

SOLAR HEATING ACADEMY

Facilitator Guide



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FACILITATOR OVERVIEW OF THIS MANUAL

This manual provides information for facilitators who present the **Introduction to Solar Heating Installer** program of the CNM WTC.

EQUIPMENT/MATERIALS/PREWORK LIST

- Laptop or desktop PC
- LCD projector
- Dry erase markers, eraser
- Masking tape or pins to hang charts
- Extra pens and/or pencils for participants
- Participant roster
- CNM New Student Registration forms
- Evaluation forms
- Handouts – one copy for each participant
- Textbook: NABCEP Solar Heating Installer Resource Guide, May 2012/v.1.0, www.nabcep.org. Clifton Park, N.Y.: North American Board of Certified Energy Practitioners, 2012.
- Textbook: Solar Water and Pool Heating Manual: Design and Installation & Repair and Maintenance, Florida Solar Energy Center, Cocoa, Florida, 2006.
- Reference: Peter N. Skinner P.E., Solar Hot Water Fundamentals: Siting, Design, and Installation, ESCO Press, E2G Solar, LLC, Second Edition 2012, www.e2gsolar.com
- Any supplemental materials you wish to use

PREWORK

- ✓ **Read this Facilitator Guide ahead of time.**
- ✓ **Preview:** NABCEP Solar Heating Installer Resource Guide

PLEASE NOTE: Organizations that want to administer the NABCEP Entry Level Exam must become a Registered Provider, per NABCEP's policies. For more details, go to <http://www.nabcep.org/entry-level-program-2/approved-providers>

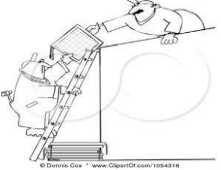
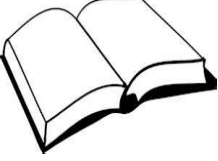
OBJECTIVES

When students have completed these modules they will be able to:

- Describe the expectations for careers in the Solar Heating industry
- Pass the Entry Level NABCEP Solar Heating Installer Exam
- Conduct a site analysis, including a load analysis
- Identify solar heating safety practices, standards, codes, and certifications
- Identify systems for specific climates and applications
- Identify proper operation and installation methods
- Identify proper use of balance-of-system, components, and materials
- Identify common solar heating maintenance items

NOTE: Contact WTC staff to verify classroom Internet connection details. Please let WTC staff know at least three business days in advance of any additional/special requirements you have for equipment, materials, and/or room set up.

FACILITATOR GUIDE ICONS – Found in This Module	
 Participant binder	 Class discussion
Ask Say (etc.) Instructor prompts	 Individual writing
 Instructor talking points icon	 Handouts

 LCD Projector/Computer/Laptop	Depending on the experience and skill levels of your audience, it might be necessary to spend time on sweating copper, torch safety, and related tools/materials. Example
 PowerPoint slides	 Individual reading exercise
 Crew exercise 2 to 4 installers	 Team exercise 5 to 8 installers
 Book	

INSTRUCTIONAL STRATEGY

“Solar Heating Installer” training consists of a series of six PowerPoint modules constructed with the singular intent of preparing adult students to take the *North American Board of Certified Energy Practitioners (NABCEP)* Entry Level Solar Heating Examination.*

The six modules are further constructed for completion in a forty-eight hour, lecture-listen, small and large group discussion, and small and large group system installation timeframe. Outside/assigned readings are an important element of the learning process and are strongly emphasized.

Written by a long-time industrial technology educator, the modules were understandably constructed with an implied instructional strategy. The writer, a student of the late Piagetian Period, is an acknowledged cognitive-developmental experientialist who borrows deeply from the information processing school and who mixes and matches Brunerian and Gagneian instructional approaches.

When using these modules the instructor should recognize the mixing and matching of both simple-to-complex and complex-to-simple instructional strategies (resulting in repetitive content) blended with classroom discussion and hands-on experiences with both solar heating training stations and residential-sized installations. The combination of instructional strategies is designed to promote the individual's cognitive development of "solar heating schemata".

Understanding the intent and imbedded instructional strategy of this module series, the instructor should weigh-in with her/his own instructional preferences and modify the PowerPoint presentation as needed.

TIME SCHEDULE

Times and session segments are approximate. Participants may need to spend more time than indicated on some subjects, less on others. Some material may be omitted and replaced with the suggested optional activities at facilitator's discretion. Adjust your times accordingly.

NOTE: Break times are not included in the following table. Facilitator has the opportunity to flex these guidelines as needed to allow for two 10-minute breaks.

MODULE 1: INTRODUCTION TO SOLAR HEATING	Minutes
Welcome to Course • Facility overview (restrooms, emergency exits, etc.) • Introduction: Facilitator • Introduction: Participants • Ground Rules	30
Overview of Course • Calendar • Course text, print, web resources • NABCEP-based objectives • Expectations of participants: class participation, reading/assignment completion, clothing	30
Pretest: Multiple choice items from NABCEP Study Guide* • Test item review/discussion	60
Brief History of Solar Water Heating	30
Solar Thermal Safety	30
Total Estimated Time (not including breaks)	180

*Please note: Pretest and answer key are provided in Appendix A.

MODULE 2: SOLAR HEATING SYSTEMS AND COMPONENTS	Minutes
Welcome and Overview	10
System Classification	180
System Components	100
Controllers	130
Heat Exchangers Heat Transfer Fluids Expansion Tanks Valves, Gauges and Meters	90
Total Estimated Time (not including breaks)*	510

*Please note: Three optional activities are included with this module. See Appendix B.

MODULE 3: SOLAR HEATING SITE AND SIZE ANALYSIS	Minutes
Solar Thermal Applications and Technologies	90
Solar Basics	20
Applying the Basics	60
Sizing a System Site Assessment	330
Total Estimated Time (not including breaks)*	500

*Please note: An optional one-hour activity is included with this module. See Appendix C.

MODULE 4: SOLAR HEATING SYSTEMS & INSTALLATION	Minutes
Solar Heating Installation Safety	60
Codes and Licenses	60
Collector Mounting	360
Component Installation	220
System Installation	120
Total Estimated Time (not including breaks)	820

*Please note: Six optional activities are included with this module. See Appendix D.

MODULE 5: SOLAR HEATING OPERATION MAINTENANCE & TROUBLESHOOTING	Minutes
Problem Assessment and System Checkout	170
Troubleshooting Checklist	60
Total Estimated Time (not including breaks)	230

*Please note: An optional one-hour activity is included with this module. See Appendix E.

MODULE 6: SOLAR SWIMMING POOLS	Minutes
Pool System Components, Installation and Operation	120
NABCEP SHW Installer Practice Test	50
Total Estimated Time (not including breaks)	170

*Please note: An optional one-hour activity is included with this module. See Appendix F.

A seventh module “Module 7: Solar Incentives and Marketing” was developed and is included in Appendix G. The content is not within the learning objectives of the NABCEP Exam and therefore is not included as part of the core course.

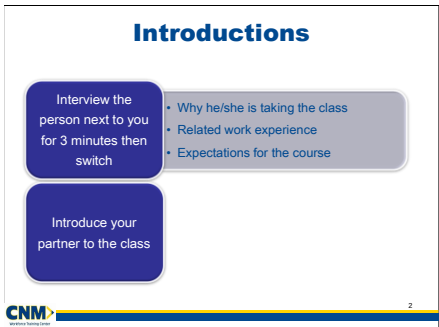
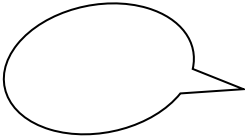
Module 1: Introduction to Solar Heating

WELCOME TO COURSE

Time: 30 minutes

Learning Activity 1

Discussion Points	Instructor/Trainee Activities
Logistics  PowerPoint Presentation  SOLAR HEATING INSTALLER Module 1: Introduction to Solar Heating  Slide 1	This module is designed for the use of an accompanying PowerPoint presentation. If you choose not to use PP, then please have facilitator information charts ready for some activities. Slide 1 should be available to view prior to participants entering the room. Welcome participants, thank them for attending, and introduce yourself. Give a short overview of your background and explain how it relates to the Solar Heating Academy and this module. Acquaint participants with locations for lavatories; vending machines, emergency exits etc.

 Slide 2	Reveal slide 2 Read Objectives to class from page 1 of this guide.
	Ask students to interview a partner for 3 minutes and then to introduce him/her to the class. Tell students your expectations for the course
	Ask participants to post their name tents.
 Attendance Roster	Remind participants of the attendance roster and that you will be sending it around so each person can initial/verify attendance for this module. Ask participants to double check that their name appears on the roster and that it is spelled correctly. This will ensure that the names are spelled correctly on the certificate of completion.
 CNM Student Registration Form	Ask if this is anyone's first class. If it is, then request that the person fill out a CNM Student Registration Form. Collect it.

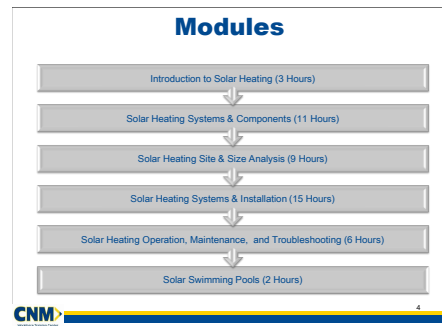
Objectives ▶ Describe the expectations for careers in the Solar Heating industry ▶ Pass the Entry Level NABCEP Solar Heating Installer Exam ▶ Conduct a site analysis, including a load analysis ▶ Identify solar heating safety practices, standards, codes, and certifications   2 Slide 3	Reveal slide 3 Read course objectives to class.
Objectives (continued) ▶ Identify systems for specific climates and applications ▶ Identify proper operation and installation methods ▶ Identify proper use of balance-of-system, components, and materials ▶ Identify common solar heating maintenance items   3 Slide 4	Reveal slide 4 Read course objectives to class.
Ground Rules ▶ Demonstrate respect for classmates/instructor ▶ Quiet cell phones, laptops etc. ▶ Participation encouraged ▶ No side bar conversations ▶ Put off-topic items in "Parking Lot"    3 Slide 5	Reveal slide 5 Allow time for participants to read the slide information. Ask: Is there anything else you'd like to add? Get agreement that they will do their best to hold up the ground rules on their side.

OVERVIEW OF COURSE

Time: 30 minutes

Learning Activity 2

Discussion Points



Slide 6

Instructor/Trainee Activities

Distribute this module's Student Guide.

Reveal slide 6

Say: This forty-eight (48) hour course is designed to prepare you to successfully pass the NABCEP entry level examination for solar heating installers. The course is presented through a series of six (6) modules. A careful analysis of NABCEP entry level examination objectives and the NABCEP solar heating examination blueprint was used to structure module content, and select course readings.

Agenda

- ▶ Course Materials
- ▶ Career Path in Solar Heating
- ▶ History of Solar Heating
- ▶ Safety
- ▶ Questions



Slide 7

Reveal slides 7 and 8

Review module topics, related readings, and texts. Students should be encouraged to review readings and to explore web sites noted in class and in their readings.

Course Materials ▶ Student Guide with Appendix ▶ Text ▶ Flash Drive ▶ Web Resources List CNM www.cnm.net Slide 8	
Career Path ▶ Entry Level Occupations – Solar Installation Helper – Mechanical Assembler ▶ Mid Level Occupations – HVAC Technician with Solar Expertise – Roofer with Solar Expertise Interstate Renewable Energy Council, Inc. Solar Energy Education & Training: Best Practices – Solar Content Integration, IREC, May 2012. www.srhua.org CNM www.cnm.net Slide 9	Reveal slides 9 and 10 Explain: Solar thermal installation relies very heavily on plumbing skills and competencies – with roofing, electrical, carpentry, and other trade skills often required. Instructor Note: You may want to refer to the Solar Interactive Career Map developed by the Interstate Renewable Energy Council. The tool is intended for use by instructors, policy-makers, and job-seekers.
Career Path (Continued) ▶ Mid Level Occupations – Solar Thermal Installer (Residential/Small Commercial) – Solar Thermal Technician (Commercial/Utility) – Electrician with Solar Expertise – Plumber with Solar Expertise ▶ Advanced Level Occupations – Solar Installation Contractor Interstate Renewable Energy Council, Inc. Solar Energy Education & Training: Best Practices – Solar Content Integration, IREC, May 2012. www.srhua.org CNM www.cnm.net Slide 10	Instruct all students to add the NABCEP website to their new “solar heating” favorites tab. Explain: The course emphasis is preparation for the NABCEP entry level exam/certification in solar heating.

NABCEP Certification ▶ Voluntary ▶ National standards by which solar heating installers with skills and experience can distinguish themselves from their competition ▶ Target candidate is person responsible for the system installation CNM www.cnm.com Slide 11	Reveal Slide 11 Instructor Note: Log on to NABCEP website in class and discuss solar heating examination pages with students. Instruct them to bookmark the site on their own computers.
	http://www.nabcep.org/certification/solar-thermal-installer-certification NABCEP solar heating objectives, found on the NABCEP website are key to questions that will appear on the entry level examination. Here is an illustration of just part of the objectives listed. Students should review the entire list to become familiar with areas from which exam questions will be written.
NABCEP Certification (continued) ▶ NABCEP Objectives ▶ NABCEP Exam Blueprint ▶ NABCEP Practice Exam CNM www.cnm.com Slide 12	Reveal Slide 12 Students may observe that there are various iterations of NABCEP’s “Exam Blueprint” available with slight variations in (chart) items and percentages. The table offered in the “NABCEP Solar Heating Installer Resource Guide” (page 6) for instance, may differ slightly from similar tables found online. Explain that such differences are slight and represent the new, emerging/developing nature of the solar heating examination.

PRETEST

Time: 60 minutes

Learning Activity 3

Discussion Points



Handouts

Instructor/Trainee Activities

Disseminate pretest.

Give students 40 minutes to complete test.

Review answers as a group.

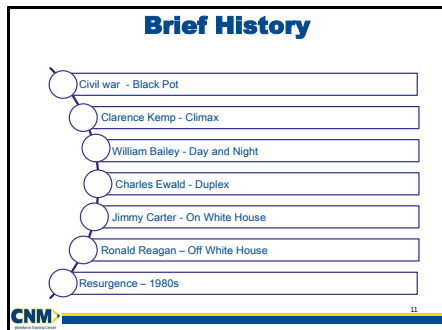
BRIEF HISTORY

Time: 30 minutes

Learning Activity 4

Discussion Points

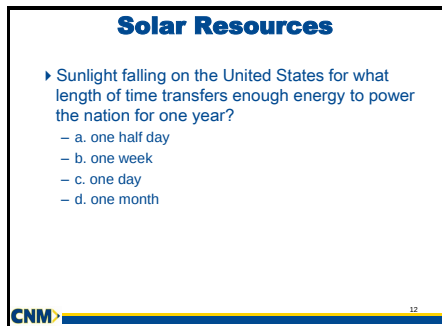
Instructor/Trainee Activities



Slide 13

Reveal Slide 13

This slide presents a sampling of important solar heating eras/players and events. The “black pot” was an early solar heating device (literally a black pot full of water) used during the civil war era. Clarence Kemp invented and sold the “Climax” roof top batch heater for homes. William Bailey came later with the “Day and Night”. President Carter had solar installed on the White House roof, President Reagan had it removed, President Obama had it installed again.



Slide 14

Reveal Slide 14

SAFETY

Time: 30 minutes

Learning Activity 5

Discussion Points

Instructor/Trainee Activities

Safety Topics

- ▶ Eye Safety
- ▶ Hand Tool Safety
- ▶ Power Tool Safety
- ▶ Electric Tool Safety
- ▶ General Safety Precautions

CNM

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Slide 15

Reveal Slide 15

Eye Safety

- ▶ How many work-related eye injuries are there each day?
- ▶ Which occupation has the highest eye injury rates?
- ▶ What are the eye hazards at a solar heating installation site?
- ▶ What is the best way to protect your eyes?

CNM

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Slide 16

Reveal Slide 16

Solar heating students should have successfully completed an OSHA course. This safety instruction is intended as a review.

Review NABCEP Chapter 5

Approximately 2000 eye injuries occur every day at work in the US. Construction workers have one of the highest eye injury rates. Particles of dust, metal, wood, slag, drywall, cement etc. are the most common source of eye injury to carpenters. Even “minor” eye injuries can cause life-long vision problems and suffering—a simple scratch from sawdust, cement, or drywall can cause corneal erosion that is recurrently painful. Hammering on metal which gives off metal slivers and the rebounding of the ordinary nail are two of the most common causes of vision loss in construction workers.



Slide 17

Reveal Slide 17

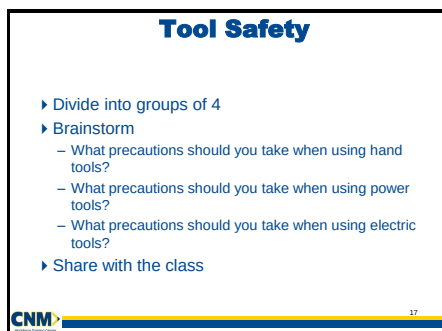
Ask: What are the differences between hand, power, and electric tools?



Slide 18

Reveal Slide 18

Explain: The greatest hazards posed by hand tools result from misuse and improper maintenance. It is important to know the power tool. Operators must read and understand the owner's manual. Labels affixed or included in the shipping container must be read and understood.



Slide 19

Reveal Slide 19

Divide the class into groups of four.
Ask them to brainstorm the questions on the slide
Debrief

Next Steps

- ▶ Please ask questions if you have any
- ▶ Please review text and flash drive materials
- ▶ Thank you!

CNM Colorado Northern Middle

18

Slide 20

Reveal Slide 20

Module 2: Solar Heating Systems & Components

WELCOME TO COURSE

Time: 10 minutes

Learning Activity 1

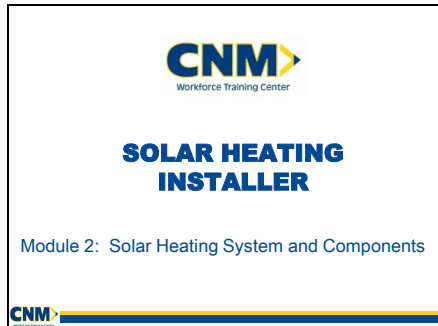
Discussion Points



PowerPoint Presentation

Instructor/Trainee Activities

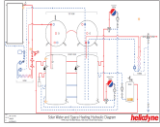
This module is designed for the use of an accompanying PowerPoint presentation. If you choose not to use PP, then please have facilitator information charts ready for some activities.



Slide 1

Slide 1 should be available to view prior to participants entering the room.

Describe the System



Slide 2

Reveal Slide 2

Ask:

What type of system is it? (Closed-loop, combo system (radiant heat and domestic hot water))

Ask:

Are the storage tanks linked in series or parallel? Why? (Parallel, for stratification)

Ask:

Where is the collector? (Top left)

Ask:

Where are the heat exchangers? Expansion tanks? Pumps? Boiler drains? P-T valves? Where is the source water? (Bottom right)

Ask:

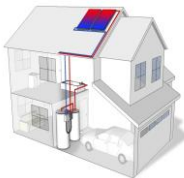
Where is the auxiliary heat source? (Boiler)

Ask:

Why are the cold/blue lines dashes (not solid lines)? (So you can read schematic if it is copied in black and white.)

Agenda

- ▶ Course Materials
- ▶ System Classification
- ▶ System Components
- ▶ Controllers
- ▶ Other Devices
- ▶ Questions



Slide 3

Reveal Slide 3

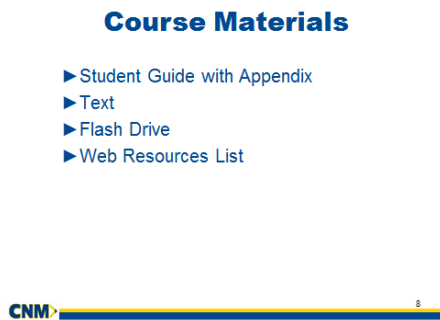
Note: Here are the major topics we will cover in Module #2.



Slide 4

Reveal Slide 4

Remind students of the Solar Heating Mantra



Slide 5

Reveal Slide 5

Mention that students should look at the

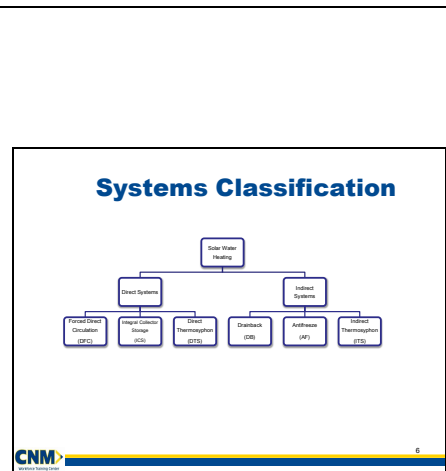
SYSTEM CLASSIFICATION

Learning Activity 2

Time: 180 minutes

Discussion Points

Instructor/Trainee Activities

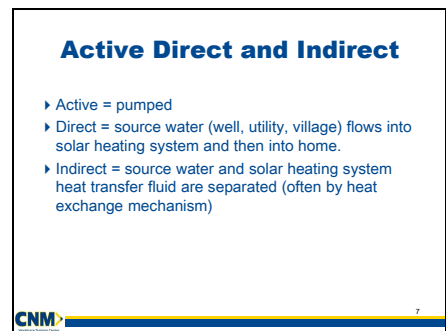


Slide 6

Reveal Slide 6

Refer to NABCEP Page 26; Figure 4-13 – Classification of solar water heating systems.

This chart is central to your understanding the various solar heating system designs and functions. The ability to quickly distinguish between system types, when on a service call in the field, will be key to your success as a system installer/maintainer.



Slide 7

Reveal Slide 7

Refer to NABCEP Solar Heating Installer Resource Guide (NABCEP Installer Guide) pages 33 thru 44

Note Solar heating professionals constantly hear the terms “active”, “inactive”, “passive”, “direct”, “fully flooded”, “pressurized” when on the job. While these terms are important, the installer recognizes that different terms may actually mean the same thing. “Active” and “pumped” systems both include circulators. “Inactive” and “passive” systems do not include circulators. “Indirect” and “closed” and even “pressurized” refer to two-circuit systems employing a heat exchanger. “Direct” and “open” refer to systems without a heat exchanger.

Direct students to highlight these terms in their text glossary, and work to understand them as quickly as possible.

Active Direct

- ▶ Water storage
- ▶ Solar collector
- ▶ Controller, timer, or P-V pump regulation
- ▶ Pump or circulator

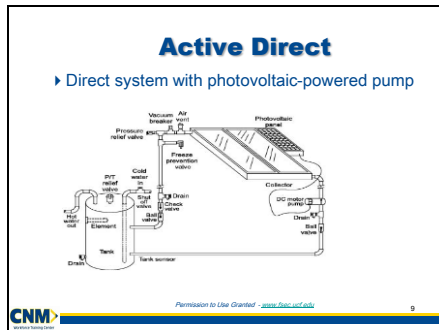
CNM 8

Slide 8

Reveal Slide 8.

Mention that these four elements are found in an active direct system.

Refer to NABCEP Page 36



Slide 9

Reveal Slide 9.

Explain importance of a vacuum breaker and air vent.

Active Indirect

- ▶ Water storage
- ▶ Solar Collector
- ▶ Controller, timer, or P-V pump regulation
- ▶ Pump or circulator
- ▶ Heat exchange mechanism
- ▶ Heat transfer fluids

CNM 11

Slide 10

Reveal Slide 10.

Inactive/Passive Direct

- ▶ Inactive/Passive = no pump
- ▶ Direct = source water (well, utility, village) flows into solar heating system and then into home.
- ▶ Include water storage and Solar Collector

CNM 12

Slide 11

Reveal Slide 11.

Refer to NABCEP Solar Heating Installer Resource Guide (NABCEP Installer Guide) pages 33 thru 44

Inactive/Passive Indirect

- ▶ Indirect = source water and SH system heat transfer fluid are separated (using heat exchange mechanism)
- ▶ Inactive Indirect systems include:
 - Water storage
 - Solar Collector
 - Heat exchange mechanism
 - Sometimes heat transfer fluids

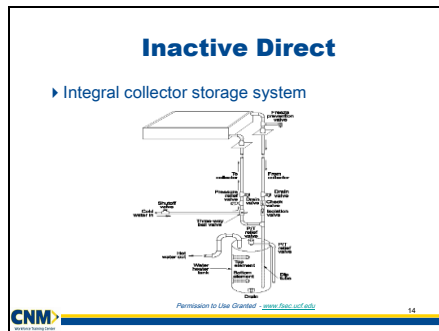
CNM 13

Slide 12

Reveal Slide 12

Refer to NABCEP Solar Heating Installer Resource Guide (NABCEP Installer Guide) pages 33 thru 44

Best example, passive thermosyphon

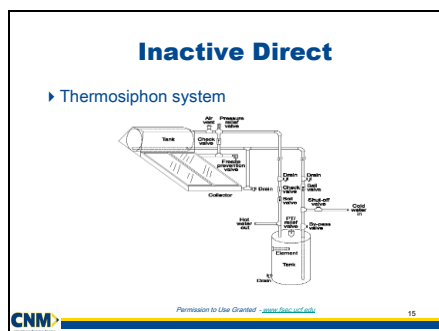


Slide 13

Reveal Slide 13

Note this is an “Integral Collector Storage” system AKA “ICS”. Students will see numerous references to “ICS” systems in their readings.

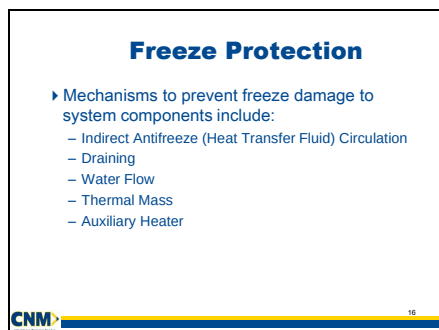
Note Illustration is missing tempering valve and vacuum breaker.



Slide 14

Reveal Slide 14

Explain that a similar configuration, plumbed with a heat exchanger inside the collector-mounted tank, would be an example of an Inactive Indirect system.



Slide 15

Reveal Slide 15

Ask: Can you describe, from your readings to date, how each of these freeze protection mechanisms work?

State: Now let’s discuss each freeze protection design.

Indirect Antifreeze Fluid Circulation

- ▶ Systems typically used in cold climates use a heat transfer fluid (propylene glycol)
- ▶ Some systems pressurized
- ▶ External heat exchanger
 - Heliodyne System (NABCEP page 41)
- ▶ Internal (in-tank) heat exchanger
 - Buderus System (NABCEP page 40)

CNM 17

Slide 16

Reveal Slide 16

Explain that students will find descriptions of various heat exchanger designs in their readings.

Discuss heat exchanger design differences (flat plate, tube-in-tube) and related safety considerations (single wall, double wall).

Note that heat exchangers will be looked at closely in subsequent module/readings.

Explain that the trend in solar heating systems is toward “plug-and-play” installations wherein the installer “hangs” a “Pump Station” (AKA in Europe: “Appliance”) which includes pump(s), commissioning valves, pressure and temperature gauges, flow gauges. etc.). This contrasts with 1970-1980 systems where the installer had to plumb together individual component parts.

Draining

- ▶ All water is removed from the collector and exposed piping.
- ▶ Water removed to conditioned space.
- ▶ System Examples:
 - Drain-down (NABCEP page 38)

CNM 37

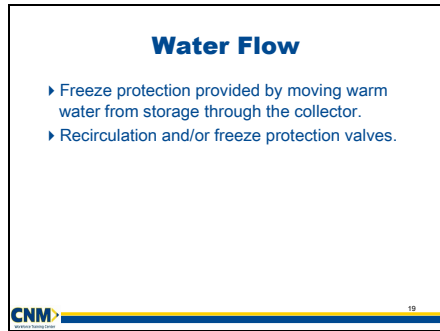
Slide 17

Reveal Slide 17

Explain that “Drain-down” systems are noted by many as the “bad boys” of solar heating systems. Drain-down systems were largely responsible for the bad reputation of residential solar heating systems in the 1970’s and 1980’s – as the one key component in the system – the drain-down valve – often malfunctioned, resulting in freeze damage to systems.

Drain-downs are commonly referred to as a part of older, “legacy” systems. Drain-downs are not commonly installed systems today.

Installers must be aware of drain-down systems and how they work – as they may come into contact with such a system on a maintenance call. Many solar heating installers claim that finding a drain-down system provides a perfect opportunity to “assist the homeowner” in upgrading to an improved/reliable system.

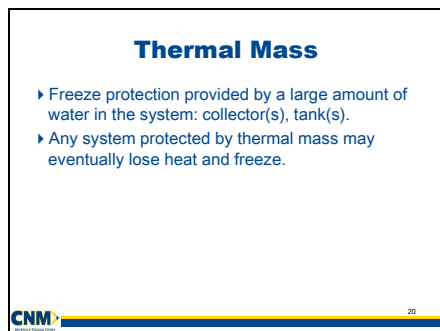


Slide 18

Reveal Slide 18

Refer to System Examples in text

- NABCEP page 32 (freeze valve), page 30 (check valve)



Slide 19

Reveal Slide 19

Refer to System Examples in text

- NABCEP page 33

SYSTEM COMPONENTS

Time: 100 minutes

Learning Activity 3

Discussion Points



Slide 20

Instructor/Trainee Activities

Reveal Slide 20

Explain that Installers must have a strategy to quickly identify solar heating systems.

Understanding system components is key to this strategy.

When approaching a system the installer looks for:

- System water source (plumbing) and distribution (hot water domestic supply line)
- Number, type and location of valves
- System size (# collectors, tank capacity)
- System complexity (active/inactive, single purpose/combi-system)
- Number, type and location of collectors and tanks
- Number, type of heat exchangers (if indirect) and pumps (if active)

And when approaching a system on paper (schematic) the installer also looks for overall system design and component parts

Refer to text

- NABCEP Chapter 4

Collectors

- ▶ Low Temperature
 - Pool
- ▶ Medium Temperature
 - Flat Plate ¹
 - Evacuated Tube ²
 - Solar Air Heater
- ▶ High Temperature
 - Parabolic Trough
 - Dish Stirling
 - Central Tower
 - Fresnel Reflector

CNM 22

Slide 21

Reveal Slide 21

Mention that the first two bullets are really the focus of this course.

