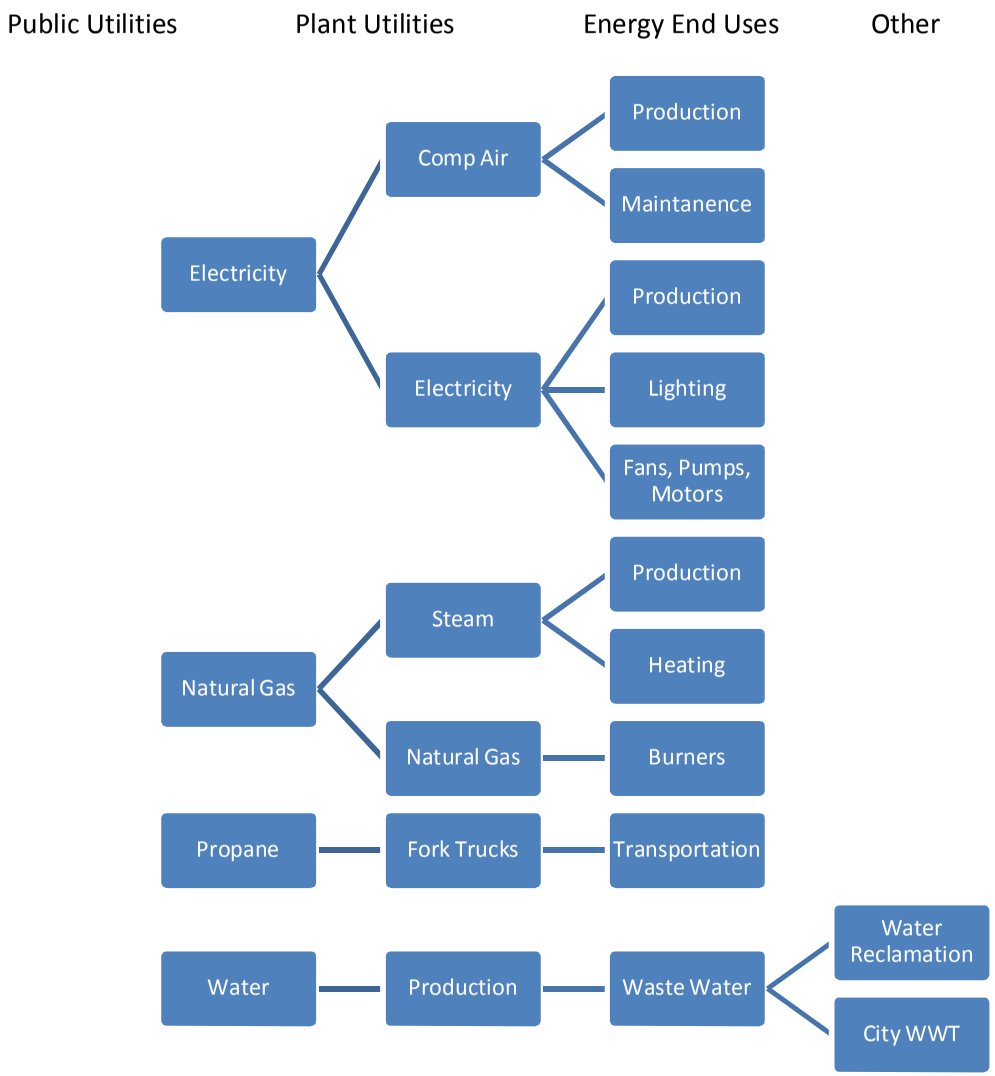
Please provide a general discription of your facilities utilities: the number, size, and type of all boilers, air compressors, chillers/cooling towers, water treatment, and air handling systems (add sheet if necessary):

The Production building is 151,000 sq ft, the Warehouse is 100,000 sq ft and the office is 10,000 sq ft. Electricity is brought in at 4160 kVA and there is one meter for the entire plant. Electricity is used for pumps, fans, compressors, motors and lighting. Natural gas is purchased from a transport company and delivered by the local gas utility. It is used primarily in the boiler to produce steam. There is one meter for the who plant. Water is supplied by the municipal water company. Waste water is recycled to concentrate solids and reduce the amount of water sent to the public waste water plant. See attachments for equipment list

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Rite Stuff Paper – Energy Map



Quick PEP Summary Report

Report Type: Energy Analysis

Case Information

Case	Just Rite Paper Co.
Industry	Wood Products, Pulp and Paper
Contact	Sally Rite
	Purdue TAP West Lafayette, Indiana

Purchased Energy Summary

Energy Source	kWh	MMBtu	Equivalent MMBtu	Cost/Equivalent MMBtu	Total Annual Cost
Electricity	50,397,707		171,964	$9.964	$1,713,522
Fuel		504,000	504,000	$9.000	$4,536,000
Steam		0	0		$0
Total	50,397,707	504,000	675,964		$6,249,522

Unit of Production Information

Total Annual Production: 45,000 Reels of Paper Rolls

Energy Source	Annual Use	Energy Use/Reels	Equivalent Energy Use/Reels (MMBtu/Reels)	Cost/Reels
Electricity, kWh	50,397,706.55	1,119.949	3.821	$38.078
Fuel/Steam, MMBtu	504,000.00	11.200	11.200	$100.800
		Totals:	15.021	$138.878

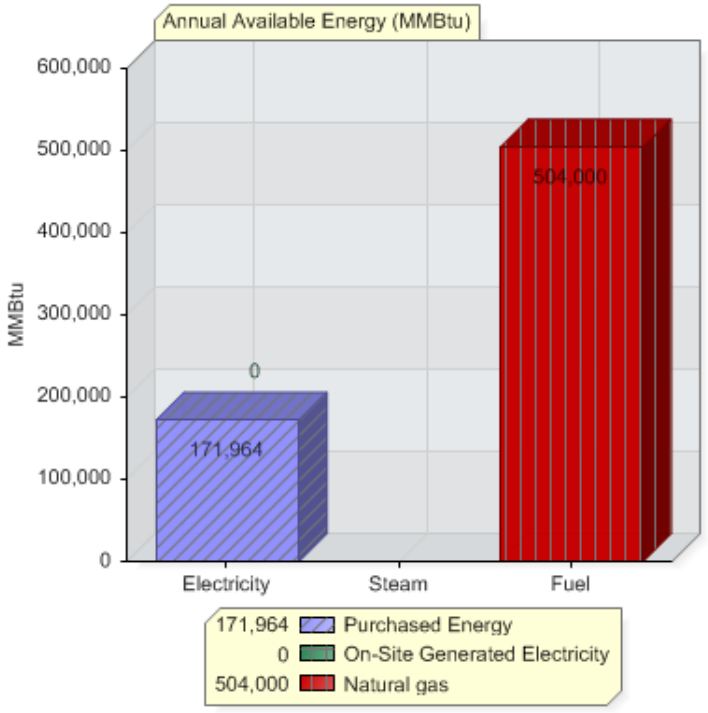
Energy Savings Potential

Energy Source	Total Energy Savings Potential	Energy Savings/Reels	Total Cost Savings	Cost Savings/Reels
Electricity, kWh	7,678,462.82	170.633	$260,400	$5.787
Fuel/Steam, MMBtu	52,900.00	1.176	$476,300	$10.584
Totals: (Equivalent Savings in MMBtu)	79,100.00 Equivalent MMBtu	1.758 Equivalent MMBtu	$736,700	$16.371

Annual Available Energy

The following chart and data table summarize the average annual energy that is available to your plant's systems. This includes purchased energy and energy that is generated on site.

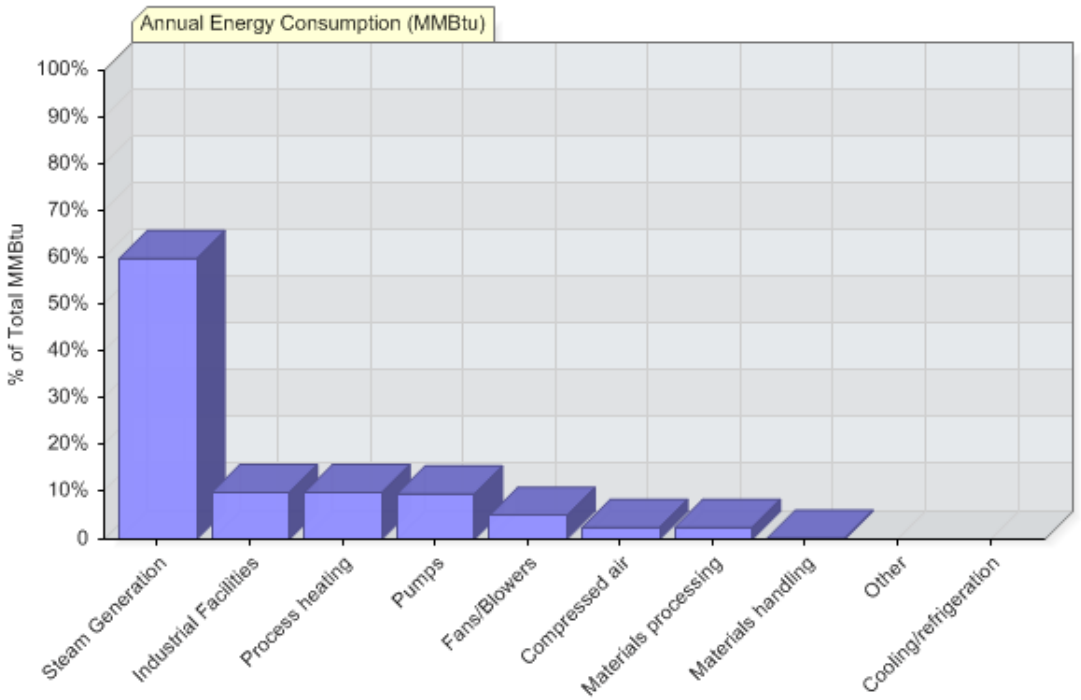
Energy Type	Energy (kWh)	Energy (MMBtu)	Cost/Value	$/MMBtu	$/kWh
Electricity	50,397,707	171,964	$1,713,522	$9.964	$0.034
Fuel/Steam		504,000	$4,536,000	$9.000	



Annual Energy Consumption

The following chart and data table summarize your plant's average annual energy consumption by plant system.

System	Annual Energy Consumption (kWh)	Annual Energy Consumption (MMBtu)	Annual Cost
Steam Generation Equipment	118,670,245	404,920	$3,645,935
Industrial Facilities: (Lighting, HVAC, and Facility Support)	19,810,554	67,596	$624,952
Process heating	19,810,554	67,596	$624,952
Pumps	19,151,128	65,346	$651,138
Fans and Blowers	10,079,541	34,393	$342,704
Compressed air	5,039,771	17,196	$171,352
Materials processing	5,039,771	17,196	$171,352
Materials handling	503,977	1,720	$17,135
Other	0	0	$0
Process cooling and refrigeration	0	0	$0
Total		675,964	$6,249,522

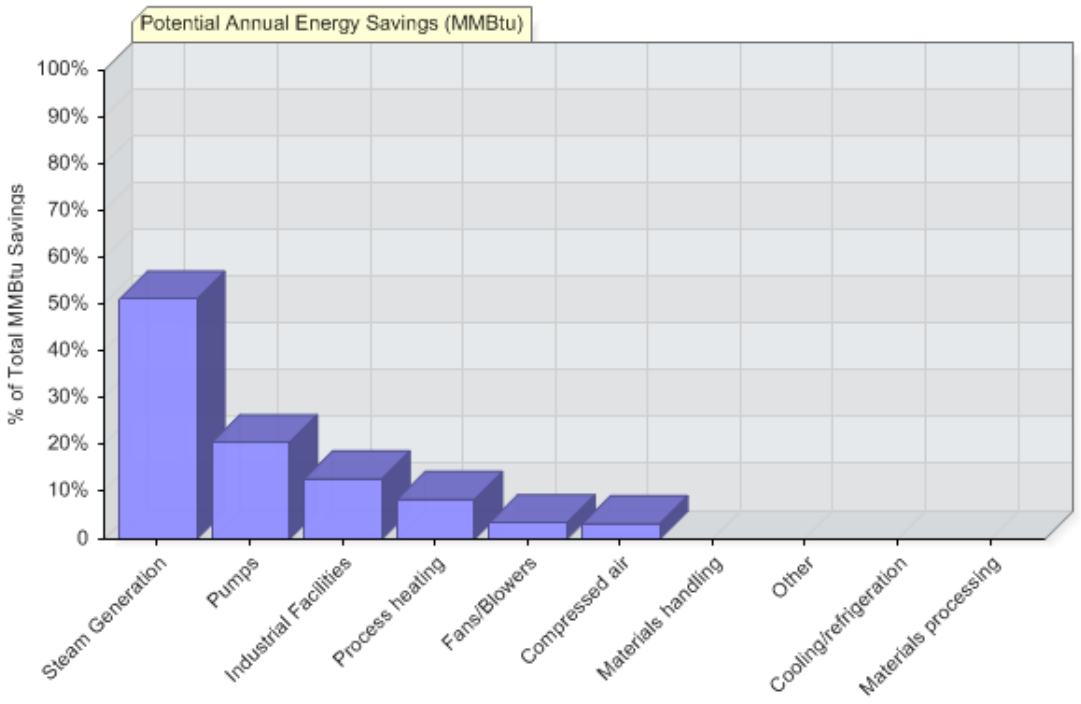


Potential Annual Energy Savings

The following chart and data table summarize your plant's potential annual energy energy savings by plant system.

NOTE: The energy and money savings listed below are only estimates based on the data you entered and U.S. national average savings for industrial plants with characteristics similar to your plant. Your actual savings will vary.

System	Potential Annual Energy Savings (kWh)	Potential Annual Energy Savings (MMBtu)	Potential Annual Cost Savings
Steam Generation Equipment	11,869,380	40,500	$364,600
Pumps	4,777,059	16,300	$162,800
Industrial Facilities: (Lighting, HVAC, and Facility Support)	2,989,325	10,200	$93,700
Process heating	1,963,576	6,700	$62,500
Fans and Blowers	820,599	2,800	$27,400
Compressed air	761,985	2,600	$25,700
Materials handling	0	0	$0
Other	0	0	$0
Process cooling and refrigeration	0	0	$0
Materials processing	0	0	$0
Total		79,100	$736,700



Potential Annual CO_2 Emissions Savings

Based on the potential energy savings identified above, your plant may be able to reduce emissions of CO_2. The following potential annual CO_2 emission savings numbers are broad estimates based on industry averages and are not meant to reflect actual realized savings at your plant. Factors such as CHP system or steam generator efficiency and primary fuel source for energy use systems such as furnaces and boilers make a large difference in the actual amount of CO_2 emission saved. These numbers are presented as a broad estimate based on estimated savings and industry averages only.

NOTE: Actual CO_2 savings from fuel/steam energy savings are based on the primary fuel source. The exact breakdown of the individual primary fuels that are used at your plant for process heating, power generation and steam generation is beyond the scope of this tool. The table below shows a range of potential CO_2 savings from fuel/steam use in your plant. The low end of the range is based on the use of fuels that contain relatively low amounts of carbon such as natural gas. The high end of the range is based on fuels that have a high amount of carbon such as coal (anthracite, bituminous or lignite). Your actual CO_2 emission reduction will depend on the actual primary fuels that are used at your plant.

Potential Annual CO_2 Savings From Electricity	10,289,000 lbs.
Potential Annual CO_2 Savings From Fuel/Steam	6,194,000 - 12,029,000 lbs.

Suggested Next Steps

Plants with characteristics similar to your plant have found that following these types of next steps can help them save money and energy.

1. General Energy Next Steps
   - Promote use of life cycle cost analysis to evaluate economics of energy efficient equipment or system for all purchases that consume significant amount of energy.
   - Develop methods for communication and feed back on energy use with a mechanism (or method) of receiving suggestions on possible opportunities for energy reduction from the employees. If possible include an incentives/reward plan.
   - Form an energy management team and establish a position of facility energy manager who would be responsible for implementation of energy management plans and will provide periodic feedback on progress to the management.
   - Develop a formal written energy management plan that is approved by the CEO or Board and includes specific annualized energy reduction goals in terms of percentage energy reduction.

2. Steam Generation Equipment - (Potential Annual Savings = $364,600) *
   - Perform a detailed Steam Energy System Assessment at your site Learn More
   - Improve thermal insulation of the overall steam system
   - Improve condensate recovery
   - Implement a BestPractices based steam trap maintenance program Learn More
   - Implement a BestPractices based leak management program Learn More
   - Improve boiler efficiency by proper blowdown management
   - Improve boiler efficiency by proper air/fuel control
   - Use the DOE Steam BestPractices Tools to identify and quantify energy saving opportunities Learn More

3. Pumps - (Potential Annual Savings = $162,800) *
   - Turn pumps ON and OFF to match needs
   - Explore the potential for using a fixed speed pump to supply base load and a smaller, properly sized fixed speed pump for trim
   - Evaluate the use of adjustable speed drives on pumps that have variable flow and are being throttled
   - Use the DOE PSAT software tool & other resources to identify and quantify energy saving opportunities Learn More
   - Perform a detailed Pumping System Assessment at your site

4. Industrial Facilities: (Lighting, HVAC, and Facility Support) - (Potential Annual Savings = $93,700) *
   - Shut-off steam / chilled water flows to air handlers that are not needed or are out of service
   - Implement night setback and weekend/vacation temperature / ventilation controls
   - Install occupancy sensors
   - Evaluate lighting upgrades that includes implementing group relamp & maintenance programs
   - Perform a detailed Lighting & HVAC System Assessment at your site to identify and quantify energy saving opportunities

5. Process heating - (Potential Annual Savings = $62,500)
   - Insulate water or air cooled parts used in the furnaces. Examples are: rolls, supports etc. used in furnaces.
   - Reduce weight of fixtures, trays and other material handling weight and use 'hot-return' as much as possible.
   - Consider use of heat from furnace flue gases to heat charge material, fixtures etc.
   - Consider use of combustion air preheating by recovering heat from furnace flue gases. Evaluate use of recuperator, regenerators or regenerative burners.
   - Maintain proper (balanced or slightly positive) pressure in furnaces using proper control to avoid air leakage in the furnace.

6. Fans and Blowers - (Potential Annual Savings = $27,400) *
   - Minimize leakage and perform tightness tests, if needed
   - Improve O&M practices such as belt tightening, cleaning fans and changing filters regularly
   - Replace dampers, variable inlet vanes with electronic variable speed drives for meeting variable loads
   - Evaluate and reduce "system effect" through better inlet and outlet designs and duct sizing
   - Use the DOE FSAT software tool & other resources to identify and quantify energy saving opportunities Learn More
   - Perform a detailed Fan and Blower System Assessment at your site

7. Compressed air - (Potential Annual Savings = $25,700) *
   - Reduce compressor operating pressure with or without controls
   - Eliminate inappropriate uses of compressed air
   - Implement air leak management program

- Use the DOE AirMaster+ software tool & other resources to identify and quantify energy saving opportunities Learn More
- Perform a detailed Compressed Air System Assessment at your site Learn More

* - High Energy/Cost Savings Opportunity

Gotham County Municipal Utilities
Calculation of LP Rate Charges

Bill To:	Big Jim Paper Co, Inc.	Date 09/24/2007	
	100 Backwater Road	Acct#: 555-12345	
	Happy Hollow GO, 46205	Site: 100 Backwater Rd	

Electric Service Rendered from 08/20/07 to 09/26/07 Schedule LP

		Demand (KVA)	
Meter Number:	901080595		
Pres Reading:	5282893920	Demand Reading 5565.31	
Prev Reading:	5285417460	X Meter Multiplier	1.025
Diff:	2523540	= Metered	5704.44
Meter Multiplier:	1.0	/ Power Factor	0.84
Consumption:	2523540	= Act-Demand	6791

Calculation of Bill

Facility Charge:			150.00
Demand Charge: Rate LP Regular		6791 kVA x $9.00	61,118.82
Energy Charge			
0 to 100,000 kWh		100000 X 0.041	4100.00
100,001 to 250,000 kWh		150000 x 0.039	5850.00
250,001 to 500,000 kWh		250000 x 0.034	8500.00
500,001 to 1,000,000 kWh		500000 x 0.030	15000.00
1,000,000 to 10,000,000 kWh		1523540 x 0.028	42659.12
Total			76,109.12
Fuel Cost Adjustment	$0.00384 x 2523540 kWh		9,690.88
Total Billing for Electric Service >>>>>			146,918.82

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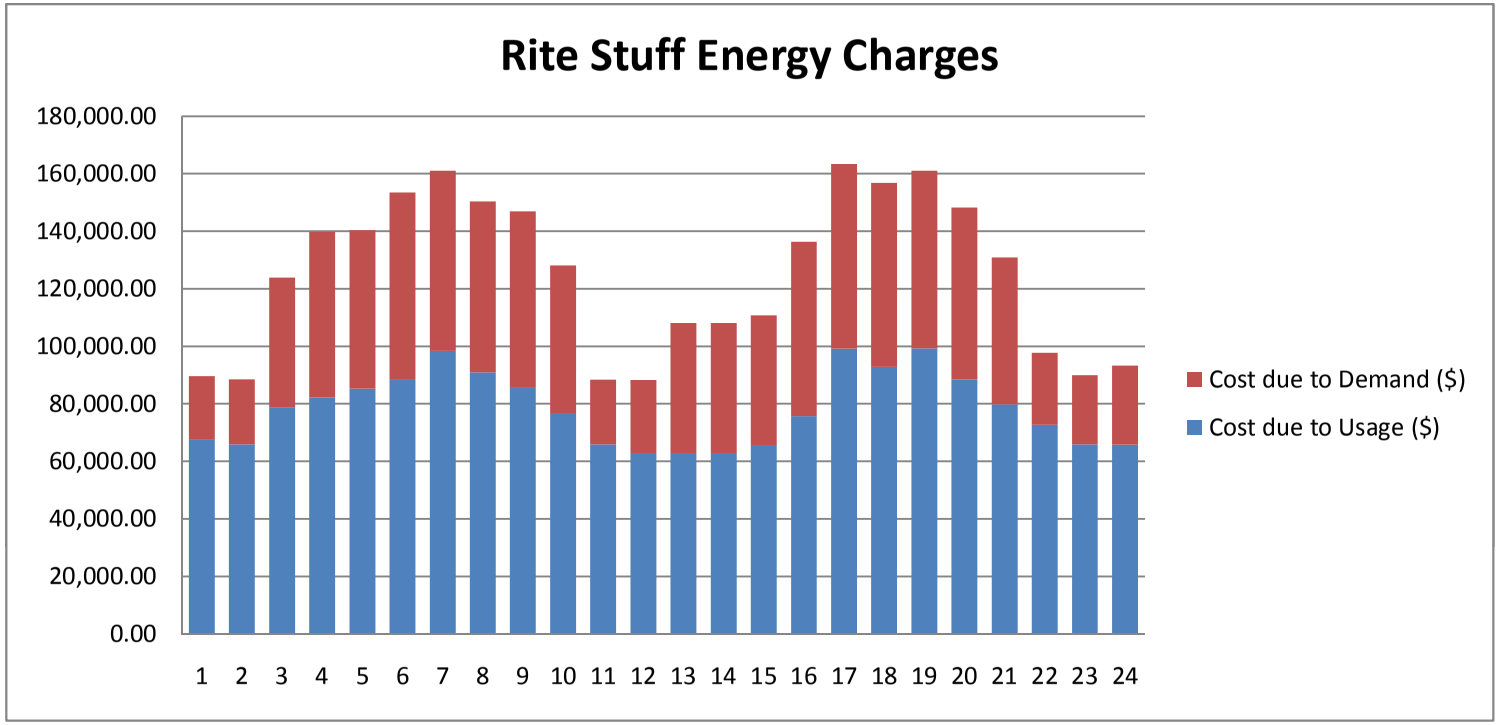
Rite Stuff Paper Mill
Electricity consumption and demand charges

Energy Pricing	
$0.034	kWh
$9.00	kW

Month	Usage, kWh	Demand, kW	Load Factor, KVAr	Power Factor	Cost due to Usage ($)	Cost due to Demand ($)	
Jan	1,983,834	2463.0	58.1	100.0%	67,450.36	22,167.00	
Feb	1,938,043	2506.0	57.0	100.0%	65,893.46	22,554.00	
Mar	2,316,765	5013.0	136.2	100.0%	78,770.01	45,117.00	
Apr	2,417,880	6397.0	210.1	99.9%	82,207.92	57,573.00	
May	2,508,892	6120.0	211.2	99.9%	85,302.33	55,080.00	
Jun	2,605,898	7214.0	209.0	100.0%	88,600.53	64,926.00	
Jul	2,893,081	6970.0	217.6	100.0%	98,364.75	62,730.00	
Aug	2,674,830	6598.0	238.1	99.9%	90,944.22	59,382.00	
Sep	2,523,540	6791.0	250.5	99.9%	85,800.36	61,119.00	
Oct	2,250,389	5735.0	194.9	99.9%	76,513.23	51,615.00	
Nov	1,938,583	2503.0	74.4	100.0%	65,911.82	22,527.00	
Dec	1,850,385	2824.0	76.9	100.0%	62,913.09	25,416.00	
Jan	1,850,343	5016.0	75.8	100.0%	62,911.66	45,144.00	
Feb	1,850,345	5016.0	191.4	99.9%	62,911.73	45,144.00	
Mar	1,930,483	5017.0	184.6	99.9%	65,636.42	45,153.00	
Apr	2,225,980	6746.0	260.1	99.9%	75,683.32	60,714.00	
May	2,918,570	7129.0	270.9	99.9%	99,231.38	64,161.00	
Jun	2,731,920	7100.0	266.3	99.9%	92,885.28	63,900.00	
Jul	2,920,180	6861.0	263.0	99.9%	99,286.12	61,749.00	
Aug	2,603,380	6635.0	264.2	99.9%	88,514.92	59,715.00	
Sep	2,348,303	5674.0	204.2	99.9%	79,842.30	51,066.00	
Oct	2,138,354	2782.0	80.4	100.0%	72,704.04	25,038.00	
Nov	1,939,383	2670.0	84.9	99.9%	65,939.02	24,030.00	
Dec	1,933,834	3058.0	86.2	100.0%	65,750.36	27,522.00	
	55,293,195				1,879,968.63	1,123,542.00	3,003,510.63

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27646597.5 yearly average kWh	$0.0543/kWh 2yr average	$ 1,501,755.32



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Energy Usage to Carbon Footprint Calculations

Rite Stuff Volume	Energy Unit	Conversion Factor	Units
50,397,696.00	kWh	0.000718	Tons CO2/kWh
5,040,000.00	MMBtu	0.05	Tons CO2/MMBtu
4,200.00	lbs Propane	0.001333	Tons CO2/lb propane

Electricity	36,186	Tons CO2
Natural Gas	252,000	
Propane	5.60	
	288,191	**Tons CO2**

Calculation - Electricity

7.18 x 10^{-4} metric tons CO_2 / kWh

(eGRID2007 Version 1.1, U.S. annual non-baseload CO_2 output emission rate,

Calculation - Natural Gas

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

0.1 mmbtu/1 therm * 14.47 kg C/mmbtu * 44 g CO_2/12 g C * 1 metric ton/1000 kg = **0.005 metric tons CO_2/therm**

Sources

EPA (2007). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Calculation - Propane

Note: Due to rounding, performing the calculations given in the equations

21,591 btu/pound * 1 mmbtu/10^6 btu * 16.99 kg C/mmbtu * 44 g CO_2/12 g C

Sources

EPA (2007). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

1 gallon propane = 95,500 Btu
1 gallon propane = 4.2lbs
emissions per pound = 0.024/18 =

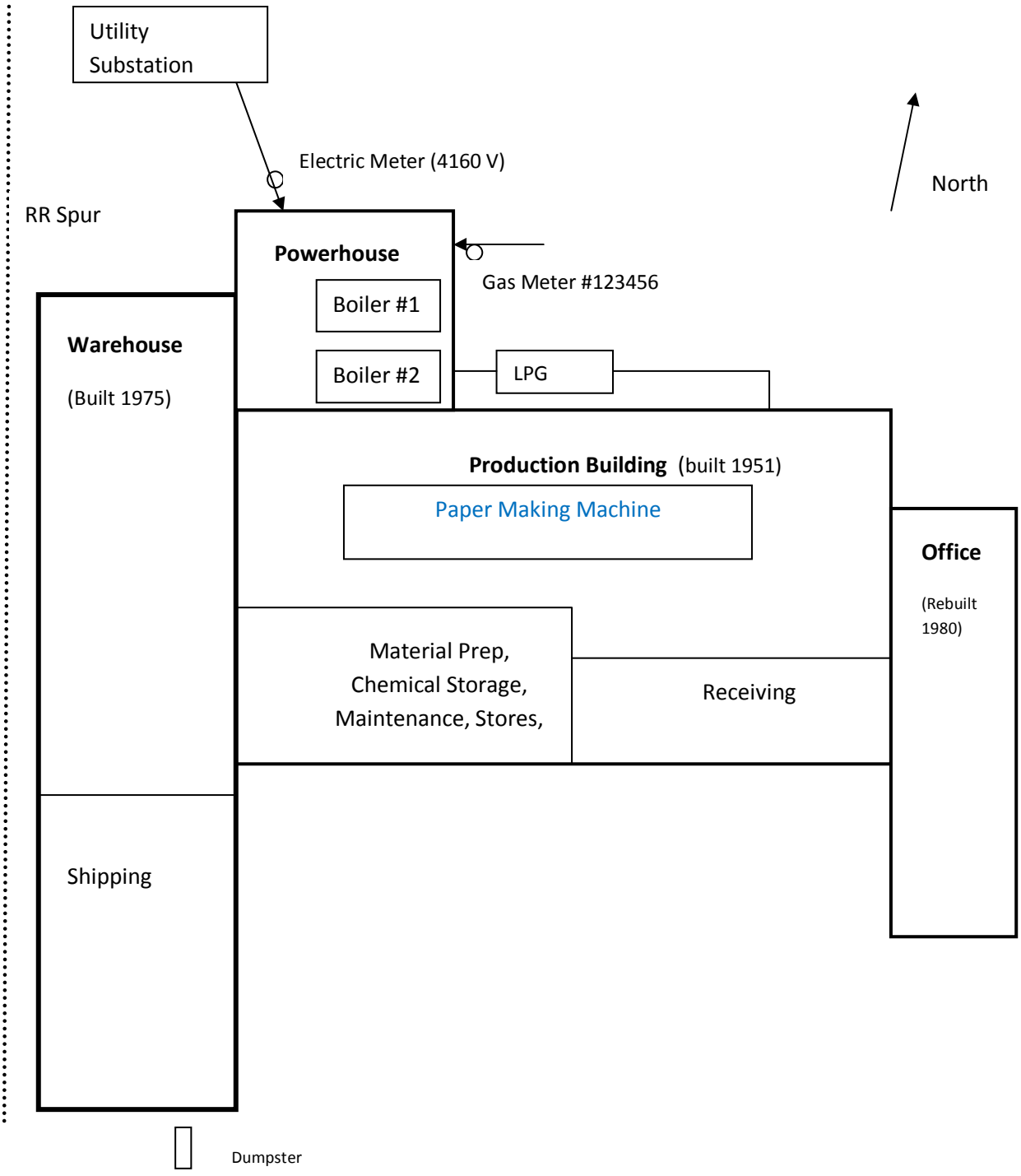
Rite Stuff CO2 Footprint Copyright (Purdue Research Foundation 2009)

Rite Stuff Energy Savings, Energy Cost Savings, & Carbon Reduction

Project	Electricity Savings (kWh)	Natural Gas Savings (MMBtu)	Propane (gallons)	Cost Savings	
Steam		72,222.00		$ 580,000.00	
Fan	529,411.00			$ 18,000.00	
HVAC		277.00		$ 2,500.00	
Lighting (warehouse)	816,400.00			$ 9,027.60	
Fork Trucks			105.50	$ 67,191.50	
Compressed Air	464,178.00			$ 15,782.00	
Lighting (office)	14,300.00			$ 486.20	
Total	1,824,289.00	72,499.00	105.50	**$ 692,987.30**	Cost Savings
	3412 Btu/kWh				
Total MMBtu	6,224.47	72,499.00	10.08	**78,733.55**	MMBtu Saved
Emission Factor	7.18×10^{-4} metric tons CO_2 / kWh	0.005 metric tons CO2/therm	0.001333 tons/CO2/lb propane		
Total CO2 reduction	1,309.84	3,625	0.06	**4,934.85**	CO2 Reduction
				288,191.00	Baseline
				283,256.15	Potential

Projects Log & Worksheet Copyright (Purdue Research Foundation 2009)

Rite Stuff Paper Mill



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Reference Information for CO2 Emission Factors

	CO2 Emissions	
Energy Source or Fuel	lbs./MM Btu	kg/MM Btu
Electricity* (see note below)	142.5	64.626
Natural gas	117.1	53.098
Residual Fuel Oil - #6	173.9	78.869
Coal (Bituminous)	215.2	97.596
Kerosene	159.5	72.351
LPG	139.0	63.056
Distillate fuel (Diesel)	161.4	73.191
Black Liquor	221.6	100.501
Blast Furnace Gas	604.6	274.190
Butane	141.8	64.309
Coke	225.1	102.100
Coke Oven Gas	103.2	46.823
Crude Petroleum	170.4	77.300
Distillate Fuel (Light Fuel Oil)	161.4	73.191
Ethane	130.0	58.970
Gasoline	156.4	70.941
Isobutane	142.0	64.419
Methane / Landfill Gas	115.3	52.271
Municipal refuse (Dry)	145.9	66.157
Peat	246.5	111.785
Propane	139.2	63.119
Wood Waste (Hog Fuel)	195.0	88.435
Other 1	162.0	73.469
Other 2	210.0	95.238

*** Note: CO2 emission coefficients vary depending on the source of electricity or location of the plant. The number used here is average fro US reported by EPA for the year 2001. This can be changed by the user by inserting a new number in CO2 value for electricity in the above table.**

TECHNICAL ASSISTANCE PROGRAM

Green Enterprise Development

LEVEL 2

Green Specialist Certificate Series

Join us for the Energy Management Workshop!

Learn how to manage energy usage and invest in energy efficiency.

One-Day Workshop • Appropriate for engineers, green team participants and environmental managers

The Green Specialist: Energy Management Workshop was designed by Purdue's Technical Assistance Program for manufacturers and others interested in learning how to manage energy usage and invest in energy efficiency to cut energy costs and reduce carbon footprint. Expect a fun, fast-paced workshop with simulations and case studies for in-depth instruction in applying green concepts and techniques.



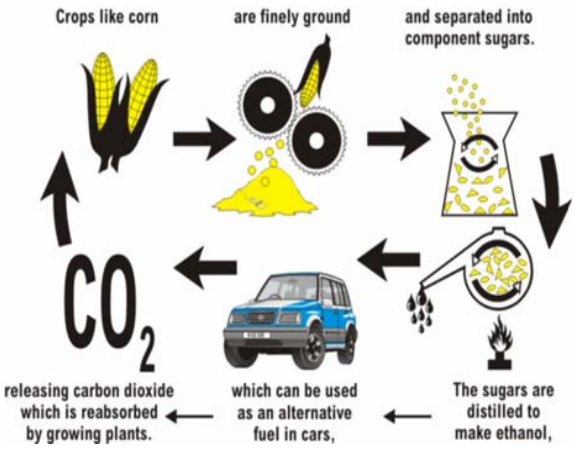
Participants will learn:

- The basic energy use alternatives
- How to manage energy usage
- How to invest in energy efficiency and minimize energy costs
- How to reduce the company's carbon footprint
- Fundamentals behind renewable energy sources
- How to include all system costs in project evaluation

Green Enterprise Development

Visit www.tap.purdue.edu/green to learn how to take the green movement to the next level.





How We Can Work With You: In addition to Green Enterprise Development, Purdue's Technical Assistance Program offers on-site public workshops and provides implementation and consulting services.

For workshop dates or to register: Visit www.tap.purdue.edu/green under "Register for Events." Cost is $395/per person.

For more information: Contact Abbey Maddy via phone at (800) 877-5182 ext. 620 or email amaddy@purdue.edu.

Black & Gold & Green Enterprise Development

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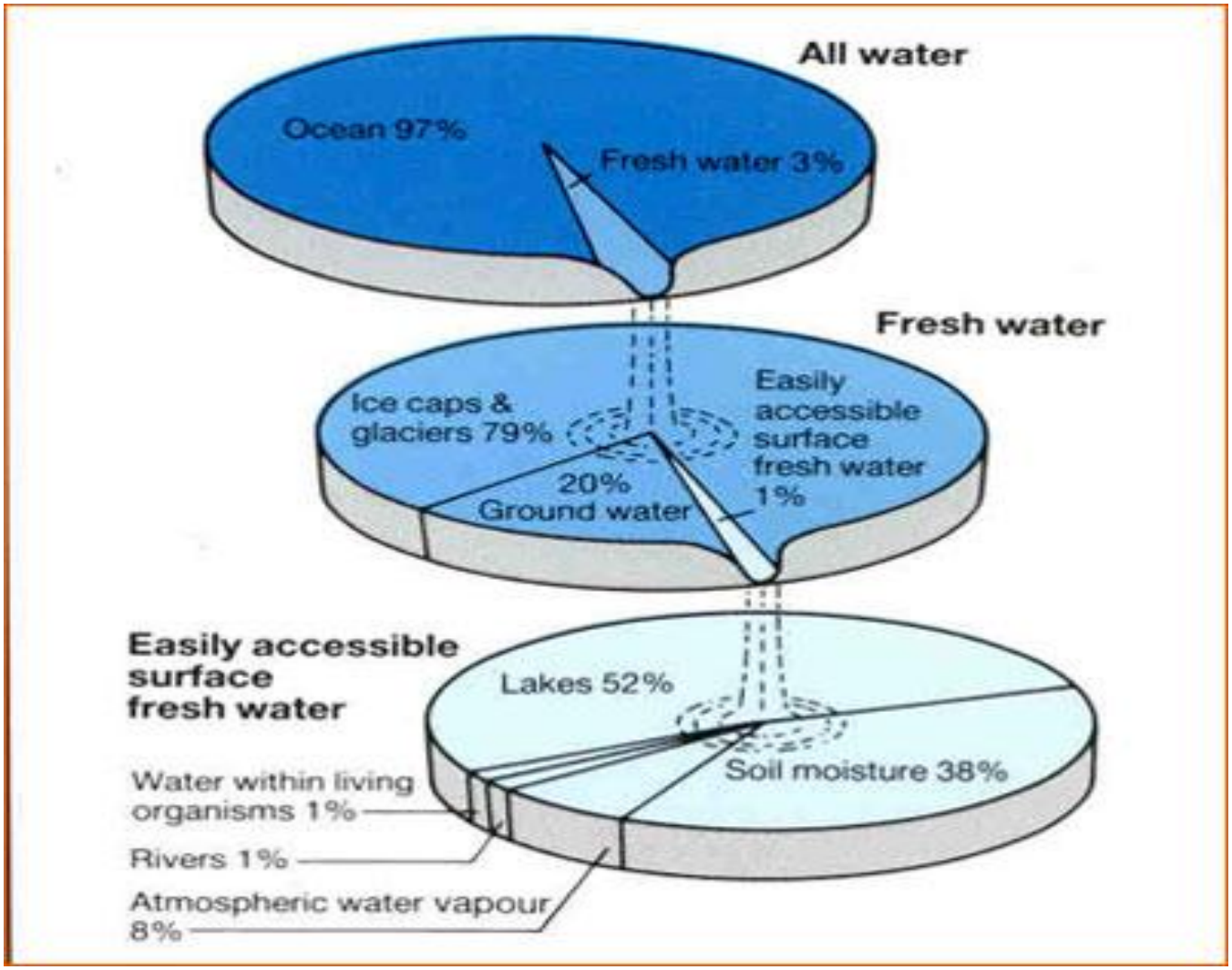
Supply Water / Waste Water Management

H_2O Conserve

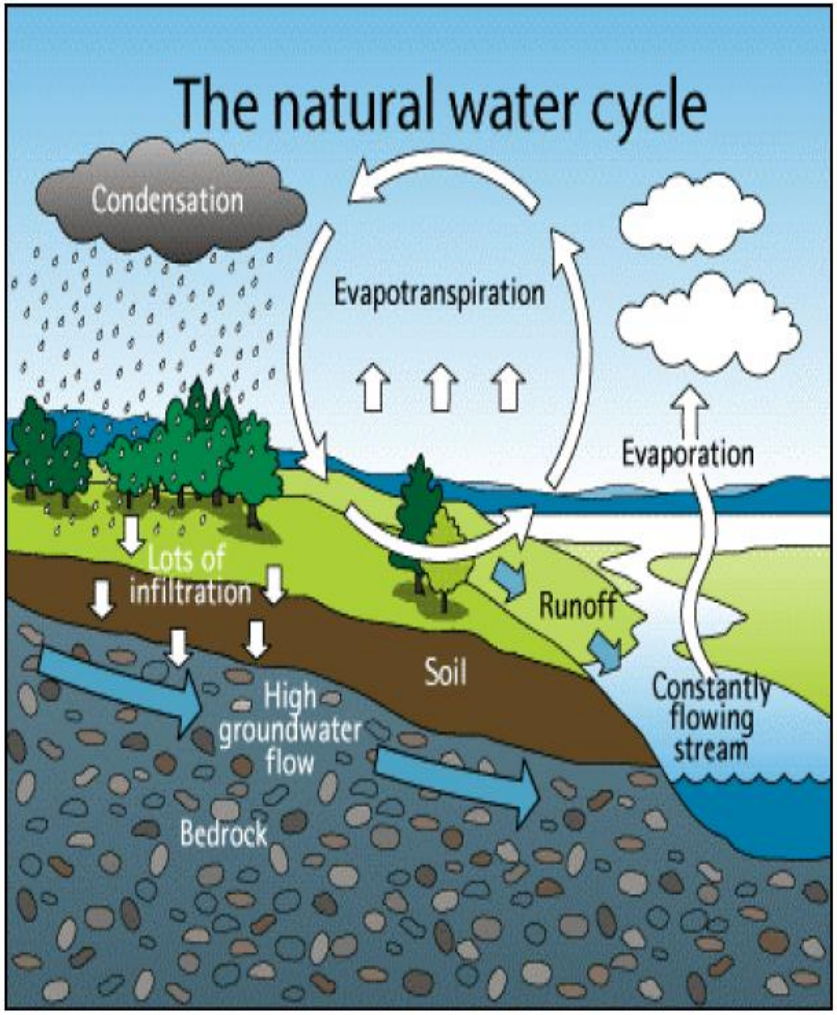
Purpose of This Module

- To provide an understanding of water supply challenges.
- To identify methods that can be implemented to reduce water use and improve the reuse of waste water.
- To provide strategies for incorporating effective water management concepts into a Green Enterprise.

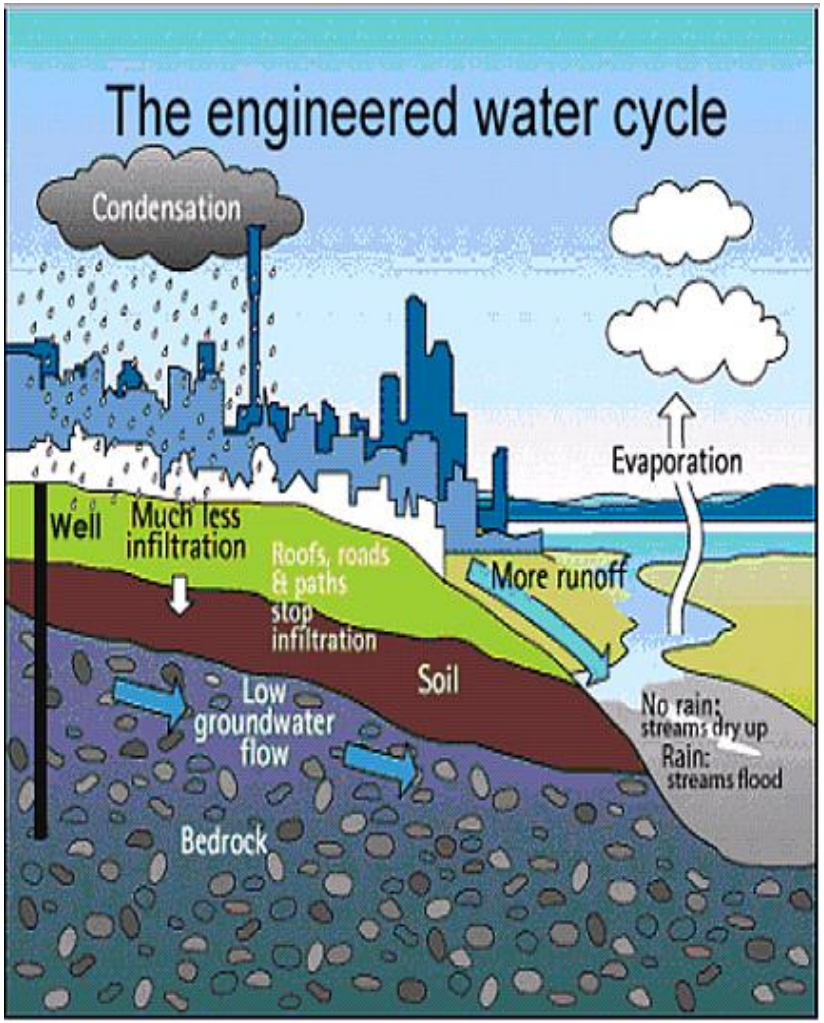
Freshwater is a Finite Resource



Water Cycle



Vs



Water Stress

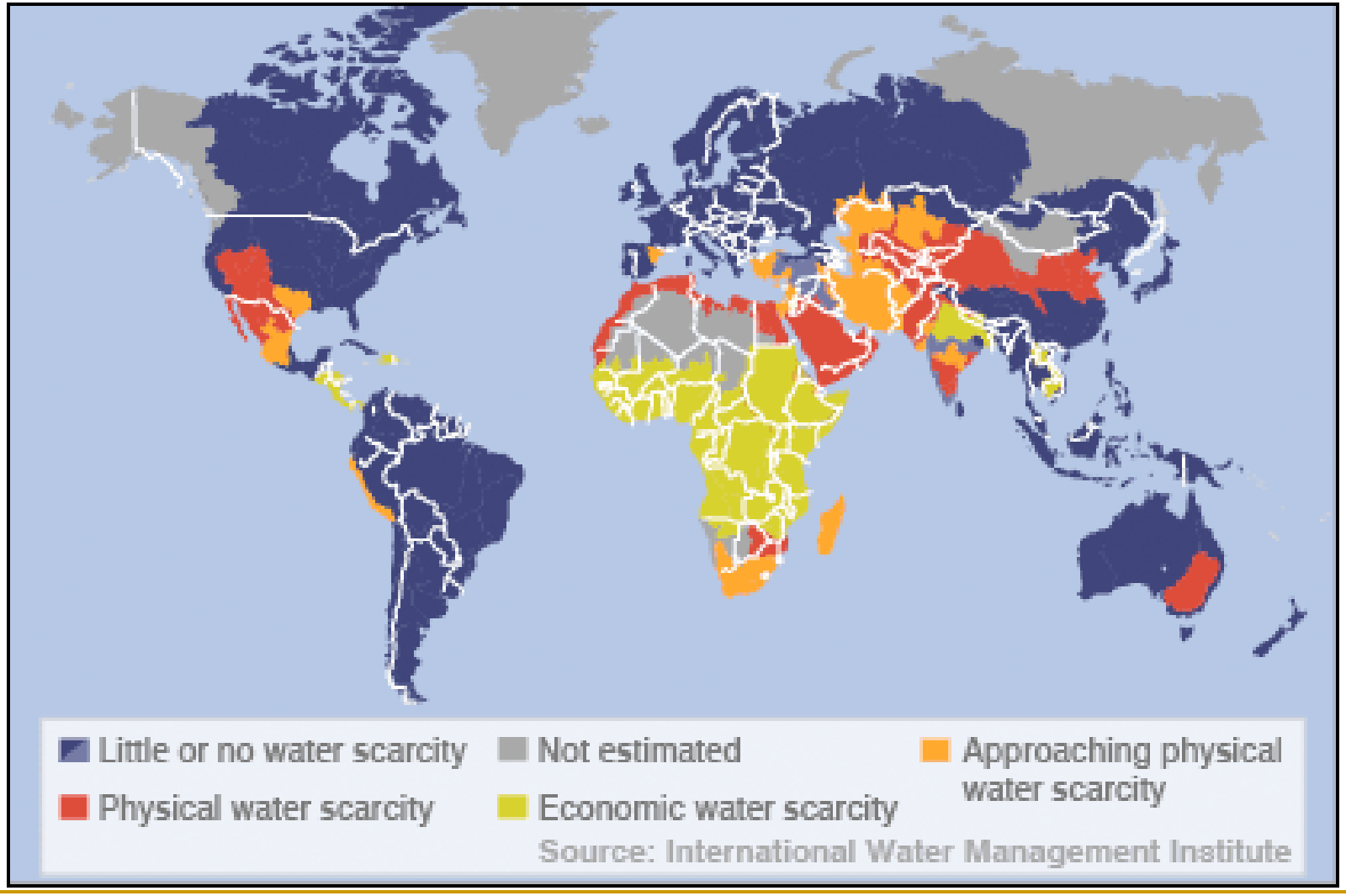
Occurs when:

- Demand for water exceeds the available amount during a certain period, or
- Poor water quality restricts use of available sources.

Causes deterioration of fresh water resources in terms of:

- Quantity - over-exploitation of aquifers, dry rivers, and
- Quality - increase in chemical nutrients, organic matter pollution, saline intrusion.

Water Scarcity



"When the well is dry, we learn the worth of water."

Ben Franklin

Course Agenda

Sustainable Water Management

Supply Water Conservation & Efficiency

Simulation – Round 1

Wastewater Management

Simulation – Round 2

Water Quality

Point Source Pollution: Causes & Treatment

Non-Point Source Pollution: Sources & Management

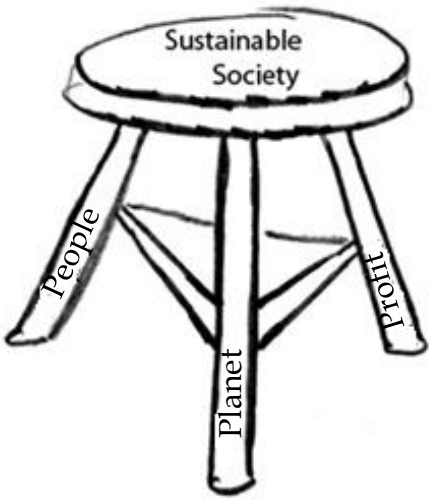
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Water Sustainability Concepts

- Consider local human and ecosystem water needs around shared water resources.
- Reduce overall use of water.
- Match water quality with appropriate use.
- Minimize adverse impacts on water quality or improve the quality of available water.
- Solve water quality challenges through prevention rather than treatment.
- Raise awareness about water sustainability and the importance of effective stewardship.



Social and Environmental Dimensions of Water Issues

- Inadequate supplies of clean freshwater contribute to public health issues, especially in non-industrial and developing nations.
- Drought, freshwater depletion, and floods contribute to population displacement.
- Water scarcity is increasingly leading to conflict, especially in arid areas.
- Ecosystem needs for freshwater are broadly affected by human activities.
- As society recognizes the value of ecosystem services and natural capital, freshwater is receiving higher priority attention.

Business Case – Water Costs are Increasing

Direct and indirect water-related costs include:

- Treatment to ensure that water inputs meet quality specs;
- Wastewater treatment and pollution mitigation to meet more stringent pollutant discharge and run-off standards;
- Supply expansion associated with dam construction, water diversion, well drilling, and securing new water allocations;
- Indirect costs from suppliers with water-intensive processes or significant water impacts;
- Worker absenteeism stemming from employee contraction of water-borne illnesses.

Business Case – Disruption Risks are Growing

Potential water-related business risks include:

- Supply shortages caused by infrastructure deterioration, contamination, or terrorist activity;
- Changing water allocations to address other industrial, agricultural, residential, and ecosystem needs;
- Supplier disruptions from water shortages in other regions;
- Opposition to new building sites or expansions stemming from existing or anticipated water uses or impacts;
- Public opposition to, or government prohibitions against, certain wastewater discharge techniques.

Business Case – Customer Expectations Evolving

- Many publicly traded companies experience shareholder initiatives aimed at corporate environmental performance or decision-making, creating pressure for a company to alter its water-related practices or strategic plans.

- At the same time, some companies are finding ways to enhance revenues by applying core competencies to address water-related needs experienced by others, such as products that use less water or services that reduce customers' water dependency.

Sustainable Water Management

- Water Efficiency
- Water Quality
- Water Services Infrastructure Planning
- Flood Risk Management
- Sustainable Drainage

Water Conservation Hierarchy– 4Rs



- Refuse (don’t use)
- Reduce (conservation)
- Reuse/Recover (divert, don’t discharge)
- Recycle (reuse directly or treat)

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Course Evaluation

Conservation and Efficiency

Conservation without efficiency is mere deprivation.

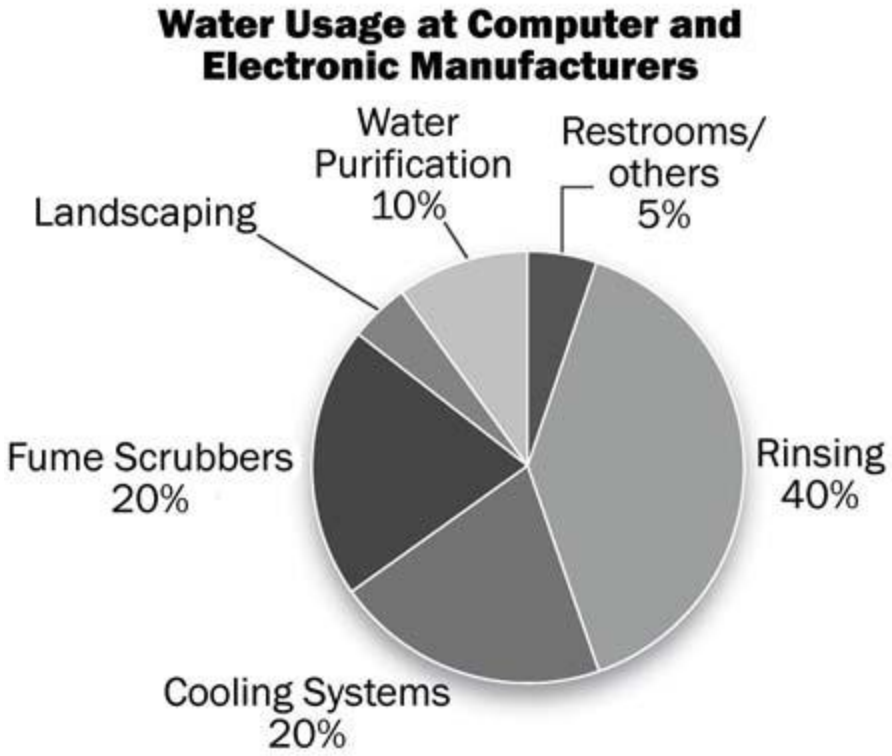
This does not meet the definition of sustainable!

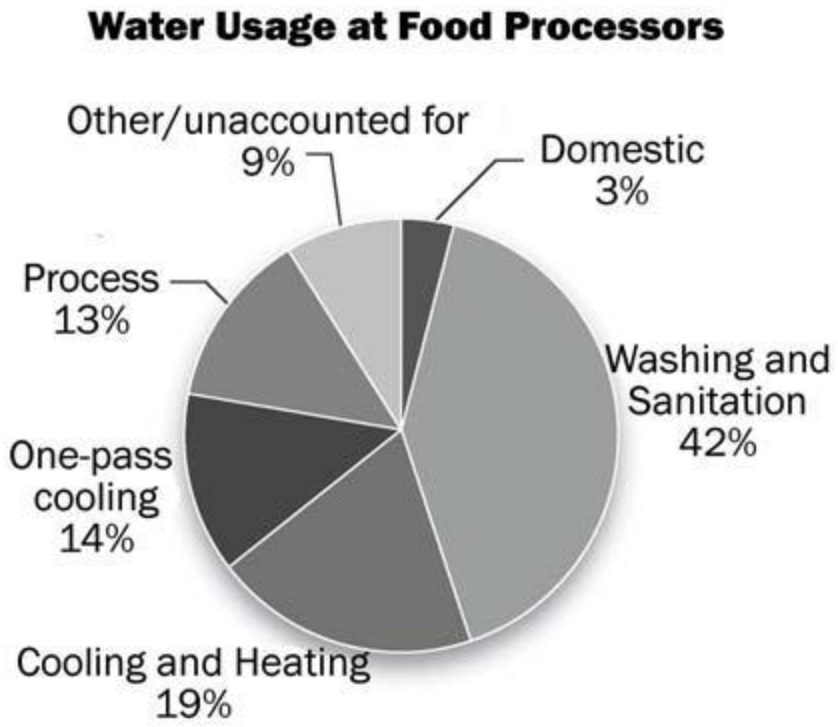


Industrial Water Uses

- Irrigation of crops
- Irrigation of lawns/landscaping
- Cleaning of raw materials
- Cleaning and rinsing of parts during production
- Maintenance of parts, equipment, facilities, vehicles
- Waste handling
- Sanitation
- Drinking by people and/or animals
- Food preparation
- Product component or manufacturing input
- Ingredient for key supplies
- Industrial processing
- Process heating/cooling
- Space heating/cooling (boiler water, steam)
- Power generation (hydropower, thermal, nuclear)
- Fire suppression
- Movement/transportation of materials or goods (water slurry, ballast water)

Water Usage – Industry Examples





Supply Management Challenges

- Demand to serve a growing and shifting population;
- Declining ground water levels/salt water intrusion;
- Variations in climate patterns;
- Total Maximum Daily Load (TMDL);
- Limited space for new conventional water supplies, e.g., reservoirs;
- Integration/prioritization with other planning initiatives, local and state objectives, etc.

Water Systems

Dynamic performance indicators:

- Reliability: likelihood that services are delivered within a given period.
- Resiliency: manner in which a system recovers from shock or failure.
- Robustness: degree to which a system can be impacted by external factors, along with the severity of the expected consequences of shock or failure.

Reliability Factors

- Meeting all current and foreseeable local, State, and Federal requirements.
- Vulnerability to damage from natural disasters, such as earthquakes.
- Redundancy to accommodate outages.
- Protection from drought.
- Protecting the natural and human environment when improvements are made.

Resilience Factors

- Redundancy of functions
- Diversity of ecosystem
- Climatic variations
- Inventories/Storage
- Alternative sources
- Importance / Prioritization

Robustness Factors

- Source availability / diversity / alternatives
- Price fluctuation sensitivity
- Impacts of quantities available for specific uses
- Quality requirements / effects of lower quality

Information for Managing Water

Methods of gathering information for water management include:

- remote sensing;
- seasonal climate forecasting;
- real-time dynamic monitoring systems.

Water Conservation Approaches

- Use efficient spray nozzles with automatic shutoffs on hoses.
- High-pressure washers clean more quickly and efficiently.
- Pressurized air-assisted spray nozzles clean with more force and less water.
- Low-flow “fogging” nozzles to rinse parts efficiently.
- Flow restrictors in water lines that supply hoses and pressure washers.
- Timers to shut off process water rinses when process is shut down.

Water Conservation Approaches

- Ensure stationary spray nozzles are aimed properly.
- Review nozzle spray patterns for optimum application.
- Replace worn spray nozzle heads.
- Use countercurrent washing techniques.
- Use conductivity controllers to regulate rinse water flow rates.
- Use spray washing/rinsing for tank cleaning vs. refilling/dropping tank washwater.
- Changes in cleaning solution type, temperature and concentration can save water.

Water Efficiency Approaches

- Check your meters at night or when no water is being used to monitor leakage.
- Use water efficient equipment, devices and appliances.
- Determine where your wasted water is going and if or how you can recycle it in other areas of your business.
- Where possible, use a water reservoir to harvest rainwater for use in your business.
- Assess water using equipment so there is no over filling.
- Set water usage targets.
- Use dry cleaning methods rather than wet cleaning.

Dry Clean-up Examples

- Sweeping floors instead of hosing with water.
- Vacuuming or sweeping dry material spills such as salt or dyes instead of using water.
- Use squeegees and scrapers first to remove residuals from machines and equipment.
- Vacuuming or sweeping particulate emissions (dust) instead of hosing with water.
- Use rubber squeegees to collect food processing residuals from the floor before hosing with water.
- Use “pigs” to purge residuals from pipes before flushing with water.

Water Efficiency Benefits

- Cost avoidance for water supply and wastewater treatment.
- Reduced stress on infrastructure.
- Prevention of future shortage episodes.
- Reduced energy usage to treat and transport.

Keep the Basics in Mind

- Public health sanitation requirements such as the USDA, FDA, and state and local health regulations.
- Environmental requirements such as water quality reuse rules and criteria.
- Other health and safety requirements, such as state and local building codes and fire safety codes.
- Customer quality expectations, such as product cleanliness specifications.

Changing Behavior vs. Equipment

- Equipment changes may be viewed as a “permanent fix” to achieve water efficiency.
- Changing employee behaviors, such as an operating procedure, may be viewed as a quick and inexpensive way to achieve similar savings without up-front capital expense.
- Consistent training and awareness in combination with proper tools and equipment will achieve more permanent water savings.

Course Agenda

Sustainable Water Management

Supply Water Conservation & Efficiency

Simulation – Round 1

Wastewater Management

Simulation – Round 2

Water Quality

Point Source Pollution: Causes & Treatment

Non-Point Source Pollution: Sources & Management

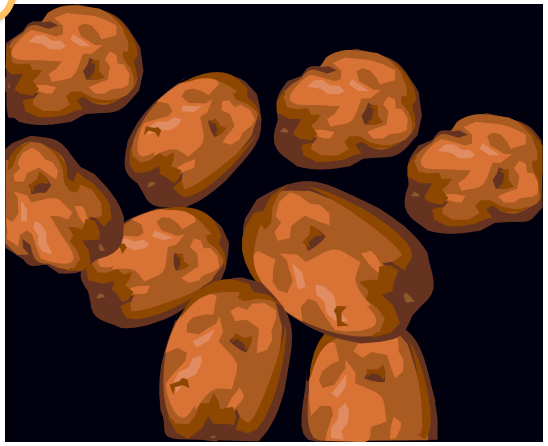
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Simulation Round 1
HydroSonic Potato Spuds

HydroSonic



Potato Spuds

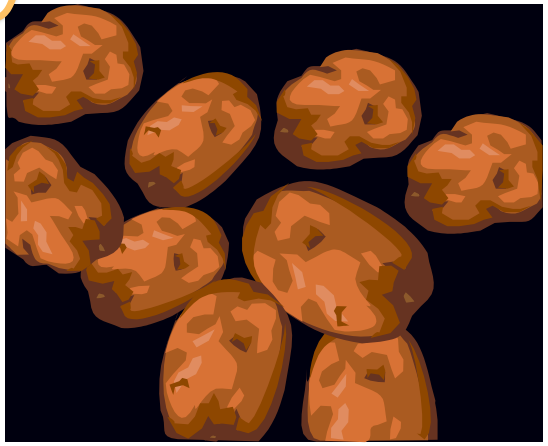
A family-owned potato production business including potato farms, storage, sorting and packing facilities.

HydroSonic produces chipping potatoes -- special spuds specifically engineered to meet the needs of potato chip makers.

They are looking to improve their efficiencies in water and energy use and have invited us to take a look at some of their operations.

Simulation Round 1
HydroSonic Potato Spuds

HydroSonic



Potato Spuds

To best understand their challenges, we're going to fill in for some of the roles in their operations and get a first-hand look at how things currently work.

Roles:

- Irrigation Team
- Transport Team
- Energy Team
- Cleaning Team
- Reservoir/Pump Team
- Industrial Engineer
- Plant Manager
- Maintenance Technicians

Lessons Learned

- What was the outcome of the potato production processes? Report out all measurements.
- What do these measurements tell us?
- What were some of the challenges you encountered?

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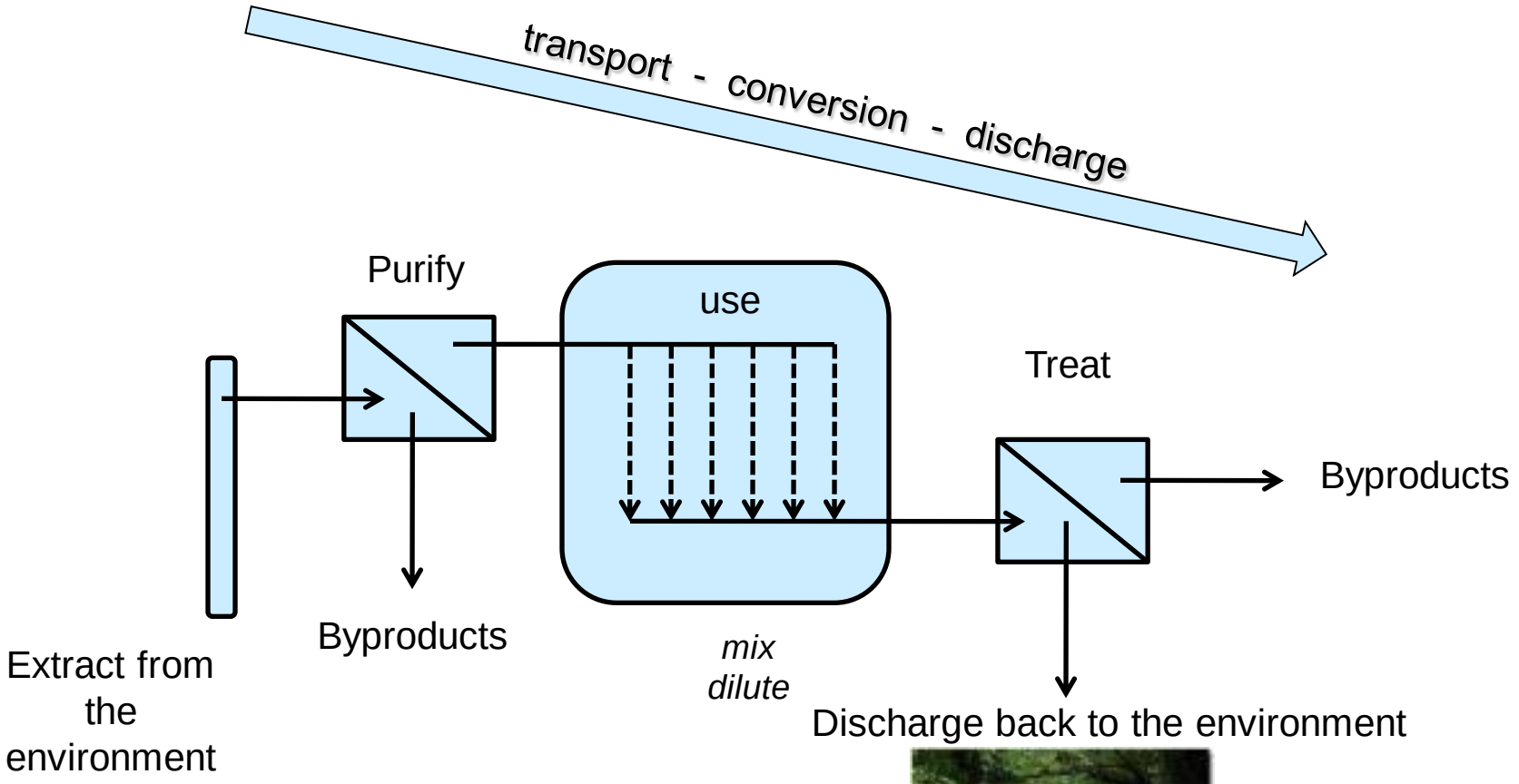
Non-Point Source Pollution: Sources & Management

Simulation – Round 3

Measuring Water Use / Waste

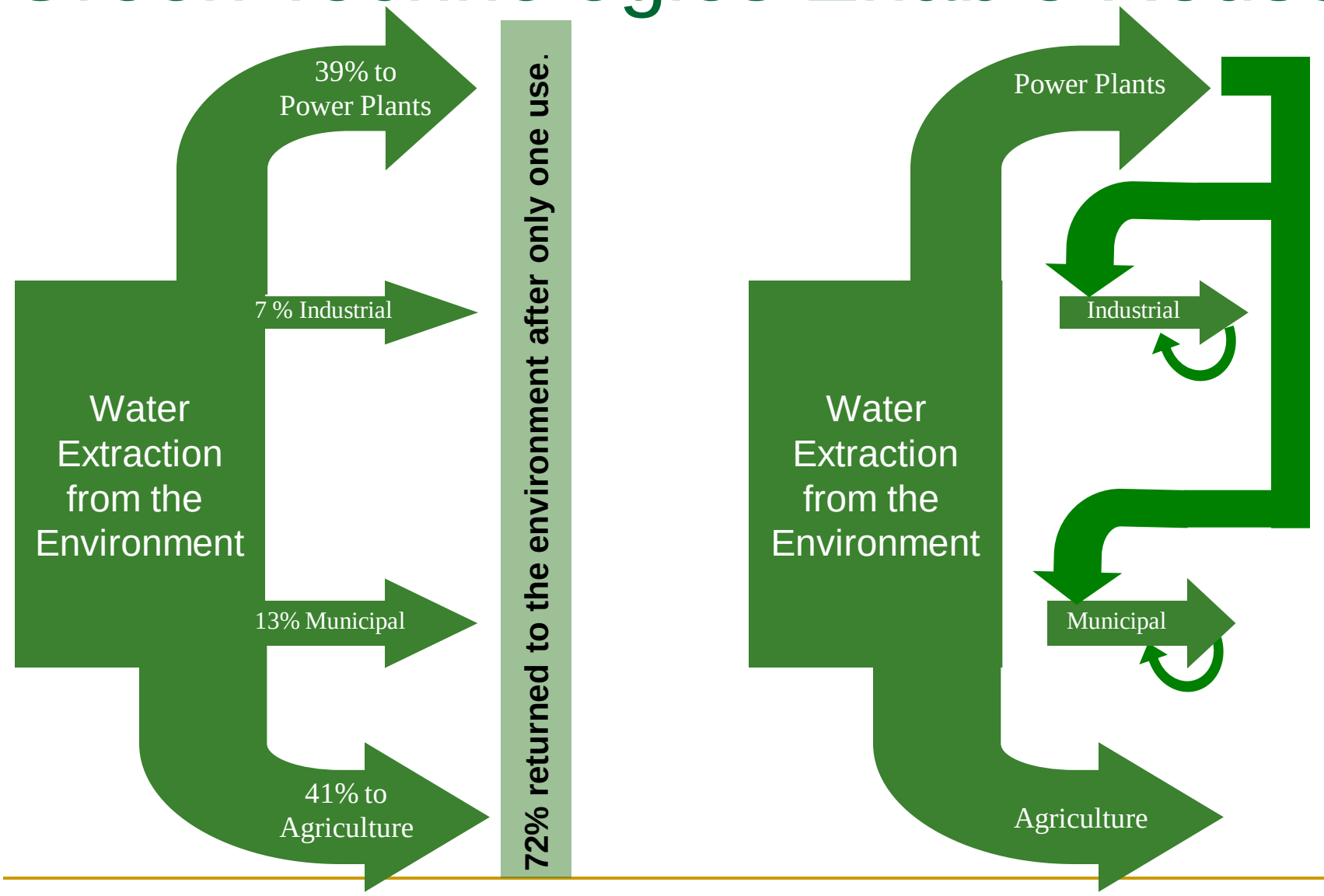
Course Evaluation

Traditional Linear Practice





Green Technologies Enable Reuse

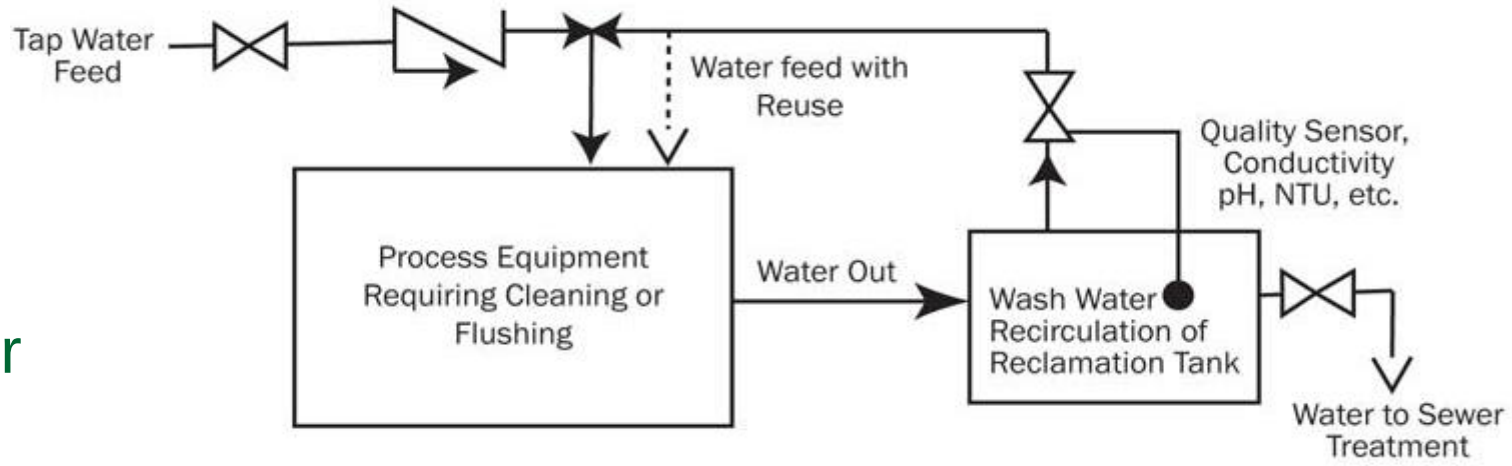


Cleaning Process Water Reuse

Before



After



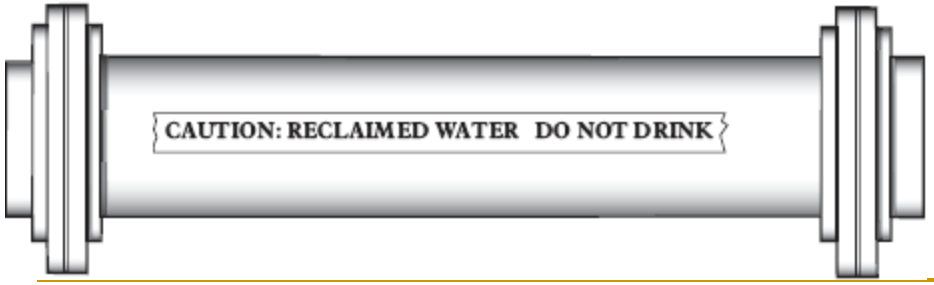
Wastewater Reuse / Recycle

- Recycled water is approved through State and local regulations for specific beneficial uses such as irrigation of lawns and crops, flushing of toilets and urinals, etc.