Refer to NABCEP page 18.

Low – Medium - High

SHW TECHNOLOGY COLLECTORS *heliodyne*

THREE TYPES OF COLLECTORS

Unglazed Collectors

Vacuum Tube Collectors

Flat Plate Collectors

CNM Reported with Permission, May 2012 23

Slide 22

Reveal Slide 22

Low Temperature

- ▶ Typically unglazed.
- ▶ Usually polypropylene.
- ▶ Types:
 - Black flat-plates
 - Black flexible mats
 - Black pipes

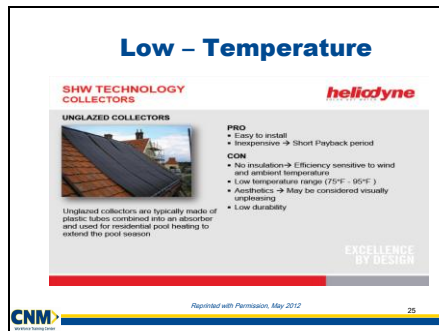
CNM 24

Slide 23

Reveal Slide 23

Refer to text

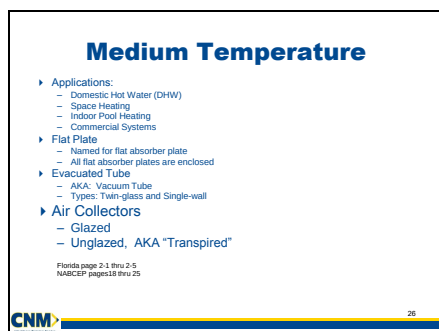
- NABCEP pages 19 & 20



Slide 24

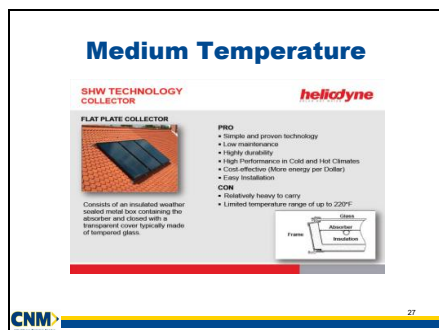
Reveal Slide 24

Note that that the “pros” and “cons” listed on the upcoming slides (except the next one) are useful comparisons and written by a flat plate manufacturer.



Slide 25

Reveal Slide 25



Slide 26

Reveal Slide 26

Medium Temperature

- ▶ Applications
 - Domestic Hot Water (DHW)
 - Space Heating
 - Indoor Pool Heating
 - Commercial Systems
- ▶ Flat Plate
 - Named for flat absorber plate
 - All flat absorber plates are enclosed

CNM 28

Slide 27

Reveal Slide 27

Refer to text

- NABCEP pages 18 thru 25

**Medium Temperature
(continued)**

- ▶ Evacuated Tube
 - AKA: Vacuum Tube
 - Types: Twin-glass and Single-wall
- ▶ Air Collectors
 - Glazed
 - Unglazed, AKA “Transpired”

CNM 29

Slide 28

Reveal Slide 28

**Medium Temperature
Collectors**

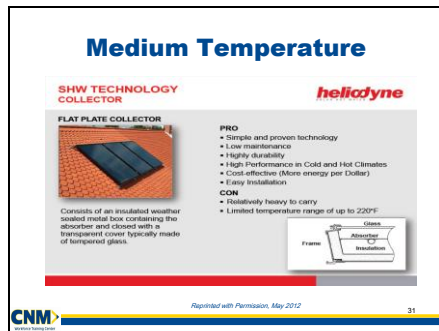
- ▶ Focus of Course
 - Flat Plate Collectors
 - Domestic Hot Water (DHW)
 - Residential
- ▶ Also Reviewed in Course
 - Evacuated Tube
 - Swimming Pool

CNM 30

Slide 29

Reveal Slide 29

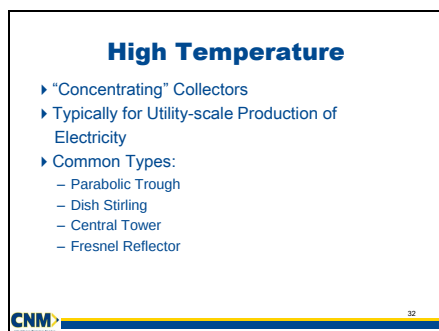
Note that many excellent diagrams and photographs of vacuum tube collectors are available on line. They are easily obtained, for example, by entering “vacuum tube solar collector” on Google and then clicking on “images”.



Slide 30

Reveal Slide 30

Note that excellent diagrams and photographs of flat plate collectors are available on line. They are easily obtained, for example, by entering “flat plate solar collector” on Google and then clicking on “images”.



Slide 31

Reveal Slide 31

Refer to NABCEP pages 25 thru 26.



Slide 32

Reveal Slide 32

Refer to NABCEP page 23

High Temperature Collectors

- ▶ High Temperature Parabolic Trough
- ▶ High Temperature Dish Stirling
- ▶ High Temperature Central Tower
- ▶ High Temperature Fresnel Reflector

CNM

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Slide 33

Reveal Slide 33

Explain: Irradiance (the amount of sunlight striking the collector) is directly linked to how much energy any collector can produce. The type selective surface on the collector absorber also factors in to the amount of energy a collector can produce.

Concentrating collectors are largely used on commercial applications and are rarely found in domestic hot water systems.

Ask: Does anyone know the differences between the collectors listed on Slide 33?

Explain:

High Temperature Dish Stirling

Mirrors or heliostats directing sunlight on to Stirling Engine which in turn produces electricity.

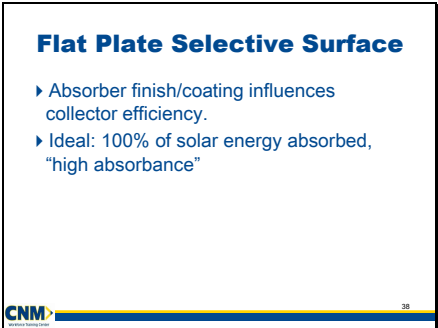
High Temperature Central Tower

“Heliostats” (mirrors) direct sunlight onto a central “power tower” (sometimes a sophisticated “boiler”). Heat from the tower is used to power turbines and generate electricity. Technology is changing almost daily. The original “Solar One” outside of Barstow, California has already been dismantled in favor of a newer design.

High Temperature Fresnel Reflector

The existing system is available for viewing at Albuquerque Sunport, behind car rental building.

Flat Plate Collectors ▶ Commercially available since 1909 ▶ Flat Plate Topics: – Construction – Absorbers – Selective Surface CNM 35 Slide 34	Reveal Slide 34 Refer to text • NABCEP pages 20 thru 22
Flat Plate Collector Construction ▶ Absorber enclosed inside glazed and insulated casing. – Usually extruded aluminum case – Hi-temp insulation – Low-iron and tempered glass – Certified SRCC OG-100 (collectors), OG-300 (systems) • System certification typically required for incentives, etc. ▶ Typical Collector Sizes – 4'x6', 4'x8', 4'x10' CNM 36 Slide 35	Reveal Slide 35 Explain solar heating systems and collectors are certified by the Solar Rating and Certification Corporation. Certification is a requirement of solar incentives (financial, federal/state/local tax) and most lending programs. Many AHJ's (Authority Having Jurisdiction) require SRCC as an element of the solar installation permitting process. Refer students to NABCEP, pages 27 – 28.
Flat Plate Collector Absorber ▶ Absorbers (enclosed inside glazed and insulated casing) – Categorized by tubing configuration • Risers and headers • Single tube serpentine – Typically copper or aluminum • System certification typically required for incentives, etc. CNM 37 Slide 36	Reveal Slide 36 Explain that typically commercially available absorbers are of the “header-and-riser” design wherein a larger (example: one inch copper) “header” pipe at either end of the collector are joined at right angles by a series of smaller (example three-eighth-inch copper) and parallel “riser” which in turn are joined (example: laser welded) to absorber plates (commonly aluminum or copper) with or without a selective surface. Commercially built variations in absorber design

	clearly exist. Provide examples (One such example, built by Schuco, is the “Steam Back” absorber. This absorber design does not include headers and individual risers, but one “serpentine” length of smaller tubing (example: three-eighth-inch copper). More at DIY site: http://mondodesigno.com/ben/serpentine.html).
 Slide 37	Reveal Slide 37. Explain that while solar insulation will be discussed further in Module #3, an introduction to a few commonly used terms is appropriate here. State: Many solar heating publications use the term “one Sun”, or “1 Sun”, or “S” where one Sun equals 1000 W/m² at the point of arrival, with kWh/(m²·day) displayed as hours/day. (Sometimes this unit is referred to as a Sol). Explain: insolation is a measure of solar radiation energy received on a given surface area and recorded during a given time. It is also called solar irradiation and expressed as hourly irradiation if recorded during an hour, daily irradiation if recorded during a day. Solar heating professionals use the unit Wh/m² (watt-hours per square meter). If this energy is divided by the recording time in hours, it is then a density of power called irradiance, expressed in W/m² (watts per square meter). Over the course of a year the average solar radiation arriving at the top of the Earth's atmosphere at any point in time is roughly 1366 watts per square meter. The radiant power is distributed across the entire electromagnetic spectrum, although most of the power is in the visible light portion of the spectrum. The Sun's rays are attenuated as they pass through the atmosphere, thus reducing the irradiance at the Earth's surface to approximately 1000 W m⁻² for a

	surface perpendicular to the Sun's rays at sea level on a clear day. The actual figure varies with the Sun angle at different times of year, according to the distance the sunlight travels through the air, and depending on the extent of atmospheric haze and cloud cover.						
Flat Plate Selective Surface ▶ Early finish: flat black paint (85% absorbtion) – Emmissivity or radiative loss ▶ “Selective Coatings” AKA “Selective Surface” – Proprietary names: “Black Chrome”, “Black Crystal”, “Sputtered Aluminum”, “Blue Sputtered”. – A climate determination. – (enclosed inside glazed and insulated casing) – Categorized by tubing configuration • Risers and headers • Single CNM 39 Slide 38	Reveal Slide 38						
Flat Plate Selective Surface SHW TECHNOLOGY COLLECTOR ABSORBER VARIOUS SURFACES <i>heliodyne</i> <table border="0"> <tbody> <tr> <td> BLACK PAINT • Low cost solution • Recommended for warm climates with high solar radiation </td> <td> $\alpha = 0.25$ $\epsilon = 0.85$ </td> </tr> <tr> <td> BLACK CHROME • First generation selective surface • Tough surface • Recommended for cool climates </td> <td> $\alpha = 0.12$ $\epsilon = 0.95$ </td> </tr> <tr> <td> BLUE SPUTTERED • State of the art technology • Optimal heat absorption with minimal emission • Suitable for all types of installations and regions • Recommended for cool climates </td> <td> $\alpha = 0.85$ $\epsilon = 0.95$ </td> </tr> </tbody> </table> α: Absorptivity → a measure of an object's ability to absorb incident energy ϵ: Emmissivity → The ability of a material to hold or release heat CNM 40 Slide 39	BLACK PAINT • Low cost solution • Recommended for warm climates with high solar radiation	$\alpha = 0.25$ $\epsilon = 0.85$	BLACK CHROME • First generation selective surface • Tough surface • Recommended for cool climates	$\alpha = 0.12$ $\epsilon = 0.95$	BLUE SPUTTERED • State of the art technology • Optimal heat absorption with minimal emission • Suitable for all types of installations and regions • Recommended for cool climates	$\alpha = 0.85$ $\epsilon = 0.95$	Reveal Slide 39 State: This is a good time for you to go back and review terms in your solar heating glossary (text). Emphasize “absorptivity” “emissivity”, “irradiance”, “insolation”, etc. Mention that glass, in addition to selective surface choices, is an important collector design consideration. State: Most quality collectors today employ a “low iron” glass. Low iron glass allows light to pass more freely than high-iron glass – which reflects light. Collectors must also pass various SRCC tests including impact resistance (glass). Dade County, Florida has some of the country’s most stringent solar collector requirements (hurricane country).
BLACK PAINT • Low cost solution • Recommended for warm climates with high solar radiation	$\alpha = 0.25$ $\epsilon = 0.85$						
BLACK CHROME • First generation selective surface • Tough surface • Recommended for cool climates	$\alpha = 0.12$ $\epsilon = 0.95$						
BLUE SPUTTERED • State of the art technology • Optimal heat absorption with minimal emission • Suitable for all types of installations and regions • Recommended for cool climates	$\alpha = 0.85$ $\epsilon = 0.95$						

	Explain that system designs vary by recommended flow rate and heat gain. If the heat transfer fluid (HTF) flows rapidly, the rise in the fluid temperature from entering the collector to exiting the collector is typically less than if it moves slowly through the collector. Recommended HTF temperature increases vary, maybe 3-4°F, or 10°-20°F, with collector size, array size, pump size, etc. (See manufacturer's notes). Stress that the key here is a counter-intuitive concept. A cool collector is an efficient collector. Explain that heating a smaller volume of HTF to a higher temperature increases heat loss from the collector and decreases the efficiency of the system. Heating a larger volume of HTF to a lower temperature decreases heat loss from the collector and increases the efficiency of the system.
Evacuated Tube Collectors ▶ Commercially available since 1970's ▶ Vacuum used as insulation/heat retention device ▶ Essentially Two Styles: – Twin-glass Evacuated Tube – Single-wall Evacuated Tube CNM 41 Slide 40	Reveal Slide 40 Refer to text • NABCEP pages 20, 23

Twin-glass Evacuated Tube

- ▶ Twin glass tubes fused together with vacuum.
- ▶ Absorber not in vacuum.
- ▶ Modular design (separate tubes)
- ▶ Essentially two absorber styles:
 - Flooded pipe
 - Heat pipe

CNM

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Slide 41

Reveal Slide 41

Refer to text

- NABCEP pages 20, 23

Twin-glass Evacuated Tube

- ▶ “Vacuum tube” contains a glass envelope in which the absorber is within a vacuum.
- ▶ Heat pipe, is in ambient air – sealed usually with a rubber or plastic stopper similar to a thermos bottle.

CNM

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Slide 42

Reveal Slide 42

Search for Google images of Twin Glass Evacuated Tube.

Note that often this is referenced as a “Sydney” tube, named after engineers working in Sydney, Australia who improved upon and popularized the design.

Note this is also referenced as a “Dewar Flask”.

Single-Wall Evacuated Tube

- ▶ Absorber inside vacuum.
- ▶ Essentially two absorber styles:
 - Flooded tube (not modular)
 - Heat pipe (modular)
- ▶ Absorber plates mechanically bonded to heat pipes.
- ▶ Heat pipes mechanically bonded to glass tube.

CNM

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Slide 43

Reveal Slide 43

Explain there were early problems with vacuum tubes – wherein the heat pipe is inside the vacuum – centered on sealing the joint between the glass tube and metal heat pipe (different coefficients of thermal expansion/contraction). Vacuum tube manufacturers today claim they have largely solved this joint problem.

Refer to NABCEP, page 23.

Collector Efficiency

- ▶ One way to demonstrate collector efficiency at various temperatures is the efficiency curve.
- ▶ See also chart in NABCEP, Page 24

CNM 45

Slide 44

Reveal Slide 44

Refer students to the “Collector Efficiency” section in NABCEP, page 24, for a concise discussion of this and similar efficiency charts.

Explain concept of “Delta T” or “ ΔT .”

State: Installers will become acutely aware of the temperature difference between the hottest part of an installed system (collector outlet) and the coldest part of the system (bottom of the storage tank). This difference in solar heating fluid temperature is referred to as “Delta T” and in print as “ ΔT ”. Solar controllers (covered in another section) use sensors (typically thermistors) to “measure or sense” solar fluid temperatures at the hottest and coolest parts of an installed system in order to function properly (turn pumps on and off).

Collector Performance

- ▶ SRCC Collector Certification (OG-100)
- ▶ SRCC Heating System Certification (OG-300)
- ▶ SRCC website: “Solar Facts – Collector Ratings: Performance Data”

CNM 45

Slide 45

Reveal Slide 45

State: When we looked at collector absorber selective surfaces (previous slide) we noted that irradiance (the amount of sunlight striking the collector) is directly linked to how much energy any collector can produce. We also noted that the type selective surface on the collector absorber also factors in to the amount of energy a collector can produce.

Review SRCC website with students: “Solar Facts – Collector Ratings: Performance Data”
http://www.solar-rating.org/facts/collector_ratings.html

State: SRCC collector and performance measurements must consider irradiance, which we may read in Btu’s per square foot per day.

Discuss SRCC chart for irradiance values on days with clear skies, mildly cloudy skies, and cloudy skies.

	Discuss SRCC Table 1 for average daily solar radiation for Albuquerque and other U.S. cities. Discuss SRCC performance ratings “OG-100” and “OG-300”. Note OG-100 certifications are for collectors only, OG-300 certifications are for complete systems. “OG” stands for “operating guidelines.”
Air Collectors ▶ Commonly used for space heating ▶ Common in New Mexico ▶ Two Styles: – Glazed – Unglazed ▶ Glazed: Heat circulated building air ▶ Unglazed: Preheat outside air for use in building ventilation system CNM Slide 46	Reveal Slide 46 Explain casual observations of residential roofs in your neighborhood may reveal solar heating installations (common in New Mexico). Refer to NABCEP page 24
Swimming Pool Collectors ▶ Some collectors are suitable for pool heating. – Low-temperature, flat-plate collectors are most common. – Design may call for medium-temperature collector. – Many different low-temp collector designs. ▶ High flow rates. ▶ Sizing affected by region/climate ▶ ROT (Rule of Thumb – One San Diego Company) – 75% of pool top surface area in collector area (on a pool where a cover is used) equals bumping the pool temp about 10 degrees CNM Slide 47	Reveal Slide 47 Provide example for your area of the nation. Share: The example of 75% collector-to-pool area shown on the slide is a Rule of Thumb (ROT) for solar swimming pool system installers in San Diego. As a solar swimming pool installer in New Mexico – where you have many microclimates (compare Taos to Las Cruces, or Raton to Carlsbad), you will recognize a different ROT on collector area to pool area as you pursue a ten degree rise in pool temperature.

Storage Tanks (includes water heaters)

- ▶ Storage tanks hold water heated in the collector
 - Single tank system
 - Two/multiple tank system
- ▶ Tanks may be pressurized or unpressurized

CNM

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Slide 48

Reveal Slide 48

Refer to text

- NABCEP pages 28, and 103 thru 107

Storage Tanks (includes water heaters)

- ▶ Tank type and size is a fundamental Solar Heating design consideration
 - Natural gas, propane fired
 - Electric element
 - Wood fired
 - 6 gal, 40 gal, 80 gal, 120 gal
 - "Tankless"

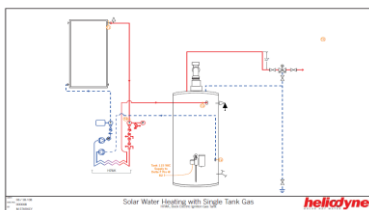
CNM

50

Slide 49

Reveal Slide 49

Single Tank Gas Water Heater System



CNM

51

Slide 50

Reveal Slide 50.

Review plumbing symbols found in the NABCEP text (pages 28-32).

Explain that installers must be able to “read” or interpret various system schematics or drawings.

Some schematics provide the installer with a system “picture.”

This slide incorporates standardized “**symbols**” derived from the American Society of Heating, Refrigeration, and Air Conditioning Engineers

	(ASHRAE). Review ASHRAE symbols illustrated in NABCEP – pages 28 through 32. Note: Engage students in “SH System Scenario” (Appendix B Activity Sheet)
Stratification ▶ Stratification refers to the temperature layering of water in SH tanks. ▶ Stratification is fundamental to a successful design & installation. ▶ Hot water for domestic use is plumbed out near the top of the tank. ▶ Good SH designs minimize “stirring” within a stratified tank. Dip Tubes CNM 32 Slide 51	Reveal Slide 51. Provide images of stratification. Note Images available in NABCEP study guide, pages 104-106, and online with Google Images “Water Tank Stratification.”
Dip Tubes ▶ Dip Tubes – Typically plastic tubes (pipes) inserted into the domestic hot water tank. – Maintain stratification within the tank. • Cold/supply line water plumbed to the top of the tank is carried inside via a dip tube to the bottom portion of the tank. – The hot water supply dip tube, if included, draws water from the top portion of the tank. CNM 33 Slide 52	Reveal Slide 52. Mention “Dip tubes” are typically constructed from plastic including PEX (cross-linked polyethylene).
	Reveal Slide 53. Explain anode construction varies with manufacturers and can be made from materials including magnesium, and aluminum. Steel water storage tanks (including fractured glass-lined tanks) will corrode and leak if unprotected against corrosion from chlorinated water on the inside

Anodes

- ▶ Protect buried/submerged metal structures from corrosion.
- ▶ Metal alloy with a more "active" voltage (more negative electrochemical potential) than the metal of the structure.
- ▶ Galvanic anode corrodes, so that the anode material is consumed in preference to the structure.
- ▶ Loss (or sacrifice) of the anode material gives rise to the alternative name of sacrificial anode.

CNM

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Slide 53

and from the earth on the outside.

Ask: True or False?

The rotten egg smell found in a hot-water system is NOT caused by a faulty or expended anode.

Explain:

The rotten egg smell is caused by bacteria. It is typically found in a little-used system (ex: vacation home).

Eliminate the smell by (1) temporarily increasing water heater temperature to ~190° F, or (2) turn on taps to run and deplete hot water source a few times, or (3) deal with the smell – with daily use it should disappear in a few weeks.

Refer to text

- NABCEP pages 102 thru 107

Ask: True or False?

The lifespan of a domestic hot water tank is typically determined by the quality/size of the anode.

Explain:

Increasing purchase prices related to "longer-lived" domestic water heaters is typically NOT related to a better-built tank.

Tanks from the same manufacturer rated "good", "better", and "best" are typically all the same except for the quality/size of the anode.

Boiler Drains

- ▶ Ones found on newer domestic water heaters are typically a plastic, use-one-time design.
- ▶ A quality installation often includes the replacement of the plastic boiler drain with a brass fitting.

CNM

55

Slide 54

Reveal Slide 54.

State: One Rule of Thumb (ROT) in domestic water heating concerns homeowners. Homeowners only think about their water heating systems when they have to buy a new water heater. While good water heater maintenance may include an annual flushing procedure (flushing frequency varies with water quality and newer water heaters are being sold as “self-cleaning” units), most people ignore their systems. As an installer you should consider replacing plastic, gate valve type tank drains with a brass ball valve or similar improvement. Old, never opened plastic drains – if opened – may never completely close again.

Anti-Scald, Mixing, & Tempering Valves

- ▶ Hot water at temperatures of ~120° F or better will cause burns if not severe and permanent damage.
- ▶ Allow SH water to enter a domestic system at 190°F and expect a lawsuit!

CNM

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Slide 55

Reveal Slide 55.

Discuss “Time/Temperature Relationship in Scalds” chart in NABCEP text, page 102, and related text.

Note that there are many excellent and similar charts available on-line.

Mixing Valve

- ▶ Term, typically used generically, referring to a device that mixes water from two or more sources.

CNM

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Slide 56

Reveal Slide 56.

Stress that many people think that Anti-scald, Mixing, and Tempering Valves are all the same. This is not true.

Tempering Valve ▶ Thermostatically controlled to mix hot and cold water sources and send water into the domestic hot water source at a set temperature. ▶ Less expensive than "Anti-scald Valves." CNM 58 Slide 57	Reveal Slide 57.
Anti-Scald Valve ▶ Operate similarly to "Tempering Valves" ▶ They shut off the domestic hot water supply when they detect an interruption in the cold water supply source. CNM 59 Slide 58	Reveal Slide 58. Mention that a person will receive a second degree burn in 3 seconds of exposure and a third degree burn in 5 seconds of exposure to water of 140°F at the discharge outlet will ensure the most safety for users. The American Journal of Public Health prefers a <u>maximum temperature of 120°F</u> for hot water. Refer to NABCEP, page 102.
Pressure Temperature Release Valve ▶ Critical safety valve, typically supplied with a new hot water tank. ▶ Two types: "Pressure Relief Valve" and "Pressure-Temperature Relief Valve" ▶ Sensitive valves. Often wrongly opened by owners and installers to test or use as an air vent. Valves will not last long or work properly if manually opened. CNM 60 Slide 59	Reveal Slide 59.

Glass Lined ▶ Maximum temperature in glass-lined – The glass lining inside of a domestic hot water tank will typically begin to break-down at -190° F or better. – Why is this important to a SH system designer/integrator? CNM 61 Slide 60	Reveal Slide 60.
Energy Cutoff Switch ▶ Gas water heater safety device that shuts off the gas supply to the unit if water temperature exceeds 190°F. ▶ Single-use switch and requires complete replacement of the entire thermostat if activated. CNM 62 Slide 61	Reveal Slide 61. Say: The Energy Cutoff Switch is often referred to as an “ECO” or “ECO valve” in the field. Note: Option here to view “Mythbuster” YouTube video showing exploding water heating tank (several videos).
CAZ ▶ Combustion Appliance Zone ▶ Make up air for gas appliances CNM 63 Slide 62	Reveal Slide 62. Explain that combustion appliances including natural gas and propane water heaters have the effect of depressurizing a home (flame consumes often conditioned air and vents combustion produces to the outside). While the pressure produced by a residential gas water heater is typically slight (about two Pascal’s), the issue of providing combustion appliances with a source of replacement air is becoming a big issue in the green building industry. Note that solar heating installers should be aware of the possible airflow/pressure impacts that gas

	appliances may have in homes, especially newer, “sealed” homes.
Slide 63	Reveal Slide 63. Note that the next several slides illustrate various types of water heaters that are available to the homeowner. They have been copied with permission from: • <u>Water Heaters: Past, Present and Future</u> William R. Hoover LLC whoover@wi.rr.com
Slide 64	Reveal Slide 64.

Condensing Residential Water Heaters

- Heater exchanger is a coil
- Glass inside the coil is different from glass on the water side
- Note condensate drain
- Vertex has same foot print as standard 50 gal heater



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CNM

Slide 65

Reveal Slide 65.

Rheem Heat Pump Water Heater



- Uniquely pumps water to the heat pump components
- 50 gallon tank
- EF = 2.0, FHR = 67 gallons
- Non-replaceable sacrificial anode
- MSRP = \$1495
- Assuming an installation cost of \$500 and annual savings of \$286, the payback is 7.0 years compared to standard electric resistance water heater.
- With Federal tax credit, payback is 4.9 yrs.

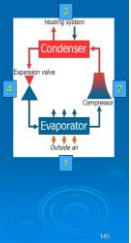
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CNM

Slide 66.

Reveal Slide 66.

HPWH Operation



1. A fan forces air through the evaporator (1). The liquid refrigerant evaporates and absorbs air heat from the ambient air.
2. The warm gaseous refrigerant is compressed (2) and the refrigerant becomes a hot liquid.
3. The refrigerant then passes through the condenser (3) and loses its heat to the water.
4. The cooler refrigerant goes through an expansion valve (4) where it returns to the gaseous state and the cycle starts over.

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CNM

Slide 67

Reveal Slide 67.

Gas Tankless Water Heaters

Principle of Operation

- Flow is sensed
- Fan purges combustion chamber
- Burner is ignited and modulated to match measured flow rate
- Heat exchanger begins to heat water as it passes through
- When flow stops, burner is extinguished and combustion chamber is purged
- Power supply is needed for the electronic controls and the fans



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Reveal Slide 68.

Slide 68

Gas Tankless Water Heaters

"Cold Water Sandwich Effect"

- The introduction of cold water into the hot water line during frequent on/off operation
- Cold water flows through the water heater during the ignition sequence delay (~ 10 sec).
- Two causes:
 - Drop in flow rate below minimum firing rate
 - Intermittent use



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Reveal Slide 69.

Slide 69

Electric Tankless Water Heaters

Older Technology

- Flow switch controls operation
 - Minimum and maximum flow rates
- Restricted flow - ¾ inch down to ½ inch tubing
- Downward plumbing connections
- Elements:
 - Heater, wet/dry, non-vented elements with different ratings
 - Turn on immediately at demand to get the desired output temperature
- Canisters contain relatively small volume of water
 - More difficult to absorb residual heat at the end of a draw
 - Cold water cooling quality



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Reveal Slide 70.

Slide 70



Slide 71

Reveal Slide 71.



Slide 72

Reveal Slide 72.



Slide 73

Reveal Slide 73.



Slide 74

Reveal Slide 74.

Pumps – Active Systems

- ▶ Internal heat exchanger use a "pump/circulator" to move the heat transfer fluid from the storage tank heat exchanger and through the collector.
- ▶ External heat exchanger use a "pump/circulator" to move the heat transfer fluid from the external heat exchanger and through the collector.
- ▶ May use a "pump circulator" to move domestic water through the external heat exchanger and storage tank.

CNM 76

Slide 75

Reveal Slide 75.

Refer to text

- NABCEP pages 97 -101.

Pumps (continued)

- ▶ Drainback systems typically require a high head pump to lift fluid to the collector.
- ▶ Active direct systems must have bronze or stainless housings and impellers.
- ▶ Indirect systems using heat transfer fluids may use a cast iron pump.
- ▶ Pumps may be AC or DC
- ▶ Pumps may be single or multiple speed.

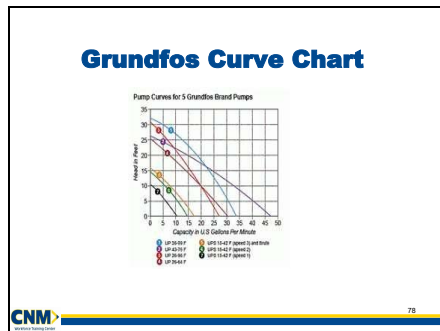
CNM 77

Slide 76

Reveal Slide 76.

Refer to text

- NABCEP pages 97 -101



Slide 77

Reveal Slide 77.

Refer to discussion of “Pump Head” and diagram, on page 98, NABCEP.

Ask students to log on to internet and find the pump curve for the pump used in the lab.

Note that some pumps/circulator include Grundfos Taco, and Wilo.

Flow

- ▶ Describes the volume of liquid pumped within a given period of time.
- ▶ Physical size of a pump determines the flow, which can pass through it.
- ▶ Flow will always be an issue when you select a pump.



Slide 78

Reveal Slide 78.

Refer to NABCEP pages 97 -101.

Discuss advantages/disadvantages of two smaller pumps over one larger pump and related applications.

Discuss advantages/disadvantages of two smaller pumps over one multi-speed pump.

Head

- ▶ Meters or inches of water column.
- ▶ Indicates how high a given pressure can lift a column of liquid.
 - Knowledge about the relationship between flow and head and about the conversion between head and pressure will enable you to perform basic sizing of a pump for a specific application.



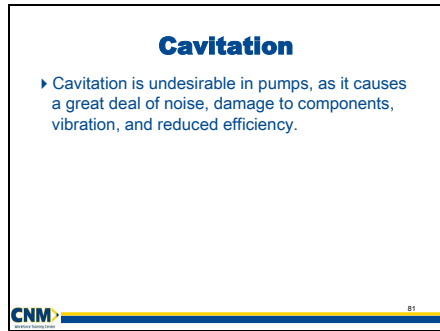
Slide 79

Reveal Slide 79.

Refer to NABCEP pages 97 -101.

Mention that plumbing two pumps in parallel increases flow rate. These are important concepts with high-head installations and with drain back systems.

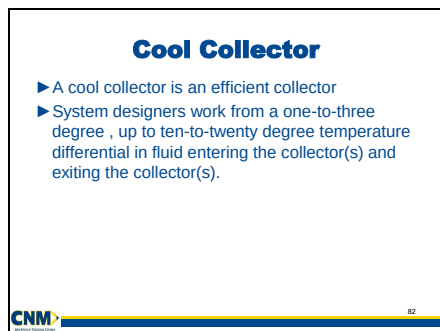
Refer to diagrams and text “4.2.4a Drain back Systems” for discussion of two-pump systems in NABCEP pages 38-40.



Slide 80

Reveal Slide 80.

Refer to NABCEP, bottom page 96 (air elimination), discussion.



Slide 81

Reveal Slide 81.

Stress that the key here is a counter-intuitive concept. A cool collector is an efficient collector.

Explain that heating a smaller volume of HTF to a higher temperature increases heat loss from the collector and decreases the efficiency of the system. Heating a larger volume of HTF to a lower temperature decreases heat loss from the collector and increases the efficiency of the system.

Ask: As an installer/integrator how does this concept affect:

- Pump selection?
- Rate of flow?
- Head
- Plumbing run?
- Collector positioning?
- Balance-of-System (BOS) components?
- Ball valves
- Check valves

Piping

- ▶ Path of fluid flow in the solar heating system.
 - Piping must be compatible with system temperatures, pressures, fluid pH, and other components.
 - Most SH systems use copper pipe.
 - Type L, K, or M is used, depending on application, “authority having jurisdiction (AHJ)”, and even local, common practice.
 - Some use stainless steel “line-set”
 - Line-sets are available in single tube or dual tube designs.
 - Line-sets are often pre-insulated
 - Many line-sets employ “O-ring” end-seals.

CNM 83

Slide 82

Reveal Slide 82.

Mention that pipe requirements will be further covered in another module section on codes.

Refer to text

- NABCEP pages 87 thru 95

Copper Piping

- ▶ Typically in ten foot and twenty foot “sticks”.
 - Half-inch and three-quarter inch are common
 - Pipe diameter selection is determined by pump size, length of run (pipe friction), and component parts.
 - Type M is thin-walled, Type L is medium-walled and Type K is thick-walled.
 - Type L is good for home use.
 - Piping must be compatible with system temperatures, pressures, fluid pH, and other components.

CNM 84

Slide 83

Reveal Slide 83.

Refer to text

- NABCEP pages 87 thru 95

Note: Excellent reference – “Copper Tube Handbook” – viewable on-line.

Copper Piping (Continued)

- ▶ Most solar heating systems use copper pipe
- ▶ Type L, K, or M is used, depending on application, “authority having jurisdiction (AHJ)”, and even local, common practice.
- ▶ Some use stainless steel “line-set”
 - Line-sets are available in single tube or dual tube designs.
 - Line-sets are often pre-insulated
 - Many line-sets employ “O-ring” end-seals.

CNM 85

Slide 84

Reveal Slide 84.

Refer to text

- NABCEP pages 87 thru 95

Type L Copper Pipe

- ▶ Thicker wall than type M copper pipe making it more durable.
- ▶ Type L is the preferred copper pipe in residential construction.
- ▶ Color coded blue, and has BLUE markings along the pipe.

CNM

86

Slide 85

Reveal Slide 85.

Refer to NABCEP, page 91.

Mention that Type K copper pipe is commercial grade and is usually not used in residential plumbing. Type K is color coded with green markings.

PIPING (Line Set)

- ▶ FlowMaxx
- ▶ 65 Foot Twin Line set
- ▶ SunMaxx Solar
5/8" Pre Insulated Line Set, 80'

CNM

87

Slide 86

Reveal Slide 86.

Explain that contractors and possibly even lead installers must weigh the higher cost of line set to time/dollars saved in the installation of copper pipe.

Ask: What are the advantages and/or disadvantages?

Explain:

Line set is more costly than copper pipe (\$/ft).

Line set is typically faster to install as it eliminates time to fit, assemble, and solder (sweat) copper fittings.

Line set is preferred by some contractors for in-home plumbing runs (attic/walls) as a protection against leaks.

Line set can limit connections on some systems to those on collector and pump station.

Line set may be purchased with insulation and sensor wire installed.

Insulation

- ▶ Most common pipe insulation used on SH systems is closed cell elastomeric foam.
- ▶ Do not use DIY home center polystyrene or polyethylene – these materials cannot handle the high temperatures of SH systems and disintegrate under ultraviolet rays.
- ▶ Exterior piping installations, and insulation, must be protected from ultraviolet light and critters.
- ▶ The installation of insulation is one of the final tasks of the integrator/installer – certainly AFTER pressure testing.

CNM

107

Slide 87

Reveal Slide 87.

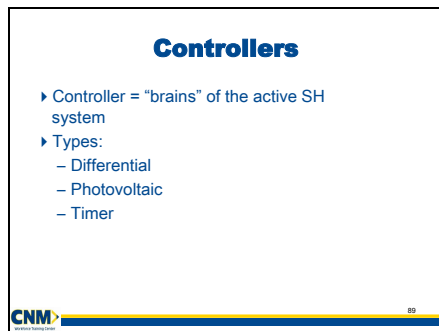
Refer to NABCEP pages 117-119.

Controllers

Time: 130 minutes

Learning Activity 4

Discussion Points



Controllers

- ▶ Controller = "brains" of the active SH system
- ▶ Types:
 - Differential
 - Photovoltaic
 - Timer

CNM

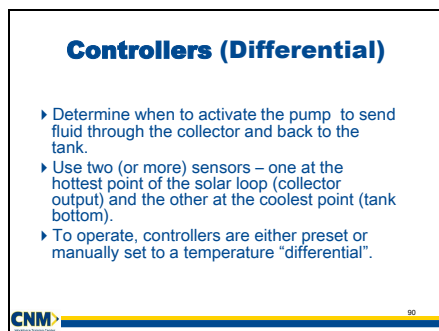
Slide 88

Instructor/Trainee Activities

Reveal Slide 88.

Refer to text

- NABCEP pages 108 thru 112



Controllers (Differential)

- ▶ Determine when to activate the pump to send fluid through the collector and back to the tank.
- ▶ Use two (or more) sensors – one at the hottest point of the solar loop (collector output) and the other at the coolest point (tank bottom).
- ▶ To operate, controllers are either preset or manually set to a temperature "differential".

CNM

Slide 89

Reveal Slide 89.

Controllers (Photovoltaic)

- ▶ Includes solar panels mounted next to the solar collector for power to the controller and DC pump.
- ▶ As the panel only generates electricity when the sun is up, the pump only circulates fluid through the SH system when sufficient energy is available.

CNM

91

Slide 90

Reveal Slide 90.

Controllers (Timer)

- ▶ A Timer Controller is typically set to turn the pump on only during the brightest portion of the day.

CNM

92

Slide 91

Reveal Slide 91.

Explain that timers are less expensive controller options for solar systems with the drawback that they are not temperature sensitive.

Mention if solar pumps are activated on cloudy days and circulate hot (stored) solar fluid through a cool collector, system heat is released to the atmosphere.

Other Devices

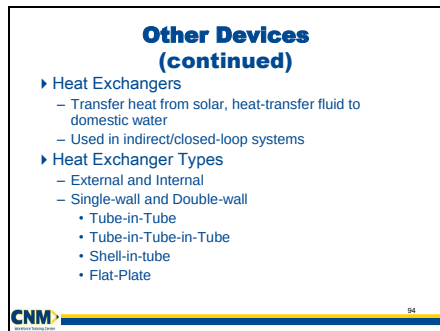
- ▶ "BOS" Balance of System -- typically denoting all components other than the solar thermal collectors. (e.g. controllers, tank, piping).
- ▶ Other components discussed here:
 - Heat Exchangers
 - Expansion tanks
 - Sensors
 - Valves, Gauges, Meters
 - Heat Transfer Fluids

CNM

93

Slide 92

Reveal Slide 92.

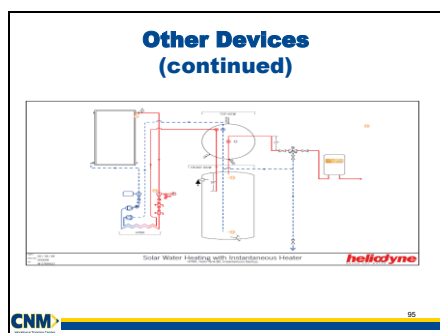


Slide 93

Reveal Slide 93.

Refer to text

- NABCEP illustrations, pages 28 – 32
- NABCEP page 107



Slide 94

Reveal Slide 94.

Ask:

Where are the following components on the illustration?

- Heat Exchanger (Look for red and blue zigzag lines on bottom left)
- Expansion tank (One expansion tank in illustration – small rectangle in blue, bottom left)
- Sensors (Located at yellow circles labeled T1, T2, T3, T4, T5)
- Valves, Gauges, Meters (Valves: Look for T&P, Drain, Mixing. Gauges: Look for “T” and “P”. Meters: None shown)
- Heat Transfer Fluid (Not shown)
- Pumps (Triangles inside circles)

Ask: Why are cold (blue) lines dashed, while hot (red) lines are continuous?

Explain: To distinguish between hot/cold lines when the diagram is copied in black and white.

Other Devices

- ▶ External Heat Exchangers
 - plumbed into the system as a separate and distinct component,
 - plumbed around the exterior skin of a tank
- ▶ Internal Heat Exchangers
 - plumbed within another system component – usually a tank.
 - The efficiency debate is currently on the external exchanger's side


96

Slide 95

Reveal Slide 95.

Refer to text

- NABCEP page 107

Heat Exchangers

- ▶ Counter-flow or Countercurrent Flow
 - Efficient SH heat exchangers take advantage of fluid counter-flow. (opposite directions).
 - Maximum amount of heat transfer that can be obtained is higher with countercurrent than concurrent (parallel) exchange because countercurrent maintains a slowly declining difference or gradient (temperature difference). In concurrent exchange the initial gradient is higher but falls off quickly, leading to wasted potential.


97

Slide 96

Reveal Slide 96.

**Heat Exchangers
(continued)**

- ▶ Single-wall and Double-wall
 - Heat exchangers may be constructed with one or two walls.
 - Double-wall heat exchangers often provide small passageways between the two walls for leak detection.
 - Some AHJ's/codes require double-walled heat exchangers.


98

Slide 97

Reveal Slide 97.

Heat Exchangers (continued)

- ▶ Some argue double-walls are only necessary when using a propylene glycol solution.
- ▶ SH heat exchanger materials must be compatible with system components and fluids. Copper is the most commonly used material.
- ▶ SH heat exchangers are sized based on heat-transfer capabilities.

CNM

99

Slide 98

Reveal Slide 98.

Explain: Many heat exchangers are designed to produce a “turbulent flow”, as opposed to a “laminar flow” – the theory being that a turbulent flow will produce a higher rate of heat exchange. Some heat exchanger manufacturers produce a turbulent flow by rifling the inside of the heat exchanger pipes. The deciding factor on whether to use single or double wall heat exchangers is the pressure differential between the solar and load loops.

Heat Exchangers (continued)

- ▶ Shell-in-Tube
 - Available with single-wall or double-wall construction.
 - Used in technologies other than SH systems.

CNM

100

Slide 99

Reveal Slide 99.

Heat Transfer Fluid

- ▶ Propylene Glycol most common
- ▶ NEVER Ethylene Glycol
- ▶ Mixed with water according to contract, geographical area, micro-climate, standard procedures.
- ▶ Sometimes requires import of quality water for mixing.
- ▶ Glycol, with additives, provides some level of protection against freezing and overheating.
- ▶ A glycol-water mix has less heat-transfer ability than pure water: the higher the percent of glycol the less efficient.

CNM

101

Slide 100

Reveal Slide 100.

Expansion Tanks ▶ Water EXPANDS when it gets cold AND it EXPANDS when it gets hot! ▶ Water, unlike air, does NOT compress. ▶ Expanding water in a closed system must have somewhere to go – or it will damage the system. ▶ Contracting water (cooling cycle) will also pull a vacuum and damage a system without an expansion tank. CNM 102 Slide 101	Reveal Slide 101. Refer to text • NABCEP pages 29, 111, & 139
Expansion Tanks ▶ Diaphragm – Must be installed in an upright - vertical position ▶ Bladder (balloon-like) – May be installed in any position. ▶ Features of Both – Most pre-charged by manufacturer – Size dependent on fluid volume and potential for elevated temperatures – Some AHJ's require an expansion on the cold water (supply) side of the system. CNM 103 Slide 102	Reveal Slide 102. Refer to text • NABCEP pages 29, 111, & 139
Valves, Gauges, Meters ▶ Air Vent ▶ Pressure-Temperature Relief Valve ▶ Pressure Relief Valve ▶ Vacuum Breaker ▶ Isolation Valve ▶ Check Valve ▶ Freeze-Protection Valve ▶ Pressure Gauges ▶ Temperature Gauges ▶ Flow Meters CNM 104 Slide 103	Reveal Slide 103 Refer to text • NABCEP, pages 28-32

Air Vent

- ▶ Allows air in the system to escape.
- ▶ Prevents air locks.
- ▶ Must be positioned vertically.
- ▶ Commonly installed at "top" of system.
- ▶ Manually closed on indirect systems after initial and annual purge.

CNM 105

Slide 104

Reveal Slide 104

Refer to text

- NABCEP, pages 28-32

Pressure-Temperature Release Valve

- ▶ AKA: "P&T" and "T&P" valve
- ▶ Protects system from excessive pressures and temperatures.
- ▶ Always plumbed to tanks.
- ▶ Inside P&T valves must drain to outside (see local AHJ/code requirements).
- ▶ Not built to be opened and closed manually to purge system.

CNM 106

Slide 105

Reveal Slide 105

Refer to text

- NABCEP, pages 28-32

Pressure Release Valve

- ▶ Protects system from excessive pressures.
 - Must be installed where the collector loop can be isolated from the storage tank.
 - Usually installed at the collector.
 - Inside P&T valves must drain to outside (see local AHJ/code requirements).

CNM 107

Slide 106

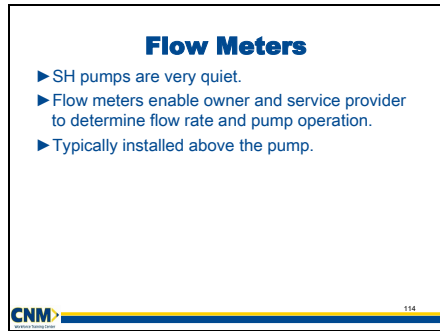
Reveal Slide 106

Refer to text

- NABCEP, pages 28-32

Vacuum Breaker ▶ Admits atmospheric pressure into the system so it may drain. ▶ Typically located at collector outlet. CNM 108 Slide 107	Reveal Slide 107 Refer to text • NABCEP, pages 28-32
Isolation Valve ▶ Typically used to isolate subsystems: example – servicing collectors. ▶ Ball valves typically preferred. CNM 109 Slide 108	Reveal Slide 108 Refer to text • NABCEP, pages 28-32
Check Valve ▶ Swing ▶ Spring ▶ Motorized ▶ Check valves allow fluid flow only in one direction. ▶ Used to prevent system thermo siphoning CNM 110 Slide 109	Reveal Slide 109.

Freeze Protection Valve ▶ Set to open at near-freezing temperatures. – Installed on collector return line above roof. – Warm water bleeds from collector through valve to protect system. – Legacy model: "Dole Valve". – Requires companion check valve. CNM 111 Slide 110	Reveal Slide 110. Note this is not considered reliable.
Pressure Gauges ▶ Used to monitor system pressure. ▶ May indicate leak. CNM 112 Slide 111	Reveal Slide 111.
Temperature Gauges ▶ Indicate fluid temperature at gauge location. ▶ Multiple gauges aid in system evaluation. CNM 113 Slide 112	Reveal Slide 112. Explain that temperature gauges are also an indicator of calcification build up at the heat exchanger.



Slide 113

Reveal Slide 113.



Slide 114

Reveal Slide 114.

Thank participants for their participation.

Module 3: Solar Heating Site and Size Analysis

SOLAR THERMAL APPLICATIONS AND TECHNOLOGIES

Learning Activity 1

Time: 90 minutes

Discussion Points

Instructor/Trainee Activities



PowerPoint Presentation

This module is designed for the use of an accompanying PowerPoint presentation. If you choose not to use PP, then please have facilitator information charts ready for some activities.



Slide 1

Slide 1 should be available to view prior to participants entering the room.

Solar Heating Mantra ▶ All SH systems must control for ▶ Over Heating ▶ Freezing ▶ Scaling Address all three whenever studying, designing, installing, servicing and troubleshooting a SH system.  CNM Center for Net-Making 2 Slide 2	Reveal Slide 2. Review Solar Heating Mantra.
Solar Site and Size Analysis ▶ NABCEP Installer Guide: Chapters 5 & 6 – Pages 45, 56, 59, 60, and 61. ▶ Home Power Articles: ▶ Florida: 1-1 thru 1-13 – Codes & Certifications – Site Assessment – SHW Primer – Simple SHW CNM Center for Net-Making 3 Slide 3	Reveal Slide 3.
Module #3 : Topics ▶ SH Applications & Technologies ▶ Solar Basics ▶ Applying the Basics ▶ Sizing a System ▶ Site Assessment ▶ Additional System Considerations CNM Center for Net-Making 4 Slide 4	Reveal Slide 4. Review: These are the major topics/subtopics that we will cover in Module Three. • Solar Heating Applications & Technologies: Residential Applications – Focus of this course, Commercial Applications, Agricultural Applications • Solar Basics: Terms & Principles, Heat Transfer, Temperature Differential or Delta T, Thermal Mass, Heat Storage • Applying the Basics: Collecting & Converting

	Solar Energy, Daily Variations, Seasonal Variations, Tilt Angle, Heat Storage • Sizing a System: Water Use Analysis, System Type Selection, Rules of Thumb – “ROT”, Sizing Software • Site Assessment: Shading Analysis, Site Characteristics, Solar Pathfinder, Siting Software • Additional System Considerations: System Safety, Economics, Materials
SH Applications and Technologies ▶ Residential Applications – Domestic hot water – FOCUS OF THIS COURSE – Swimming Pool and Spa – Course short topic – Space Heating – Water purification – distillation – Air Conditioning ▶ Commercial Applications – Hotels, schools, apartments/condominiums, recreational areas, hospitals, nursing homes, restaurants, laundries, car washes, beverage manufacturing, cane sugar refining, canning facilities. CNM 5 Slide 5	Reveal Slide 5. Explain that Solar heating applications and technologies includes the categories you see on this slide and the next slide, including the “Residential Applications” of domestic hot water – which is the focus of this course, and “Swimming Pool and Spa” which will be briefly covered as related questions are possible on the NABCEP entry level examination.
SH Applications and Technologies ▶ Agricultural Applications – Crop drying, Green houses, Dairy processing, Meat processing, Food processing ▶ Space Heating – Radiant Heating – Fan-coil ▶ Radiant heating is commonly referred to as “HYDRONICS” CNM 6 Slide 6	Reveal Slide 6.

Domestic Hot Water

- ▶ Records of solar collectors in the United States dating back to before 1900.
- ▶ Black-painted tank mounted on a roof.
- ▶ 1896 Clarence Kemp of Baltimore created the first 'batch water heater' as they are known today.
- ▶ Flat-plate collectors for solar water heating were used in Florida and Southern California in the 1920s.
- ▶ Surge of interest in solar heating in North America after 1960.

CNM

Slide 7

Reveal Slide 7.

Say: Look at the three solar heating system schematics in your NABCEP text on page 57. These illustrations demonstrate how solar radiation is absorbed in the collector, the temperature of the water being pumped through the collector increases, and the heated water is transferred to the storage tank.

Explain that generally, the solar collector and thermal storage unit can operate independently of heated water demand. Thus solar energy can be stored whenever there is sufficient solar radiation.

Note that in the USA, solar heating is most predominant in the residential market.

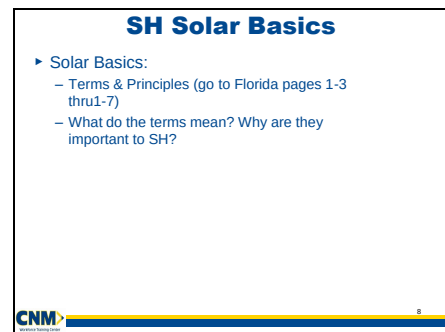
Explain that residential solar thermal installations fall into two groups: passive and active systems.

SOLAR BASICS

Time: 20 minutes

Learning Activity 2

Discussion Points



SH Solar Basics

- ▶ Solar Basics:
 - Terms & Principles (go to Florida pages 1-3 thru 1-7)
 - What do the terms mean? Why are they important to SH?

CNM

Slide 8

Instructor/Trainee Activities

Reveal Slide 8.

View the following on-line segment

<http://solarhotwaterpanels.alternativeenergyguru.com/tag/rahus-solar-schoolhouse/>

Refer to NABCEP pages 7 through 9.

APPLYING THE BASICS

Learning Activity 3

Time: 60 minutes

Discussion Points

Applying the Basics

- ▶ Collecting & Converting Solar Energy
- ▶ Daily Variations
- ▶ Seasonal Variations
- ▶ Tilt Angle
- ▶ Heat Storage
- ▶ (Florida pages 1-7 thru1-13)
- ▶ (NABCEP Chapter 3)

CNM

Slide 9

Instructor/Trainee Activities

Reveal Slide 9.

Review NABCEP Chapter Three with students.

Review NABCEP glossary (pages 7,8,9), highlighting terms: albedo radiation, altitude angle, azimuth, conduction, convection, diffuse radiation, direct beam radiation, equinox, incidence angle, insolation, irradiance, magnetic declination, radiation, solar noon, solar south, solstice, and zenith.

Applying the Basics

- ▶ Infrared (IR) light
 - _ Electromagnetic radiation with longer wavelengths than those of visible light, and includes most of the thermal radiation emitted by objects (absorber, glass)
- ▶ Ultraviolet (UV) light
 - _ Electromagnetic radiation with a wavelength shorter than that of visible light but longer than X-rays.

CNM

Slide 10

Reveal Slide 10.

Ask: What does most of the heating in a solar collector – IR or UV?

Explain: IR does the majority of heating. After entering the collector, UV waves largely change to a longer wavelength, typically in the IR range. UV entering the solar collector will provide some “heat”.

Solar energy absorbed by the collector warms collector components and these light waves are re-emitted as infrared (IR) heat.

Longer IR waves have difficulty passing back out through the collector glass.

Daily Variations ▶ Solar energy striking the Earth's surface averages about 1,000 watts per square meter under clear skies with the surface directly perpendicular to the sun's rays ▶ 1,000W/m² as "one sun" or "S" = 317 BTU/ft². ▶ Greenhouse effect principle; solar radiation incident upon the transparent surface of the solar collector is transmitted through this surface. The inside of the solar collector is insulated and may be evacuated, the energy contained within the solar collector is trapped and thus heats the coolant contained within the tubes.  170 Slide 11	Reveal Slide 11. Note that many solar heating publications use the term "one Sun", or "1 Sun", or "S" where one Sun equals 1000 W/m² at the point of arrival, with kWh/(m²·day) displayed as hours/day. (Sometimes this unit is referred to as a Sol). Review section 3.1 in NABCEP. Mention that Irradiance on a solar collector may vary from 700 W/m² to 900 W/m² on a sunny day – between 9AM and 3PM.
Seasonal Variations ▶ Solar Maps – NREL – Solar maps provide monthly average daily total solar resource information on grid cells. – Isolation values represent the resource available to a flat plate collector, such as a photovoltaic panel, oriented due south at an angle from horizontal to equal to the latitude of the collector location. – Typical practice for PV system installation, although other orientations are also used.  12 Slide 12	Reveal Slide 12. Explain that solar designers and installers must be aware of seasonal variations in the system microclimates. Discuss seasonal variations in respect to content on NABCEP pages 56, 59, 60, 61. Review NREL website in class. Ask students to bookmark site on their computers. Refer to text • NABCEP, Chapter 3 Option: Explore NREL website with students in class. Examine NREL solar maps. Optional website: PVWATTS

Tilt Angle ▶ The ROT with collector tilt is tilt to latitude (see previous slide). – Tilt may increase/decrease collector output. – Tilt collectors to align with a lower winter sun when doing an install on a winter ski cabin. – Tilt collectors to align with a higher summer sun when doing an install at a summer cabin. – A rare homeowner will choose to manually adjust collector tilt throughout the seasons to maximize collector output. Slide 13	Reveal Slide 13. Explain that tilt is often a moot issue when homeowners are worried about aesthetics, and often collectors are mounted parallel to the roof. Refer to text • NABCEP Chapter 3
Heat Storage ▶ Water Heater Tank ▶ Solar Storage Tank ▶ Pressurized and Non-Pressurized ▶ Various Capacities: 40 gal, 80 gal, 119 gal Slide 14	Reveal Slide 14. Explain that Solar Heating tanks for domestic use include the familiar water heater (gas/propane), the unusual wood fired heater (remote areas), and standard tanks specifically designed for SH storage either alone or linked for additional capacity/storage. Tanks may be pressurized or not. Domestic water heaters are available in familiar gallon capacities up to 120 gallons. 120 gallon capacity and larger tanks are usually considered a commercial application/install. Many commercial installations involve the truck/crane-in of huge storage tanks set on exterior concrete pads, and plumbed and insulated (usually spray) in place. References: NABCEP pages 103-107.

Water Use Analysis

- ▶ Range of water use analyses techniques:
 - An extensive, pencil-and-paper exercise (Florida Appendix 2).
 - On-line at agency web sites (e.g. Florida Solar Energy Center, Solar Distributor websites)



Slide 15

Reveal Slide 15.

Explain that sizing a system includes a water use analysis, a careful selection of system type, some solar heating “rules of thumb” (ROT’s), and the use of sizing software.

Emphasize that water use analysis is an important element in the design of a SH that meets a customer’s needs.

Water Use Analysis (continued)

- ▶ Estimate 20 gallons per person.
- ▶ Consider hot water use (e.g. shower) uses tempered (with cold) hot water.



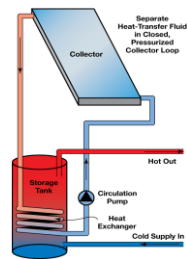
Slide 16

Reveal Slide 16.

Mention that the NREL (National Renewable Energy Laboratory – Colorado) provides on-line insolation values for the U.S.

Refer to <http://www.nrel.gov/gis/solar.html>

System Type Selection



Slide 17

Reveal Slide 17.

Note that system selection is huge (often far beyond the decisions an entry level installer/integrator will make).

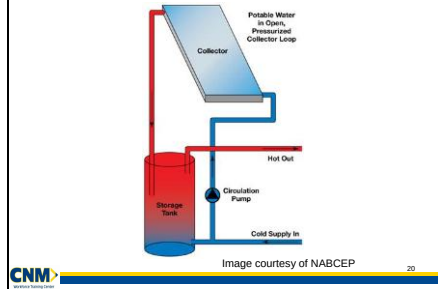
Say “For example, an active, open loop system in Alaska is probably not a great idea as it will freeze.

You also understand that a hunting cabin could have a very simple, passive thermosiphon design as long as the hunters all took showers at 3PM or 4PM.”

Mention that these two extremes demonstrate the many variables that must be taken into account when selecting a specific SH system – the first example is primarily a geographical and temperature extremes decision, the second example requires changes in

	thinking and human behavior. All system selections must be carefully thought through. Remind students of the Solar Heating Mantra.
System Type Selection (continued) ▶ These two extremes demonstrate the many variables that must be taken into account when selecting a specific SH system – the first example is primarily a geographical and temperature extremes decision, the second example requires changes in thinking and human behavior. All system selections must be carefully thought through. ▶ Remember your SH Mantra. CNM Slide 18	Reveal Slide 18.
System Type Selection (continued) CNM Slide 19	Reveal Slide 19. Explain that commonly, as an entry-level installer/integrator, you will not have a large hand in system selection. Note that solar heating contractors will often offer customers only one or two system types (produced by one or two different manufacturers). The one or two choices offered to a customer still have the potential to be modified/customized to meet design considerations (e.g. different size tanks, more or fewer collectors, larger or smaller heat exchanger, higher- or lower-head pump, etc.).
	Reveal Slide 20. Explain that it is very reasonable that a contractor offer clients products from only one or two manufacturers for reasons including: • System familiarity for contractor and installers; • Spare parts and specialized tooling for specific systems; • Contractor/distributor relationships;

System Type Selection



Slide 20

- Ease of record-keeping, billing, invoicing, credit-on-account, exchanges, etc.