- Conserves valuable drinking water for drinking.



www.dnr.state.mo.us/magazine/ 1996_sum/revolving_fund.htm



Recycled water is not generally allowed for direct potable use (although technically feasible).

Water Recycling Benefits

When wastewater is treated for recycling, some nutrients are left in it that is good for plants. As a result, recycled water is great for irrigating most landscaping, crops and golf courses.



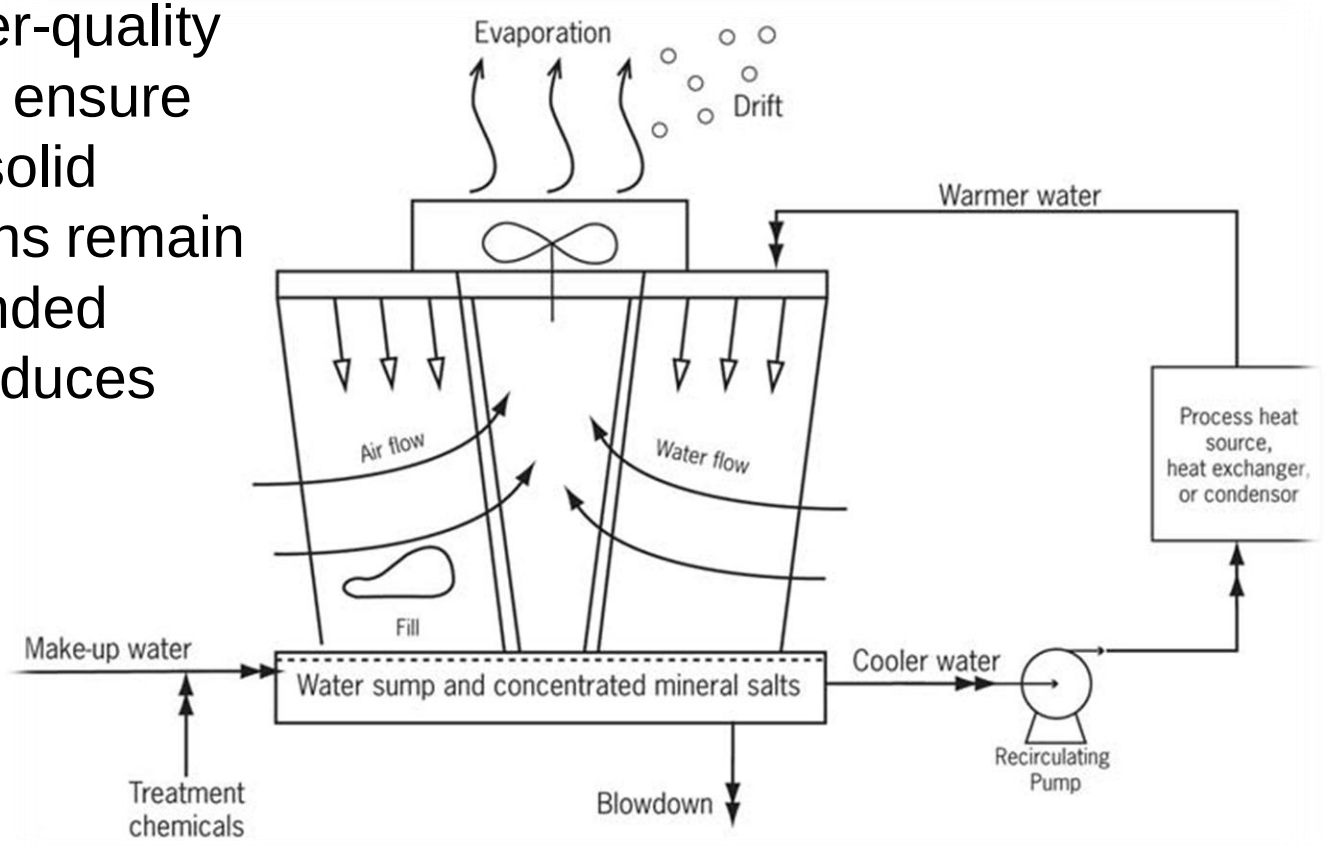


www.accessvegas.com/ las-vegas-golf-courses.htm

Because of it's nutrient content, recycled water is actually better suited than drinking water for some of the applications where drinking water gets used the most.

Cooling Towers

Regular water-quality testing helps ensure suspended-solid concentrations remain at recommended levels and reduces bio-fouling.



Cooling Tower Water Efficiency

- Optimizing cycles of concentration
- Using alternative sources of makeup water
- Installing and properly maintaining drift eliminators
- Using automatic controls to control blowdown
- Sub-metering makeup water and blowdown
- Implementing an effective maintenance program
- Ensuring that towers are appropriately sized for the cooling load
- Installing variable-frequency drives (VFDs) on motors
- Installing automatic shutoff control devices
- Using sidestream filtration

Cooling Tower Water Reuse

Some facilities have the opportunity to reuse water from other processes for cooling tower makeup water, including:

- Reject reverse-osmosis water,
- Wastewater from once-through cooling systems, and
- Municipal wastewater effluent.

Reusing Cooling Water

Frequently facilities use water for “once-through” cooling of small heat-generating equipment.

Water-efficiency opportunities for single-pass cooling including:

- Reusing for other processes, such as boiler makeup water, landscaping, rinsing, or washing.
- Reducing flow and monitoring the temperature differential between the influent and effluent water to make sure it’s within the parameters established by the manufacturers.
- Installing automatic shutoff controls when system is not in use.
- Using a cooling tower or other heat-absorbing medium for water to be recycled.

Boiler Water Efficiency

- Boilers require makeup water to compensate for uncollected condensate or to replace blowdown water.
- Have a tendency to develop leaks as they age which wets the insulation, causing both heat and water losses.
- Scaling is one of the leading causes of boiler tube failures.
  - Scale is equivalent to having a thin film of insulation between the furnace gases and boiler water.
  - Can drop a boiler's efficiency by as much as 10–12%.
- Installing a condensate recovery system that reuses condensate water as makeup water.
  - Can save up to 70% of the water used in a boiler, and significantly reduce energy costs.

Boiler Water Efficiency

- Adopting a leak-detection program.
- Control scale in boilers with a preventive maintenance program.
- Install automatic controls for chemical treatment systems.
- Re-insulate boiler or hot water lines that have become worn/damaged.
- Control blowdown by releasing water from the boiler and making it up with fresh water.
  - Excessive blowdown leads to the loss of water and energy, but insufficient blowdown can lead to the buildup of impurities and scale.
  - Blowdown can range from 1–25%, based on the condition and age of the boiler as well as the quality of the local water.

Water Efficiency in Industry
- Case Studies -

Bull HN Information Systems, Inc. - printed circuit boards-

Conservation and waste minimization programs have reduced water use by almost 230,000 gallons per day by tracking all the process water and water going to cooling towers and boilers through automated controls systems and a unique filtration system.

Carlovers Carwash

Each new site employs the latest technology to save on light and heat and conserve and recycle water. All water is filtered and treated for reuse up to 80% of all water used during washing. This amounts to an annual saving in excess of 1 billion litres of water.

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Point Source Pollution: Causes & Treatment

Non-Point Source Pollution: Sources & Management

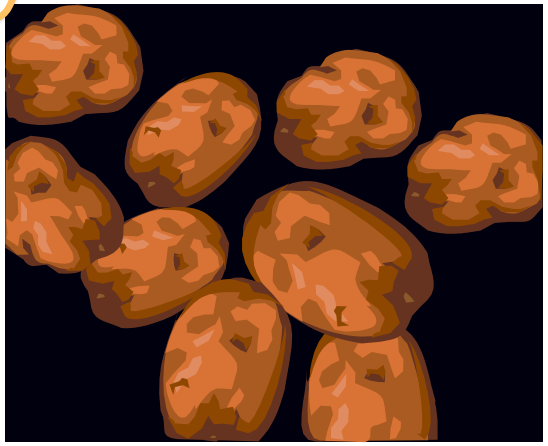
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Simulation Round 2
HydroSonic Potato Spuds

HydroSonic



Potato Spuds

What changes should we consider for improving the water and energy efficiency at HydroSonic?

How can we implement these changes?

Lessons Learned

- What was the outcome of the potato production processes? Report out all measurements.
- What do these measurements tell us?
- What were some of the challenges you encountered?

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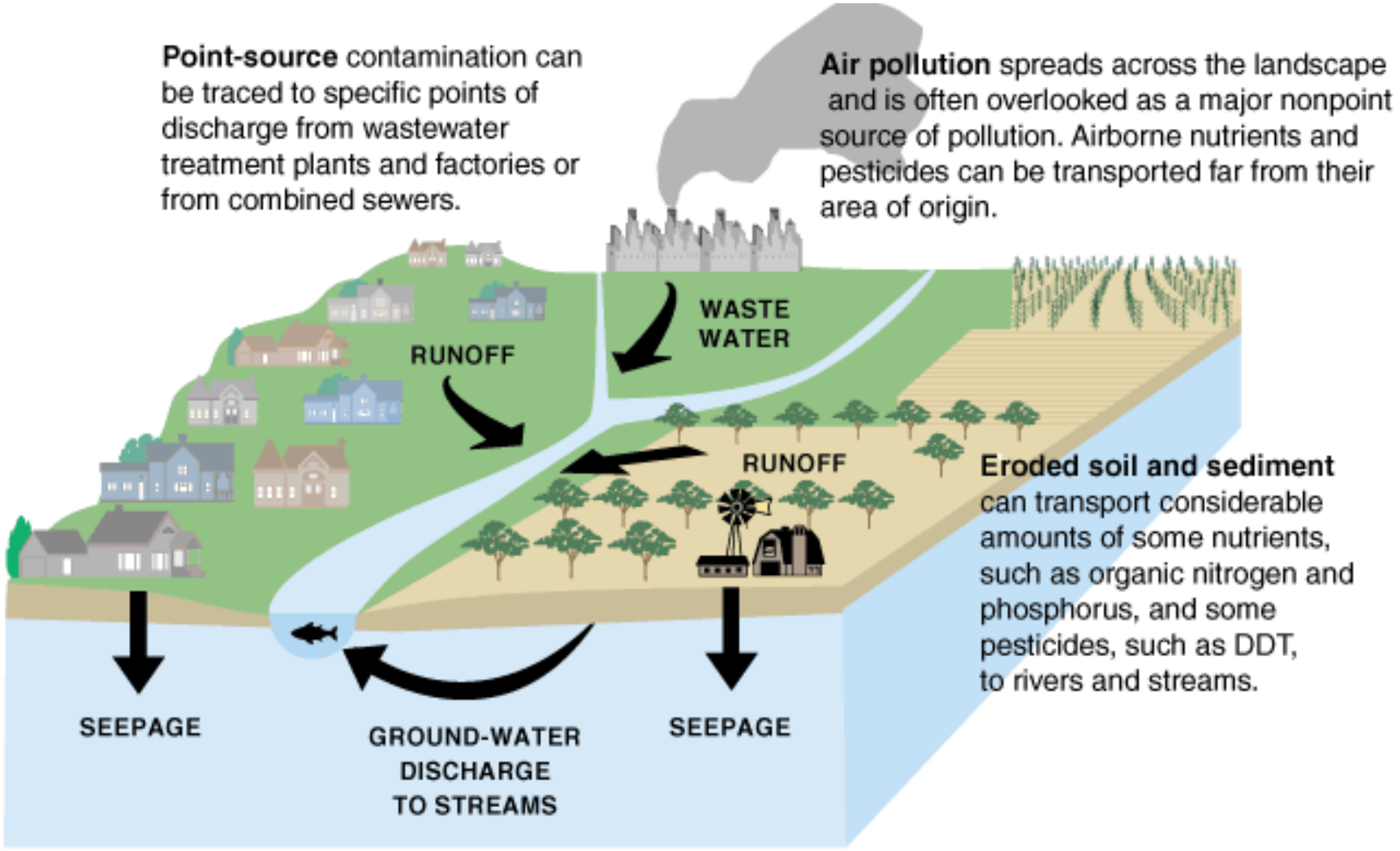
Non-Point Source Pollution: Sources & Management

Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Water Pollution



Key Water Quality Issues



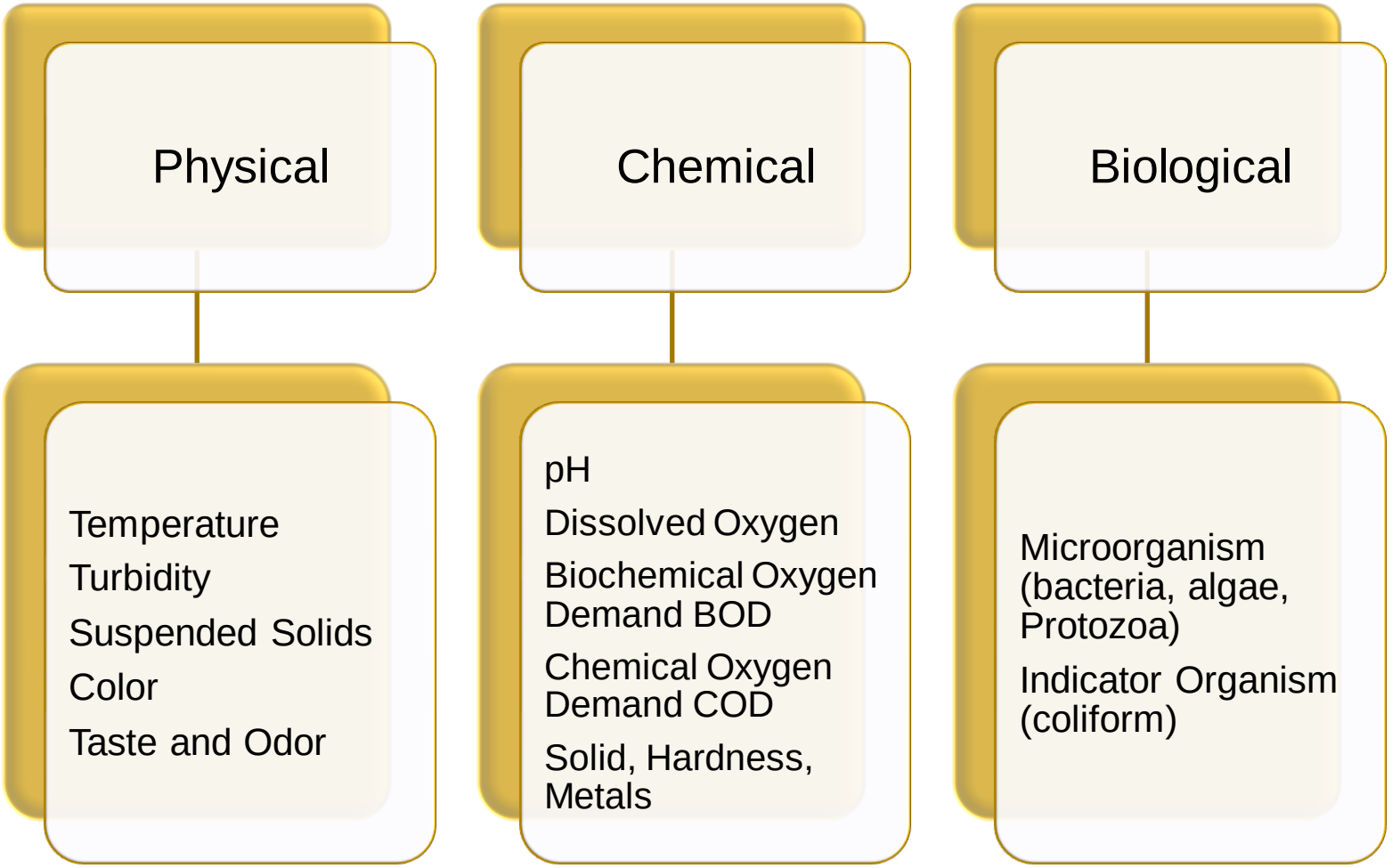
- Nutrients promoting undesirable forms of life
  - Nitrogen: Power plants (NOx), farm runoff, fertilizers
  - Phosphorus: fertilizers, detergents



- Pathogens from untreated or poorly treated sewage
- Oxygen-depleting substances in municipal and some industrial wastewater
- Toxic organics which disrupt metabolism and reproduction
- Toxic metals
- Suspended solids



Quality Parameters

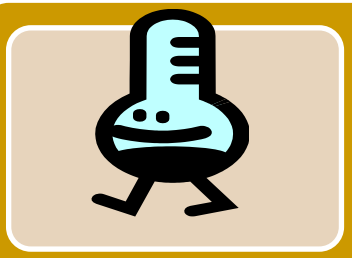


Industrial Supply Water Indicators



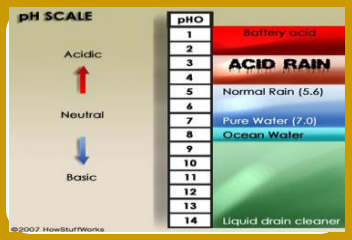
Dissolved Oxygen (DO)

- is a relative measure of the amount of oxygen that is dissolved or carried in a given medium.
- A high DO speed up corrosion in water pipes.



Temperature

- It directly affects the amount of dissolved oxygen in the water.



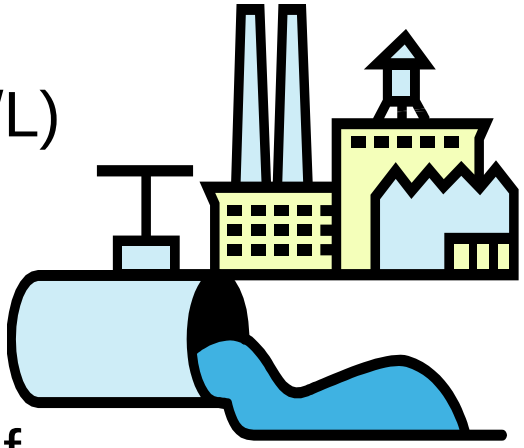
pH

- Its a measure of how acidic (H+) or basic (OH-) a solution is.

Optimal pH for industrial water supplies		
Process	**Minimum**	**pH Range**
Food canning and freezing	7.5	--
Washing clothes	--	6.0-6.8
Rayon manufacturing	--	7.8-8.3
Steel making	--	6.8-7.0
Tanning leather	--	6.0-8.0

Waste Water Quality Indicators

- Biochemical oxygen demand (BOD) (mg/L)
  - amount of oxygen consumed by biological organisms in a body of water
- Chemical oxygen demand (COD) (mg/L)
  - total dissolved organic material
- Suspended Solids (TSS)
  - particles that suspend in a sample of water



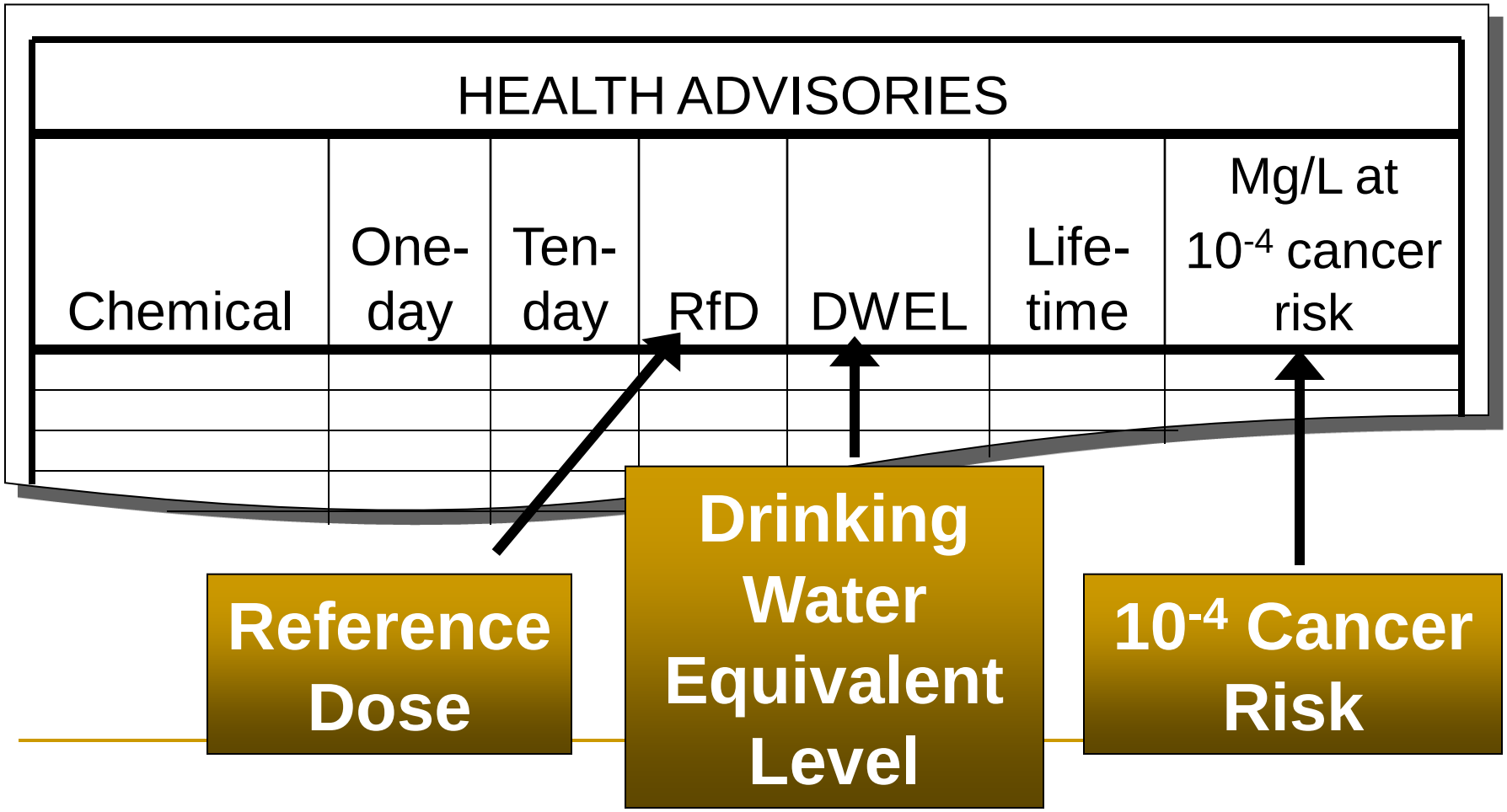
Adverse Effects of Nutrients in Wastewater

- Increased biomass of algae and other plants
- Decreases in water transparency
- Dissolved oxygen depletion
- Increased incidences of fish kills
- Decreases in perceived aesthetic value of the water body
- Taste, odor and water treatment problems

Water Quality & Impact Influencers

- Vulnerability of water source
- Community concerns
- Shareholder concerns
- Employee concerns
- Customer concerns
- Public Health concerns
- Ecosystem Health concerns
- Political concerns

Drinking Water and Health Advisory Summary Tables



Water Standards

- US EPA
  - Stream standards
  - Effluent standards
  - Drinking water standards
- The Clean Water Act. NPDES permits.
- Executive Order 13123:
  Greening the Government Through Efficient Energy Management

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Point Source Pollution

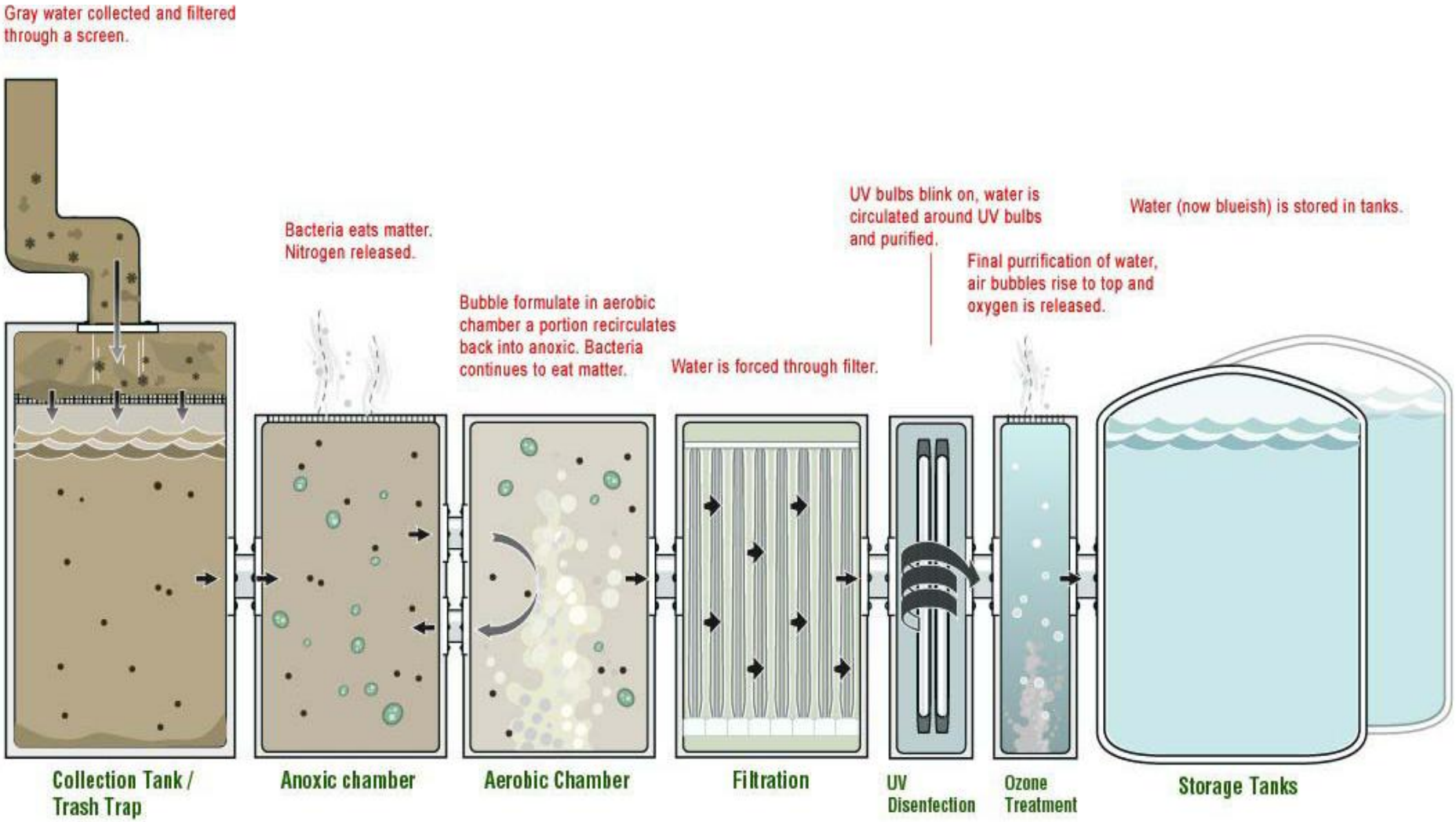
- The U.S. Environmental Protection Agency (EPA) defines point source pollution as “any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack”.
- Factories and sewage treatment plants are two common types of point sources. Factories, including oil refineries, pulp and paper mills, and chemical, electronics and automobile manufacturers, typically discharge one or more pollutants in their discharged waters (called effluents).
- Some factories discharge their effluents directly into a waterbody. Others treat it themselves before it is released, and still others send their wastes to sewage treatment plants for treatment.

What Impacts Water Quality?

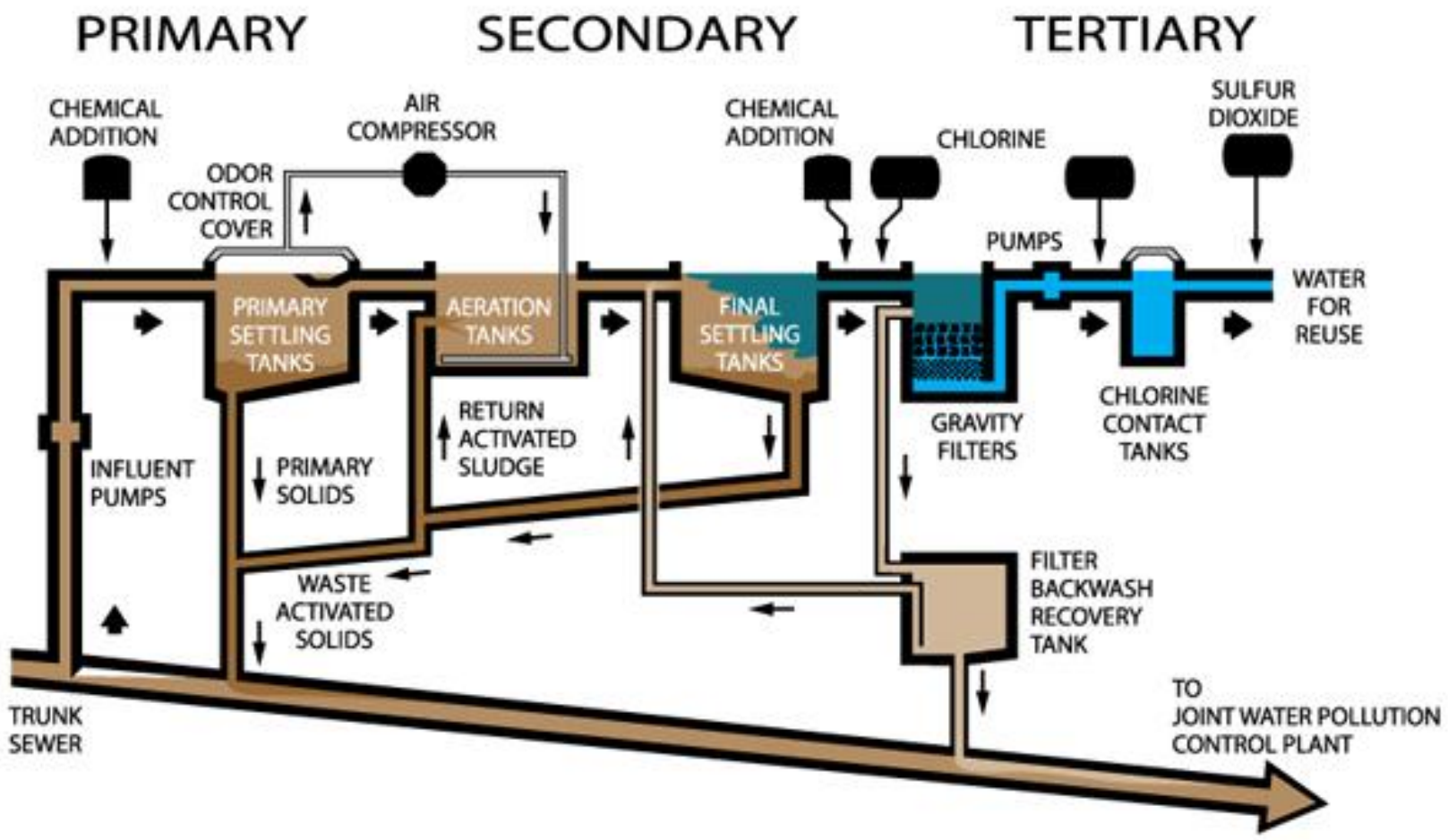
Other Industrial Activities:

- Air deposition into water (e.g., acid rain)
- Potential for spills to surface water
- Leaking tanks and pipes
- Changes to impervious surfaces caused by construction and development

Industrial Treatment - Nonpotable Use



Municipal / Industrial Treatment



Primary Treatment

A clarification step is the first part of conventional treatment for waste and surface water treatment.

Usually consists of:

- Screening - to remove large objects, such as stones or sticks, that could plug lines or block tank inlets.
- Physical chemical treatment - such as a grit chamber to slow down the flow to allow grit to fall out.
- Sedimentation tank - settleable solids sink and are pumped away; oils float to the top and are skimmed off.

Secondary Treatment

Utilizes biological treatment processes where microorganisms convert non-settleable to settleable solids.

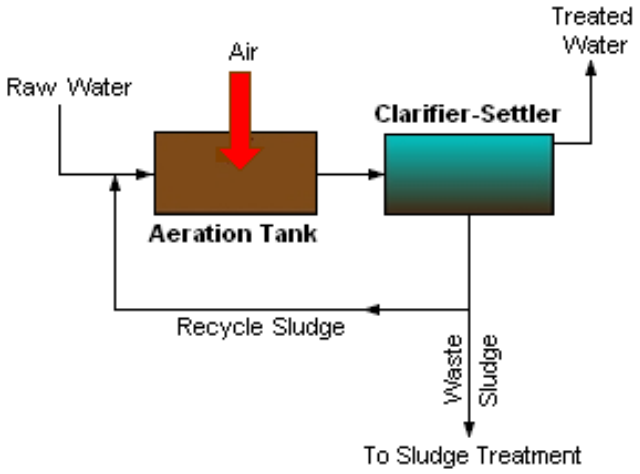
Typically followed by sedimentation so settleable solids sink.

Common options include:

- Activated Sludge
- Trickling Filters
- Lagoons

Secondary Treatment
Activated Sludge

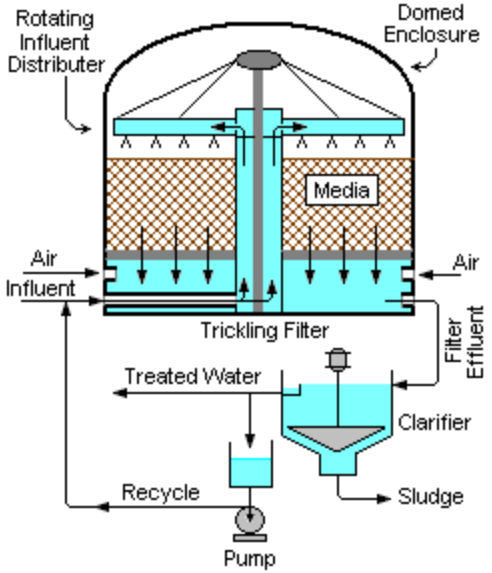
- Uses microorganisms to break down organic material with aeration and agitation.
- Bacteria-containing “activated sludge” is continually recirculated back to the aeration basin to increase the rate of organic decomposition.





Secondary Treatment Trickling Filters

- Beds of coarse media (often stones or plastic) 3-10 ft. deep.
- Wastewater is sprayed into the air (aeration), then allowed to trickle through the media.
- Microorganisms, attached to and growing on the media, break down organic material in the wastewater.
- Trickling filters drain at the bottom; the wastewater is collected and then undergoes sedimentation.

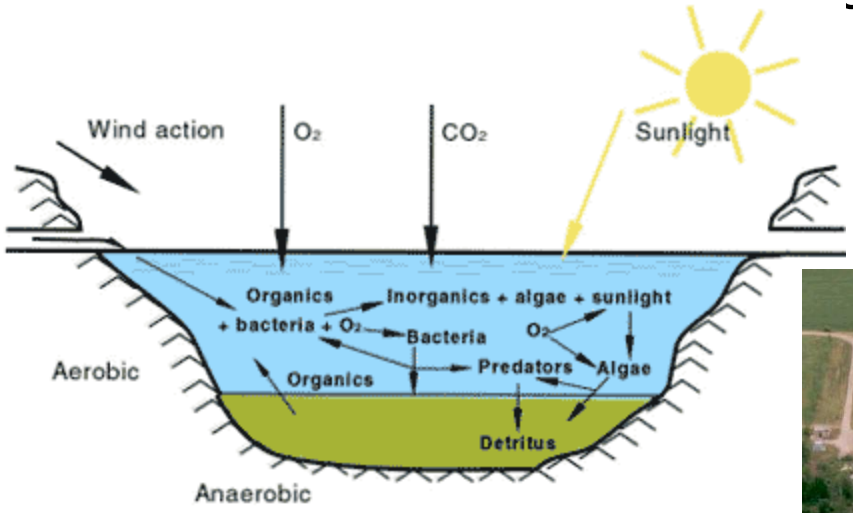




Secondary Treatment

Lagoons

- These are slow, cheap, and relatively inefficient, but can be used for various types of wastewater.
- They rely on the interaction of sunlight, algae, microorganisms, and oxygen (sometimes aerated).



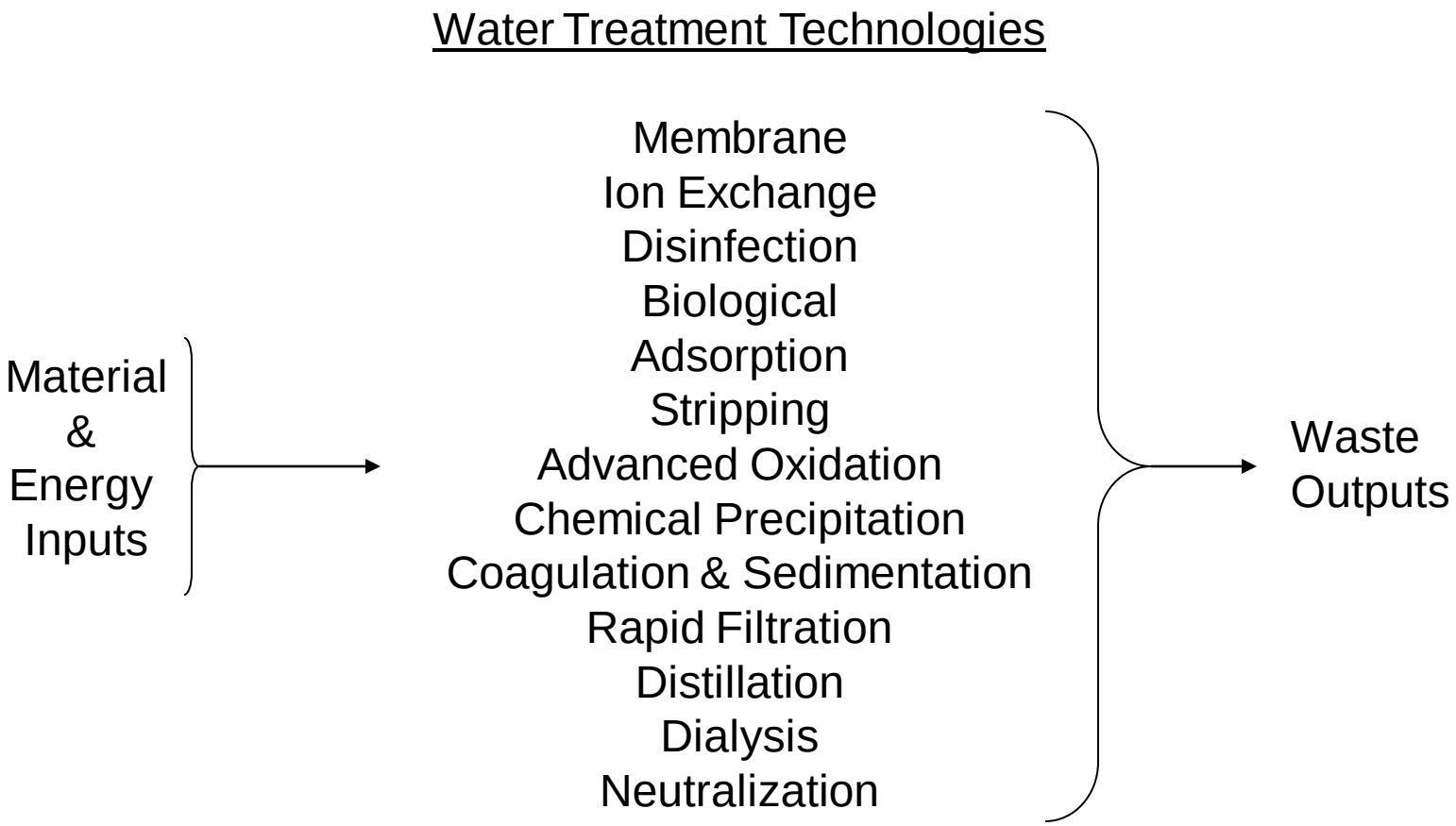


Tertiary Treatment

- Subject to a regulatory requirements that each industry sector has to follow, as well as the final characteristics of their effluent.
- May include processes to remove nutrients such as nitrogen and phosphorus, and carbon adsorption to remove chemicals.



Lifecycle Assessment



Course Agenda

Sustainable Water Management

Supply Water Conservation & Efficiency

Simulation – Round 1

Wastewater Management

Simulation – Round 2

Water Quality

Point Source Pollution: Causes & Treatment

Non-Point Source Pollution: Sources & Management

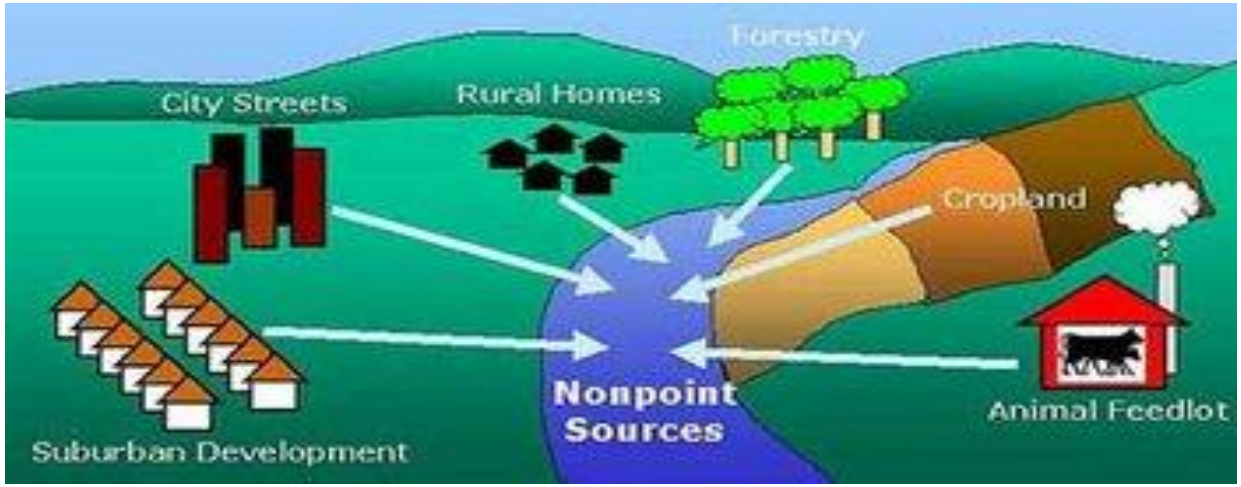
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Non-Point Source Pollution

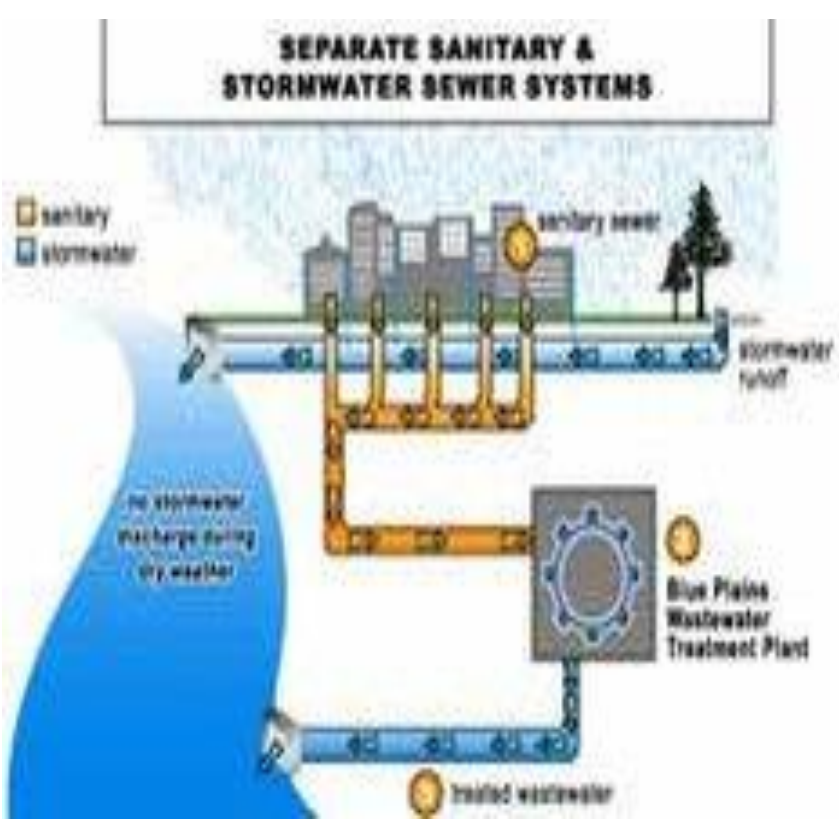
Forestry activities including tree and vegetation removal, especially along stream and river beds, and road construction.



Oil, grease, and toxic chemicals from urban runoff and energy production.

Excess fertilizers, herbicides, insecticides, and animal wastes from agricultural lands and residential areas.

Sewer Systems
Separate vs. Combined





Urban Runoff Challenges

- Traditional urban run-off management techniques are band-aid solutions that try to solve a problem that should not exist.
- Traditional retentions ponds and urban run-off treatment are bad for environmental quality and corporate liability.

Strategies for Urban Runoff

- Buildings: install Green Roofs (vegetated roof covers). Green Roofs retain water and virtually eliminate run-off. Green roofs conserve significant amounts of energy by reducing heating & cooling costs. Green roofs protect the underlying waterproofing layer and extend roof life.

- Parking Lots: install pervious pavement. Pervious pavement allows precipitation to infiltrate into the ground rather than run-off. Water infiltration is a natural process for attenuating pollution and recharges ground water aquifers.

- Site Development: During building construction, retain as much of the native topsoil in place as possible. Require construction contractors to excavate & grade only the minimal building and parking lot footprint rather than grading the entire site down to hard pan. The “standard” practice of removing all topsoil on a construction site drastically exacerbates water run-off problems in the future.

Economic Affects of Urban Runoff

- Mass die-offs of fish and dirty-looking water affect the beauty and health of coastal lands and waters.
- If the physical and environmental well-being of these areas is diminished, people will naturally find it less appealing to visit the waterways.
- Reduced tourists' contributions, as well as decreasing waterfront property values can impact the economic status of waterway community's.

Sustainable Drainage Systems (SUDS)

- Swales are grassland depressions, which lead water overland from the drained surface to a storage or discharge system.
- Balancing Ponds are designed to retain flood events, reducing peak flows and limiting the risk of flooding.
- Porous Pavements is an alternative to conventional paving in which water permeates through the paved structure rather than draining off it.









SUDS Site Suitability

	Residential	Commercial / Industrial	High Density	Retrofit	Contaminated site
Green Roofs	Yes	Yes	Yes	Yes	Yes
Rainwater Harvesting	Yes	Yes	Yes	Yes	Yes
Permeable Pavements	Yes	Yes	Yes	Yes	Yes
Infiltration Trenches	Yes	Yes	Yes	Yes	No
Filtration Drains	Yes	Yes	Yes	Yes	Yes
Swales	Yes	Yes	No	Yes	Yes
Basins	Yes	Yes	No	Yes	Yes

Advantages of SUDS

- Manage runoff flow rates;
- Reduce the impact of flooding from urbanization;
- Protect or enhance water quality;
- Provide a habitat for wildlife in urban watercourses; and
- Encourage natural groundwater recharge, where appropriate.

Course Agenda

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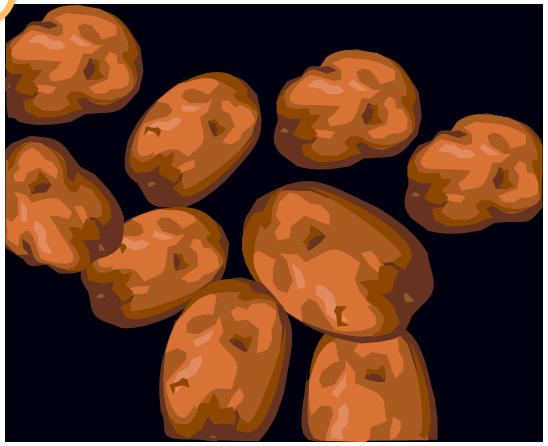
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Simulation Round 3
HydroSonic Potato Spuds

HydroSonic



Potato Spuds

What changes should we consider for improving the water and energy efficiency at HydroSonic?

How can we implement these changes?

Lessons Learned

- What was the outcome of the potato production processes? Report out all measurements.
- What do these measurements tell us?
- What were some of the challenges you encountered?

Course Agenda

Sustainable Water Management

Simulation – Round 1

Supply Water Conservation & Efficiency

Simulation – Round 2

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Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Water Program – Utility Component

- Include water supply and wastewater utility costs and approaches in the analysis.
- Anticipate increased water and wastewater service costs when considering options.
  - Ask utilities to provide any expected increases.
  - Anticipate future increases in production or number of employees that will influence water consumption.
- Encourage water and wastewater utilities to provide rebates and other financial incentives to offset the cost of implementing a water conservation measure.
  - Use efficiency/conservation plan as a bargaining point.

Water Program – Total Costs

Use total cost accounting methods to perform economic comparison of water efficient techniques. Consider:

- water and wastewater costs;
- on-site pretreatment costs;
- marginal cost for capacity expansion; and
- energy savings (especially heat).

Water Program Considerations

- Program goals should not only consider the technical side for water efficiency, but also should consider the human side, such as changing behaviors and attitudes toward water use.
- Do the simple tasks first to gain acceptance and positive feedback for the program.

Course Agenda

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Course Evaluation

PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM



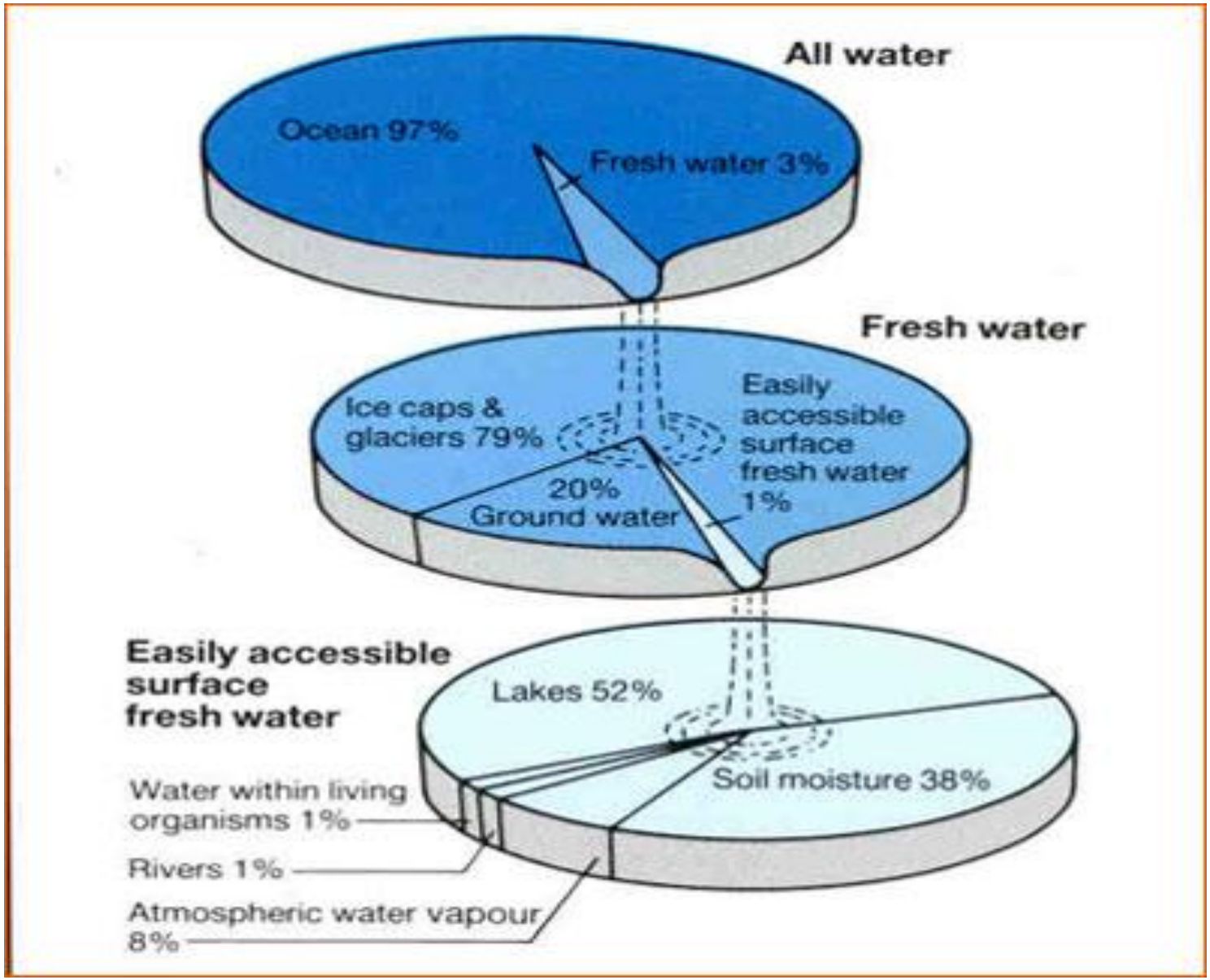
Supply Water / Waste Water Management

H_2O Conserve

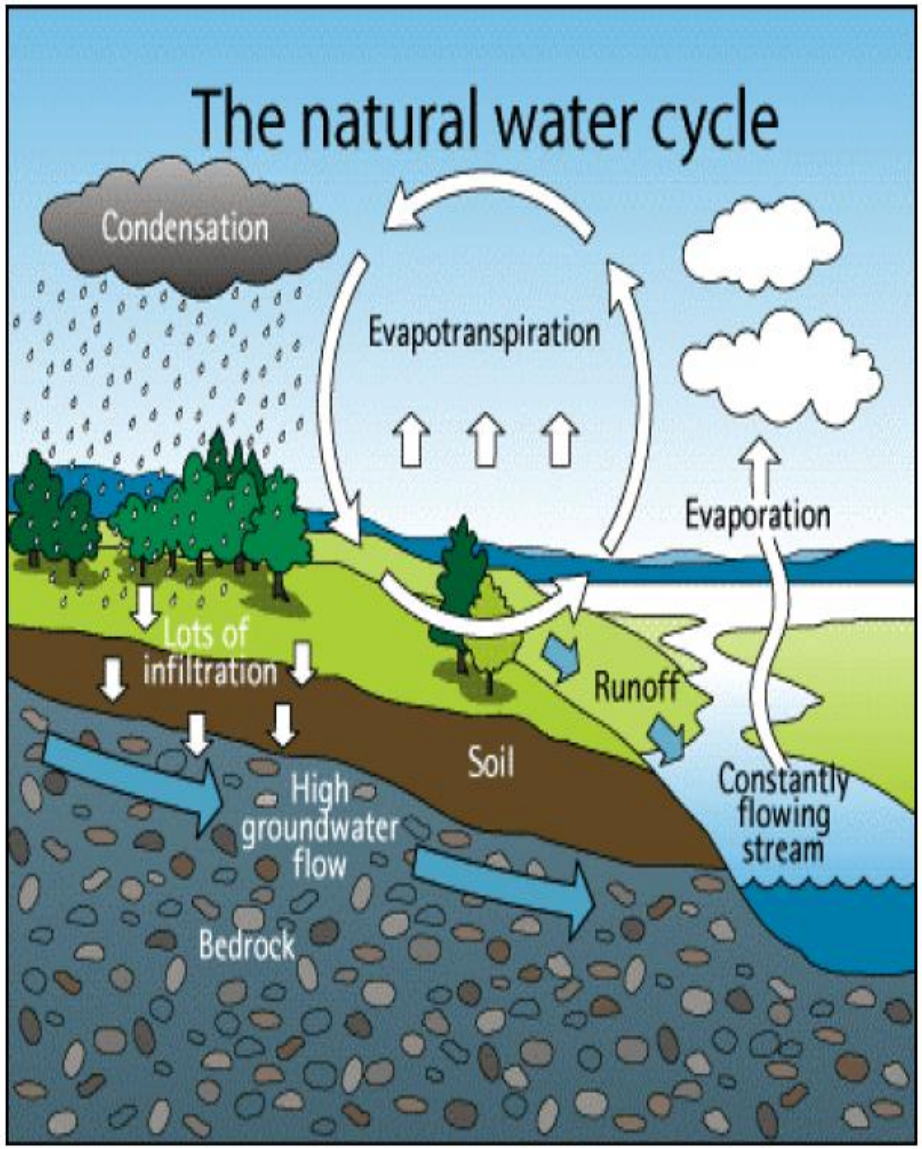
Purpose of This Module

- To provide an understanding of water supply challenges.
- To identify methods that can be implemented to reduce water use and improve the reuse of waste water.
- To provide strategies for incorporating effective water management concepts into a Green Enterprise.

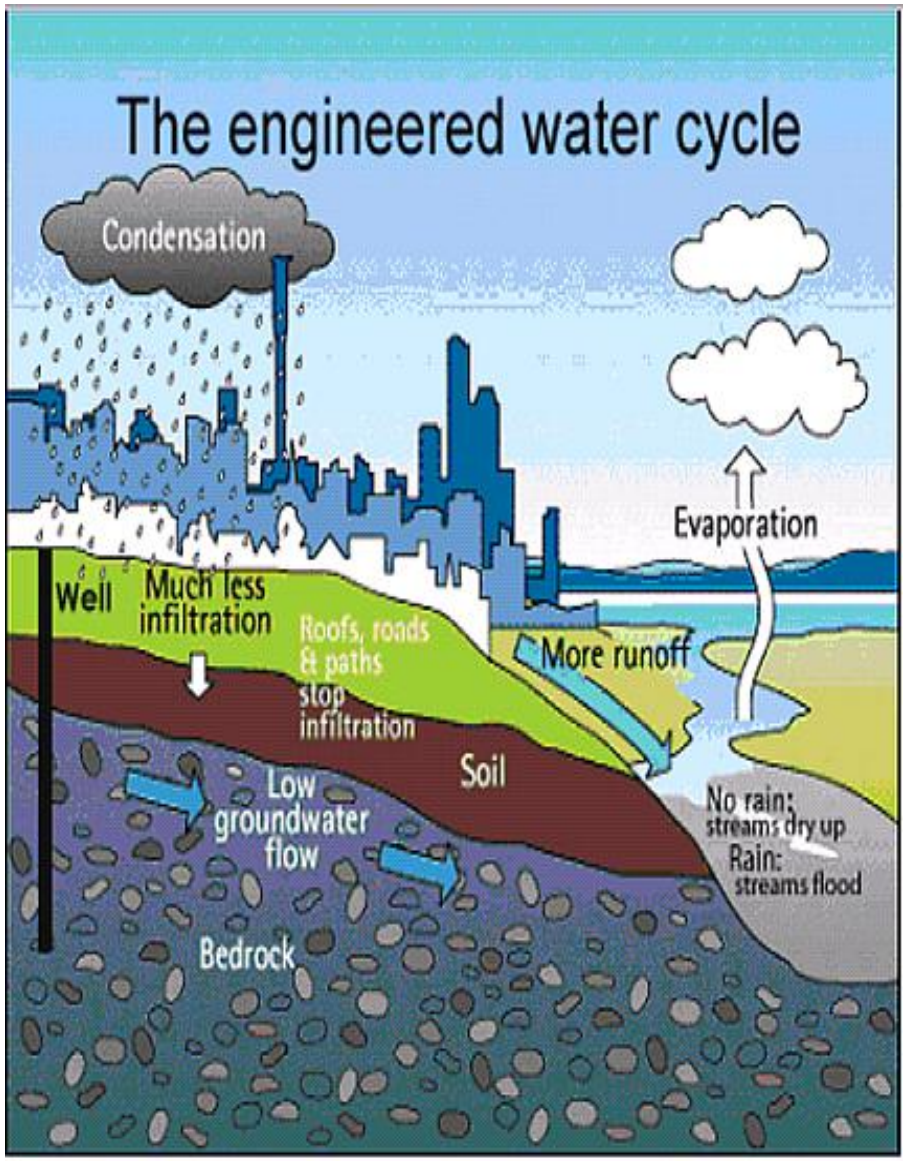
Freshwater is a Finite Resource



Water Cycle



Vs



Water Stress

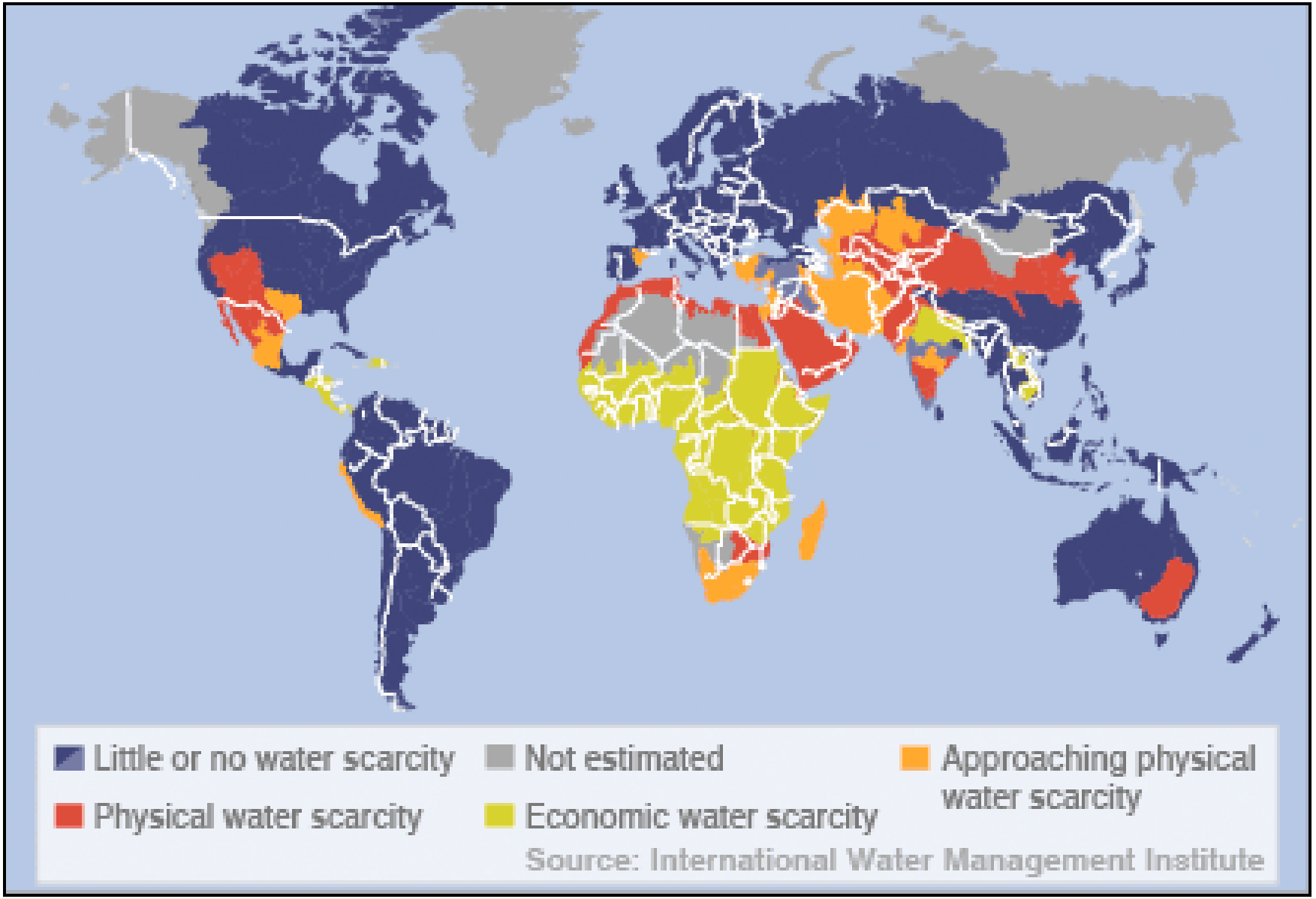
Occurs when:

- Demand for water exceeds the available amount during a certain period, or
- Poor water quality restricts use of available sources.

Causes deterioration of fresh water resources in terms of:

- Quantity - over-exploitation of aquifers, dry rivers, and
- Quality - increase in chemical nutrients, organic matter pollution, saline intrusion.

Water Scarcity



"When the well is dry, we learn the worth of water."

Ben Franklin

Course Agenda

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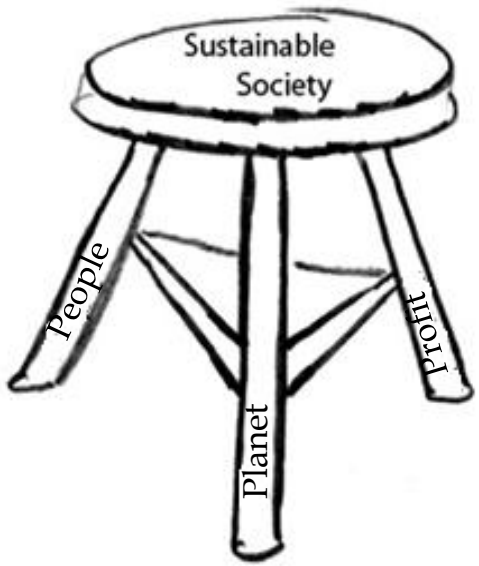
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Water Sustainability Concepts

- Consider local human and ecosystem water needs around shared water resources.
- Reduce overall use of water.
- Match water quality with appropriate use.
- Minimize adverse impacts on water quali or improve the quality of available water.
- Solve water quality challenges through prevention rather than treatment.
- Raise awareness about water sustainability and the importance of effective stewardship.



Social and Environmental Dimensions of Water Issues

- Inadequate supplies of clean freshwater contribute to public health issues, especially in non-industrial and developing nations.
- Drought, freshwater depletion, and floods contribute to population displacement.
- Water scarcity is increasingly leading to conflict, especially in arid areas.
- Ecosystem needs for freshwater are broadly affected by human activities.
- As society recognizes the value of ecosystem services and natural capital, freshwater is receiving higher priority attention.

Business Case – Water Costs are Increasing

Direct and indirect water-related costs include:

- Treatment to ensure that water inputs meet quality specs;
- Wastewater treatment and pollution mitigation to meet more stringent pollutant discharge and run-off standards;
- Supply expansion associated with dam construction, water diversion, well drilling, and securing new water allocations;
- Indirect costs from suppliers with water-intensive processes or significant water impacts;
- Worker absenteeism stemming from employee contraction of water-borne illnesses.

Business Case – Disruption Risks are Growing

Potential water-related business risks include:

- Supply shortages caused by infrastructure deterioration, contamination, or terrorist activity;
- Changing water allocations to address other industrial, agricultural, residential, and ecosystem needs;
- Supplier disruptions from water shortages in other regions;
- Opposition to new building sites or expansions stemming from existing or anticipated water uses or impacts;
- Public opposition to, or government prohibitions against, certain wastewater discharge techniques.

Business Case – Customer Expectations Evolving

- Many publicly traded companies experience shareholder initiatives aimed at corporate environmental performance or decision-making, creating pressure for a company to alter its water-related practices or strategic plans.

- At the same time, some companies are finding ways to enhance revenues by applying core competencies to address water-related needs experienced by others, such as products that use less water or services that reduce customers' water dependency.

Sustainable Water Management

- Water Efficiency
- Water Quality
- Water Services Infrastructure Planning
- Flood Risk Management
- Sustainable Drainage

Water Conservation Hierarchy–4Rs



- Refuse (don’t use)
- Reduce (conservation)
- Reuse/Recover (divert, don’t discharge)
- Recycle (reuse directly or treat)

Course Agenda

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Measuring Water Use / Waste

Course Evaluation

Conservation and Efficiency

Conservation without efficiency is mere deprivation.

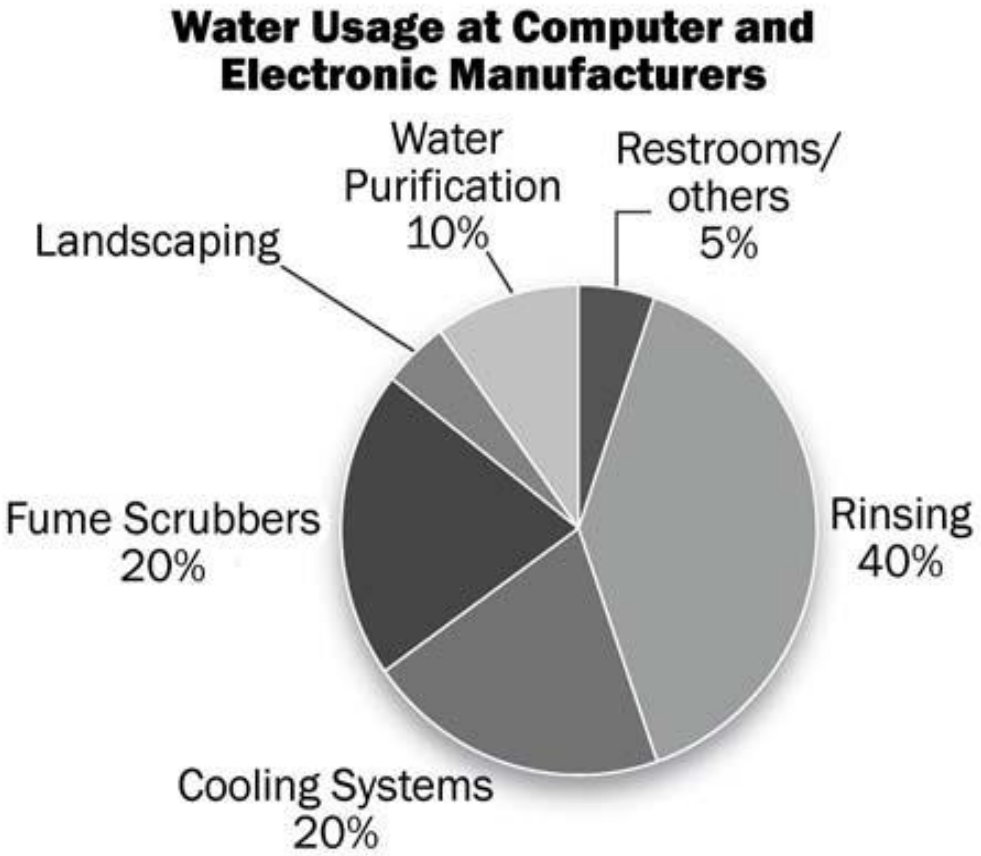
This does not meet the definition of sustainable!

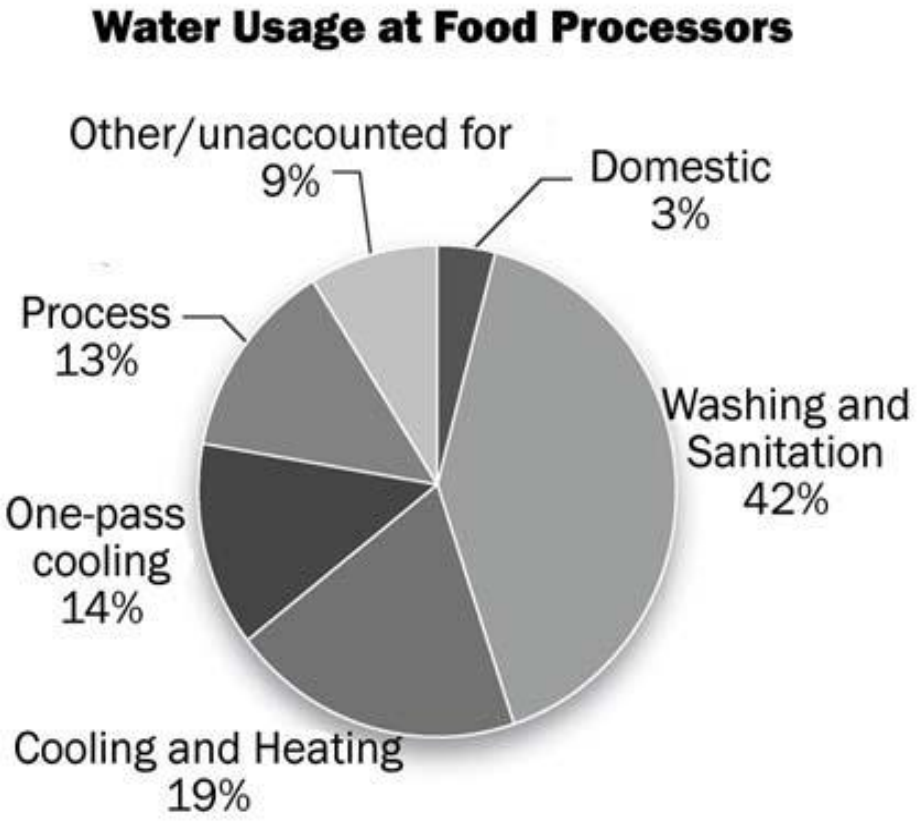


Industrial Water Uses

- Irrigation of crops
- Irrigation of lawns/landscaping
- Cleaning of raw materials
- Cleaning and rinsing of parts during production
- Maintenance of parts, equipment, facilities, vehicles
- Waste handling
- Sanitation
- Drinking by people and/or animals
- Food preparation
- Product component or manufacturing input
- Ingredient for key supplies
- Industrial processing
- Process heating/cooling
- Space heating/cooling (boiler water, steam)
- Power generation (hydropower, thermal, nuclear)
- Fire suppression
- Movement/transportation of materials or goods (water slurry, ballast water)

Water Usage – Industry Examples





Supply Management Challenges

- Demand to serve a growing and shifting population;
- Declining ground water levels/salt water intrusion;
- Variations in climate patterns;
- Total Maximum Daily Load (TMDL);
- Limited space for new conventional water supplies, e.g., reservoirs;
- Integration/prioritization with other planning initiatives, local and state objectives, etc.

Water Systems

Dynamic performance indicators:

- Reliability: likelihood that services are delivered within a given period.
- Resiliency: manner in which a system recovers from shock or failure.
- Robustness: degree to which a system can be impacted by external factors, along with the severity of the expected consequences of shock or failure.

Reliability Factors

- Meeting all current and foreseeable local, State, and Federal requirements.
- Vulnerability to damage from natural disasters, such as earthquakes.
- Redundancy to accommodate outages.
- Protection from drought.
- Protecting the natural and human environment when improvements are made.

Resilience Factors

- Redundancy of functions
- Diversity of ecosystem
- Climatic variations
- Inventories/Storage
- Alternative sources
- Importance / Prioritization

Robustness Factors

- Source availability / diversity / alternatives
- Price fluctuation sensitivity
- Impacts of quantities available for specific uses
- Quality requirements / effects of lower quality

Information for Managing Water

Methods of gathering information for water management include:

- remote sensing;
- seasonal climate forecasting;
- real-time dynamic monitoring systems.