Note that the internet provides a number of system comparison charts, many produced by manufacturers to support/promote their products.

System Type Selection (continued)



Slide 21

Reveal Slide 21.

Explain that one of the very “big deals” in solar heating systems over the last few years is the concept of “Plug-and-Play”.

Old school systems were largely built in place.

Collectors were purchased by a contractor who also had a truck-load of parts: pumps, pipe, valves, heat exchangers, etc. System installation on-site required hours of careful cutting, fitting, soldering, torqueing, and more fitting.

SIZING A SYSTEM

Time: 330 minutes

Learning Activity 4

Discussion Points	Instructor/Trainee Activities
Sizing a System ▶ Rules of Thumb (ROTs) – Energy Conservation – Roof Load – Open or Closed Loop – Hot Water Demand – Collector Area Slide 22	Reveal Slide 22. Mention that Solar systems should be sized to provide 60% to 80% of load. Roof loading is not an issue with collectors weighing less than 150 pounds. Use open loop only if there is never an issue with freezing. Closed loop recommended for hard water areas. Demand is generally calculated at 20 gallons per user. Explain that collector area is dependent on collector type, collector efficiency, and geographical area, and shading and space limitations.
Sizing Software ▶ Online resources are available at agency web sites (e.g. Florida Solar Energy Center) ▶ Manufacturer's websites offer system-specific calculators Slide 23	Reveal Slide 23. Mention that sizing software goes hand-in-hand with the resources discussed under "Water Use Analysis". Many solar installation contractors use software and equipment including Solar Pathfinder and Solmetric SunEye. Refer to NABCEP, page 60-61.

Shading Analysis

- ▶ It's like having a firm grip on the obvious – solar collectors must be in the sun!
- ▶ ROT – collectors face to the south.
 - To get maximum SH system performance, collectors must face the sun (south) at noon.

CNM

24

Slide 24

Reveal Slide 24.

Refer to Shading Analysis (NABCEP Pages 59-61).

Say: “Countless installers have arrived to install systems only to find that the homeowner wants to place the collectors “where they can’t be seen from the street”, or “where they don’t ruin my architectural aesthetic”, or “on the back of the house”, or “well, I decided not to cut that tree down” – usually meaning they want to install the collectors in an often shaded area!”

Note that often structures, trees/vegetation shade a large part of the otherwise “prime” position for collectors.

Explain that homes are rarely lined up to compass points, requiring a southwest or even southeast collector orientation. Sometimes all large roof areas are facing east and west.

Shading Analysis (continued)

- ▶ The YMCA Method
- ▶ “Solar Pathfinder”
- ▶ “Solmetric Sun Eye”
- ▶ “Google Earth”

CNM

25

Slide 25

Reveal Slide 25.

Mention that shading analysis, using your solar window, may be accomplished in a variety of ways.

Say: “The YMCA method - simply outstretching your arms at 10AM and 2PM, or 8AM and 4PM gives you the East/West aspects of your solar window – within which you can identify shading factors.”

Note that there are also simple devices like the Solar Pathfinder (with or without related software) and advanced software/equipment systems such as the “Solmetric Sun Eye.”

Explain that some companies perform shading analyses employing “Google Earth.”

Discuss finding true South and magnetic declination

	(NABCEP pages 59-61).
Site Assessment ▶ System installation obstacles ▶ Site access barriers/difficulties  Slide 26	Reveal Slide 26. Note that while Shading Analysis directly pertains to system performance, Site Assessment relates to a variety of concerns including system installation obstacles and site access barriers/difficulties. An analysis of the system site should have been conducted by a lead sales/contractor/person/team.
Site Assessment (continued) ▶ Access to the cellar, where you must install a new tank, is lined with canned fruit (glass Mason jars). ▶ You think of it, it can and has happened ▶ A site assessment walk through is a first step when you arrive on a new installation job – don't even get the ladder off of the truck!  Slide 27	Reveal Slide 27. Explain some of these “Real life occurrences”: Say: “So you arrive on site and there is no place to safely park your service truck.” “The homeowner has just installed fresh sod directly in your prime work zone and you have no plywood to lay.” “The homeowner has just finished redoing flowerbeds exactly where you must place your ladder.” “The designated roof installation area has three vents and two skylights that were “missed” on your drawings“ “A site assessment walk through is a first step when you arrive on a new installation job – don’t even get the ladder off of the truck until you have evaluated the site!” Refer to NABCEP Page 68.

Solar Pathfinder

- ▶ The Chrome Dome siting/shading tool (similar to Pathfinder) is described in Florida, Appendix 1, and the Pathfinder is briefly discussed in NABCEP, pages 60-61.
- ▶ We will work with Pathfinders in class.
- ▶ The Solar Pathfinder web site includes documentation (operation manual) and instructional videos.

CNM

28

Slide 28

Reveal Slide 28.

Explain solar heating will vary in terms of references to optimal solar window hours for insolation. Some will claim that 10AM to 4PM are optimal hours, others reference 9AM to 3PM, and so forth.

Note that the optimal solar window time span is considered to provide 700 to 900 W/m² of insolation.

Domestic Hot Water: Additional System Considerations

- ▶ System Safety
 - Equipment Failure - Tank
 - Myth Buster's exploding tank!
 - TV showed what happens when temperature is allowed to get too high in a storage water heater.
 - They did not point out that they had over- ridden three (3) separate safety features.
 - 1 Thermostat
 - 2 ECO (Energy Cut Off)
 - 3 T & P valve

CNM

29

Slide 29

Reveal Slide 29.

Mention that system safety is a multifaceted concern involving equipment, design and installation. Safety concerns include:

- Equipment Failure -Water Heater Tank
- Water Temperature Safety – Disease
- Installer/Integrator Competence
- Single-wall vs. Double-wall Heat Exchanger
- Source/Supply Water
- Valves, Gauges, Meters

Define “ECO” = An energy cut off (ECO) switch is mounted inside the probe attached to the back of the gas valve and extends inside the water heater. The ECO functions as a high limit switch. If water temperature inside the tank reaches about 190°F, the ECO disables the water heater. The entire gas valve must be replaced if this happens.

Reveal Slide 30.

Explain that T/P valves open when either the temperature or pressure in the unit exceeds the levels at which the valve is set. Most valves are rated to open at 210 degrees and 150 pounds pressure. Code requirements in some AHJ's to plumb/drain T/P to out

Domestic Hot Water: Additional System Considerations (continued) ▶ Water heater/storage tank seismic bracing? ▶ T/P valve installed properly? ▶ Set on 18" high stand in a garage? ▶ Anti-scald/tempering valve installed? ▶ Expansion tank installed? ▶ Not installed in bathroom?  Slide 30	of building. Stand designed for prevention of igniting gas/other fumes. Local codes may vary on height and other requirements. Water heaters up to 50-gallons and manufactured after July 1, 2004 are now flammable vapor-ignition resistant (but 18" stand is still required). Vent-type water heaters may never be installed in a bedroom or in a bathroom that contains a bathtub. This also means they may not be installed in a closet or room directly off of a bedroom or bathroom with a bathtub. Refer to NABCEP pages 102-107.
Domestic Hot Water: Additional System Considerations (continued) ▶ CAZ – Combustion Appliance Zone – Gas water heaters – vent pressure of two Pascal's – Potential for spillage of gas water heater flue gases into the home. – Fumes harmful and even deadly  Slide 31	Reveal Slide 31. Explain that water heaters vent flue gasses at a pressure of two Pascal's, a pressure equal to the weight of two Post-It notes. These fumes are harmful and even deadly, especially Carbon Monoxide which is odorless, colorless, and tasteless. A potential exists for the spillage of natural gas and propane water heater flue gases into the home. This problem increases with highly insulated and sealed "green" homes. Consider need for make-up air with combustion appliances. Refer to state/local codes for CAZ requirements.
	Reveal Slide 32. Explain that the table shows that a person will receive a second degree burn in 3 seconds of exposure and a third degree burn in 5 seconds of exposure to water of 140°F at the discharge outlet will ensure the most

Domestic Hot Water: Additional System Considerations

► Exposure Time

Cold Temperature	Fahrenheit Temperature	2 nd Degree Burn No Irreversible Damage	3 rd Degree Burn Full Thickness Injury
40°	104°	2 hours	2 hours
45°	113°	20 minutes	45 minutes
48°	118°	10 minutes	20 minutes
50°	122°	5 minutes	10 minutes
55°	131°	2 minutes	4.2 minutes
60°	140°	17 seconds	30 seconds
65°	149°	5 seconds	9 seconds

*Activation temperature = 120° max (response time is less than 5 seconds)



Slide 32

safety for users.

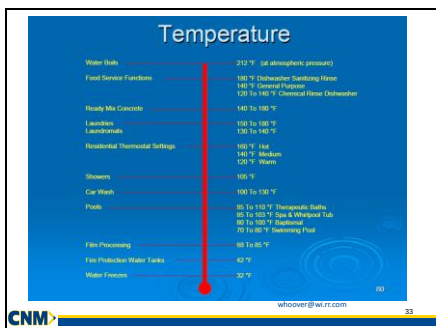
Note that the American Journal of Public Health prefers a maximum temperature of 120°F for hot water.

Explain that the Consumer Product Safety Commission and the plumbing industry have published a voluntary standard which states that the maximum allowable temperature at the water outlet to the bathing area should be 120°F.

There are national standards set forth by the major plumbing code making bodies, which specify a maximum temperature of 120°F for delivered hot water.

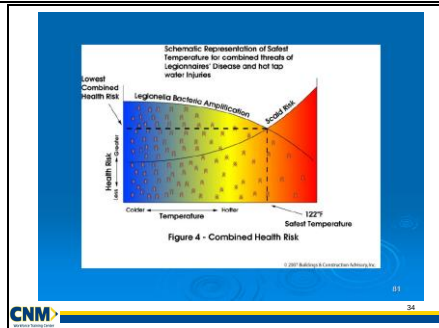
Note that the major code making bodies include

- Southern Building Code Congress International (South)
- National Association of Plumbing, Heating and Cooling Contractors (NJ, DE, MO, NE)
- Council of American Building Officials (Regulate 1 & 2 family homes in U.S.)
- International Association of Plumbing and Mechanical Officials (West)
- Building Officials and Code Administrators (Northwest and Midwest)



Slide 33

Reveal Slide 33.



Slide 34

Reveal Slide 34.

Explain that the most common sources of Legionella and Legionnaires' disease outbreaks include domestic hot water systems, and spas. The least expensive and most effective control method is keeping all cold water below 25°C (78°F) and all hot water above 51°C (124°F).

In a solar hot water system, lukewarm water could remain for several days in the storage tank, which may suggest a greater risk of legionella bacteria contamination. Yet, the risk posed by the hazardous bacteria can be minimized. Back-up heating, including gas-fired or electric systems can ensure the required temperature is maintained to eliminate legionella.

Valves, Gauges, Meters

- Air Vent
 - Allows air in the system to escape.
 - Prevents air locks.
 - Must be positioned vertically.
 - Commonly installed at "top" of system.
 - Manually closed on indirect systems after initial and annual purge.

Slide 35

Reveal Slide 35.

Note the symbol and photo in NABCEP, page 31.

Refer to NABCEP pages 44 (diagram) and 140 (troubleshooting).

Valves, Gauges, Meters

- Pressure-Temperature Release Valve
 - AKA: "P&T" and "T&P" valve
 - Protects system from excessive pressures and temperatures.
 - Always plumbed to tanks.
 - Inside P&T valves must drain to outside (see local AHJ/code requirements).
 - Not built to be opened and closed manually to purge system.

Slide 36

Reveal Slide 36.

Note the symbols and photos in NABCEP, pages 29 and 30.

Refer to NABCEP pages 44, 102 and 103.

Valves, Gauges, Meters ▶ Pressure Release Valve – Protects system from excessive pressures. – Must be installed where the collector loop can be isolated from the storage tank. – Usually installed at the collector. – Inside P&T valves must drain to outside (see local AHJ/code requirements). CNM 37 Slide 37	Reveal Slide 37. Refer to symbol and photo in NABCEP, page 29.
Valves, Gauges, Meters ▶ Vacuum Breaker – Admits atmospheric pressure into the system so it may drain. – Typically located at collector outlet. CNM 38 Slide 38	Reveal Slide 38. Refer to symbol and photo in NABCEP, page 31. Note that vacuum breakers have been used for years on drain back systems, but the installer should consider an alternative in hard water areas. Refer to NABCEP pages 38 and 39.
Valves, Gauges, Meters ▶ Isolation Valve – Typically used to isolate subsystems: example – servicing collectors. – Ball valves typically preferred. CNM 39 Slide 39	Reveal Slide 39. Say: “Isolation valves” are typically ball valves. Refer to symbol and photo in NABCEP, page 30.

Valves, Gauges, Meters

- ▶ Check Valve
 - Swing
 - Spring
 - Motorized

Check valves allow fluid flow only in one direction.
Used to prevent system thermosiphoning
(Ex: Cool water in nighttime roof-mounted collector pulled by gravity into storage tank pushing heated water into the cool collector).

CNM 40

Slide 40

Reveal Slide 40.

Note that valves in solar systems may be the swing, spring, or motorized type.

Refer to symbol and photo in NABCEP, page 30.

Valves, Gauges, Meters

- ▶ Freeze Protection Valve
 - Set to open at near-freezing temperatures.
 - Installed on collector return line above roof.
 - Warm water bleeds from collector through valve to protect system.
 - Legacy model: "Dole Valve."
 - Requires companion check valve.

CNM 41

Slide 41

Reveal Slide 41.

Refer to symbol and photo in NABCEP, page 32.

Valves, Gauges, Meters

- ▶ Pressure Gauges
 - Used to monitor system pressure.
 - May indicate leak.
- ▶ Temperature Gauges
 - Indicate fluid temperature at gauge location.
 - Multiple gauges aid in system evaluation.

CNM 42

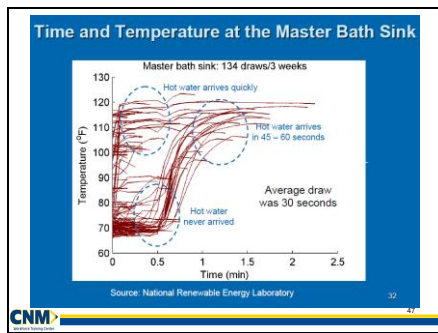
Slide 42

Reveal Slide 42.

Refer to symbols and photos in NABCEP, page 31.

Valves, Gauges, Meters ▶ SH pumps are very quiet. ▶ Flow meters enable owner and service provider to determine flow rate and pump operation. ▶ Typically installed above the pump. CNM 43 Slide 43	Reveal Slide 43. Refer to symbol and photo in NABCEP, page 30. See also pages 97-101.
Materials ▶ Metals: Copper, brass, cast iron, steel, stainless steel ▶ Rubber: O-rings, washers ▶ Solder: Non-lead only CNM 44 Slide 44	Reveal Slide 44. Ask: What materials do you find on solar heating systems? Explain: Metals such as copper, brass, cast iron, steel, stainless steel. Rubber: O-rings and rubber washers used on solar systems are high temperature materials – not typically available at DIY stores. Exposed insulation must be shielded (i.e. stainless, aluminum) to protect insulation from UV, weather, and critters. This shielding is usually selected with some aesthetic consideration in regards to building features/design/color. Say: “If you have any type of leaded solder in your tool box, expect the inspector to fail your job with instructions to tear everything out and start over with fresh materials”

Materials (continued) ▶ Plastics: Pex, PVC, CPVC, Insulation  Slide 45	Reveal Slide 45. Explain that pex and other plastics, while used in radiant heating applications are not commonly used in SH systems due to possible high heat ranges. PVC or CPVC pipe for solar pool circuits, the design will determine the choice. Design considerations must always be made regarding potential high temperature ranges and local AHJ requirements. SH piping insulation exposed to sun/weather must be a high quality, typically closed-cell variety - not the inexpensive indoor pipe insulation commonly found at DIY stores.
Hot Water Economics ▶ Energy and Hot Water Use _ Hot water and household energy use _ Hot water flow rate distribution _ Time and temperature at the master bathroom  Slide 46	Reveal Slide 46. Note that adding a solar system to a residence in Florida can save the homeowner in a range of \$200 to \$500 per year in energy costs (dependent on system size). Say: “You understand the solar sizing ROT of 20 gallons of hot water per day per person. Other hot water ROT’s such as it takes thirty seconds for water at a faucet to reach 105°F can and are being challenged. A thirty second wait can equate to a water waste in excess of 1400 gallons per year. Recirculation (“recirc”) systems are one possible solution to water waste, however poorly designed recirc systems can be very inefficient and costly. Green home designs are clustering hot water systems in small spaces or incorporating point-of-use systems.”



Slide 47

Reveal Slide 47.

Explain that hot water flow rates on this graphic (master bath sink) in light of a proposed “new green standard”: hot water must be available at all household taps within three cups of water (hot water available at the tap within an initial flow/volume of three cups).

Note that new “green” standard sets the volume of water flowing from a residential hot water tap before hot water emerges is “Three Cups.”

Human Motivations

- ▶ “Heck No’s” (anti-utility)
- ▶ “Fixed Income” (worried about rising energy bills)
- ▶ “Greenies” (go green, environmentalists)
- ▶ “Hippies”, “Off-gridders” (independence)
- ▶ “Look at Me’s” (social/political reasons)
- ▶ “Tax Breaks” (incentives, write-offs)
- ▶ Other motivations?

CNM

Slide 48

Reveal Slide 48.

Ask: What motivates people to want a solar heating system at their home?

Explain: This slide presents a few reasons why people want a system.

Ask: Can you think of others?

Explain: The sharp-eyed installer will note that homeowners with solar air systems or solar photovoltaic systems installed at their residences are prime prospects for a solar heating system installation.

Thank you!

It's been a pleasure working with you today as we complete Solar Heating Module #3.

Instructor ID #:
Class ID #:

CNM

Slide 49

Reveal Slide 49.

Module 4: Solar Heating Systems & Installation

SOLAR HEATING INSTALLATION SAFETY

Time: 60 minutes

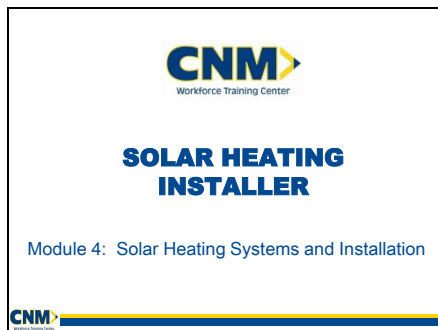
Learning Activity 1

Discussion Points

Logistics



PowerPoint Presentation



Slide 1

Instructor/Trainee Activities

This module is designed for the use of an accompanying PowerPoint presentation. If you choose not to use PowerPoint, then please have facilitator information charts ready for some activities.

Slide 1 should be available to view prior to participants entering the room.

FIRST: Your SH Mantra (Yes, Again!)

- ▶ All SH systems must control for:
 - ▶ Over Heating
 - ▶ Freezing
 - ▶ Scaling

Address all three whenever studying, designing, installing, servicing and troubleshooting a SH system.



Slide 2

Reveal Slide 2.

MODULE #4 : TOPICS

SH Systems and Installation

- ▶ SH Installation Safety
- ▶ Codes and Licenses
- ▶ Collector Mounting
- ▶ Component Installation
- ▶ System Installation Checkout and Start-up Procedures



Orlando Valley College SH Class "On Roof"



Slide 3

Reveal Slide 3.

Explain: “Module Four focuses on solar heating installations. We will cover installation safety, including fall protection and ladder safety; collector mounting, including roof work considerations, and roof penetrations; component installation, including pump and collector to storage piping installation; system installation, including pressure testing and instructions to the homeowner; and codes and licenses. It is imperative that all students review all designated section in their NABCEP text in addition to supplementary readings.”

SH Systems and Installation

- ▶ NABCEP Installer Guide:
 - Chapters 7, 8 & 9
- ▶ Florida: 3-2 thru 3-35
- ▶ Home Power Articles:
 - Installation Basics
 - SHW Mounting



Slide 4

Reveal Slide 4.

Mention that it is very important that you find the time to read your text, review articles, and bring questions from your readings to class.

There are also many training videos online that you may want to review.

SH Systems and Installation: Topics

- ▶ SH Installation Safety
 - Fall Protection
 - Ladder Safety
 - Selection and Use of Personal Protection Equipment (PPE)

CNM

5

Slide 5

Reveal Slide 5.

Review solar heating safety concerns.

New Mexico worksite safety programs operate under the category of OSHA Voluntary Protection Programs (VPP'S). Other states (16) have mandatory/required safety programs such as California's I2P2 (Injury and Illness Prevention Program).

Explain that the New Mexico Occupational Health & Safety Bureau web site provides "Sample Written Programs" designed to assist employers comply with OHSB (Occupational Health and Safety Bureau) standards as written programs are required for various employer activities. Samples are available for the following: Fall Protection for Construction, Hazard Communication, Permit Required Confined Spaces, Respiratory, and Trenching and Evacuation.

The Occupational Health and Safety Bureau (OHSB) is a state regulatory agency that is part of the New Mexico Environment Department. It has the responsibility of enforcing Occupational Health and Safety Regulations within New Mexico. New Mexico has adopted the Federal OSHA Regulations and has promulgated some State specific regulations. The scope of NM OHSB's jurisdiction includes all private industry and public entities such as city, county, and state government; excluding Federal Employees.

SH Installation Safety Fall Protection

- ▶ See NABCEP pages 48-49.
- ▶ Falls and deaths are a reality in solar installations.
- ▶ See OSHA web site and links.
- ▶ http://www.osha.gov/dep/greenjobs/solar_falls.html
- ▶ See fall protection short: <http://www.youtube.com/watch?v=JWRiB9fbOdo>
- ▶ YOU SHOULD ALL TAKE AN OSHA 10 CLASS!

CNM

6

Slide 6

Reveal Slide 6.

Refer to NABCEP pages 48-49.

Note that all safety topics in this course are "test-prep" only. This is not safety training. This safety review is only designed to cover aspects of fall protection, ladder safety, and PPE that could appear on the entry level NABCEP exam.

Refer to OSHA web site and links.

Explain that examples of OSHA standards include

	requirements for employers to: provide fall protection; prevent trenching cave-ins; prevent exposure to some infectious diseases; ensure the safety of workers who enter confined spaces, etc. General Duty Clause: employers must keep their workplaces free of serious recognized hazards: cited when no specific OSHA standard applies to the hazard. (Reference: “All About OSHA”, OSHA 3302-02R, 2012).
Falls in Construction Falls are the leading cause of deaths in the construction industry. Most fatalities occur when employees fall from open-sided floors and through floor openings. Falls from as little as 4 to 6 feet can cause serious lost-time accidents and sometimes death. Open-sided floors and platforms 6 feet or more in height must be guarded. CNM Slide 7	Reveal Slide 7. Explain that the issues of how to provide fall protection for employees at construction sites are difficult ones. There are so many different types of work and so many different kinds of fall hazards that it is not possible to organize fall protection into a neat set of rules that fit all situations. OSHA reflects this difficulty when it places its rules for fall protection in several different subparts in the Construction Standards, depending primarily on the nature of the work being undertaken. There are separate locations, for example, for fall protection during work on scaffolds, during work on certain cranes and derricks, during work in tunnels, during work on stairways and ladders, during steel erection, etc. Refer to NABCEP resource guide, page 48.



Slide 8

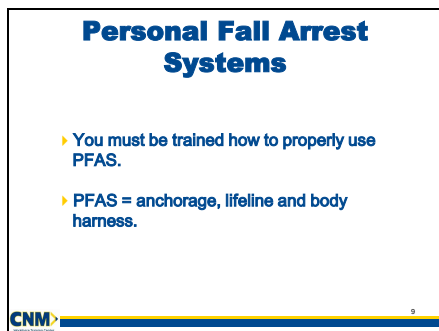
Reveal Slide 8.

Say: “If an employee can fall six feet or more onto a lower level, fall protection must be provided.”

Ask: How do you know what fall protection you will need?

Explain: In most cases, a guardrail system, a safety net system, or a personal fall arrest system must be used. In some cases fences, barricades, covers, equipment guards or a controlled access zone may be used.

Employees must be protected not just from falling off a surface, but from falling through holes and from having objects fall on them from above.



Slide 9

Reveal Slide 9.

Explain that a personal fall arrest system places the employee into a body harness that is fastened to a secure anchorage so that he/she cannot fall. Body belts are not acceptable as personal fall arrest systems. A few key requirements include:

- There should be no free fall more than 6 feet.
- There should be prompt rescue after a fall.
- PFAS's must be inspected prior to each use.
- PFAS's must not be used until they have been inspected by a competent person.

Safety Line Anchorages

- ▶ Must be independent of any platform anchorage and capable of supporting at least 5,000 pounds per worker.

CNM

10

Slide 10

Reveal Slide 10.

There have been cases of OSHA site visits where one installer was wearing a PFAS but with no safety rope attached. He was fined in the neighborhood of \$1000 for not being “hooked up”. Two other installers were on the roof working with him – they were properly tied off – but they were also fined about \$1000 for letting their buddy work without a safety line. The contractor in charge of the job was fined in the neighborhood of \$5000 for letting this happen.

NOW – here’s your story – you go home that evening and announce to your loved ones that the budget that month will be short by \$1000 because your workmate didn’t have his harness rope in place. How popular are you at home now!

NOW AGAIN – go estimate the contractor’s profit on this job! (NONE).

Reference 1926. 502(d)(15)

Safety Nets

- ▶ Place as close as possible, but no more than 30 feet below where employees work.

CNM

11

Slide 11

Reveal Slide 11.

How do safety net systems protect me?

Safety net systems catch the employee if he/she does fall. The safety nets:

- Must be strong enough to support a falling employee;
- Must have sufficiently small mesh openings so the employee cannot fall through the net;
- Must be close enough to the surface of the walking/working surface so that the fall into the safety net will not still injure the employee (never more than 30 feet below the walking/working level);
- Must be close enough to the edge of the working surface (the **outer edge** of the net between 8-13 feet from the edge of the walking/working surface, depending on the distance to the walking/working

	surface) so that the falling employee will not slip past the net. Reference 1926.502(c)
 Slide 12	Reveal Slide 12. Explain: "Unprotected sides and edges." "Each employee on a walking/working surface (horizontal and vertical surface) with an unprotected side or edge which is 6 feet (1.8 m) or more above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems." Reference 1926.501(b)(10) Reference 1926.501(b)(11) - steep roofs Roofers - First refer to STD 3-0.1A "If workers are working on roofs with unprotected sides and edges 6 feet or more above lower levels, they shall be protected from falling by guardrail systems, safety net systems, personal fall arrest systems or a combination of a warning line system and guard-rail system, warning line system and safety net system, warning line system and personal fall arrest system, or warning line system and safety monitoring system." Reference 1926.501(b)(1)

Fall Protection

► QUIZ (Quickly write down answers)

- 1. Fall protection equipment does not include which of the following?
 - Guard rails
 - Safety nets
 - Personal fall arrest system
 - Safety glasses
- 2. Wall opening barriers must support at least
 - 200 pounds
 - 300 pounds
 - 500 pounds
 - 1000 pounds
- 3. To be safe, an anchor point has to support how much weight per person?
 - 1000 pounds
 - 3000 pounds
 - 5000 pounds

CNM 13

Slide 13

Reveal Slide 13.

Ask students the answer the “Quick quiz.”

Explain that the answers are on the next slide.

Fall Protection

► ANSWERS

- 1. Fall protection equipment does not include which of the following?
 - Guard rails
 - Safety nets
 - Personal fall arrest system
 - **Safety glasses**
- 2. Wall opening barriers must support at least
 - **1910.23(e)(9)**
 - Wall opening barriers (rails, rollers, picket fences, and half doors) shall be of such construction and mounting that, when in place at the opening, the barrier is capable of withstanding a load of at least 200 pounds applied in any direction (except upward) at any point on the top rail or corresponding member.
- 3. To be safe, an anchor point has to support how much weight per person?
 - (b) Dee-rings and snap-hooks shall be capable of sustaining a minimum tensile load of 5,000 pounds (22.2 kN).
 - (3) Lanyards and vertical lifelines which tie-off one employee shall have a minimum breaking strength of 5,000 pounds (22.2 kN)

CNM 14

Slide 14

Reveal Slide 14.

“Regulations (Standards - 29 CFR) - Table of Contents • Part Number: 1910 • Part Title: Occupational Safety and Health Standards • Subpart: F • Subpart Title: Powered Platforms, Manlifts, and Vehicle-Mounted Work Platforms • Standard Number: 1910.66 App C • Title: Personal Fall Arrest System (Section I - Mandatory; Sections II and III - Non-Mandatory)”

Ladder Angle

Non-self-supporting ladders (that lean against a wall or other support):

Position at an angle where the horizontal distance from the top support to the foot of the ladder is **1/4** the working length of the ladder.



CNM 15

Slide 15

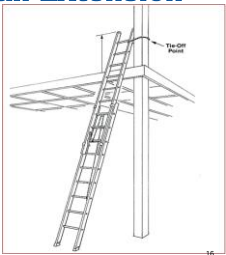
Reveal Slide 15.

Explain: The Working length of ladder is the distance along the ladder between the foot and top support. It is 4 to 1.

Reference 1926.1053(b)(5)

Ladder Rail Extension

- ▶ When using a portable ladder for access to an upper landing surface, the side rails must extend at least 3 feet above the upper landing surface.



CNM

Slide 16

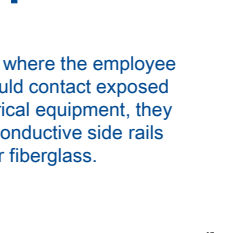
Reveal Slide 16.

Explain: “When portable ladders are used for access to an upper landing surface, the side rails must extend at least 3 feet above the upper landing surface. When such an extension is not possible, the ladder must be secured, and a grasping device such as a grab rail must be provided to assist workers in mounting and dismounting the ladder. A ladder extension must not deflect under a load that would cause the ladder to slip off its support.”