Water Conservation Approaches

- Use efficient spray nozzles with automatic shutoffs on hoses.
- High-pressure washers clean more quickly and efficiently.
- Pressurized air-assisted spray nozzles clean with more force and less water.
- Low-flow “fogging” nozzles to rinse parts efficiently.
- Flow restrictors in water lines that supply hoses and pressure washers.
- Timers to shut off process water rinses when process is shut down.

Water Conservation Approaches

- Ensure stationary spray nozzles are aimed properly.
- Review nozzle spray patterns for optimum application.
- Replace worn spray nozzle heads.
- Use countercurrent washing techniques.
- Use conductivity controllers to regulate rinse water flow rates.
- Use spray washing/rinsing for tank cleaning vs. refilling/dropping tank washwater.
- Changes in cleaning solution type, temperature and concentration can save water.

Water Efficiency Approaches

- Check your meters at night or when no water is being used to monitor leakage.
- Use water efficient equipment, devices and appliances.
- Determine where your wasted water is going and if or how you can recycle it in other areas of your business.
- Where possible, use a water reservoir to harvest rainwater for use in your business.
- Assess water using equipment so there is no over filling.
- Set water usage targets.
- Use dry cleaning methods rather than wet cleaning.

Dry Clean-up Examples

- Sweeping floors instead of hosing with water.
- Vacuuming or sweeping dry material spills such as salt or dyes instead of using water.
- Use squeegees and scrapers first to remove residuals from machines and equipment.
- Vacuuming or sweeping particulate emissions (dust) instead of hosing with water.
- Use rubber squeegees to collect food processing residuals from the floor before hosing with water.
- Use “pigs” to purge residuals from pipes before flushing with water.

Water Efficiency Benefits

- Cost avoidance for water supply and wastewater treatment.
- Reduced stress on infrastructure.
- Prevention of future shortage episodes.
- Reduced energy usage to treat and transport.

Keep the Basics in Mind

- Public health sanitation requirements such as the USDA, FDA, and state and local health regulations.
- Environmental requirements such as water quality reuse rules and criteria.
- Other health and safety requirements, such as state and local building codes and fire safety codes.
- Customer quality expectations, such as product cleanliness specifications.

Changing Behavior vs. Equipment

- Equipment changes may be viewed as a “permanent fix” to achieve water efficiency.
- Changing employee behaviors, such as an operating procedure, may be viewed as a quick and inexpensive way to achieve similar savings without up-front capital expense.
- Consistent training and awareness in combination with proper tools and equipment will achieve more permanent water savings.

Course Agenda

Sustainable Water Management

Supply Water Conservation & Efficiency

Simulation – Round 1

Wastewater Management

Simulation – Round 2

Water Quality

Point Source Pollution: Causes & Treatment

Non-Point Source Pollution: Sources & Management

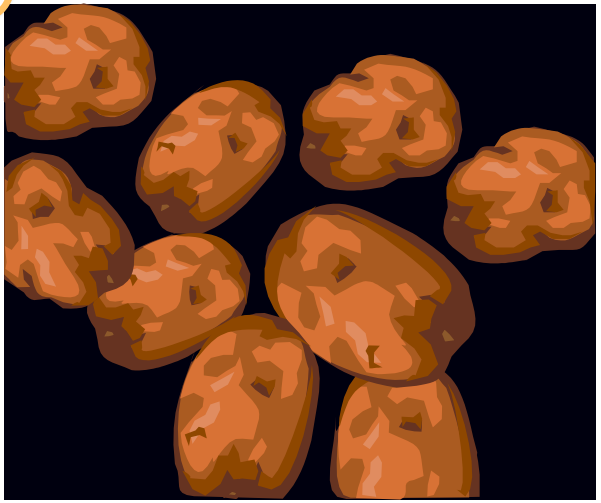
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Simulation Round 1
HydroSonic Potato Spuds

HydroSonic Potato Spuds



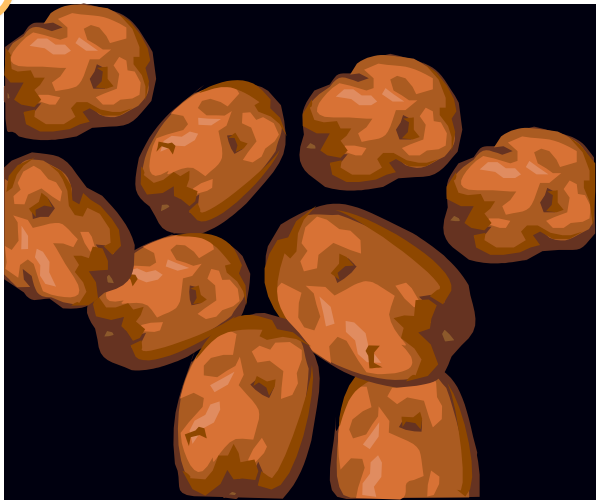
A family-owned potato production business including potato farms, storage, sorting and packing facilities.

HydroSonic produces chipping potatoes -- special spuds specifically engineered to meet the needs of potato chip makers.

They are looking to improve their efficiencies in water and energy use and have invited us to take a look at some of their operations.

Simulation Round 1
HydroSonic Potato Spuds

HydroSonic



Potato Spuds

To best understand their challenges, we're going to fill in for some of the roles in their operations and get a first-hand look at how things currently work.

Roles:

- Irrigation Team
- Transport Team
- Energy Team
- Cleaning Team
- Reservoir/Pump Team
- Industrial Engineer
- Plant Manager
- Maintenance Technicians

Lessons Learned

- What was the outcome of the potato production processes? Report out all measurements.
- What do these measurements tell us?
- What were some of the challenges you encountered?

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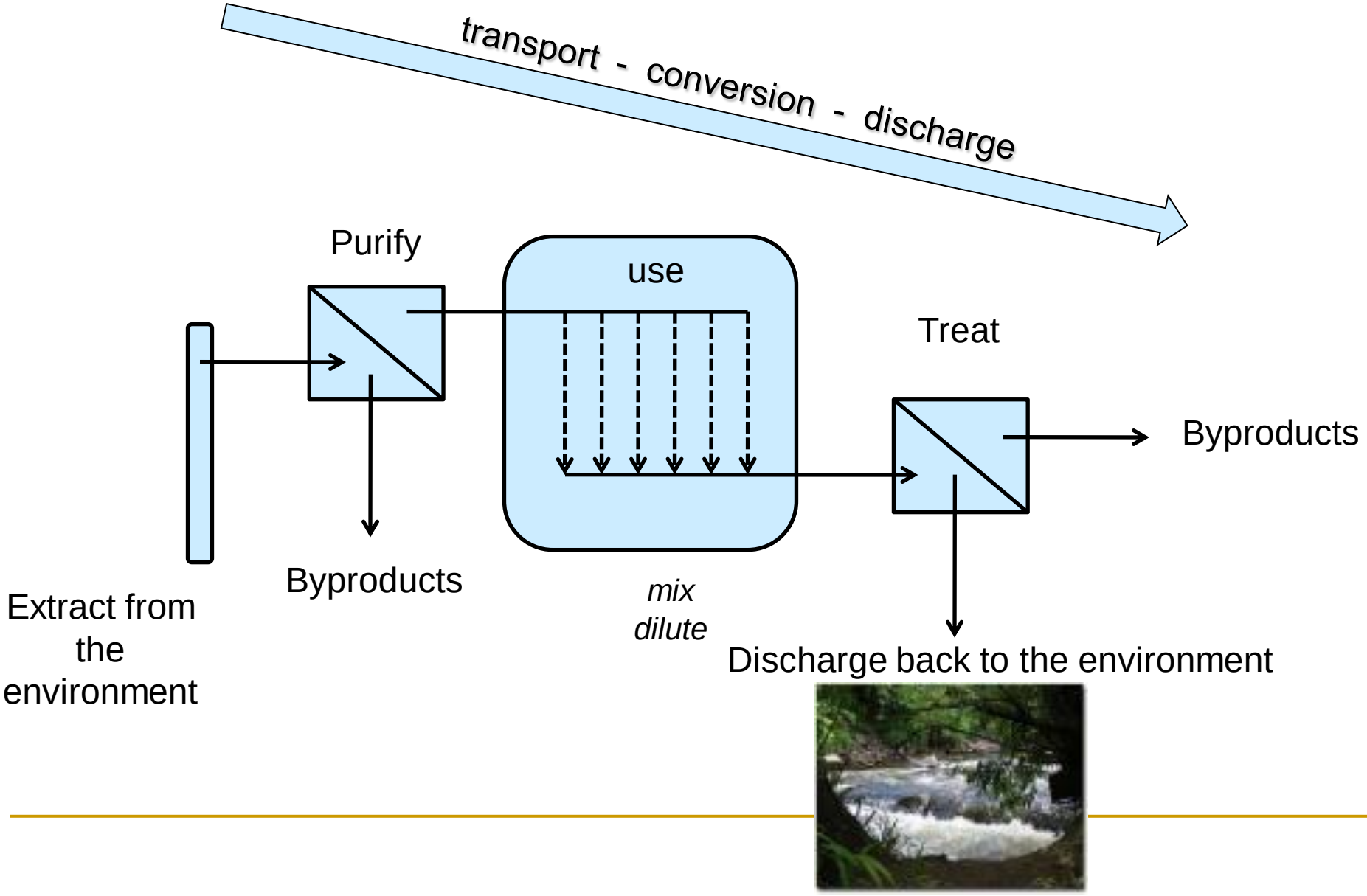
Non-Point Source Pollution: Sources & Management

Simulation – Round 3

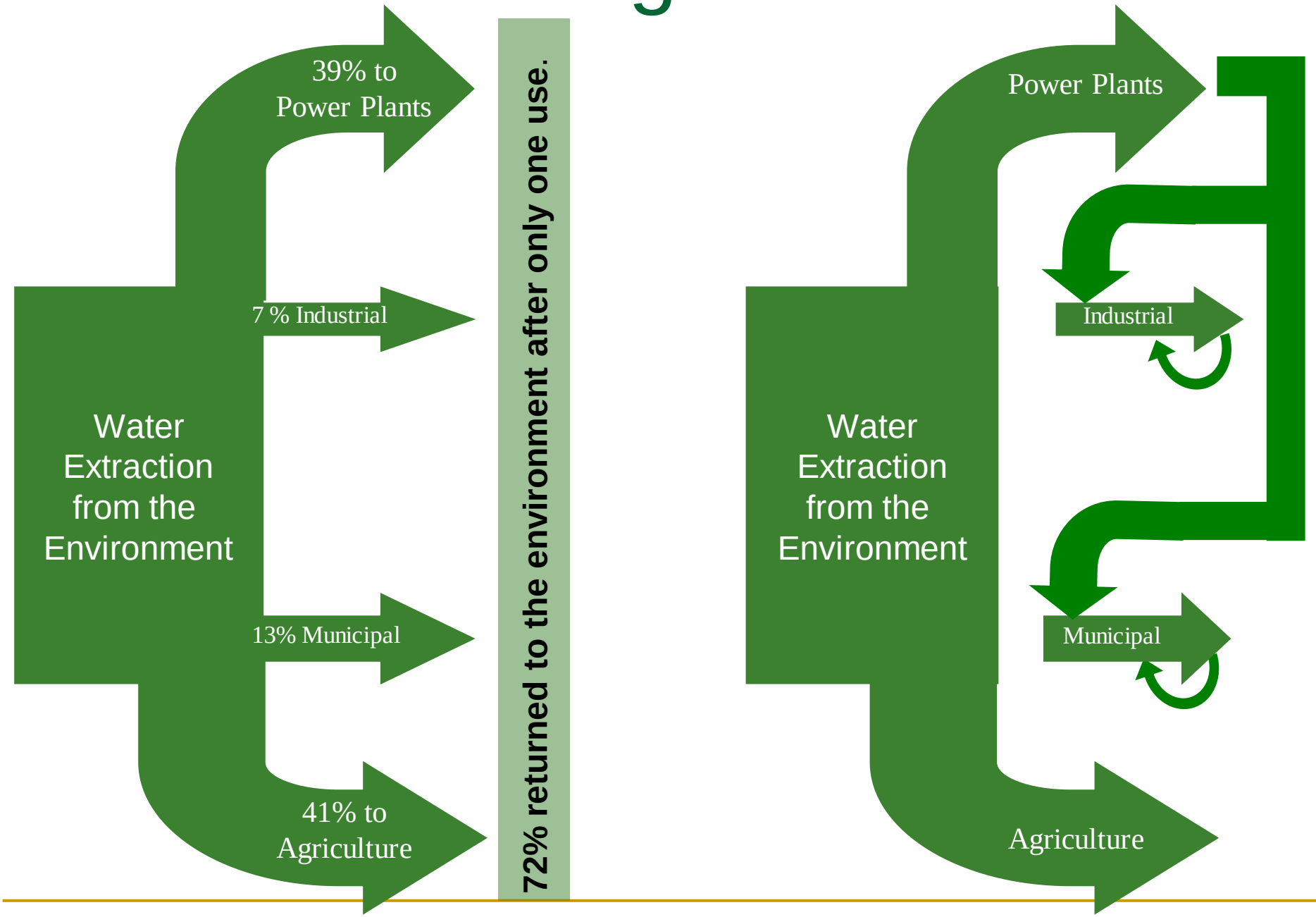
Measuring Water Use / Waste

Course Evaluation

Traditional Linear Practice



Green Technologies Enable Reuse

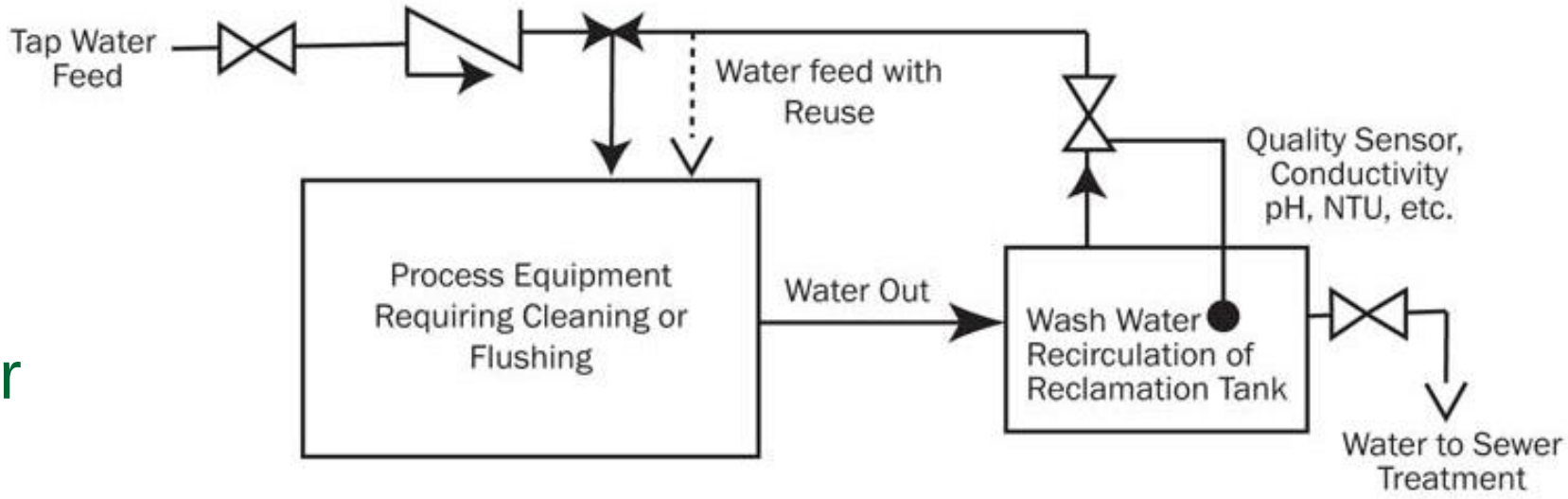


Cleaning Process Water Reuse

Before



After



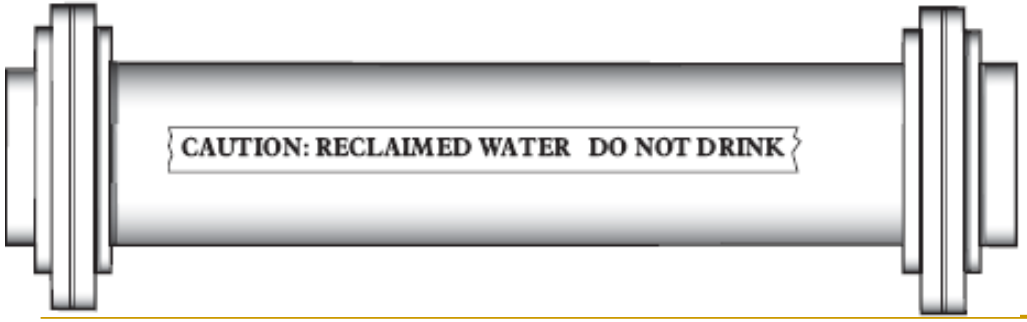
Wastewater Reuse / Recycle

- Recycled water is approved through State and local regulations for specific beneficial uses such as irrigation of lawns and crops, flushing of toilets and urinals, etc.



www.dnr.state.mo.us/magazine/ 1996_sum/revolving_fund.htm

- Conserves valuable drinking water for drinking.



Recycled water is not generally allowed for direct potable use (although technically feasible).

Water Recycling Benefits

When wastewater is treated for recycling, some nutrients are left in it that is good for plants. As a result, recycled water is great for irrigating most landscaping, crops and golf courses.



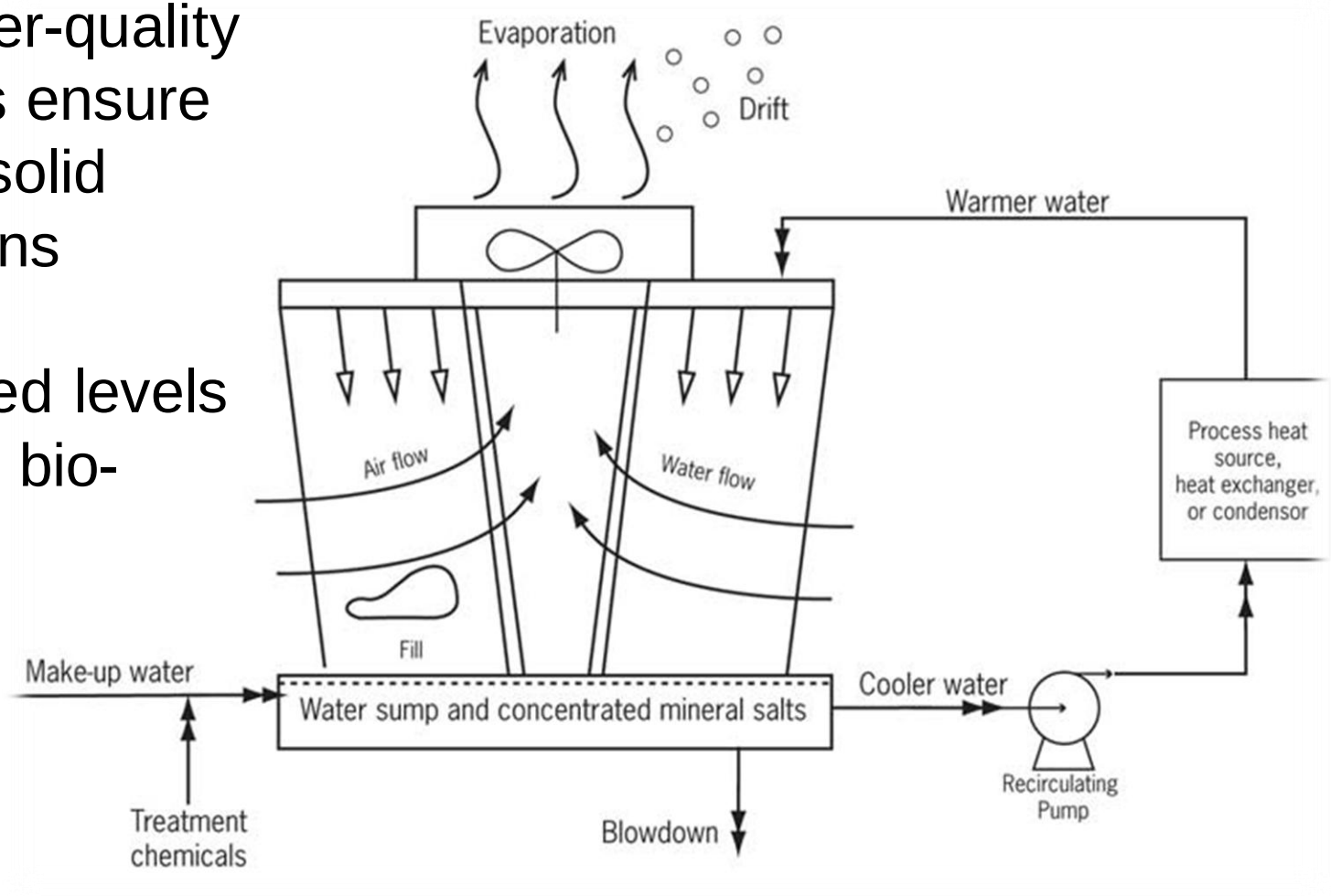


www.accessvegas.com/ las-vegas-golf-courses.htm

Because of it's nutrient content, recycled water is actually better suited than drinking water for some of the applications where drinking water gets used the most.

Cooling Towers

Regular water-quality testing helps ensure suspended-solid concentrations remain at recommended levels and reduces bio-fouling.



Cooling Tower Water Efficiency

- Optimizing cycles of concentration
- Using alternative sources of makeup water
- Installing and properly maintaining drift eliminators
- Using automatic controls to control blowdown
- Sub-metering makeup water and blowdown
- Implementing an effective maintenance program
- Ensuring that towers are appropriately sized for the cooling load
- Installing variable-frequency drives (VFDs) on motors
- Installing automatic shutoff control devices
- Using sidestream filtration

Cooling Tower Water Reuse

Some facilities have the opportunity to reuse water from other processes for cooling tower makeup water, including:

- Reject reverse-osmosis water,
- Wastewater from once-through cooling systems, and
- Municipal wastewater effluent.

Reusing Cooling Water

Frequently facilities use water for “once-through” cooling of small heat-generating equipment.

Water-efficiency opportunities for single-pass cooling including:

- Reusing for other processes, such as boiler makeup water, landscaping, rinsing, or washing.
- Reducing flow and monitoring the temperature differential between the influent and effluent water to make sure it’s within the parameters established by the manufacturers.
- Installing automatic shutoff controls when system is not in use.
- Using a cooling tower or other heat-absorbing medium for water to be recycled.

Boiler Water Efficiency

- Boilers require makeup water to compensate for uncollected condensate or to replace blowdown water.
- Have a tendency to develop leaks as they age which wets the insulation, causing both heat and water losses.
- Scaling is one of the leading causes of boiler tube failures.
  - Scale is equivalent to having a thin film of insulation between the furnace gases and boiler water.
  - Can drop a boiler's efficiency by as much as 10–12%.
- Installing a condensate recovery system that reuses condensate water as makeup water.
  - Can save up to 70% of the water used in a boiler, and significantly reduce energy costs.

Boiler Water Efficiency

- Adopting a leak-detection program.
- Control scale in boilers with a preventive maintenance program.
- Install automatic controls for chemical treatment systems.
- Re-insulate boiler or hot water lines that have become worn/damaged.
- Control blowdown by releasing water from the boiler and making it up with fresh water.
  - Excessive blowdown leads to the loss of water and energy, but insufficient blowdown can lead to the buildup of impurities and scale.
  - Blowdown can range from 1–25%, based on the condition and age of the boiler as well as the quality of the local water.

Water Efficiency in Industry
- Case Studies -

Bull HN Information Systems, Inc. - printed circuit boards-

Conservation and waste minimization programs have reduced water use by almost 230,000 gallons per day by tracking all the process water and water going to cooling towers and boilers through automated controls systems and a unique filtration system.

Carlovers Carwash

Each new site employs the latest technology to save on light and heat and conserve and recycle water. All water is filtered and treated for reuse up to 80% of all water used during washing. This amounts to an annual saving in excess of 1 billion litres of water.

Course Agenda

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Point Source Pollution: Causes & Treatment

Non-Point Source Pollution: Sources & Management

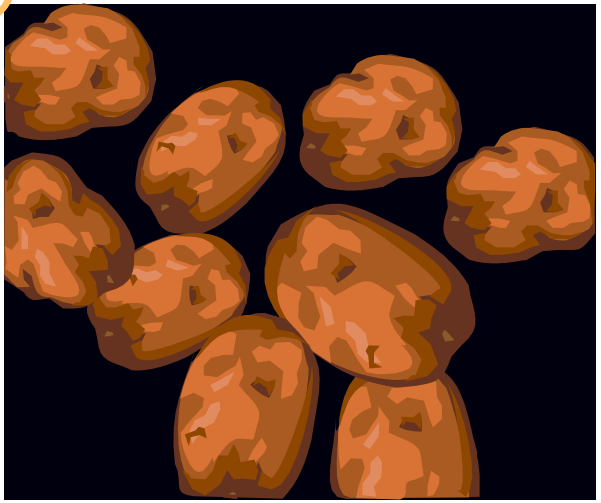
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Simulation Round 2
HydroSonic Potato Spuds

HydroSonic



Potato Spuds

What changes should we consider for improving the water and energy efficiency at HydroSonic?

How can we implement these changes?

Lessons Learned

- What was the outcome of the potato production processes? Report out all measurements.
- What do these measurements tell us?
- What were some of the challenges you encountered?

Course Agenda

Sustainable Water Management

Supply Water Conservation & Efficiency

Simulation – Round 1

Wastewater Management

Simulation – Round 2

Water Quality

Point Source Pollution: Causes & Treatment

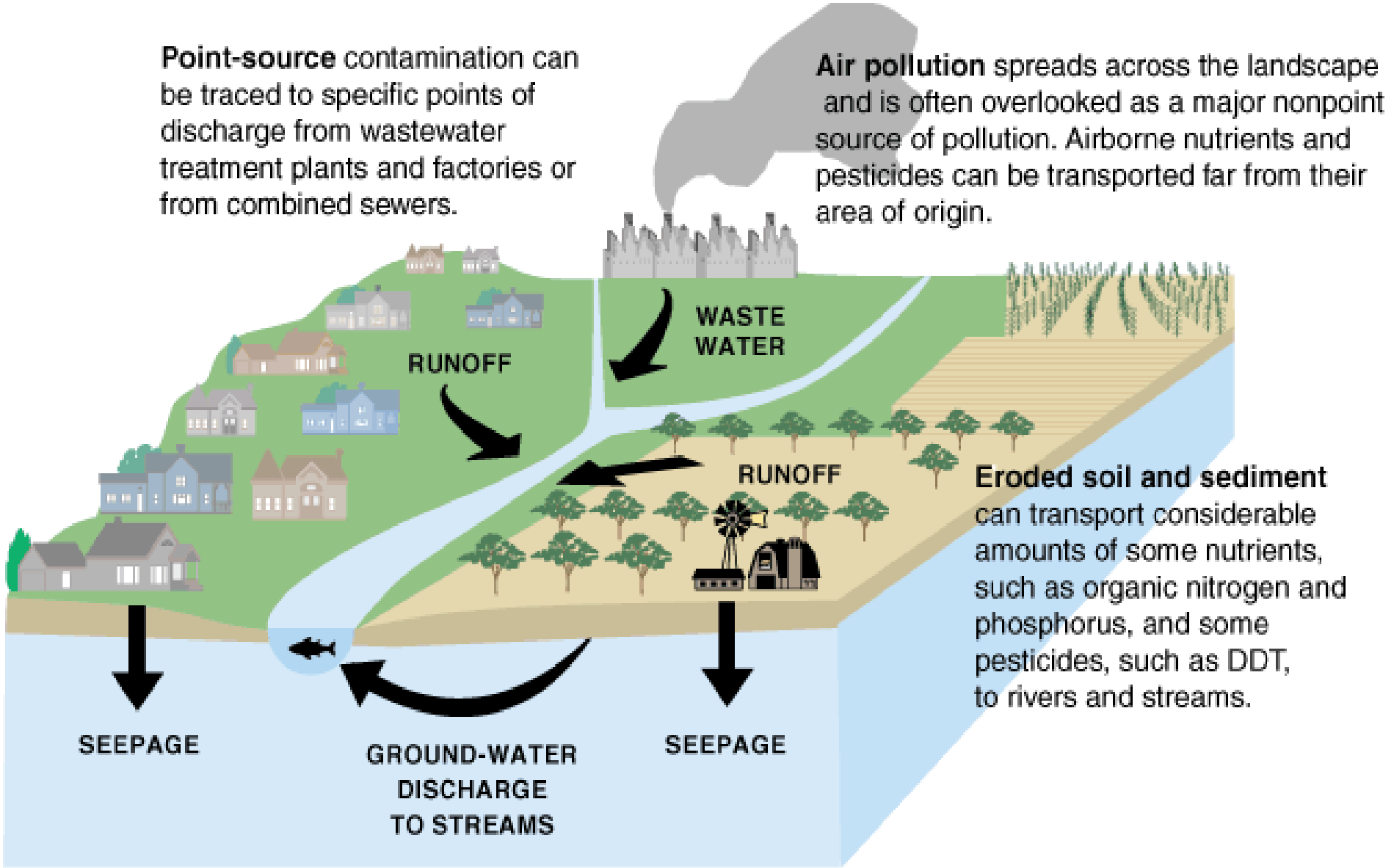
Non-Point Source Pollution: Sources & Management

Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Water Pollution



Key Water Quality Issues



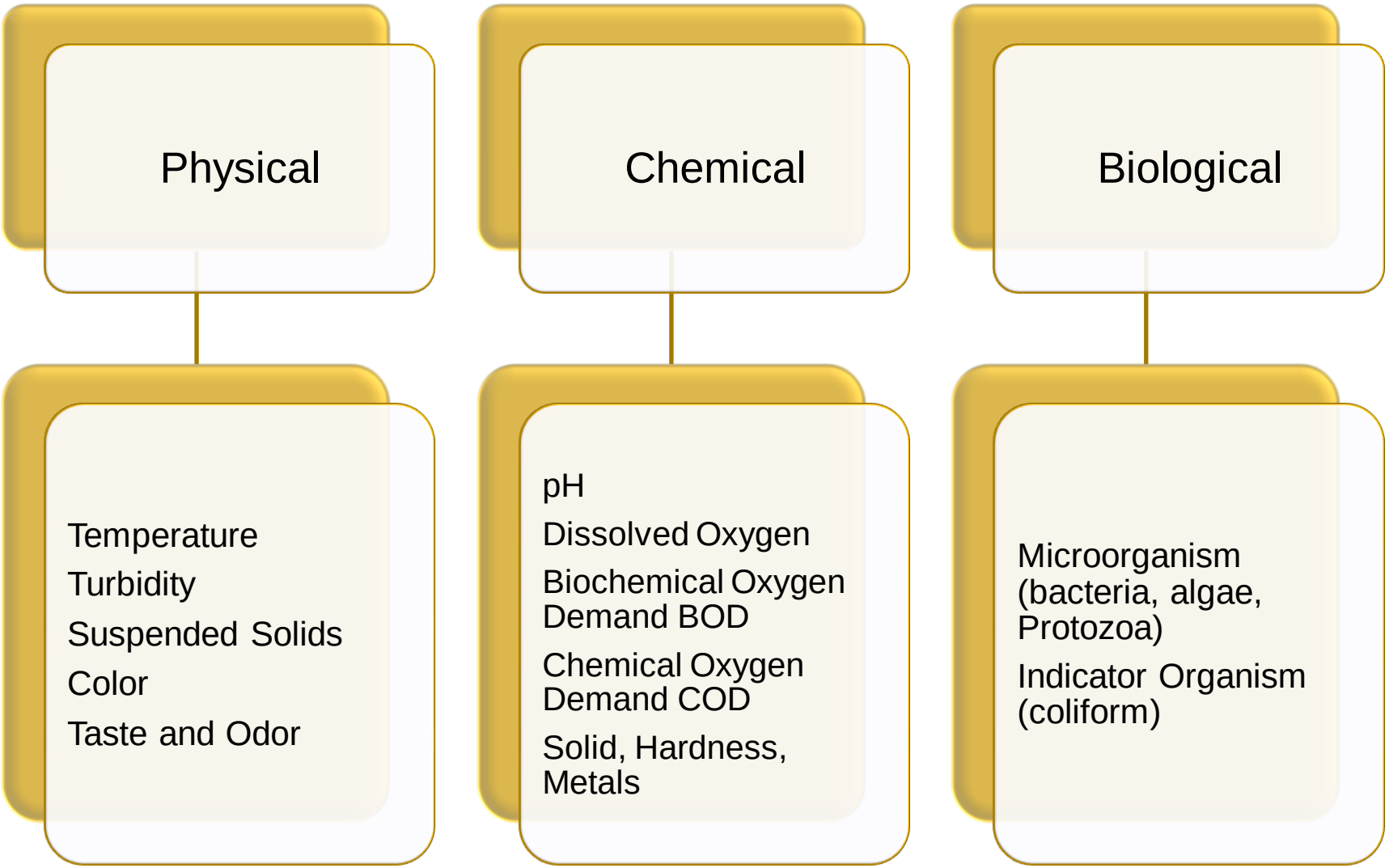
- Nutrients promoting undesirable forms of life
  - Nitrogen: Power plants (NOx), farm runoff, fertilizers
  - Phosphorus: fertilizers, detergents



- Pathogens from untreated or poorly treated sewage
- Oxygen-depleting substances in municipal and some industrial wastewater
- Toxic organics which disrupt metabolism and reproduction
- Toxic metals
- Suspended solids



Quality Parameters

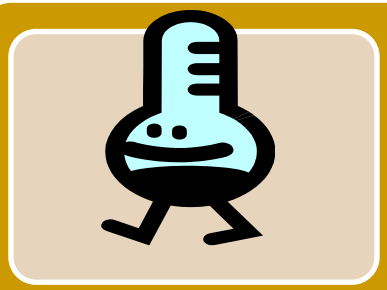


Industrial Supply Water Indicators



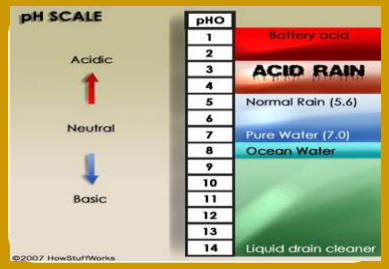
Dissolved Oxygen (DO)

- is a relative measure of the amount of oxygen that is dissolved or carried in a given medium.
- A high DO speed up corrosion in water pipes.



Temperature

- It directly affects the amount of dissolved oxygen in the water.



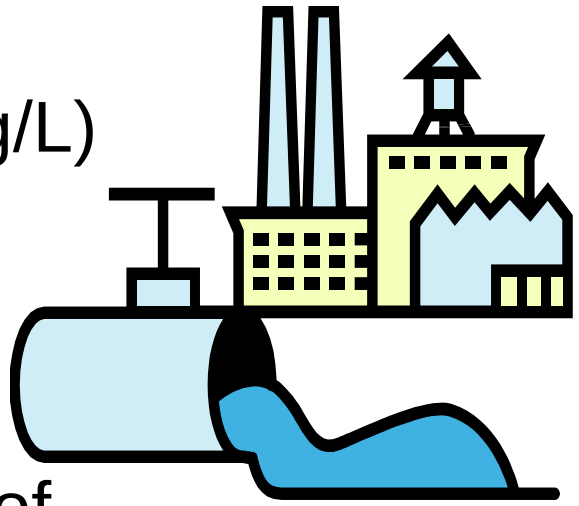
pH

- Its a measure of how acidic (H+) or basic (OH-) a solution is.

Optimal pH for industrial water supplies		
Process	**Minimum**	**pH Range**
Food canning and freezing	7.5	--
Washing clothes	--	6.0-6.8
Rayon manufacturing	--	7.8-8.3
Steel making	--	6.8-7.0
Tanning leather	--	6.0-8.0

Waste Water Quality Indicators

- Biochemical oxygen demand (BOD) (mg/L)
  - amount of oxygen consumed by biological organisms in a body of water
- Chemical oxygen demand (COD) (mg/L)
  - total dissolved organic material
- Suspended Solids (TSS)
  - particles that suspend in a sample of water



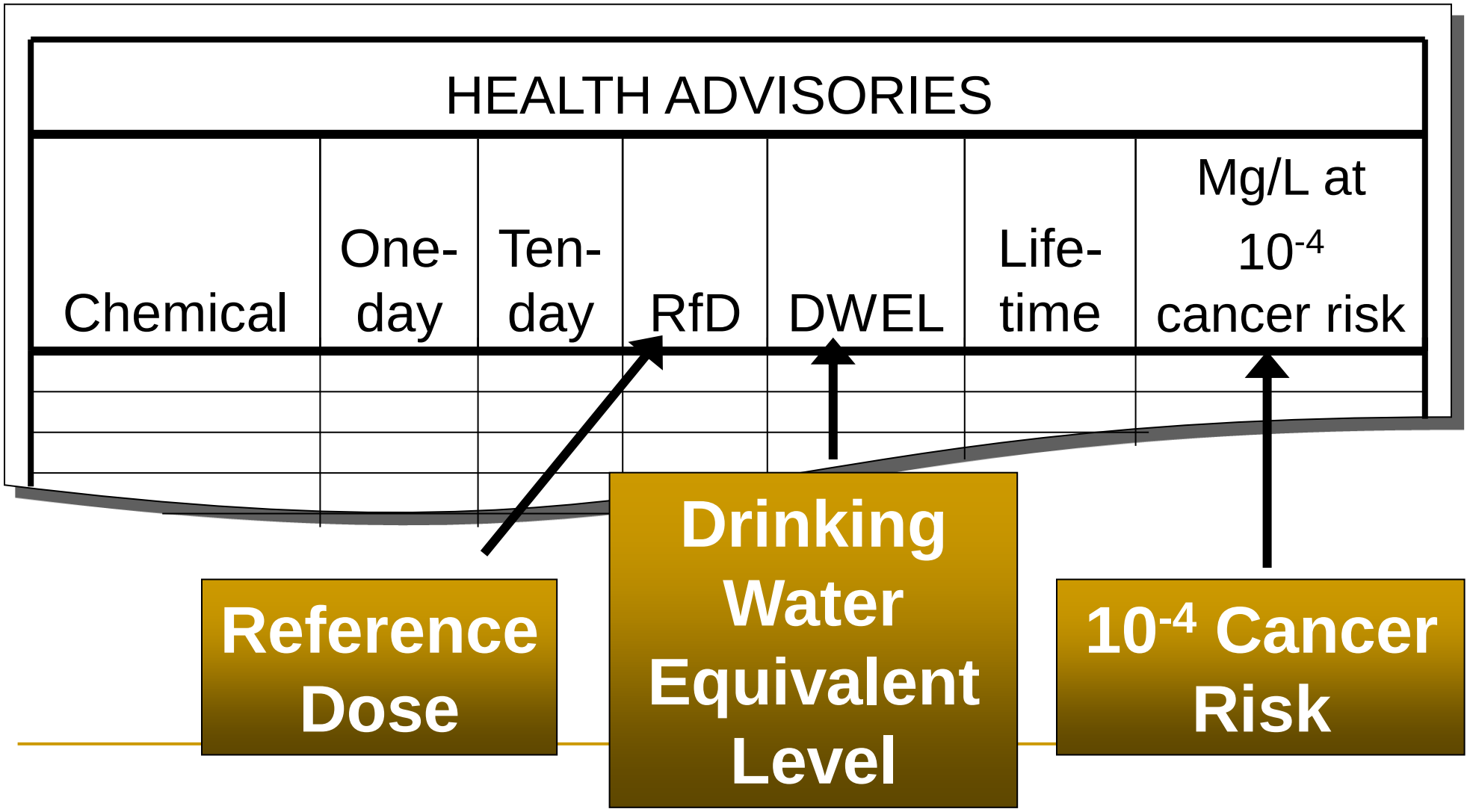
Adverse Effects of Nutrients in Wastewater

- Increased biomass of algae and other plants
- Decreases in water transparency
- Dissolved oxygen depletion
- Increased incidences of fish kills
- Decreases in perceived aesthetic value of the water body
- Taste, odor and water treatment problems

Water Quality & Impact Influencers

- Vulnerability of water source
- Community concerns
- Shareholder concerns
- Employee concerns
- Customer concerns
- Public Health concerns
- Ecosystem Health concerns
- Political concerns

Drinking Water and Health Advisory Summary Tables



Water Standards

- US EPA
  - Stream standards
  - Effluent standards
  - Drinking water standards
- The Clean Water Act. NPDES permits.
- Executive Order 13123:
  Greening the Government Through Efficient Energy Management

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Water Quality

Point Source Pollution: Causes & Treatment

Non-Point Source Pollution: Sources & Management

Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Point Source Pollution

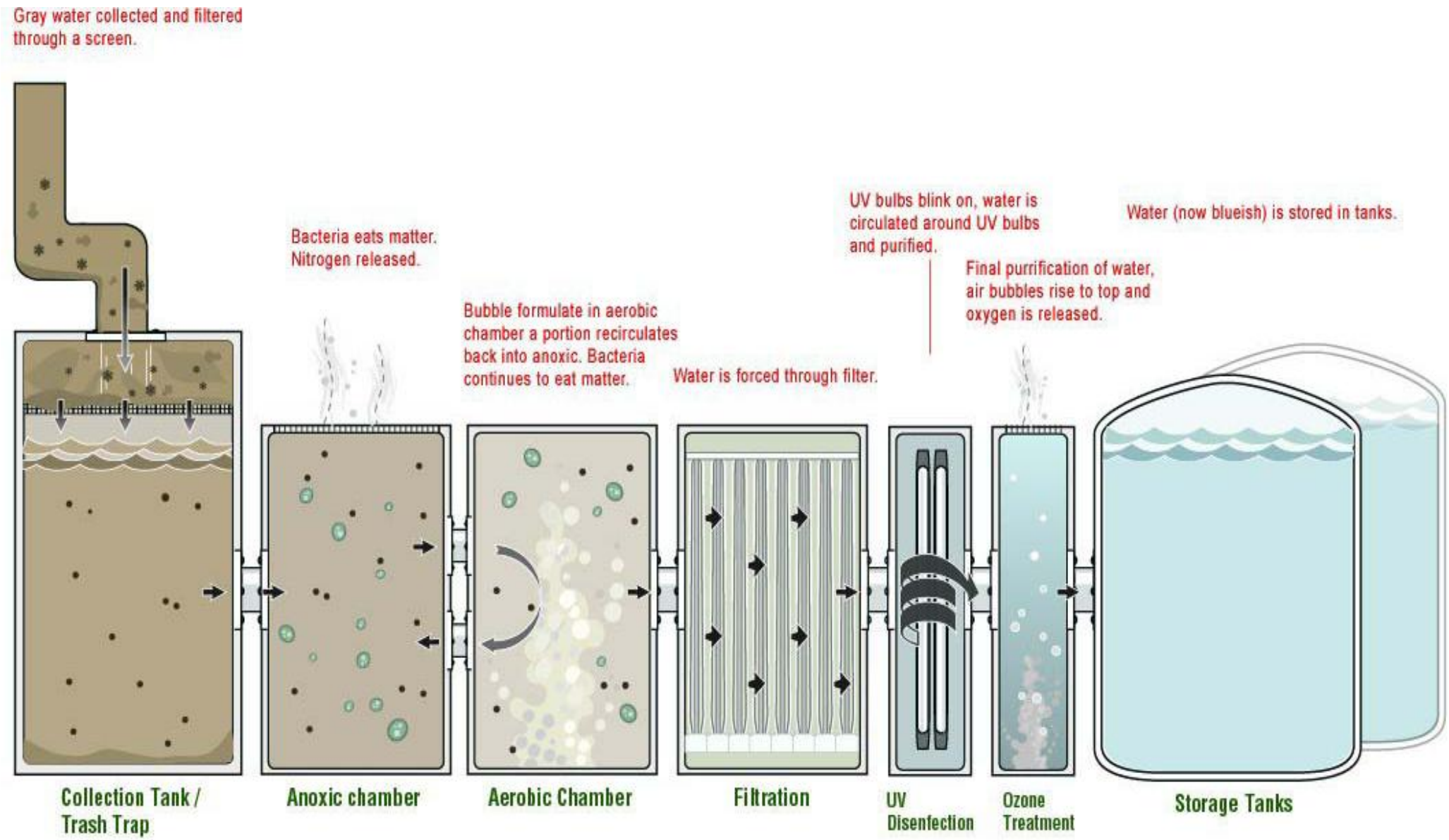
- The U.S. Environmental Protection Agency (EPA) defines point source pollution as “any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack”.
- Factories and sewage treatment plants are two common types of point sources. Factories, including oil refineries, pulp and paper mills, and chemical, electronics and automobile manufacturers, typically discharge one or more pollutants in their discharged waters (called effluents).
- Some factories discharge their effluents directly into a waterbody. Others treat it themselves before it is released, and still others send their wastes to sewage treatment plants for treatment.

What Impacts Water Quality?

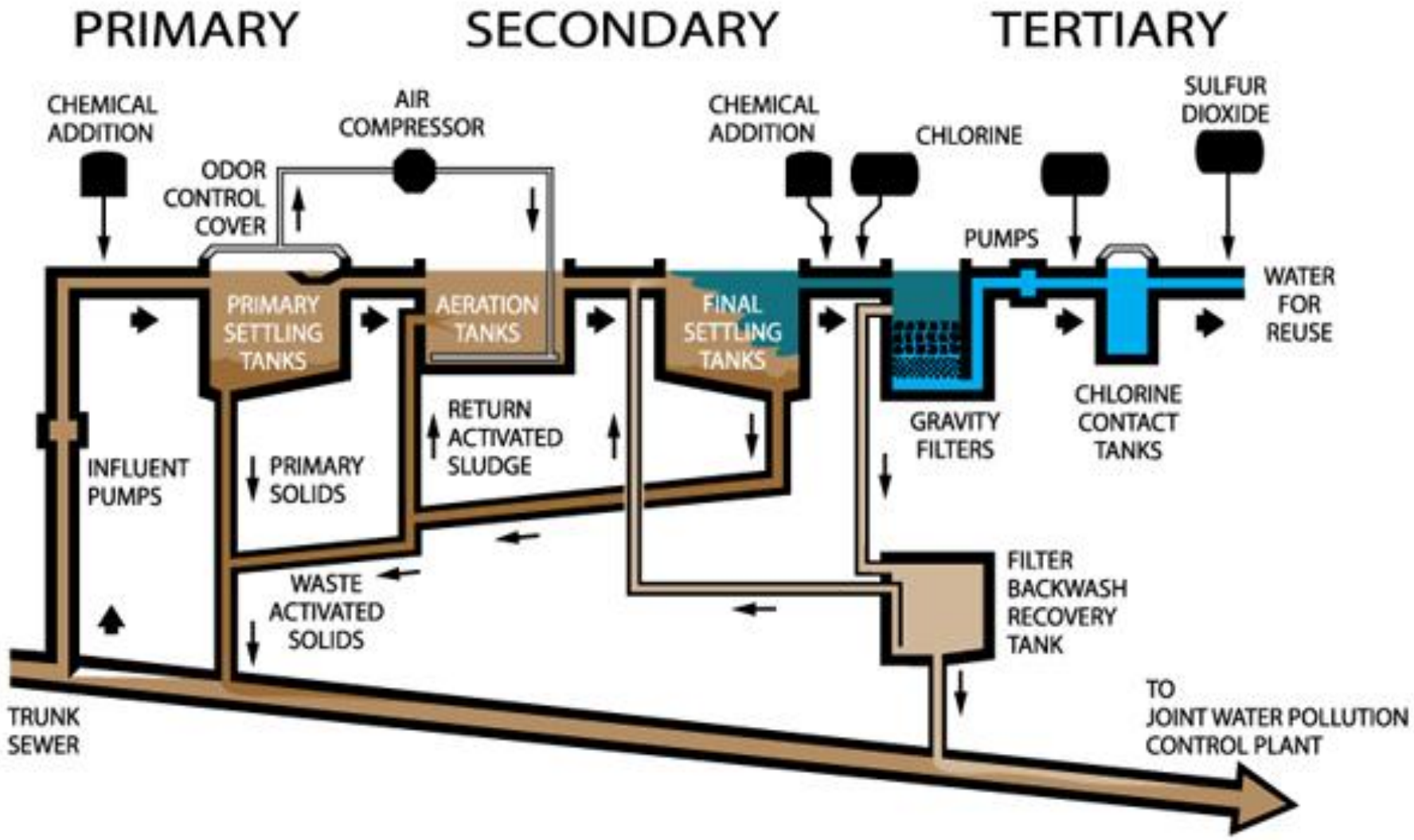
Other Industrial Activities:

- Air deposition into water (e.g., acid rain)
- Potential for spills to surface water
- Leaking tanks and pipes
- Changes to impervious surfaces caused by construction and development

Industrial Treatment - Nonpotable Use



Municipal / Industrial Treatment



Primary Treatment

A clarification step is the first part of conventional treatment for waste and surface water treatment.

Usually consists of:

- Screening - to remove large objects, such as stones or sticks, that could plug lines or block tank inlets.
- Physical chemical treatment - such as a grit chamber to slow down the flow to allow grit to fall out.
- Sedimentation tank - settleable solids sink and are pumped away; oils float to the top and are skimmed off.

Secondary Treatment

Utilizes biological treatment processes where microorganisms convert non-settleable to settleable solids.

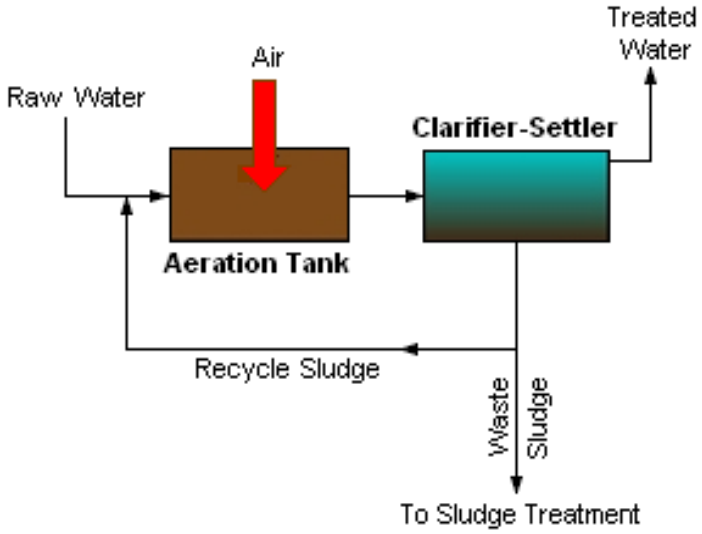
Typically followed by sedimentation so settleable solids sink.

Common options include:

- Activated Sludge
- Trickling Filters
- Lagoons

Secondary Treatment
Activated Sludge

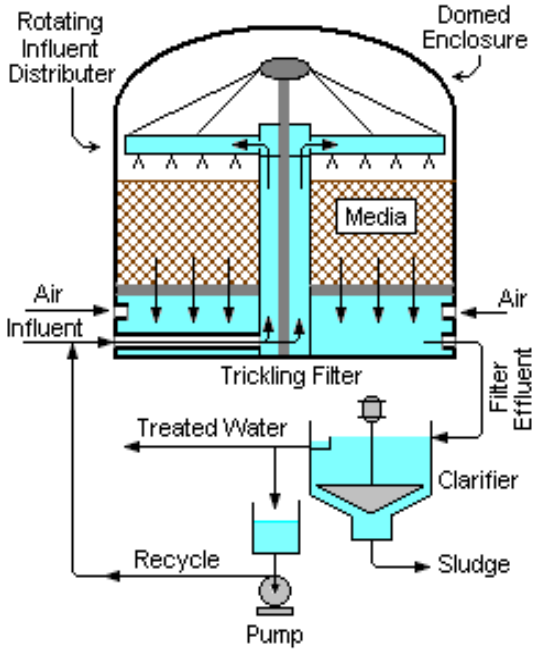
- Uses microorganisms to break down organic material with aeration and agitation.
- Bacteria-containing “activated sludge” is continually recirculated back to the aeration basin to increase the rate of organic decomposition.





Secondary Treatment Trickling Filters

- Beds of coarse media (often stones or plastic) 3-10 ft. deep.
- Wastewater is sprayed into the air (aeration), then allowed to trickle through the media.
- Microorganisms, attached to and growing on the media, break down organic material in the wastewater.
- Trickling filters drain at the bottom; the wastewater is collected and then undergoes sedimentation.

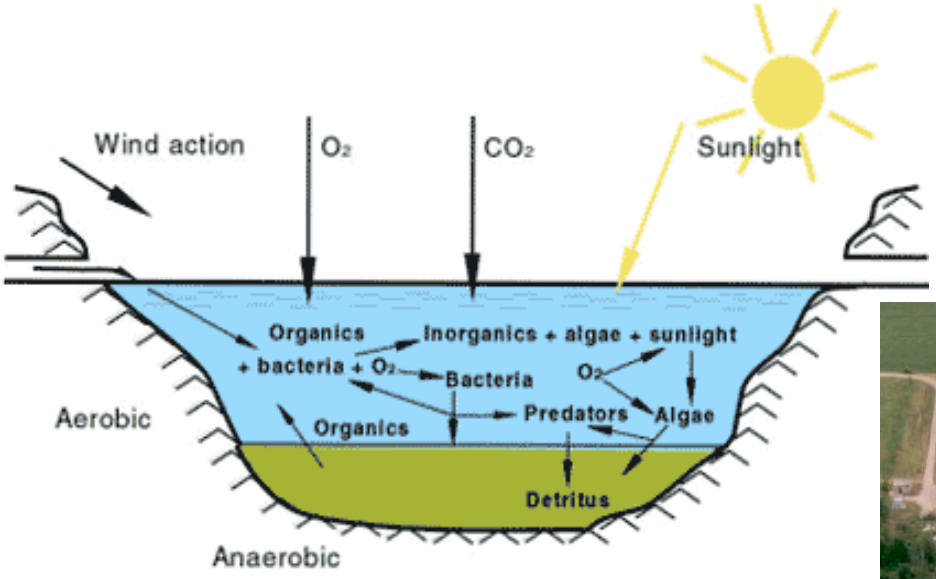




Secondary Treatment

Lagoons

- These are slow, cheap, and relatively inefficient, but can be used for various types of wastewater.
- They rely on the interaction of sunlight, algae, microorganisms, and oxygen (sometimes aerated).



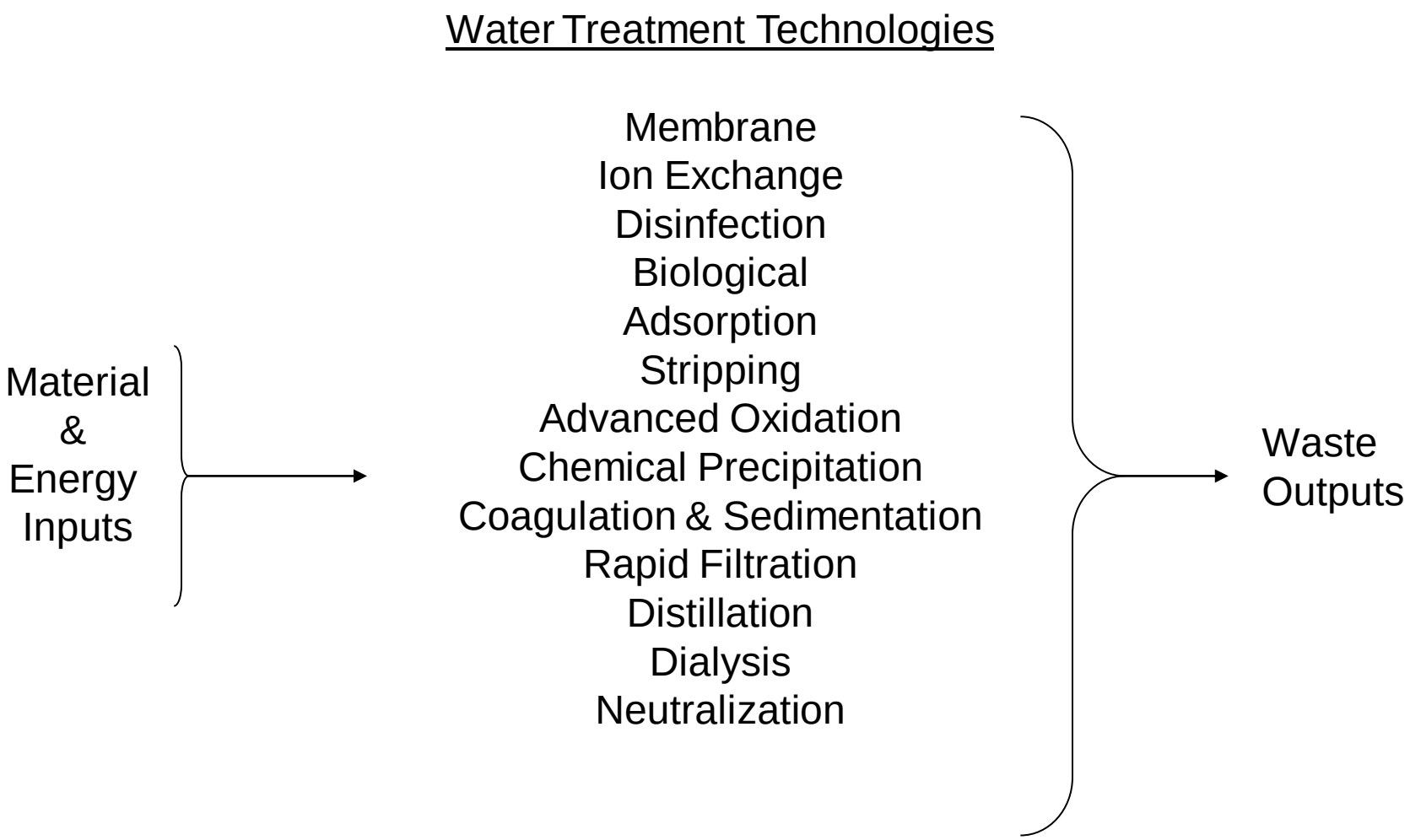


Tertiary Treatment

- Subject to a regulatory requirements that each industry sector has to follow, as well as the final characteristics of their effluent.
- May include processes to remove nutrients such as nitrogen and phosphorus, and carbon adsorption to remove chemicals.



Lifecycle Assessment



Course Agenda

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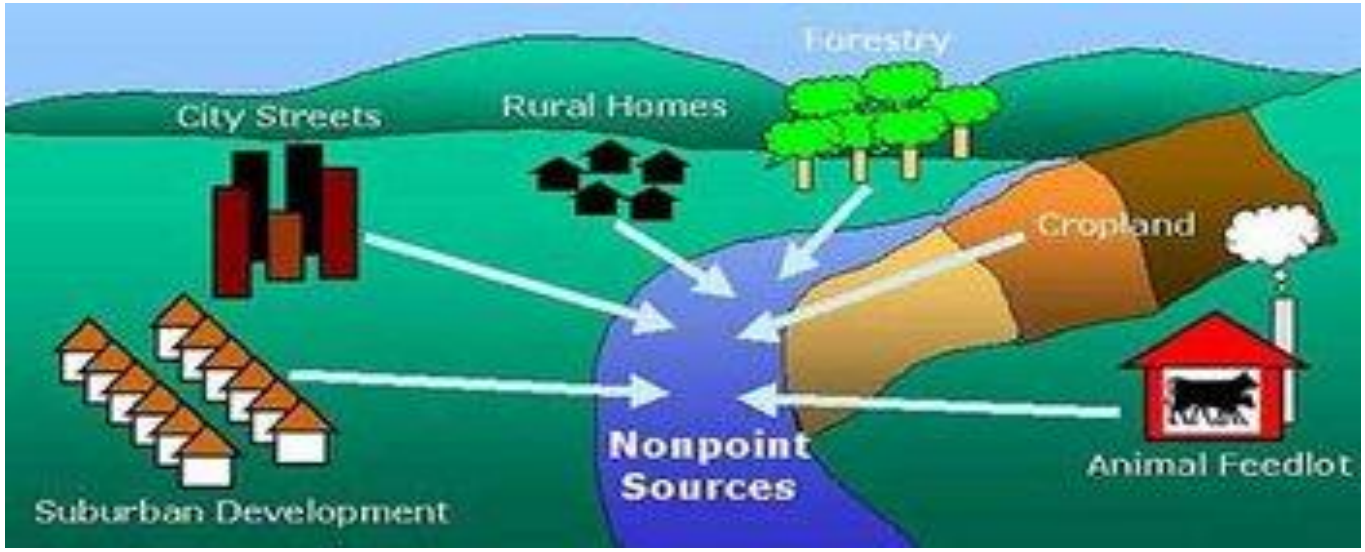
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Non-Point Source Pollution

Forestry activities including tree and vegetation removal, especially along stream and river beds, and road construction.

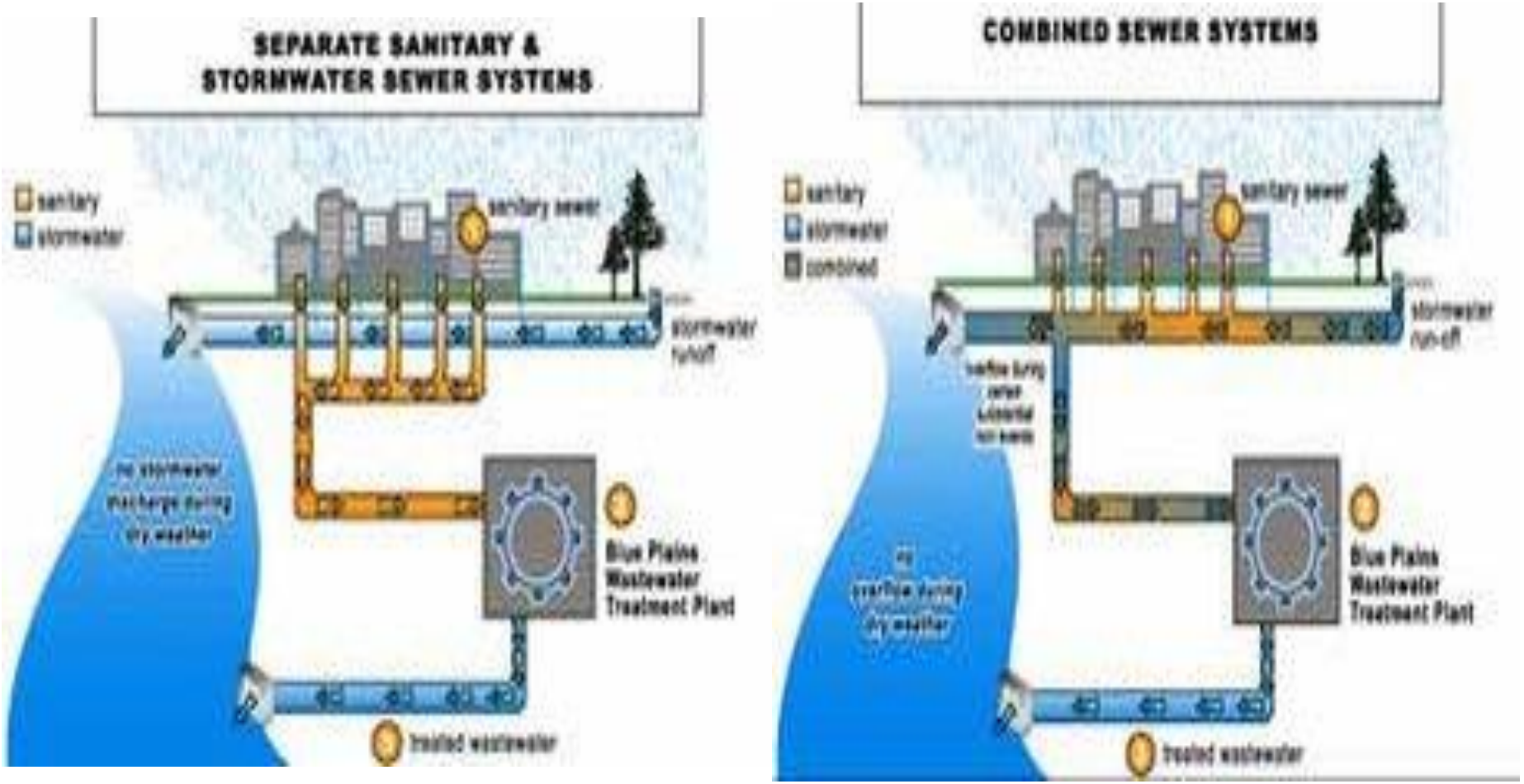


Oil, grease, and toxic chemicals from urban runoff and energy production.

Excess fertilizers, herbicides, insecticides, and animal wastes from agricultural lands and residential areas.

Sewer Systems

Separate vs. Combined



Urban Runoff Challenges

- Traditional urban run-off management techniques are band-aid solutions that try to solve a problem that should not exist.
- Traditional retentions ponds and urban run-off treatment are bad for environmental quality and corporate liability.

Strategies for Urban Runoff

- Buildings: install Green Roofs (vegetated roof covers). Green Roofs retain water and virtually eliminate run-off. Green roofs conserve significant amounts of energy by reducing heating & cooling costs. Green roofs protect the underlying waterproofing layer and extend roof life.

- Parking Lots: install pervious pavement. Pervious pavement allows precipitation to infiltrate into the ground rather than run-off. Water infiltration is a natural process for attenuating pollution and recharges ground water aquifers.

- Site Development: During building construction, retain as much of the native topsoil in place as possible. Require construction contractors to excavate & grade only the minimal building and parking lot footprint rather than grading the entire site down to hard pan. The “standard” practice of removing all topsoil on a construction site drastically exacerbates water run-off problems in the future.

Economic Affects of Urban Runoff

- Mass die-offs of fish and dirty-looking water affect the beauty and health of coastal lands and waters.
- If the physical and environmental well-being of these areas is diminished, people will naturally find it less appealing to visit the waterways.
- Reduced tourists' contributions, as well as decreasing waterfront property values can impact the economic status of waterway community's.

Sustainable Drainage Systems (SUDS)

- Swales are grassland depressions, which lead water overland from the drained surface to a storage or discharge system.
- Balancing Ponds are designed to retain flood events, reducing peak flows and limiting the risk of flooding.
- Porous Pavements is an alternative to conventional paving in which water permeates through the paved structure rather than draining off it.









SUDS Site Suitability

	Residential	Commercial / Industrial	High Density	Retrofit	Contaminated site
Green Roofs	Yes	Yes	Yes	Yes	Yes
Rainwater Harvesting	Yes	Yes	Yes	Yes	Yes
Permeable Pavements	Yes	Yes	Yes	Yes	Yes
Infiltration Trenches	Yes	Yes	Yes	Yes	No
Filtration Drains	Yes	Yes	Yes	Yes	Yes
Swales	Yes	Yes	No	Yes	Yes
Basins	Yes	Yes	No	Yes	Yes

Advantages of SUDS

- Manage runoff flow rates;
- Reduce the impact of flooding from urbanization;
- Protect or enhance water quality;
- Provide a habitat for wildlife in urban watercourses; and
- Encourage natural groundwater recharge, where appropriate.

Course Agenda

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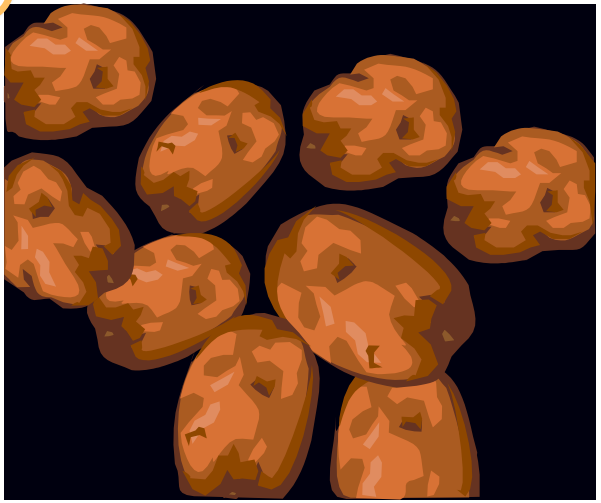
Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Simulation Round 3
HydroSonic Potato Spuds

HydroSonic



Potato Spuds

What changes should we consider for improving the water and energy efficiency at HydroSonic?

How can we implement these changes?

Lessons Learned

- What was the outcome of the potato production processes? Report out all measurements.
- What do these measurements tell us?
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Non-Point Source Pollution: Sources & Management

Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

Water Program – Utility Component

- Include water supply and wastewater utility costs and approaches in the analysis.
- Anticipate increased water and wastewater service costs when considering options.
  - Ask utilities to provide any expected increases.
  - Anticipate future increases in production or number of employees that will influence water consumption.
- Encourage water and wastewater utilities to provide rebates and other financial incentives to offset the cost of implementing a water conservation measure.
  - Use efficiency/conservation plan as a bargaining point.

Water Program – Total Costs

Use total cost accounting methods to perform economic comparison of water efficient techniques. Consider:

- water and wastewater costs;
- on-site pretreatment costs;
- marginal cost for capacity expansion; and
- energy savings (especially heat).

Water Program Considerations

- Program goals should not only consider the technical side for water efficiency, but also should consider the human side, such as changing behaviors and attitudes toward water use.
- Do the simple tasks first to gain acceptance and positive feedback for the program.

Course Agenda

Sustainable Water Management

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Simulation – Round 3

Measuring Water Use / Waste

Course Evaluation

TECHNICAL ASSISTANCE PROGRAM

Green Enterprise Development

LEVEL 2
Green Specialist Certificate Series

Join us for the H_2O Conserve Workshop!

Learn the principles and practices used in the operation and design of water systems.

One-Day Workshop • Appropriate for engineers, green team participants and environmental managers

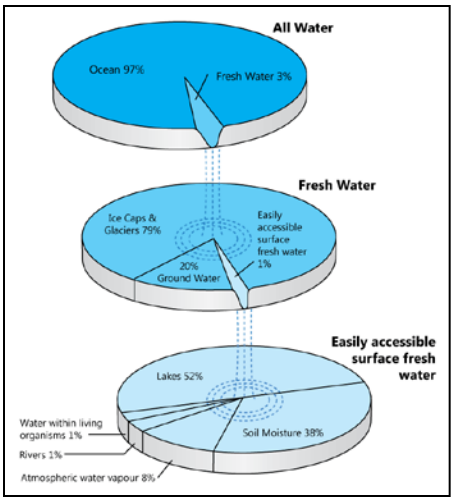
The Green Specialist: H_2O Conserve Workshop was designed by Purdue's Technical Assistance Program for manufacturers and others interested in learning the principles and practices used in the operation and design of water systems. Expect a fun, fast-paced workshop with simulations and case studies for in-depth instruction in applying green concepts and techniques.

Participants will learn:

- The design of water systems
- The principles and practices used in the operation of water systems
- How to identify alternative methods
- How to reduce costs and conserve an endangered resource
- Water Pollution Prevention, Reduction & Treatment



Fresh Water is a finite resource.



Green Enterprise Development

Visit www.tap.purdue.edu/green to learn how to take the green movement to the next level.



How We Can Work With You: In addition to Green Enterprise Development, Purdue's Technical Assistance Program offers on-site public workshops and provides implementation and consulting services.

For workshop dates or to register: Visit www.tap.purdue.edu/green under "Register for Events." Cost is $395/per person.

For more information: Contact Abbey Maddy via phone at (800) 877-5182 ext. 620 or email amaddy@purdue.edu.

Black & Gold & Green Enterprise Development

Technical Assistance Program
6640 Intech Blvd., Suite 120
Indianapolis, IN 46278-2012
(800) 877-5182 or (317) 275-6810 Fax (317) 275-2375
www.tap.purdue.edu/green

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TECHNICAL ASSISTANCE PROGRAM

Pollution Solutions



Air Emissions and Climate Impact

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Purpose of This Module

- To provide an understanding of climate challenges related to air emissions.
- To identify methods that can be implemented to reduce use of substances or processes that generate emissions into the air.
- To improve the air quality within facilities and sent into the atmosphere through industrial emissions.
- To provide strategies for incorporating effective air emissions management concepts into a Green Enterprise.

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

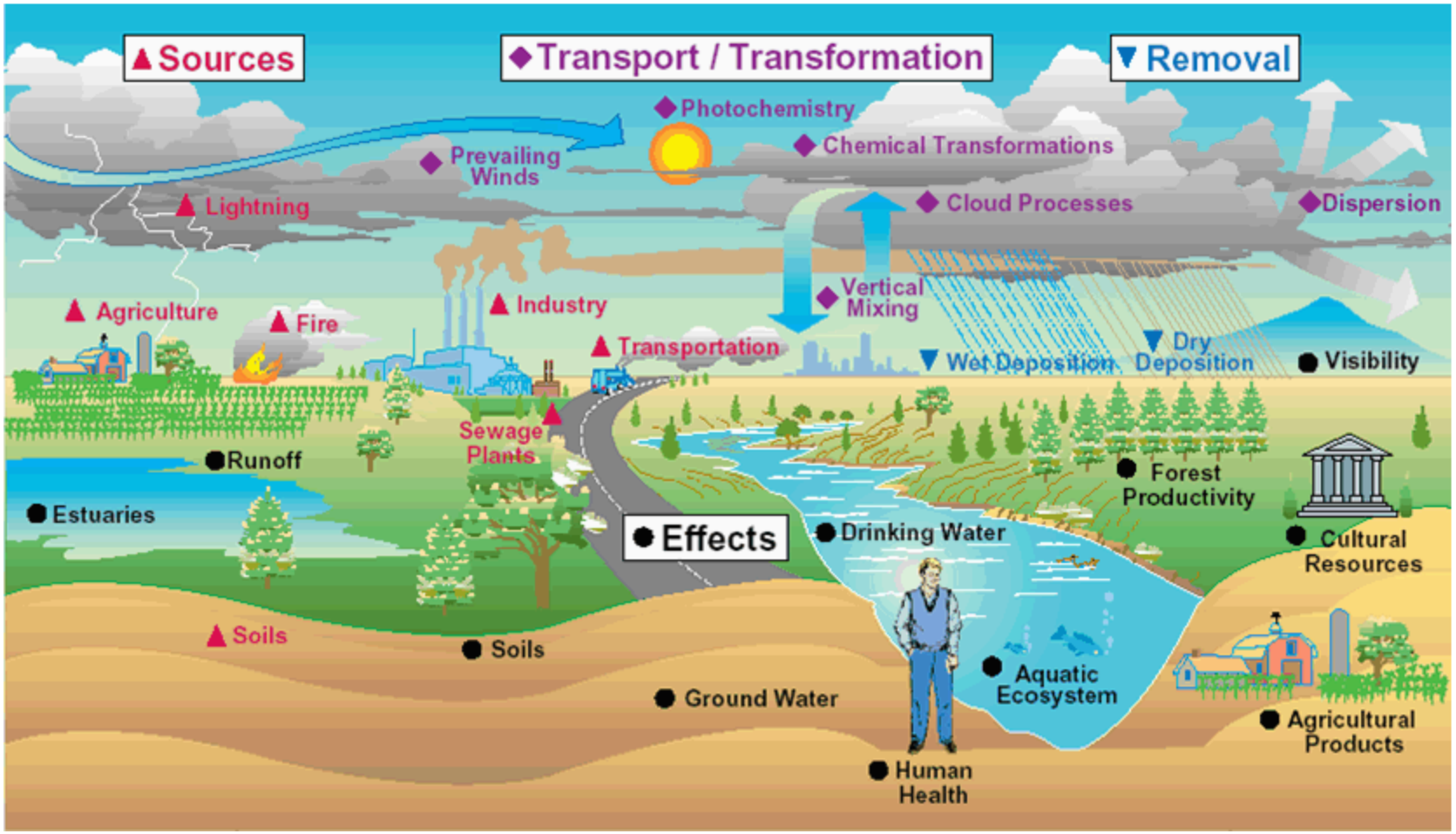
Simulation – Round 3

Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

Air Pollution



Source: www.epa.gov

Why Air Pollution Concerns You

- Breathing polluted air can make you ill.
- Air pollution damages trees, crops, plants, waterways and animals.
- Can damage buildings, monuments, and other structures.
- Reduces visibility levels and interferes with aviation safety.

	MAJOR SOURCES	HEALTH EFFECTS	ENVIRONMENTAL EFFECTS
SO_2	Industry	Respiratory and cardiovascular illness	Precursor to acid rain, which damages lakes, rivers, and trees; damage to cultural relics
NO_x	Vehicles; industry	Respiratory and cardiovascular illness	Nitrogen deposition leading to over-fertilization and eutrophication
PM	Vehicles; industry	Particles penetrate deep into lungs and can enter bloodstream	Visibility
CO	Vehicles	Headaches and fatigue, especially in people with weak cardiovascular health	
Lead	Vehicles (burning leaded gasoline)	Accumulates in bloodstream over time; damages nervous system	Fish/animal kills
Ozone	Formed from reaction of NO_x and VOCs	Respiratory illness	Reduced crop production and forest growth; smog precursor
VOCs	Vehicles; industrial processes	Eye and skin irritation; nausea; headaches; carcinogenic	Smog precursor

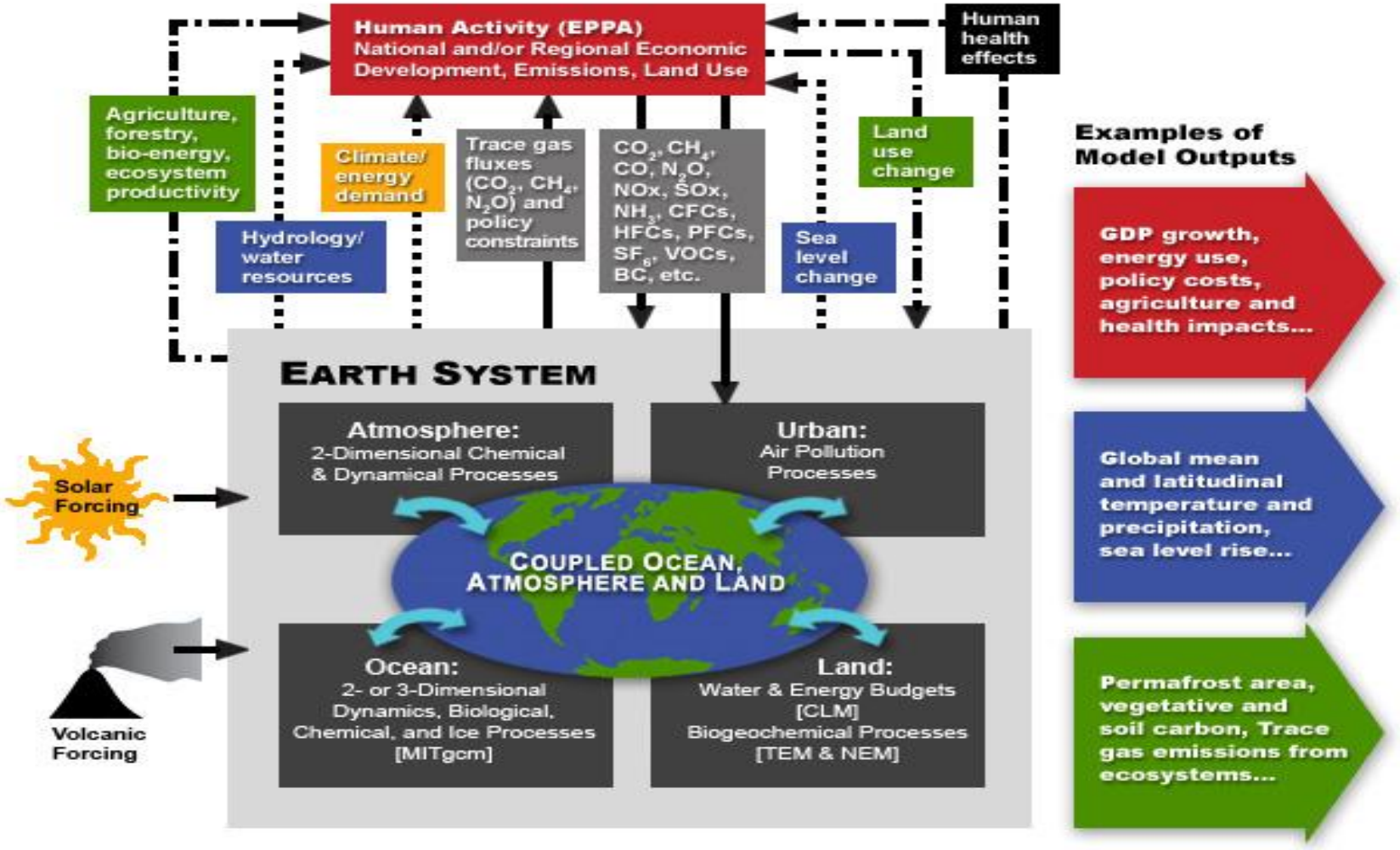
Source: World Research Institute

Health Concerns



- Burning of eyes and nose, cataracts;
- Irritation of your throat and breathing difficulties;
- Respiratory problems;
- Aggravation of heart or respiratory diseases;
- Sunburn, skin cancer;
- Birth defects, brain and nerve damage

Impact Modeling Factors



Economic Impacts of Air Pollution

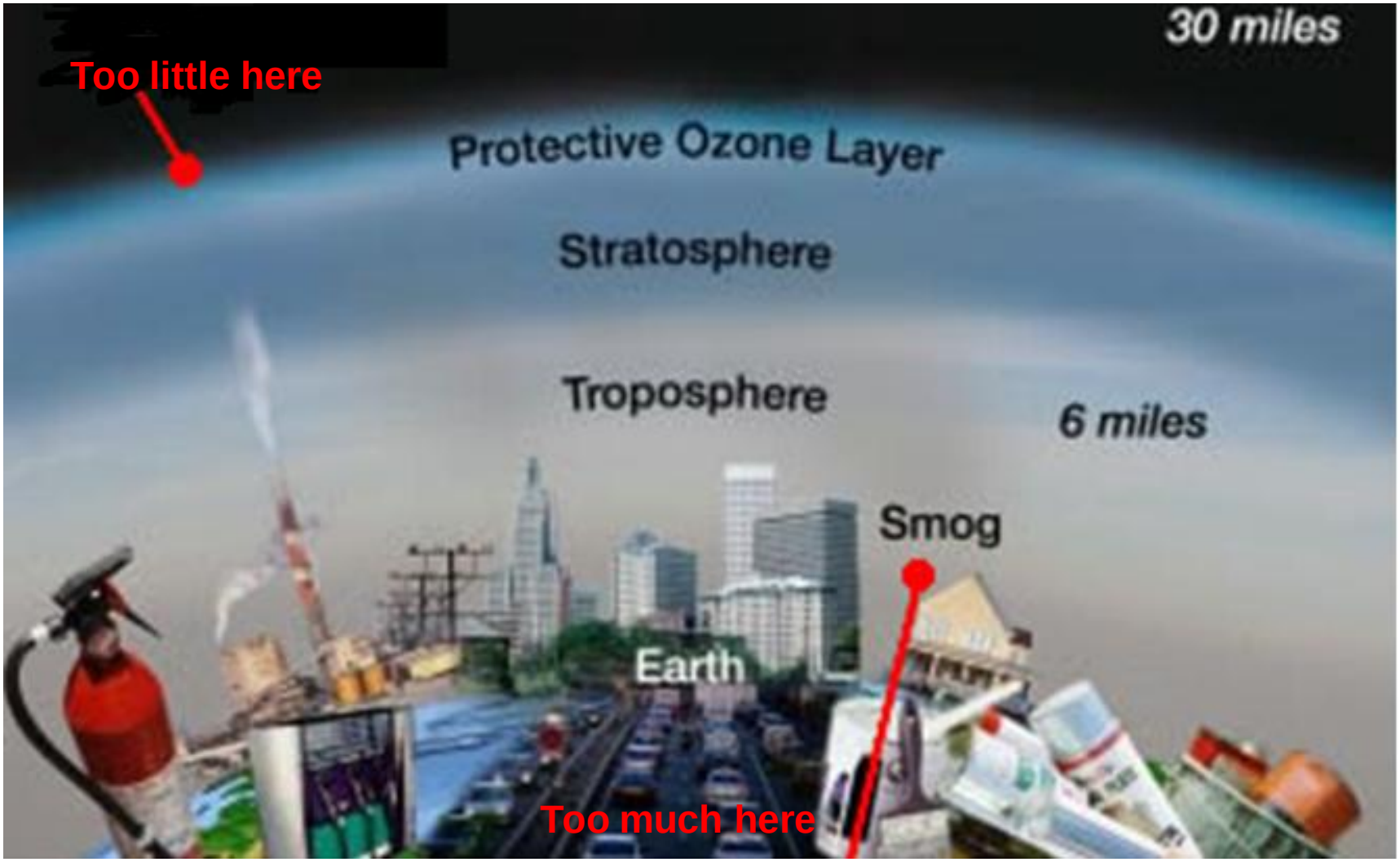
- Illnesses lead to lost days at work and school.
- Agricultural crop and commercial forest yield reductions impact billions of dollars each year.

Ozone

- Stratospheric or “good” ozone absorbs 93-99% of the sun’s high frequency UV light which is potentially damaging to life on Earth.

- Ground-level ozone is formed when two types of pollutants react in the presence of sunlight.

Ozone Layers



Effects of Ozone Depletion

Increased amounts of UV radiation reach Earth.

- Can lead to more cases of skin cancer, cataracts, and weakened immune systems.
- Damages sensitive crops, such as soybeans; reduce crop yields; and harms marine organisms.

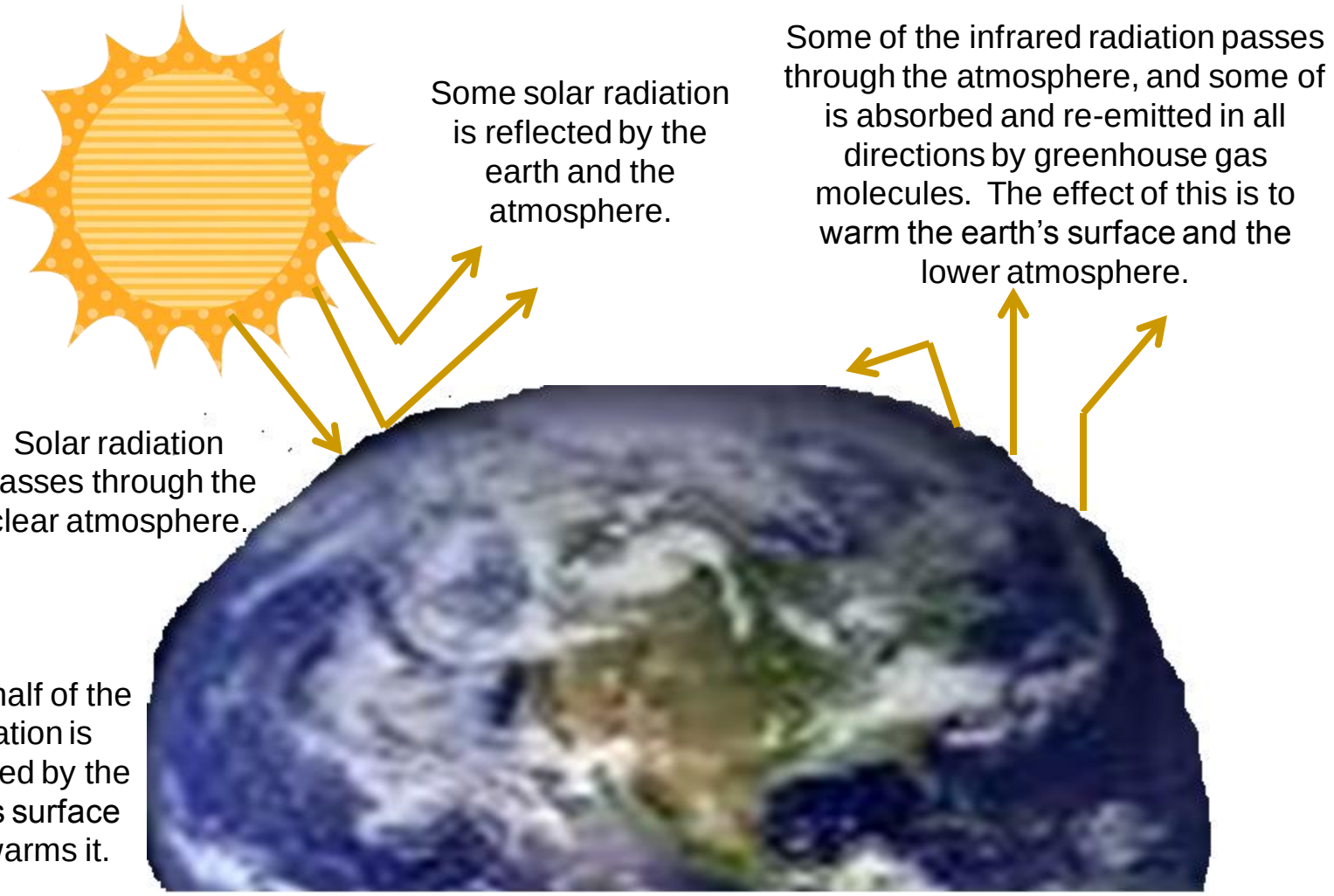
Ground-level Ozone



Found in emissions from:

- Vehicles, construction equipment, lawn and garden equipment ;
- Small industries such as gas stations;
- Industrial/consumer products such as paints and cleaners.

The Greenhouse Effect



U.S. EPA Model

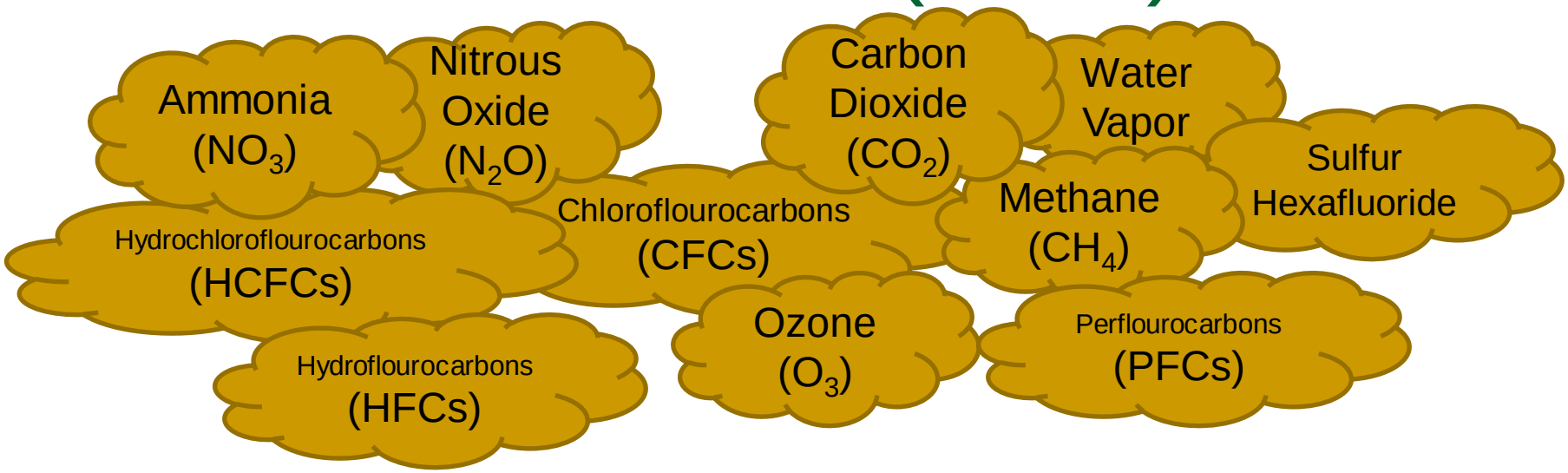
Climate Change





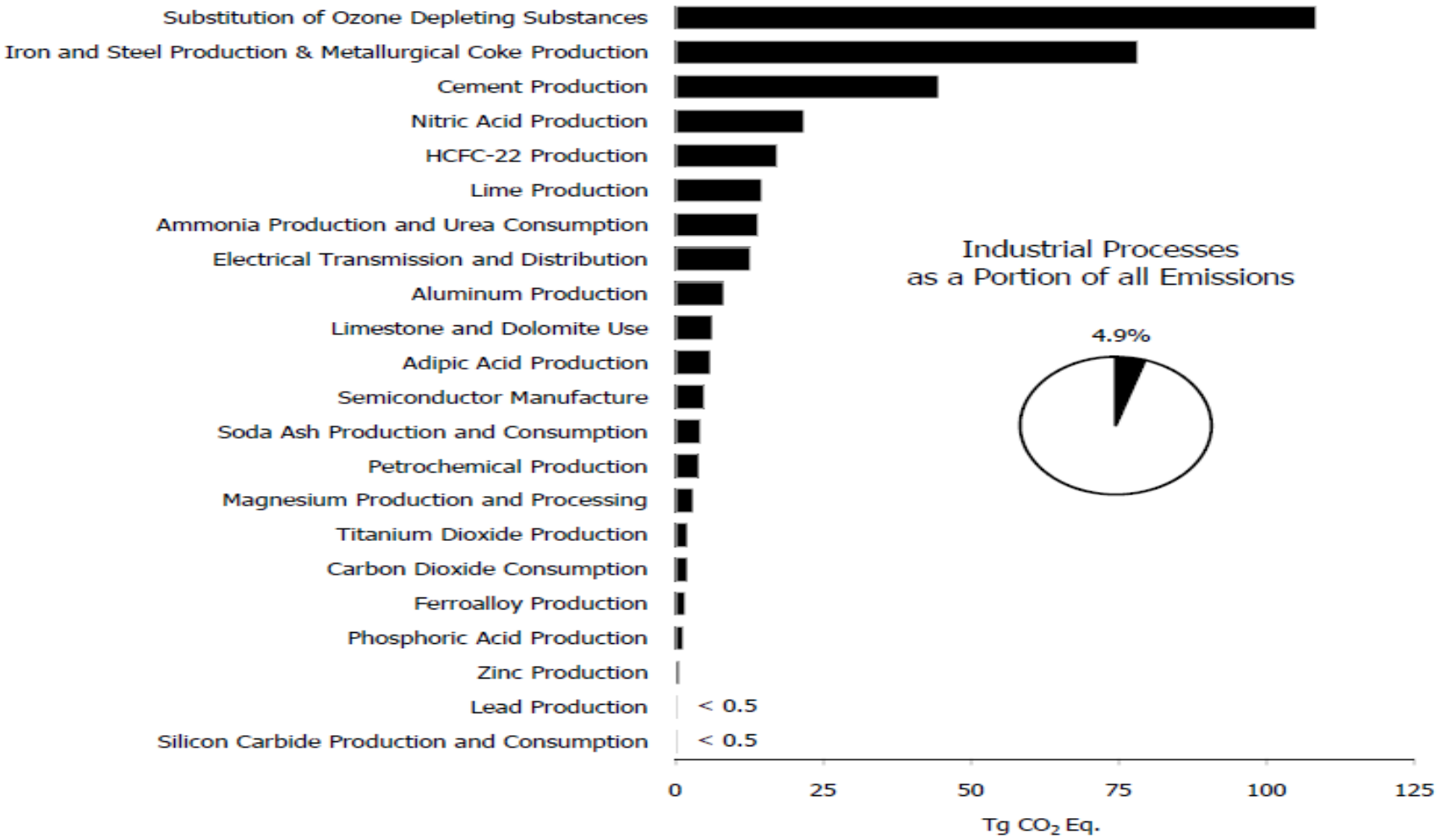
May occur as a result of increased emissions of greenhouse gases from both natural and human induced processes.

Greenhouse Gases (GHG)



Atmospheric problems	SO_2	NOx	NH_3	VOC	CO	CH_4
Photochemical smog		+		+	+	+
Winter smog	+					
Acidification	+	+	+		+	
Eutrophication		+	+			
Climate change		+		+	+	+

Industrial Process GHG Emissions



Volatile Organic Compounds (VOCs)

Any organic compound that is evaporating or vaporizing readily under normal conditions.

VOCs are useful as:

- fuels
- solvents
- scents
- propellants
- refrigerants
- drugs
- pesticides

Volatile Organic Compounds (VOCs)

- Total VOCs (TVOC) is the concentration of all VOCs in a given sample where there may be several different VOCs present.

- A VOC number, VOC rating, or VOC content expresses the amount of volatile material in a sample, either in pounds per gallon, grams per liter or as a percentage by mass.

Hazardous Air Pollutants (HAPs)

- Chemicals which can cause adverse effects to human health or the environment.
- High concentrations of HAPs are primarily due to pollution sources like trucks or small businesses that have not had the same regulatory scrutiny as large industrial facilities.
- Very small number of chemicals and chemical categories appear to account for the majority of health risks associated with HAPs, e.g., diesel emissions from vehicles and equipment.

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

Simulation – Round 3

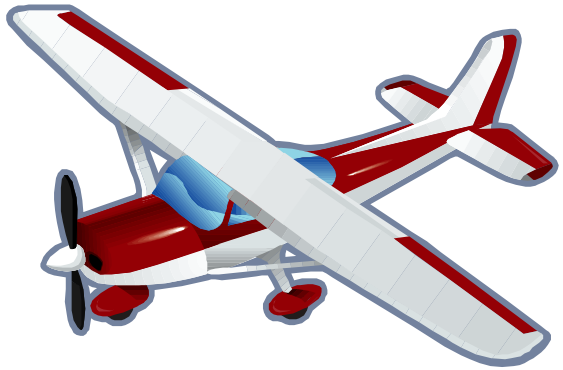
Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

Simulation Round 1

Innovative



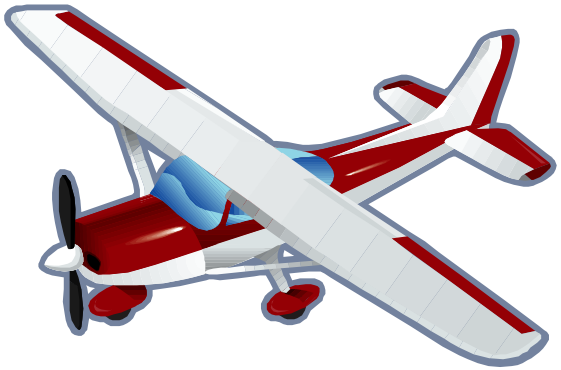
Aero Solutions

Innovation Aero Solutions, a light aircraft manufacturer, is aware of some of the effects that air emissions have on the visibility for the pilots of their aircraft.

Innovative Aero recognizes that some of their manufacturing practices may be contributing to this problem, even if only in a small way.

Simulation Round 1

Innovative



Aero Solutions

To best understand their challenges, we're going to fill in for some of the roles in their operations and get a first-hand look at how things currently work.

Roles:

- Cutting
- Sanding
- Grinding
- Painting
- Bonding
- Quality
- Maintenance

Lessons Learned

- What was the outcome of the airplane production process? Report out all measurements.
- What do these measurements tell us?
- What were some of the challenges you encountered?

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

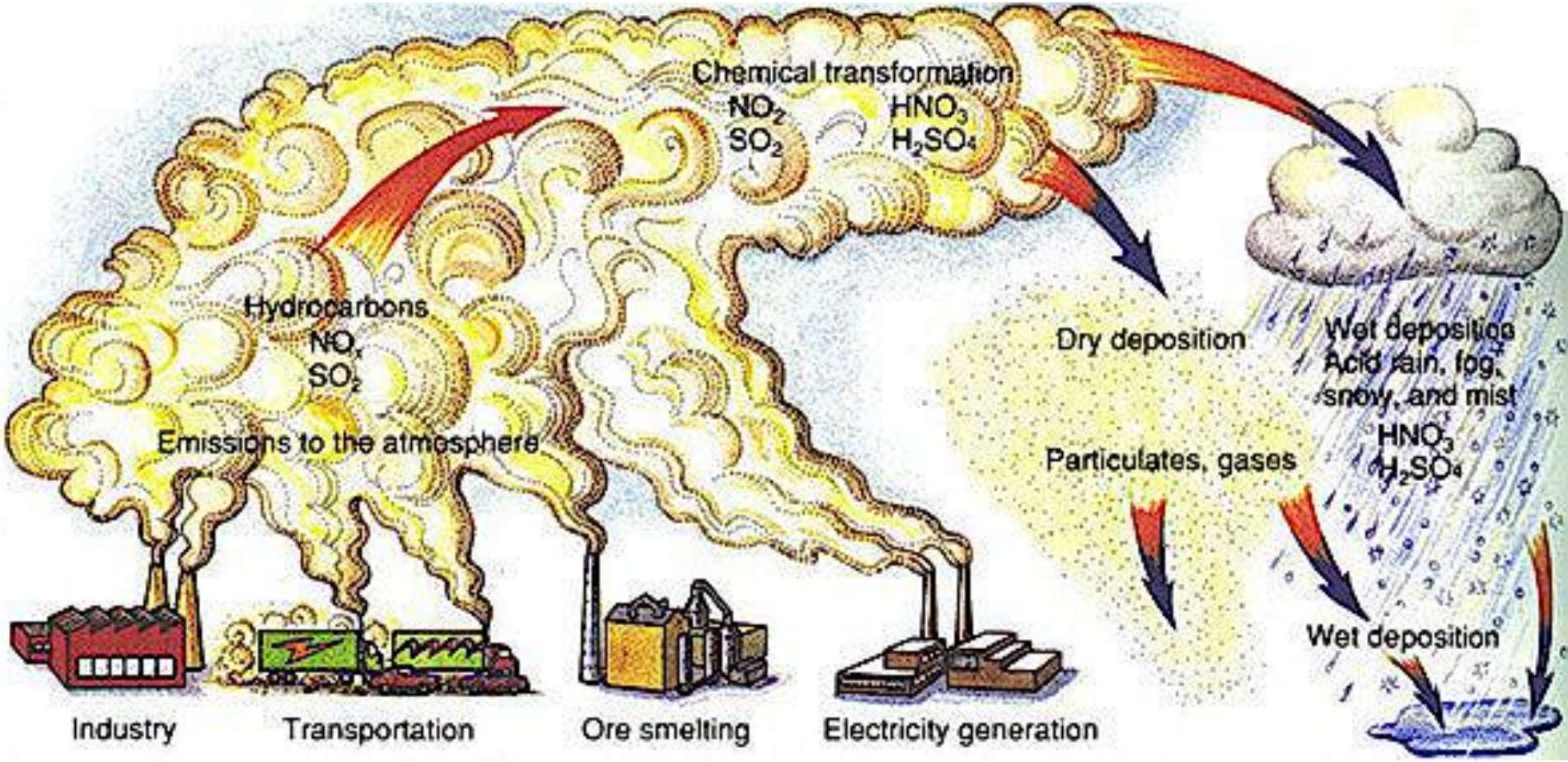
Simulation – Round 3

Air / Noise Sampling & Control

Measuring Emissions

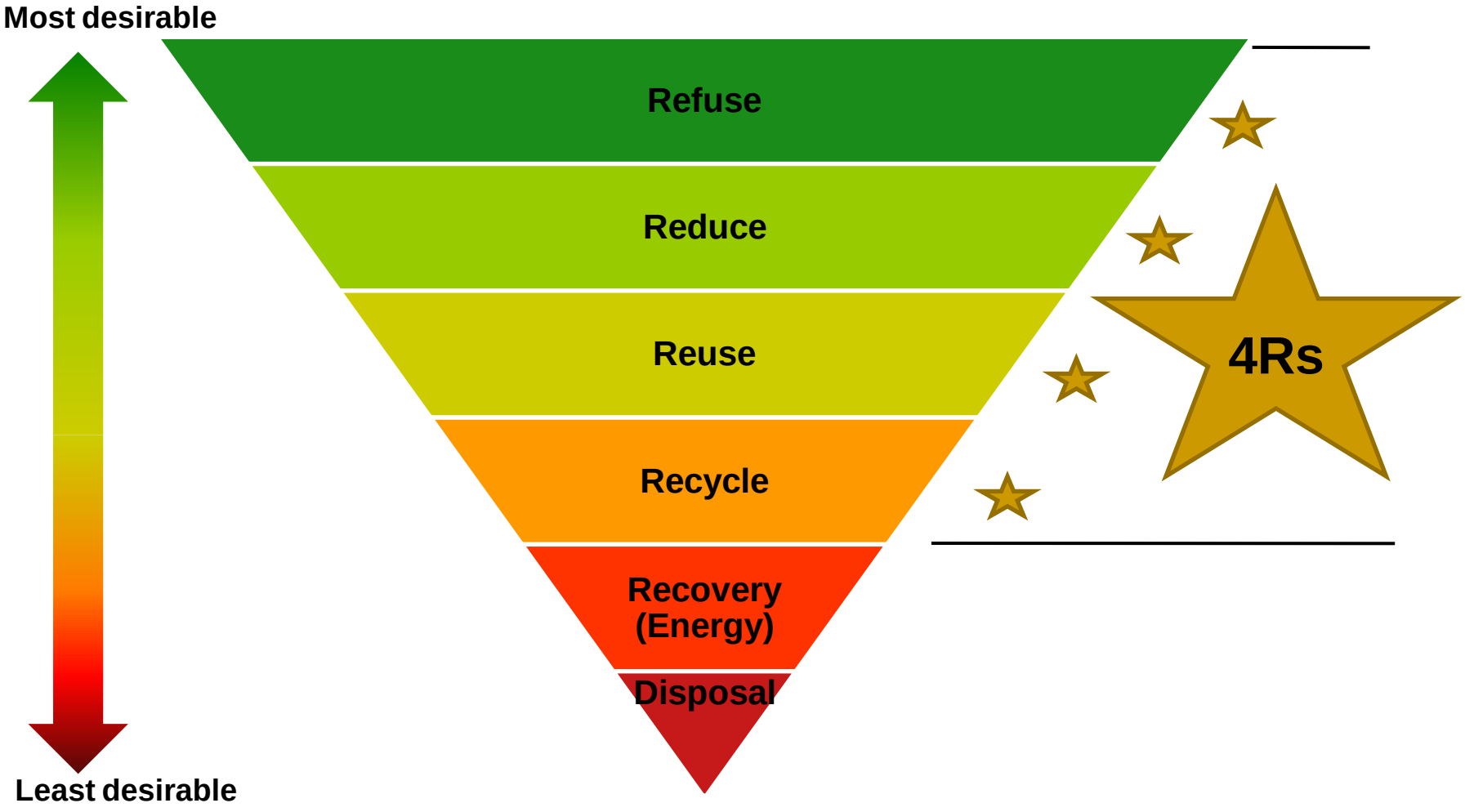
Course Evaluation

Air Pollution



Source:
www.pages.drexel.edu

Waste Hierarchy



Classifications

- Physical
- Chemical
- Thermal
- Biological
- Solidification/Stabilization



Common Air Pollutants

- Volatile organic compounds (VOCs)
- Particulate matter
- Acid gases
- Miscellaneous chemicals including metals and radionuclides

Air Pollution Prevention

- Focus on both *source* of the air emissions and toxicity *reduction*.
- Indirect pollution prevention measures covers the entire product lifecycle, including *transportation*.

Clean Air Act (CAA)

Authorizes U.S. EPA to establish National Ambient Air Quality Standards to protect public health and welfare, and regulate emissions of hazardous air pollutants by:

- Reducing outdoor, or ambient, concentrations of pollutants that cause smog, haze, acid rain, etc.;
- Reducing emissions of toxic pollutants that cause cancer or other serious health effects;
- Phase out production and use of chemicals that destroy stratospheric ozone.

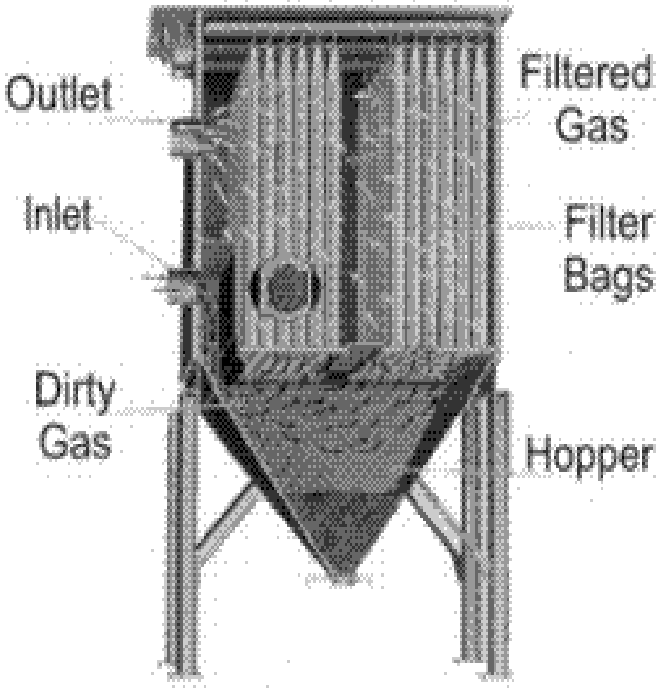
Emissions Reduction Technologies

- Filters
- Scrubbers
- Centrifugal separators
- Electrostatic precipitators
- Incineration
- Condensation
- Adsorption



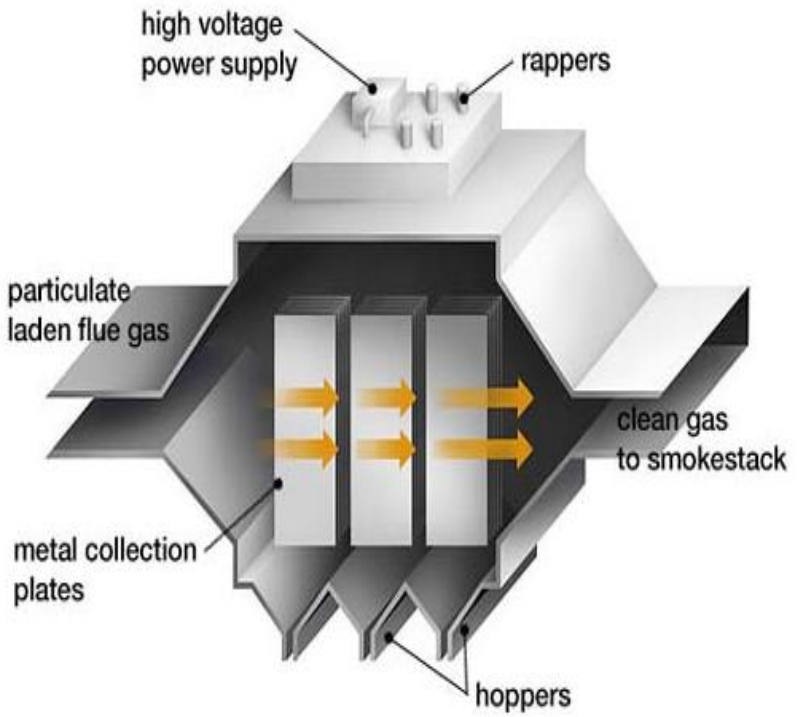
Fabric Filters

- Dust passes through a fabric bag and collects in the bag or filter. Once a cake of dust is formed, further collection is achieved by retention on the cloth fibers.
- The air to cloth ratio is an important design parameter with the optimum ratio dependent upon the particle type.
- If the particle is greater than a micron, it is possible to get efficiencies of 99+%, as long as there are no holes in the fabric.



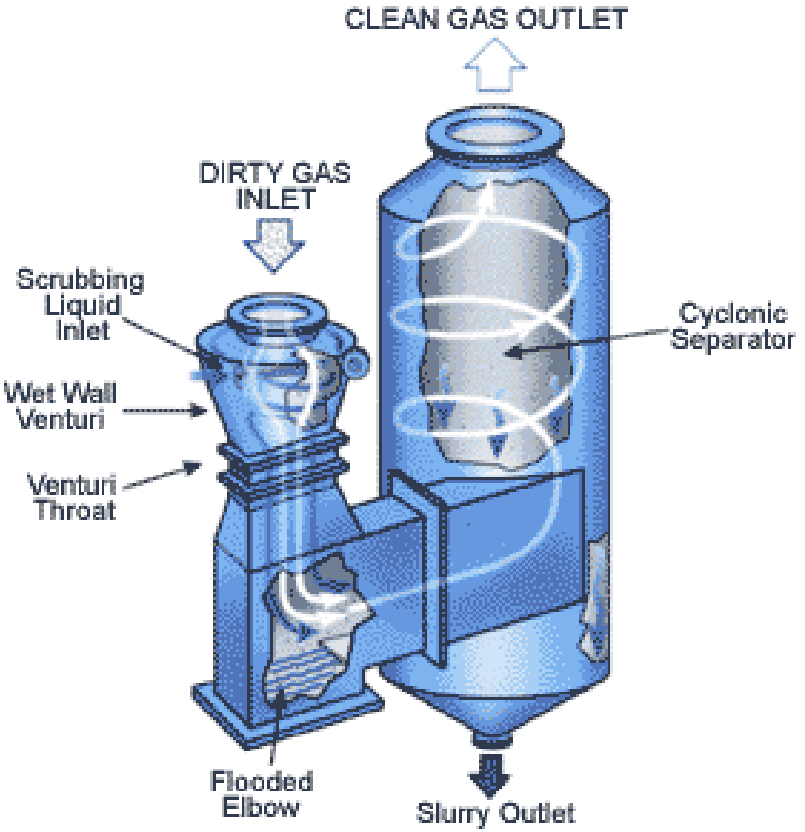
Electrostatic Precipitators

- Delivers a high voltage across the contaminated gas flowing through the device. Particles become negatively charged and move towards collection plates.
- Removes particles greater than one micron to efficiencies of 99+%.



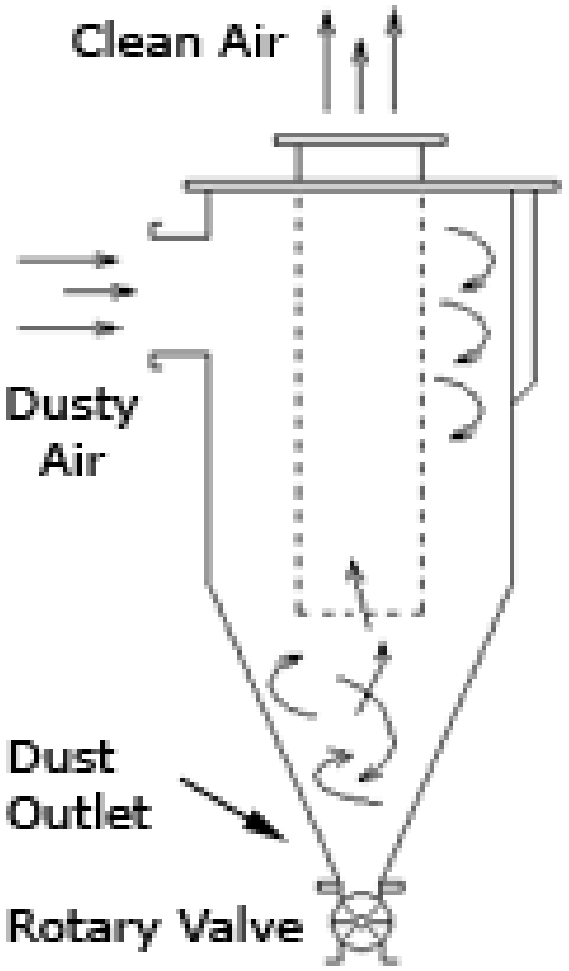
Scrubber

- Wet collector captures particulates by contact of the solids with water droplets.
- Gaseous pollutants can also be transferred to a liquid through the operation of a scrubber.
- Efficiencies of scrubbers can be 99%.



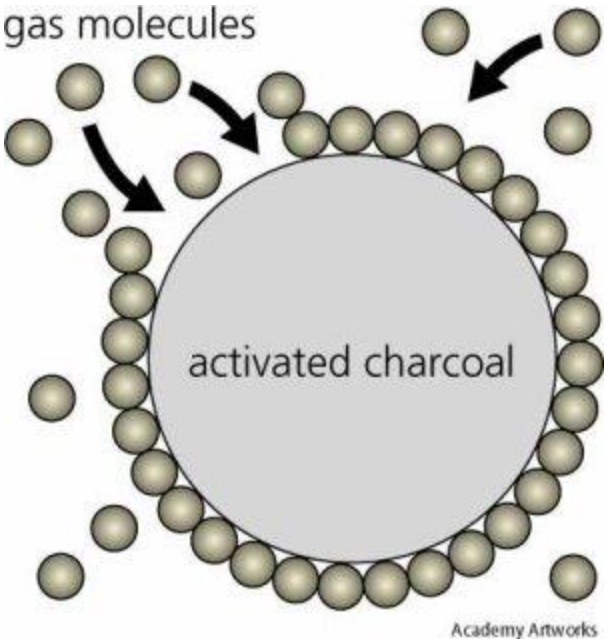
Settling Chamber

- Large chamber where gas velocity is reduced to such an extent that the particulates settle to the bottom.
- Remove large particles – great than 60 microns.

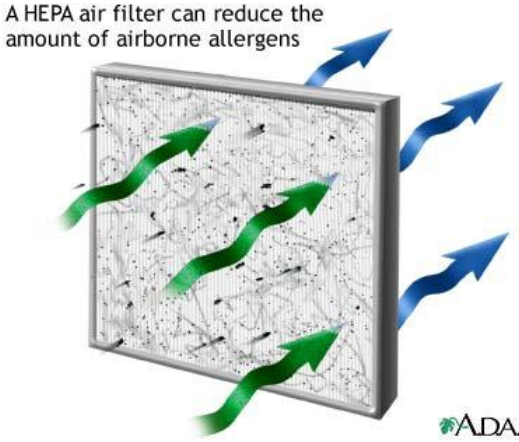


VOC Removal

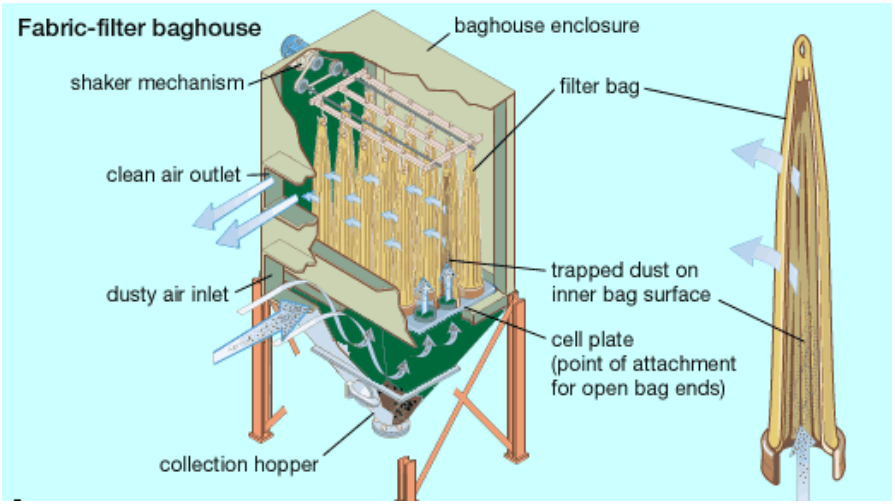
- Incineration (at 1600-2000 degrees F)
- Condensation
- Adsorption on activated charcoal



Particulate Removal



- High Efficiency Particulate Air (HEPA) Filters
- Baghouses
- Sand Bed Filters
- Wet Scrubber
- Dry Inertial Devices
- Electrostatic Precipitators



Other Air Contaminants

- Acids (neutralization with NaOH in scrubber)
- Fission products (charcoal filter)
- Sulfur dioxide (washed before burning or scrubbers)
- Oxides of nitrogen (reduce combustion temperature & catalytic converter)
- HCl (NaOH scrubbers)
- CO (catalytic converters)
- Heavy metals (dry filters)
- CFCs (removed by regulations or bath of Na metal)

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

Simulation – Round 3

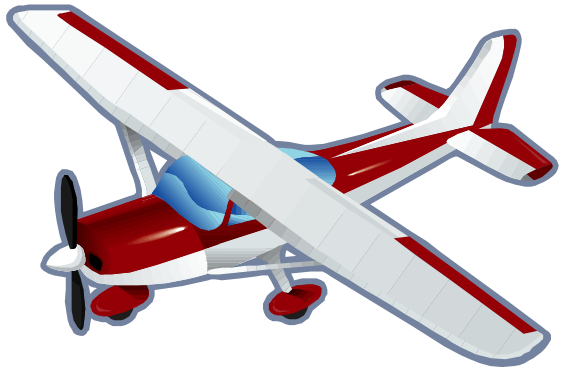
Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

Simulation Round 2
Innovative Aero Solutions

Innovative



Aero Solutions

Let's brainstorm some ideas that we might be able to put into practice at Innovative Aero to help reduce their air emissions.

Shall we try out some of these ideas to see what impact they have?

Lessons Learned

- What was the outcome of the airplane production process? Report out all measurements.
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Measuring Noise

- *Decibel (dB) Unit* - the accepted unit for noise is a relative measure of sound intensity.
- *Frequency (Hz) Unit* – Rate at which the compression wave arrive at or pass a fixed point. Frequency is perceived as pitch.
- *Hearing threshold shift* - a change in the loudness of the quietest sound that can be heard by an individual.
- *Intensity* – also known as loudness (power per unit area)

When Is Sound Noise?

- Any undesired sound (ANSI).
- Sounds of duration , intensity, or other quality that cause physiological or psychological harm to humans or other living things.
- Any sound > 90 decibels - no matter how beautiful it happened to be.



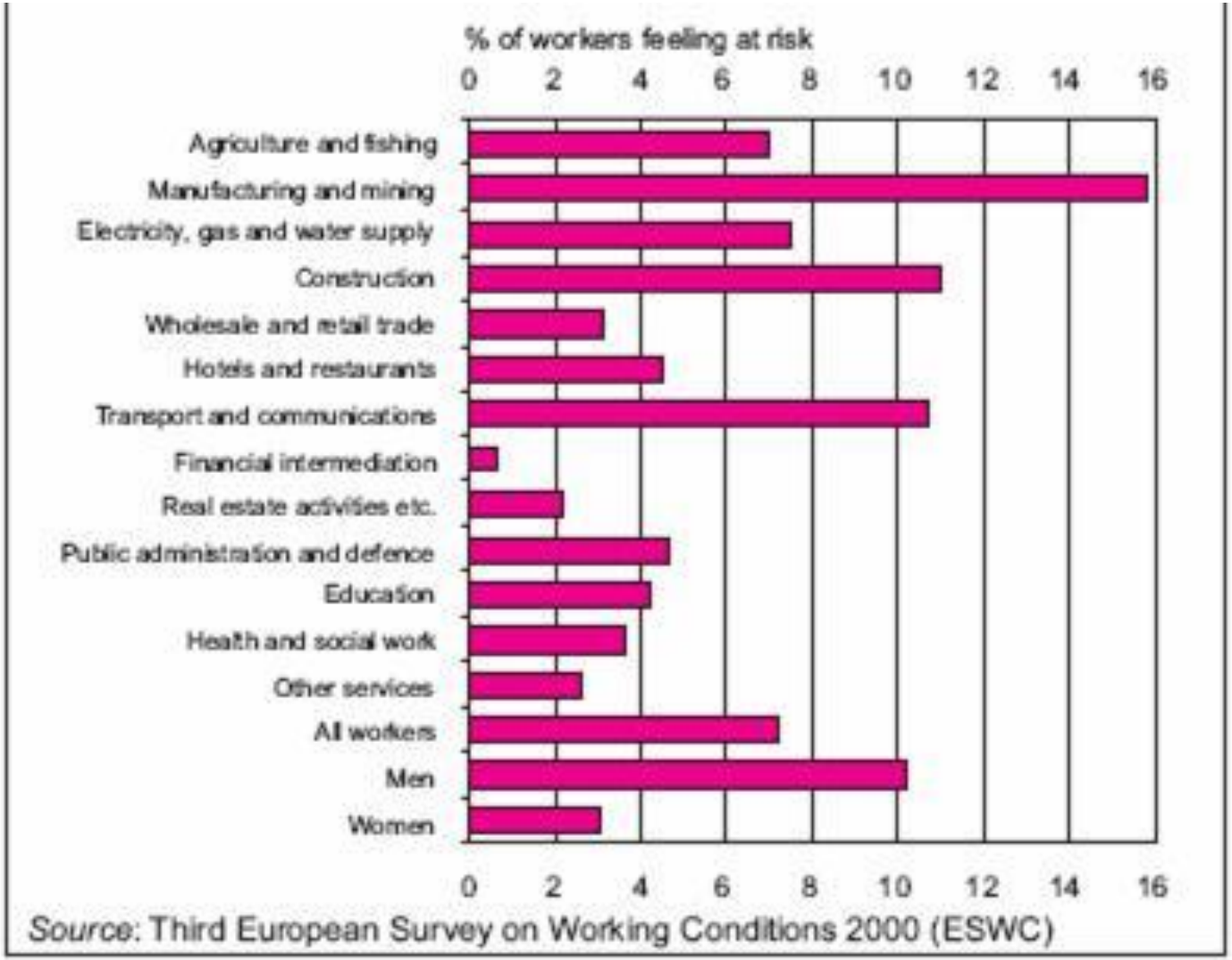
Hearing Loss



In the U.S., 1 in 10 people exposed to workplace noise has a noise-induced hearing impairment.

Degree of hearing loss	Hearing loss range (dB HL)
Normal	-10 to 15
Slight	16 to 25
Mild	26 to 40
Moderate	41 to 55
Moderately severe	56 to 70
Severe	71 to 90
Profound	91+

Who is at Risk?

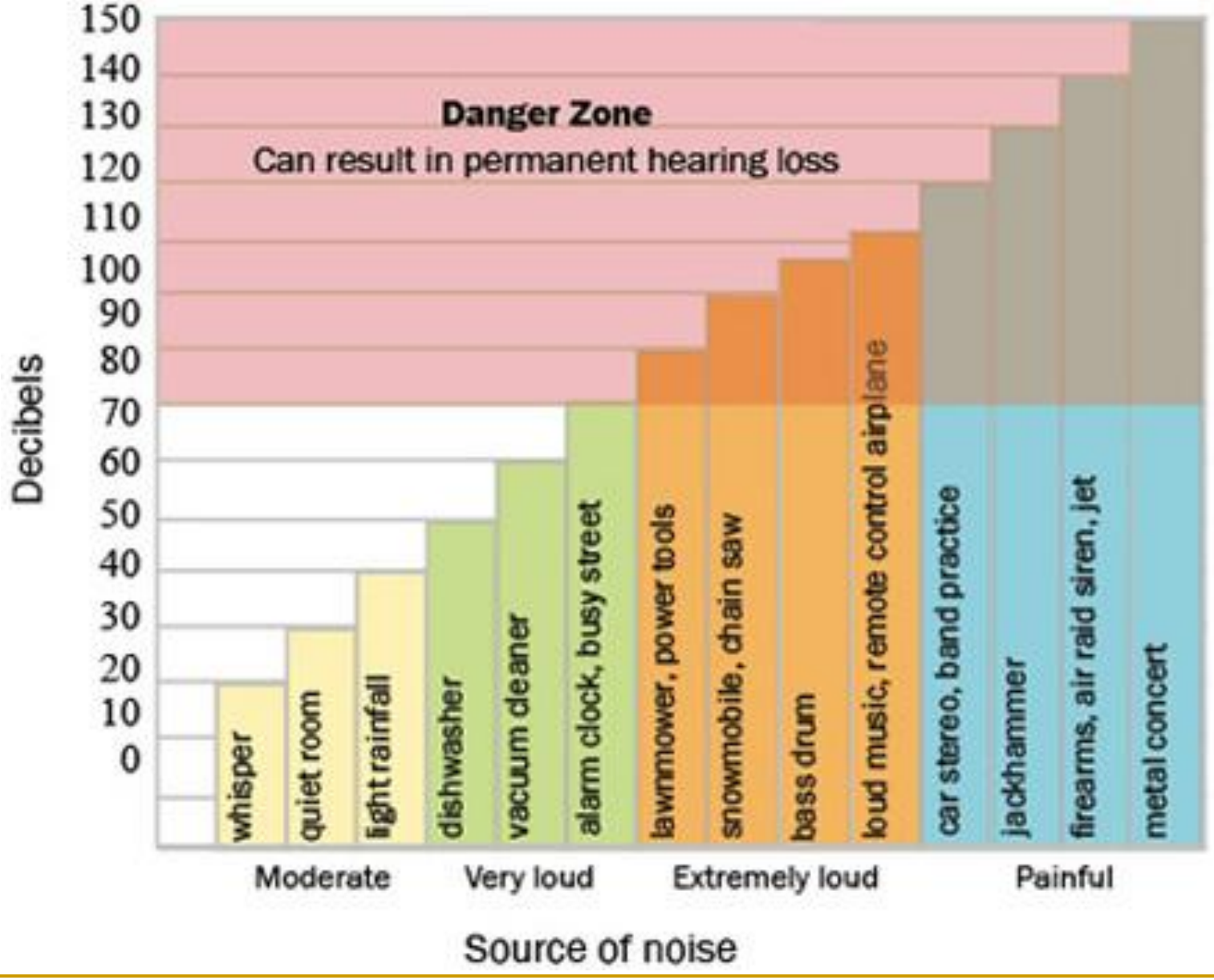


Factors in Noise Exposure Effects

- Variation in individual susceptibility;
- Total energy of the sound;
- Frequency distribution of the sound;
- Noise characteristics of the exposure (continuous, intermittent, or series of impacts);
- Total daily duration of exposure;
- Length of employment in the noise environment.

Familiar Sound Sources

Jet plane at takeoff	150 dBA
Painful	135 dBA
Rock band	110 dBA
Dishwasher up close	95 dBA
Motorcycle at 25 feet	90 dBA
Heavy street traffic at 15 feet	85 dBA
TV audio	70 dBA
Conversation	60 dBA
Light traffic at 100 feet	50 dBA
Leaves rustling	10 dBA


Decibels
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Danger Zone
Can result in permanent hearing loss
whisper
quiet room
light rainfall
dishwasher
vacuum cleaner
alarm clock, busy street
lawnmower, power tools
snowmobile, chain saw
bass drum
loud music, remote control airplane
car stereo, band practice
jackhammer
firearms, air raid siren, jet
metal concert
Moderate
Very loud
Extremely loud
Painful
Source of noise

Legislating Quiet

- OSHA regulates occupational noise.
  - Engineering and administrative controls are required at levels > 90dBA
  - Hearing conservation program required at 85 dBA
- EPA does not regulate other forms of environmental noise but recommends a maximum of 85 dBA averaged over 8 hours.
- Local noise control laws have increased in the U.S. but are difficult to enforce.

Course Agenda

Air Contamination

Simulation – Round 1

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Noise Pollution

Industrial Hygiene

Simulation – Round 3

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Course Evaluation

Industrial Hygiene (IH)

Recognition, evaluation, and control of environmental factors or workplace stresses that may cause:

- sickness,
- impaired health and well-being, or
- significant discomfort among workers or among the citizens of the community

Human Health Risk Assessment (HHRA)

- What environmental stressors are people exposed to and at what levels and for how long?
- Are some people more likely to be susceptible to environmental stressors due to factors such as age, genetics, pre-existing health conditions, ethnic practices, gender, etc.?
- Are some people more likely to be exposed to environmental stressors because of factors such as where they work, where they play, where they live, what they like to eat, etc.?
- What types of health problems may be caused by environmental stressors such as chemicals and radiation?
- What is the chance that people will experience health problems when exposed to different levels of environmental stressors?

Purposes of IH Testing

- Compliance (including substance-specific standards)
- Health risk assessment
- Determine need for/ effectiveness of engineering controls
- Documentation for Worker's Comp. claims
- Documentation for litigation purposes
- Provide information to occupational health physicians
- Incident/complaint investigation
- Complement bio-monitoring results
- Select PPE

Environmental Factors/Stresses

- Chemical: Excessive airborne concentrations of mists, vapors, gases, or solids in the form of dusts or fumes
- Physical: Excessive levels of non-ionizing radiation, ionizing radiation, noise, vibration, and extremes of temperature and pressure
- Biological: Any living organism or its properties that can cause an adverse response in humans

Chemical Emissions Factors

- Exposed liquid surface
- Ventilation rates
- Evaporation rates
- Pattern of airflow
- Concentration of vapor in workroom air
- Housekeeping



Physical Aspects

- Exposed machinery due to improper guarding / protection
- Confined space entry
- Lack of ventilation
- Inadequate PPE



Airborne Biological Hazards

- Sources include bacteria, viruses, insects, plants, birds, animals, and humans.
- Cause a variety of health effects ranging from skin irritation and allergies to infections, e.g., tuberculosis.



Key Elements of Hazard Evaluation

- Route of entry of the chemical into the body.
- Quantity of material that must be in contact with a body cell and for what period of time to produce injury.
- Probability that the material will be absorbed or come in contact with body cells.
- Rate of generation of airborne contaminants.
- Control measures in place.

Routes of Entry

- Inhalation
  - Involves airborne contaminants that can be inhaled directly into the lungs
  - Is the major route of entry for hazardous chemicals in the work environment
- Absorption
  - Absorption through the skin can occur quite rapidly if the skin is cut or abraded
- Ingestion
  - Toxic compounds can be absorbed from the gastrointestinal tract into the blood
  - Toxic materials that are readily soluble in digestive fluids can be absorbed into the blood from the digestive system

Human Health Risk Assessment

Step 1: Hazard Identification

- What health problems are caused by the pollutant?

Step 2: Dose-Response Assessment

- What are the health problems at different exposures?

Step 3: Exposure Assessment

- How much of the pollutant are people exposed to during a specific time period?
- How many people are exposed?

Step 4: Risk Characterization

- What is the extra risk of health problems in the exposed population?

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

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Simulation – Round 3

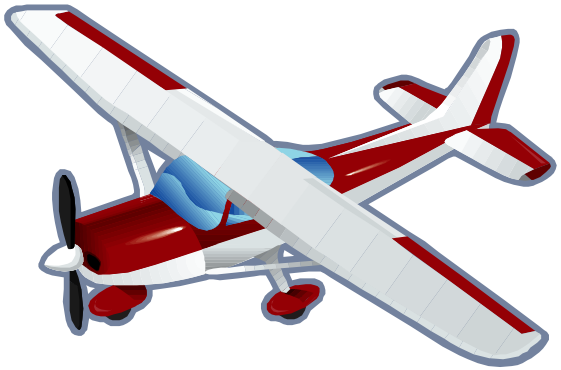
Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

Simulation Round 3

Innovative



Aero Solutions

Let's brainstorm some ideas that we might be able to put into practice at Innovative Aero to help reduce their sound emissions.

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Lessons Learned

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Measuring Emissions

Course Evaluation

Air Quality Index

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 – 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 – 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 – 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 – 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 – 300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

Hearing and Lung Conservation Program Requirements

- Exposure Monitoring
- Audiometric Testing
- Hearing Protection
- Employee Training
- Recordkeeping



Controlling Noise

Change the process to generate less noise:

- Alternative equipment – manual vs. automated
- Shield the noise-generating devices or processes at the source
- Shield the receiver
- Move noisy things away from the people, e.g., vacuum system motors, generators, etc.

Monitoring Strategy



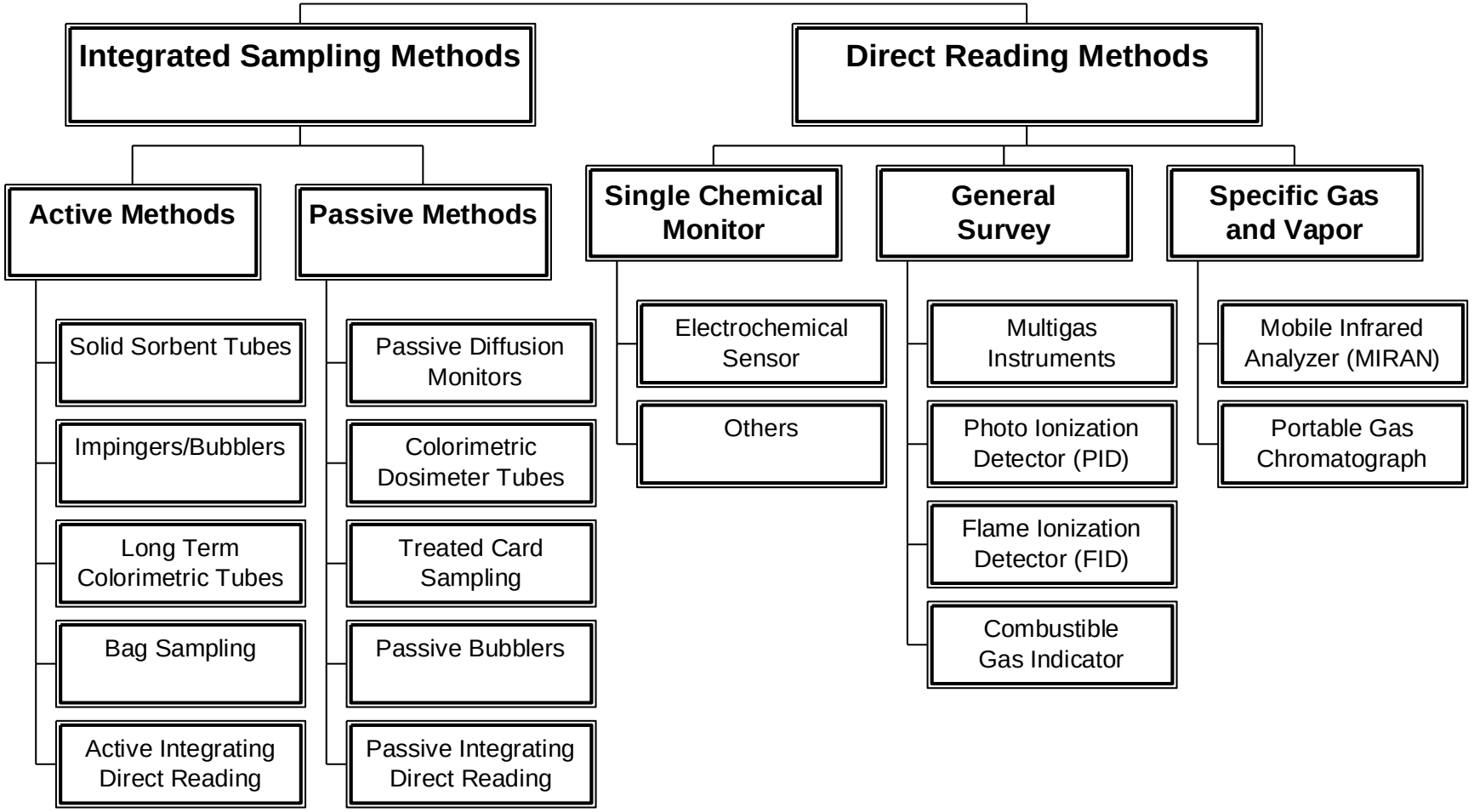
- Type of instruments to be used;
- Range of readings expected;
- Establishing action levels;
- Documentation procedures;
- Sampling procedures;
- Use approved NIOSH methods;
- Quality at the Source.

Industrial Air/Noise Sampling



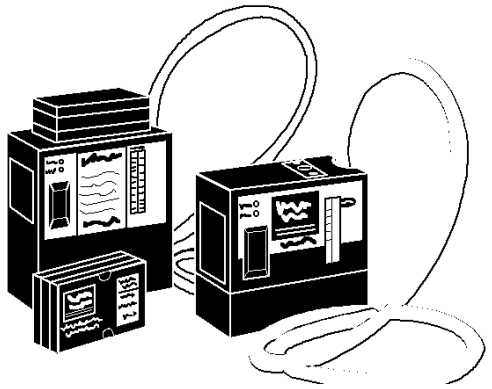
- Personal
  - Sampling device is directly attached to the employee and worn continuously in the breathing/hearing zone during all work and rest operations.
- Breathing/Noise Zone
  - Sampling device remains in worker's breathing/hearing zone throughout workday.
- General Air (Area)
  - More appropriate for measuring source emissions rather than personal exposures.

Gas and Vapor Techniques

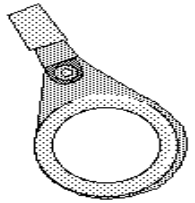


Active Air Sampling Methods

- Air moving device pulls air across sampling media or into measuring instrument.
- Most common device is the personal sampling pump.
- Requires careful calibration to determine flow rate of sampling pump.



Passive Air Sampling Methods



- Rely on natural air currents and/or worker movement to bring contaminant to surface of sampling device.
- Control the rate at which the sample moves from the surface of sampling device to the active sites on sampling media.
- Typically used for personal samples for gases and vapors.

Noise Measurement Devices

- Sound Level Meters (SLMs)
- Octave-Band Analyzers (OBAs)
- Noise Dosimeters
- Audiometers

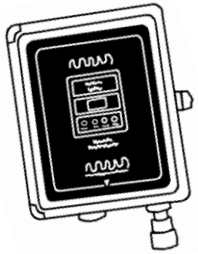


“Real-Time” Samplers



- Sometimes called direct reading or instantaneous monitors.

- Many instruments have continuously updated display and integrating capabilities for recordkeeping.



Sampling Best Practices

- Sample as much of the eight hours as possible to be representative;
- Take more than one consecutive sample (to increase the accuracy of the average);
- Keep sample times and sample volumes (e.g. flow rates) similar;
- Turn off and remove sampling pumps before an employee leaves a potentially contaminated area, such as breaks;
- Must have quality control over sample and count break times as part of 8 hour shift but not the lunch period.

Sampling Summary

- Great advancements in direct-reading instrument technology have been made in recent years
- However, still most direct-reading instruments are used only for qualitative field contaminant screening
- Validation of more direct-reading methods is an initiative of NIOSH

National Institute for Occupational Safety and Health
NIOSH

Sample Duration

- Full Period Consecutive Samples - two or more samples are obtained during the entire shift
- Full Period Single Sample – samples obtained during full period of shift (i.e. the same sample is taken all day long without changing media)
- Partial Period Consecutive Samples - one or more samples are obtained for only a portion of shift
- Grab Samples - taken over number of short periods of time (usually minutes or seconds) taken at random intervals over the shift

Occupational Standards

Hours of exposure	Occupation standard
8	90 dBA
4	95 dBA
2	100 dBA
1	105 dBA

- Maximum allowable impulse noise is 140 dBA.
- Maximum allowable continuous sound is 115 dBA.

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Simulation – Round 1

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Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

Emission Factors

- Representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant
- Expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant, e.g., pounds of VOC emitted per year.

Emission Equation

The general equation for emissions estimation is:

$$E = A \times EF \times (1-ER/100)$$

where:

E = emissions

A = activity rate

EF = emission factor

ER =overall emission reduction efficiency

Emission Calculation Steps

- Step 1
  - Know what is in the Emission
  - Determine what is volatile and non-volatile
- Step 2
  - Understand the difference between “Percent by Weight” and “Percent By Volume”
- Step 3
  - Calculate the emission content

Emission Calculation Example

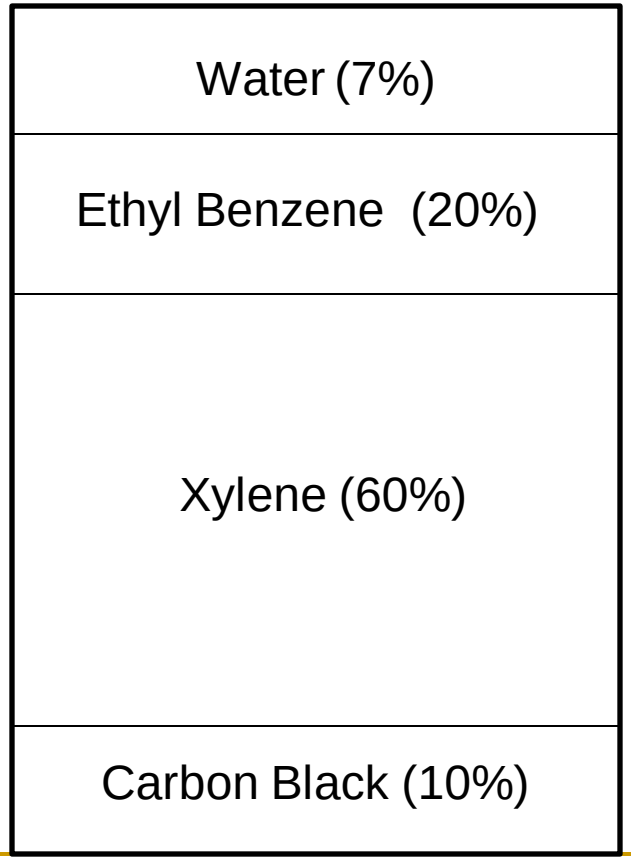
Company A applied 20,000 gallons of LCOAT coating last year.

Determine the pounds of VOC emitted last year.

- MSDS Information - Chemicals in LCOAT:
  - Ethylene benzene 15-20% by weight
  - Xylene 55-60% by weight
  - Carbon black <10% by weight
  - Water 7% by weight
- Density: 8.10 lb/gal

Step 1

Know what is in the Emission



Volatile:

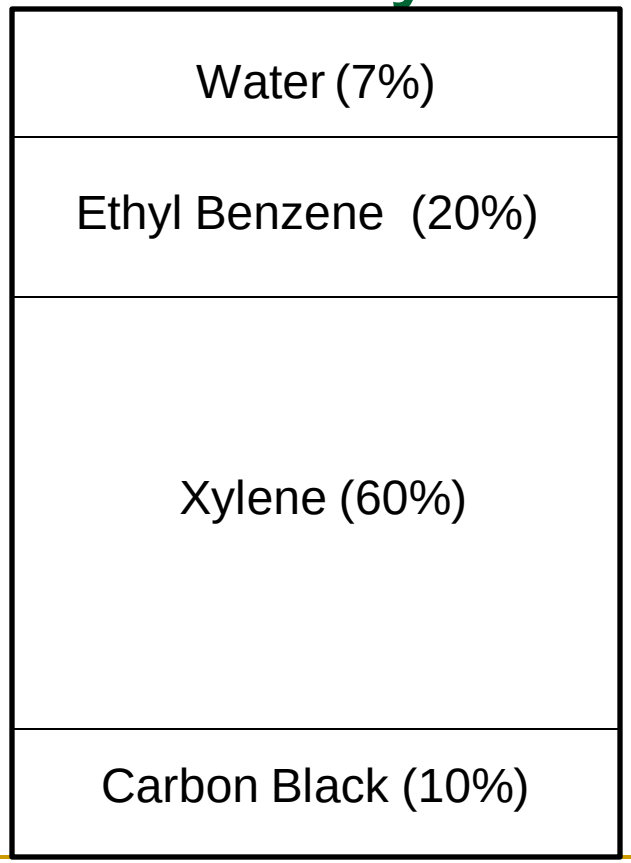
- Water
- Ethyl Benzene
- Xylene

Non-volatile:

- Carbon Black

Step 2

Understand difference between "% by Weight" and "% By Volume"



By Weight:

- Water
- Ethyl Benzene
- Xylene
- Carbon Black

Step 3

Calculate the emission content

Calculate pounds of VOC per gallon of coating.

% by weight VOC / 100 X density of coating = lbs VOC / gal of coating

80/100 X 8.10 lbs./gal = 6.48 lbs./gal

Calculate pounds of VOC emitted last year.

lbs VOC / gallon of coating X gallons of coating used / year = lbs VOC emitted / year

6.48 lbs/gal X 20,000 gal/year = 129,600 lbs/year

Threshold Limit Values (TLV)

- Airborne concentrations of substances and reprehensive conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect.
- Categories of TLVs:
  - TIME-WEIGHTED AVERAGE (TLV–TWA)
  - SHORT-TERM EXPOSURE LIMIT (TLV–STEL)
  - CEILING (TLV–C)

Time Weighted Average

- Use sampling media that collects the contaminant over the entire time period of the sample.
- Volume is determined from the pump flow rate (active sample) or the contaminant diffusion coefficient (passive sampling.)
- The combination of contaminant mass and sample volume gives an estimate of the concentration of the contaminant in the worker's zone "averaged" or "integrated" over the time of the sample.

Summary

- **Air Contamination**
  - Health Concerns
  - Ozone Changes
- **Air Pollution Prevention**
  - Classifications
  - Contamination Removal
- **Noise Pollution**
  - Hearing Loss
  - Effects
- **Industrial Hygiene**
  - Factors
  - Risk Assessment
- **Sampling and Measuring Emissions**
  - Strategies
  - Factors

One Key to Success

$$R = Q \times A$$

RESULTS = QUALITY OF SOLUTION **x** ACCEPTANCE

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

Simulation – Round 3

Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM

Pollution Solutions



Air Emissions and Climate Impact

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Purpose of This Module

- To provide an understanding of climate challenges related to air emissions.
- To identify methods that can be implemented to reduce use of substances or processes that generate emissions into the air.
- To improve the air quality within facilities and sent into the atmosphere through industrial emissions.
- To provide strategies for incorporating effective air emissions management concepts into a Green Enterprise.