Reference 1926.1053(b)(1)

Near Energized Electrical Equipment

- ▶ If using ladders where the employee or the ladder could contact exposed energized electrical equipment, they must have nonconductive side rails such as wood or fiberglass.



CNM

Slide 17

Reveal Slide 17.

Reference 1926.1053(b)(12)

Overhead Power Lines

- ▶ Stay at least 10 feet away.
- ▶ Post warning signs.
- ▶ Assume that lines are energized.
- ▶ Use wood or fiberglass ladders, not metal.
- ▶ Power line workers need special training and PPE.



Slide 18

Reveal Slide 18.

Ask: “How Do I Avoid Hazards?”

- “Look for overhead power lines and buried power line indicators. Post warning signs.
- Contact utilities for buried power line locations.
- Stay at least 10 feet away from overhead power lines.
- Unless you know otherwise, assume that overhead lines are energized.
- Get the owner or operator of the lines to de-energize and ground lines when working near them.
- Other protective measures include guarding or insulating the lines.
- Use non-conductive wood or fiberglass ladders when working near power lines.”

1926.416(a)

Ladder Safety

- ▶ QUIZ (Quickly write down answers)
 - 1. If using a straight ladder to reach a roof, how many rungs should extend beyond the roof edge for proper support?
 - One
 - Two
 - Three
 - Four
 - 2. What is the correct relationship between a ladder's distance away from the wall versus its “working length”?
 - 3 to 1
 - 4 to 1
 - 5 to 1
 - 3. When climbing a ladder, how many “contact points” (hands – feet) should be touching the ladder at all times?
 - Two
 - Three
 - Four



Slide 19

Reveal Slide 19.

Refer to “Quick quiz” questions.

Provide answers on next slide.

Ladder Safety

► ANSWERS

- 1. If using a straight ladder to reach a roof, how many rungs should extend beyond the roof edge for proper support?
 - One
 - Two
 - **Three**
 - Four
- 2. What is the correct relationship between a ladder's distance away from the wall versus its "working length"?
 - 3 to 1
 - **4 to 1**
 - 5 to 1
- 3. When climbing a ladder, how many "contact points" (hands – feet) should be touching the ladder at all times?
 - Two
 - **Three**
 - Four

CNM 20

Slide 20

Reveal Slide 20.

Reference 1926.1053(b)(5)

Explain the Working length of ladder

“Distance along the ladder between the foot and top support.”

Reference 1926.1053(b)(1)

“When portable ladders are used for access to an upper landing surface, the side rails must extend at least 3 feet above the upper landing surface. When such an extension is not possible, the ladder must be secured, and a grasping device such as a grab rail must be provided to assist workers in mounting and dismounting the ladder. A ladder extension must not deflect under a load that would cause the ladder to slip off its support.”

Reference 1926.501(b)(10)

Reference 1926.501(b)(11) - steep roofs

Roofers - First refer to STD 3-0.1A

“If workers are working on roofs with unprotected sides and edges 6 feet or more above lower levels, they shall be protected from falling by guardrail systems, safety net systems, personal fall arrest systems or a combination of a warning line system and guard-rail system, warning line system and safety net system, warning line system and personal fall arrest system, or warning line system and safety monitoring system.”

Personal Protection Equipment Responsibilities

Employer

Assess workplace for hazards.
Provide personal protective equipment (PPE).
Determine when to use.
Provide PPE training for employees and instruction in proper use.

Employee

Use PPE in accordance with training received and other instructions.
Inspect daily and maintain in a clean and reliable condition.

CNM

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Slide 21

Reveal Slide 21

1926.95(a), 1926.95(b)

Explain:

“Employers must provide PPE for employees if

- Their work environment presents a hazard or is likely to present a hazard to any part of their bodies;

OR

- Their work processes present a hazard or are likely to present a hazard to any part of their bodies; OR

- During their work, they might come into contact with hazardous chemicals, radiation, or mechanical irritants; AND

- You are unable to eliminate employee exposure or potential exposure to the hazard by engineering, work practice, or administrative controls.

OVERALL, EMPLOYERS MUST: Inform workers about chemical hazards through training, labels, alarms, color-coded systems, chemical information sheets and other methods; Provide safety training to workers in a language and vocabulary they can understand; Keep accurate records of work-related injuries and illnesses; Perform tests in the workplace, such as air sampling, required by some OSHA standards; Provide required personal protective equipment at no cost to workers (Employers must pay for most types of required personal protective equipment. See above); Provide hearing exams or other medical tests required by OSHA standards; Post OSHA citations and injury and illness data where workers can see them; Notify OSHA within eight hours of a workplace fatality or when three or more workers are hospitalized (1-800-321-OSHA [6742]); Prominently display the official OSHA “Job Safety and Health – It’s the Law” poster that describes rights and responsibilities under the OSH Act; Not retaliate or discriminate against workers for using their rights under the law, including their right to report a work-related injury or illness.”

Examples of PPE

Body Part Protection Equipment

Eye	Safety Glasses, Goggles
Face	Face Shields
Head	Hard Hats
Feet	Safety Shoes
Hands and arms	Gloves
Bodies	Vests
Hearing	Earplugs, Earmuffs

CNM

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Slide 22

Reveal Slide 22

Note “that respirators and electrical protective equipment (gloves, sleeves, blankets, etc.) are also considered PPE. However, because OSHA has specific requirements for them, they are not discussed here.”

“OVERALL, WORKERS HAVE TO RIGHT TO:
Working conditions that do not pose a risk of serious harm; File a confidential complaint with OSHA to have their workplace inspected; Receive information and training about hazards, methods to prevent harm, and the OSHA standards that apply to their workplace (The training must be done in a language and vocabulary workers can understand); Receive copies of records of work-related injuries and illnesses that occur in their workplace; Receive copies of the results from tests and monitoring done to find and measure hazards in their workplace; Receive copies of their workplace medical records; Participate in an OSHA inspection and speak in private with the inspector; File a complaint with OSHA if they have been retaliated or discriminated against by their employer as the result of requesting an inspection or using any of their other rights under the OSH Act; File a complaint if punished or discriminated against for acting as a “whistleblower” under the 20 additional federal laws for which OSHA has jurisdiction.”

Eye Protection for Employees Who Wear Eyeglasses

Ordinary glasses do not provide the required protection. Proper choices include:

- Prescription glasses with side shields and protective lenses
- Goggles that fit comfortably over corrective glasses without disturbing the glasses
- Goggles that incorporate corrective lenses mounted behind protective lenses

CNM

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Slide 23

Reveal Slide 23.

Explain that prescription lenses must meet specifications of ANSI Z87.1-1968.

[ANSI = American National Standards Institute]
[www.ansi.org/]

1926.102(a)(3)

Safety Shoes

Impact-resistant toes and heat-resistant soles protect against hot surfaces common in roofing and paving

Some have metal insoles to protect against puncture wounds

May be electrically conductive for use in explosive atmospheres, or nonconductive to protect from workplace electrical hazards

CNM

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Slide 24

Reveal Slide 24.

Explain:

“Conductive Shoes (Written for P-V installers but important for SH installers to understand).”

“Electrically conductive shoes protect against the buildup of static electricity. Essentially, these shoes ground the employees wearing them. Employees working in explosive and hazardous locations such as explosives manufacturing facilities or grain elevators must wear conductive shoes to reduce the risk of static electricity buildup on an employee’s body that could produce a spark and cause an explosion or fire. During training, employees must be instructed not to use foot powder or wear socks made of silk, wool, or nylon with conductive shoes. Foot powder insulates and retards the conductive ability of the shoes. Silk, wool, and nylon produce static electricity. Conductive shoes are not general-purpose shoes and must be removed upon completion of the tasks for which they are required. Employees exposed to electrical hazards must **NEVER** wear conductive shoes.

Safety-Toe Shoes

Safety-toe shoes are nonconductive and will prevent an employee’s feet from completing an electrical

	circuit to ground. They protect employees against open circuits of up to 600 volts in dry conditions. Use the shoes with other insulating equipment and precautions to reduce or eliminate the potential for providing a path for hazardous electrical energy. NOTE: Don't wear nonconductive footwear in explosive or hazardous locations Solar Heating Installer Note: Service style boots on a hot asphalt tile roof, even many tar-and gravel roofs, will ruin the roof – requiring the you/contractor to replace the roof at your/his/her own expense. Work with your contractor/installers to identify safety shoes that will not damage the roof.”
Selecting the Right Hard Hat <u>Class A</u> General service (building construction, shipbuilding, lumbering) Good impact protection but limited voltage protection <u>Class B</u> Electrical/utility work Protects against falling objects and high-voltage shock and burns <u>Class C</u> Designed for comfort, offers limited protection Protects against bumps from fixed objects, but does not protect against falling objects or electrical shock CNM Slide 25	Reveal Slide 25. Explain: “HARD HATS Hard hats require a hard outer shell and a shock-absorbing lining. The lining should incorporate a head band and straps that suspend the shell from 1 to 1-1/4 inches away from the user's head to provide shock absorption during impact and ventilation during wear. Protective helmets purchased after July 5, 1994, must comply with ANSI Z89.1-1986, whereas those purchased before this date must meet the ANSI Z89.1-1969 standard. NOTE: Helmets must be worn as designed to be in compliance with ANSI standards. Do <u>not</u> wear helmets backwards. Employers must make sure that hard hats continue to provide sufficient protection to employees by training employees in the proper use and maintenance of hard hats, including daily inspection. Remove hard hats from service if the suspension system shows signs of deterioration or no longer holds the shell away from the employee's head. Also make sure the brim or shell is not cracked, perforated or deformed or shows signs of exposure to heat, chemicals, or ultraviolet light.

	Paints, paint thinners, and some cleaning agents can weaken the shell of the hard hat and may eliminate electrical resistance. Q. Why is there a bill on the front of the “BASEBALL CAP” style safety hat? The bill protects your nose from falling objects. Q. Why can't I put decals/stickers on my hard hat? Stickers and decals potentially hide hard hat defects and damage which would render the hat unsafe to use. Note: In some areas, an OSHA inspector can fine you for placing decals/stickers on your hard hat. Hard hats come in many styles: http://www.hardhats.4ursafety.com/hard-hats.html http://www.1staidsupplies.com/store.php?action=show_detail&crn=93&rn=443 “
Hand Protection <u>Gloves</u> Solar thermal installers/integrators must deal everyday with at least two realities: ▶ HEAT: Collectors are usually framed in aluminum – leave them in the sun for just a bit on a hot summer day and they're too toasty to pick up bare-handed. Tools and ladders and other equipment can also get “warm” in the summer – too hot to grab. ▶ SHARP EDGES: Aluminum collector frames are notorious for sharp corners and often razor sharp corner burrs. Deburring copper pipe has a way of gouging out a bare hand too. It's a good idea to show up on the job with at least one pair of sturdy work gloves. CNM Slide 26	Reveal Slide 26. Refer to OSHA Publication 3151, Assessing the Need for Personal Protective Equipment: A Guide for Small Business Employers. 1926.100

Dangers of Electrical Shock

Currents above 10 mA* can paralyze or "freeze" muscles.
Currents more than 75 mA can cause a rapid, ineffective heartbeat -- death will occur in a few minutes unless a defibrillator is used.
75 mA is not much current -- a small power drill uses 30 times as much.

* mA = milliampere = 1/1,000 of an ampere

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Slide 27

Reveal Slide 27.

Note that this presentation emphasizes hazard identification, avoidance, and control – not standards. No attempt has been made to treat the topic exhaustively. It is essential that trainers tailor their presentations to the needs and understanding of their audience.

This presentation is not a substitute for any of the provisions of the Occupational Safety and Health Act of 1970 or for any standards issued by the U.S. Department of Labor.

Explain that whenever you work with power tools or electrical circuits there is a risk of electrical hazards, especially electrical shock. Risks are increased at construction sites because many jobs involve electric power tools.

Say: "For example, 1/10 of an ampere (amp) of electricity going through the body for just 2 seconds is enough to cause death.

Currents above 10 mA can paralyze or "freeze" muscles. When this "freezing" happens, a person is no longer able to release a tool, wire, or other object. In fact, the electrified object may be held even more tightly, resulting in longer exposure to the shocking current. For this reason, hand-held tools that give a shock can be very dangerous. If you can't let go of the tool, current continues through your body for a longer time, which can lead to respiratory paralysis (the muscles that control breathing cannot move). You stop breathing for a period of time. People have stopped breathing when shocked with currents from voltages as low as 49 volts. Usually, it takes about 30 mA of current to cause respiratory paralysis."

1926 Subpart K - Electrical

Shock Severity

Severity of the shock depends on:
Path of current through the body
Amount of current flowing through the body (amps)
Duration of the shocking current through the body

LOW VOLTAGE DOES NOT MEAN LOW HAZARD



Slide 28

Reveal Slide 28.

Explain that other factors that may affect the severity of the shock include:

- The voltage of the current.
- The presence of moisture
- The general health of the person prior to the shock.

Note that low voltages can be extremely dangerous because, all other factors being equal, the degree of injury increases the longer the body is in contact with the circuit.

Explain that the resistance of the body varies based on:

- The amount of moisture on the skin (less moisture = more resistance)
- The size of the area of contact (smaller area = more resistance)
- The pressure applied to the contact point (less pressure = more resistance)
- Muscular structure (less muscle = less resistance)

Selection and Use of Personal Protection Equipment (PPE)

- QUIZ (Quickly write down answers)
- 1. The employer is not responsible to:
 - A. Assess workplace for hazards
 - B. Provide personal protective equipment (PPE)
 - C. Determine when to use PPE
 - D. Inspect daily and maintain in a clean and reliable condition
 - 2. If you wear prescription glasses you must wear:
 - A. Prescription glasses with side shields and protective lenses
 - B. Goggles that fit comfortably over corrective glasses without disturbing the glasses
 - C. Goggles that incorporate corrective lenses mounted behind protective lenses
 - D. All of the above
 - 3. Currents above ____? ____ can paralyze or "freeze" muscles.
 - A. 10 mA
 - B. 25 mA
 - C. 75 mA



Slide 29

Reveal Slide 29.

Refer to "Quick quiz."

Provide answers on next slide.

Selection and Use of Personal Protection Equipment (PPE)

► ANSWERS

- 1. The employer is not responsible to:
 - A. Assess workplace for hazards
 - B. Provide personal protective equipment (PPE)
 - C. Determine when to use PPE
 - D. **Inspect daily and maintain in a clean and reliable condition**
- 2. If you wear prescription glasses you must wear:
 - A. Prescription glasses with side shields and protective lenses
 - B. Goggles that fit comfortably over corrective glasses without disturbing the glasses
 - C. Goggles that incorporate corrective lenses mounted behind protective lenses
 - D. **All of the above**
- 3. Currents above ____? ____ can paralyze or “freeze” muscles.
 - A. **10 mA**
 - B. 25 mA
 - C. 75 mA



Slide 30

Reveal Slide 30.

Review answers.

Say: “This slide concludes our safety review.”

CODES AND LICENSES

Time: 60 minutes

Learning Activity 2

Discussion Points



Slide 31

Instructor/Trainee Activities

Reveal Slide 31.

Say: “As we consider installation practices, equipment and systems, it is important to understand codes and licenses.

Explain that the following is an overview of selected aspects of solar codes and contractor licensing.

Refer to NABCEP pages 64-67 and IAPMO
<http://www.iapmo.org/Pages/IAPMOgroup.aspx>

New Mexico Construction Industries Licensing Act, NMSA 1978, **Section 60-13-3.**

[NMSA = New Mexico Statutes Annotated]

Note that this is not a Codes training class.

Say: “This class is only designed to cover aspects of codes and licensing that could appear on the entry level solar heating NABCEP exam. Codes will predictably play a much bigger role in the **FULL** NABCEP exam.

Students planning to go on to take the full SH NABCEP exam should be encouraged to seek out further SH and codes training.

Students pursuing contracting careers should be encouraged to seek out codes training.”

Codes and Licenses

► New Mexico SOLAR HEATING Codes

- The state of New Mexico uses the **Uniform Codes** published by IAPMO, including the **Uniform Solar Energy Code**.
- The International Association of Plumbing and Mechanical Officials (IAPMO) works with government and industry to implement comprehensive plumbing and mechanical systems around the world. There are many IAPMO codes and standards that pertain to photovoltaic installations, including:
 - [Uniform Solar Energy Code](#)
 - [IAPMO IGC 086-2002 - PASSIVE SOLAR WATER HEATERS](#)
 - [IAPMO IGC 190-2003 - AIR BASE SOLAR THERMAL COLLECTOR](#)

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Slide 32

Reveal Slide 32.

Refer to NABCEP pages 64-67.

Show website:

<http://www.nmcpr.state.nm.us/nmac/parts/title14/14.009.0006.htm>

Refer to:

New Mexico Regulation & Licensing Department

http://www.rld.state.nm.us/construction/Rules_and_Laws.aspx

DSIRE: Database of State Incentives for Renewables & Efficiency

http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NM10R

New Mexico Construction Industries Licensing Act, NMSA 1978, **Section 60-13-3.**

Uniform Solar Energy Code

IAPMO IGC 086-2002 - PASSIVE SOLAR WATER HEATERS

IAPMO IGC 190-2003 - AIR BASE SOLAR THERMAL COLLECTOR

Reference

<http://www.solarabcs.org/codes-standards/IAPMO/index.html>

[IAPMO = The International Association of Plumbing and Mechanical Officials] [www.iapmo.org/]

Codes and Licenses – Cont.

- ▶ The *Uniform Plumbing Code*® (UPC) sections in this code are taken from the 2009 edition of the *Uniform Plumbing Code*.
- ▶ The *Uniform Mechanical Code*® (UMC) sections in this code are taken from the 2009 edition of the *Uniform Mechanical Code*.
- ▶ An American National Standard *IAPMO/ANSI USEC 1-2009*



Slide 33

Reveal Slide 33.

Refer to NABCEP pages 64-67.

Say: “Key provisions of the 2009 USEC and changes from the 2006 edition include:

Comprehensively covers solar thermal systems and photovoltaic systems

Allows the installation of single wall heat exchangers

Requires access to solar collector and its components for maintenance and repair purposes

Provides protection requirements for freezing

temperatures, water hammer, rodents, corrosion, ultraviolet radiation, decay and termites

Waterproofing requirements when solar collector is installed on a building structure for the prevention.”

Codes and Licenses

- ▶ **New Mexico SH Codes**
- ▶ The advantages of a *Uniform Solar Energy Code*®, acceptable in various jurisdictions as a means of promoting the public's health, safety and welfare, has long been recognized.
- ▶ The “Solar Heating Notes” that follow provide code examples important to the SH installer.

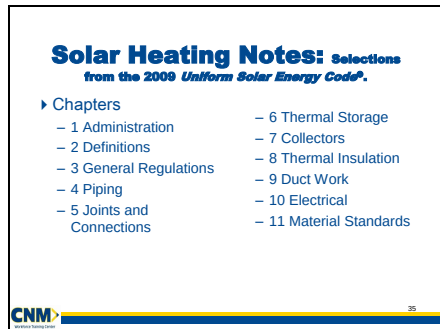


Slide 34

Reveal Slide 34.

Mention that “Notes” are organized by code chapters.

Have at least one copy of the code available, during this presentation, for review, clarification, topic expansion.

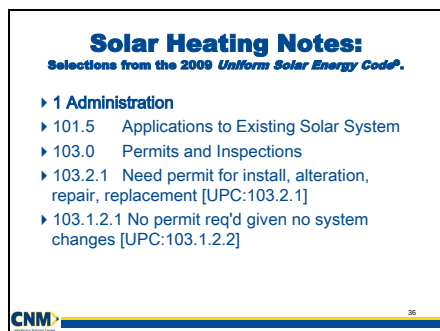


Slide 35

Reveal Slide 35.

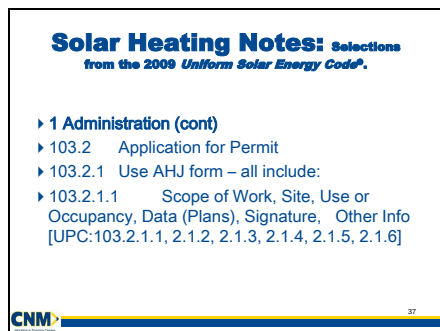
Note:

“SOLAR HEATING NOTES” is a series of PowerPoint slides highlighting a selection (not all) of solar heating related codes taken from the 2009 UNIFORM SOLAR ENERGY CODE. It is very important to have at least one copy of the code available, during this presentation, for review.



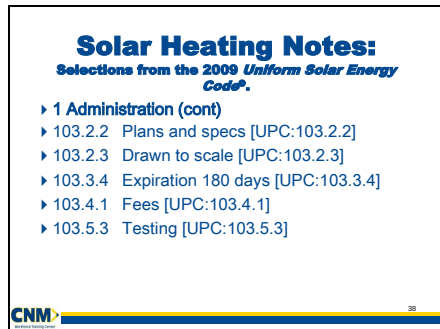
Slide 36

Reveal Slide 36.



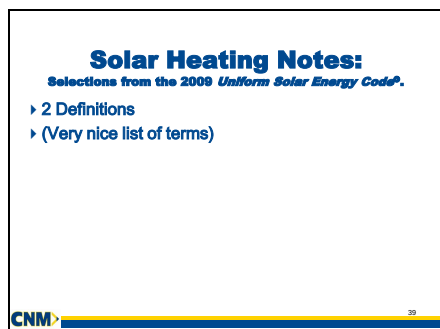
Slide 37

Reveal Slide 37.



Slide 38

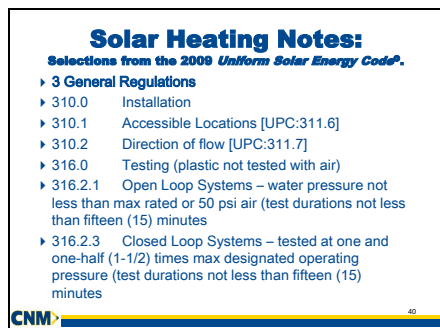
Reveal Slide 38.



Slide 39

Reveal Slide 39.

Refer to glossary in NABCEP text.



Slide 40

Reveal Slide 40.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **3 General Regulations (cont)**
- ▶ 316.3 Storage Tanks
- ▶ 316.3.1 Pressure Type. Tested as prescribed in 316.2.3
- ▶ 316.3.2 Non Pressure Type. Tested with water for period of twenty-four (24) hours

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Slide 41

Reveal Slide 41.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **3 General Regulations (cont)**
- ▶ 319.0 Safety Requirements
- ▶ 319.4 Water temperature. ...water @ 140°F shall be equipped ... tempering valve or temperature-limiting device to limit ... to a maximum of 140°F or less.
- ▶ 319.5 Spark or Flame. Solar equipment ... glow, spark, or flame ... in a residential garage.. not less than eighteen (18) inches above the floor level unless ... vapor ignition resistant.

CNM 42

Slide 42

Reveal Slide 42.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **4 Piping**
- ▶ 401.0 Unlawful Connections
- ▶ 401.1 General. No installation of solar piping, ..., shall be made ...will be possible for used, unclean, polluted, or contaminated water, ...to enter any portion of the potable water system ... by reason of back-siphonage, by suction, ...

CNM 43

Slide 43

Reveal Slide 43.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ 4 Piping (cont)
- ▶ 402.0 Identification of a Potable and Nonpotable Water System [UPC:601.2]
- ▶ 402.1 Potable Water (**LABEL**) Green background, white lettering [UPC:601.2.1]

CNM 44

Slide 44

Reveal Slide 44.

Say: “Labeling. Code requirements for SH system labeling are highlighted with “(LABEL)”

“It appears that the 2012 edition of the code will address labeling better than the 2009 code does.”

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ 4 Piping (cont)
- ▶ 402.2 Nonpotable Water (**LABEL**) Yellow background, block lettering, uppercase “CAUTION: NONPOTABLE WATER, DO NOT DRINK”.
- ▶ Labeled every twenty (20) feet, at least once per room
- ▶ Each outlet labeled
- ▶ Visible from floor level
- ▶ Direction of normal flow indicated.

CNM 45

Slide 45

Reveal Slide 45.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ 4 Piping (cont)
- ▶ 406.1.1 Copper tube, Type L, not less
- ▶ Exception: Type M, above ground, in or on building, or underground outside of structure [UPC:604.2]
- ▶ 406.5.2 Water Heater Connections. PEX tubing shall not be installed within the first eighteen (18) inches of piping connected to a water heater. [UPC:604.13.2]
- ▶ 406.8 Flexible Corrugated Connectors. Limited to twenty-four (24) inches in length. [UPC:604.12]

CNM 46

Slide 46

Reveal Slide 46.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **4 Piping (cont)**
- ▶ 407.2 Control Valve. A control valve shall be installed immediately ahead of each water-supplied solar system.
- ▶ 407.4 Closed Loop Systems. ...valves used to charge/drain system shall be of loose key type, ... outlets capped or ... handles removed when ... operational.
- ▶ 409.0 Automatic Air Vents. Install at high point.

CNM 47

Slide 47

Reveal Slide 47.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **4 Piping (cont)**
- ▶ 410.0 Vacuum Relief Valves.
- ▶ 410.1 Installation. Install at high point: drain down and drain back.
- ▶ 412.0 Check Valves. Install ... system design would allow reverse thermosiphoning ... into the collector array.
- ▶ 413.0 Flow Directions. Systems shall have flow directions indicated on system components and piping or ... a diagrammatic representation of the ..., permanently affixed ... ready visible location. **(LABEL)**

CNM 48

Slide 48

Reveal Slide 48.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **5 Joints and Connections (cont)**
- ▶ 503.0 Special Joints
- ▶ 503.4 Unions. Installed not more than 12 inches from equipment (tank, regulating equipment, and similar) that facilitates removal/replacement. [UPC:609.5]

CNM 259

Slide 49

Reveal Slide 49.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **5 Joints and Connections (cont)**
- ▶ 502.6 Solvent Cement Plastic Pipe Joints. Plastic ...
- ▶ ABS pipe and fittings shall be cleaned and then joined with solvent cement(s).
- ▶ CPVC pipe and fittings shall be cleaned and then joined with listed primer(s) and solvent cement(s).
- ▶ Exception:
- ▶ PVC pipe and fittings shall be cleaned and then joined with listed primer(s) and solvent cement(s). [UPC:316.1.6]

CNM 50

Slide 50

Reveal Slide 50.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **5 Joints and Connections (cont)**
- ▶ 503.0 Special Joints
- ▶ 503.4 Unions. Installed not more than 12 inches of equipment (tank, regulating equipment, and similar) that facilitates removal/replacement. [UPC:609.5]

CNM 51

Slide 51

Reveal Slide 51.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **6 Thermal Storage**
- ▶ 602.0 Expansion Tanks
- ▶ 602.1 Need for expansion tank on hot water system. ...secured to support twice the weight of a full tank – no strain on connecting pipes.
- ▶ 603.0 Test Pressure for Tanks Used in Solar Systems. Test pressure = 2 times working pressure, but not less than 300 psi.

CNM 52

Slide 52

Reveal Slide 52.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **7 Collectors**
- ▶ 701.2 Mounting. ...Maintain roof integrity, water integrity, roof surface.
- ▶ 701.4 Construction. "Panels" constructed to prevent interior condensation, outgassing.
- ▶ 701.5 Glass. Tempered glass.
- ▶ 701.7 Stagnation Condition. Capable of withstanding stagnation.

CNM 53

Slide 53

Reveal Slide 53.

Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **7 Collectors (cont)**
- ▶ 704.0 Fire Safety Requirements
- ▶ 704.1... Collectors functioning as building components must comply with Building Code.
- ▶ 704.2 Above or On the Roof. Shall not reduce required fire-resistance/retardance of roof covering materials.
- ▶ Exceptions:
- ▶ One- and two-family dwellings.
- ▶ Mounted on buildings less than three stories providing...

CNM 54

Slide 54

Reveal Slide 54.

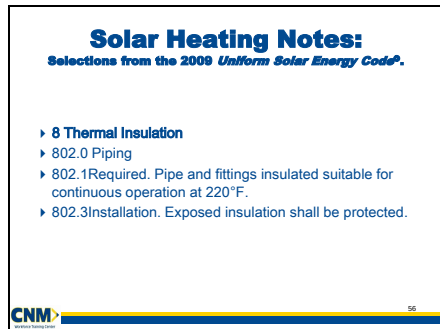
Solar Heating Notes:
Selections from the 2009 Uniform Solar Energy Code®.

- ▶ **7 Collectors (cont)**
- ▶ 705.0 Collector Installation
- ▶ 705.2 Safety. Allow workspace access on roof next to installed collectors..
- ▶ 705.3 Waterproofing. Joints, bolts, supports, sealed.

CNM 55

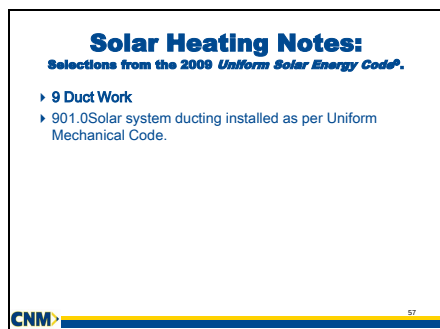
Slide 55

Reveal Slide 55.



Slide 56

Reveal Slide 56.



Slide 57

Reveal Slide 57.



Slide 58

Reveal Slide 58.

Refer to New Mexico Construction Industries Licensing Act, NMSA 1978, **Section 60-13-3**.