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

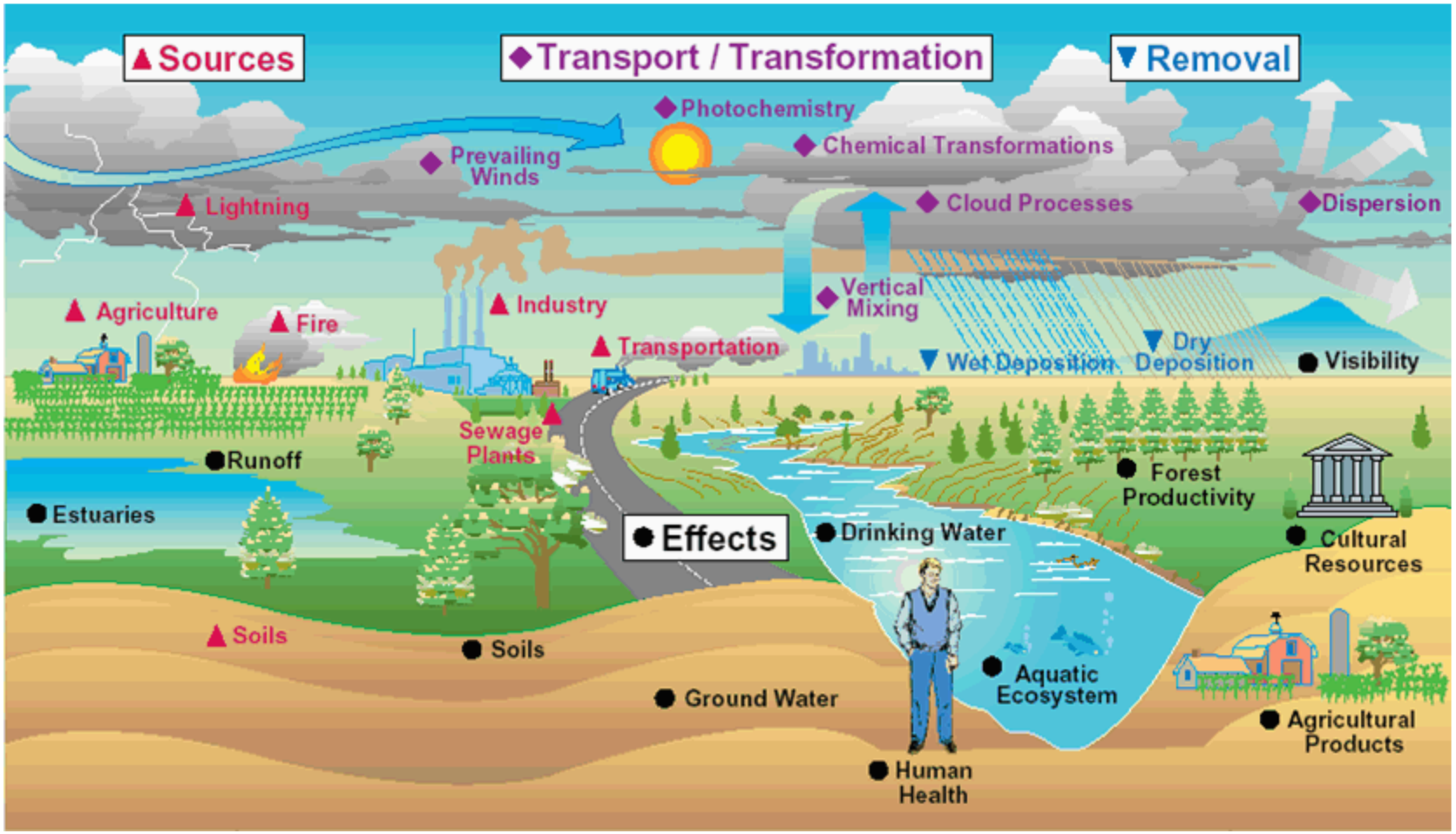
Simulation – Round 3

Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

Air Pollution



Source: www.epa.gov

Why Air Pollution Concerns You

- Breathing polluted air can make you ill.
- Air pollution damages trees, crops, plants, waterways and animals.
- Can damage buildings, monuments, and other structures.
- Reduces visibility levels and interferes with aviation safety.

	MAJOR SOURCES	HEALTH EFFECTS	ENVIRONMENTAL EFFECTS
SO_2	Industry	Respiratory and cardiovascular illness	Precursor to acid rain, which damages lakes, rivers, and trees; damage to cultural relics
NO_x	Vehicles; industry	Respiratory and cardiovascular illness	Nitrogen deposition leading to over-fertilization and eutrophication
PM	Vehicles; industry	Particles penetrate deep into lungs and can enter bloodstream	Visibility
CO	Vehicles	Headaches and fatigue, especially in people with weak cardiovascular health	
Lead	Vehicles (burning leaded gasoline)	Accumulates in bloodstream over time; damages nervous system	Fish/animal kills
Ozone	Formed from reaction of NO_x and VOCs	Respiratory illness	Reduced crop production and forest growth; smog precursor
VOCs	Vehicles; industrial processes	Eye and skin irritation; nausea; headaches; carcinogenic	Smog precursor

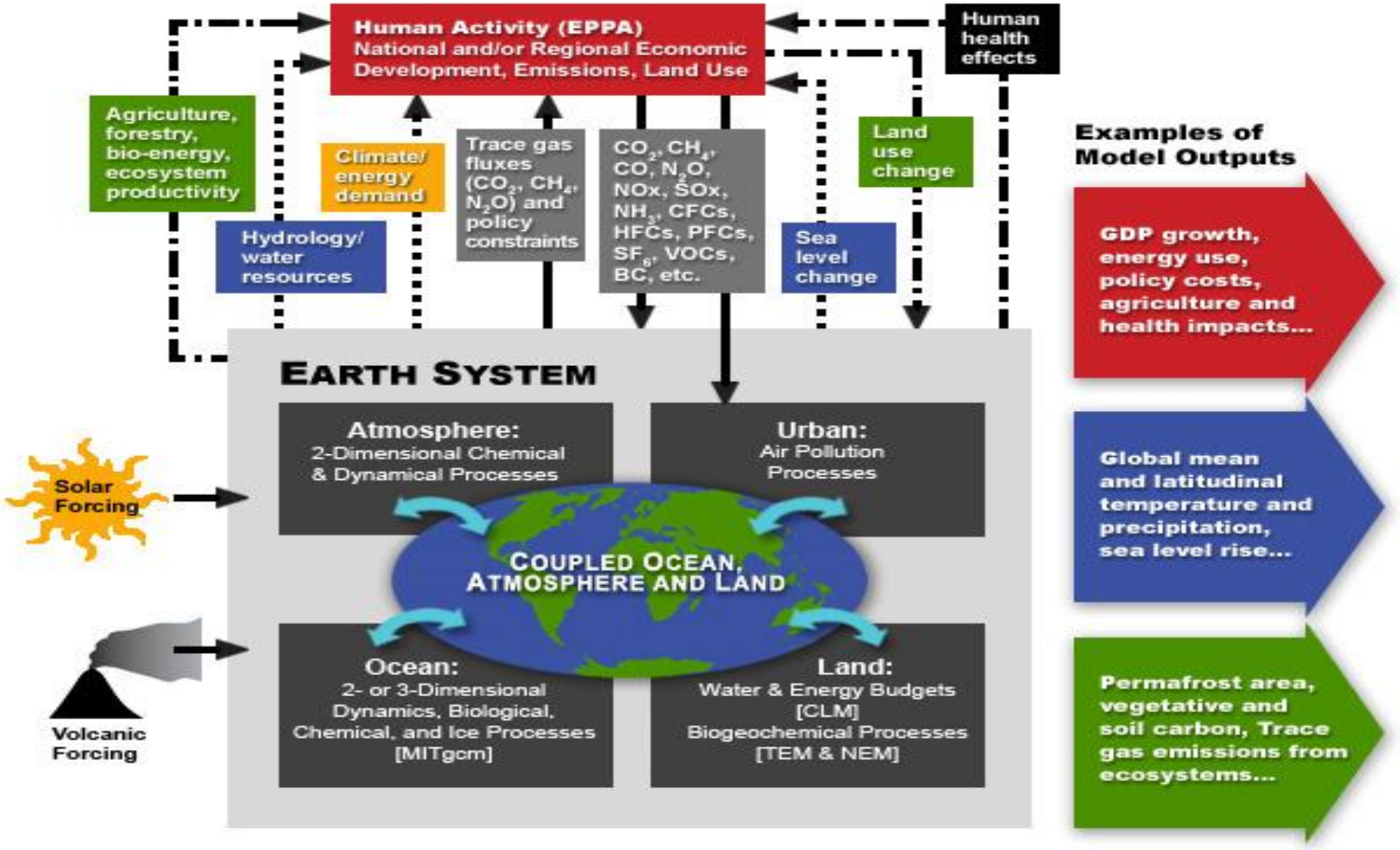
Source: World Research Institute

Health Concerns



- Burning of eyes and nose, cataracts;
- Irritation of your throat and breathing difficulties;
- Respiratory problems;
- Aggravation of heart or respiratory diseases;
- Sunburn, skin cancer;
- Birth defects, brain and nerve damage

Impact Modeling Factors



Economic Impacts of Air Pollution

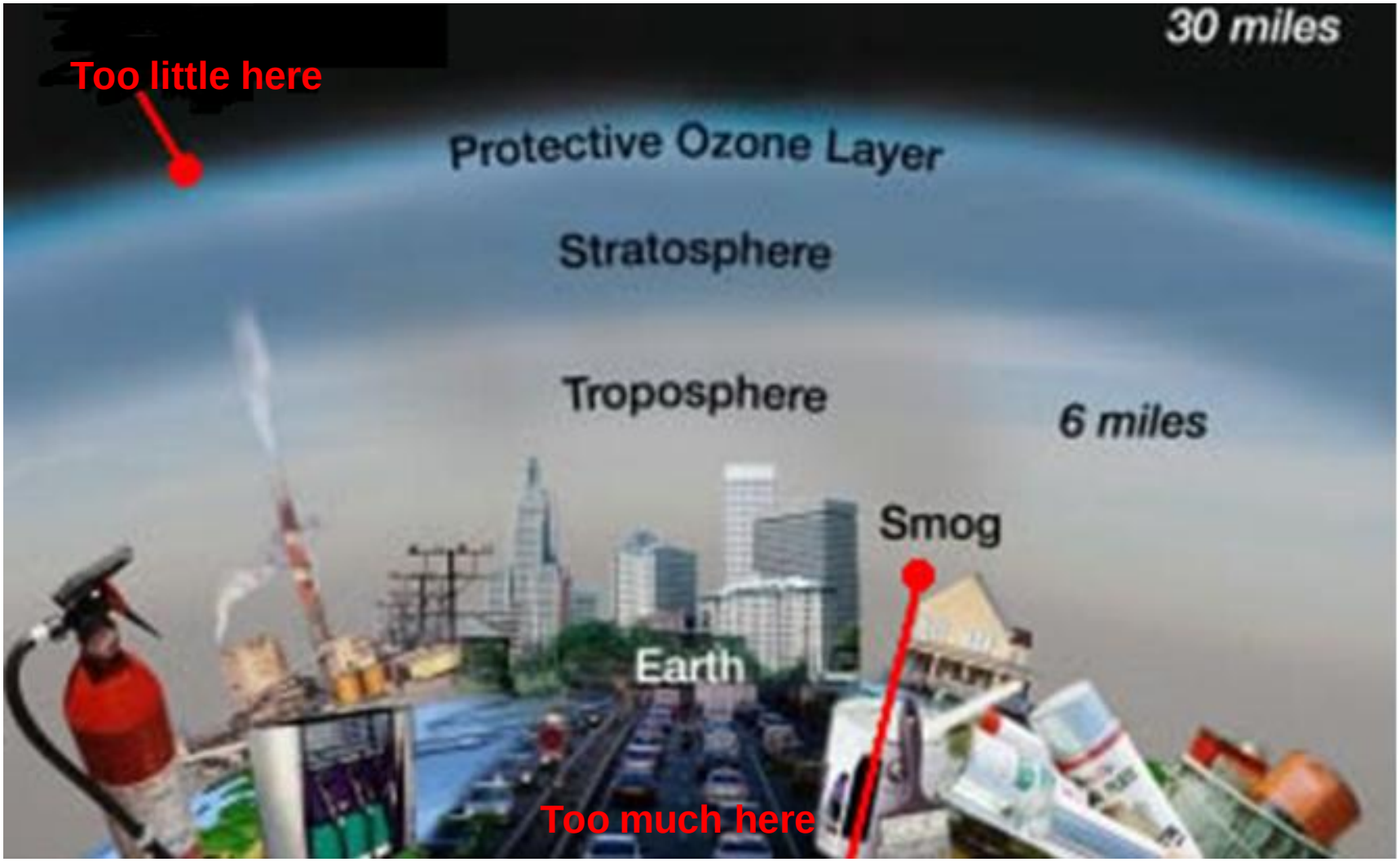
- Illnesses lead to lost days at work and school.
- Agricultural crop and commercial forest yield reductions impact billions of dollars each year.

Ozone

- Stratospheric or “good” ozone absorbs 93-99% of the sun’s high frequency UV light which is potentially damaging to life on Earth.

- Ground-level ozone is formed when two types of pollutants react in the presence of sunlight.

Ozone Layers



Effects of Ozone Depletion

Increased amounts of UV radiation reach Earth.

- Can lead to more cases of skin cancer, cataracts, and weakened immune systems.
- Damages sensitive crops, such as soybeans; reduce crop yields; and harms marine organisms.

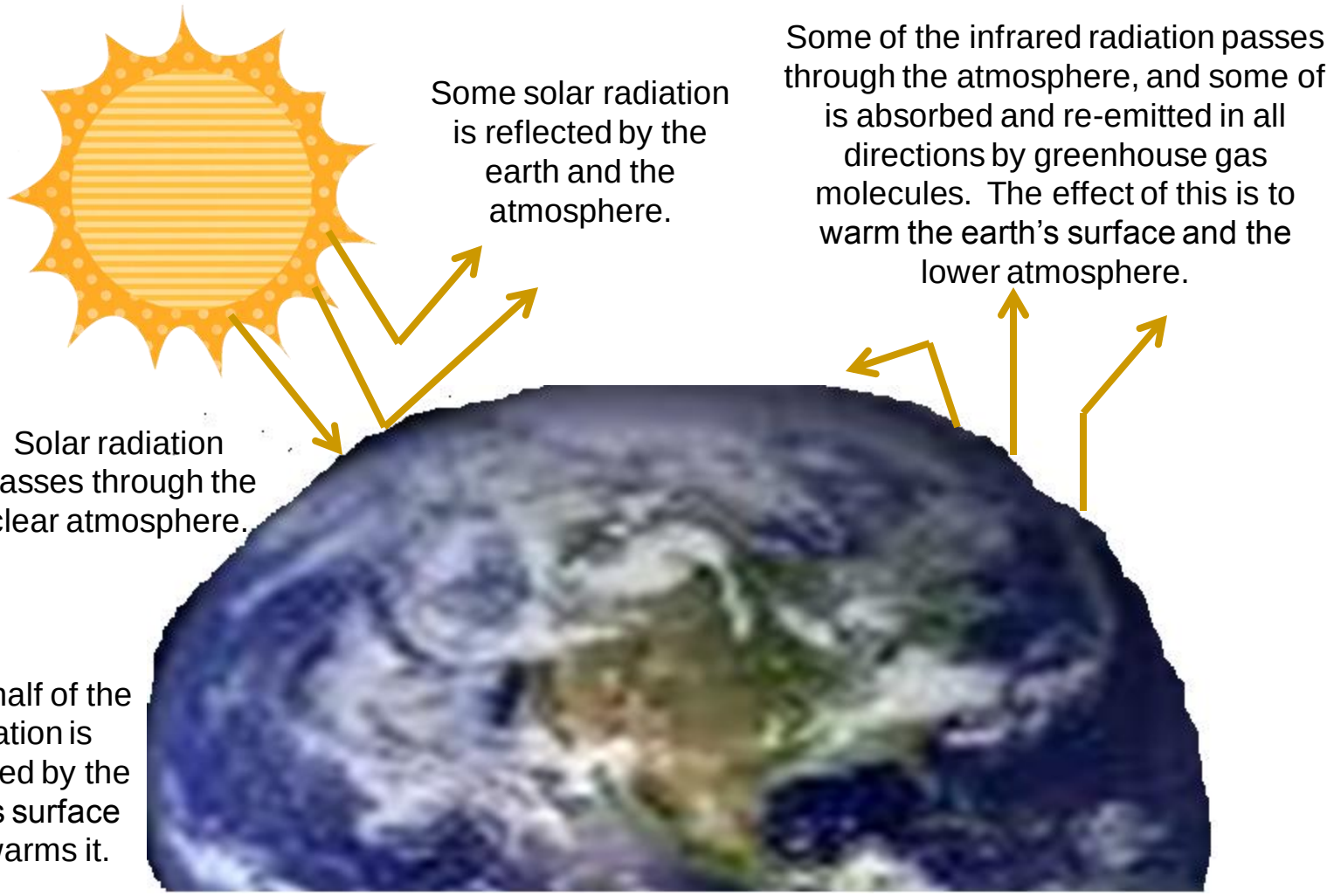
Ground-level Ozone



Found in emissions from:

- Vehicles, construction equipment, lawn and garden equipment ;
- Small industries such as gas stations;
- Industrial/consumer products such as paints and cleaners.

The Greenhouse Effect



U.S. EPA Model

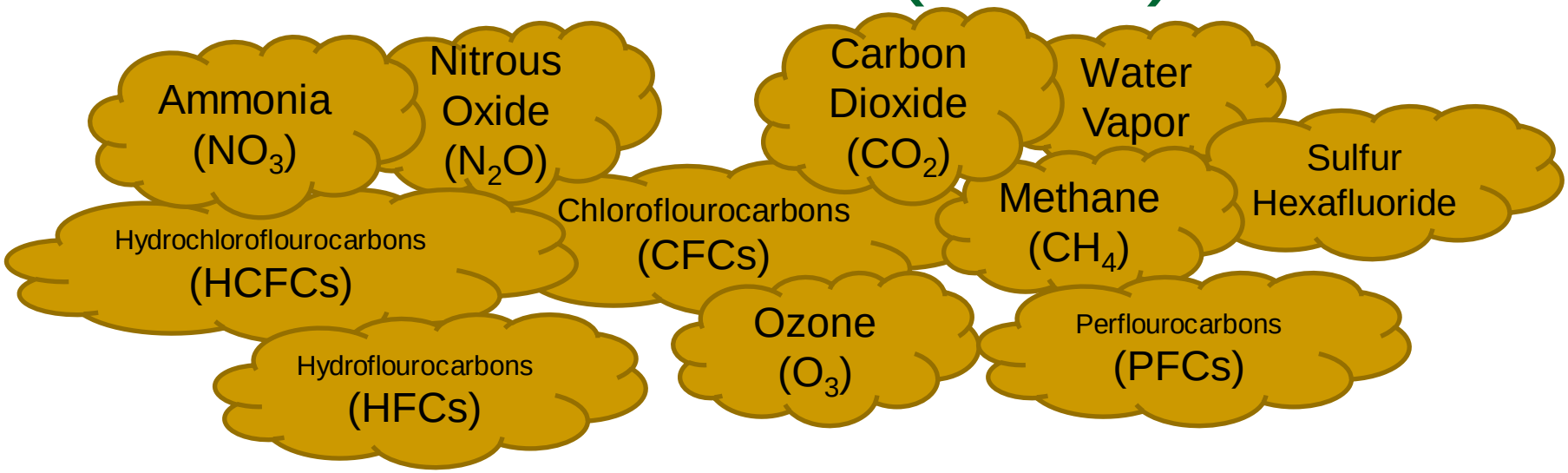
Climate Change





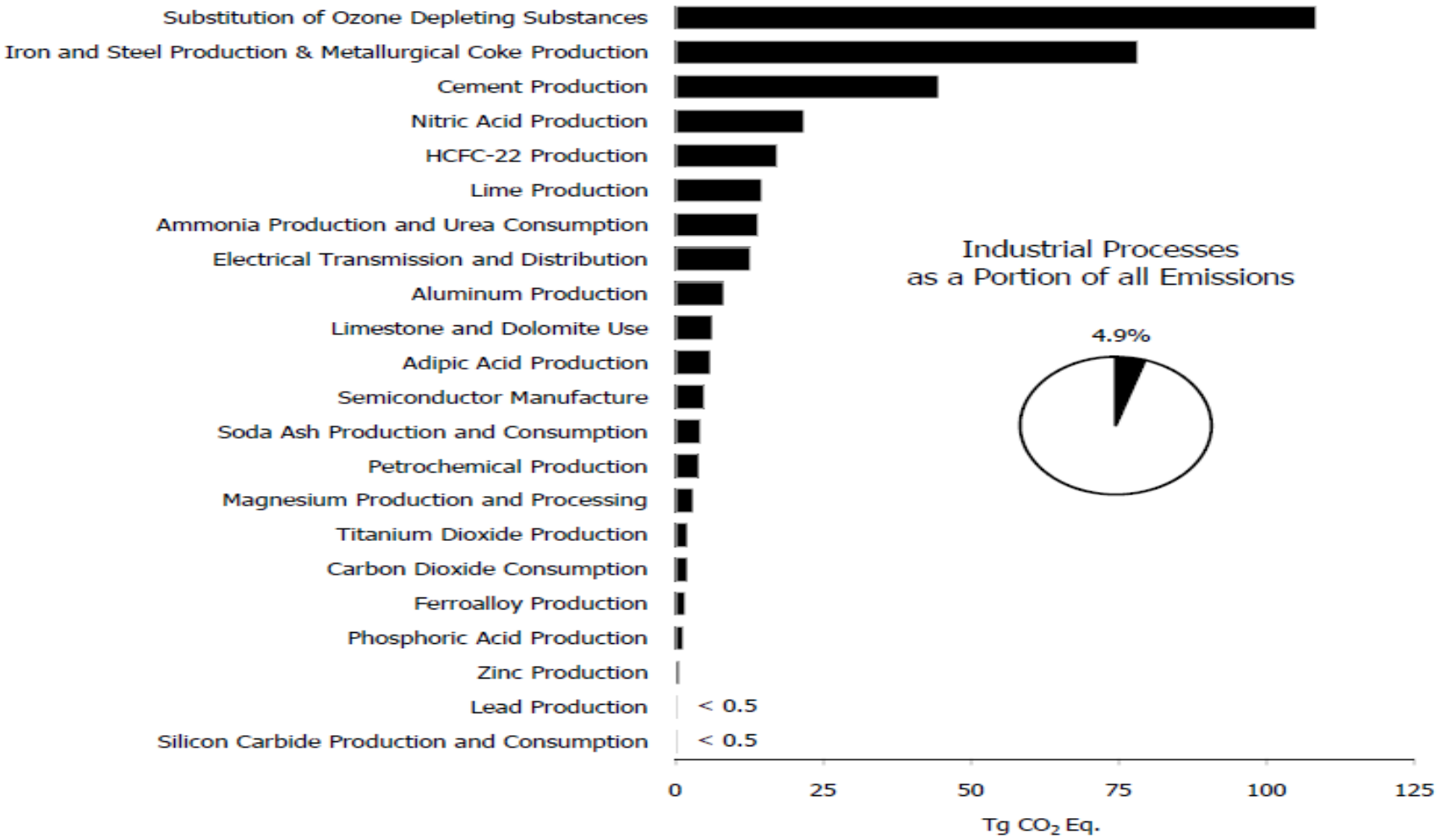
May occur as a result of increased emissions of greenhouse gases from both natural and human induced processes.

Greenhouse Gases (GHG)



Atmospheric problems	SO_2	NOx	NH_3	VOC	CO	CH_4
Photochemical smog		+		+	+	+
Winter smog	+					
Acidification	+	+	+		+	
Eutrophication		+	+			
Climate change		+		+	+	+

Industrial Process GHG Emissions



Volatile Organic Compounds (VOCs)

Any organic compound that is evaporating or vaporizing readily under normal conditions.

VOCs are useful as:

- fuels
- solvents
- scents
- propellants
- refrigerants
- drugs
- pesticides

Volatile Organic Compounds (VOCs)

- Total VOCs (TVOC) is the concentration of all VOCs in a given sample where there may be several different VOCs present.

- A VOC number, VOC rating, or VOC content expresses the amount of volatile material in a sample, either in pounds per gallon, grams per liter or as a percentage by mass.

Hazardous Air Pollutants (HAPs)

- Chemicals which can cause adverse effects to human health or the environment.
- High concentrations of HAPs are primarily due to pollution sources like trucks or small businesses that have not had the same regulatory scrutiny as large industrial facilities.
- Very small number of chemicals and chemical categories appear to account for the majority of health risks associated with HAPs, e.g., diesel emissions from vehicles and equipment.

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

Simulation – Round 3

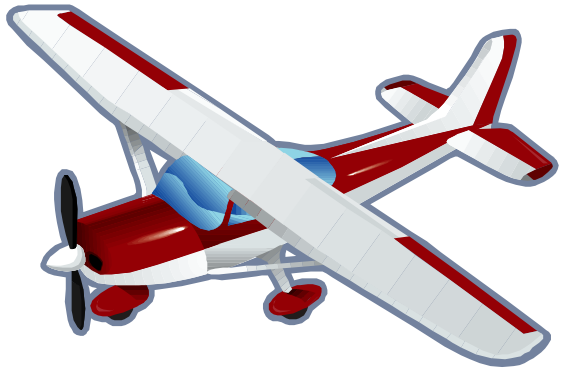
Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

Simulation Round 1

Innovative



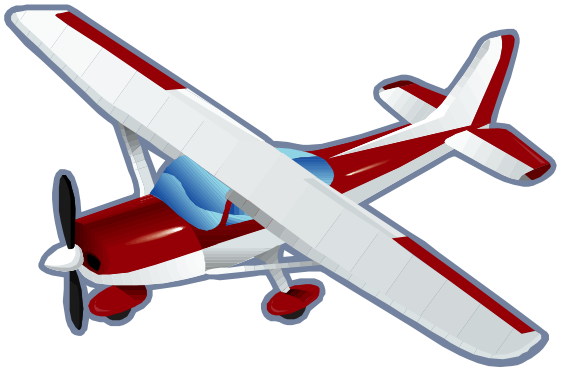
Aero Solutions

Innovation Aero Solutions, a light aircraft manufacturer, is aware of some of the effects that air emissions have on the visibility for the pilots of their aircraft.

Innovative Aero recognizes that some of their manufacturing practices may be contributing to this problem, even if only in a small way.

Simulation Round 1

Innovative



Aero Solutions

To best understand their challenges, we're going to fill in for some of the roles in their operations and get a first-hand look at how things currently work.

Roles:

- Cutting
- Sanding
- Grinding
- Painting
- Bonding
- Quality
- Maintenance

Lessons Learned

- What was the outcome of the airplane production process? Report out all measurements.
- What do these measurements tell us?
- What were some of the challenges you encountered?

Course Agenda

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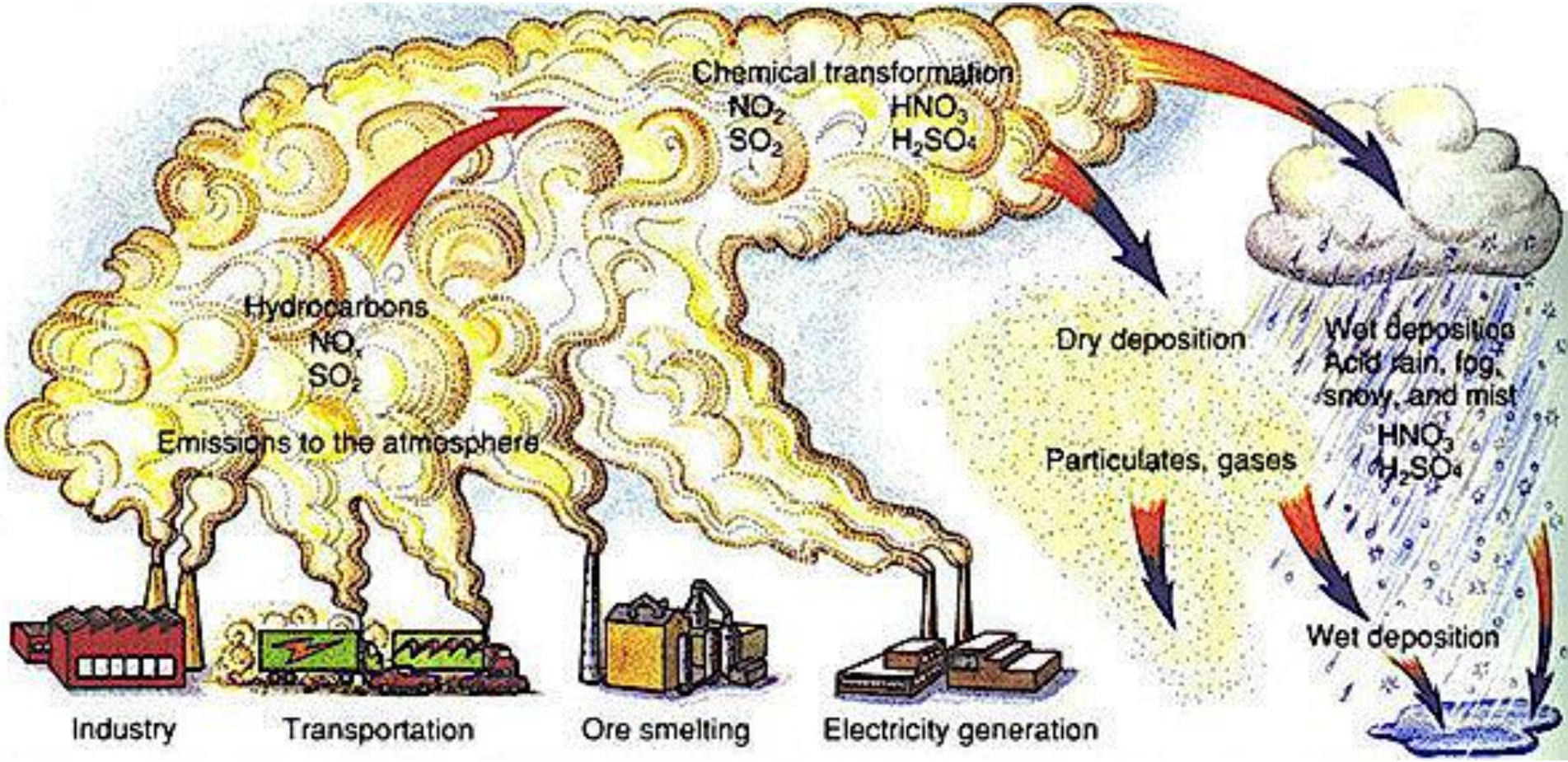
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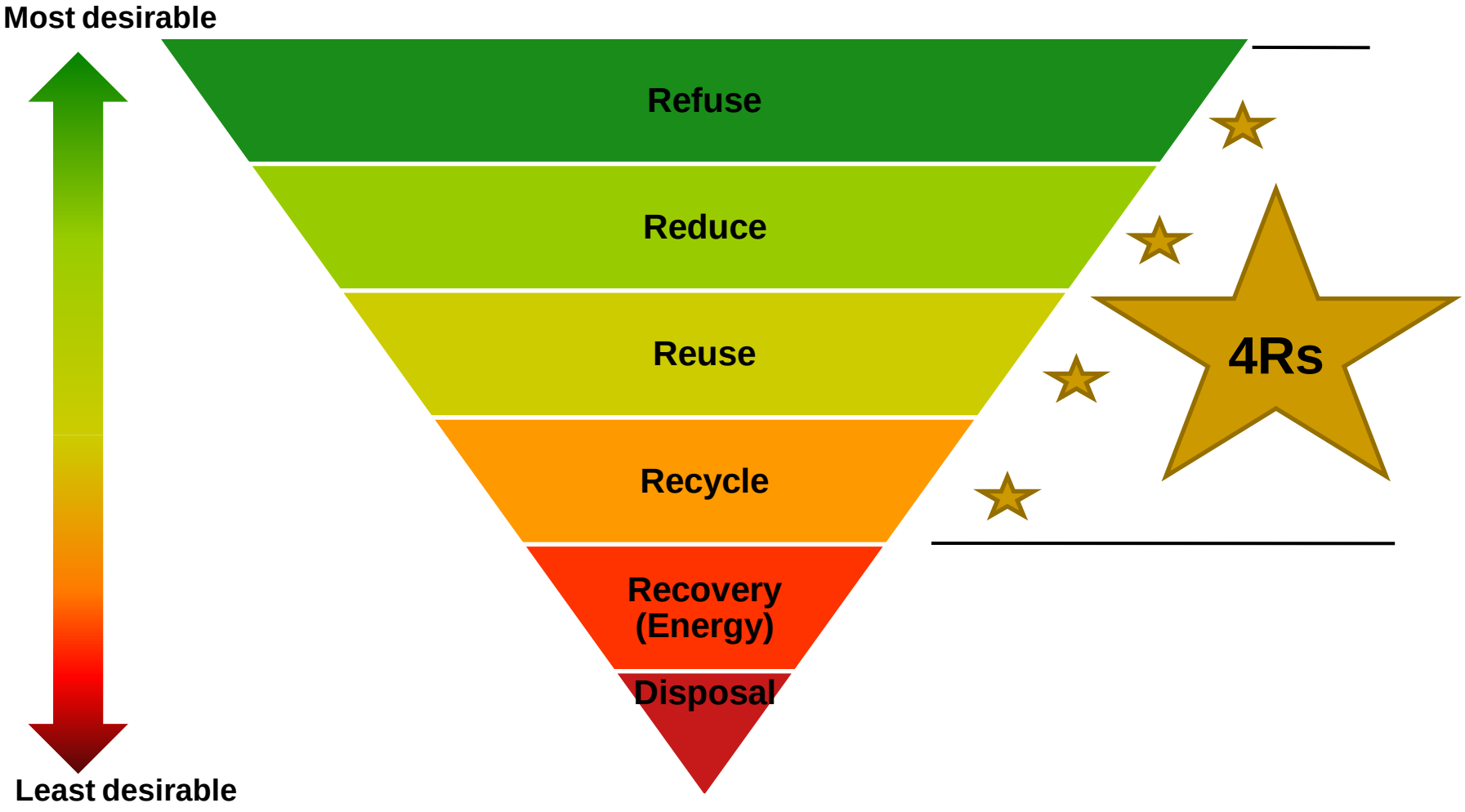
Course Evaluation

Air Pollution



Source:
www.pages.drexel.edu

Waste Hierarchy



Classifications

- Physical
- Chemical
- Thermal
- Biological
- Solidification/Stabilization



Common Air Pollutants

- Volatile organic compounds (VOCs)
- Particulate matter
- Acid gases
- Miscellaneous chemicals including metals and radionuclides

Air Pollution Prevention

- Focus on both *source* of the air emissions and toxicity *reduction*.
- Indirect pollution prevention measures covers the entire product lifecycle, including *transportation*.

Clean Air Act (CAA)

Authorizes U.S. EPA to establish National Ambient Air Quality Standards to protect public health and welfare, and regulate emissions of hazardous air pollutants by:

- Reducing outdoor, or ambient, concentrations of pollutants that cause smog, haze, acid rain, etc.;
- Reducing emissions of toxic pollutants that cause cancer or other serious health effects;
- Phase out production and use of chemicals that destroy stratospheric ozone.

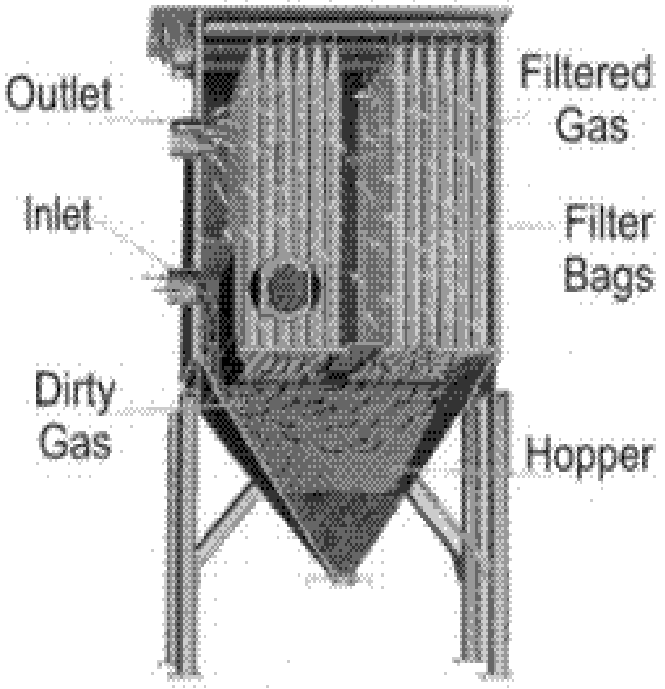
Emissions Reduction Technologies

- Filters
- Scrubbers
- Centrifugal separators
- Electrostatic precipitators
- Incineration
- Condensation
- Adsorption



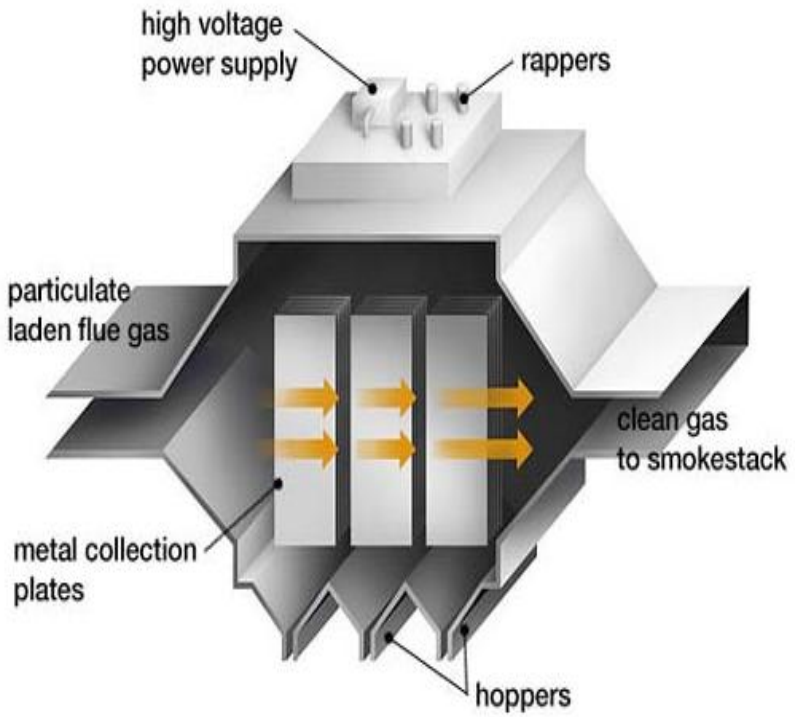
Fabric Filters

- Dust passes through a fabric bag and collects in the bag or filter. Once a cake of dust is formed, further collection is achieved by retention on the cloth fibers.
- The air to cloth ratio is an important design parameter with the optimum ratio dependent upon the particle type.
- If the particle is greater than a micron, it is possible to get efficiencies of 99+%, as long as there are no holes in the fabric.



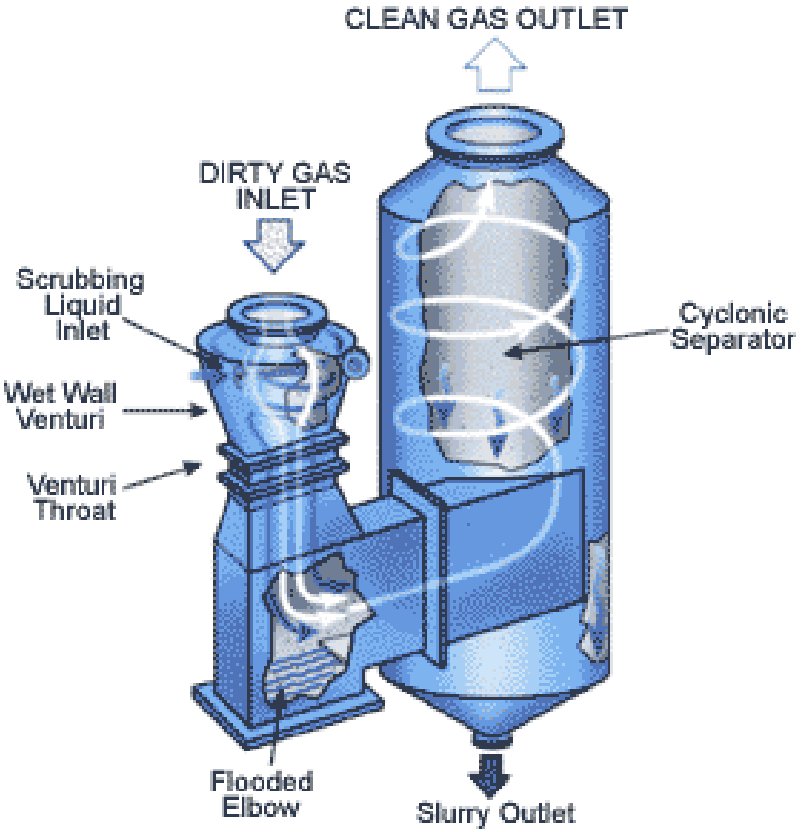
Electrostatic Precipitators

- Delivers a high voltage across the contaminated gas flowing through the device. Particles become negatively charged and move towards collection plates.
- Removes particles greater than one micron to efficiencies of 99+%.



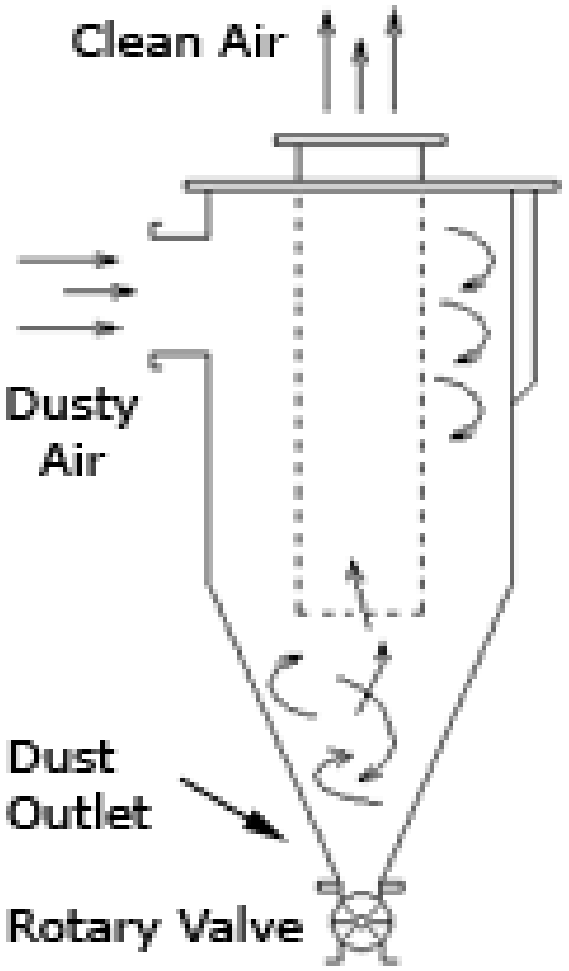
Scrubber

- Wet collector captures particulates by contact of the solids with water droplets.
- Gaseous pollutants can also be transferred to a liquid through the operation of a scrubber.
- Efficiencies of scrubbers can be 99%.



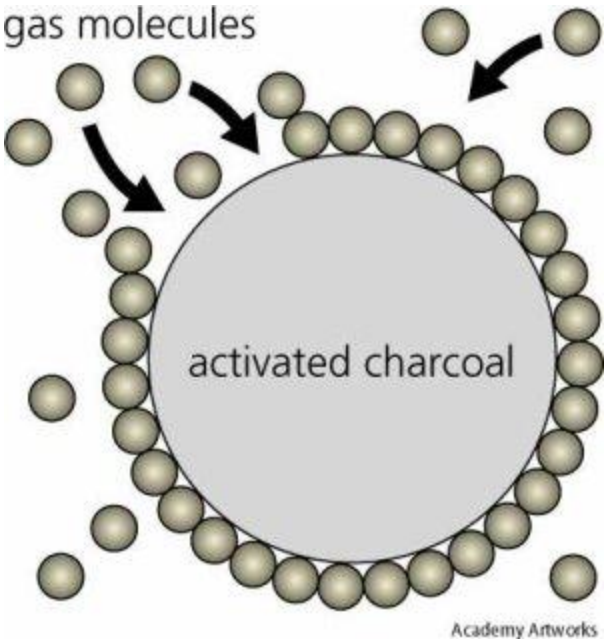
Settling Chamber

- Large chamber where gas velocity is reduced to such an extent that the particulates settle to the bottom.
- Remove large particles – great than 60 microns.

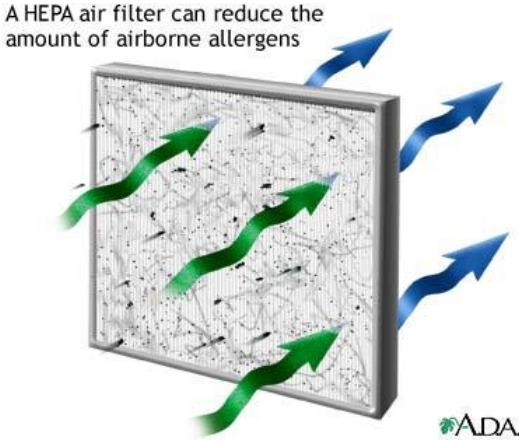


VOC Removal

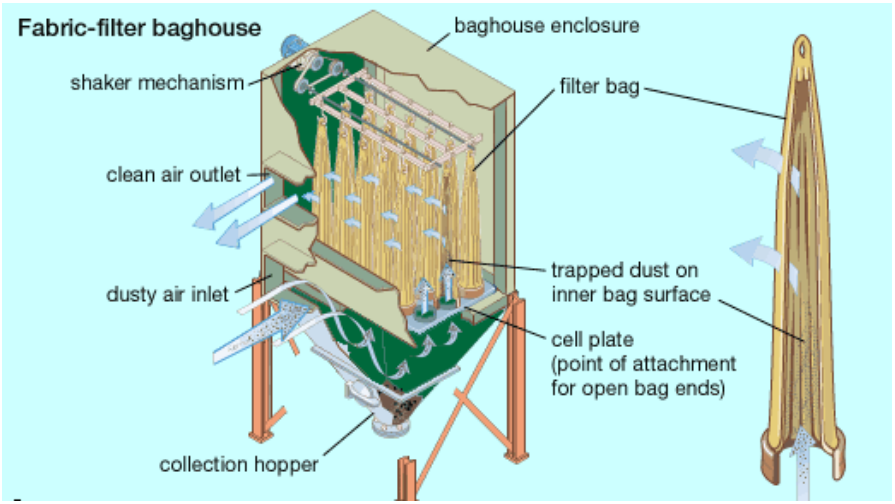
- Incineration (at 1600-2000 degrees F)
- Condensation
- Adsorption on activated charcoal



Particulate Removal



- High Efficiency Particulate Air (HEPA) Filters
- Baghouses
- Sand Bed Filters
- Wet Scrubber
- Dry Inertial Devices
- Electrostatic Precipitators



Other Air Contaminants

- Acids (neutralization with NaOH in scrubber)
- Fission products (charcoal filter)
- Sulfur dioxide (washed before burning or scrubbers)
- Oxides of nitrogen (reduce combustion temperature & catalytic converter)
- HCl (NaOH scrubbers)
- CO (catalytic converters)
- Heavy metals (dry filters)
- CFCs (removed by regulations or bath of Na metal)

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

Simulation – Round 3

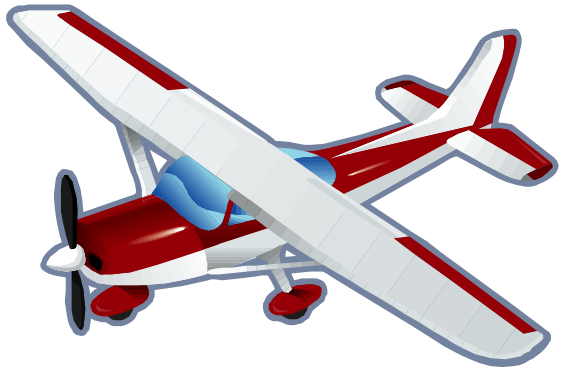
Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

Simulation Round 2
Innovative Aero Solutions

Innovative



Aero Solutions

Let's brainstorm some ideas that we might be able to put into practice at Innovative Aero to help reduce their air emissions.

Shall we try out some of these ideas to see what impact they have?

Lessons Learned

- What was the outcome of the airplane production process? Report out all measurements.
- What do these measurements tell us?
- What were some of the challenges you encountered?

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Air Contamination

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Measuring Noise

- *Decibel (dB) Unit* - the accepted unit for noise is a relative measure of sound intensity.
- *Frequency (Hz) Unit* – Rate at which the compression wave arrive at or pass a fixed point. Frequency is perceived as pitch.
- *Hearing threshold shift* - a change in the loudness of the quietest sound that can be heard by an individual.
- *Intensity* – also known as loudness (power per unit area)

When Is Sound Noise?

- Any undesired sound (ANSI).
- Sounds of duration , intensity, or other quality that cause physiological or psychological harm to humans or other living things.
- Any sound > 90 decibels - no matter how beautiful it happened to be.



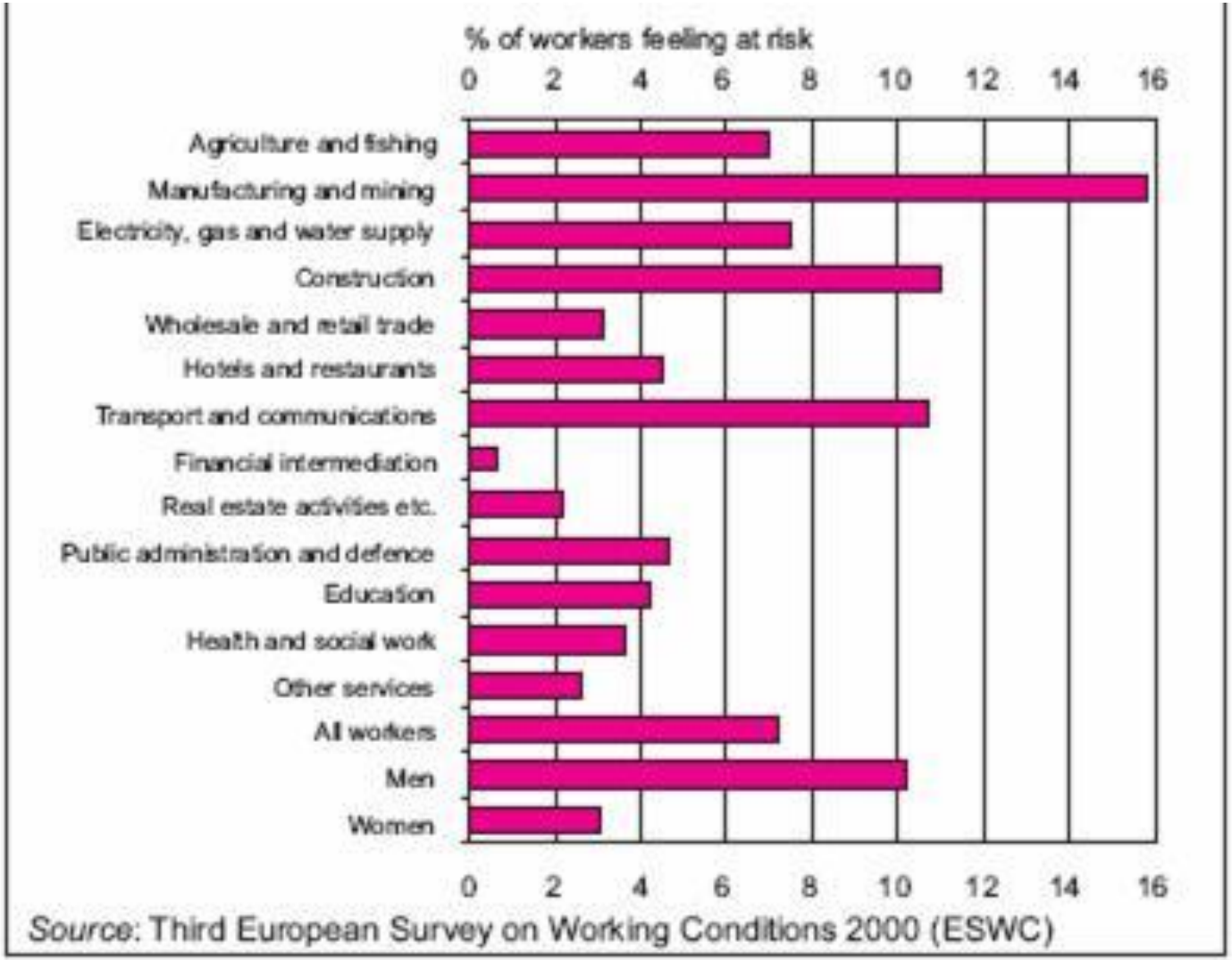
Hearing Loss



In the U.S., 1 in 10 people exposed to workplace noise has a noise-induced hearing impairment.

Degree of hearing loss	Hearing loss range (dB HL)
Normal	-10 to 15
Slight	16 to 25
Mild	26 to 40
Moderate	41 to 55
Moderately severe	56 to 70
Severe	71 to 90
Profound	91+

Who is at Risk?

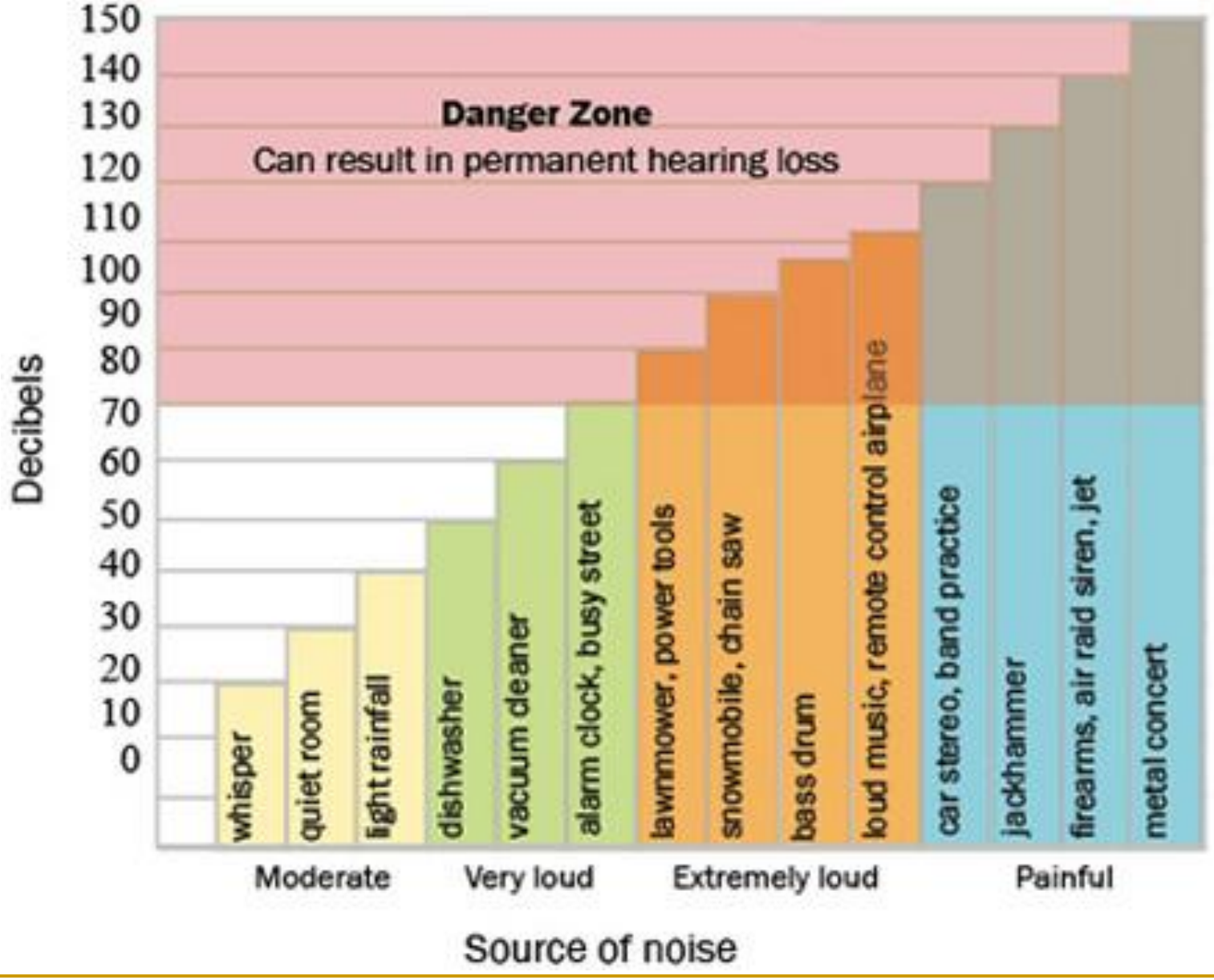


Factors in Noise Exposure Effects

- Variation in individual susceptibility;
- Total energy of the sound;
- Frequency distribution of the sound;
- Noise characteristics of the exposure (continuous, intermittent, or series of impacts);
- Total daily duration of exposure;
- Length of employment in the noise environment.

Familiar Sound Sources

Jet plane at takeoff	150 dBA
Painful	135 dBA
Rock band	110 dBA
Dishwasher up close	95 dBA
Motorcycle at 25 feet	90 dBA
Heavy street traffic at 15 feet	85 dBA
TV audio	70 dBA
Conversation	60 dBA
Light traffic at 100 feet	50 dBA
Leaves rustling	10 dBA


Decibels
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Danger Zone
Can result in permanent hearing loss
whisper
quiet room
light rainfall
dishwasher
vacuum cleaner
alarm clock, busy street
lawnmower, power tools
snowmobile, chain saw
bass drum
loud music, remote control airplane
car stereo, band practice
jackhammer
firearms, air raid siren, jet
metal concert
Moderate
Very loud
Extremely loud
Painful
Source of noise

Legislating Quiet

- OSHA regulates occupational noise.
  - Engineering and administrative controls are required at levels > 90dBA
  - Hearing conservation program required at 85 dBA
- EPA does not regulate other forms of environmental noise but recommends a maximum of 85 dBA averaged over 8 hours.
- Local noise control laws have increased in the U.S. but are difficult to enforce.

Course Agenda

Air Contamination

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Simulation – Round 3

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Course Evaluation

Industrial Hygiene (IH)

Recognition, evaluation, and control of environmental factors or workplace stresses that may cause:

- sickness,
- impaired health and well-being, or
- significant discomfort among workers or among the citizens of the community

Human Health Risk Assessment (HHRA)

- What environmental stressors are people exposed to and at what levels and for how long?
- Are some people more likely to be susceptible to environmental stressors due to factors such as age, genetics, pre-existing health conditions, ethnic practices, gender, etc.?
- Are some people more likely to be exposed to environmental stressors because of factors such as where they work, where they play, where they live, what they like to eat, etc.?
- What types of health problems may be caused by environmental stressors such as chemicals and radiation?
- What is the chance that people will experience health problems when exposed to different levels of environmental stressors?

Purposes of IH Testing

- Compliance (including substance-specific standards)
- Health risk assessment
- Determine need for/ effectiveness of engineering controls
- Documentation for Worker's Comp. claims
- Documentation for litigation purposes
- Provide information to occupational health physicians
- Incident/complaint investigation
- Complement bio-monitoring results
- Select PPE

Environmental Factors/Stresses

- Chemical: Excessive airborne concentrations of mists, vapors, gases, or solids in the form of dusts or fumes
- Physical: Excessive levels of non-ionizing radiation, ionizing radiation, noise, vibration, and extremes of temperature and pressure
- Biological: Any living organism or its properties that can cause an adverse response in humans

Chemical Emissions Factors

- Exposed liquid surface
- Ventilation rates
- Evaporation rates
- Pattern of airflow
- Concentration of vapor in workroom air
- Housekeeping



Physical Aspects

- Exposed machinery due to improper guarding / protection
- Confined space entry
- Lack of ventilation
- Inadequate PPE



Airborne Biological Hazards

- Sources include bacteria, viruses, insects, plants, birds, animals, and humans.
- Cause a variety of health effects ranging from skin irritation and allergies to infections, e.g., tuberculosis.



Key Elements of Hazard Evaluation

- Route of entry of the chemical into the body.
- Quantity of material that must be in contact with a body cell and for what period of time to produce injury.
- Probability that the material will be absorbed or come in contact with body cells.
- Rate of generation of airborne contaminants.
- Control measures in place.

Routes of Entry

- Inhalation
  - Involves airborne contaminants that can be inhaled directly into the lungs
  - Is the major route of entry for hazardous chemicals in the work environment
- Absorption
  - Absorption through the skin can occur quite rapidly if the skin is cut or abraded
- Ingestion
  - Toxic compounds can be absorbed from the gastrointestinal tract into the blood
  - Toxic materials that are readily soluble in digestive fluids can be absorbed into the blood from the digestive system

Human Health Risk Assessment

Step 1: Hazard Identification

- What health problems are caused by the pollutant?

Step 2: Dose-Response Assessment

- What are the health problems at different exposures?

Step 3: Exposure Assessment

- How much of the pollutant are people exposed to during a specific time period?
- How many people are exposed?

Step 4: Risk Characterization

- What is the extra risk of health problems in the exposed population?

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Air Contamination

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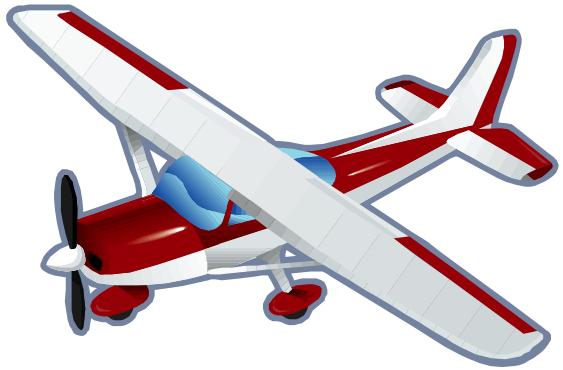
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Innovative



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Air Quality Index

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 – 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 – 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 – 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 – 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 – 300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

Hearing and Lung Conservation Program Requirements

- Exposure Monitoring
- Audiometric Testing
- Hearing Protection
- Employee Training
- Recordkeeping



Controlling Noise

Change the process to generate less noise:

- Alternative equipment – manual vs. automated
- Shield the noise-generating devices or processes at the source
- Shield the receiver
- Move noisy things away from the people, e.g., vacuum system motors, generators, etc.

Monitoring Strategy



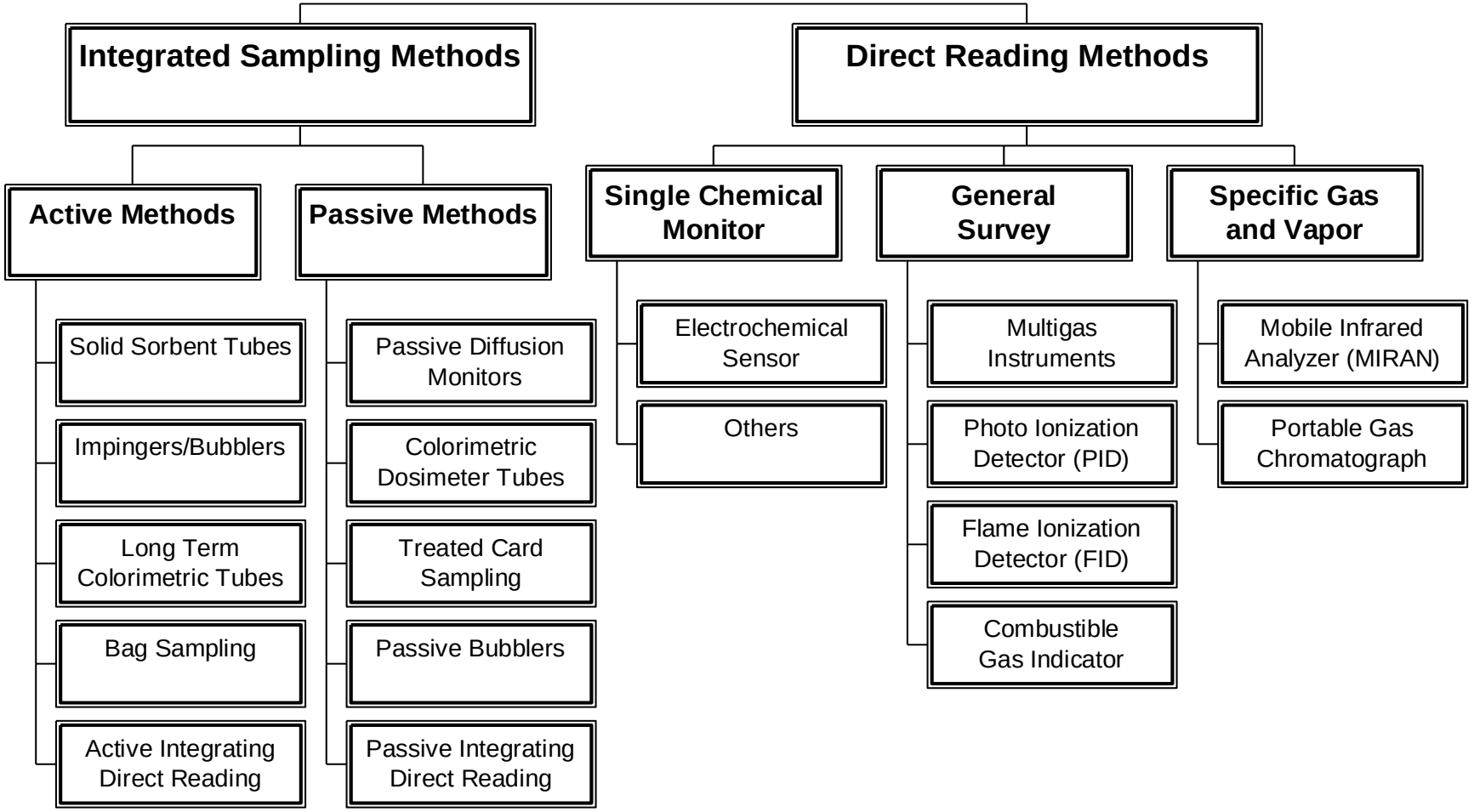
- Type of instruments to be used;
- Range of readings expected;
- Establishing action levels;
- Documentation procedures;
- Sampling procedures;
- Use approved NIOSH methods;
- Quality at the Source.

Industrial Air/Noise Sampling



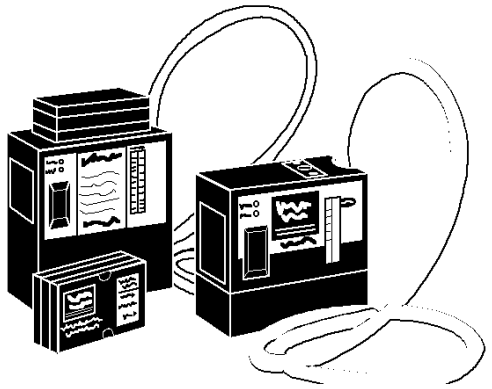
- Personal
  - Sampling device is directly attached to the employee and worn continuously in the breathing/hearing zone during all work and rest operations.
- Breathing/Noise Zone
  - Sampling device remains in worker's breathing/hearing zone throughout workday.
- General Air (Area)
  - More appropriate for measuring source emissions rather than personal exposures.

Gas and Vapor Techniques

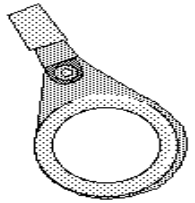


Active Air Sampling Methods

- Air moving device pulls air across sampling media or into measuring instrument.
- Most common device is the personal sampling pump.
- Requires careful calibration to determine flow rate of sampling pump.



Passive Air Sampling Methods



- Rely on natural air currents and/or worker movement to bring contaminant to surface of sampling device.
- Control the rate at which the sample moves from the surface of sampling device to the active sites on sampling media.
- Typically used for personal samples for gases and vapors.

Noise Measurement Devices

- Sound Level Meters (SLMs)
- Octave-Band Analyzers (OBAs)
- Noise Dosimeters
- Audiometers

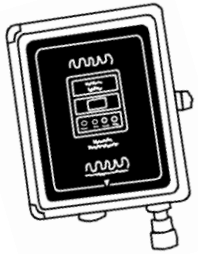


“Real-Time” Samplers



- Sometimes called direct reading or instantaneous monitors.

- Many instruments have continuously updated display and integrating capabilities for recordkeeping.



Sampling Best Practices

- Sample as much of the eight hours as possible to be representative;
- Take more than one consecutive sample (to increase the accuracy of the average);
- Keep sample times and sample volumes (e.g. flow rates) similar;
- Turn off and remove sampling pumps before an employee leaves a potentially contaminated area, such as breaks;
- Must have quality control over sample and count break times as part of 8 hour shift but not the lunch period.

Sampling Summary

- Great advancements in direct-reading instrument technology have been made in recent years
- However, still most direct-reading instruments are used only for qualitative field contaminant screening
- Validation of more direct-reading methods is an initiative of NIOSH

National Institute for Occupational Safety and Health
NIOSH

Sample Duration

- Full Period Consecutive Samples - two or more samples are obtained during the entire shift
- Full Period Single Sample – samples obtained during full period of shift (i.e. the same sample is taken all day long without changing media)
- Partial Period Consecutive Samples - one or more samples are obtained for only a portion of shift
- Grab Samples - taken over number of short periods of time (usually minutes or seconds) taken at random intervals over the shift

Occupational Standards

Hours of exposure	Occupation standard
8	90 dBA
4	95 dBA
2	100 dBA
1	105 dBA

- Maximum allowable impulse noise is 140 dBA.
- Maximum allowable continuous sound is 115 dBA.

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

Simulation – Round 3

Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

Emission Factors

- Representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant
- Expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant, e.g., pounds of VOC emitted per year.

Emission Equation

The general equation for emissions estimation is:

$$E = A \times EF \times (1-ER/100)$$

where:

E = emissions

A = activity rate

EF = emission factor

ER =overall emission reduction efficiency

Emission Calculation Steps

- Step 1
  - Know what is in the Emission
  - Determine what is volatile and non-volatile
- Step 2
  - Understand the difference between “Percent by Weight” and “Percent By Volume”
- Step 3
  - Calculate the emission content

Emission Calculation Example

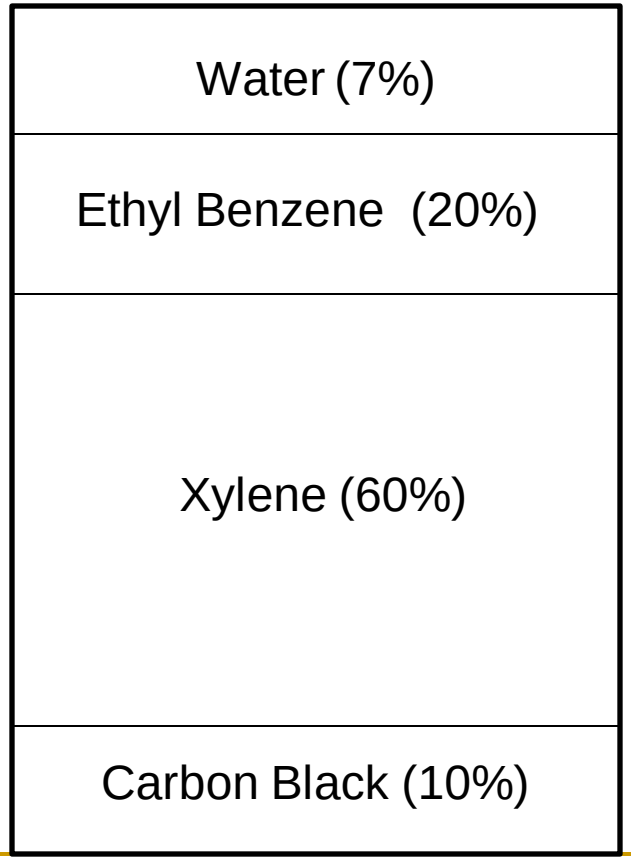
Company A applied 20,000 gallons of LCOAT coating last year.

Determine the pounds of VOC emitted last year.

- MSDS Information - Chemicals in LCOAT:
  - Ethylene benzene 15-20% by weight
  - Xylene 55-60% by weight
  - Carbon black <10% by weight
  - Water 7% by weight
- Density: 8.10 lb/gal

Step 1

Know what is in the Emission



Volatile:

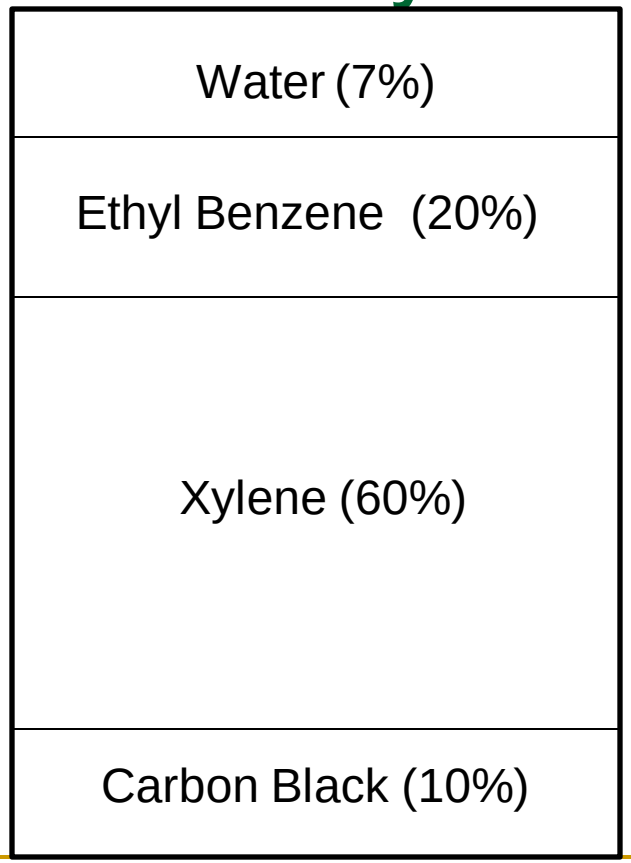
- Water
- Ethyl Benzene
- Xylene

Non-volatile:

- Carbon Black

Step 2

Understand difference between "% by Weight" and "% By Volume"



By Weight:

- Water
- Ethyl Benzene
- Xylene
- Carbon Black

Step 3

Calculate the emission content

Calculate pounds of VOC per gallon of coating.

% by weight VOC / 100 X density of coating = lbs VOC / gal of coating

80/100 X 8.10 lbs./gal = 6.48 lbs./gal

Calculate pounds of VOC emitted last year.

lbs VOC / gallon of coating X gallons of coating used / year = lbs VOC emitted / year

6.48 lbs/gal X 20,000 gal/year = 129,600 lbs/year

Threshold Limit Values (TLV)

- Airborne concentrations of substances and reprehensive conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect.
- Categories of TLVs:
  - TIME-WEIGHTED AVERAGE (TLV–TWA)
  - SHORT-TERM EXPOSURE LIMIT (TLV–STEL)
  - CEILING (TLV–C)

Time Weighted Average

- Use sampling media that collects the contaminant over the entire time period of the sample.
- Volume is determined from the pump flow rate (active sample) or the contaminant diffusion coefficient (passive sampling.)
- The combination of contaminant mass and sample volume gives an estimate of the concentration of the contaminant in the worker's zone "averaged" or "integrated" over the time of the sample.

Summary

- **Air Contamination**
  - Health Concerns
  - Ozone Changes
- **Air Pollution Prevention**
  - Classifications
  - Contamination Removal
- **Noise Pollution**
  - Hearing Loss
  - Effects
- **Industrial Hygiene**
  - Factors
  - Risk Assessment
- **Sampling and Measuring Emissions**
  - Strategies
  - Factors

One Key to Success

$$R = Q \times A$$

RESULTS = QUALITY OF SOLUTION **x** ACCEPTANCE

Course Agenda

Air Contamination

Simulation – Round 1

Air Pollution Prevention, Reduction & Treatment

Simulation – Round 2

Noise Pollution

Industrial Hygiene

Simulation – Round 3

Air / Noise Sampling & Control

Measuring Emissions

Course Evaluation

TECHNICAL ASSISTANCE PROGRAM

Green Enterprise Development

LEVEL 2

Green Specialist Certificate Series

Join us for the Pollution Solutions Workshop!

Learn how to use innovative methods to improve and reduce air pollution.

One-Day Workshop • Appropriate for engineers, green team participants and environmental managers

The Green Specialist: Pollution Solutions Workshop was designed by Purdue's Technical Assistance Program for manufacturers and others interested in learning how to use innovative methods to improve emission control and environmental management systems, and new technologies to reduce air pollution. Expect a fun, fast-paced workshop with simulations and case studies for in-depth instruction in applying green concepts and techniques.

Participants will learn:

- Air sampling benefits
- Methods to incorporate into emission control
- Ozone concerns and impacts
- New technologies for preventing air pollution
- How to lower emission expenses





Green Enterprise Development

Visit www.tap.purdue.edu/green to learn how to take the green movement to the next level.



How We Can Work With You: In addition to Green Enterprise Development, Purdue's Technical Assistance Program offers on-site public workshops and provides implementation and consulting services.

For workshop dates or to register: Visit www.tap.purdue.edu/green under "Register for Events." Cost is $395/per person.

For more information: Contact Abbey Maddy via phone at (800) 877-5182 ext. 620 or email amaddy@purdue.edu.

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Indianapolis, IN 46278-2012
(800) 877-5182 or (317) 275-6810 Fax (317) 275-2375
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PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM

Green Chemistry



Managing Chemical Use &
Hazardous Waste

Purpose of This Module

- To provide an understanding of chemical waste streams.
- To identify methods to reduce chemical use and the associated chemical waste that results from production.
- To provide strategies for incorporating chemical and hazardous waste reduction into an overall sustainability approach.

Course Agenda

The Principles of Green Chemistry

Regulatory Requirements and Directives

Environmental Hazard Prevention/Reduction

Exercise: Cleaners

Design Improvement

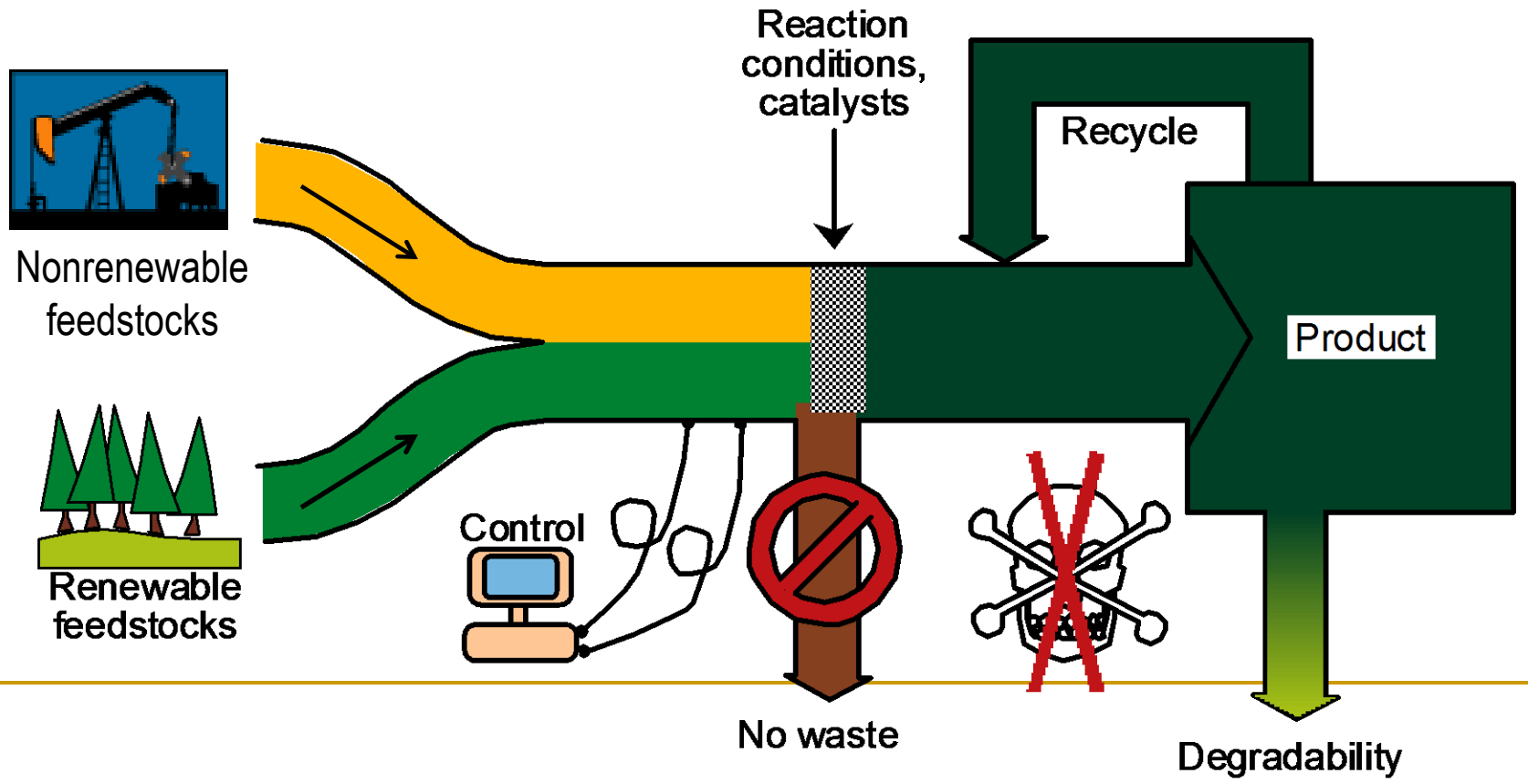
Process Improvement

Measuring Chemical Use/Waste

Course Evaluation

What is Green Chemistry?

Sustainable practice of chemical science and manufacturing within a framework of industrial ecology that is safe, non-polluting, consuming minimum amounts of energy and material resources while producing virtually no wastes.



Definitions

- Catalyst: a substance that speeds up a chemical reaction without itself undergoing any permanent chemical change.
- Reagent: a substance or compound consumed during a chemical reaction.
- Solvent: a liquid or gas that dissolves a solid, liquid, or gaseous solute, resulting in a solution.
- Acid: any chemical compound that, when dissolved in water, gives a solution with a hydrogen ion activity greater than in pure water.
- Base: an aqueous substance that can accept hydrogen ions, also the oxides or hydroxides of metals.
- Enzymes: biomolecules that catalyze, or increase the rates, of) chemical reactions.

Green Chemistry Philosophy

- Design products and processes to reduce use and generation of hazardous substances.
- Design processes to maximize raw material that ends up in the product;
- Use safe, environment-benign substances, including solvents;
- Design energy-efficient processes;
- Utilize the best form of waste disposal -- do not create waste in the first place!



More Like Mother Nature

Plants, for example, have access only to air, a few trace minerals in the soil and energy from the sun, yet they carry out hugely complex chemical transformations.

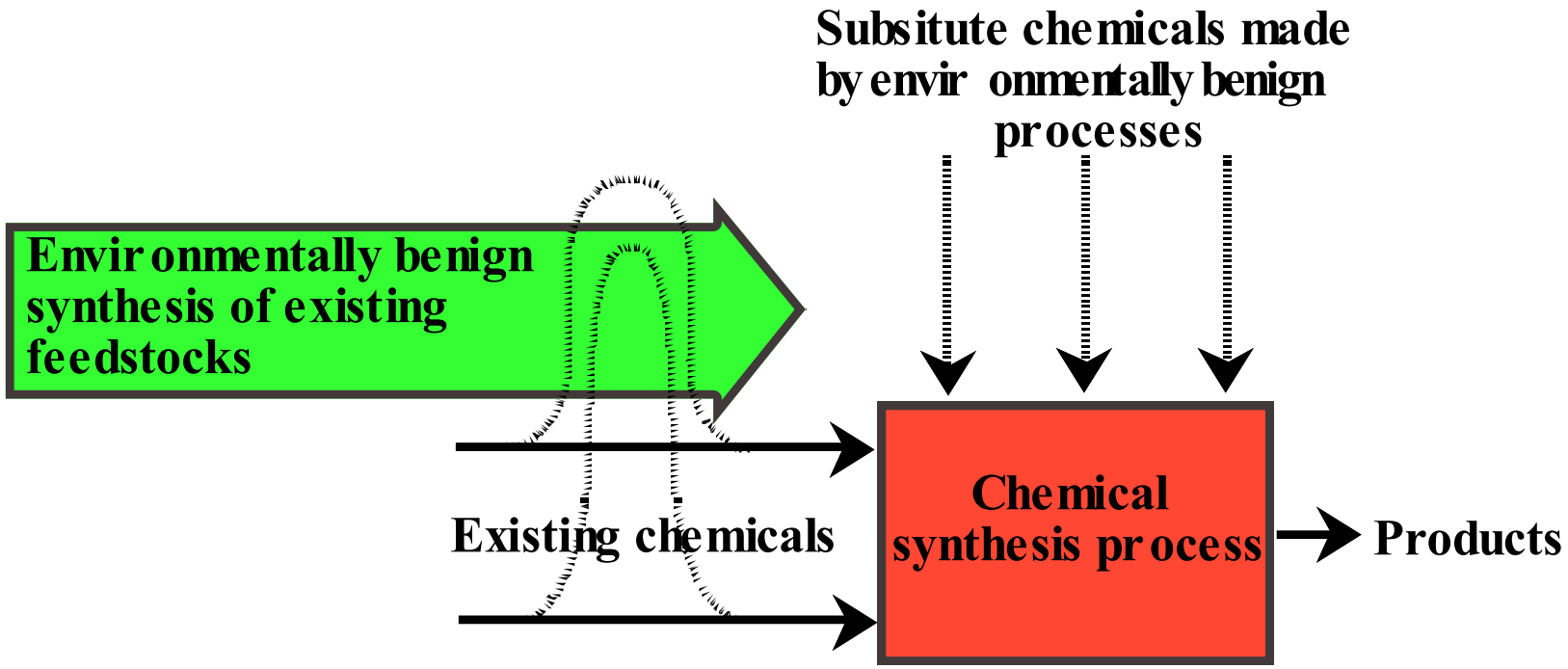


Green Chemistry - PRODUCTIVELY

Prevent wastes
Renewable materials
Omit derivation steps
Degradable chemical products
Use safe synthetic methods
Catalytic reagents
Temperature, pressure ambient
In-process monitoring
Very few auxiliary substances
E-factor, maximize feed in product
Low toxicity of chemical products
Yes, it is safe

Green vs. Synthetic Chemistry

Synthetic chemistry involves finding ways to make new chemicals and alternate ways to make known chemicals.



Course Agenda

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Drivers for Change



International Drivers: ROHS

- Commonly referred to as the ***Restriction of Hazardous Substances Directive***
- Adopted in February 2003 by the European Union.
- Restricts the use of six hazardous substances in the manufacture of electrical and electronic equipment :
  - Restricts use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs) (7/06)
  - Deca-bromodiphenylether (deca-BDE) (6/08)

International Drivers: WEEE

- The **Waste Electrical and Electronic Equipment Directive** is another European Directive which became law in February 2003.

- The directive imposes the responsibility for the end-of-life management of waste from electrical and electronic equipment onto the manufacturers of such equipment.

International Drivers: REACH

- The law which went into force on June 1, 2007, is one more European Community Regulation focused on chemicals and their safe use.
- Deals with the **R**egistration, **E**valuation, **Authorization** and Restriction of **Ch**emical substances.
  - Requires all manufacturers and importers into the European Union (EU) to register all chemical substances into a database managed by the European Chemicals Agency in Helsinki (11/08)

Environmental Management System

- ISO 14001 is an international standard that provides a *framework* for continual improvement of environmental performance, control and regulatory compliance.
  - Became a standard in 1996, with the most recent version being released in 2004.
  - Implementers select Significant Aspects and Impacts which may include Chemical management application.

ISO 14001
Environmental Aspects / Impacts

- Significant Aspect:
  Proper labeling and segregation of chemicals in storage areas

- Objectives:
  Implement and maintain proper labeling and segregation of chemicals
  Reduce both types and quantities of chemical used in the plant

- Target:
  Hazardous chemicals

- Area or Product Line:
  All departments

ISO 14001
Environmental Aspects / Impacts

- Significant Aspect:
  Material Safety Data Sheets (MSDS)

- Objectives :
  Implement and maintain an updated knowledge base of MSDS

- Target:
  Develop and maintain chemical inventory list
  Assess and update as necessary current MSDS knowledge base

- Area or Product Line:
  All departments

EPA Drivers: Toxic Substances Act

- TSCA addresses the production, importation, use, and disposal of specific chemicals including polychlorinated biphenyls (PCBs), asbestos, radon, and lead-based paint.

EPA Drivers: Pollution Prevention Act

- PPA focused industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use.
- Practices include recycling, source reduction, and sustainable agriculture.

OSHA Drivers: MSDS

- The purpose of a ***Material Safety Data Sheet*** is to inform industrial purchasers and users of hazardous chemicals of the reasonably foreseeable physical and chemical hazards that may arise from the use of those chemicals.
- Most materials packaged for consumer use are exempt from the requirements of the Hazard Communication Standard (HCS).
- The MSDS should include precautions for normal use, handling, storage, disposal, and spill cleanup.

OSHA Drivers: MSDS (continued)

- The recommended format for MSDS includes 16 sections:

Identification
Hazard(s) identification
Composition/information on ingredients
First-aid measures
Fire-fighting measures
Accidental release measures
Handling and storage
Exposure controls/personal protection
Physical and chemical properties
Stability and reactivity
Toxicological information
Ecological information
Disposal considerations
Transport information
Regulatory information
Other information

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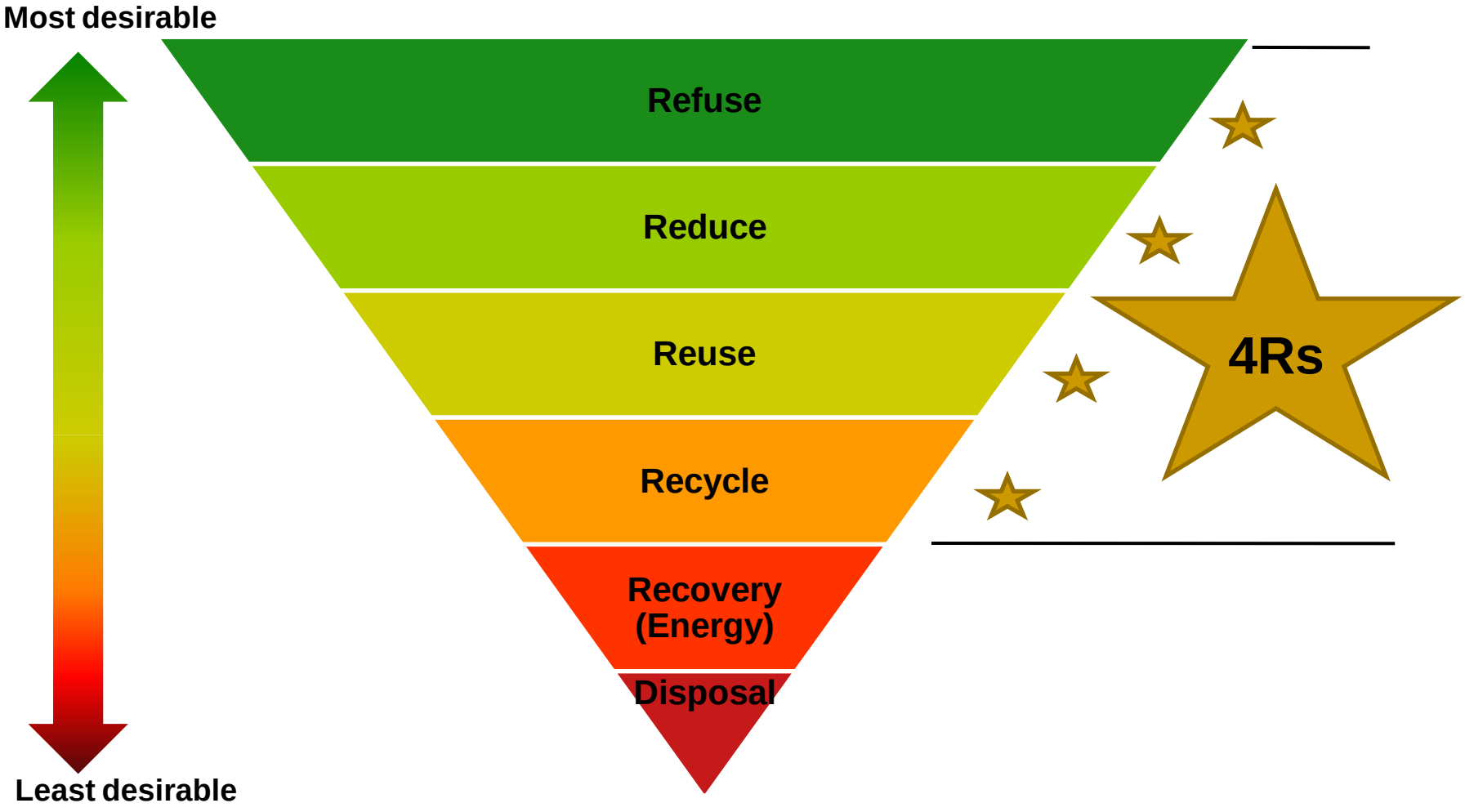
Design Improvement

Process Improvement

Measuring Chemical Use/Waste

Course Evaluation

Waste Hierarchy



Sustainable Chemistry Hierarchy

- Source reduction and/or prevention of chemical hazards:
  - Use feedstocks and reagents that are less hazardous,
  - Design chemical products that are easier to reuse or recycle,
  - Design chemical products to be less hazardous;
- Reuse or recycle chemicals;
- Treat chemicals to render them less hazardous;
- Dispose of chemicals properly.

Chemical Waste Prevention

- Implement process controls;
- Optimize solvent use;
- Improve maintenance to eliminate fugitive emissions;
- Change to continuous processes vs. batch;
- Choose the least environmentally detrimental options.

Chemical Waste Reduction

- Use fewer fossil fuels;
- Choose alternative materials, such as:
  - Select nanocoatings to reduce cutting oil use,
  - Apply polymers to metal components to repel grease and oil to reduce cleaning,
  - Choose synthetic motor oils that require fewer oil changes;
- Do not bleach, e.g., food products.

Chemical Waste Recycle/Reuse

- Energy recovery, e.g., natural gas, methane
- Solvent reclamation;
- Hydraulic oil filtering;
- Etching acid recovery;
- Catalyst recovery, e.g., exotic metals.

Chemical Substitution

- Substitute non-toxic or less toxic cleaners /detergents/ solvents;
- Replace rodent poison with traps;
- Replace mercury thermometers;
- Use cleaning “erasers” instead of cleaner solutions;
- Use powder coating in place of solvent-based paints for coatings;
- Use software to determine the greenest methods and reagents: rowan.edu/greenengineering.

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Course Evaluation

Blind Test: Cleaners

- We’re going to test some different cleaning products without knowledge of what the cleaning product is.
- Each group will test the same cleaners on the same problem areas and provide independent feedback on the results.

Blind Test: Results

- What did you find during the blind test?
- Did all of the cleaning solutions work the same?
- What were the differences in the cleaning results?

Course Agenda

The Principles of Green Chemistry

Regulatory Requirements and Directives

Environmental Hazard Prevention/Reduction

Exercise: Cleaners

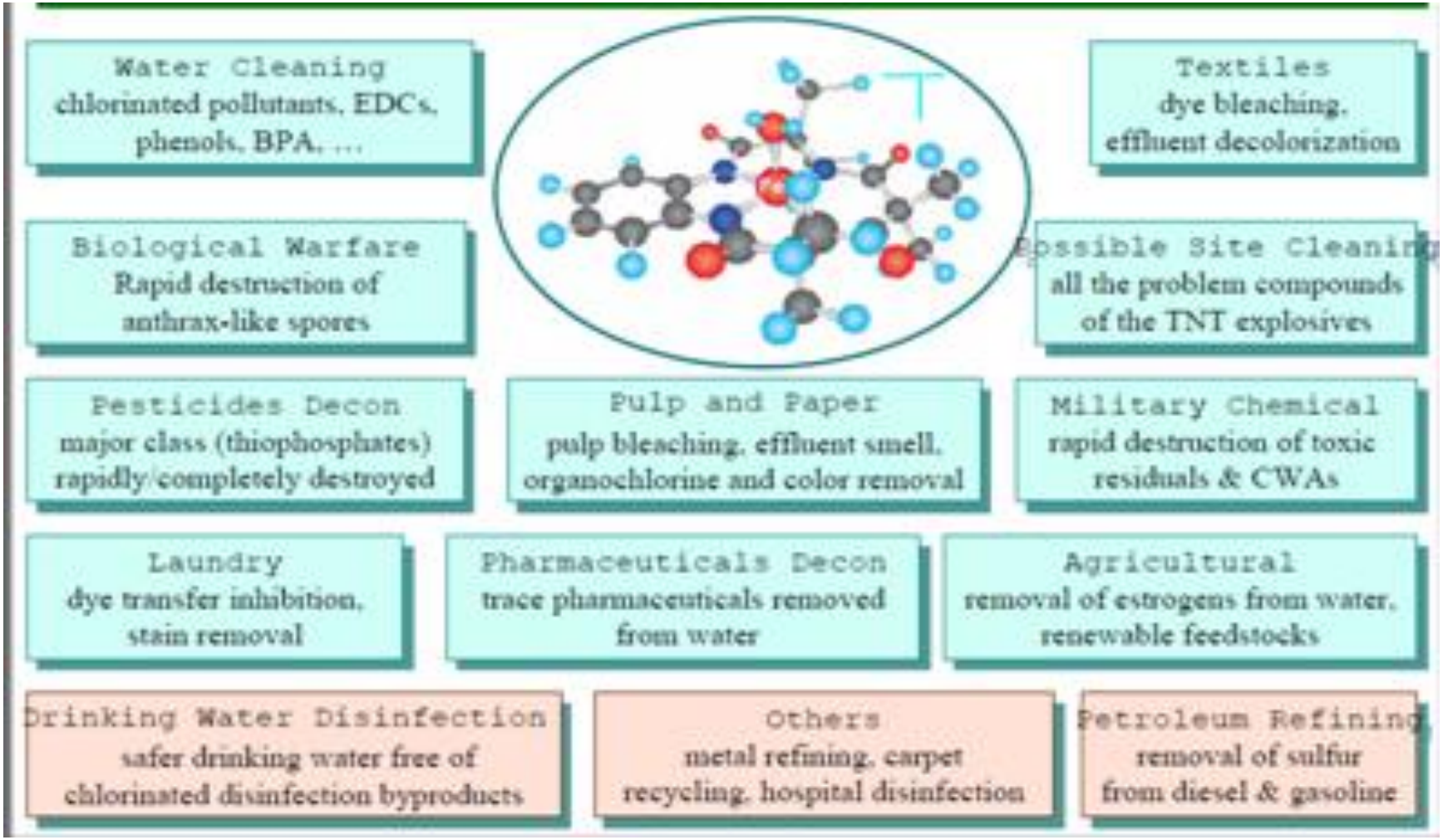
Design Improvement

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Measuring Chemical Use/Waste

Course Evaluation

Chemical Problems of the Past



Hit List Chemicals

- Toxic Heavy Metals:
  - Cadmium
  - Chromium
  - Cobalt
  - Lead
  - Copper
  - Mercury
  - Tin
  - Zinc
- Organic Solvents:
  - Perchloroethylene
  - Trichloroethylene
  - 1,1,1-Trichloroethane
  - Carbon tetrachloride
  - Methyl chloride
  - Methylene chloride

Sustainable Futures Assessment

Risk = Hazard x Exposure

- Environmental Fate Hazard

  (If Hazard = 0, Low Toxicity Concern)
  - Aquatic Toxicity
  - Cancer Health Effects / Non-Cancer Health Effects

- Exposure Assessment

  (If Exposure = 0, Minimal Exposure Expected)
  - Occupational
  - Aquatic
  - General Population

Reduction of Risk

Risk = F{hazard × exposure}

- Reduced exposure: The hazard remains, but exposure to it is reduced, such as by wearing safety goggles around an eye hazard (a command and control approach)
- Reduced hazard: The hazard is diminished or eliminated at its source; measures still may be taken to reduce exposure to remaining hazard
- Hazard exposure is less costly because costs of protective measures may be reduced

Failure Mode & Effects Analysis

- FMEA is a method used to assess *overall* risk in processes and products.
- Can be an excellent tool to identify *potential chemical hazards* associated with your process or product.

FMEA: Risk Priority Number

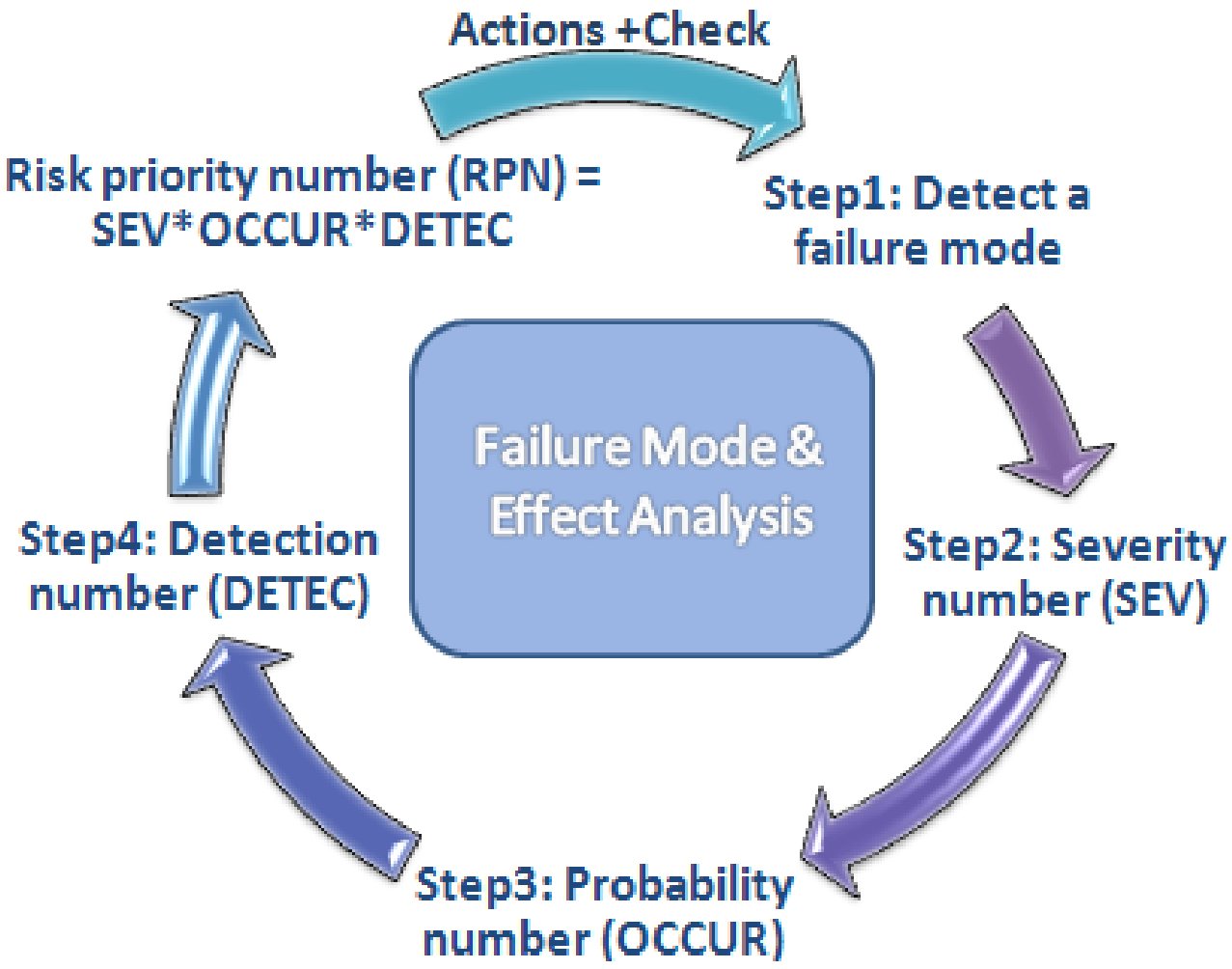
- **Severity (S)** Rating the impact of the hazard
- **Occurrence (O)** Rating the frequency of the hazard
- **Detection (D)** Rating the detectability of the hazard

By multiplying these three rating together, we get the

Risk Priority Number (RPN)

S X O X D = RPN

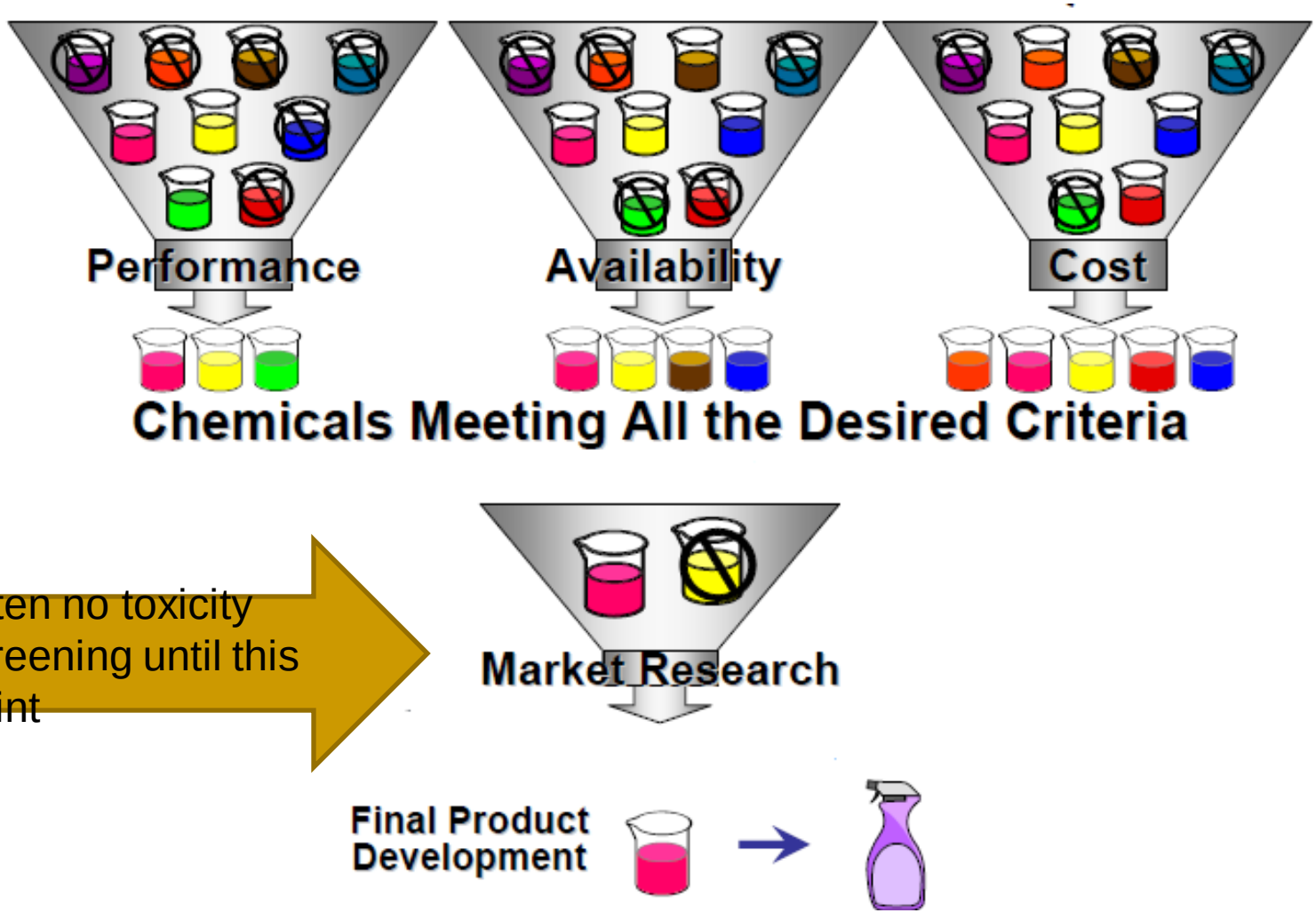
FMEA Steps


Actions +Check
Risk priority number (RPN) = SEV*OCCUR*DETEC
Step1: Detect a failure mode
Failure Mode & Effect Analysis
Step4: Detection number (DETEC)
Step2: Severity number (SEV)
Step3: Probability number (OCCUR)

Design: Producing Chemicals

- More efficient
  - fewer reaction steps,
  - fewer resources required,
  - less waste;
- Simpler to use
  - stable in air,
  - at normal temperatures and pressures;
- Environmentally friendly
  - non-hazardous components,
  - benign waste products.

Typical Product R & D of Past



Design FMEA

Function	Potential Failure Mode	Potential Effects(s) of Failure	S	Potential Cause(s) of Failure	O	Current Process Controls	D	RPN	CRIT	Recommended Action(s)	Responsibility and Target Completion Date	Action Results					
												Action Taken	S	O	D	RPN	CRIT
Dispense amount of cash requested by customer	Does not dispense cash	Customer very dissatisfied	8	Out of cash	5	Internal low-cash alert	5	200	**40**								
		Incorrect entry to demand deposit system		Machine jams	3	Internal jam alert	10	240	24								
		Discrepancy in cash balancing		Power failure during transaction	2	None	10	160	16								
	Dispenses too much cash	Bank loses money	6	Bills stuck together	2	Loading pro-cedure (riffle ends of stack)	7	84	12								
		Discrepancy in cash balancing		Denominations in wrong trays	3	Two-person visual verification	4	72	18								
	Takes too long to dispense cash	Customer somewhat annoyed	3	Heavy computer network traffic	7	None	10	210	21								
				Power interruption during transaction	2	None	10	60	6								

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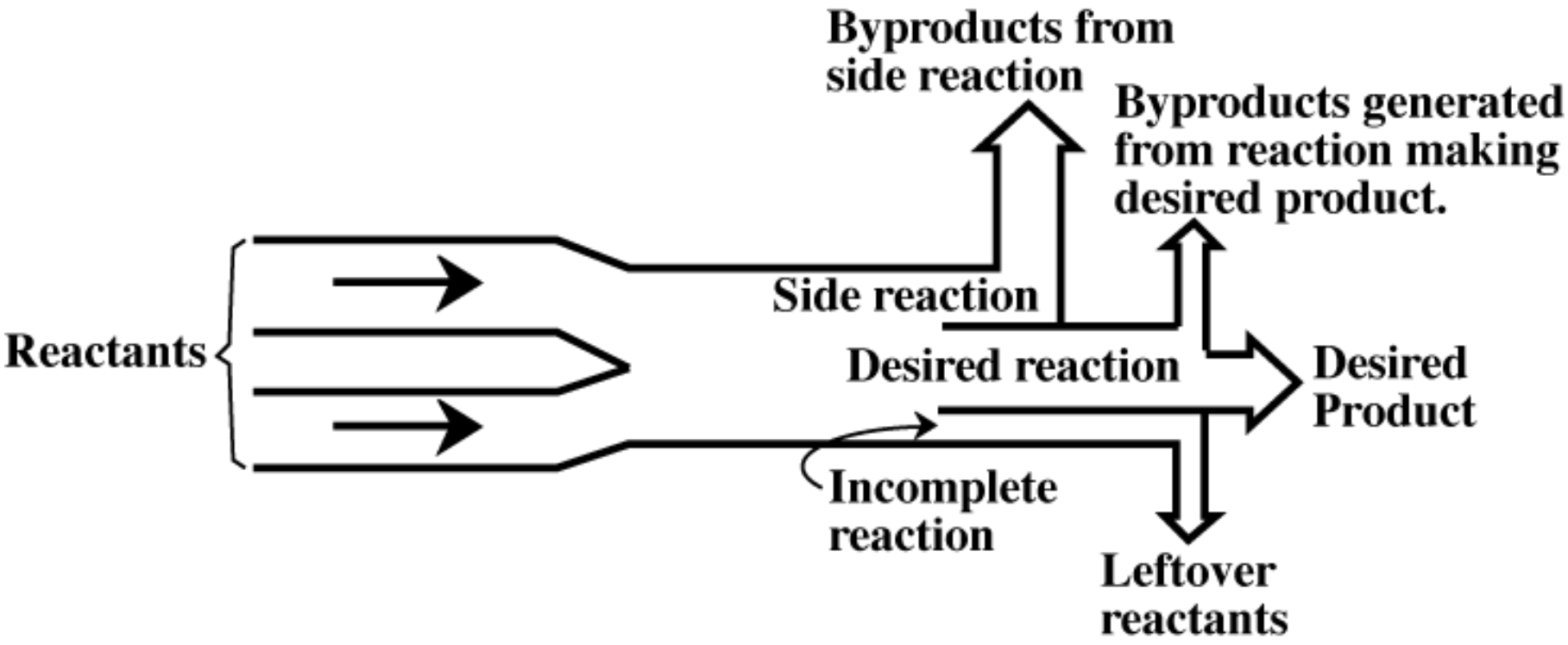
Measuring Chemical Use/Waste

Course Evaluation

Questions to Ask

- Why should a certain process use a certain route which can have a negative impact on the workers or environment?
  - Is an alternative available?
- Why should a certain material be used in an application?
  - Can another one be used that lasts longer, can be reused, and is still cost effective?
- What is the source of the chemical waste that is being generated?

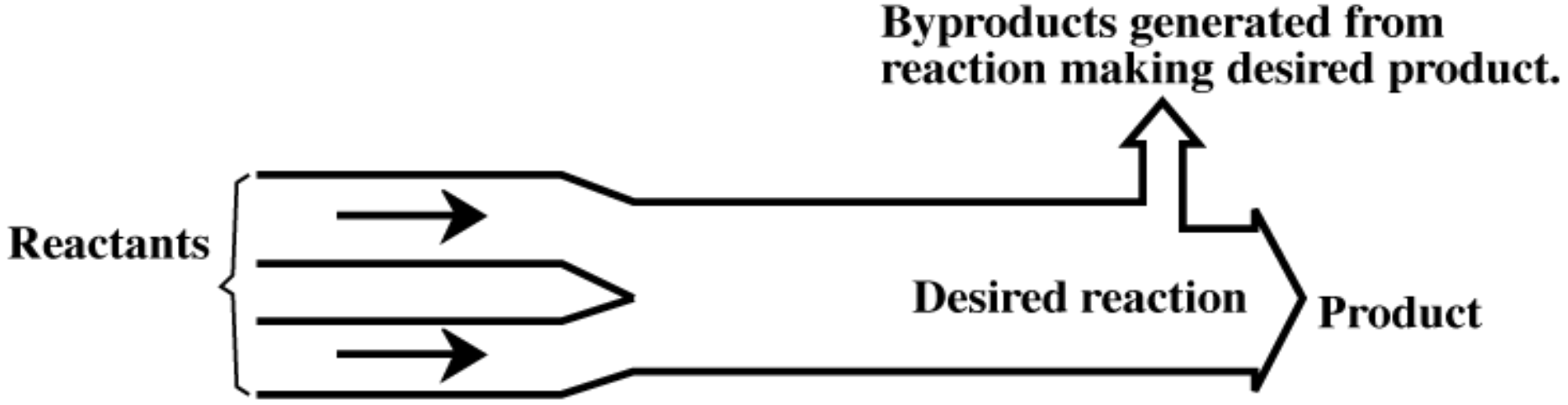
Reaction Byproducts



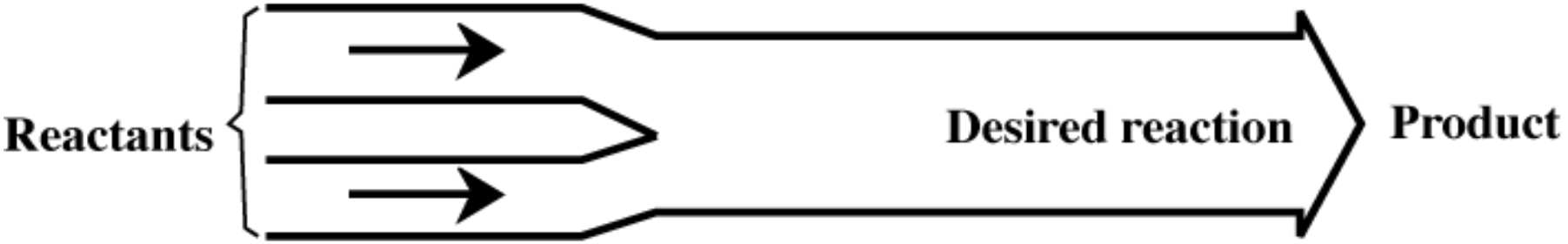
(a) Typical reaction with less than 100% yield and with byproducts

Typical reaction with less than 100% yield and with byproducts

Zero Waste is the Goal



(b) Reaction with 100% yield, but with byproducts inherent to the reaction



(c) Reaction with 100% atom economy, no leftover reactants, no byproducts

Continuous Processes



- Fewer chemicals may be required in switching from batch reactions to continuous processing.
- Also safer, typically gives a higher purity product and may use less energy.

Process: Chemical Controls

- Manage chemical suppliers;
- Order chemicals in the most appropriate quantity;
- Maintain up-to-date chemical inventory lists;
- Get full disclosure on MSDS sheets;
- Error-proof to eliminate waste;
- Buy pre-mixed reagents for safety and time-savings;
- Implement take-back programs.

Process FMEA

Function	Potential Failure Mode	Potential Effects(s) of Failure	S	Potential Cause(s) of Failure	O	Current Process Controls	D	RPN	CRIT	Recommended Action(s)	Responsibility and Target Completion Date	Action Results					
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The Issue of Solvents

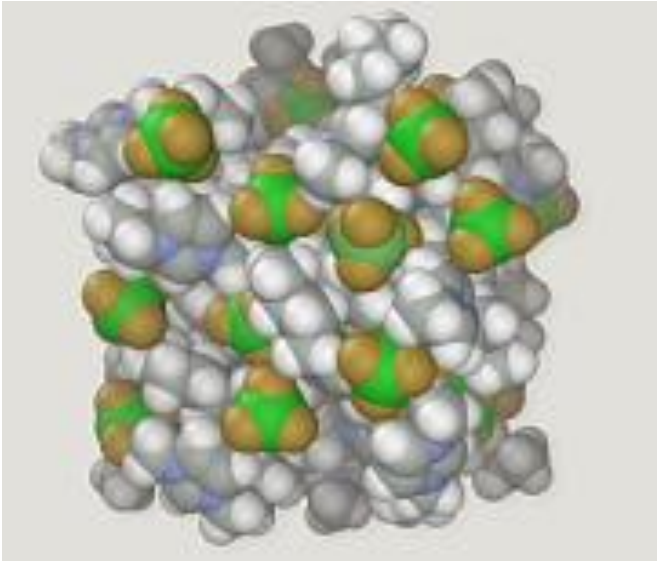
- Substitute with a less harmful solvent, such as water.
- Use Supercritical Carbon Dioxide as a solvent.
- Switch to another process requiring no solvent.
- Enclose the operation so the solvent is not lost.
- Place something on the plant outlet to destroy or recover the solvent.

Supercritical Carbon Dioxide

- Carbon dioxide in a fluid state while also being at or above both its critical temperature and pressure.
- Yields uncommon properties, adopt properties midway between a gas and a liquid.
- Becoming an important commercial and industrial solvent due to its role in chemical extraction, as well as its low toxicity and environmental impact.

Ionic Liquids

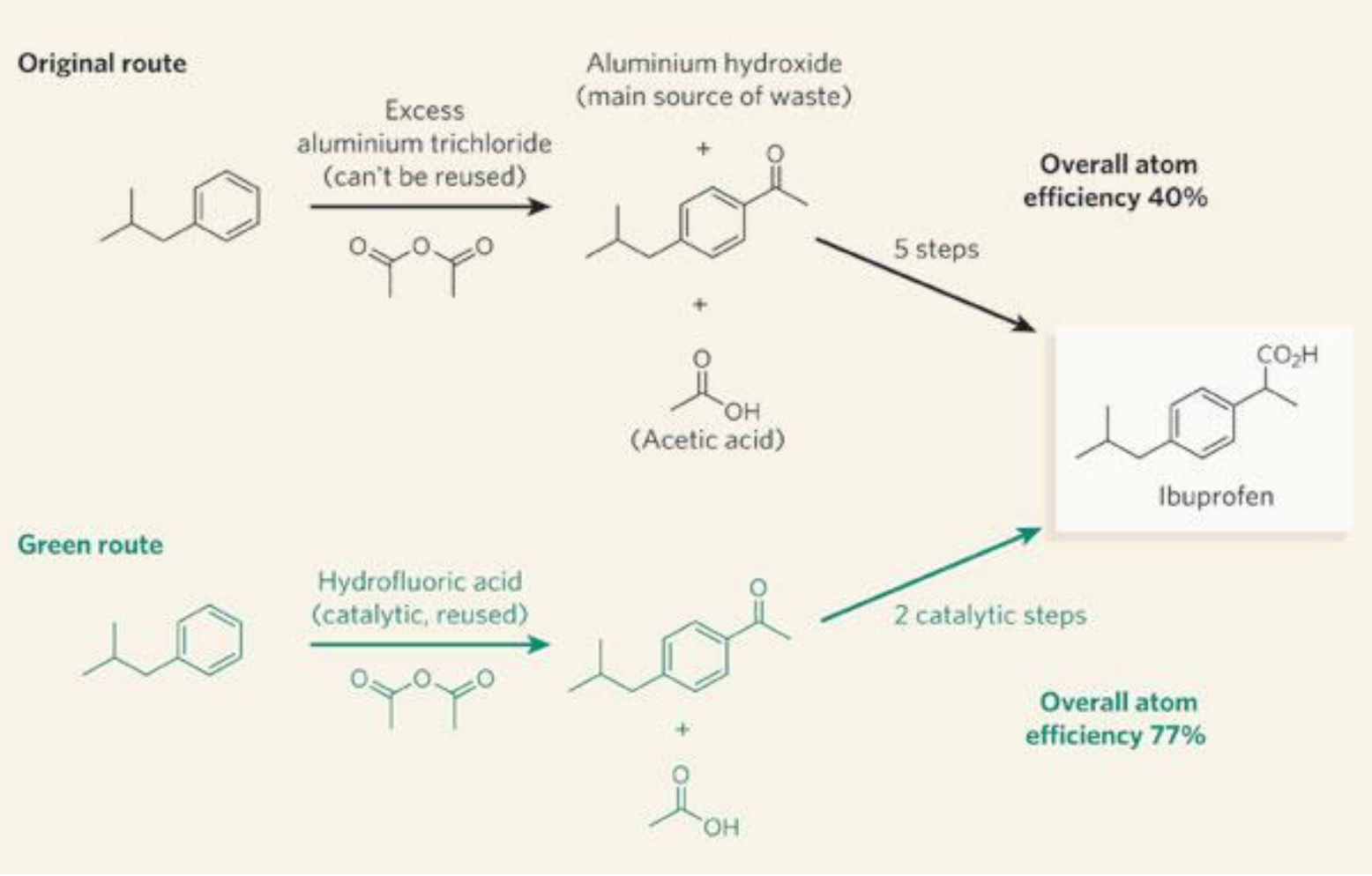
- Known as liquid electrolytes, ionic melts, ionic fluids, fused salts, liquid salts, or ionic glasses, generally used to refer to salts that form stable liquids.
- Of interest due to their extremely low- saturated vapor pressures.
- Also does not evaporate the way 'ordinary' liquids do, which has substantial scientific and commercial implications.



Disadvantages of Alternatives

- For water
  - Most organic compounds are insoluble in water
  - Recovering products (energy intensive to evaporate)
- For supercritical carbon dioxide
  - Energy intensive
- For ionic liquids
  - Potential toxicity

Process Improvement



Quantifying How Green a Process Is

- Several methods have been used but normally the easiest parameter to measure is the amount of waste generated per process:
  - From the balanced chemical equation for a process, the theoretical quantity of waste can be calculated per unit mass of starting material, assuming that the yield of product is 100% (in reality, the waste generated is typically higher than the theoretical)

Biomass Conversion

- The use of enzymatic reactions in place of conventional catalysis as a low cost option in the manufacture of several generic pharmaceuticals:
  - The use of enzymes to convert biomass (instead of petroleum feedstock) into chemicals has shown some process.
  - The downsides include the seasonal nature of crops, possible conflicts with food supplies, and variety in composition.

Roundup



- Monsanto developed an alternative way of making the popular herbicide Roundup®.
- They now avoid the use of extremely toxic hydrogen cyanide, along with avoiding production of cyanide-containing waste.
- Risks to people working at the manufacturing plant, to those living nearby and to the environment, are greatly reduced.
- Much smaller amount of waste produced is also safer since it does not contain cyanide.

Facility / Grounds Maintenance

- Instead of fogging, or treating the entire facility with insecticide, using crack and crevice methods for specific areas.
- Preventing infestation with more efficient cleaning practices, better pest control barriers.
- Using trapping methods instead of poison.



Course Agenda

The Principles of Green Chemistry

Regulatory Requirements and Directives

Environmental Hazard Prevention/Reduction

Exercise: Cleaners

Design Improvement

Process Improvement

Measuring Chemical Use/Waste

Course Evaluation

Green Chemistry is Sustainable

- Economic: At a high level of sophistication, green chemistry normally costs less in conventional economic terms (as well as environmental costs) than chemistry as it is traditionally practiced
- Materials: By efficiently using materials, maximum recycling, and minimum use of virgin raw materials, green chemistry is sustainable with respect to materials
- Waste: By reducing insofar as possible, or even totally eliminating their production, green chemistry is sustainable with respect to wastes

Green Chemistry Benefits

- Reduce waste which eliminate costly end-of stream treatments;
- Safer products;
- Reduced use of energy and resources;
- Improved competiveness of chemical manufacturers and their customers.

Internal Metrics

- Scrap
- Rework
- Permits- Air, water, solid waste
- Outputs of waste streams
- Utilities costs
- Chemical inventory
- MSDS
- Environmental aspects/impacts

E-factor

- The E-factor is the mass of the waste generated in the process divided by the mass of the product.
- All processes should aim at the lowest possible E-factor.
- For truly green processes, the E-factor should be zero.

Industry-Specific E-factor Examples

- Bulk chemical manufacturing = <5
  - However, volumes produced are high, thus, waste generated is also high.
- Pharmaceuticals = >100

The Risks of No Risks

- Refusal to take any risks can cause scientific and economic progress to stagnate.
- Example: Refusal to take the risks of thermally treating wastes (hazardous waste incineration) can lead to waste accumulation, or important industrial processes making the waste may be ceased.
- Example: Unwillingness to take risks involved with nuclear energy can lead to greenhouse warming from using fossil fuels or to economic stagnation from energy shortages.

Summary

- Modern life depends on the petrochemical industry.
- Most drugs, paints, and plastics are derived from a non-renewable resource.
- Current processes for making chemical products are not sustainable in terms of resources and environmental impact.
- Green chemistry aims to tackle this problem and real progress is being made.

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PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM

Green Chemistry



Managing Chemical Use &
Hazardous Waste

Purpose of This Module

- To provide an understanding of chemical waste streams.
- To identify methods to reduce chemical use and the associated chemical waste that results from production.
- To provide strategies for incorporating chemical and hazardous waste reduction into an overall sustainability approach.

Course Agenda

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Demonstration: Green Plastics

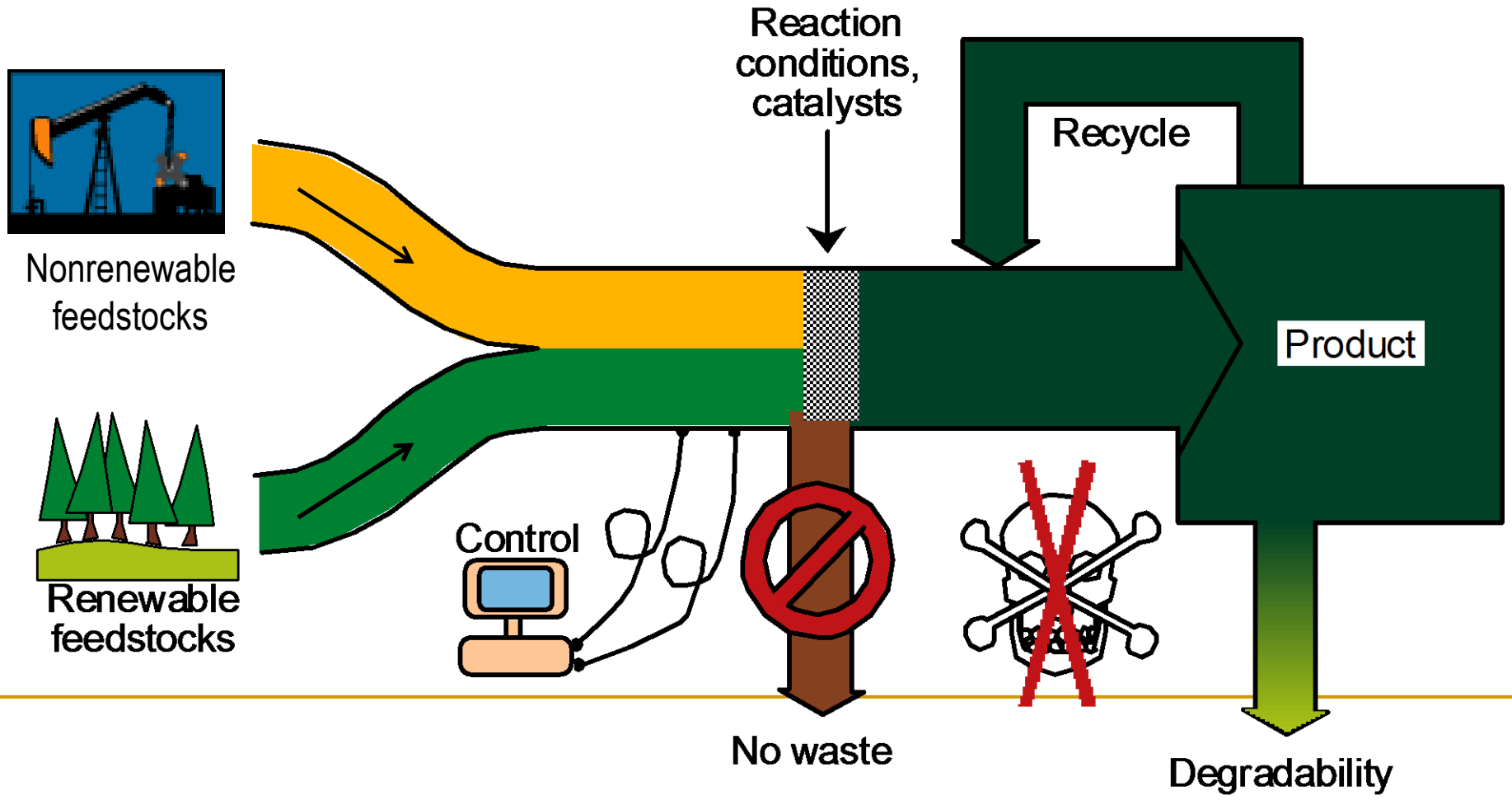
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Course Evaluation

What is Green Chemistry?

Sustainable practice of chemical science and manufacturing within a framework of industrial ecology that is safe, non-polluting, consuming minimum amounts of energy and material resources while producing virtually no wastes.



Definitions

- Catalyst: a substance that speeds up a chemical reaction without itself undergoing any permanent chemical change.
- Reagent: a substance or compound consumed during a chemical reaction.
- Solvent: a liquid or gas that dissolves a solid, liquid, or gaseous solute, resulting in a solution.
- Acid: any chemical compound that, when dissolved in water, gives a solution with a hydrogen ion activity greater than in pure water.
- Base: an aqueous substance that can accept hydrogen ions, also the oxides or hydroxides of metals.
- Enzymes: biomolecules that catalyze, or increase the rates, of) chemical reactions.

Green Chemistry Philosophy

- Design products and processes to reduce use and generation of hazardous substances.
- Design processes to maximize raw material that ends up in the product;
- Use safe, environment-benign substances, including solvents;
- Design energy-efficient processes;
- Utilize the best form of waste disposal -- do not create waste in the first place!



More Like Mother Nature

Plants, for example, have access only to air, a few trace minerals in the soil and energy from the sun, yet they carry out hugely complex chemical transformations.

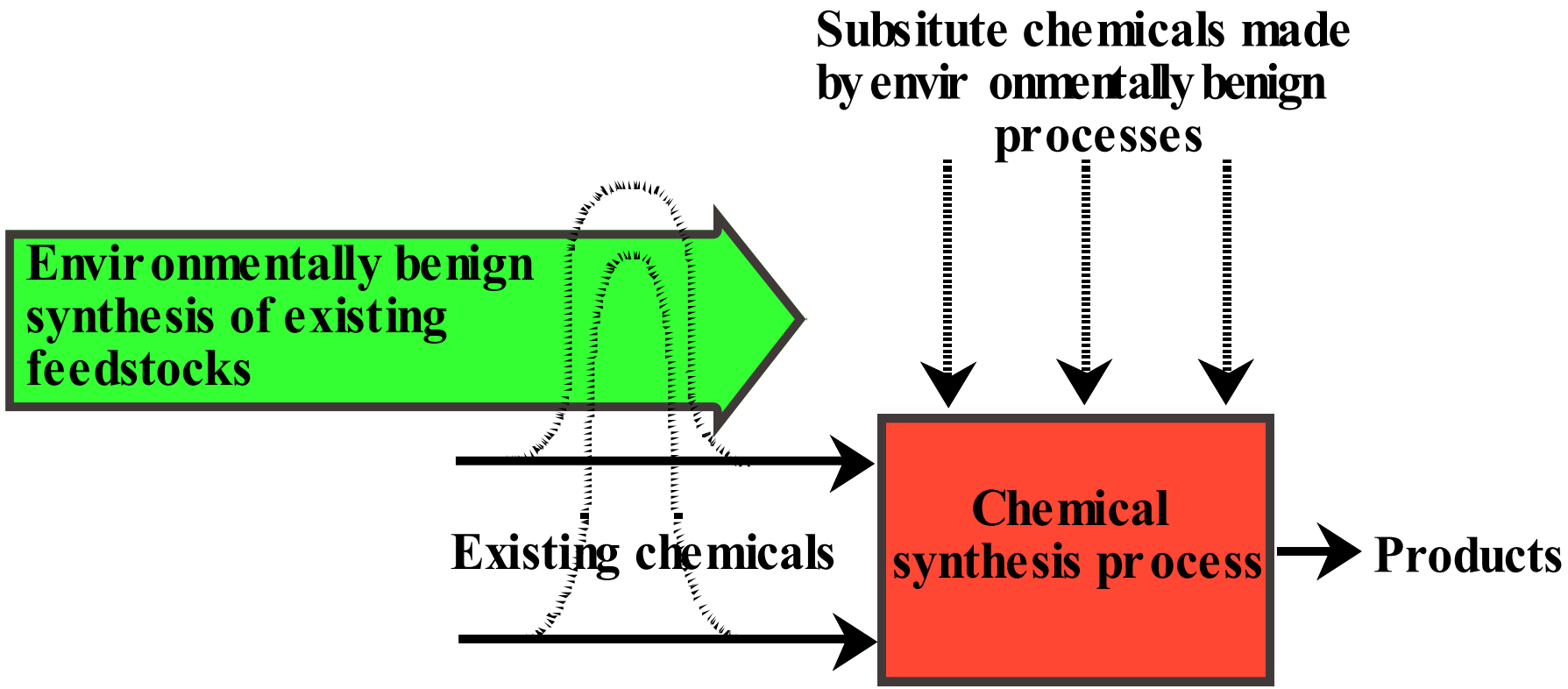


Green Chemistry - PRODUCTIVELY

Prevent wastes
Renewable materials
Omit derivation steps
Degradable chemical products
Use safe synthetic methods
Catalytic reagents
Temperature, pressure ambient
In-process monitoring
Very few auxiliary substances
E-factor, maximize feed in product
Low toxicity of chemical products
Yes, it is safe

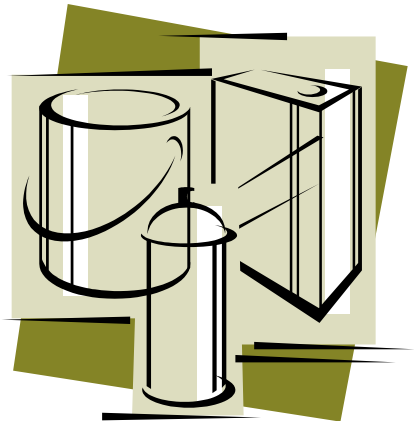
Green vs. Synthetic Chemistry

Synthetic chemistry involves finding ways to make new chemicals and alternate ways to make known chemicals.



Green Chemistry Addresses Hazards

- Applied to a wide range of industrial and consumer goods, including:
  - paints, dyes, fertilizers, pesticides, plastics, medicines, electronics, dry cleaning, energy generation, and water purification.



- Physical hazards - being explosive or flammable;
- Toxicity - being carcinogenic or cancer causing, or lethal;
- Global hazards - climate change or stratospheric ozone depletion.

Hazardous Waste

- Waste that is dangerous or potentially harmful to our health or the environment.
- Can be liquids, solids, gases, or sludges.
- Can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes.
- Typically require special handling, management and disposal.



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Hit List Chemicals

- Toxic Heavy Metals:
  - Cadmium
  - Chromium
  - Cobalt
  - Lead
  - Copper
  - Mercury
  - Tin
  - Zinc



- Organic Solvents:
  - Perchloroethylene
  - Trichloroethylene
  - 1,1,1-Trichloroethane
  - Carbon tetrachloride
  - Methyl chloride
  - Methylene chloride

Drivers for Change



International Drivers: ROHS

- Commonly referred to as the ***Restriction of Hazardous Substances Directive***
- Adopted in February 2003 by the European Union.
- Restricts the use of six hazardous substances in the manufacture of electrical and electronic equipment :
  - Restricts use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs) (7/06)
  - Deca-bromodiphenylether (deca-BDE) (6/08)

International Drivers: WEEE

- The **Waste Electrical and Electronic Equipment Directive** is another European Directive which became law in February 2003.

- The directive imposes the responsibility for the end-of-life management of waste from electrical and electronic equipment onto the manufacturers of such equipment.

International Drivers: REACH

- The law which went into force on June 1, 2007, is one more European Community Regulation focused on chemicals and their safe use.
- Deals with the **R**egistration, **E**valuation, **Authorization** and Restriction of **Ch**emical substances.
  - Requires all manufacturers and importers into the European Union (EU) to register all chemical substances into a database managed by the European Chemicals Agency in Helsinki (11/08)

Environmental Management System

- ISO 14001 is an international standard that provides a *framework* for continual improvement of environmental performance, control and regulatory compliance.
  - Became a standard in 1996, with the most recent version being released in 2004.
  - Implementers select Significant Aspects and Impacts which may include Chemical management application.

ISO 14001
Environmental Aspects / Impacts

- Significant Aspect:
  Proper labeling and segregation of chemicals in storage areas

- Objectives:
  Implement and maintain proper labeling and segregation of chemicals
  Reduce both types and quantities of chemical used in the plant

- Target:
  Hazardous chemicals

- Area or Product Line:
  All departments

ISO 14001
Environmental Aspects / Impacts

- Significant Aspect:
  Material Safety Data Sheets (MSDS)

- Objectives :
  Implement and maintain an updated knowledge base of MSDS

- Target:
  Develop and maintain chemical inventory list
  Assess and update as necessary current MSDS knowledge base

- Area or Product Line:
  All departments

EPA Drivers: Toxic Substances Act

- TSCA addresses the production, importation, use, and disposal of specific chemicals including polychlorinated biphenyls (PCBs), asbestos, radon, and lead-based paint.

EPA Drivers: Pollution Prevention Act

- PPA focused industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use.
- Practices include recycling, source reduction, and sustainable agriculture.

OSHA Drivers: MSDS

- The purpose of a ***Material Safety Data Sheet*** is to inform industrial purchasers and users of hazardous chemicals of the reasonably foreseeable physical and chemical hazards that may arise from the use of those chemicals.
- Most materials packaged for consumer use are exempt from the requirements of the Hazard Communication Standard (HCS).
- The MSDS should include precautions for normal use, handling, storage, disposal, and spill cleanup.

OSHA Drivers: MSDS (continued)

- The recommended format for MSDS includes 16 sections:

Identification
Hazard(s) identification
Composition/information on ingredients
First-aid measures
Fire-fighting measures
Accidental release measures
Handling and storage
Exposure controls/personal protection
Physical and chemical properties
Stability and reactivity
Toxicological information
Ecological information
Disposal considerations
Transport information
Regulatory information
Other information

Course Agenda

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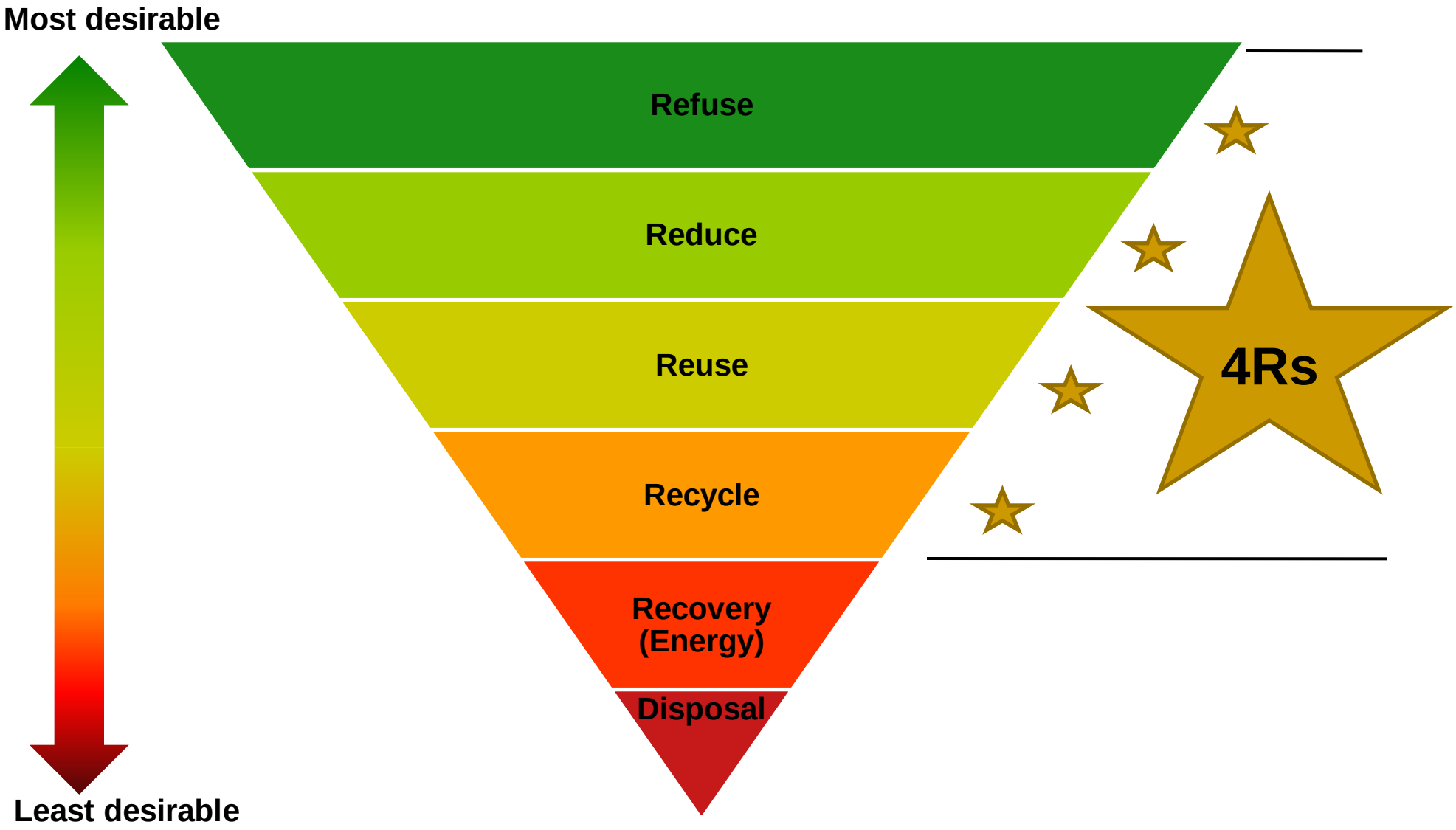
Demonstration: Green Plastics

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Waste Hierarchy



Sustainable Chemistry Hierarchy

- Source reduction and/or prevention of chemical hazards:
  - Use feedstocks and reagents that are less hazardous,
  - Design chemical products that are easier to reuse or recycle,
  - Design chemical products to be less hazardous;
- Reuse or recycle chemicals;
- Treat chemicals to render them less hazardous;
- Dispose of chemicals properly.

Chemical Waste Prevention



- Implement process controls;
- Optimize solvent use;
- Improve maintenance to eliminate fugitive emissions;
- Change to continuous processes vs. batch;
- Choose the least environmentally detrimental options.

Chemical Waste Reduction

- Use fewer fossil fuels;
- Choose alternative materials, such as:
  - Select nanocoatings to reduce cutting oil use,
  - Apply polymers to metal components to repel grease and oil to reduce cleaning,
  - Choose synthetic motor oils that require fewer oil changes;
- Do not bleach, e.g., food products.

Chemical Waste Recycle/Reuse

- Energy recovery, e.g., natural gas, methane
- Solvent reclamation;
- Hydraulic oil filtering;
- Etching acid recovery;
- Catalyst recovery, e.g., exotic metals.

E-Waste

- Secondary computers, entertainment device electronics, mobile phones, and other items such as television sets and refrigerators whose material or residue is dumped or disposed or discarded by the buyer rather than recycled, reused, etc.

- Causes serious health and pollution problems because it contains serious contaminants such as lead, cadmium, beryllium and brominated flame retardants.



E-Waste Problem: CRT Monitors

- Contain many valuable, but also toxic, substances, like Cadmium.
  - Used in rechargeable computer batteries, contacts and switches in older CRT monitors.
  - Can bio-accumulate in the environment and is extremely toxic to humans, in particular kidneys and bones.
  - Also banned in the European RoHS directive.
- CRT monitors also contain plastics, including: Polyvinyl chloride (PVC) cabling and printed circuit boards, connectors, plastic covers and cables.
  - When incinerated or land-filled, these PVCs release dioxins that affect human reproductive and immune systems.
- Mercury, which is used in lighting devices within the flat screen displays, can cause damage to the nervous system, kidney and brain, and can be passed on through breast milk.

E-Waste Problem: Mobile Phones

- Can contain over 40 elements including base metals (copper, tin, etc.), special metals (cobalt, indium, antimony, etc.), and precious metals (silver, gold, palladium, etc.)

- Li-Ion battery contains about 3.5 grams of cobalt.
  - This appears to be very little, but with the leverage of 1.2 billion mobile phones sold globally in 2007, this leads to a significant metal demand.

Reusing / Recycling E-Waste

- Due to the complex composition of valuable and hazardous substances, specialized, often “high tech” methods are required to process e-waste to maximize resource recovery and minimize potential harm to humans or the environment.
- Use of specialized methods is rare, with much of the world’s e-waste traveling to developing countries, where crude techniques are used to extract precious materials.
- Recycling in these instances usually focuses on a few valuable elements like gold and copper with often poor recycling yields, while most other metals are discarded.

Hazardous Waste Treatment/Disposal

- Treatment can neutralize the waste; recover energy or material resources; render the waste less hazardous; or make the waste safer to transport, store, or dispose.
- One common method of treatment is combustion or incineration, which is used to destroy hazardous organic constituents and reduce the volume of waste.



- Underground injection wells are the most commonly used disposal method for liquid hazardous waste.
  - Because of potential impact upon drinking water resources, these are also regulated under the Safe Drinking Water Act (SDWA) and by the Underground Injection Control (UIC) Program.

Priority & Toxic Chemicals Reduction



- U.S. EPA is working to eliminate or reduce priority chemicals in commercial products, waste streams, and industrial releases through programs like the National Partnership for Environmental Priorities (NPEP.)
- The 31 priority chemicals are Federal priorities because they are persistent, bioaccumulative, and highly toxic. The focus is on reducing priority and toxic chemicals to better protect human health and the environment.

Hazardous Waste Recycling

- Common hazardous waste reclamation activities involve recovery of spent solvents, e.g., acetone, or metals, e.g., lead.

- In 2007, about 1.8 million tons - just under 5% - of hazardous wastes were managed by recycling (metals, solvent, or other recovery).