“Any one engaged in construction-related contracting in New Mexico must be licensed. This includes general construction work, electrical, mechanical and plumbing and LP gas. The activities that are considered to be contracting in New Mexico are defined in the Construction Industries Licensing Act, NMSA 1978, **Section 60-13-3**.”

	http://www.rld.state.nm.us/uploads/files/Construction%20Industries%20Licensing%20Act%20Section%2060-13-3.pdf “New Mexico issues contracting licenses in approximately 100 different classifications. These classifications can be found in the New Mexico Administrative Code, Title 14, Chapter 6. http://www.nmcpr.state.nm.us/nmac/ title14/T14C006.htm” “New Mexico Licenses Construction Industries Licensing Act, NMSA 1978, Section 60-13-3. Definition; contractor. As used in the Construction Industries Licensing Act [60-13-1 NMSA 1978], "Contractor": A. means any person who undertakes, offers to undertake by bid or other means or purports to have the capacity to undertake, by himself or through others, contracting. Contracting includes constructing, altering, repairing, installing or demolishing any: (14) air conditioning, conduit, heating or other similar mechanical works; (15) electrical wiring, plumbing or plumbing fixture, consumers' gas piping, gas appliances or water conditioners; or (16) similar work, structures or installations which are covered by applicable codes adopted under the provisions of the Construction Industries Licensing Act.”
--	---

Codes and Licenses

- › 14.6.6.9 GENERAL CONSTRUCTION
- › B. License Classifications.
- › (2) Residential and commercial building.
- › (a) GB-2. Residential.
- › (b) GB-98. General building.
- › 14.6.6.10 ELECTRICAL
- › B. License classifications.
- › (1) Residential and commercial.
- › (a) EE-98. Residential and commercial ...
- › (b) ER-1. Residential electrical wiring.

CNM

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Slide 59

Reveal Slide 59.

Say: “License numbers and titles are provided here in list form to illustrate to the student the variety and number of contractor licenses in New Mexico. This is just a few of the many classifications.”

Source:

www.nmcpr.state.nm.us/nmac/parts/title14/14.006.0006.htm

Codes and Licenses

- › 14.6.6.11 MECHANICAL AND PLUMBING
- › B. License classifications.
- › (1) Residential and commercial.
- › (a) MM-1. Plumbing.
- › (c) MM-3. Heating, ventilation & air conditioning (HVAC).
- › (e) MM-98 Mechanical.
- › C. Journeyman classifications.
- › (1) JP. Journeyman plumber.
- › (2) JPF. Journeyman pipe fitter.
- › (5) JR. Journeyman refrigeration.

CNM

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Slide 60

Reveal Slide 60.

Note the usual license required in New Mexico to pull a solar heating permit is an MM-98, with a licensed Journeyman required to do the installation.

COLLECTOR MOUNTING

Learning Activity 3

Time: 210 minutes

Discussion Points

Collector Positioning

- ▶ Ideally a collector should be positioned:
 - to face true south (north of equator), and
 - with a tilt angle at latitude.
- ▶ Given site considerations:
 - a collector may face within **30° to 45°** either east or west of true south
 - Consider your **Solar Window**
 - optimum tilt angles = site latitude **plus or minus 15°**
 - Albuquerque: Latitude: N 35° 11' 12.6845", or 35°N

CNM

Slide 61

Instructor/Trainee Activities

Reveal Slide 61.

Review Module Three concepts: declination, compass orientation, solar window, sun path, altitude. Latitude.

Discuss latitude determination. GPS (many telephones with GPS and/or apps); also Internet

Refer to (<http://www.findlatitudeandlongitude.com/> etc.).

Refer to Latitude examples for Albuquerque (at CNM-WTC):

Latitude: N 35° 11' 12.6845", Longitude:W 106° 34' 58.8144"

Santa Fe: Latitude: N 35° 40' 22.4985", Longitude:W 105° 58' 26.8359"

Gallup: Latitude: N 35° 31' 23.8266", Longitude:W 108° 43' 54.082"

Tucumcari: Latitude: N 35° 10' 58.0373", Longitude:W 103° 43' 18.9258"

Raton: Latitude: N 36° 54' 21.5276", Longitude:W 104° 26' 29.502"

Las Cruces: Latitude: N 32° 19' 27.3921", Longitude:W 106° 47' 13.5938"

Note: "Facing collectors within 30 degrees to 45 degrees east or west of true south affects performance by about 10%."

Collector Positioning

- ▶ Performance versus Aesthetics
 - Aesthetic considerations vary in intensity with the client and system location.
 - The mounted collector should not detract from building's overall appearance/attractiveness.

CNM

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Slide 62

Reveal Slide 62.

Explain that collector performance determination begins with manufacturer/distributor claims regarding their collector design(s). A standardized and tested performance rating for a collector should be available on-line at the SRCC website.

Review Module Two: SRCC OG-100 and SRCC OG-300 topics).

Say: “Installers may joke about a basic design rule: “If it looks good, it is good”, but aesthetics do play an important role in a system’s overall acceptance by the buyer/client. You can do the very best installation of a lifetime, from a system operation point of view, but if the end-product “looks messy” or “looks unsightly” or just plain “ugly” to the buyer/client --- you/your company just did your reputation and future sales more harm than good.”

Explain: “Beware of home owner association and/or codes, covenants and restrictions that dictate structural and aesthetic do’s and don’ts.”

Refer to NABCEP page 67.

Collector Positioning

Roof Mounted Collectors

- ▶ Roof mounted collectors should:

- shed water/rain and plant detritus,
- Prevent puddling around roof penetrations.
- limit collector-to-storage pipe runs to <100 feet.

▶ Pictured:

- Getting it WRONG

Old School & Wrong



CNM

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Slide 63

Reveal Slide 63.

Explain that:

- Flush mounted collectors should not inhibit rain water drainage nor cause standing water on the roof (which could back up under shingles and enter the attic -- or work through roof penetrations to attic spaces). Collectors should not form roof dams for leaves, needles, and other organic material.

- The hot return piping on the illustrated motel pool

	system runs from top left, all the way under the array, to come off the roof next to the cold supply side plumbing. Backwards. The short line should be the hot water run-to-pool, not the cold return. (OH YES, look closely at the far left collector – yes, it is leaking).
Collector Positioning ▶ Wind Loading – Withstand wind-loads of 146 miles per hour. – Many collector racking systems tested to 180 MPH. – Thermal expansion and contraction may loosen improperly installed fasteners.  CNM Slide 64	Reveal Slide 64. Refer to text • NABCEP page 63 • Web Site illustration: http://www.precisionsolar.net/hw_photor.php Note that wind loading is a serious consideration for the solar heating system designer. Installers have the final obligation to ensure that roof arrays have been installed as per the design which should meet or exceed code requirements. Consider necessity of running lag bolts into roof rafters on center. Consider necessity of keeping collectors away from roof ridges, roof eaves, and other places where wind loading may be greater than roof center. Note that the “Dade County” reference is a common solar standard given the hurricane conditions in Florida. Roof mounted solar systems in Florida have been known to survive intact with all surrounding roofing materials stripped away by gale/hurricane force winds.

Collector Positioning

- ▶ Rack Mounting
 - Distances between rows calculated to minimize or eliminate shading.
 - ROT: Between-row separation = 2.5 times row height.
 - Or: $d = h + \tan \theta$



Slide 65

Reveal Slide 65.

Refer to Web illustration:

http://www.precisionsolar.net/hw_photor.php

Explain that collectors “in front” must not shade collectors “behind” (detail on next slide).

“Think here about winter months when the sun is lower on the horizon (greater potential for shading).

For small systems, it may be sufficient to simply use a rule of thumb (**ROT**), such as the inter-row separation should be about 2.5 times the row height (reasonably good for 40 degree latitude).

A standard formula is " $d = h + \tan \theta$ " where d is the minimum distance between rows, h is the height differential between the top of one row and the bottom of the row to the north, and θ is the solar altitude angle.

There are successively more sophisticated ways of calculating inter-row spacing that take into account seasonal variations of the sun’s path at the site (shade analysis tool, 3-D CAD programs, even Google Sketchup).

Ultimately, the goal is to get the most production of the system given the constraints imposed by its site.”

Collector Positioning

- ▶ Standoff Mounting
 - Very common racking
 - Easily matches roof slope
 - Usually faster install time than racking.
 - May be used to set collectors at angle different from roof slope.
 - Allows for drainage (rain) and debris (leaves) flow.
 - Huge variety of mounts.



Slide 66

Reveal Slide 66.

Refer to Web illustration:

<http://www.hgtvremodels.com/home-systems/solar-power-small-steps-toward-big-savings/index.html>

Explain: “Standoff racking employs “rails” and “legs”, along with roof flashing which may be integral to leg mounts (example: “P-V Quick Mount”)

Standoff racking components may be used to tilt collectors up to 45°. Typical installations, however, are designed to match or come close to the actual roof slope – for aesthetic purposes.

Installers must be able to mount a wide variety of “legs” and “rails”, however it is in a contractor’s best interest to stick with one or two types.

Ask: Why?

Explain that answer items may include: Installer familiarity; familiarity = speed; missing parts/spare parts on hand; use of same tools on each job; contractor relationship with distributors = credit line/trust.

Collector Positioning

- ▶ Direct Mounting
 - Collectors may be mounted directly on the roof surface.
 - Waterproof flashing is built up around the collector.



Slide 67

Reveal Slide 67.

Refer to web illustration:

<http://www.behance.net/gallery/Clearline-Solar-Panels-Pitched-Slate-Roof/2506561>

Discuss concerns such as:

- Waterproofing
- Mildew prevention
- Rot prevention

Ask: “Could heat buildup under the collector be a concern?”

Collector Positioning

- ▶ Integral Mounting
 - Collector mounting incorporated in to roof structure.
 - Collector(s) serve as finished roof surface.
 - Typically installed during new roof construction.
 - Not your common installation.



Slide 68

Refer to Slide 68.

Refer to web illustration:

<http://www.greentherm.ie/blogs/news/3359152-the-only-bba-approved-solar-thermal-product-available-on-the-market-is-now-listed-on-the-harp-database>

Collector Positioning

- ▶ Ground Mounting
 - Ground mounting is often a good alternative to roof mounting.
 - Local codes and AHJ requirements must be followed for a ground mount.
 - A popular elevated ground mount design provides shaded automobile parking (think Albuquerque's Sunport).

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Slide 69

Reveal Slide 69.

Ask: “What are some of the occasions/reasons why a ground-mounted solar system would be better installation than a roof mounted system?”

Explain that Code and AHJ (Authority Having Jurisdiction) requirements could include:

- Installation site restrictions/requirements:
 - Required number of feet from property line
 - Fencing/security (animal/child proofing)
 - Foundation specifications (concrete below frost line, etc.)
 - Not blocking view/shading property (of owner and/or neighbor)
 - Pipe run requirements
 - Additional inspections
 - Other?

Roof Work Considerations

- ▶ “Illegal”?
- ▶ “Legal”?
 - Safety
 - Roof damage
 - OSHA regulations
 - Lifting collectors on to roof

CNM

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Slide 70

Reveal Slide 70.

Say: “Your first climb up the ladder on the morning of a new install gives you the first real view of your installation surface. It is not uncommon to look up over the gutter only to spot roof vents and even skylights positioned in the location of your proposed system! (And don’t forget the roof may be slippery from night-time dew during some seasons of the year).”

Explain: “Always consider safety concerns of the job: Need for harness systems? Need for scaffolding? Need for safety rails?”

Discuss: Always consider possible damage to the roof and/or roof gutters when using a ladder. Ladder standoffs protect gutters from damage and the need to replace an entire residential gutter system (it’s

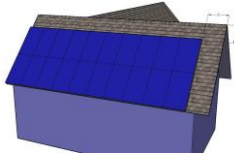
	happened when matching gutters were not available!). Ask: “How can you comply with OSHA regulations and safely move heavy collectors on to a roof?” Explain that if you observe OSHA’s “three-points of contact” while climbing a ladder, carrying a collector up a ladder by hand or using a harness system where you must hold on to a strap with one hand is “illegal”. Ask: “What other methods could be used?” Examples: Homebuilt lift: YouTube. http://www.youtube.com/watch?v=M7GRPyVsZLY Commercial crane lift: YouTube. http://www.youtube.com/watch?v=twJ724FrdAo
Slide 71	Reveal Slide 71. Explain that “Dead Load” static forces that are relatively constant for an extended time. They can be in tension or compression. “Live Load” usually unstable or moving loads. These dynamic loads may involve considerations such as impact, momentum, vibration, slosh dynamics of fluids, and –walking/working on the roof. Roofs are designed to hold the weight of all roofing/structural and covering materials. This load is commonly referred to as the “dead load” rating of a roof. Clearly dead load ratings for sheet metal covered roofs are different from concrete tile covered roofs. Additionally, roofs in snow and high wind areas are built with a higher live load rating. Typical live load on roof = local requirements for wind and snow. (Usually 30 lbs. per sq. ft.) Typical dead load of roof of wood shingle construction

	= 10 lbs. per sq. ft. Clearly, the installation of light-weight, unglazed solar pool collectors on a given roof bring a different roof load consideration to the design table than when you install glazed collectors. Ask: “As an installer what would you do if you were assigned to install batch collectors on an older roof constructed with 2x4 rafters on 24 inch centers?”
Slide 72	Reveal Slide 72. Refer to web illustration: http://toughmuddertrainingdiary.wordpress.com/page/2/ Explain that as you gain installation experience you will be able to spot roof concerns right away. Roofs often present problems to the installers that were overlooked by the system designer. Older roofs may have structural concerns or be of an original design too weak or unsuitable for a quality installation. Sagging or “sway-back” roofs may be stable, but installing a straight-line collector array will accent existing roof problems, leaving the client unhappy and your company with a “shoddy” reputation. Even a poor shingle job will stand out next to a straight-edge collector – making the entire situation look bad from afar. Batch system installs may require “beefing up” rafters inside the attic to safely hold the collector load. Note: Roofers have been known to fall through weak spots in roofs – to fall right through the attic and into the kitchen!

**Roof Work
Considerations**

**Cross-Gable
Roof**

Single and multiple collector array installations should consider fire fighter and maintenance access.



Slide 73

Reveal Slide 73.

Refer to

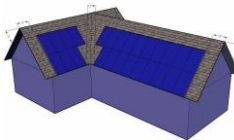
http://gov.ca.gov/docs/ec/CalFIRE_Solar_PV_guideline.pdf

This provides guidelines for installations to increase public safety for all structures equipped with solar photovoltaic systems.

May also apply to solar heating installations.
Check with AHJ regarding codes/regulations.

**Roof Work
Considerations**

**Cross-Gable
Roof With Valley**



Slide 74

Reveal Slide 74.

Refer to

http://gov.ca.gov/docs/ec/CalFIRE_Solar_PV_guideline.pdf

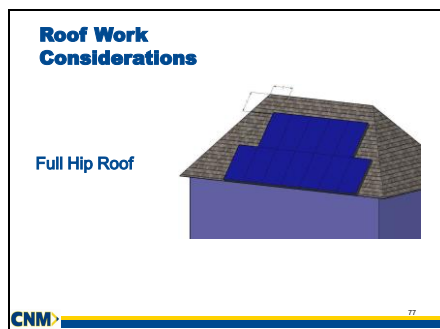
This provides guidelines for installations to increase public safety for all structures equipped with solar photovoltaic systems.

May also apply to solar heating installations.
Check with AHJ regarding codes/regulations.



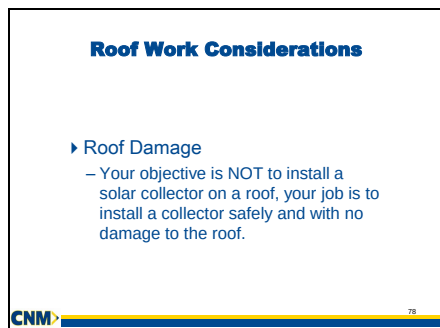
Slide 75

Reveal Slide 75.



Slide 76

Reveal Slide 76.



Slide 77

Reveal Slide 77.

“A true and sad story.

Installers working for a solar contractor worked two days on a residential roof -- in a hot, summer sun -- to install a huge solar system. Problem -- they were wearing service style boots during the install and their heavy boots damaged the soft asphalt shingles so badly that the contractor was “compelled” to order the installers back to the worksite -- to complete dismantle the solar system, wait for another contractor -- a roofing contractor -- to install a new

	roof – then the solar installers re-installed the solar system – this time wearing softer sled shoes and protecting the roof while working. All costs of the take-down, re-roofing, and re-install were paid out of the solar contractor’s pocket!” Consider your footwear choices carefully. Also, a second pair of shoes to wear home prevents roofing tar and other sticky-gooey sealants from getting on the carpet at home! Explain that service-style, hard-soled boots will probably ruin a hot, asphalt shingled roof. The same foot-wear will also crack slate and concrete tiled roofs. Note that a roll of “hallway runner” carpet is good to keep on hand in the service truck. Other used and soft carpet pieces are great for protecting roofs, gutters, and other structures from ladders, tools, and equipment. Remember, you place the good or soft side down in contact with the roof.
Slide 78 content: The slide is titled 'Site Preparation' in blue. Below it, a blue arrow points to 'On The Roof'. Underneath, two bullet points are listed: '- Collector roof mounts are ANCHORED to roof rafters or trusses' and '- NOT roof sheathing!'. At the bottom left is the CNM logo, and at the bottom right is the number 79. Slide 78	Reveal Slide 78. Explain that solar heating installers should approach each new installation assignment with a set of drawings, along with system inventory and other system details, detailing the installation design and location. Say: “Your first job on the roof is to layout the collector mounting site and anchoring points. You must take a given system plan (drawing) and duplicate it on the roof.” “Important hand and power tools at this juncture include a chalk line, level, drill motor and bit set, compass, flashlight, walkie-talkies, and a two-foot length of #10 copper grounding wire.” Explain: “There are many “tricks” to locating rafters

	while standing on a roof. • Locate exposed rafter ends at edge of roof and trace back up the roof. • Measure from one end of the roof and “guesstimate” rafters are on 16” centers – drill exploratory holes to confirm • The copper wire is bent and inserted in to a drilled exploratory hole in an attempt to “feel” the side of a rafter. Problems faced include: rafters, especially on older homes, are often bent or settled out of alignment. Commercial stud finders are usually problematic due to the many tar paper and shingle nails and staples in the roof.”
Slide 79 is a presentation slide titled "Site Preparation". It features the heading "On the Roof" and shows three images of different types of bolts: a standard lag bolt, a "J" bolt, and a U-bolt. Text on the slide states "Images of 'J' bolts. Required in NM by some AHJ's". A URL is provided at the bottom: "http://www.albello.com/product.htm?122643642_bolt_1_16x60_8x11.html". The slide also includes a CNM logo and a small number "80" in the bottom right corner. Slide 79	Reveal Slide 79. Explain that most assuredly the best method for hitting rafters on-center (lag bolts) or on-side (“J” bolts) is working with one installer on the roof and a second installer inside the attic. This is the reason for listing a flashlight and walkie-talkies on the previous tools list. Working in an attic brings its own difficulties and surprises – such as dealing with vermin, vermin residue, and stepping through a drywall floor/ceiling into the room below. Explain: • Lag bolts should be stainless steel. Some may use galvanized – but should expect unhappy callbacks when the “galvies” leave rust stains on the roof. • Lags need pilot holes. Measure lag root and select appropriate drill for pilot holes.

	Ask: “How many threads must a nut engage (on a bolt or threaded rod) to be a maximum strength?” Explain: Threads equal in length to the diameter of the bolt/threaded rod. (Typically nuts are sized to equal diameter length).
The image shows a presentation slide titled 'Site Preparation' with a sub-header 'In The Basement/Cellar/Garage'. It lists four bullet points: 'Where is the system pump station to be located?', 'Where is the existing water heater and water connections?', 'Is the existing water tank in good working order?', and 'What else?'. The slide has a blue header, a white body, and a blue footer with the CNM logo and the number 81. Slide 80	Reveal Slide 80. Ask the following questions: • Where is the system pump station to be located? • Where are the existing water heater and water connections? • Is the existing water tank in good working order? • Where do I install and secure the new solar tank (if included)? • Do I have adequate access space to move old tanks out and new tanks into place? • Where are my possible pump station electrical connections? • Where are my power tool electrical connections? • Where will my “to collector” and “from collector” pipe runs be positioned? • Where do I position my fire extinguisher? It is much easier to think things through before doing the heavy lifting! Explain that solar heating installers should approach each new installation assignment with a set of drawings, along with system inventory and other system details, detailing the installation design and location. An early walk-through at the job site is important in locating the positions of all system components, source water/plumbing, drainage, and electrical connections.

Site Preparation

► Inside/Outside

- INSIDE: Where does my pipe run?
 - Roof penetrations?
 - Through the attic?
 - Through a chase?
 - Inside a wall?
 - What else?
- OUTSIDE: Where does my pipe run?
 - Through the eaves or around the eaves?
 - Roof penetrations?
 - Other?

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Slide 81

Reveal Slide 81.

Ask the following questions:

Inside

Where does my pipe run?

Roof penetrations?

Through the attic?

Through a chase?

Inside a wall?

Through a bedroom closet?

Soldered or line set?

Outside

Where does my pipe run?

Through the eaves or around the eaves?

Roof penetrations?

Outside wall?

How will it be disguised/finished?

Insulation and UV protection?

Other?

Explain that solar heating installers should approach each new installation assignment with a set of drawings, along with system inventory and other system details, detailing the installation design and location.

An early walk-through at the job site is important in locating the positions of all system components, source water/plumbing, drainage, and electrical connections.

Define chase.

Explain that chase is a horizontal or vertical box in which a flue pipe, generally a chimney flue, is located. The chase is built around the flue and it extends above the roofline by an amount specified in the Building Code. Chases can also contain plumbing pipes or wiring.

Roof Penetration

- ▶ Pipe flashing
 - Flashing is placed around solar collector pipes which protrude from the roof of a building to deflect water away from seams or joints.
- ▶ Collector mount flashing
 - Largely dependent on manufacturer's specifications and recommendations.
- ▶ Working with asphalt shingles
 - Two valuable tools:
 - Flat bar
 - Roofing bar



Slide 82

Reveal Slide 82.

Explain that drilling a hole into a roof rafter to mount a collector rack, drilling a hole through the roof cover and sheathing for a pipe run – all roof penetrations are a serious operation.

A roof penetration may void a roof covering warranty – not a small consideration.

You “own” all roof penetrations that you make as an installer. It is your responsibility to ensure that all roof penetrations that you make are purposeful and well-sealed.

Roof penetration concerns cover a wide variety of: roof types – gable, flat, hip, Mansard, etc. roofing materials – tar and gravel, asphalt shingle, wood shake, membrane, standing seam (metal), corrugated steel, clay and Spanish barrel tile, slate tile, adobe, concrete tile, etc. sealant materials – silicone, asphalt, butyl rubber, urethane, etc. flashing types – Oatey, EPDM or Silicone vent pipe, thermoplastic, boots, etc. and a wide variety of brand names and contractor/installer preferences.

Examples:

Installing a pipe flashing on a metal roof:

http://www.youtube.com/watch?v=HI_FKn00-M0

Installing a pipe flashing on an asphalt shingle roof:

<http://www.youtube.com/watch?feature=endscreen&v=pjXA9gSCQQ8&NR=1>

Removing asphalt shingles:

http://www.youtube.com/watch?v=8PX_noHwDxw&feature=related

Bracket Mounting and Sealing

- “Brackets”, AKA “feet”, “legs”, “boots”, etc., attach the collector to underlying rafters or trusses.
- Bracket installation varies by manufacturer.



Slide 83

Reveal Slide 83.

Refer to NABCEP pages 77 through 90.

Web illustration:

<http://www.thedarkphoenix.info/install-solar-panels-tile-roof/>

Review mounting brackets:

- Pitch pan
- Spanner mounting
- Lag bolt
- “J” bolt

Explain that the next slide helps to illustrate just a small number of collector mounting systems and distributors.

Bracket Mounting and Sealing

– Many Players:

- Distributors
- Manufacturers
- Suppliers
- Contractors

Heliodyne
SunEarth
Alternative Energies
Thermomax
FAFCO
Apricus
Buderus
Solar Heat Exchange
Aurora
Quick Mount PV
Fast Jack
S-61™ Clamps
Unirac
MORE.....



Slide 84

Reveal Slide 84.

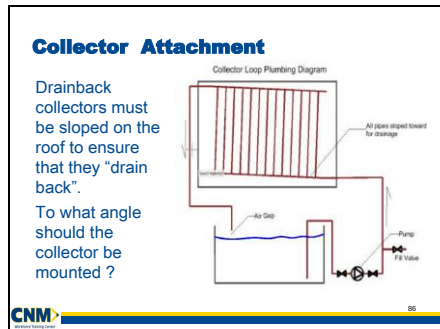
Refer to:

Heliodyne	http://www.heliodyne.com/
SunEarth	http://sunearthinc.com/
Alternative Energies	http://www.aetsolar.com/
EnerWorks	http://enerworks.com/
Thermomax	http://www.solarthermal.com/
FAFCO	http://www.fafco.com/
Apricus	http://www.apricus.com/
Buderus	http://www.buderus.us/residentialhomeowners/products/solarproducts.html

Solar Heat Exchange
<http://www.solarheatexchangemanufacturing.com/>

Solar Roofs
<http://www.solarroofs.com/>

Aurora (Solene)
<http://www.solene.com/aurora.php>



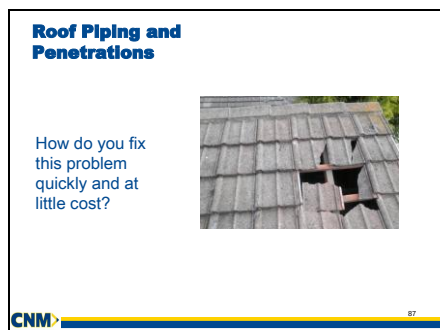
Slide 85

Reveal Slide 85.

Explain that regardless if a collector is rack mounted, standoff mounted, direct mounted, or integral mounted, the related hardware (rack, rails, brackets, lag bolts, flashing, etc.) should be predetermined and loaded on to the installation truck prior to arriving on the install site. Many parts are manufacturer specific (proprietary parts).

Pre-planning is key as missing small parts can create a nightmare situation – holding up a job and chewing up installer time. A kit of extra spare parts is always a great idea just in case a small part is dropped and lost.

Explain that the drain back collector is typically set at the standard $\frac{1}{4}$ " per foot slope. This arrangement should be considered carefully on a shingled roof as the collector may contrast negatively (in an aesthetic manner) with the apparent straight line of the roofing shingles.



Slide 86

Reveal Slide 86.

Present the following scenario:

One of your junior installers wore the wrong boots on the job today and broke these concrete tiles while in the process of attempting a collector pipe penetration. What is the easiest and least expensive way to fix this problem? Oh yes, we forgot to mention that the roof is twelve years old and the roofing manufacturer no longer makes tiles in this color.

Explain: As senior installer you call your contractor to inform him/her that some tiles were broken and that you need the best possible replacement product

	to fix the roof – color and design/texture being the most critical concerns. The smart contractor will have predicted that this problem could occur and has a good source for replacement tiles. In the process of installing your collector racks, you remove tiles that will be hidden under the collectors and you replace the broken and exposed tiles with these old tiles. When the contractor brings the replacements to the job site, you install the “close enough” tiles where they will be hidden from view by the collectors. To be on the up-and-up this should be done with the homeowner’s knowledge – and even better – a potential problem discussed with the homeowner prior to the install. Breakage does occur, is all part of the process.
 Slide 87	Reveal Slide 87. Explain that a copper pipe review from a previous module. Type M is commonly used on residential installs, particularly when inside the building envelope. Local codes/requirements, AHJ rulings may dictate the type of copper used on an install. Installs using copper inside of the building envelope require extreme care in both soldering/fire prevention and leak detection (pressure test). The use of line set has the potential for creating only four collector-loop connections: two at the collectors and two at the pump station. Fewer leak concerns when working inside the building envelope. Many installers insist on using type L and K (to handle high heat) of evacuated tube collectors.



Slide 88

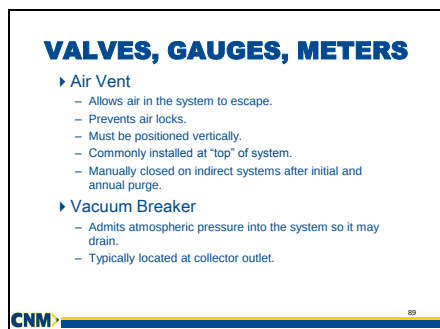
Reveal Slide 88.

Explain that a copper pipe review from a previous module.

Type M is commonly used on residential installs, particularly when inside the building envelope. Local codes/requirements, AHJ rulings may dictate the type of copper used on an install. Installs using copper inside of the building envelope require extreme care in both soldering/fire prevention and leak detection (pressure test).

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Many installers insist on using type L and K (to handle high heat) of evacuated tube collectors.



Slide 89

Reveal Slide 89.

Refer to NABCEP page 31.

Explain that after opening and closing the air vent in the process of pressure testing and flushing the system, remember to close the air vent after bleeding air on the final heat transfer fluid charge sequence.

Ask: "What system would you expect to NOT find an air vent?"

	Explain: Drain back system. Ask: “What system WOULD you expect to find an air vent?” Explain: Drain back system.
Slide 90	Reveal Slide 90. Refer to NABCEP pages 32 & 30. Web illustration: http://www.solarfreeze protection.com/products.html This valve provides one method to prevent collector piping freezing. Ask: Would you expect to find freeze protection valve on a Direct system? Indirect system? Explain: “As “warm water bleeds from the collector through valve” – then the system must have a replacement supply of warm water. Direct systems (open systems) have replacement water available. Indirect systems (closed systems) do not.” Say: “Question the design that calls for a freeze valve on an indirect system which, when opened, drains the collector to prevent freezing. This would not be appropriate on a system charged with a solar fluid such as glycol. And the system is no longer operational – the solar fluid is gone! The system pump will now see a short life span as it burns itself out the following day due to the absence of solar fluid. One other method of freeze protection promoted by a few manufacturers is to run hot/warm fluid from collector storage through the collector at night or

	during freezing conditions to prevent system damage. Problems here? And then there is the notorious “Drain back” system with a “drain back valve” often failed to open and systems froze as a result.” Explain check valve. Swing, Spring, Motorized. Check valves allow fluid flow only in one direction. Used to prevent system thermosiphoning (cool water in nighttime roof-mounted collector pulled by gravity into storage tank pushing heated water into the cool collector). The check valve is installed down-line of the freeze valve described on the previous slide.
Slide 91	Reveal Slide 91. Refer to web illustration: http://goodsolarwaterheater.blog.com/2011/07/18/solar-collectors-in-boise/ Refer to text • NABCEP page 85-86 Explain that collectors may be linked together in series or in parallel, and the number of collectors that can be combined together in a single array will vary with the system design and manufacturer. Multiple collectors in an array should always be linked in PARALLEL unless the manufacturer specifies otherwise. The basic concept to understand is even and equal or relatively uniform solar fluid flow through all collectors in the array. Piping diagrams will largely be found on legacy systems. The common collector linkage today is illustrated in the photo above – one collector is directly linked to its neighbor. Ask: “Why would there be a limit on the number of collectors that could be joined together in an array?”