Chemical Substitution

- Substitute non-toxic or less toxic cleaners /detergents/ solvents;
- Replace rodent poison with traps;
- Replace mercury thermometers;



- Use cleaning “erasers” instead of cleaner solutions;
- Use powder coating in place of solvent-based paints for coatings;
- Use software to determine the greenest methods and reagents: rowan.edu/greenengineering.

Course Agenda

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Blind Test: Cleaners

- We’re going to test some different cleaning products without knowledge of what the cleaning product is.
- Each group will test the same cleaners on the same problem areas and provide independent feedback on the results.

Blind Test: Results

- What did you find during the blind test?
- Did all of the cleaning solutions work the same?
- What were the differences in the cleaning results?

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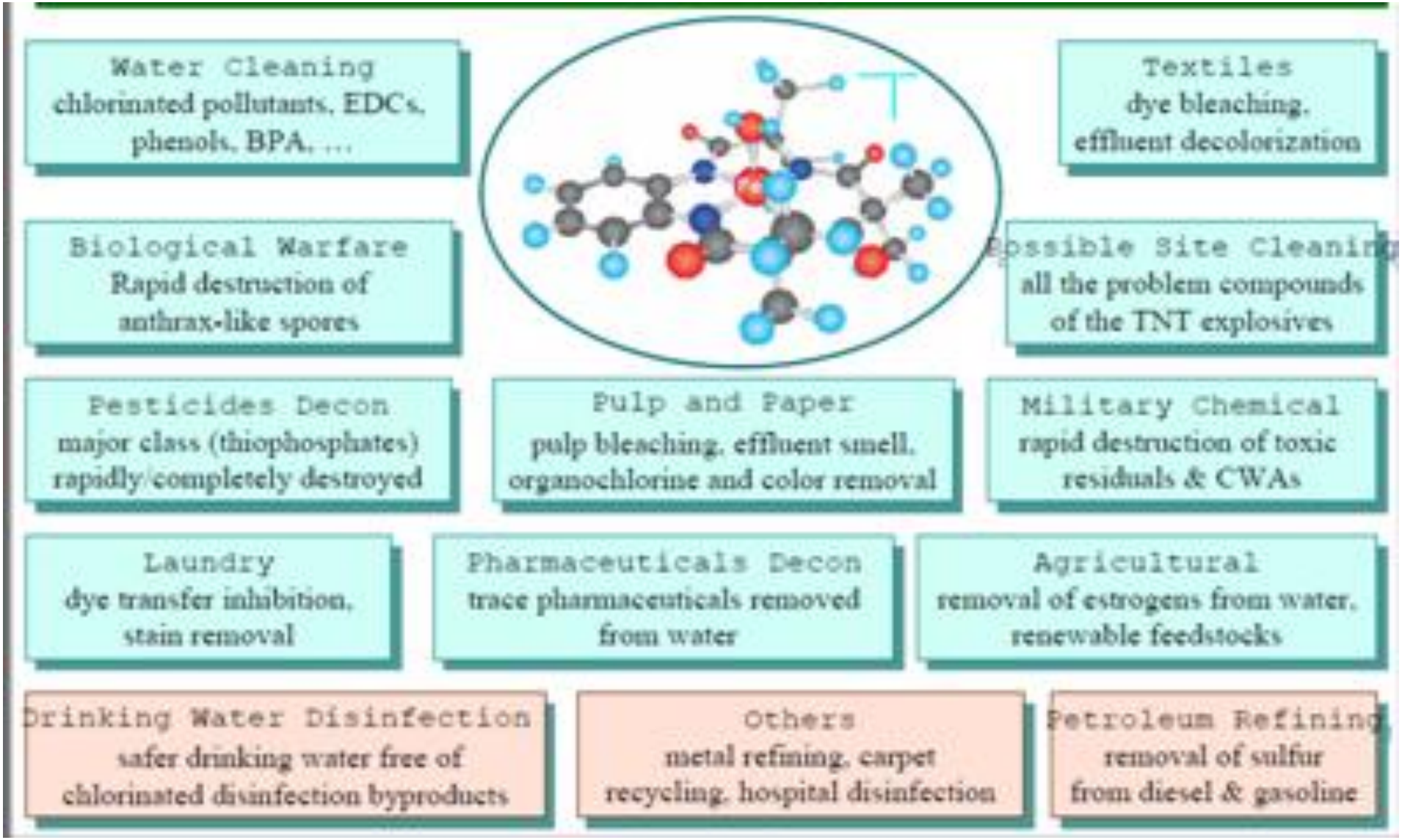
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Chemical Problems of the Past



Sustainable Futures Assessment

Risk = Hazard x Exposure

- Environmental Fate Hazard

  (If Hazard = 0, Low Toxicity Concern)
  - Aquatic Toxicity
  - Cancer Health Effects / Non-Cancer Health Effects

- Exposure Assessment

  (If Exposure = 0, Minimal Exposure Expected)
  - Occupational
  - Aquatic
  - General Population

Reduction of Risk

Risk = F{hazard × exposure}

- Reduced exposure: The hazard remains, but exposure to it is reduced, such as by wearing safety goggles around an eye hazard (a command and control approach)
- Reduced hazard: The hazard is diminished or eliminated at its source; measures still may be taken to reduce exposure to remaining hazard
- Hazard exposure is less costly because costs of protective measures may be reduced

Design: Producing Chemicals

- More efficient
  - fewer reaction steps,
  - fewer resources required,
  - less waste;
- Simpler to use
  - stable in air,
  - at normal temperatures and pressures;
- Environmentally friendly
  - non-hazardous components,
  - benign waste products.

Typical Product R & D of Past



Often no toxicity screening until this point.





Failure Mode & Effects Analysis

- FMEA is a method used to assess *overall* risk in processes and products.
- Can be an excellent tool to identify *potential chemical hazards* associated with your process or product.

FMEA: Risk Priority Number

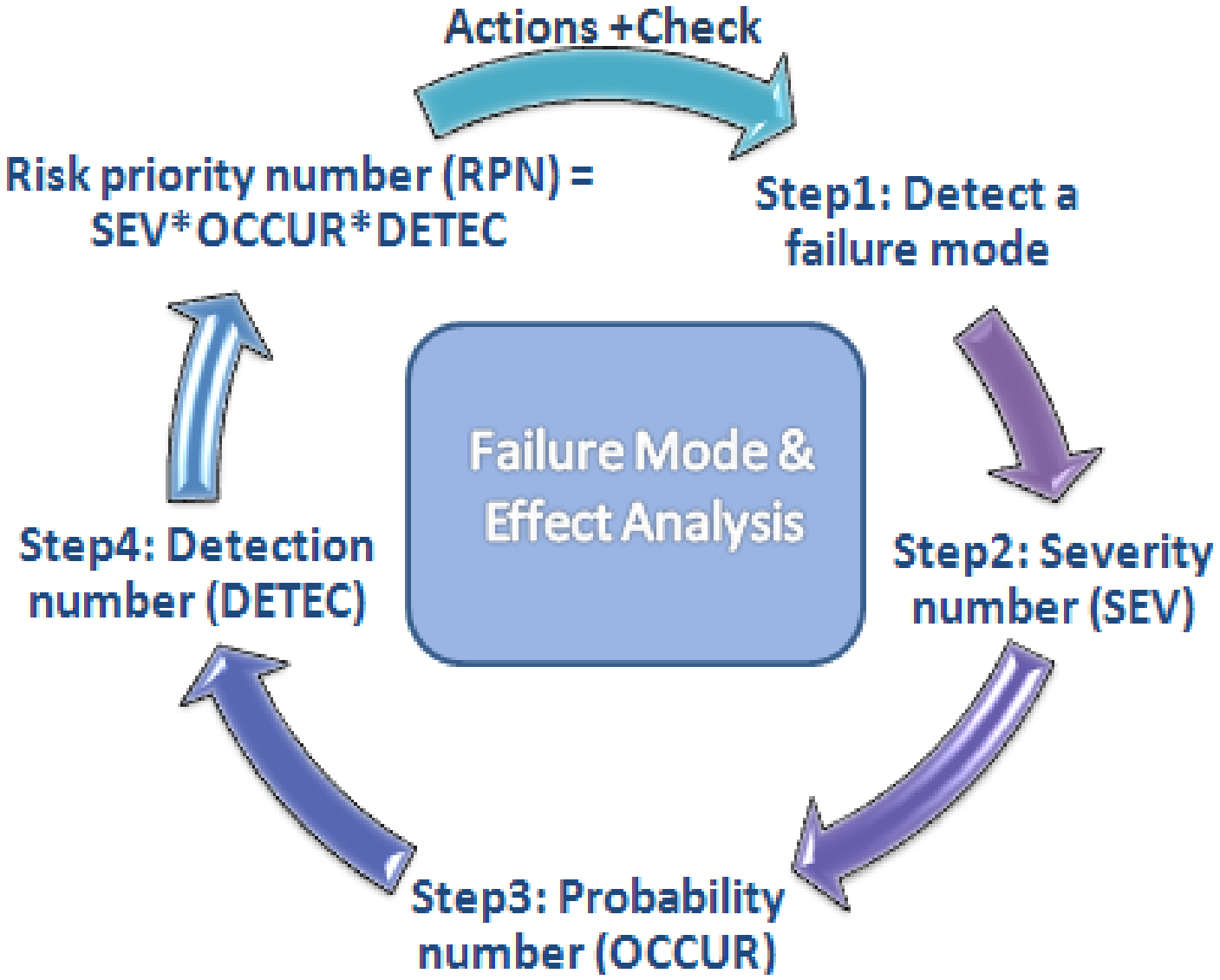
- **Severity (S)** Rating the impact of the hazard
- **Occurrence (O)** Rating the frequency of the hazard
- **Detection (D)** Rating the detectability of the hazard

By multiplying these three rating together, we get the

Risk Priority Number (RPN)

S X O X D = RPN

FMEA Steps


Actions +Check
Risk priority number (RPN) = SEV*OCCUR*DETEC
Step1: Detect a failure mode
Failure Mode & Effect Analysis
Step4: Detection number (DETEC)
Step2: Severity number (SEV)
Step3: Probability number (OCCUR)

Design FMEA

Function	Potential Failure Mode	Potential Effects(s) of Failure	S	Potential Cause(s) of Failure	O	Current Process Controls	D	RPN	CRIT	Recommended Action(s)	Responsibility and Target Completion Date	Action Results					
												Action Taken	S	O	D	RPN	CRIT
Dispense amount of cash requested by customer	Does not dispense cash	Customer very dissatisfied	8	Out of cash	5	Internal low-cash alert	5	200	**40**								
				Machine jams	3	Internal jam alert	10	240	24								
		Incorrect entry to demand deposit system		Power failure during transaction	2	None	10	160	16								
		Discrepancy in cash balancing															
	Dispenses too much cash	Bank loses money	6	Bills stuck together	2	Loading procedure (riffle ends of stack)	7	84	12								
		Discrepancy in cash balancing		Denominations in wrong trays	3	Two-person visual verification	4	72	18								
	Takes too long to dispense cash	Customer somewhat annoyed	3	Heavy computer network traffic	7	None	10	210	21								
				Power interruption during transaction	2	None	10	60	6								

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Green Plastics

Plastic Facts:

- Total volume of plastics produced worldwide has surpassed that of steel and continues to increase.
- Virtually all plastics are made from nonrenewable resources, such as oil, coal or natural gas.
- Plastics waste is increasing, adding to the already burdensome problems of waste management.

Green Plastics:

- Can be made using polymers that come from agricultural and marine feedstocks.
- Are biodegradable, making them a natural material for use in such applications as compostable collection bags for food or yard waste.

Bioplastics

- Have to possess adequate physical properties through the development of adequate formulations and plastics processing.
- Have to be cost-competitive. Commercially available biopolymers are typically more expensive than synthetic polymers.
  - Currently only starch competes with synthetic polymers in terms of cost.
- Need a paradigm shift.
  - Legislation
  - Consumer acceptance.

Green Plastic Manufacturing

- Let’s watch a demonstration of how a green plastic can be manufactured.



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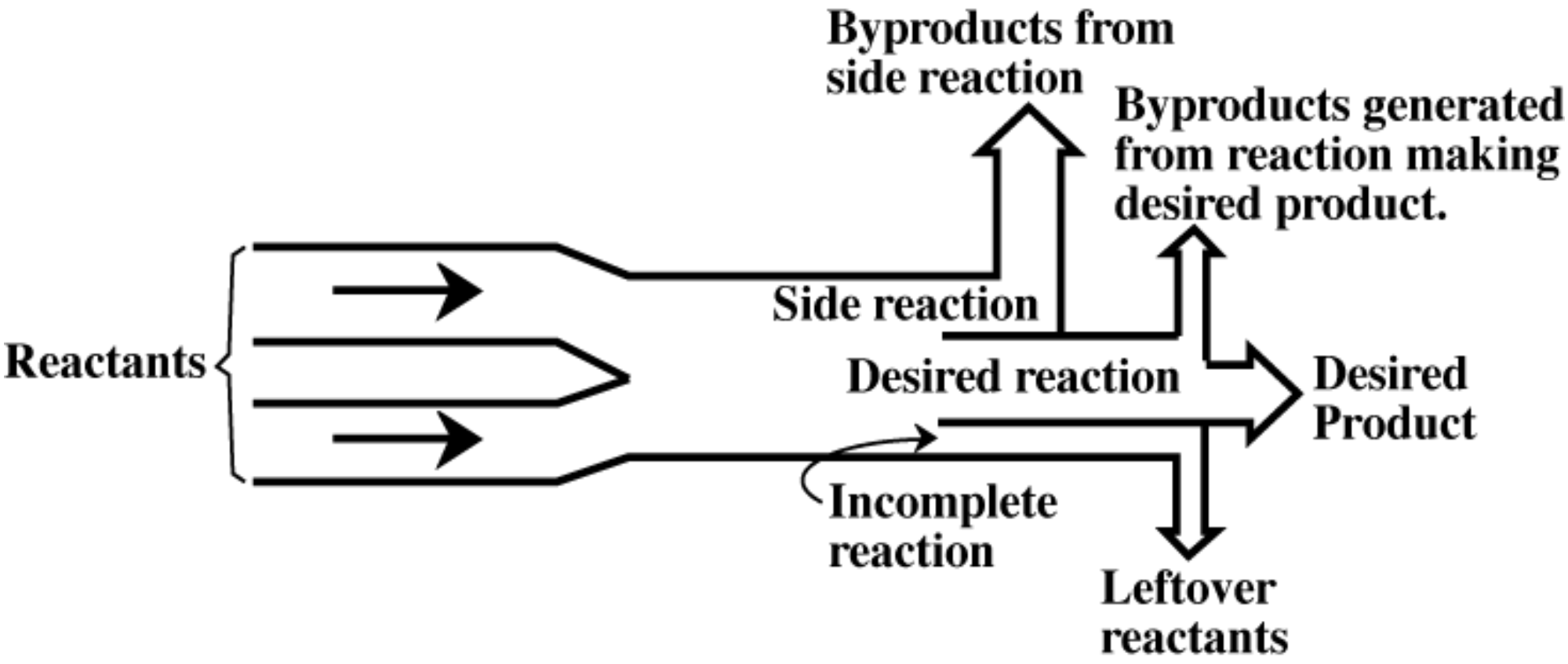
Measuring Chemical Use/Waste

Course Evaluation

Questions to Ask

- Why should a certain process use a certain route which can have a negative impact on the workers or environment?
  - Is an alternative available?
- Why should a certain material be used in an application?
  - Can another one be used that lasts longer, can be reused, and is still cost effective?
- What is the source of the chemical waste that is being generated?

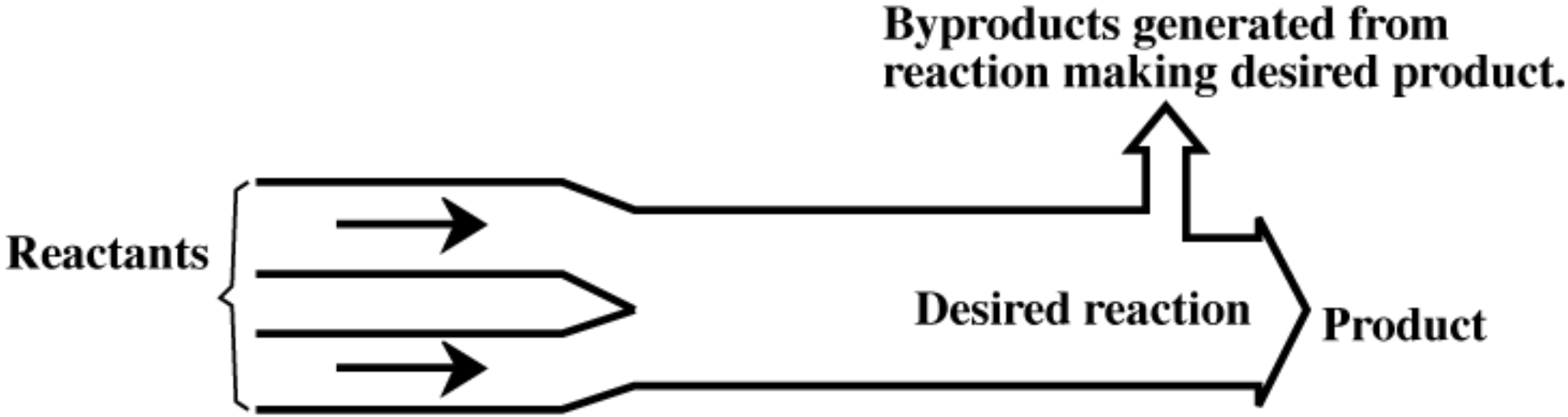
Reaction Byproducts



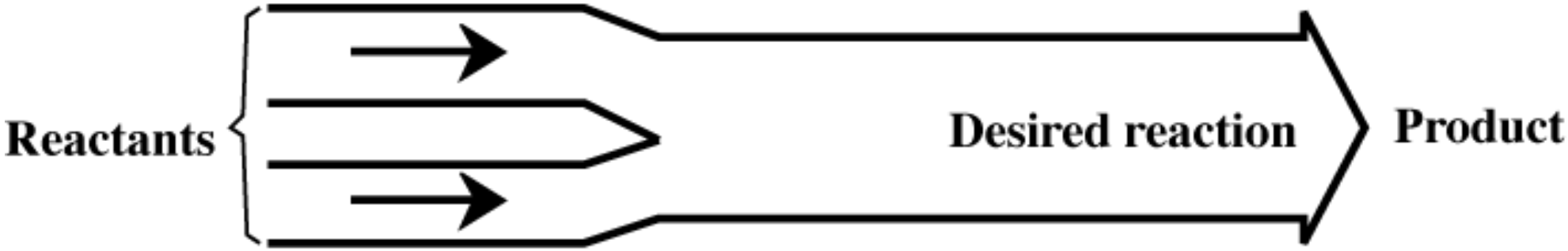
(a) Typical reaction with less than 100% yield and with byproducts

Typical reaction with less than 100% yield and with byproducts

Zero Waste is the Goal



(b) Reaction with 100% yield, but with byproducts inherent to the reaction

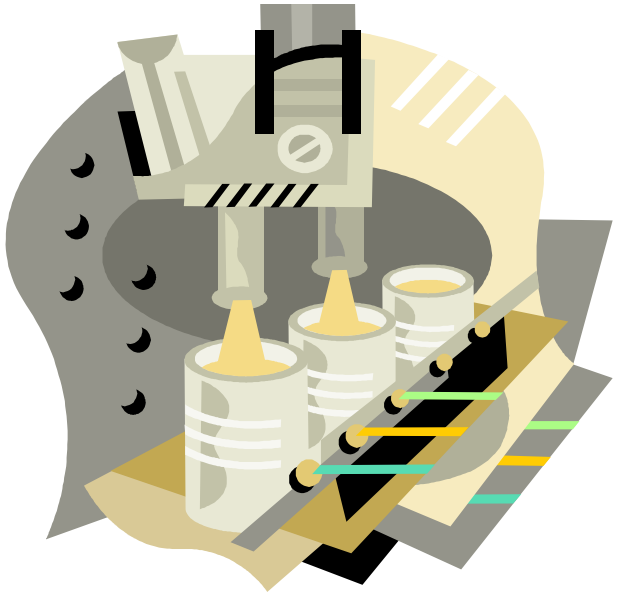


(c) Reaction with 100% atom economy, no leftover reactants, no byproducts

Process FMEA

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Continuous Processes



- Fewer chemicals may be required in switching from batch reactions to continuous processing.
- Also safer, typically gives a higher purity product and may use less energy.

Process: Chemical Controls

- Manage chemical suppliers;
- Order chemicals in the most appropriate quantity;
- Maintain up-to-date chemical inventory lists;
- Get full disclosure on MSDS sheets;
- Error-proof to eliminate waste;
- Buy pre-mixed reagents for safety and time-savings;
- Implement take-back programs.

The Issue of Solvents

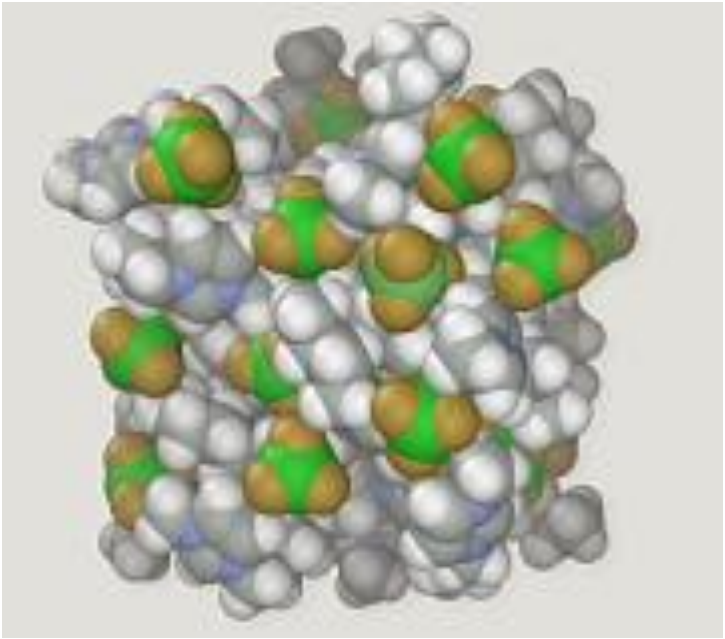
- Substitute with a less harmful solvent, such as water.
- Use Supercritical Carbon Dioxide as a solvent.
- Switch to another process requiring no solvent.
- Enclose the operation so the solvent is not lost.
- Place something on the plant outlet to destroy or recover the solvent.

Supercritical Carbon Dioxide

- Carbon dioxide in a fluid state while also being at or above both its critical temperature and pressure.
- Yields uncommon properties, adopt properties midway between a gas and a liquid.
- Becoming an important commercial and industrial solvent due to its role in chemical extraction, as well as its low toxicity and environmental impact.

Ionic Liquids

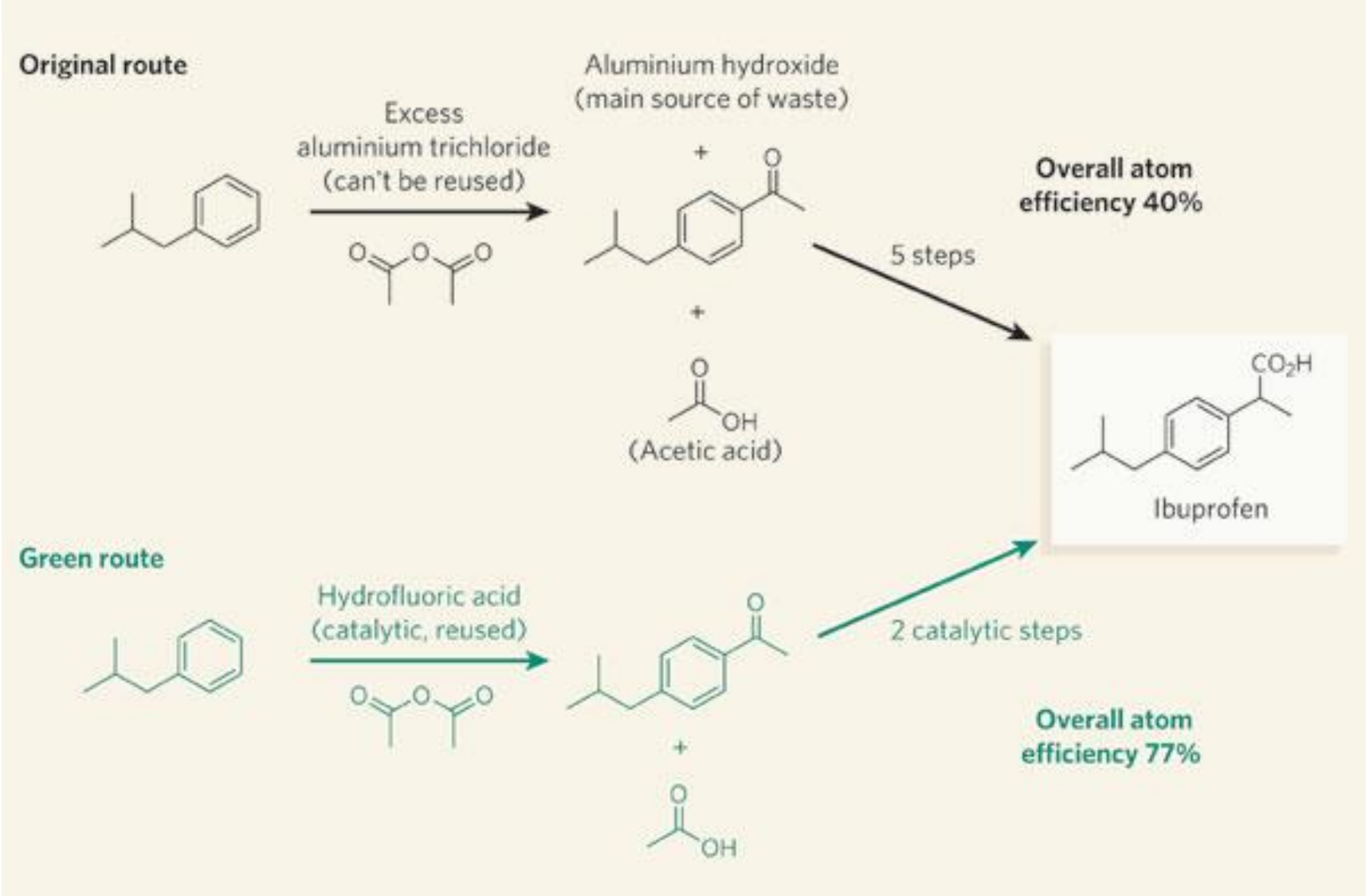
- Known as liquid electrolytes, ionic melts, ionic fluids, fused salts, liquid salts, or ionic glasses, generally used to refer to salts that form stable liquids.
- Of interest due to their extremely low- saturated vapor pressures.
- Also does not evaporate the way 'ordinary' liquids do, which has substantial scientific and commercial implications.



Disadvantages of Alternatives

- For water
  - Most organic compounds are insoluble in water
  - Recovering products (energy intensive to evaporate)
- For supercritical carbon dioxide
  - Energy intensive
- For ionic liquids
  - Potential toxicity

Process Improvement



E-Waste

Reducing waste from electronics requires multiple considerations:

- E-Purchasing
- E-Reuse
- E-Recycling



E-Purchasing

- The Electronic Product Environmental Assessment Tool (EPEAT) is a system in which manufacturers declare their products' conformance to a comprehensive set of environmental criteria in 8 environmental performance categories.
- These environmental criteria are contained in a public standard IEEE 1680.
- Helps purchasers evaluate, compare and select desktop computers, notebooks and monitors based on their environmental attributes.

Hazardous Waste

- Hazardous waste is waste that is dangerous or potentially harmful to our health or the environment. Hazardous wastes can be liquids, solids, gases, or sludges. They can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes.

Quantifying How Green a Process Is

- Several methods have been used but normally the easiest parameter to measure is the amount of waste generated per process:
  - From the balanced chemical equation for a process, the theoretical quantity of waste can be calculated per unit mass of starting material, assuming that the yield of product is 100% (in reality, the waste generated is typically higher than the theoretical)

Biomass Conversion

- The use of enzymatic reactions in place of conventional catalysis as a low cost option in the manufacture of several generic pharmaceuticals:
  - The use of enzymes to convert biomass (instead of petroleum feedstock) into chemicals has shown some process.
  - The downsides include the seasonal nature of crops, possible conflicts with food supplies, and variety in composition.

Roundup



- Monsanto developed an alternative way of making the popular herbicide Roundup®.
- They now avoid the use of extremely toxic hydrogen cyanide, along with avoiding production of cyanide-containing waste.
- Risks to people working at the manufacturing plant, to those living nearby and to the environment, are greatly reduced.
- Much smaller amount of waste produced is also safer since it does not contain cyanide.

Facility / Grounds Maintenance

- Instead of fogging, or treating the entire facility with insecticide, using crack and crevice methods for specific areas.
- Preventing infestation with more efficient cleaning practices, better pest control barriers.
- Using trapping methods instead of poison.



Course Agenda

The Principles of Green Chemistry

Regulatory Requirements and Directives

Environmental Hazard Prevention/Reduction

Exercise: Cleaners

Design Improvement

Demonstration: Green Plastics

Process Improvement

Measuring Chemical Use/Waste

Course Evaluation

Green Chemistry is Sustainable

- Economic: At a high level of sophistication, green chemistry normally costs less in conventional economic terms (as well as environmental costs) than chemistry as it is traditionally practiced
- Materials: By efficiently using materials, maximum recycling, and minimum use of virgin raw materials, green chemistry is sustainable with respect to materials
- Waste: By reducing insofar as possible, or even totally eliminating their production, green chemistry is sustainable with respect to wastes

Green Chemistry Benefits

- Reduce waste which eliminate costly end-of stream treatments;
- Safer products;
- Reduced use of energy and resources;
- Improved competiveness of chemical manufacturers and their customers.

Internal Metrics

- Scrap
- Rework
- Permits- Air, water, solid waste
- Outputs of waste streams
- Utilities costs
- Chemical inventory
- MSDS
- Environmental aspects/impacts

Environmental Impact Factor

- E-factor measures quantity of waste produced in making a product, compared to amount of useful material obtained (the product).

E-factor = mass of waste ÷ mass of product

OR

E-factor = (mass of inputs - mass of outputs) ÷ mass of product

- Lower the E-factor, the less waste is produced.

E-factor Examples

- Bulk chemical manufacturing = <5
  - However, volumes produced are high, thus, waste generated is also high.
- Pharmaceuticals = >100

Improving E-factor

- Eliminate or reduce the amount of material that goes into the product;
- Recycle some of the materials that go in to the process;
- Find alternative uses for the by-products.

The Risks of No Risks

- Refusal to take any risks can cause scientific and economic progress to stagnate.
- Example: Refusal to take the risks of thermally treating wastes (hazardous waste incineration) can lead to waste accumulation, or important industrial processes making the waste may be ceased.
- Example: Unwillingness to take risks involved with nuclear energy can lead to greenhouse warming from using fossil fuels or to economic stagnation from energy shortages.

Summary

- Modern life depends on the petrochemical industry.
- Most drugs, paints, and plastics are derived from a non-renewable resource.
- Current processes for making chemical products are not sustainable in terms of resources and environmental impact.
- Green chemistry aims to tackle this problem and real progress is being made.

Course Agenda

The Principles of Green Chemistry

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TECHNICAL ASSISTANCE PROGRAM

Green Enterprise Development

LEVEL **2**

Green Specialist Certificate Series

Join us for the Green Chemistry Workshop!

Learn how to apply Green Chemistry principles and techniques in all facets of business.

One-Day Workshop • Appropriate for engineers, green team participants and environmental managers

The Green Specialist: Green Chemistry Workshop was designed by Purdue's Technical Assistance Program for manufacturers and others interested in learning how to apply Green Chemistry principles and techniques in all facets of the business. From cleaning to machining, to better manage chemical use and the resulting chemical waste. Expect a fun, fast-paced workshop with simulations and case studies for in-depth instruction in applying green concepts and techniques.

Participants will learn:

- Principles of Green Chemistry
- "Hit list" chemicals, e-waste and associated regulatory standards
- How to achieve a healthier, safer environment through process reengineering
- How to reduce or eliminate use and generation of hazardous substances
- Ways to maximize the amount of raw material that ends up in the product
- To use safe, environment-benign substances whenever possible
- Design energy-efficient processes





Green Enterprise Development

Visit www.tap.purdue.edu/green to learn how to take the green movement to the next level.



How We Can Work With You: In addition to Green Enterprise Development, Purdue's Technical Assistance Program offers on-site public workshops and provides implementation and consulting services.

For workshop dates or to register: Visit www.tap.purdue.edu/green under "Register for Events." Cost is $395/per person.

For more information: Contact Abbey Maddy via phone at (800) 877-5182 ext. 620 or email amaddy@purdue.edu.

Black & Gold & Green Enterprise Development

Technical Assistance Program
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TECHNICAL ASSISTANCE PROGRAM



Environmental Waste Stream Mapping

Purpose of This Module

- To provide an understanding of what environmental wastes include.
- To begin identifying environmental wastes in your company along with their associated waste streams.
- To provide strategies for prioritizing and eliminating environmental wastes.

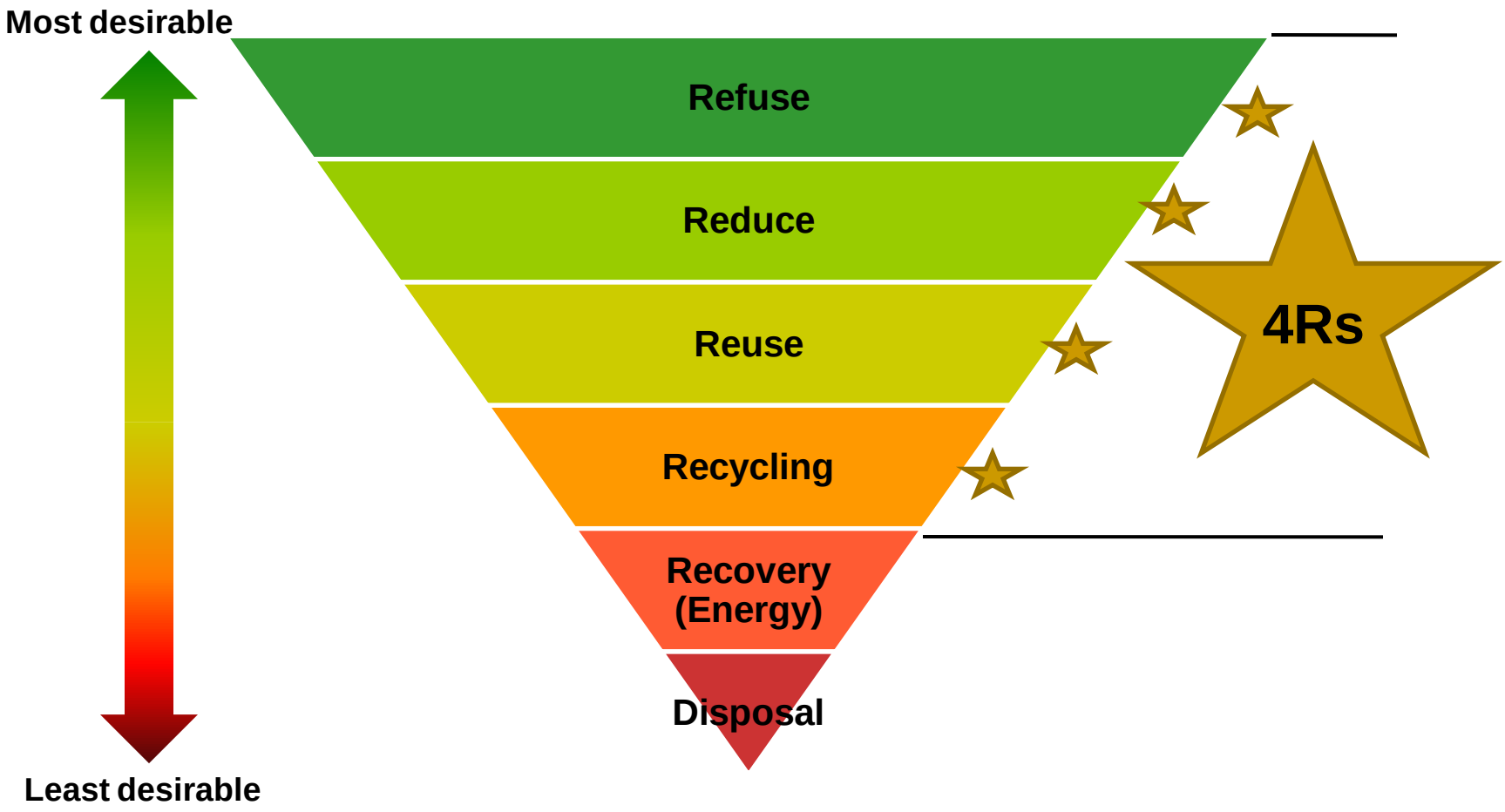
Key Questions



We'll try to address these questions:

- What are included as environmental wastes?
- How will you know when you see environmental waste?
- Where should you look for environmental wastes?
- How do you measure environmental impacts of a process?
- What are environmentally-preferable process options?

Waste Hierarchy



Sustainability Benefits

Business:

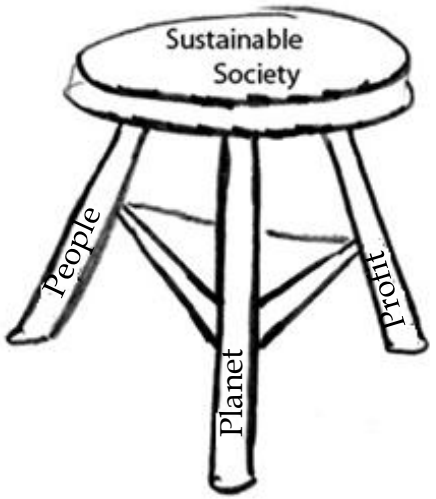
- Produces more efficient operations and reduces costs.
- Reduces risk of regulatory noncompliance and enhances public image.
- Mitigates risk for employee health and safety.

Environmental:

- Slows depletion of natural resources.
- Reduces pollution.
- Conserves valuable landfill space.

Global Society:

- More resources and energy become available for
- Closing the loop (cradle-to-cradle) generates new jobs.



Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

What / How to Improve

Considering Alternatives

Implementation Action Plan

Course Evaluation

The Green Approach

Minimize the potential negative environmental impacts of your business and use all of your resources as efficiently as possible.



Green = FEWER

Full use of Raw Material

Energy Efficiency

Water conservation

Eliminating Toxic Material

Reduction of:

- Transportation Wastes
- Emissions to Air and Water
- Solid & Hazardous Wastes
- Regulatory obligations / risks



Managing Resource Use & Waste

Resource Management

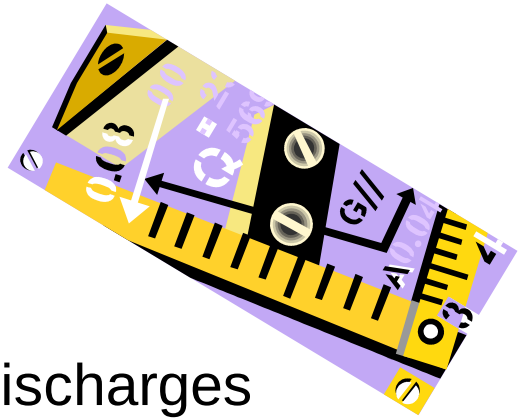
Minimize resource use and ensure a reliable resource supply.

Waste Management

Improve reuse/recycling of wastes and overall reduction of waste.

Waste Stream Metrics





Water

- Water Use
- Wastewater Discharges

Air

- Air Quality
- Air Emissions

Solids

- Materials Use
- Solid Waste Generation

Toxic Materials

- Chemical Use
- Hazardous Waste Generation

Energy

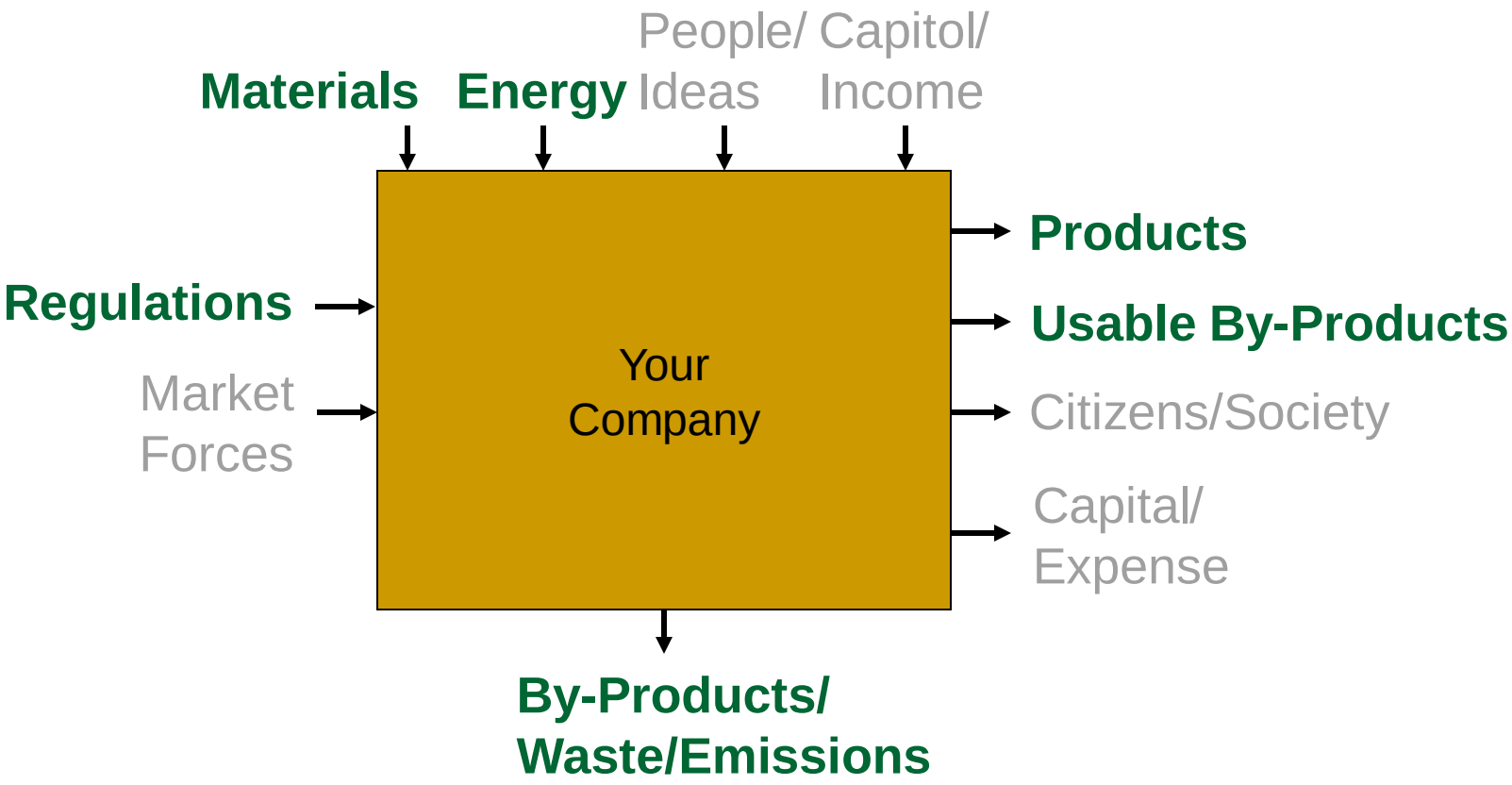
- Energy Used
- Energy Loss/Waste

4Rs the Waste Stream





Sustainable Process



Cradle to Cradle View



Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

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Environmental Waste

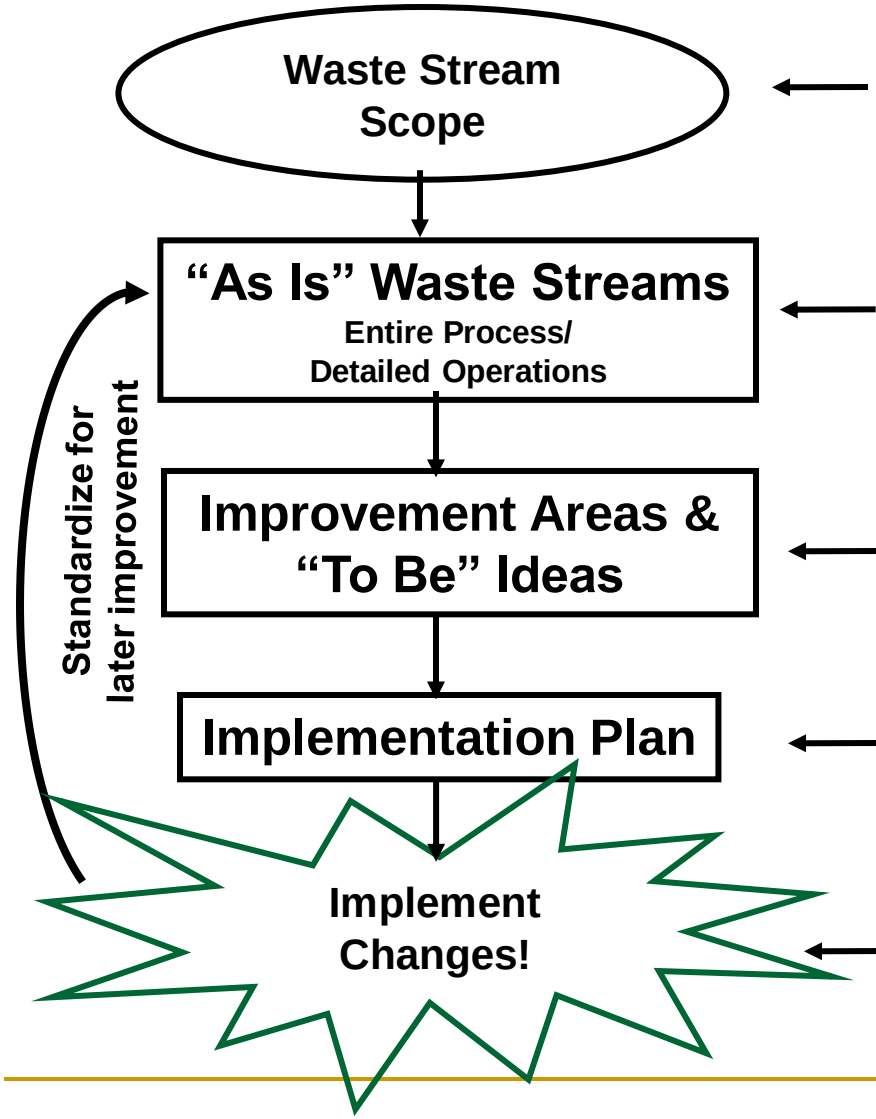
Environmental waste is:

- an unnecessary use of resources, or
- a substance released to the air, water, or land that could harm human health or the environment.

Examples include:

- Excess use of energy, water, or materials to meet customer needs;
- Air and water pollution;
- Trash, discarded scrap, hazardous materials.

Waste Stream Mapping Approach



Determine the Waste Stream(s) to be improved.

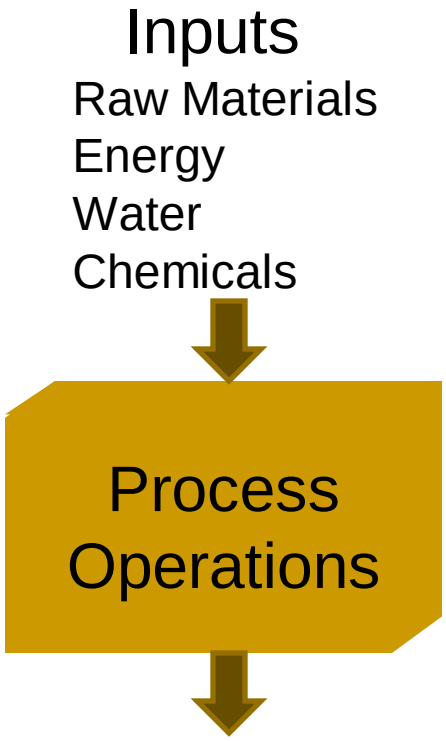
Understand how things currently operate. Identify areas where there is waste. Quantify waste and determine source(s).

Apply 4Rs to the resources/ wastes to design a Green approach**.**

Screen the improvement options and develop a detailed implementation plan to support improvement objectives (what, who, when).

Make the changes - this is the goal of mapping!

Process Inputs / Output Wastes



Waste Stream Inputs/Outputs

	Milling	Welding	Washing	Painting	Assembly	Packaging
Inputs	Raw Metal Machine Fluid Process H_2O Electricity Compressed Air	Welding Rods Process H_2O Electricity	Acids Detergent Process H_2O Electricity Air	Paint Thinner Natural Gas Compressed Air	Fasteners Electricity Compressed Air	Corrugated Cardboard Metal Bands Plastic Wrap Skids Tape
Output Wastes	Metal Scrap Broken Tools Waste H_2O	Product Rejects Spent Rods Slag Heat Greywater Fumes Weld Dust	Acid Detergent Greywater	Product Rejects Acid Detergent Heat Fumes	Product Rejects Fastener Scrap	Metal Band Scraps Plastic Wrap Damaged Skids

Solids Water Air Chemicals Energy

What to Consider for Scope

- Pollution and other environmental wastes throughout the facility as well as within specific processes.
- Explicit materials used versus needed.
- Environmental and human health risks.
- Environmental regulations and permitting limitations.
- Common or repeated materials / wastes across multiple process steps.

Maximize Benefits

- Integrate environmental considerations into all business areas.
- Include environmental performance metrics in business goals to be monitored and managed.
- Involve environmental personnel in Mapping & follow-on activities.
- Use specific tools to target environmental endpoints.
- Improve efficiency and effectiveness of environmental agency processes.



Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

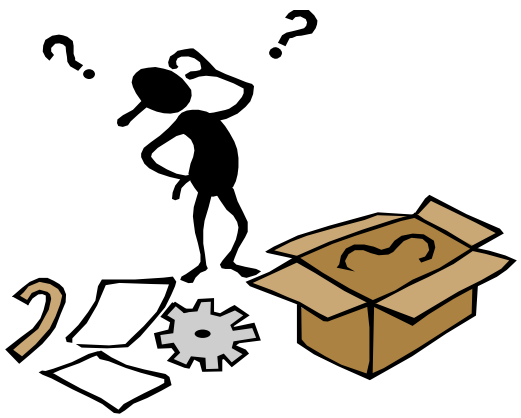
What / How to Improve

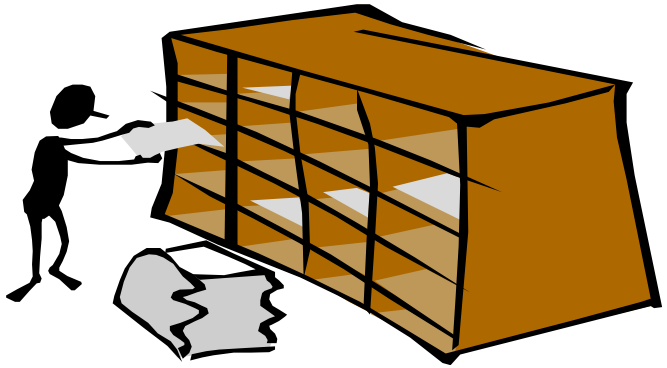
Considering Alternatives

Implementation Action Plan

Course Evaluation

Information Gathering





Good information is prerequisite to an effective waste reduction program. Include:

- Quantitative data regarding types and amounts of waste generated and associated costs. Also amount and cost of resources purchased.
- Qualitative information to tell how the waste is dealt with and consistency of practices dealing with waste.

Information Gathering Methods

Facility Walk-through	• Process steps • Resource/waste flow • Types of waste generated • Generation points • Waste collection/processing methods
Purchasing/Utility Records	• Resource purchase/use quantity • Costs
Production Records	• Consumption of resources used in production • Resource(s) flow • Efficiencies, up-time, etc. • Special process resource, e.g., hazardous
Hauler/Waste Treatment Records	• Volumes/weights/frequency of waste hauled • Waste treatment impacts • Recycling volumes, frequency, etc. • Costs

Environmental Waste - Where to Look?

- Processes or equipment with high energy, water, and material use.
- Processes or products with significant liquid, solid or hazardous waste generation.
- Areas or processes requiring environmental permits or reporting to environmental agencies.
- Areas, processes or equipment with pollution control equipment.
- Processes or products using toxic chemicals that require personal protective equipment (PPE).

Common Operations to Look At



- Metal casting
- Metal fabrication and machining
- Plastic injection molding
- Thermoforming
- Welding
- Waste management
- Equipment maintenance
- Shipping and receiving
- Chemical and heat treatment of materials
- Metal finishing and plating
- Painting and coating
- Cleaning and surface preparation
- Bonding and sealing
- Chemical and hazardous materials management

Waste Stream Focus:
Materials Use / Solid Waste

Materials / Solid Waste Challenges

- Mixed waste streams
- Hazardous/toxic materials, e.g., e-waste
- Contamination
- Packaging
- Customer specifications
- Material extraction, e.g., post-assembly
- Material separation / collection
- By-product / Waste exchange identification

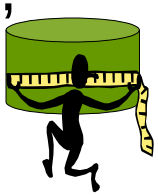


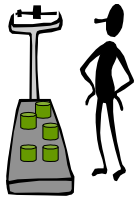
Materials / Solid Waste Questions

- Are there mechanisms for evaluating potential alternate materials being used to make product?
- Do any processes generate an excessive amount of solid waste when compared with other processes?
- Are solid by-products generated that could be reused as a material input – internally or externally?
- Is material waste segregated/collected for recycle/reuse?
- Is the entire product lifecycle analyzed for ways to improve the overall environmental impact of the product/processes?

Solid Waste Data to Collect

- Type and amount of different materials purchased, used, reused, recycled, discarded;
- Methods for material receipt, handling, storage, segregation/collection and/or discard;
- Costs associated with waste/recycle collection, container rental, removal, disposal;
- Recycling/Waste Exchange (potential) revenues;
- Recycled-content products/materials purchased.





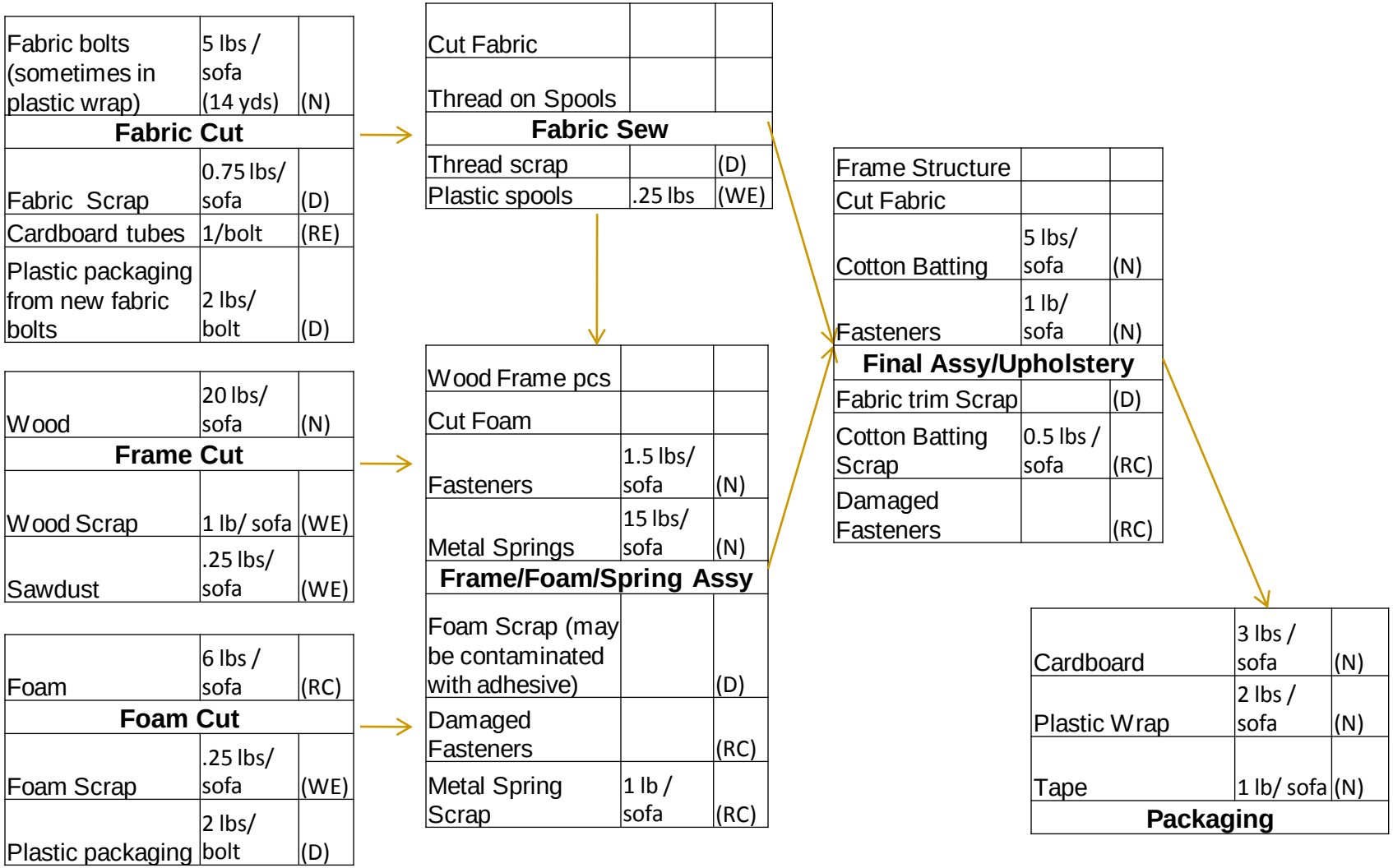
Solids Waste Stream – “As Is”

Plant-wide

Material Purchased	Waste Collection/ Disposal	Recycle Collection/ Handling	Recycling / Waste Exchange Revenues	Material/ By-product Reuse Savings
Wood - $XXXXXX Fabric - $XXXXXX Foam - $XXXXXX Cotton Batting- $XXXXXX Thread- $XXXX Metal Springs- $XXXXXX Fasteners - $XXXX Cardboard Pkg - $XXXXXX Plastic Pkg - $XXXXXX	$120,000 / yr	$1000 / yr	$12,000 / yr	$0

Data Collection is first step after defining the Waste Stream scope.

Solids Waste Stream – "As Is"



Waste Management Code:
D = Dispose *RC = Recycle*
RU = Reuse Internally *WE = Contribute to Waste Exchange*

Material Management Code:
N = Purchase New *RU= Reuse from Internal Waste*
WE = Obtain from Waste Exchange *RC = Recycled Content*

Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

What / How to Improve

Considering Alternatives

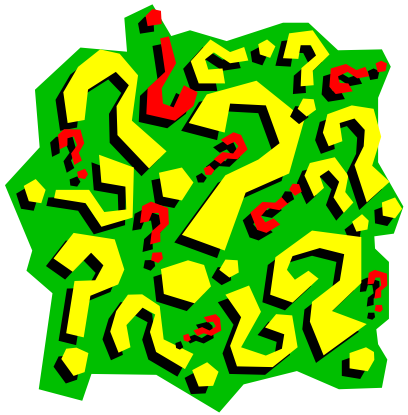
Implementation Action Plan

Course Evaluation

Getting to the “To Be” Approach

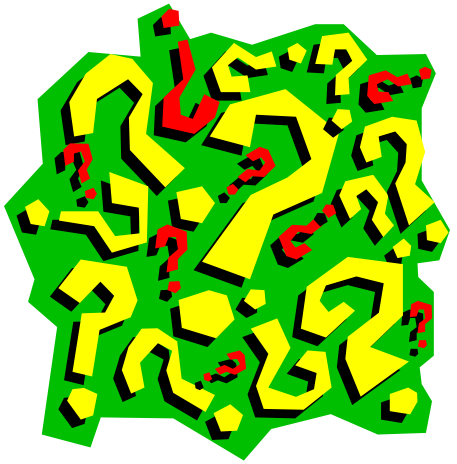
What would be needed for an environmentally-preferred "To Be" approach with:

- Zero environmental and production wastes?
- Products and processes that pose no risks to human health or the environment?
- No need for environmental permits?



Getting to the “To Be” Approach

- Can one process or operation use the “waste” output from another process instead of using virgin materials?
- What are appropriate targets for improving environmental performance?
- Where are kaizen events or six sigma projects needed to address significant environmental wastes?



Problems Can Have Many Causes

- Process Methods
- Chemical Choices
- Product Specifications
- Energy Rates
- Water Sources/Flow
- Mixed Waste
- Production Inefficiencies
- Transportation Inefficiencies
- Capacity Utilization
- Product Quality
- Market Demand



Waste Stream Focus:
Materials Use / Solid Waste

Materials / Solid Waste Questions

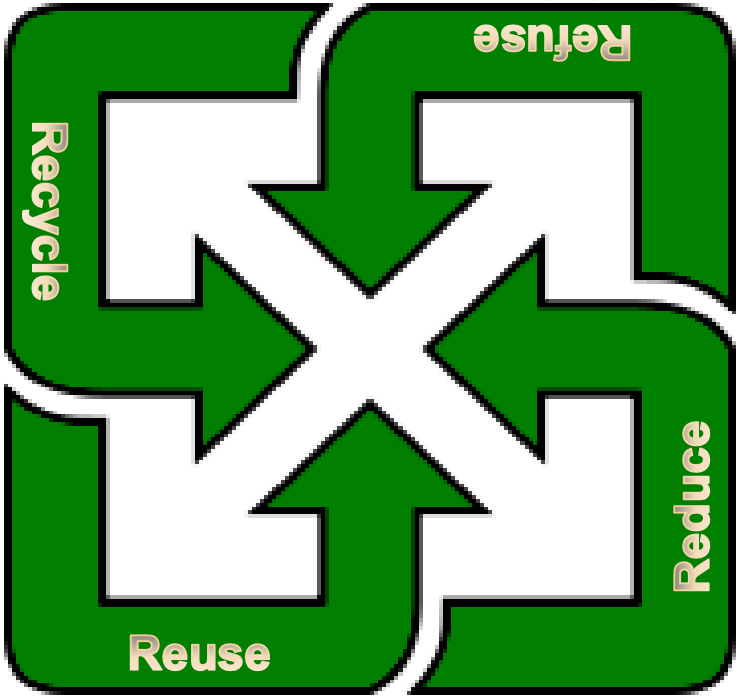
- What types/quantities of materials are used? Do they contain recycled content? Is material lifecycle considered in the purchasing process?
- How can the overall amount of materials be reduced – both within the product and used by the process?
- Can waste materials be separated/collected at the source?
- How can solid wastes be reused or recycled? Are there processes that could use the waste materials as inputs?
- How can non-value-added use of materials be eliminated, e.g., excess packaging, unneeded containers, etc.?

Materials/ Solid Waste Elimination

Clean Production;
Source Reduction;
Design for Environment;
Product Lifecycle Analysis

Materials Conversion

Alternative materials;
Dematerialization;
Lightweighting



Materials/ Solid Waste Reduction

Waste collection/ separation at the source;
Buy product/materials with recycled content

Materials Recovery

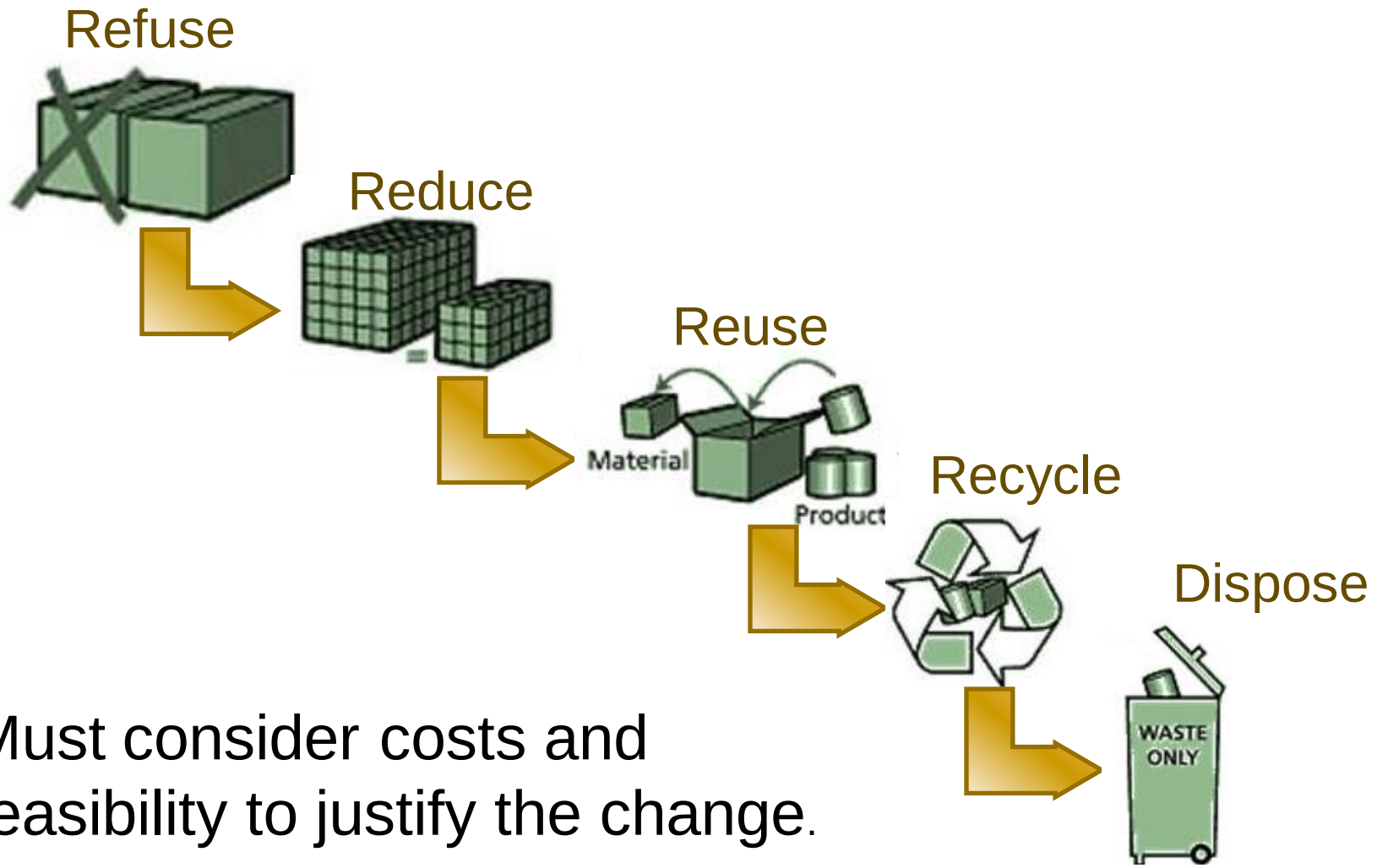
Packaging reuse;
Waste exchange;
By-product upgrades;
Take-back programs

Materials Management Methods

- Refuse, Reduce, Reuse, Recycle
  - Packaging (incoming and outgoing)
  - Purchase recycled content materials / products
  - By-product utilization / Waste Exchange
- Design for the Environment
  - Source Reduction / Dematerialization
  - Alternative materials in the product / used in the process
  - Materials with longer lifecycle / reusability
- Equipment Improvements
  - Cleaning / Maintenance / Replacement

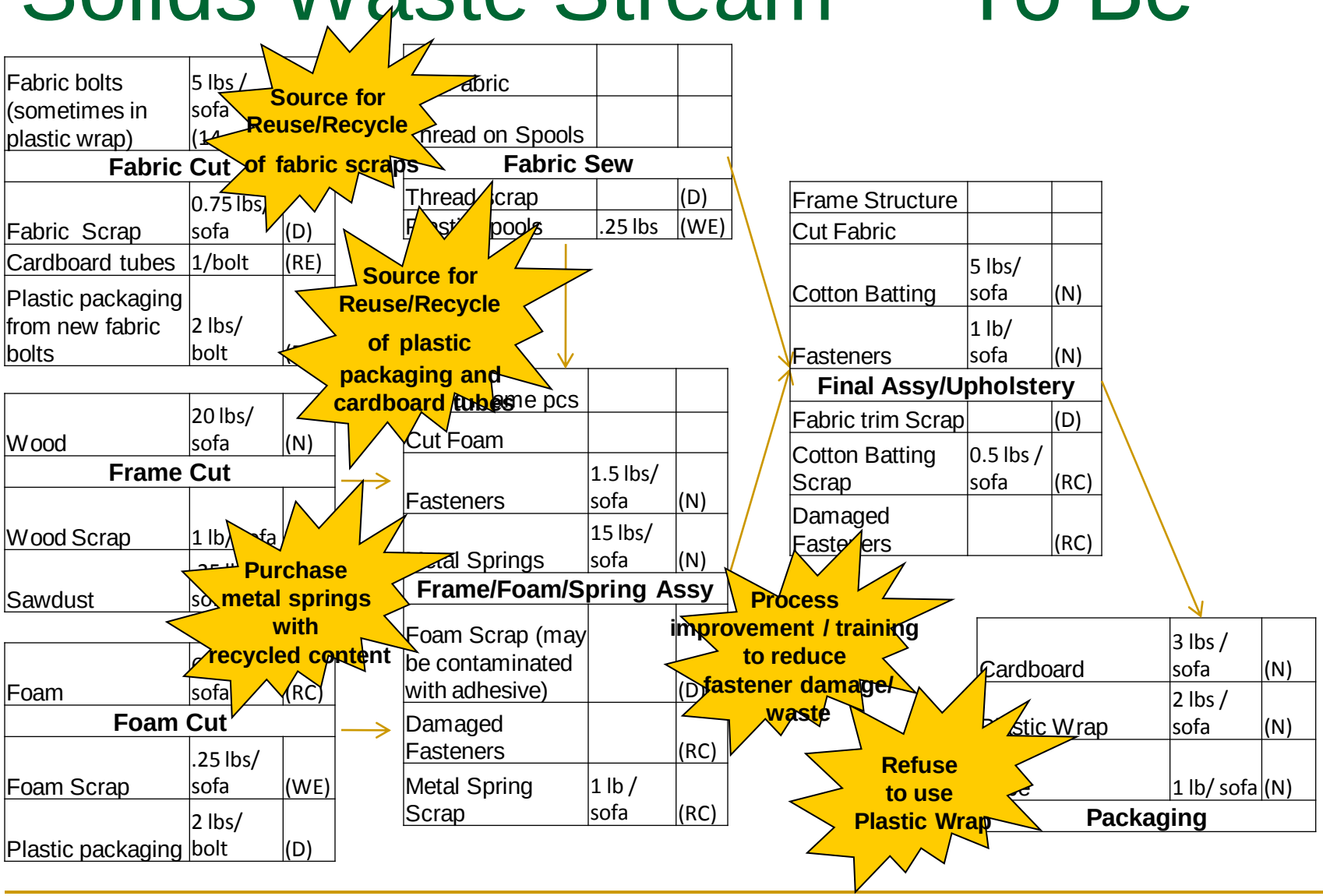


Start at the TOP of the Hierarchy



Must consider costs and feasibility to justify the change.