	Explain Think inside pipe diameter and pipe run length (friction/flow), pump capacity (head), and collector efficiency.
Slide 92	Reveal Slide 92. Refer to web illustrations: http://www.solartubs.com/solar-insulated-piping.html http://www.urecon.com/systems/solar_heating.html NABCEP pages 90-93. Explain Insulation on solar systems must withstand high temperatures and resist UV deterioration. The higher the temperature differential between ambient temperature and pipe/water temperature, the greater the R value requirement (typically thickness) for solar system pipe insulation. Explain that ELASTOMERIC insulation is used on solar piping, and is commonly used in HVAC installations. HIGH TEMPERATURE FIBERGLASS, URETHANE, and ISOCYANURATES may be used on high temperature evacuated tube systems. NEVER use polyethylene foam insulation as available at hardware stores. It will literally melt, and create a mess. DEFINITION: R-VALUE: a measure of THERMAL RESISTANCE used in the building and construction industry. It may apply to any material. The higher the number, the better the insulation's effectiveness. (R value is 1/h.) R-value is the <u>reciprocal</u> of U-value. The R-value depends on the <u>type of insulation</u> and includes its material, thickness, and density. The

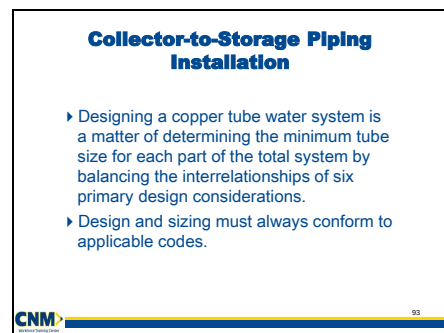
	effectiveness of insulation's resistance to heat flow also depends on how and where the insulation is installed. For example, insulation that is compressed will not provide its full rated R-value. THERMAL RESISTANCE is a heat property and a measure of a temperature difference by which an object or material resists a HEAT FLOW(heat per time unit or thermal resistance). Refer to http://www.globalindustrial.com/g/plumbing/pipe-tube-bending-cutting/pipe-and-tubing-insulation/k-flex-clad-wt-insulation Explain that insulation on solar systems must withstand high temperatures and resist both UV deterioration, weather and “critter” damage. Paint, aluminum flashing, down-spout material all provides some degree of weather resistance, UV, mechanical and animal abuse protection. Insulation is applied AFTER pressure testing. Ask: “Why?” Explain: DO NOT insulate pumps, vacuum breaker openings, tempering valves, anti-scald valves, pressure and pressure/temperature release valves, nor air vent tops. On legacy systems do no insulate Dole Valves or the pipe extension going to the Dole Valve.
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COMPONENT INSTALLATION

Learning Activity 4

Time: 180 minutes

Discussion Points



Collector-to-Storage Piping Installation

- ▶ Designing a copper tube water system is a matter of determining the minimum tube size for each part of the total system by balancing the interrelationships of six primary design considerations.
- ▶ Design and sizing must always conform to applicable codes.

CNM 93

Slide 93

Instructor/Trainee Activities

Reveal Slide 93.

Explain that designing a copper tube water system is a matter of determining the minimum tube size for each part of the total system by balancing the interrelationships of six primary design considerations:

1. Available main pressure;
2. Pressure required at individual components;
3. Static pressure losses due to height;
4. Water demand (gallons per minute);
5. Pressure losses due to the friction of water flow in the system;
6. Velocity limitations based on noise and erosion.

Design and sizing must always conform to applicable codes. In the final analysis, design must also reflect judgment and results of engineering.

While the installer works with a pre-engineered plan, she/he must understand these basic design concepts to both install an efficient system and to note and alert the contractor of required “mid-course design changes”.

Note that tube supports—drawn temper tube, because of its rigidity, is preferred for exposed piping. Unless otherwise stated in plumbing codes, drawn temper tube requires support for horizontal lines at about 8-foot intervals for sizes of 1-inch and smaller, and at about 10-foot intervals for larger sizes. Vertical lines are usually supported at every story or at about 10-foot intervals.

Collector-to-Storage Piping Installation

- ▶ Drawn tempered tube requires support for horizontal lines at about 8-foot intervals for sizes of 1-inch and smaller, and at about 10-foot intervals for larger sizes.
- ▶ Vertical lines are usually supported at every story or at about 10-foot intervals



Slide 94

Reveal Slide 94.

Refer to NABCEP page 94

Note that tube supports—Drawn temper tube, because of its rigidity, is preferred for exposed piping. Unless otherwise stated in plumbing codes, drawn temper tube requires support for horizontal lines at about 8-foot intervals for sizes of 1-inch and smaller, and at about 10-foot intervals for larger sizes. Vertical lines are usually supported at every story or at about 10-foot intervals.

Storage Tank Installation

- ▶ Typical residential solar storage tanks come in common sizes up to 119 gallons.
- ▶ Residential systems are commonly two-tank systems, but designs do vary widely.



Slide 95

Reveal Slide 95.

Note that installers will find a huge variety in solar heating tank choices.

- Some home owners want a system that incorporates their existing water heater and a second storage tank.
- Some want a new tank, or two new tanks for increased capacity.
- Some tanks are simple storage tanks, others come with external (wrap-around) or internal heat exchangers (usually copper or stainless steel coils). Even other solar tanks come with a backup electric element to heat water on cloudy days.

Often the residential design is limited to the storage tank space available (basement, garage, cellar), and it may be even further limited by physical access to the desired location (something the installer usually finds out the hard way).

Note that many local codes/AHJ rulings hold that any water tank or 120 gallons or greater is a “commercial” installation – read that – lots more permit paperwork!

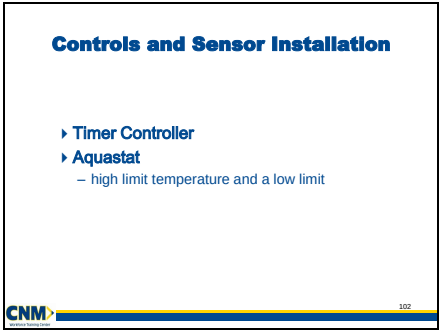
	Ask: Why is the storage tank pictured above rated at 119 gallons? Remember to follow earthquake strapping and other local requirements.
Slide 96	Reveal Slide 96. Refer to web illustration: http://www.solarpowerworldonline.com/2011/11/discussing-solar-thermal-storage-at-spi-2011/ Define STRATIFICATION - the goal of an efficient storage system. Explain that a heavily insulated tank can retain heat for days. Water is convenient heat storage medium, because it has a high specific heat capacity. Compared with other substances it can store more heat per unit of weight (and volume). Water is non-toxic and low in cost. With stratification water layers have different temperatures, and water mixing within the hot water storage tanks vertical water column must be minimized. The purpose is to maintain the vertical stratification of the water column. This is achieved by: Hot from-collector return water is sent into the top (unless it is going into a heat exchange coil) -- and to-collector water is taken from the bottom. Domestic usage gets hot water out at the top and cool supply water is sent in at the bottom.

	When a stratified hot water storage tank has closed water circuits, the water temperatures can be up to 90...95°C (194°...203°F) at the top - and 20...40°C (68°...104°F) at the bottom. Some solar storage tanks and most residential water heaters are a glass-lined steel tank construction. Ask: “What is the hot water limit you should observe?” Explain: “Glass linings may begin crazing at about 195°-200°F.” Ask: “What is the nature and function of “dip tubes” in a solar or water heater tank?” Explain: “Determine or “fix” levels at which cold water (supply) is introduced into the tank – in bottom third or so of tank – and hot water is drawn – in top third or so of tank.”
Pump Installation ▶ Solar heating “pumps” or “circulators”. ▶ Indirect systems commonly have two pumps, one for the closed collector loop, the other for the domestic water supply. ▶ Drainback systems often use variable speed pumps. ▶ Pumps are made from various materials and the system design will dictate which pump may be used. ▶ Cavitation over time will ruin a pump. CNM 97 Slide 97	Reveal Slide 97. Explain that solar heating “pumps” or “circulators” are literally the heart of a system. Pumps must be selected to match system designs. Indirect systems commonly have two pumps, one for the closed collector loop, the other for the domestic water supply. Drain back systems often use variable speed pumps, starting up at a higher speed to get the fluid into the collector, then stepping down once the fluid begins its return to the storage tank. Pumps are made from various materials and the system design will dictate which pump may be used. Pumps do not like air. Cavitation over time will ruin a pump. Pumps running dry will have a very short life indeed.

	Specific systems will require specific pumps (as well as other component parts). Ask: “What relationship does a systems’ OG-300 rating have to do with pump selection?” Say: “Pump location is often very important – example – drain back system.” “If you are installing a pump (or controller, or??) that requires you to connect a whip (cord/plug), be aware that some codes/AHJ require you to be a licensed electrician to do so.”
Slide 98	Reveal Slide 98. Refer to NABCEP pages 97-101 <i>Instructor Note</i> <i>Log on to favorite web site to run students through cut sheet examples and pump performance charts.</i> EXAMPLE: PUMP, GRUNDFOS UPS15-58FC/LC Grundfos circulating pump 1/25 HP for solar domestic hot water heating. Stainless steel construction with cast iron volute. Standard flange mount. Removable check valve and three speed operation complete with line cord for plug in operation. Maximum head 19 feet. List Price: \$95.54 / Each <i>Example here:</i> <i>http://www.sunsourceproducts.com/catalog/productdetail.asp?cat=CP&part=0011</i> <i>Grundfos Installation Guide (0.36 MB)</i> <i>Grundfos Product Guide (9.35 MB)</i> Ask: “Can you research a pump on-line in order to select a pump that will adequately perform on a drain back system in a three story house? (Two story house with solar storage in a basement). What are your design parameters? (a few listed here)

	• Total head from tanks to collectors. • Number/size of collectors? Size of drain back tank? Length of pipe runs? Size/diameter of pipe? • Placement of drain back tank: On top of tank? In second story bedroom closet? In attic? Other? • Placement of drain back pump(s): Two (tandem) pumps in basement? Low head pump in conditioned attic? Other?"
Slide 99	Reveal Slide 99. Refer to NABCEP PAGES: 109-111. Example: Steca on web: http://www.solarhotusa.com/products/Steca.html “The Steca model TR 0301 U differential temperature control provides automatic, safe and reliable operation of domestic solar water heating systems. The TR 0301 U output is wired to a pump that circulates the heat transfer fluid between the solar thermal collectors and the storage tank during the course of the day. This microprocessor-based TR 0301 U utilizes two RTD (resistance temperature detector) type sensors to monitor collector and tank temperatures with digital accuracy.” “The LCD gives the homeowner a variety of real time information including system temperatures at up to three separate locations.” Define differential controller. “A differential solar controller is an electronic device that, working in conjunction with temperature sensors, controls the circulating pump in a solar heating system to harvest as much heat as possible from the solar collectors and also to protect the system from overheating. The basic job of the controller is to turn the circulating pump on when there is heat available in the panels, moving the working fluid through the panels to the heat exchanger. Overheat protection is

	achieved by turning the pump off when the store reaches its maximum temperature.” Explain: Most commercial controllers display the temperature of the hot water in the store and provide general status information about the system, including overall energy production.
Controls and Sensor Installation ▶ Differential controllers determine when to activate the pump to send fluid through the collector and back to the tank. ▶ Differential controllers use two (or more) sensors – one at the hottest point of the solar loop (collector output) and the other at the coolest point (tank bottom). ▶ To operate, controllers are either preset or manually set to a temperature “differential”. CNM 100 Slide 100	Reveal Slide 100. Refer to NABCEP PAGES: 109-111. Explain: Differential Controllers: Common controller. Instructor: Helpful to have controllers in class for show-and-tell.
Controls and Sensor Installation Electricity Basics: Thermistors A thermistor is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. Thermistors are widely used as temperature sensors in SH systems. CNM 101 Slide 101	Reveal Slide 101. Refer to web image of various sensors: news.thomasnet.com Refer to NABCEP pages 110-111. Explain that Thermistors, in relationship to SH controllers, are commonly referred to as “sensors”. SH sensors or thermistors come in a variety of shapes and sizes. Many SH thermistors are about ¼ inch in diameter. They come in bolt-on, screw-in, clamp-on, immersion, and well types, to name a few. Outer casings are sturdy but may be easily crushed, so handle with care. SH thermistors are typically 10,000 ohm (10K) thermistors, some older controllers use 5,000 ohm (5K) sensors. Some sensors are “direct” reading,

	meaning that resistance increases as temperature increases. Other sensors are “indirect” reading – resistance goes down as temperature goes up. You will always consult system records to determine what type of readings you should expect from the thermistor you are measuring. Discuss different ohm ranges for sensors and different between “positive” reading and “negative” reading sensors.
 Slide 102	Reveal Slide 102. Refer to web illustration: http://www.blueridgecompany.com/radiant/hydrionic/617/taco-timers-aquastat Explain: “The Taco Clock Timers and Temperature Aquastat are designed to control the operation of Taco circulators on domestic hot water recirculation systems for maximum comfort and energy efficiency. They are adaptable to any "00" Series circulator by attaching the enclosure or wiring to the electrical box.” Define aquastat: “A device used in hydronic heating systems for controlling water temperature. Aquastats have a high limit temperature and a low limit. If the thermostat is calling for heat, the solar storage tank pump will start and/or the boiler will fire until the high limit is reached.” Refer to web illustration for timer: http://www.pvsolarchina.com/10a-12v-24v-dc-eprc10-mt-dual-timer-solar-light-controller.html

Controls and Sensor Installation

► Photovoltaic Controller

- Paired with P-V panel and DC pump
- Circulation Pump runs when the sun shines

CNM

103

Slide 103

Reveal Slide 103.

Explain: “Circulation Pump runs when the sun shines. Runs faster when more sun, more hot water. No controller, no probes, no power needed. Creates off-grid split solar water heater system. Powered directly by 10 W solar PV panel.”

“A Photovoltaic Controller includes solar panels mounted next to the solar collector for power to the controller and DC pump.

As the panel only generates electricity when the sun is up, the pump only circulates fluid through the SH system when sufficient energy is available.”

Refer to web illustration:

http://www.seabirdsolar.com/scripts/pump_solar_water.php

Define photovoltaic controller. “A photovoltaic (PV) powered solar controller uses solar electricity produced on-site to run the pump that delivers the solar-heated transfer fluid to the hot water store. The most practical benefit of a PV powered controller is the resultant simplicity of the overall system. Rather than using complex algorithms based on store and panel temperatures, the pump is driven directly by the PV panel: when the sun shines, the pump runs. The claims are that in practice this is nearly (90-99%) as efficient a practical control algorithm as most others achieve and has obvious advantages for reduced system complexity.”

Explain that a disadvantage to the PV powered approach is that the pump stops immediately after the sun is occluded. The simple direct-PV pump approach limits systems to using flat plate collectors.

Ask: “Why is this system limited to flat plate collectors?”

Explain: Evacuated tube collectors generate greater heat, and if the solar PV system is subjected to clouds, on an otherwise hot and sunny day, there will be a huge build-up of hot water with no pumping – no place to go.

SH Systems and Installation: Topics

- ▶ System Installation, Checkout and Start-up Procedures
 - Pressure Testing
 - Flushing the System
 - Testing the Pump and Controls
 - Cleanup
 - Instructing the Homeowner



Slide 104

Reveal Slide 104.

Explain that a newly installed system must be “commissioned” using some universal or manufacturer recommended check-out and start-up steps.

Generally the steps for system activation and start-up include:

Pressure Testing
Flushing the System
Testing the Pump and Controls
Cleanup
Instructing the Homeowner

SYSTEM INSTALLATION CHECKOUT AND STARTUP PROCEDURES

Learning Activity 5

Time: 120 minutes

Discussion Points

Pressure Testing

- ▶ Testing with compressed air is a good initial test – especially with pipe runs in the attic, walls, etc.
- ▶ Typically accomplished by monitoring a pressure gauge over a specified amount of time.
- ▶ A drop in pressure over time and you start looking for a leak.
- ▶ A final pressure test is accomplished with water.

CNM

105

Slide 105

Instructor/Trainee Activities

Reveal Slide 105.

Explain that pressure testing is a critical step in a quality installation.

Pressure test requirements are found in manufacturer installation instructions (paper or on-line) and often in local codes/AHJ requirements. Pressure tests are run at pressures far above operating pressures – sometimes called “safety factors”.

Ask: At what pressure must you test a system in your area? (Hint: Refer to Solar Code).

Direct Systems: @ maximum operating pressure + safety factor (code).

Indirect Systems: @ design pressure.

Flushing the System

- ▶ Flush the collector loop first.
- ▶ Flush the storage tank loop next.
- ▶ Flush with water – then think about adding your expensive solar fluid to the system.
- ▶ Ensure that your solar fluid (e.g.: glycol) is compatible with your system.
- ▶ Remember – if you are working in a confined space, such as a basement, things are bound to get wet. Locate drains, hoses, buckets, rags, mops, etc., before pressure testing and flushing your system.
- ▶ Save for drainback collector loops, you must ensure that you are purging all air from your systems.
- ▶ Florida pages: 3-28 & 3-29
- ▶ VIEW: Heliodyne Installation DVD



Slide 106

Reveal Slide 106.

Explain that flushing is also a critical step in a quality installation.

Flushing drives out any dirt, dust, solder bits – anything that will compromise a clean fluid system.

Flushing techniques may vary by system type, but regardless of system you should follow the golden rule of flushing – NEVER flush a system THROUGH the pump(s). Always bypass the pumps when flushing or you run the risk of fouling an impeller/turbine.

OTHER DEVICES (BOS)

- ▶ Heat Transfer Fluid
 - Propylene Glycol most common
 - NEVER Ethylene Glycol
 - A glycol-water mix has less heat-transfer ability than pure water: the higher the percent of glycol the less efficient.



Slide 107

Reveal Slide 107.

Explain that Propylene Glycol is the most common NEVER Ethylene Glycol mixed with water according to contract, geographical area, micro-climate, standard procedures.

Sometimes requires import of quality water for mixing. Glycol, with additives, provides some level of protection against freezing and overheating. A glycol-water mix has less heat-transfer ability than pure water: the higher the percent of glycol the less efficient.

Note: Charging a system with a heat transfer fluid takes place AFTER the system is pressure tested AND flushed.

Define “BOS” = Balance of System

Testing the Pump and Controls

- ▶ Check pump function.
 - If variable speed is it set properly?
 - Flow meter confirmation?
- ▶ Run differential controller through manufacturer's test steps.
- ▶ Check sensors with multimeter.

CNM

108

Slide 108

Reveal Slide 108.

Say: “Now that your system is charged, check pump and control functions.

Set differential controller pump switch to “on”. Recognize that solar pumps should run in almost a completely silent mode. If there is noise, you may have to address air in the system.

Controls and Sensor Installation

- ▶ **Multimeter**
 - Test for Voltage
 - Test for Continuity
 - Test for Resistance

CNM

109

Slide 109

Reveal Slide 109.

Mention that installers must be able to perform three tests using a multimeter:

Test for Voltage

1. Select AC or DC in appropriate range on meter.
2. Touch negative probe to a known ground.
3. Touch the positive lead to the wire you are testing. Probes must touch metal, not paint, rust.
4. View reading on display.

Test for Continuity

If a circuit has a path through which electricity can flow, it is said to have continuity. If current cannot flow, because of extremely high resistance or a break in the circuit, the circuit is said to be “open” and have no continuity

1. Turn off power to the circuit
2. Select “ohms” or “resistance” on your meter.
3. Touch probe tips across component or portion of circuit for which you want to determine continuity.

Probes must touch metal, not paint, rust.

	4. Read meter. If the reading is low, you have continuity. If the reading is “infinity” you have an open circuit. Explain that testing for continuity lets you know if a circuit is open or closed. Testing for continuity can help you to identify good or blown fuses, open or shorted wires or conductors, operational switches, and circuit paths. If using a dial or meter (analog) multimeter you must touch the probes together, after selecting an ohms scale, and turn the thumbwheel until the needle sits at zero. Test for Resistance 1. Turn off power to the circuit 2. Select “ohms” or “resistance” on your meter. 3. Touch negative probe to a known ground. 3. Touch probe tips across component or portion of circuit for which you want to determine resistance. - Probes must touch metal, not paint, rust. - Do not touch the probe tips with your fingers. 4. View reading on display. Refer to Temperature and Resistance Chart on page 3-31 in Florida. Explain that resistance is measured in ohms and tells us how much a circuit resists the flow of electric current. SH controller sensors (typically “Thermistors”) are measured in Ohms.
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Controls and Sensor Installation

- ▶ Insulation
 - Closed cell elastomeric foam.
 - “Armaflex”, “Rubatex”
 - NO DIY! home center polystyrene or polyethylene.
- ▶ Exterior piping protection.
 - Coatings, Shieldings
- ▶ Insulation AFTER pressure testing.
- ▶ System labeling!

CNM

110

Slide 110

Reveal Slide 110.

Refer to NABCEP pages 117 – 118

Note that system insulation and UV protection efforts come AFTER system pressure testing.

Say: “And last, **SYSTEM LABELING** - Label to meet code/AHJ requirements **AND** -Label beyond code/AHJ to allow another installer and the homeowner the opportunity to quickly understand system components – most fundamentally – fluid flows through the collector, storage and domestic loops.”

Cleanup

- ▶ Cleanup time!
 - One very important aspect of the job often overlooked.

CNM

111

Slide 111

Reveal Slide 111.

Say: “You can do a world-class installation but if the homeowners are looking at mud, scraps, wire insulation, duct tape, splattered solder – any kind of mess left behind – that’s what gets their time and attention – not the perfect system.

One of your system installer goals is to keep employed. This is largely accomplished in the residential solar business by personal referrals – from very happy and satisfied clients.

Clean up your mess – every day, in fact, not just at the end of the job.”

Instructing the Homeowner

- ▶ Careful instruction minimizes unpaid callbacks!
- ▶ Careful instruction includes leaving a colorful and tabbed system information binder – ablaze with your company logo and contact information.



Slide 112

Reveal Slide 112.

Explain that there are many **motivations** behind “instructing the homeowner” **carefully**.

“Careful Instruction”.

Get creative with your system binders or holders or?

Diagrams

Cut sheets

Manufacturer inserts/instructions.

Essentially everything that you are required to do for permitting.

An important tab in your binder – that you review with your client – is the long-term system maintenance contract that she/he should consider and sign before you leave.

Thank you!

It's been a pleasure working with you today as we complete Solar Heating Module #4.

Instructor ID #:
Class ID #:

113

Slide 113

Reveal Slide 113.

Module 5: Solar Heating Operation, Maintenance & Troubleshooting

PROBLEM ASSESSMENT AND SYSTEM CHECKOUT

Learning Activity 1

Time: 170 minutes

Discussion Points

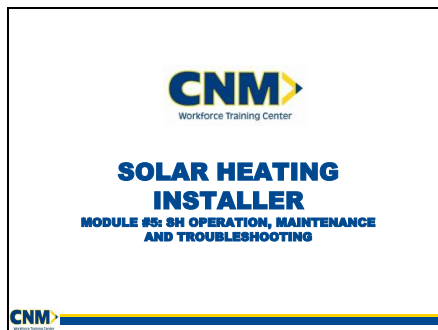
Instructor/Trainee Activities

Logistics



PowerPoint Presentation

This module is designed for the use of an accompanying PowerPoint presentation. If you choose not to use PowerPoint, then please have facilitator information charts ready for some activities.



Slide 1

Slide 1 should be available to view prior to participants entering the room.

**FIRST: Your SH Mantra
(Yes, Again!)**

All SH systems must control for:

1. Over Heating
2. Freezing
3. Scaling

Address all three whenever studying, designing, installing, servicing and troubleshooting a SH system.

Have Fun!

CNM

Slide 2

Reveal Slide 2.

SH Operation, Maintenance, and Troubleshooting

- ▶ NABCEP Installer Guide:
 - Chapter 10
- ▶ Florida: 4-1 thru 4-28
- ▶ Home Power Articles:
 - Overcoming Overheating
 - Troubleshooting Part 1

CNM

Slide 3

Reveal Slide 3.

Explain that as installers gain experience they will often be assigned solar heating troubleshooting jobs.

Solar heating installers with highly developed troubleshooting skills are typically in high demand!

MODULE #5 : TOPICS

SH Operation, Maintenance, and Troubleshooting

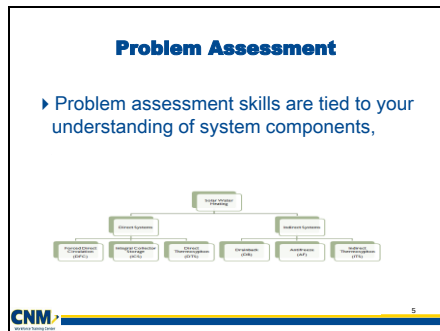
- ▶ Problem Assessment and System Checkout
 - Problem Assessment
 - The Initial Service Call
 - Common Problems
 - Other Potential Problems
 - System Checkout
- ▶ Troubleshooting Checklist

CNM

Slide 4

Reveal Slide 4.

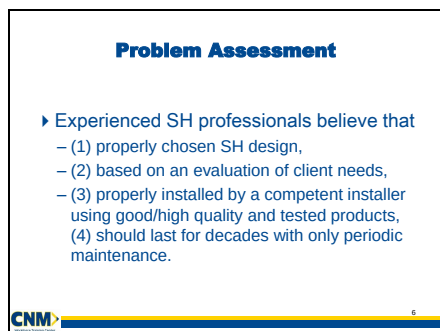
Mention that troubleshooting solar heating systems requires that you understand system types (design/function), system components, and how the system components work. You must also know what questions to ask the system owner/user to dial in on potential symptoms and causes. This slide outlines a helpful troubleshooting strategy.



Slide 5

Reveal Slide 5.

Explain that this flowchart is provided in your NABCEP text, page 26. It provides a nice classification of solar heating systems which you must understand to be a valued installer and troubleshooter. Your first step in troubleshooting is to identify the troubled system and understand the function of the system's components.



Slide 6

Reveal Slide 6.

Explain that experiences that you gain from the very beginning as a SH installer/integrator will certainly add to your mental list of knowing what to ask and what to look for.

Primary in your thinking should be your SH Mantra:
All SH systems must control for:

- Overheating
- Freezing
- Scaling

As you build your understanding of systems, gain installation experience and conceptualize key concepts -- all the “pieces” that influence system selection, design installation and function -- you will develop a “sense” or mental “roadmap” empowering your ability to diagnose SH problems.

Note that experienced SH professionals believe that **90% of problems** encountered with SH systems are a result of incorrect (often inferior) components, poor workmanship, or an inappropriate system for the climate.

The Initial Service Call

- ▶ **CONTACT INFO**
 - ▶ Date, time, name of caller, caller's cell number
 - ▶ Client's name, client's spouse's name, address, address zip code, home phone, cell phone, work phone
 - ▶ ☐ SH system your outfit installed? ☐ Another company installed? If other, name? *(checklist)*
 - ▶ SH system site address *(may be different than home)*, address zip code
- ▶ **SYSTEM INFO**
 - ▶ System type: ☐ Drainback, ☐ Closed Loop Glycol ... *(checklist)*
 - ▶ System siting: ☐ Roof mount *(how many stories/high – how long a ladder will you need to take?)*, ☐ Ground mount ... *(checklist)*
- ▶ **What Else?**



Slide 7

Reveal Slide 7.

Review

PART ONE: THE PLANNING & PAPERWORK

If your contractor contacts you to go solo on a service call – that's huge. It means that he believes your SH experience and understanding are at a "Problem Solving" level.

If you are the SH contractor then the call is coming from a client, a new client/referral call, from another SH contractor buddy too busy to take a service call, or from a SH marketing/sales firm that contracts-out installations and service calls.

You pull out your "Service Call" form and pencil/pen from inside your aluminum clipboard box, clip on a form and start filling in your sheet (or maybe you're digital?).

Remind students to "CONSTRUCT A FORM AND BE CERTAIN YOU HAVE ALL OF THE INFORMATION, TOOLS AND EQUIPMENT YOU WILL NEED BEFORE CLIMBING INTO THE TRUCK."

The Initial Service Call

- ▶ **SYSTEM ACCESS**
 - Can you get to all system components?
- ▶ **CALL TYPE**
 - ☐ Service Maintenance
 - ☐ Annual maintenance, ☐ Seven year glycol replacement
 - ☐ Problem Call
 - ☐ No hot water, ☐ Insufficient hot water
- ▶ **PROMISED RESPONSE**
- ▶ **TIME AND MILEAGE**
- ▶ **More...**



Slide 8

Reveal Slide 8.

Review

SYSTEM ACCESS

Can you get to all system components?

Site contact at home? Neighbor with key?

Kids at home? Dog secured?

Neighborhood watch informed?

Gated community guard notified?

Side gate to rear roof access unlocked?

Tank access in garage/basement/cellar/outbuilding?

	Review CALL TYPE Service Maintenance Annual maintenance Seven year glycol replacement Problem Call No hot water Insufficient hot water Visible leak on roof Visible leak – interior wall/ceiling, Visible leak outside plumbing Visible leak tank/pump station Review PROMISED RESPONSE Did the boss tell the frantic client that you would arrive in thirty minutes to take care of the problem (the job is 45 miles away and you’re still brushing your teeth)? Who clarifies response time with client? You? Boss? Review TIME AND MILEAGE Check on company policy for service calls. They probably want to know details such as: Time you started your response – loading truck Time you left your current site – pulled out of the driveway Truck mileage (odometer) reading Names of in-route stops to obtain components/supplies/equipment Mileage (odometer) at site arrival Arrival time Parts-run mileage (odometer) reading Time and odometer reading when you leave job site ... etc.
--	--

The Initial Service Call

► CLIENT COMMUNICATION

- It is critical that someone communicates with the client at the end of the work day to be sure that she/he understands the process of work and details regarding the work.
- Be clear with your boss WHO it is that communicates with the client.