Solids Waste Stream – "To Be"



Waste Management Code:

D = Dispose *RC = Recycle*

RU = Reuse Internally *WE = Contribute to Waste Exchange*

Material Management Code:

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WE = Obtain from Waste Exchange *RC = Recycled Content*

Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

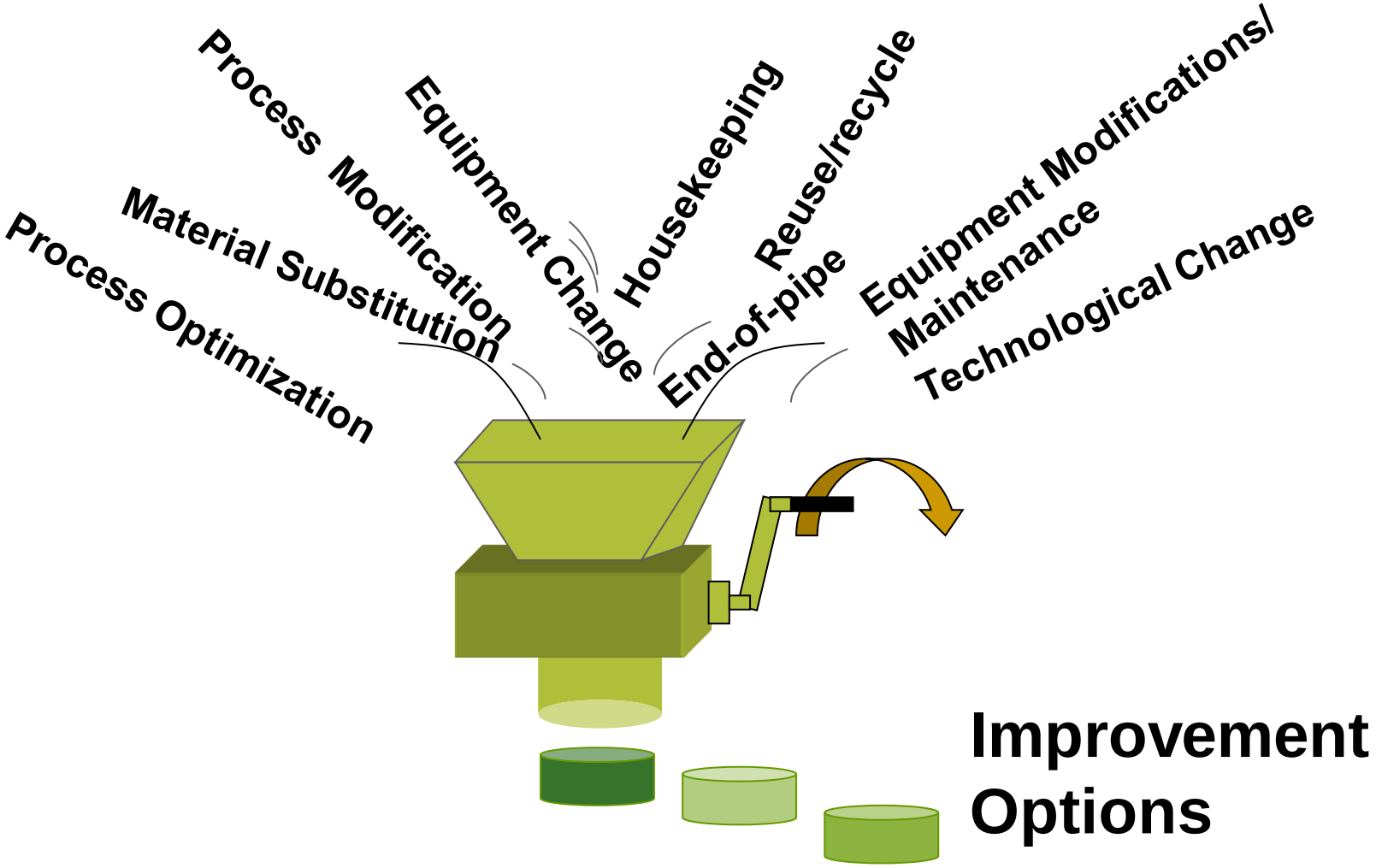
What / How to Improve

Considering Alternatives

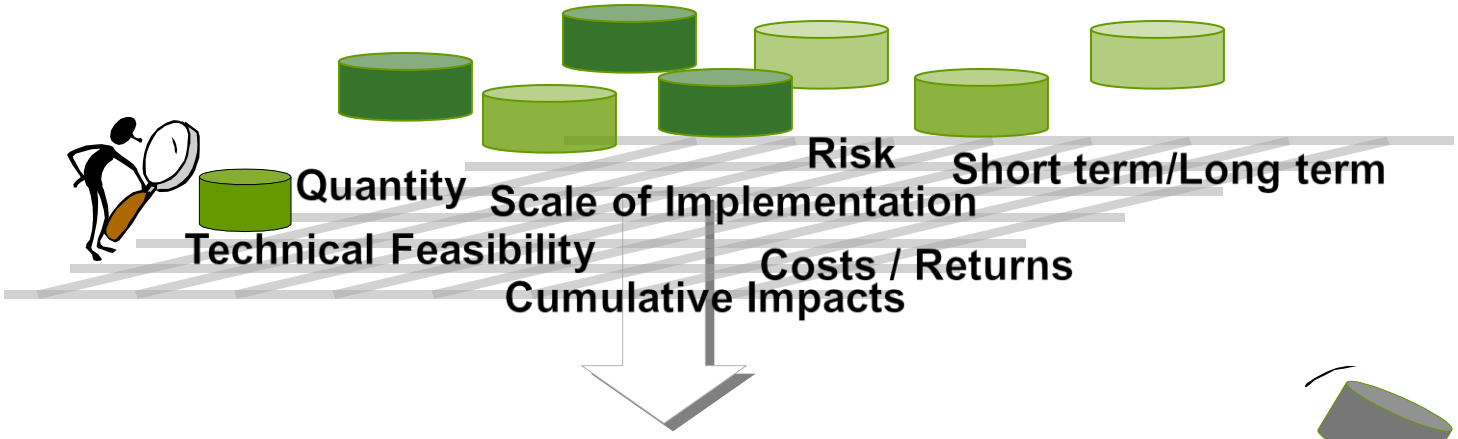
Implementation Action Plan

Course Evaluation

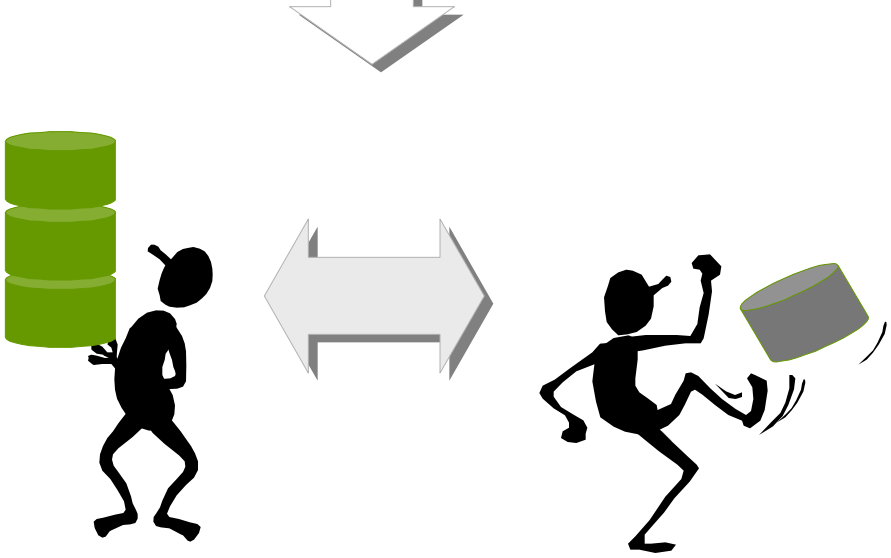
Identifying Improvement Options



Evaluating Options



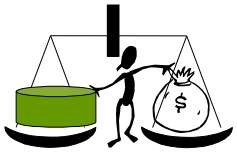
- Economical
- Technically sound
- High returns



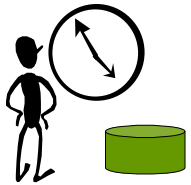
- High Cost
- High risk
- Complicated technology

Cost of Waste

The cost of waste is not only the cost of waste disposal, but can include other costs such as:



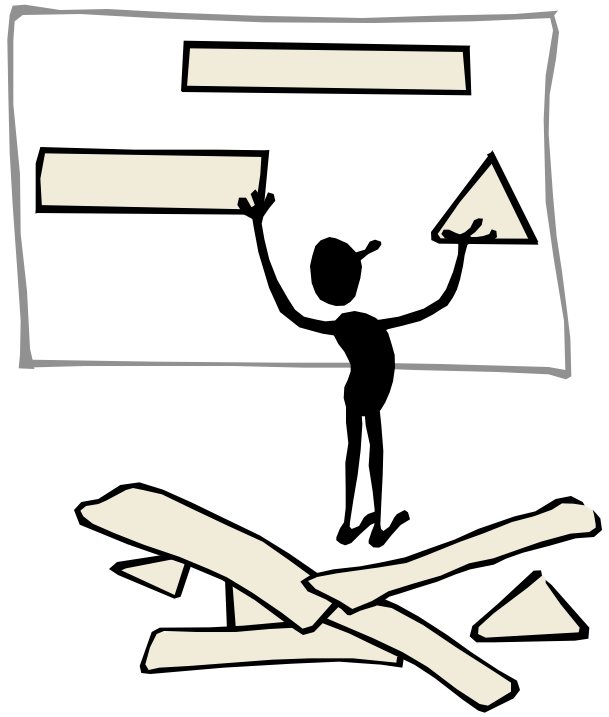
- Waste treatment/transportation cost;
- Inefficient energy use cost;
- Purchase cost of wasted raw material;
- Production cost for the waste material;
- Management time spent on waste material;



- Lost revenue for what could have been a product instead of waste;
- Potential liabilities due to waste.

Changes May Require Approval

- Changes to the type, volume, or introduction/issuance procedure for chemicals/materials used by employees.
- Changes to the type or volume of waste generated by a process, including all media such as air emissions, water discharges, and liquid and solid waste.
- Changes to the physical layout of the processes (e.g., moving work or storage areas), to equipment and technologies used, or to the facility (e.g., moving, replacing, or installing vent hoods, stacks, floor drains or process tanks).



Specific Information to Consider

New Equipment	• Potential/Preferred Suppliers (pricing, terms, reliability) • Installation space • Cost (capital, operating) • Personnel requirements (skills, training)
New material/chemicals	• Potential/Preferred Suppliers (pricing, terms) • Effects on other processes • Safety sheets • Transport considerations
Modification of existing process / Change in operating practices	• Costs • Effects on other processes • Impact on customer requirements • Personnel requirements (skills, training)

Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

What / How to Improve

Considering Alternatives

Implementation Action Plan

Course Evaluation

Implementation Plan

	Area	Issue	Impact (H, M, L)	Cost/Effort (H, M, L)	Owner	Target Date
1						
2						
3						
4						
5						

Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

What / How to Improve

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PURDUE UNIVERSITY
TECHNICAL ASSISTANCE PROGRAM



Environmental Waste Stream Mapping

Purpose of This Module

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- To begin identifying environmental wastes in your company along with their associated waste streams.
- To provide strategies for prioritizing and eliminating environmental wastes.

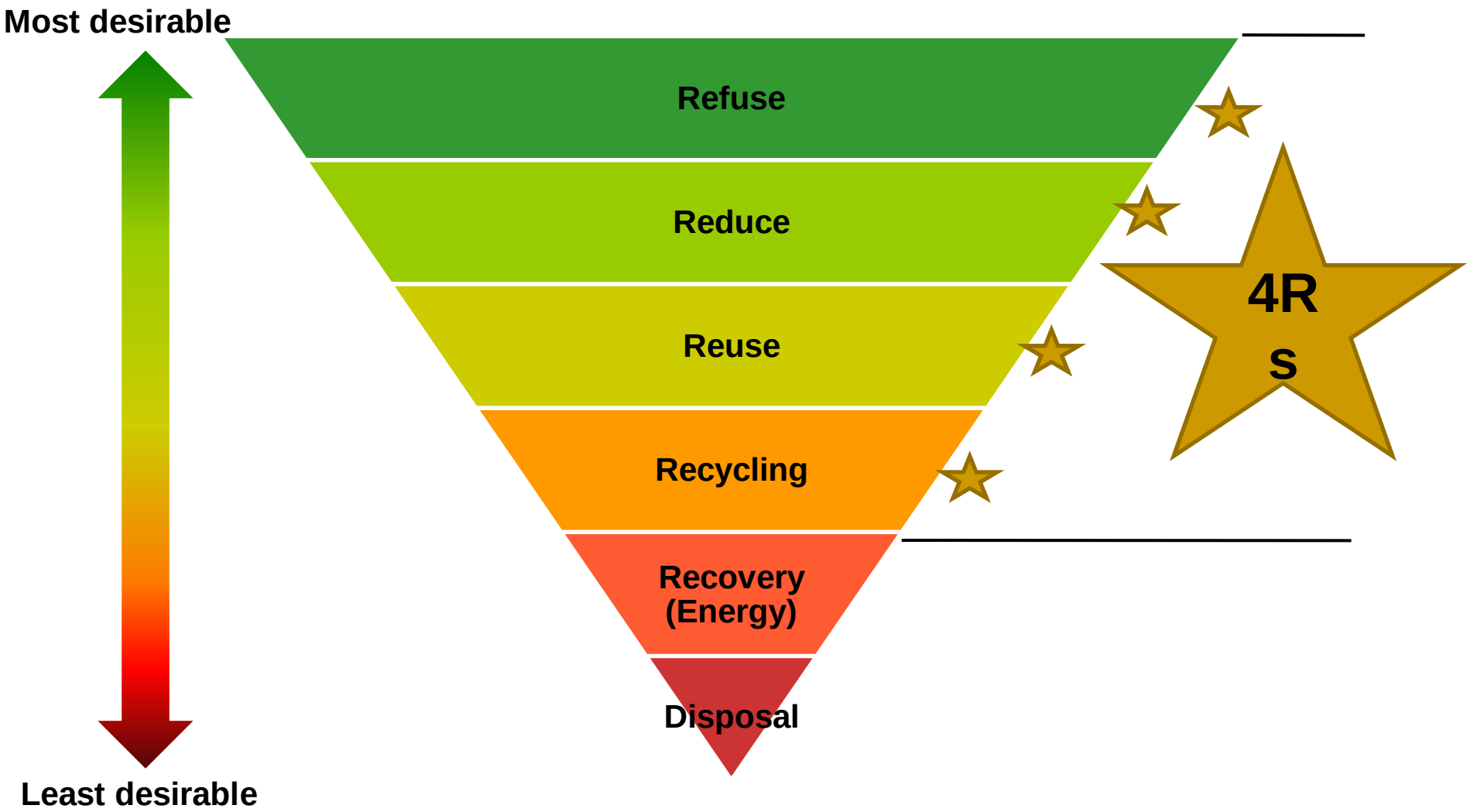
Key Questions



We'll try to address these questions:

- What are included as environmental wastes?
- How will you know when you see environmental waste?
- Where should you look for environmental wastes?
- How do you measure environmental impacts of a process?
- What are environmentally-preferable process options?

Waste Hierarchy



Sustainability Benefits

Business:

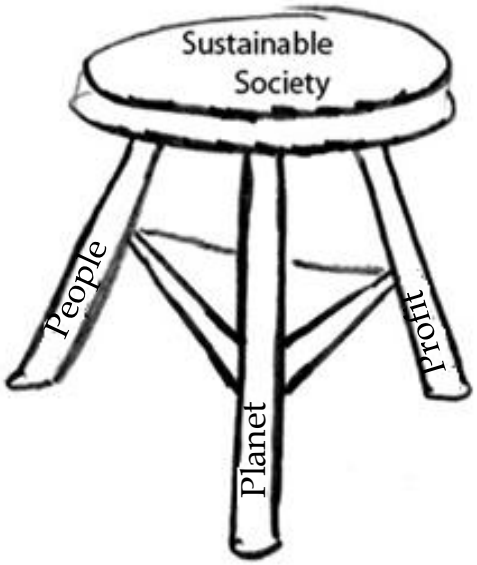
- Produces more efficient operations and reduces costs.
- Reduces risk of regulatory noncompliance and enhances public image.
- Mitigates risk for employee health and safety.

Environmental:

- Slows depletion of natural resources.
- Reduces pollution.
- Conserves valuable landfill space.

Global Society:

- More resources and energy become available for
- Closing the loop (cradle-to-cradle) generates new jobs.



Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

What / How to Improve

Considering Alternatives

Implementation Action Plan

Course Evaluation

The Green Approach

Minimize the potential negative environmental impacts of your business and use all of your resources as efficiently as possible.



Green = FEWER

Full use of Raw Material

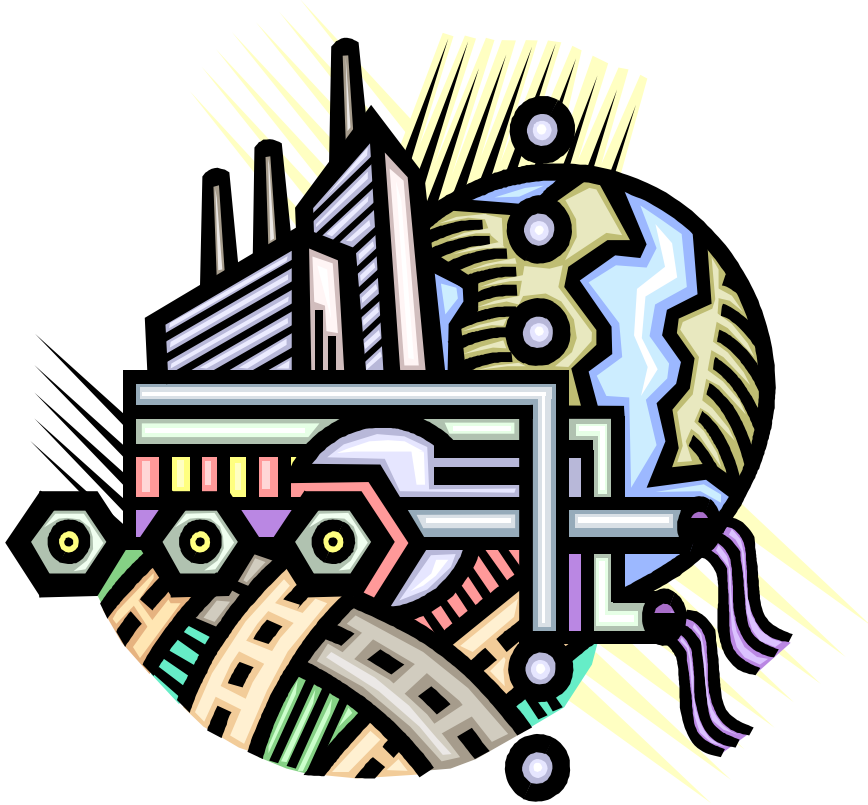
Energy Efficiency

Water conservation

Eliminating Toxic Material

Reduction of:

- Transportation Wastes
- Emissions to Air and Water
- Solid & Hazardous Wastes
- Regulatory obligations / risks



Managing Resource Use & Waste

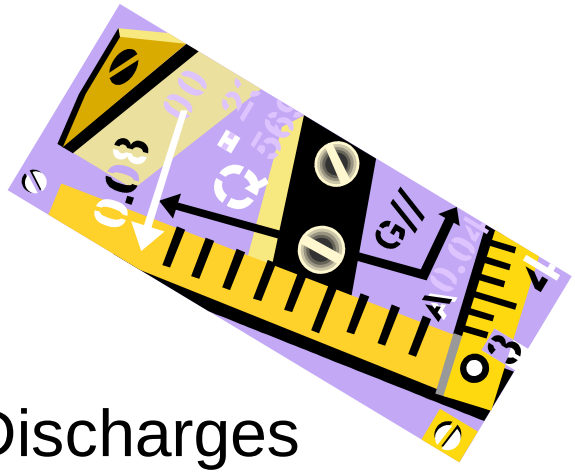
Resource Management

Minimize resource use and ensure a reliable resource supply.

Waste Management

Improve reuse/recycling of wastes and overall reduction of waste.

Waste Stream Metrics





Water

- Water Use
- Wastewater Discharges

Air

- Air Quality
- Air Emissions

Solids

- Materials Use
- Solid Waste Generation

Toxic Materials

- Chemical Use
- Hazardous Waste Generation

Energy

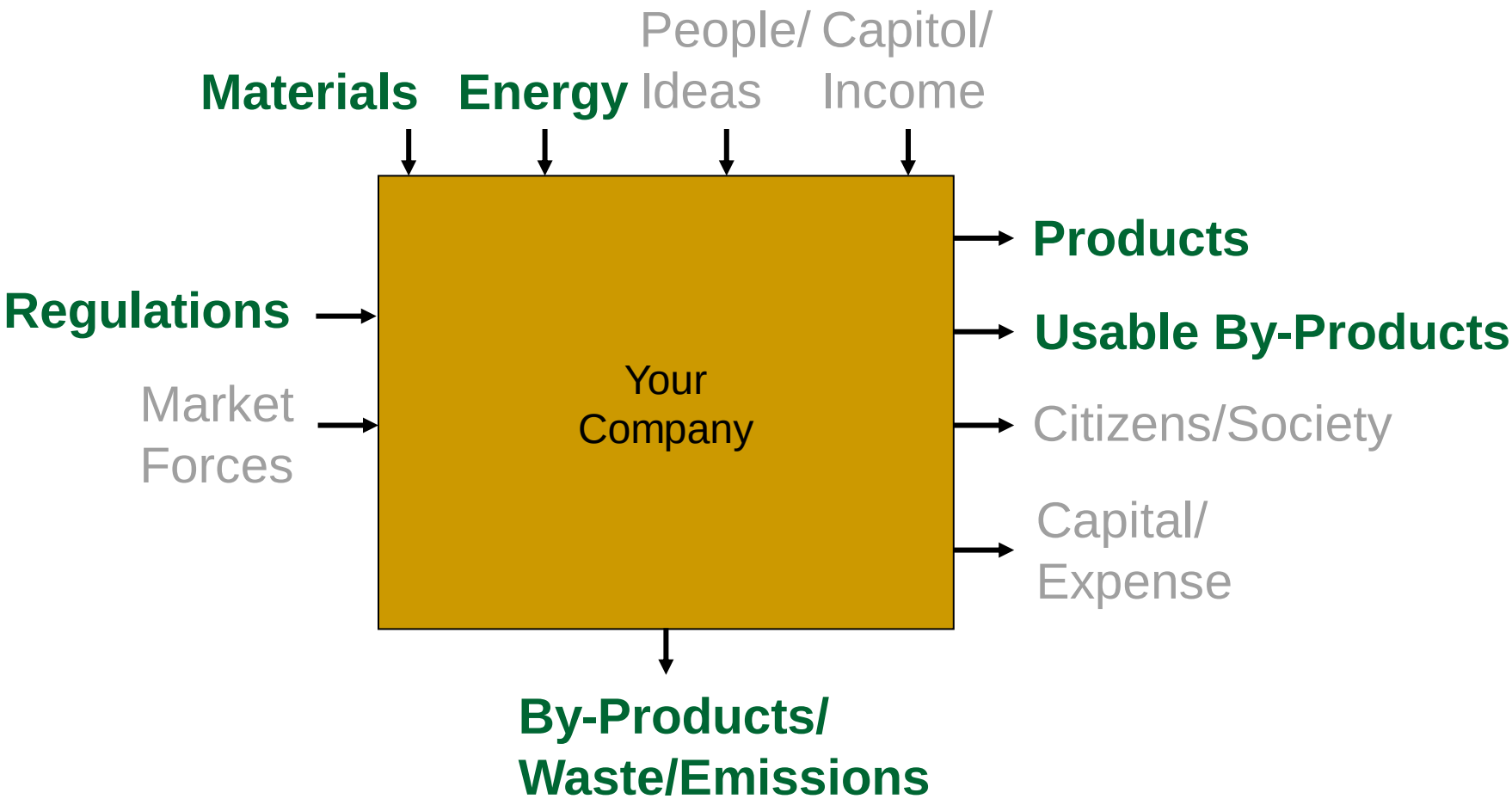
- Energy Used
- Energy Loss/Waste

4Rs the Waste Stream





Sustainable Process



Cradle to Cradle View



Course Agenda

Resource & Waste Management

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Environmental Waste

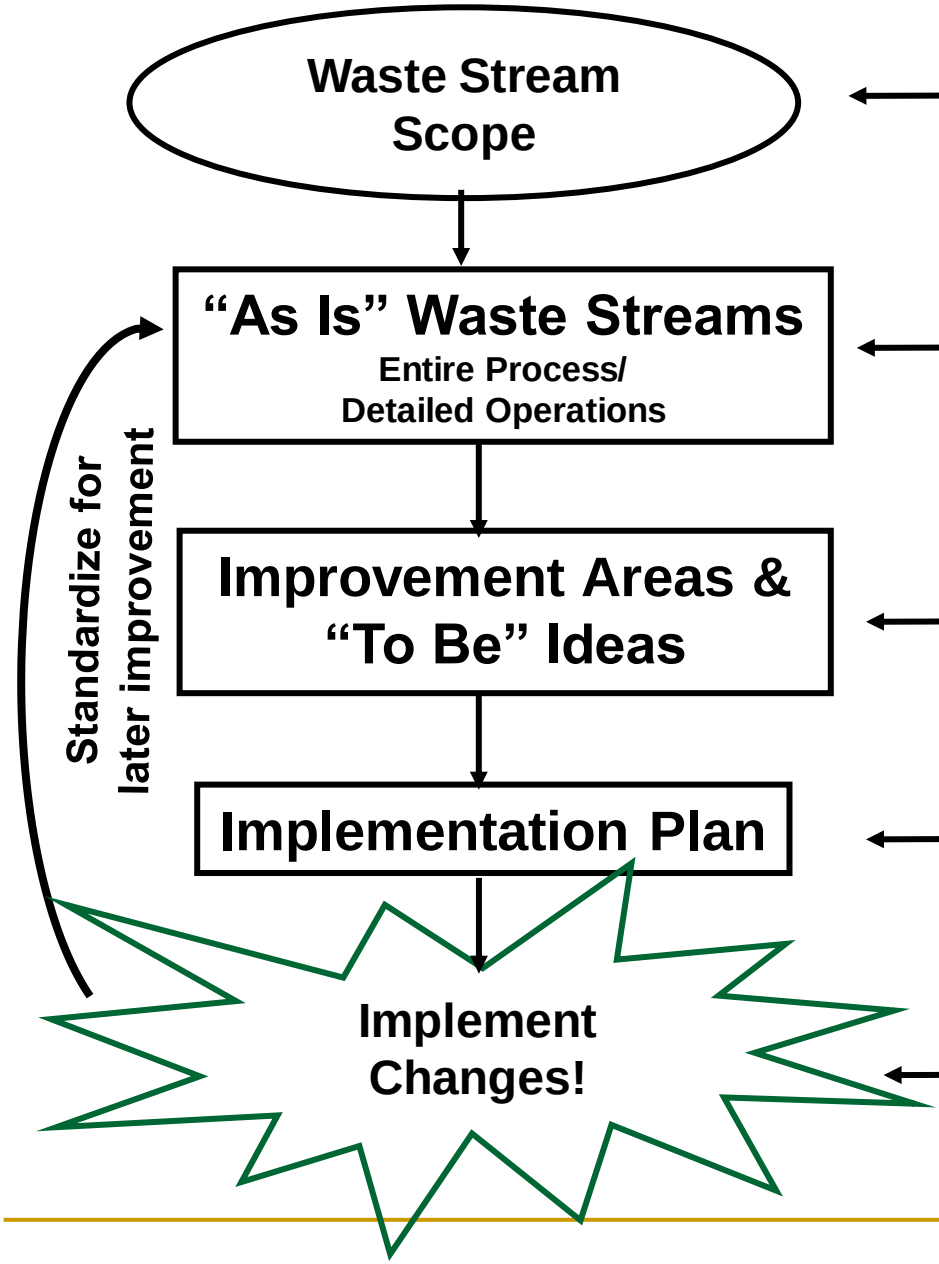
Environmental waste is:

- an unnecessary use of resources, or
- a substance released to the air, water, or land that could harm human health or the environment.

Examples include:

- Excess use of energy, water, or materials to meet customer needs;
- Air and water pollution;
- Trash, discarded scrap, hazardous materials.

Waste Stream Mapping Approach



Determine the Waste Stream(s) to be improved.

Understand how things currently operate. Identify areas where there is waste. Quantify waste and determine source(s).

Apply 4Rs to the resources/ wastes to design a Green approach.

Screen the improvement options and develop a detailed implementation plan to support improvement objectives (what, who, when).

Make the changes - this is the goal of mapping!

Process Inputs / Output Wastes

Inputs

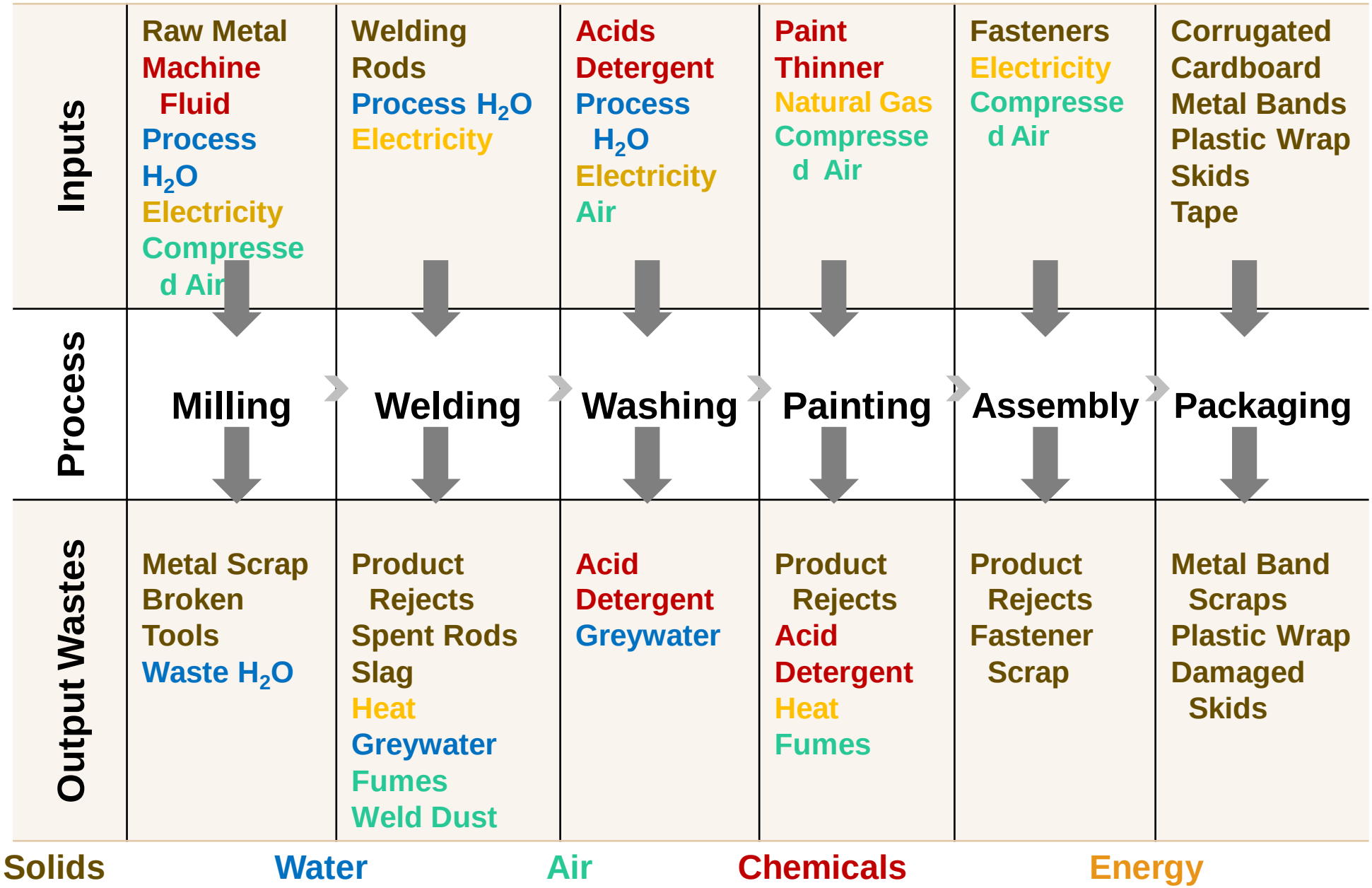
Raw Materials
Energy
Water
Chemicals



Output Wastes

Air Emissions
Effluents
Solid Waste
Heat Losses
Off-spec Products
By-products
Hazardous Materials
Energy Inefficiencies

Waste Stream Inputs/Outputs

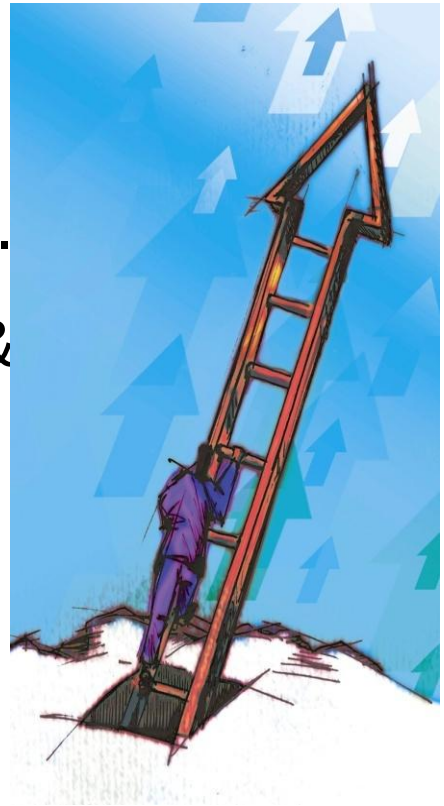


What to Consider for Scope

- Pollution and other environmental wastes throughout the facility as well as within specific processes.
- Explicit materials used versus needed.
- Environmental and human health risks.
- Environmental regulations and permitting limitations.
- Common or repeated materials / wastes across multiple process steps.

Maximize Benefits

- Integrate environmental considerations into all business areas.
- Include environmental performance metrics in business goals to be monitored and managed.
- Involve environmental personnel in Mapping & follow-on activities.
- Use specific tools to target environmental endpoints.
- Improve efficiency and effectiveness of environmental agency processes.



Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

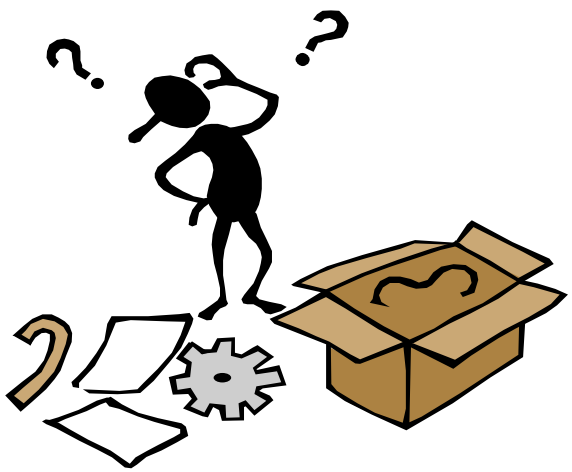
What / How to Improve

Considering Alternatives

Implementation Action Plan

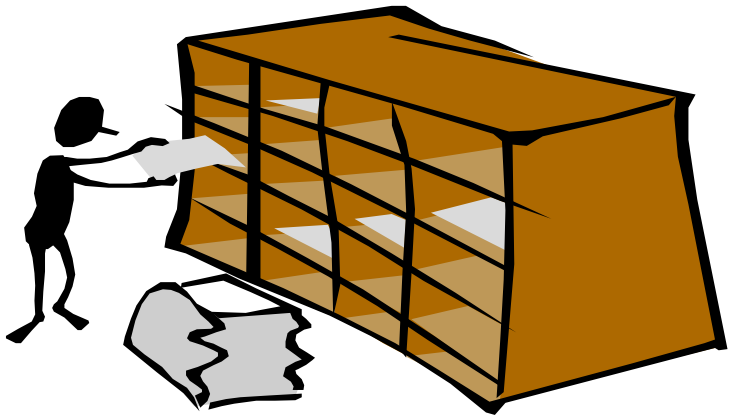
Course Evaluation

Information Gathering



Good information is prerequisite to an effective waste reduction program. Include:

- Quantitative data regarding types and amounts of waste generated and associated costs. Also amount and cost of resources purchased.



- Qualitative information to tell how the waste is dealt with and consistency of practices dealing with waste.

Information Gathering Methods

Facility Walk-through	• Process steps • Resource/waste flow • Types of waste generated • Generation points • Waste collection/processing methods
Purchasing/Utility Records	• Resource purchase/use quantity • Costs
Production Records	• Consumption of resources used in production • Resource(s) flow • Efficiencies, up-time, etc. • Special process resource, e.g., hazardous
Hauler/Waste Treatment Records	• Volumes/weights/frequency of waste hauled • Waste treatment impacts • Recycling volumes, frequency, etc. • Costs

Environmental Waste - Where to Look?

- Processes or equipment with high energy, water, and material use.
- Processes or products with significant liquid, solid or hazardous waste generation.
- Areas or processes requiring environmental permits or reporting to environmental agencies.
- Areas, processes or equipment with pollution control equipment.
- Processes or products using toxic chemicals that require personal protective equipment (PPE).

Common Operations to Look At



- Metal casting
- Metal fabrication and machining
- Plastic injection molding
- Thermoforming
- Welding
- Waste management
- Equipment maintenance
- Shipping and receiving
- Chemical and heat treatment of materials
- Metal finishing and plating
- Painting and coating
- Cleaning and surface preparation
- Bonding and sealing
- Chemical and hazardous materials management

Waste Stream Focus:
Materials Use / Solid Waste

Materials / Solid Waste Challenges

- Mixed waste streams
- Hazardous/toxic materials, e.g., e-waste
- Contamination
- Packaging
- Customer specifications
- Material extraction, e.g., post-assembly
- Material separation / collection
- By-product / Waste exchange identification

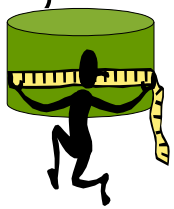


Materials / Solid Waste Questions

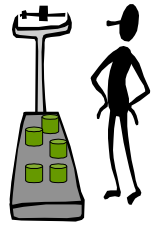
- Are there mechanisms for evaluating potential alternate materials being used to make product?
- Do any processes generate an excessive amount of solid waste when compared with other processes?
- Are solid by-products generated that could be reused as a material input – internally or externally?
- Is material waste segregated/collected for recycle/reuse?
- Is the entire product lifecycle analyzed for ways to improve the overall environmental impact of the product/processes?

Solid Waste Data to Collect

- Type and amount of different materials purchased, used, reused, recycled, discarded;



- Methods for material receipt, handling, storage, segregation/collection and/or discard;
- Costs associated with waste/recycle collection, container rental, removal, disposal;



- Recycling/Waste Exchange (potential) revenues;
- Recycled-content products/materials purchased.

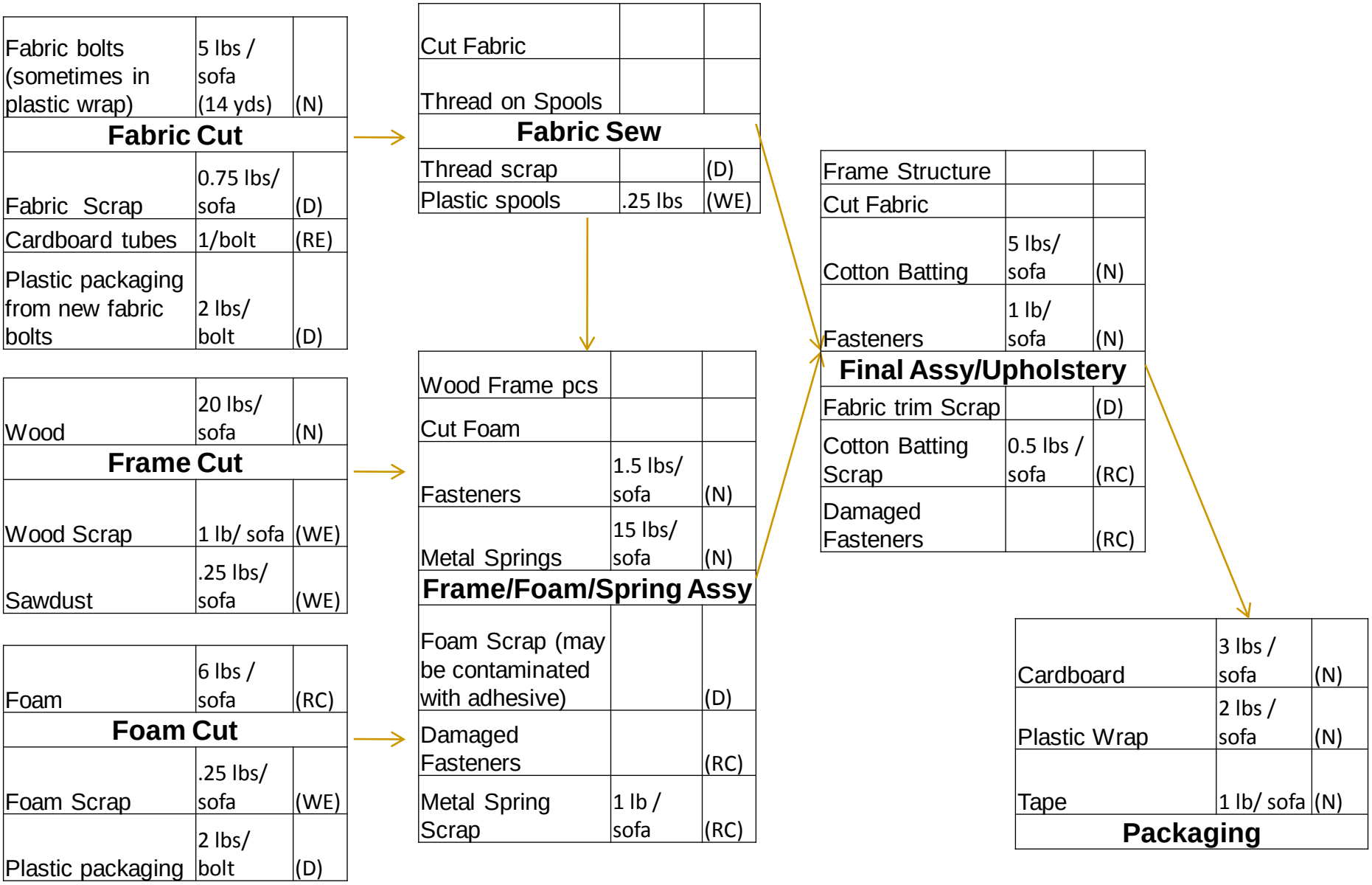
Solids Waste Stream – “As Is”

Plant-wide

Material Purchased	Waste Collection/ Disposal	Recycle Collection/ Handling	Recycling / Waste Exchange Revenues	Material/ By-product Reuse Savings
Wood - $XXXXXX Fabric - $XXXXXX Foam - $XXXXXX Cotton Batting- $XXXXXX Thread- $XXXX Metal Springs- $XXXXXX Fasteners - $XXXX Cardboard Pkg - $XXXXXX Plastic Pkg - $XXXXXX	$120,000 / yr	$1000 / yr	$12,000 / yr	$0

Data Collection is first step after defining the Waste Stream scope.

Solids Waste Stream – "As Is"



Waste Management Code:
D = Dispose RC = Recycle
RU = Reuse Internally WE = Contribute to Waste Exchange

Material Management Code:
N = Purchase New RU= Reuse from Internal Waste
WE = Obtain from Waste Exchange RC = Recycled Content

Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

What / How to Improve

Considering Alternatives

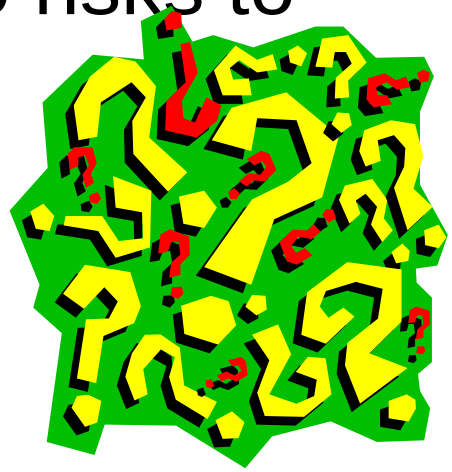
Implementation Action Plan

Course Evaluation

Getting to the “To Be” Approach

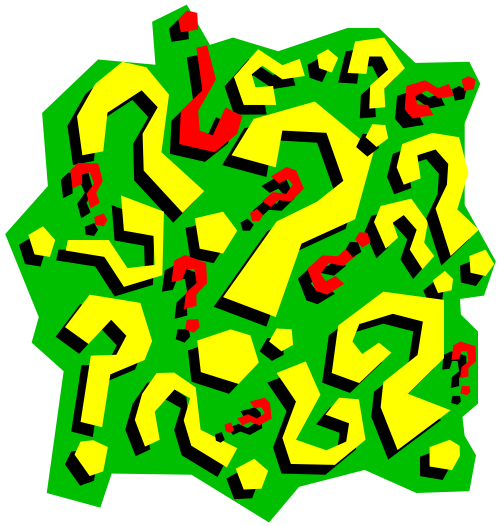
What would be needed for an environmentally-preferred "To Be" approach with:

- Zero environmental and production wastes?
- Products and processes that pose no risks to human health or the environment?
- No need for environmental permits?



Getting to the “To Be” Approach

- Can one process or operation use the “waste” output from another process instead of using virgin materials?
- What are appropriate targets for improving environmental performance?
- Where are kaizen events or six sigma projects needed to address significant environmental wastes?



Problems Can Have Many Causes

- Process Methods
- Chemical Choices
- Product Specifications
- Energy Rates
- Water Sources/Flow
- Mixed Waste
- Production Inefficiencies
- Transportation Inefficiencies
- Capacity Utilization
- Product Quality
- Market Demand



Waste Stream Focus:
Materials Use / Solid Waste

Materials / Solid Waste Questions

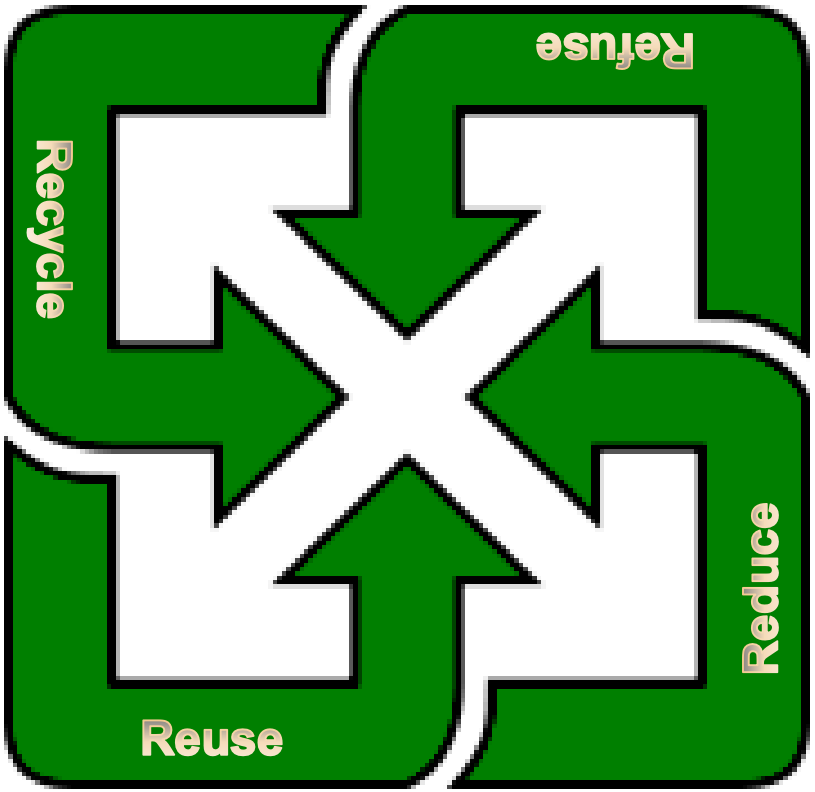
- What types/quantities of materials are used? Do they contain recycled content? Is material lifecycle considered in the purchasing process?
- How can the overall amount of materials be reduced – both within the product and used by the process?
- Can waste materials be separated/collected at the source?
- How can solid wastes be reused or recycled? Are there processes that could use the waste materials as inputs?
- How can non-value-added use of materials be eliminated, e.g., excess packaging, unneeded containers, etc.?

Materials/ Solid Waste Elimination

Clean Production;
Source Reduction;
Design for Environment;
Product Lifecycle Analysis

Materials Conversion

Alternative materials;
Dematerialization;
Lightweighting



Materials/ Solid Waste Reduction

Waste collection/ separation at the source;
Buy product/materials with recycled content

Materials Recovery

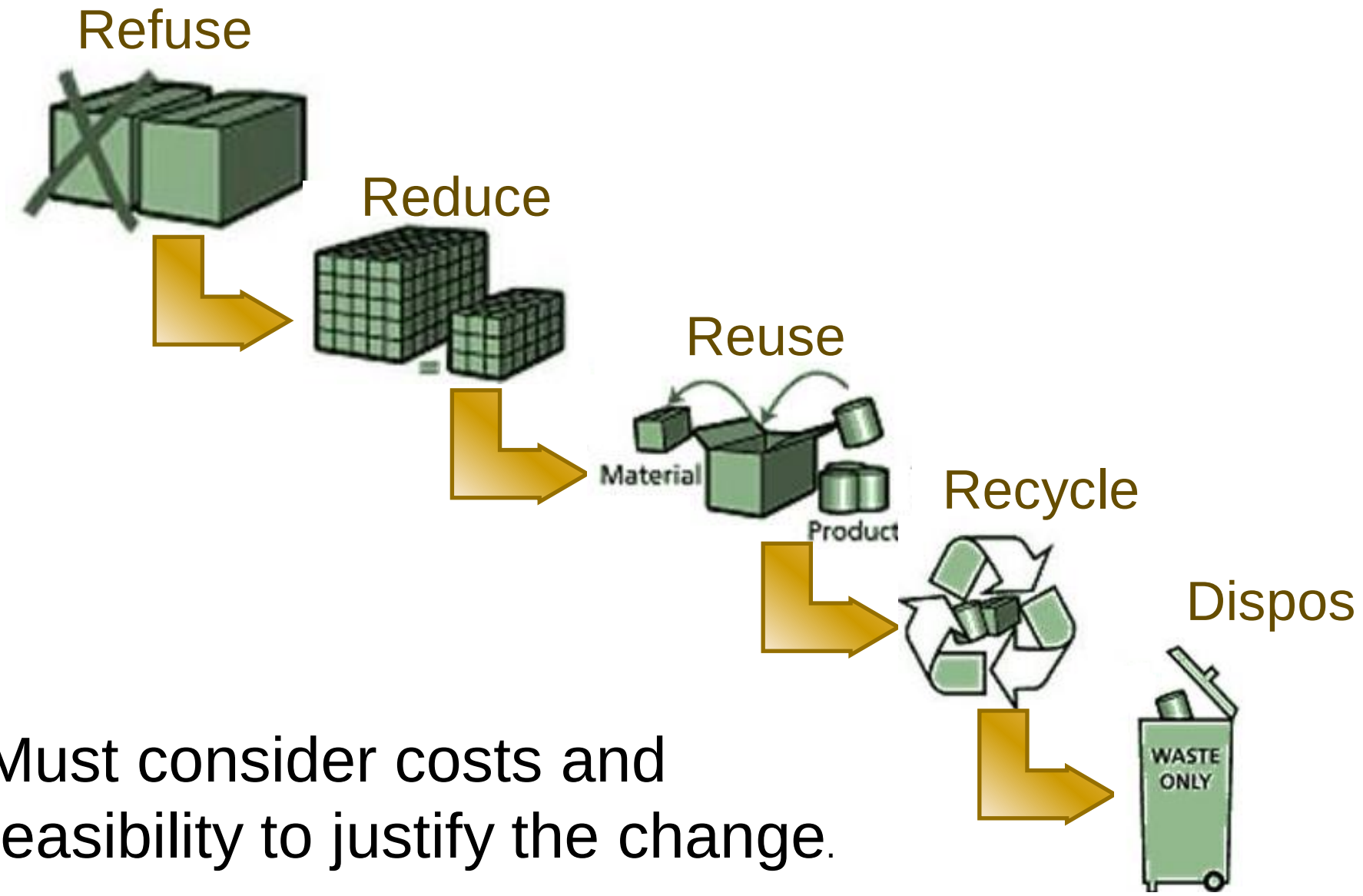
Packaging reuse;
Waste exchange;
By-product upgrades;
Take-back programs

Materials Management Methods

- Refuse, Reduce, Reuse, Recycle
  - Packaging (incoming and outgoing)
  - Purchase recycled content materials / products
  - By-product utilization / Waste Exchange
- Design for the Environment
  - Source Reduction / Dematerialization
  - Alternative materials in the product / used in the process
  - Materials with longer lifecycle / reusability
- Equipment Improvements
  - Cleaning / Maintenance / Replacement

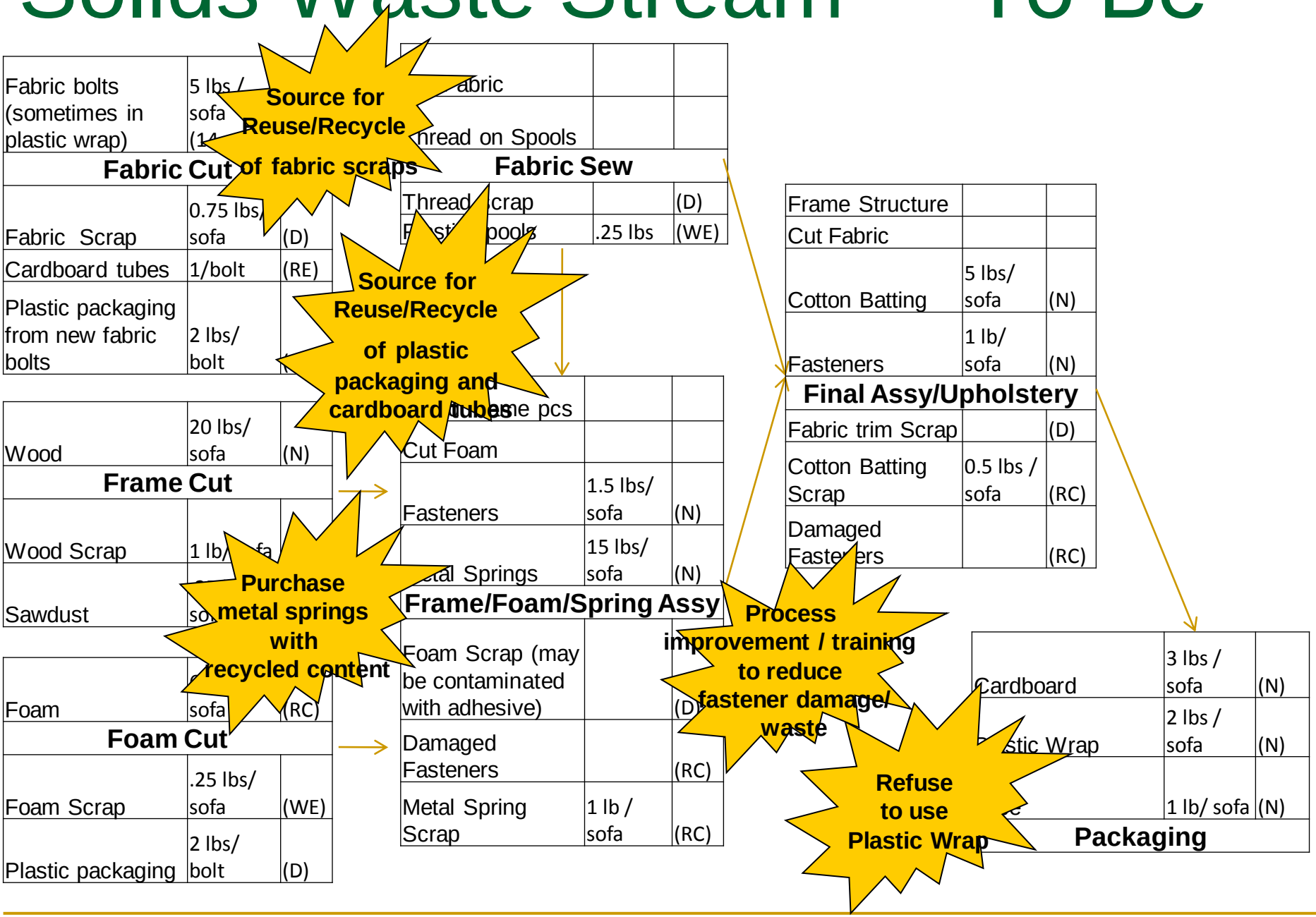


Start at the TOP of the Hierarchy



Must consider costs and feasibility to justify the change.

Solids Waste Stream – "To Be"



Waste Management Code:
D = Dispose RC = Recycle
RU = Reuse Internally WE = Contribute to Waste Exchange

Material Management Code:
N = Purchase New RU= Reuse from Internal Waste
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Course Agenda

Resource & Waste Management

Environmental Waste Streams

Seeing the Waste

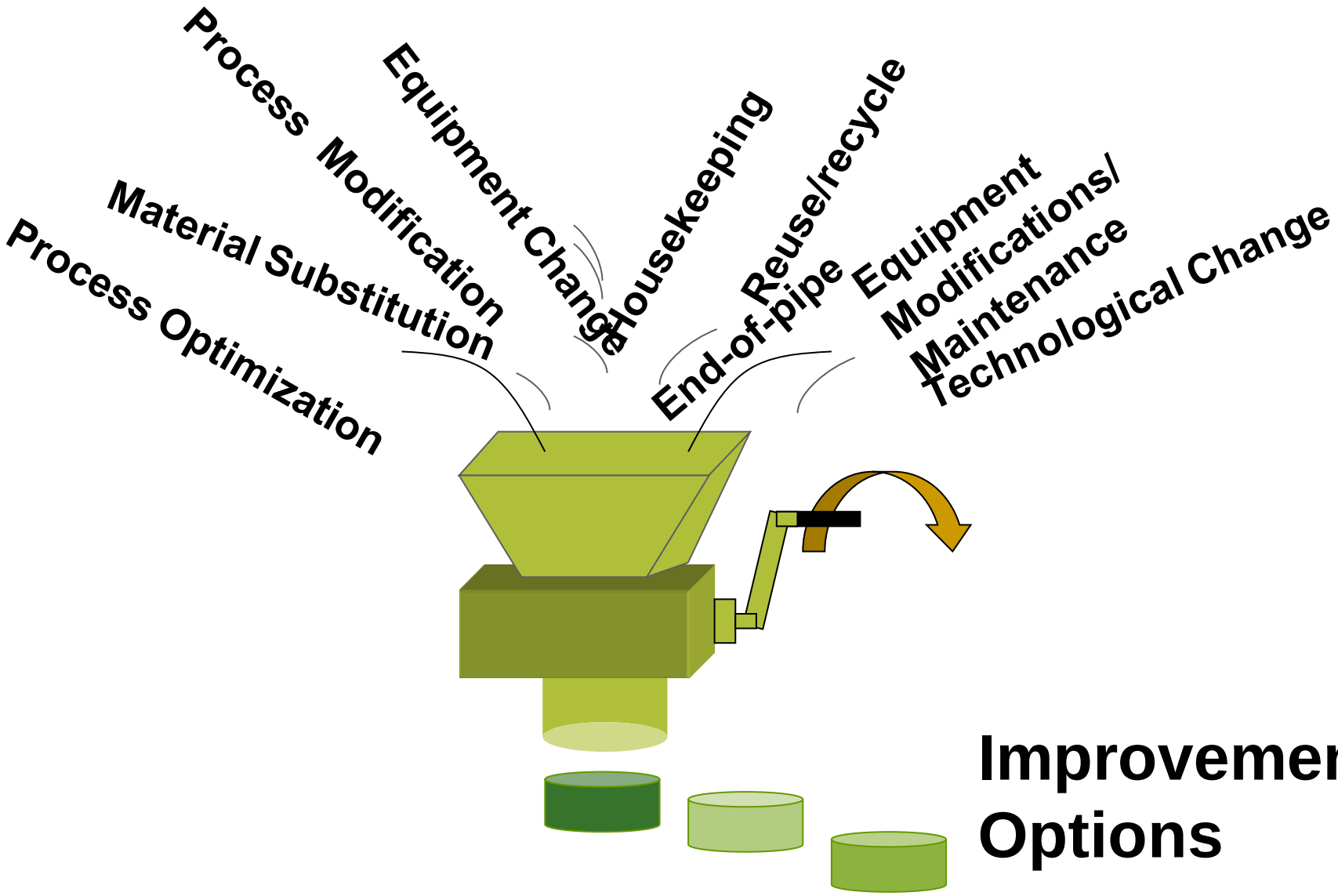
What / How to Improve

Considering Alternatives

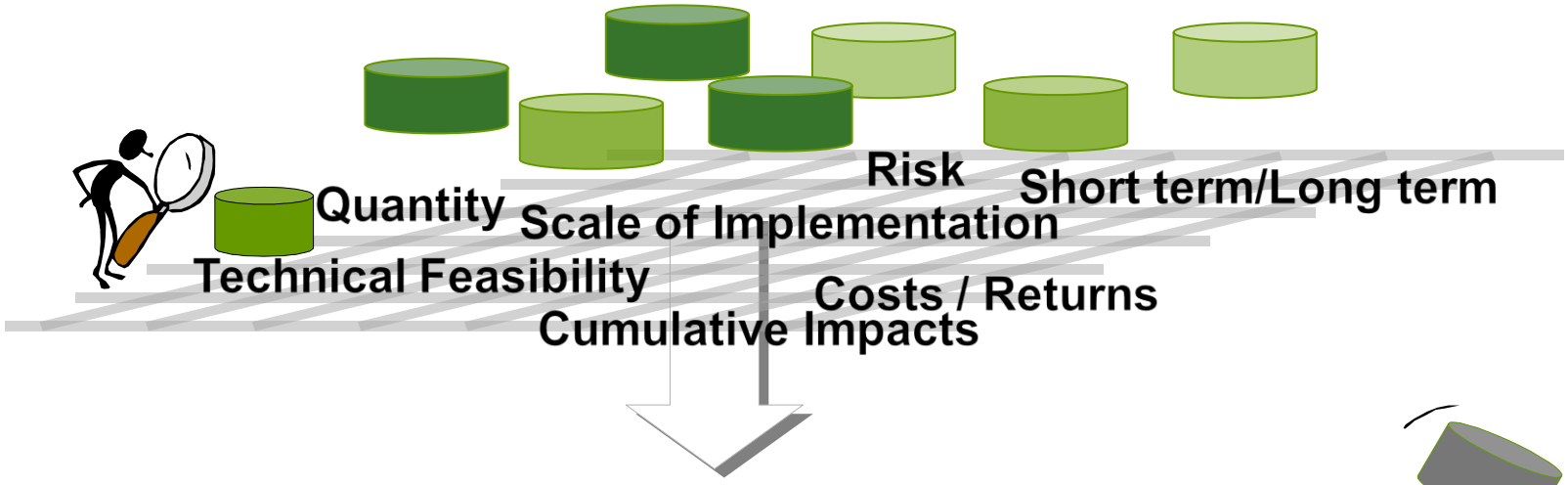
Implementation Action Plan

Course Evaluation

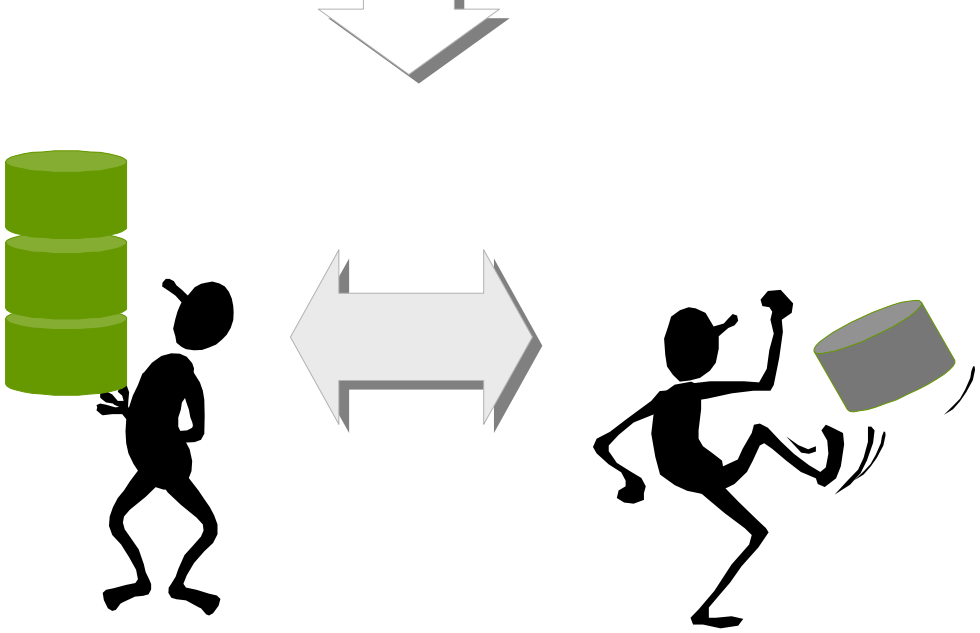
Identifying Improvement Options



Evaluating Options



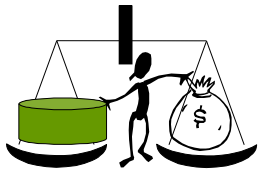
- Economical
- Technically sound
- High returns



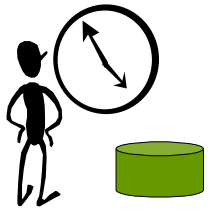
- High Cost
- High risk
- Complicated technology

Cost of Waste

The cost of waste is not only the cost of waste disposal, but can include other costs such as:



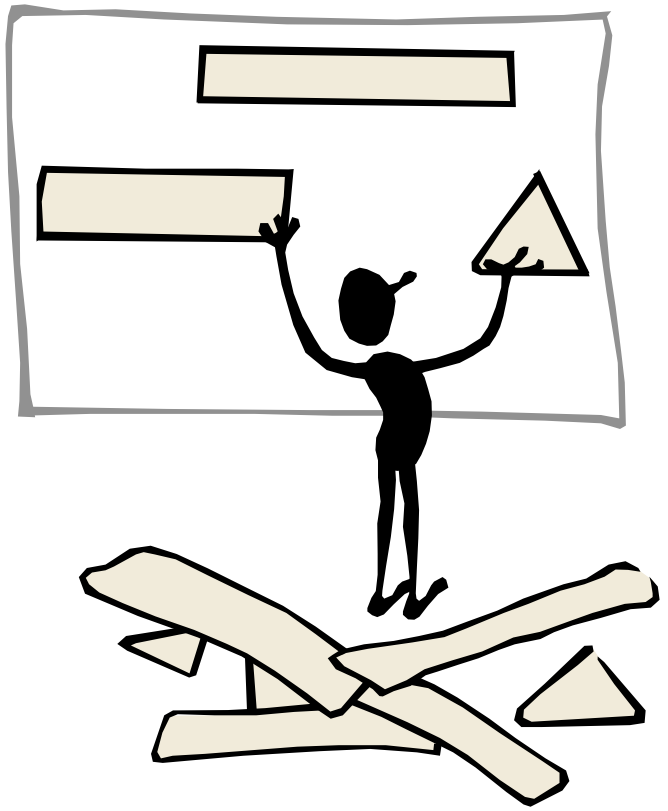
- Waste treatment/transportation cost;
- Inefficient energy use cost;
- Purchase cost of wasted raw material;
- Production cost for the waste material;
- Management time spent on waste material;



- Lost revenue for what could have been a product instead of waste;
- Potential liabilities due to waste.

Changes May Require Approval

- Changes to the type, volume, or introduction/issuance procedure for chemicals/materials used by employees.
- Changes to the type or volume of waste generated by a process, including all media such as air emissions, water discharges, and liquid and solid waste.
- Changes to the physical layout of the processes (e.g., moving work or storage areas), to equipment and technologies used, or to the facility (e.g., moving, replacing, or installing vent hoods, stacks, floor drains or process tanks).



Specific Information to Consider

New Equipment	• Potential/Preferred Suppliers (pricing, terms, reliability) • Installation space • Cost (capital, operating) • Personnel requirements (skills, training)
New material/chemicals	• Potential/Preferred Suppliers (pricing, terms) • Effects on other processes • Safety sheets • Transport considerations
Modification of existing process / Change in operating practices	• Costs • Effects on other processes • Impact on customer requirements • Personnel requirements (skills, training)

Course Agenda

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Implementation Action Plan

Course Evaluation

Implementation Plan

	Area	Issue	Impact (H, M, L)	Cost/Effort (H, M, L)	Owner	Target Date
1						
2						
3						
4						
5						

Course Agenda

Resource & Waste Management

Environmental Waste Streams

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What / How to Improve

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TECHNICAL ASSISTANCE PROGRAM

Green Enterprise Development

LEVEL 3

Green Enterprise Development

Join us for the Waste Stream Mapping Workshop!

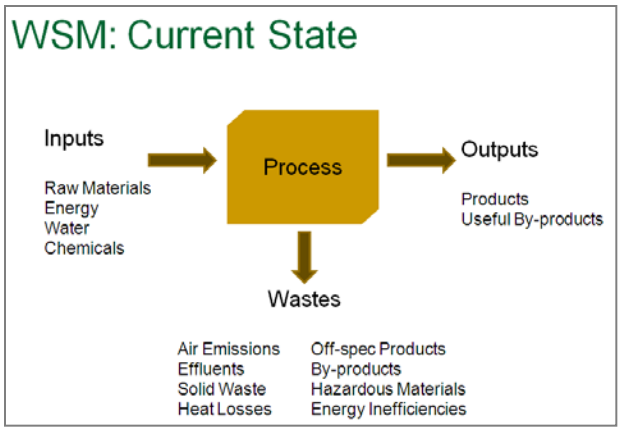
Learn how green thinking can help reduce or eliminate waste stream output.

Two-Day Workshop • Appropriate for engineers, green team participants and environmental managers

Waste Stream Mapping (WSM) provides a VSM like tool that will help companies identify waste stream opportunities focusing on energy, solid waste, water or hazardous wastes. Participants will learn how things currently operate, identify improvement areas, develop an implementation plan and finally make the change for an environmentally-preferred future state.

Participants will learn:

- How green thinking can help reduce or remove waste stream output
- To enable visualization of how processes create waste
- Where opportunities exist to reduce or eliminate waste
- Evaluate multiple environmental waste streams
- Integrates root cause analysis & problem solving tools



Green Enterprise Development



Visit www.tap.purdue.edu/green to learn how to take the green movement to the next level.

Note: Waste Stream Mapping (WSM) – though not a required component of the Specialist or Champion levels, it is a smart addition as it provides a VSM like tool that will help identify opportunities.

How We Can Work With You: In addition to Green Enterprise Development, Purdue's Technical Assistance Program offers on-site public workshops and provides implementation and consulting services.

For workshop dates or to register: Visit www.tap.purdue.edu/green under "Register for Events."
Cost for this event is $790/per person.

For more information: Contact us via phone at (800) 877-5182 ext. 620 or email MEPworkshops@purdue.edu.

Black & Gold & Green Enterprise Development

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(800) 877-5182 or (317) 275-6810 Fax (317) 275-2375
www.tap.purdue.edu/green

PURDUE UNIVERSITY

1. SUSTAINABILITY & GLOBAL CONDITIONS

1.1. Sustainable Consumption and Production
  1.1.1. Sustainable Consumption & Production
1.2. Climate Change and Causes of Global Warming
1.3. Natural Resource Protection
1.4. Ecosystems & Biodiversity

2. MATERIAL AND SOLID WASTE MANAGEMENT

2.1 Solid Waste Streams
2.2 Solid Waste Management
2.3 Refuse, Reduce, Reuse, Recycle
2.4 Product Lifecycle Analysis
  2.4.1 Cradle-to-Cradle
  2.4.2 Waste creation/Product discard
  2.4.3 Green Purchasing/Procurement
2.5 Design for Environment
  2.5.1 Alternative Materials Considerations (cost, design, function, performance, etc.)
  2.5.2 Source Reduction
  2.5.3 Dematerialization
  2.5.4 By-Product Reduction
  2.5.5 Restructuring production/distribution systems
  2.5.6 Identifying/implementing synergies
2.6 Zero Waste/Zero Landfill
  2.6.1 Waste Exchange
2.7 Measuring Material Use and Solid Waste
  2.7.1 Data Sources for Material Use/Solid Waste
  2.7.2 Common Metrics/Measures
  2.7.3 Analysis & Trending
  2.7.4 Expressing Material & Solid Waste in Monetary/Cost Terms

3. ENERGY MANAGEMENT

3.1 Non-Renewable Energy Sources
3.2 Renewable Energy Sources
3.3 Major Energy Systems
  3.3.1 Building Envelope
  3.3.2 HVAC
  3.3.3 Electrical Supply
  3.3.4 Lighting
  3.3.5 Boiler and Steam
  3.3.6 Hot Water
  3.3.7 Compressed Air
  3.3.8 Motor Driven Systems
  3.3.9 Process Heating
  3.3.10 Special Purpose Process Equipment
3.4 Energy Audits
3.5 Measuring Energy Use
  3.5.1 Data Sources for Energy Utilization (utility bills, meters, etc.)
  3.5.2 Common Energy Metrics/Measures
  3.5.3 Analysis & Trending
  3.5.4 Expressing Energy & Energy Waste in Monetary/Cost Terms

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4. CHEMICAL WASTE MANAGEMENT/GREEN CHEMISTRY

- 4.1 The Principles of Green Chemistry
  - 4.1.1 "Hit List" Chemicals
  - 4.1.2 Electronic waste (e-waste)
- 4.2 Auxiliary Substances
  - 4.2.1 Substitutions
  - 4.2.2 Enclosure/recovery
- 4.4 Process Reengineering
  - 4.4.1 Switching from batch reactions to continuous processing
  - 4.4.2 Alternative Reactions/Catalysts
- 4.5 Environmental Hazard Prevention/Reduction
- 4.6 Regulatory Standards (e.g. RoHs, WEEE, REACH, ISO, OSHA, EPA, etc.)
- 4.7 Measuring Chemical Use/Waste
  - 4.6.1 Data Sources for Chemical Use/Waste
  - 4.6.2 Common Chemical Metrics/Measures
  - 4.6.3 Analysis & Trending
  - 4.6.4 Expressing Chemical & Chemical Waste in Monetary/Cost Terms

5. CLIMATE/ AIR EMISSIONS MANAGEMENT

- 5.1 Air Contaminants
  - 5.1.1 Global warming
  - 5.1.2 Ozone depletion
  - 5.1.3 Air quality index
- 5.2 Industrial Hygiene
  - 5.2.1 Environmental factors/stresses
  - 5.2.2 Measurement of airborne chemical exposures (calibration, collection, analysis, evaluation)
  - 5.2.3 Regulatory Standards, e.g., OSHA, acceptable levels
- 5.3 Pollution Prevention, Reduction & Treatment
- 5.4 Noise Pollution
  - 5.4.1 Accepted Units for Noise
  - 5.4.2 Regulatory standards, e.g., OSHA, EPA, etc.
  - 5.4.3 Noise Measurement Devices & Processes
  - 5.4.4 The Effects of Noise
  - 5.4.5 Controlling Noise
- 5.5 Air Sampling
  - 5.5.1 Purpose and components of air sampling
  - 5.5.2 Types of Air Samples (e.g. personal, breathing zone, general air/area, time weighted average, etc.)
  - 5.5.3 Health risk assessment
  - 5.5.4 Determine need for/effectiveness of engineering controls
  - 5.5.5 Incident/complaint investigation
  - 5.6 Measuring Emissions
    - 5.6.1 Data Sources for Air/Noise emissions
    - 5.6.2 Emissions factors/metrics
    - 5.6.3 Analysis & Trending
    - 5.6.4 Expressing Air/Noise Management in Monetary/Cost Terms

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6. SUPPLY WATER / WASTEWATER MANAGEMENT

- 6.1 Water Cycle
  - 6.1.1 Environmental changes impacting water cycle
- 6.1 Supply Water Resources & Conservation
  - 6.1.1 Sustainable drainage
  - 6.1.2 Water efficiency
  - 6.1.3 Water quality
  - 6.1.4 Legislation and Regulatory Standards (e.g., EPA)
- 6.2 Water Contaminants
- 6.3 Water Pollution Identification, Prevention, Monitoring, Reduction & Treatment
- 6.4 Measuring Water Use/Waste
  - 6.4.1 Data Sources for Water Use/Waste
  - 6.4.2 Common Metrics/Measures
  - 6.4.3 Analysis & Trending
  - 6.4.4 Expressing Water Use & Wastewater in Monetary/Cost Terms

7. ENVIRONMENTAL BUSINESS MANAGEMENT

- 7.1 Green Business Philosophy
  - 7.1.1 Green products & eco-design
  - 7.1.2 Green packaging
  - 7.1.3 Clean production
  - 7.1.4 Green supply chain & transport
- 7.2 Standards, Regulations, Permitting
  - 7.2.1 Environmental Management Standards (EMS), e.g., ISO 14001
  - 7.2.2 Environmental Protection Agency
  - 7.2.3 Industry Specific Standards
- 7.3 Business Case for Sustainability
  - 7.3.1 Financial aspects (e.g., triple bottom line, investment, investment recovery, etc.)
  - 7.3.2 Environmental Performance Measurement
  - 7.3.3 Strategic Value

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