► SWEEP AND CLEAN OUT THE DOOR

CNM

Slide 9

Reveal Slide 9.

Review

CLIENT COMMUNICATION

You finished the job. Or maybe you must come back another day with new parts that must be ordered. Or whatever....

It is critical that someone communicates with the client at the end of the work day to be sure that she/he understands the process of work and details regarding the work.

Be clear with your boss WHO it is that communicates with the client. It's not a great idea to have BOTH you AND the boss telling the client what's what.

SWEEP AND CLEAN OUT THE DOOR

You ALWAYS leave a job site looking better than when you walked on. Yes, you are tired and this takes time, but it is worth every minute.

Many installers/contractors have been bad-mouthed by clients for leaving a messy job site behind. Clients will even notice that you left bits of stripped wire insulation on the concrete floor of the cellar. You can have just completed a world-class installation, but they will only see the debris – and then they'll be sure to tell neighbors, friends, and co-workers all about your messy company.

The Initial Service Call

► SERVICE CALL REPORT

- Itemized list of parts, part costs (especially if you had to pay out-of-pocket), initial findings, troubleshooting activities, solution taken to remedy problem, ... what else?

CNM

Slide 10

Reveal Slide 10.

Review

SERVICE CALL REPORT

Here is your itemized list of parts, part costs (especially if you had to pay out-of-pocket), initial findings, troubleshooting activities, solution taken to remedy problem, time-on-job, mileage, and whatever else your company may require.

You compile a running list of these items while on the

	job (you will forget), and compile your summary to turn in along with any receipts (paper clips/envelopes?) you accumulated on the call while sitting in your truck before you pull away from the job site.
Running the Call ▶ ARRIVING ON SITE ▶ Make contact with the owner/caller ▶ Eyeball the problem. – A simple toolkit will help in this process: • Strong-beam flashlight • Troubleshooting mirror (automotive type on telescoping rod) • Pad, pencil • Digital camera • What else? CNM Slide 11	Reveal Slide 11. Review ARRIVING ON SITE Clearly your first assignment on reaching the site of the service call is to make contact with the owner/caller and to eyeball the problem. A simple toolkit will help in this process: - Strong-beam flashlight - Troubleshooting mirror (automotive type on telescoping rod) - Pad, pencil - Digital camera - Pressure gauge, pH tester, thermometer (laser?) - Probe (screwdriver) - Gloves, rag, hard hat, shirt with company logo And don't forget to wipe your boots. REFERENCE NABCEP (Chapter 10) details service and maintenance protocols. We will walk through these "routines" in class and discuss details, implications, and insights. (Move to next slide).

Running the Call

► ON-SITE ANALYSIS AND TESTING

- Your initial conversation with the client will direct your thinking towards related problem-solution scenarios.
 - “The system is leaking down the outside wall next to our new driveway” (yes, where someone just hit it with a vehicle).

CNM

12

Slide 12

Review Slide 12.

Review

ON-SITE ANALYSIS AND TESTING

While we will walk through NABCEP’s “Routines”, be reminded that they are very detailed and not designed to be pursued page-by-page. Your initial conversation with the client will direct your thinking towards related problem-solution scenarios.

Examples:

“The system is leaking down the outside wall next to our new driveway” (yes, where someone just hit it with a vehicle).

“Our two-year old system used to provide us with a greater solar fraction – now we always run out of solar hot water on a cloudy morning” (yes, their two college graduates, who have been away for four years, are now living at home).”

So we can have fun with some service calls, but remember that our SH professional friends tell us that 90% of SH related problems are related to incorrect (often inferior) components, poor workmanship, or an inappropriate system for the climate.

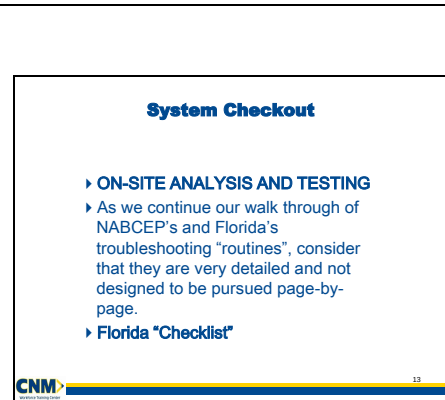
Review NABCEP’s “Hall of Shame” (pages 142-143)

TROUBLESHOOTING CHECKLIST

Learning Activity 2

Time: 60 minutes

Discussion Points



System Checkout

- ▶ **ON-SITE ANALYSIS AND TESTING**
- ▶ As we continue our walk through of NABCEP's and Florida's troubleshooting "routines", consider that they are very detailed and not designed to be pursued page-by-page.
- ▶ Florida "Checklist"

CNM 13

Slide 13

Instructor/Trainee Activities

Reveal Slide 13.

Review NABCEP – Case studies A and B, pages 144-148.

Explain:

While some manufacturers have developed system specific troubleshooting guides/charts, this generic checklist will take you from stumbling around to performing a pin-point examination of system and component functions. This "sleuthing" checklist could take years to develop on your own, and you can soon appreciate the specific targeting that this device provides.

Again, we will walk-through the checklist in class and discuss.

Note that three simple system line drawings are provided here, if needed, to illustrate troubleshooting concepts.

Typical direct pumped system:

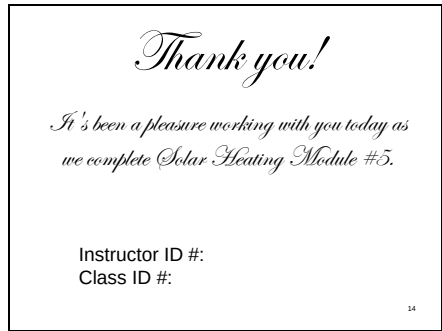
http://www.fsec.ucf.edu/en/consumer/solar_hot_water/homes/system_types.htm#DirectPumpedSystems

Direct system with photovoltaic-powered pump

http://www.fsec.ucf.edu/en/consumer/solar_hot_water/homes/system_types.htm#DirectPumpedSystems

Integral collector storage system

http://www.fsec.ucf.edu/en/consumer/solar_hot_water/homes/images/en9fig5.gif



Reveal Slide 14.

Slide 14

Module 6: Solar Swimming Pools

POOL SYSTEM COMPONENTS, INSTALLATION, AND OPERATION

Learning Activity 1

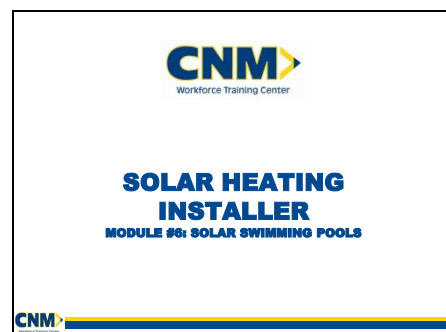
Time: 120 minutes

Discussion Points

Logistics



PowerPoint Presentation

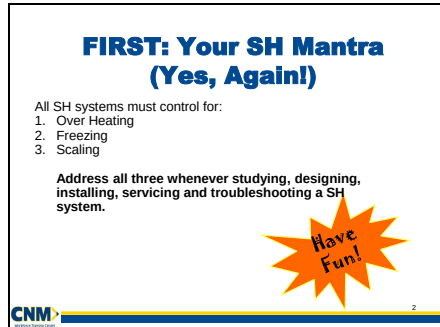


Slide 1

Instructor/Trainee Activities

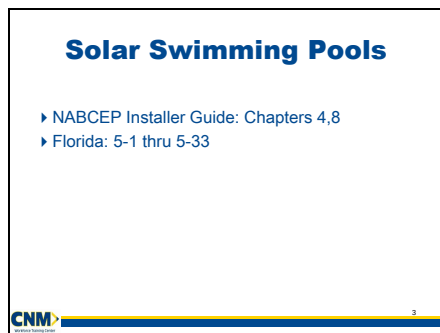
This module is designed for the use of an accompanying PowerPoint presentation. If you choose not to use PowerPoint, then please have facilitator information charts ready for some activities.

Slide 1 should be available to view prior to participants entering the room.



Slide 2

Reveal Slide 2.



Slide 3

Reveal Slide 3.

Explain that this module focuses on residential, outdoor solar heated swimming pools. And, as you work through this module, think about home spas as well!

Refer to module topics:

- Heat Loss Mechanisms
- Passive Pool Heating
- Pool Covers
- Active Pool Heating
- Collector Installation
- Activating the System

Refer to web Illustrations:

Spa: <http://www.solartubs.com/solar-heating-projects.html>

This outdoor spa design uses vacuum tubes – but it is also located in the Northwest Territories, Canada.
Commercial Swim Pool: <http://blog.umasolar.com/>

MODULE #6 : TOPICS

Solar Swimming Pools

- ▶ Pool System Components, Installation and Operation
- ▶ This module focuses only on the majority of residential pools – outdoor pools with unglazed collectors.

CNM

Slide 4

Reveal Slide 4.

Refer to web illustration -Pool Components:

http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13230w.harveysph.com/solar-thermal.php

Refer to solar pool system animation “Solar Pool Heating Design Basics” on web @ <http://www.h2otsun.com/>

Heat Loss Mechanisms

- ▶ 70% of swimming pool heat loss is due to **EVAPORATION** from the pool surface.
- ▶ **CONVECTIVE** loss up to 20%.
- ▶ **RADIATIVE** heat loss about 10%.
- ▶ **CONDUCTIVE** heat loss is very minimal.

CNM

Slide 5

Reveal Slide 5.

Explain that 70% of swimming pool heat loss is due to EVAPORATION from the pool surface.

Evaporative losses are proportional to wind speed at pool level (basic physics: the faster the speed the faster the evaporation the faster the cooling).

Up to 20% of swimming pool heat loss is due to CONVECTIVE losses that occur when air, cooler than the water temperature, blows across the surface of the pool.

About 10% of swimming pool heat loss is due to RADIATIVE when sky temperatures are cooler than pool water temperatures.

CONDUCTIVE heat loss (through the concrete liner into the ground) is very minimal.

Passive Pool Heating

- ▶ The least expensive way to heat your pool.
 - Locate the pool in a sunny area.
 - Locate the pool in an area away from the wind – or build windbreaks.
 - Use a pool cover when the pool is not in use.

CNM

6

Slide 6

Reveal Slide 6.

Pool Covers

- ▶ Pool covers are effective in reducing heat loss by reducing evaporation.
- ▶ Two traditional covers:
 - Opaque
 - Woven safety covers used at commercial pools.
 - Transparent
 - Reduce evaporation with benefit of acting like solar collector.

CNM

7

Slide 7

Reveal Slide 7.

Explain that pool covers are effective in reducing heat loss by reducing evaporation.

There are two traditional covers:

Opaque

Woven safety covers used at commercial pools.

Transparent

Reduce evaporation with benefit of acting like solar collector.

Covers additionally keep debris out of the pool and reduce the amount of chemicals used in the pool.

Covers with a good fit help to “seal” against evaporative losses.

Active Pool Heating

- Basics: The primary purpose behind installing a residential solar swimming pool system is to provide the occupants with two extra and pleasant swimming months in the year
- SH solar pools are generally simple and inexpensive in comparison to domestic SH systems, and they typically operate at high efficiencies.
- “Heat Loss”, “Pool Cover”, and “Passive Pool” resolutions all go hand-in-hand with SH swimming pool systems.

CNM

Slide 8

Reveal Slide 8.

Explain that the primary purpose behind installing a residential solar swimming pool system is to provide the occupants with two extra and pleasant swimming months in the year – generally he/she can use the pool one month prior to using a non-solar heated pool, and his/her swim time extends one month beyond his/her use of a non-solar heated pool. Two months extended pool use – that’s a SH swimming pool ROT. (If they get more than two months extra pool time, take the credit!).

SH solar pools are generally simple and inexpensive in comparison to domestic (household) SH systems and they typically operate at high efficiencies. “Heat Loss”, “Pool Cover”, and “Passive Pool” resolutions all go hand-in-hand with SH swimming pool systems. Arguably one should not exist without the other – but the physical location of the pool, in addition to other factors, often determines the best possible system design.

Active Pool Heating

- Economics: Solar swimming pools save money.
- Solar heated swimming pools may be indoor or outdoor.
- Low-temperature, outdoor solar pool systems have no heat exchanger, and the pool is the “storage tank”.

CNM

Slide 9

Reveal Slide 9.

Explain that solar swimming pools save money. Clients should realize a true benefit over previous pool heating costs with a properly installed and functional SH pool system.

Solar heated swimming pools may clearly be indoor or outdoor. Outdoor solar pools are typically low temperature (72°F - 85°F) systems using unglazed collectors. Indoor pools may closely resemble open or closed loop systems with glazed collectors. Right from the start the astute SH student will realize that low-temperature, outdoor solar pool systems have no heat exchanger (open loop systems), nor do

	they have storage tanks (well – the pool itself is the “storage tank”). Additionally, the student observes the use of plastic pipe runs instead of copper or line-set runs – all due to the lower temperatures in the system.
Collector Installation ▶ Many types of collectors are suitable for pool heating. ▶ Low-temperature, unglazed collectors are most common. ▶ Many different low-temp collector designs. ▶ High flow rates. ▶ Sizing affected by regional climate. ▶ ROT (Rule of Thumb) – 75% of pool top surface area in collector area (on a pool where a cover is used) equals bumping the pool temp about 10 degrees (San Diego) CNM California Network of Microclimates Slide 10	Reveal Slide 10. Explain that many types of collectors are suitable for pool heating. Low-temperature, unglazed collectors are most common. (Design may call for medium-temperature collector). Many different low-temp collector designs. High flow rates. Sizing is affected by region climate Note that the statement that “75% of pool top surface area in collector area (on a pool where a cover is used) equals bumping the pool temp about 10 degrees” is a San Diego, California ROT. The astute installer will quickly learn what the collector sizing ROT is for the microclimates she/he works.
Collector Installation ▶ Collector installation is fairly straight-forward. – The roof layout is done according to the roof plan drawn by the system designer. – Most unglazed pool collectors will be mounted, similar to drainback collectors, with a slight pitch CNM California Network of Microclimates Slide 11	Reveal Slide 11. Explain that collector installation is fairly straight-forward. First the installer notes that the flexible collectors are heavy (but nothing close to the weight of glazed collectors) and getting them on to the roof with assistance is a good idea. The roof layout is done according to the roof plan

	drawn by the system designer. Tape measures and chalk lines are handy to “keep within the lines”. Most unglazed pool collectors will be mounted, similar to drain back collectors, with a slight pitch – in order that they completely drain when the system is shut down. This is very important in regions where freezing temperatures come with the winter months. Check your plans/specifications for details. Refer to text • NABCEP pages 42-44
Slide 12	Reveal Slide 12. Explain collector installation... As unglazed collectors are relatively thin and lightweight, and water volume inside the collector is usually a gallon or less, roof load is not typically a design consideration. Roof penetrations are also not typically a huge concern, with a SH pool installation, as most/all of the piping runs are usually outside of the dwelling envelope. Often pipe runs attached to an outside wall require roof penetrations in the eaves – but these penetrations – while they should be “dressed” like an attic penetration (flashing, caulking, etc.), are not running in conditioned house or non-conditioned attic spaces. Unglazed pool collectors often come in a kit, including connectors, clamps, straps, and even stainless lag bolts. As with glazed collectors, all lag screw penetrations must pass-through roofing and sheathing materials and into a roof rafter on-center. All lag penetrations are sealed with an appropriate sealant.

	Refer to text NABCEP pages 42-44
Slide 13	Reveal Slide 13. Explain collector installation... “Your SH contractor should have received/on-file installation guidelines for the specific SH system products you are to install. Additionally, most manufacturers provide installation manuals and other important information on-line.” Mention considerations... Roof Orientation: Unglazed pool collectors, just like glazed collectors, want to face South. Mounted on a South facing roof the collectors will perform well. Options to South facing roofs are flat roof, or a rack-mounted ground mount. A West orientation will work if there is no other choice (calculate performance and the probable addition of a collector or two). Lastly, building a South facing rack on a North facing roof has been done – but what a job! And it often looks ugly! Arrays: The usual solar pool collector array is one continuous row. This is the easy array to install. Note: The system designer should have calculated flow through the array along with the number of collectors in the array. Different collectors have different limitations on the number of collectors you can link together in series. Check plan and/or manufacturer’s specifications if in doubt.

Collector Installation

- Pool Pump:** Existing pool pumps at many installations, specifically on one-story high roof mount systems, are often adequate.
- Systems may be designed for flow rates in the range of 4 or 5 gallons per minute. A typical one horsepower pump may be sufficient.



Slide 14

Reveal Slide 14.

Explain

Pool Pump: Clearly the horsepower of the swimming pool filtration pump must be adequate to supply the solar system with water at the recommended flow rate necessary for the collectors being installed. Existing pool pumps at many installations, specifically on one-story high roof mount systems, are often adequate. However, it is important that the system designer inspect the existing pump to note both horsepower and age/condition features. Systems may be designed for flow rates in the range of 4 or 5 gallons per minute. Again, a one horsepower pump may be sufficient unless you are looking at a long pipe run or other influencing factor such as a large number of collectors.

Note: Aged, screeching, poor-performance pumps - sucking high amperage - may be a huge phantom expense to the homeowner. You could be a hero, in such a case, even with the suggestion of replacing a costly pump.

Collector Installation

- Piping
 - White PVC or CPVC pipe is often found on SH pool installations. A client may prefer black pipe as believing it looks better on their roof. Often white pipe is painted to match. Check your plan.
 - Plumb your system to plan. Consider flow rate through multiple collectors: see Florida, page 5-27.



Slide 15

Reveal Slide 15.

Explain collector installation...

As unglazed collectors are relatively thin and lightweight, and water volume inside the collector is usually a gallon or less, roof load is not typically a design consideration.

Roof penetrations are also not typically a huge concern, with a SH pool installation, as most/all of the piping runs are usually outside of the dwelling envelope. Often pipe runs attached to an outside wall require roof penetrations in the eaves – but these

	penetrations – while they should be “dressed” like an attic penetration (flashing, caulking, etc.), are not running in conditioned house or non-conditioned attic spaces. Unglazed pool collectors often come in a kit, including connectors, clamps, straps, and even stainless lag bolts. As with glazed collectors, all lag screw penetrations must pass-through roofing and sheathing materials and into a roof rafter on-center. All lag penetrations are sealed with an appropriate sealant. Refer to text NABCEP pages 42-44 Explain Fluid flow rate and uniformity through the collector array are fundamental considerations to your installation. Web illustration: http://www.fsec.ucf.edu/en/consumer/solar_hot_water/pools/index.htm
Collector Installation - PVC or CPVC or ? (check local codes, AHJ). - 1-1/2" and 2" pipe is common. - Under-sizing pipe leads to a reduced flow rate. - Runs should be as short as possible. - Slope-Drain like drainback systems.  Slide 16	Reveal Slide 16. Explain Pipe: PVC or CPVC or? (Check local codes, AHJ). 1-1/2" and 2" pipe are common, but each system design may call for a different size. Under-sizing pipe leads to a reduced flow rate. Runs should be as short as possible. “Hot Return” pipe should have the shortest run. Why? Refer to manufacturer for pipe clamp types. Sizes and spacing. Slope-Drain: Like drain back systems, solar pool collectors and related pipe runs should be sloped so pool water drains when the system is off. Reference: http://www.solarhotusa.com/support/literature/files/Pool-instructions.pdf

Collector Installation

- ▶ Diverter Valve
 - Used for diverting, shutting-off, or mixing applications.
- ▶ Ball Valve
 - Used to cut off, isolate and regulate system flow.
- ▶ Check Valve
 - Why do we use check valves in a pool system?
- ▶ Solar Pinch Valve
 - One potential flow controller.
- ▶ Solar Pool Flow Meter
- ▶ Solar Pool Thermometer



Slide 17

Reveal Slide 17.

Explain:

Diverter Valve (a plastic three-way ball valve)
Used for diverting, shutting-off, or mixing applications.
Manual valves shown. Also available in automatic types.

Ball Valve

Used to cut off, isolate and regulate system flow.
Manual valves shown. Also available in automatic types.

Manual or automatic (motorized) ball valves may be used to shut off flow to the collectors when it is determined (by human or linked controller) that collectors are cooler than pool water, etc.

Check Valve

True Union Spring Check valve.
Why do we use check valves in a pool system?

Solar Pinch Valve

One potential flow controller. When sensors indicate that collectors are cooler than pool water it shuts off flow to collectors, etc.

Solar control unit with temperature limitation
Hydraulic pinch valve.

Solar Pool Flow Meter

An important
Installation –
Commissioning –
Maintenance –
Troubleshooting tool.

Solar Pool Thermometer

Another important
Installation –
Commissioning –
Maintenance –
Troubleshooting tool.

Activating the System

- ▶ **FIRST purge.** Dirt, small plastic chips, it must all be flushed out.
- ▶ **SECOND pressure test.** Testing at twice the operating pressure is recommended.



Slide 18

Reveal Slide 18.

Explain that your solar pool installation job is finished.

Now you must **activate** the system.

FIRST you **purge**. Dirt, small plastic chips, it must all be flushed out.

Remembering good install procedures you purge FROM the filter and pump not into the filter and pump (no trash getting into the pump impeller). You also purge so that all of that trash does not find its way into the pool.

SECOND you **pressure test**. Testing at twice the operating pressure is recommended. Remember to pressure test with air – especially if any plumbing is in the attic or walls or?

Activating the System

- ▶ **THIRD** check all **automatic controls** for proper function.
- ▶ **FOURTH** check **flow rate** against specs.
- ▶ **FIFTH** (done on a sunny day) check for **temperature rise**.



Slide 19

Reveal Slide 19.

Mention that **THIRD** check all **automatic controls** for proper function.

FOURTH check **flow rate** against specs.

FIFTH (done on a sunny day) check for **temperature rise** – the difference between collector inflow and outflow. Check against manufacturer's specifications; understand that a modest increase (5-10°F) is okay with low-temperature collectors.

Activating the System

- ▶ **LAST walk** the pool owner through the entire operation of his/her new solar pool heater.
 - During this owner walk-through you provide the all-important **binder or folder** containing system instructions, diagrams, etc.
- ▶ **HAPPY SWIMMING**



Slide 20

Reveal Slide 20.

Mention that the LAST walk the pool owner through the entire operation of his/her new solar pool heater. This procedure:

1. saves unnecessary callbacks
2. Provides the owner with bragging rights with neighbors – and potential new jobs for you!
3. Trains the owner to make simple system adjustments.

During this owner walk-through you provide him/her with the all-important **binder or folder** containing system instructions, diagrams, component cut sheets, and his/her copy of your **signed maintenance contract**.

HAPPY SWIMMING

Reference:

<http://www.solarhotusa.com/support/literature/files/Pool-instructions.pdf>

Thank you!

It's been a pleasure working with you today as we complete Solar Heating Module #6.

Instructor ID #:
Class ID #:

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Slide 21

Reveal Slide 21.

Appendix A

Module 1: Supporting Materials

Pre-Test

Pre-Test Answer Key

SOLAR HEATING INSTALLER

PRACTICE QUESTIONS

1. When is insulation placed on the system?

- a. Prior to installation
- b. While under construction and accessible
- c. After pressure test
- d. After commissioning

2. What is the minimum slope on a drain-back system pipe outside of conditioned space?

- a. 20%
- b. ½ inch per foot
- c. ¼ inch per foot
- d. 3 inches

3-5. What are three things you always consider to protect your Solar Heating System?

- a. Protecting your system against low temperatures
- b. Protecting your system against harmful UV radiation
- c. Protecting your system against high temperatures
- d. Protecting your system against bird/rodent damage
- e. Protecting your system against wind/hail damage
- f. Protect your system against scaling (water quality)

6. Where do you get the diagram for a hydraulic OG-300 system?

- a. SRCC <http://www.solar-rating.org/>
- b. Plumbing Code
- c. Underwriters Laboratory
- d. Building Code

7. What is the approximate maximum desirable temperature for the bottom of a glass lined steel Solar Hot Water storage tank?

- a. 220 degrees Fahrenheit
- b. 300 degrees Fahrenheit
- c. 180 degrees Fahrenheit
- d. 120 degrees Fahrenheit

8. Polysun is computer simulation software that does what mainly?

- a. Gives system pricing information for Domestic SH systems
- b. Calculates and estimates the solar fraction of Domestic SH systems in a given geographical location
- c. Compares various forms of renewable energy to one another and suggests the best option to the installer
- d. Presents Solar Hot Water to the consumer in a fun interactive video game format

9. Sunlight falling on the United States for what length of time transfers enough energy to power the nation for one year?

- a. one half day
- b. one week
- c. one day
- d. one month

10. The water in a solar storage tank can get very hot so it's important to regulate the hot water output temperature to prevent scalding. This valve can be set at different hot water output temperatures and automatically mixes the hot solar water with the cold water inlet. Typical set temperature is between 120-140 degrees. What is the name of this valve?

- a. Tempering Valve
- b. Temperature Valve
- c. Mixing Valve
- d. Isolation Valve

11. The Solar Fraction is the ratio of energy supplied by the sun to the amount of energy needed to supply the total hot water demand. As an example a Solar Fraction of 20% is where only 1/5th of the energy needed to heat hot water is supplied by the sun. What is the most desirable solar fraction to achieve when designing a new Solar Heating system?

- a. at least 80% during winter months
- b. 100%
- c. 80% or greater
- d. 60% to 80%

12. The longest day of the year is:

- a. December 13
- b. December 21
- c. June 21
- d. July 13

13. When calculating the optimal size Solar Heating systems what is the normal daily hot water consumption for one person in the United States?

- a. 50 gallons
- b. 40 gallons
- c. 30 gallons
- d. 20 gallons

14. Carrying the collector by the header is allowed when:

- a. You're actually on the roof and getting a grip on the collector is difficult
- b. Removing a collector from a stack of other collectors
- c. It's okay in all the mentioned scenarios
- d. You need to attach straps to the collector to pull it onto the roof
- e. It's never okay to carry the collector by the headers

15. This system uses a glycol and water mixture circulating through the collectors to prevent freezing, corrosion, scaling and boiling.

- a. Closed Loop
- b. Open Loop
- c. Thermosyphon
- d. Prototype

16. The collector splice kit's main purpose is to:

- a. Connect collector rails at different angles to allow for unique roofs
- b. Connect collector rails to accommodate an array of more than 2 collectors
- c. Add seasoning to dishes for people who like their food spicy!
- d. Add strength to a single collector mounting

17. What is a "riser sleeve"?

- a. Pipe insulation for long pipe runs to and from the collector array
- b. Special insulation used to protect the collectors when not in use
- c. A type of insulation designed specifically to insulate DOS connections
- d. A convenient way to carry your peanut butter cup candies

18. A Schrader valve is located on the underside of the expansion tank. This is the same type of valve used to fill an automobile tire. When no pressure exists in the piping connecting the roof to the Helio-Pak how much pressure should exist in the expansion tank? (This is called a pre-charge pressure)

- a. 100 psi
- b. No pressure
- c. 50 psi
- d. 25 psi

19. Solar Heating storage tanks are normally tall and thin in order to keep the cold water entering the tank somewhat separated from the existing hot water in the tank. This feature causes allows hotter water to be drawn from the tank before it becomes cold. What is the name of the property this tank design feature promotes?

- a. isolation
- b. saturation
- c. layering
- d. stratification

20. What amount of water storage is recommended for every square foot of collector area? (Tricky question: How much hot water per square foot plus how much storage per gallon of production.)

- a. 2.5 to 3 gallons
- b. 1.5 to 3 gallons
- c. .5 to 1.5 gallons
- d. Any amount over 1.5 gallons

21. The expansion tank absorbs excess water pressure, and provides overpressure protection which could otherwise damage the plumbing structure or exhaust fluid through the pressure relief valve. Some tanks use a bladder instead of a diaphragm. Which of these choices is a feature of this type of tank that is especially beneficial to an installer?

- a. Mounts in any orientation
- b. Must be mounted in a vertical position.
- c. Larger simpler to install size
- d. Less sensitive to glycol

22. What was the name of the first commercial solar water heater designed by Clarence Kemp, sold in the United states in 1891?

- a. Solar Snapper
- b. Hot Box
- c. Solar Still
- d. Solar Climax

23. What type absorber surface produces the highest solar energy capture?

- a. Black Chrome
- b. Black Paint
- c. Acid Etched
- d. Blue Sputtered

24. Insulating the pipe runs on a system is primarily necessary because

- a. None of these reasons
- b. it reduces the amount of heat loss
- c. it looks nicer than copper pipes
- d. it keeps the moisture contained during condensation

25. Air valves are either manually operated or automatic and are mounted in the flow of glycol to allow excess air to escape. Air valves should be installed at the highest point in the solar loop. This prevents air locks which will restrict flow of the fluid and reduce the heat transfer in the solar loop. How should float type air vents be positioned?

- a. horizontally
- b. air valves are not sensitive to orientation
- c. 45 degrees from vertical
- d. vertically

26. Solar Heating is suitable for all regions of the United States.

- a. True
- b. False



SOLAR HEATING INSTALLER

PRACTICE QUESTIONS

ANSWER KEY

1. When is insulation placed on the system?

- a. Prior to installation
- b. While under construction and accessible
- c. After pressure test ←
- d. After commissioning

2. What is the minimum slope on a drain-back system pipe outside of conditioned space?

- a. 20%
- b. ½ inch per foot
- c. ¼ inch per foot ←
- d. 3 inches

3-5. What are three things you always consider to protect your Solar Heating System?

- a. Protecting your system against low temperatures ←
- b. Protecting your system against harmful UV radiation
- c. Protecting your system against high temperatures ←
- d. Protecting your system against bird/rodent damage
- e. Protecting your system against wind/hail damage
- f. Protect your system against scaling (water quality) ←

6. Where do you get the diagram for a hydraulic OG-300 system?

- a. SRCC <http://www.solar-rating.org/> ←
- b. Plumbing Code
- c. Underwriters Laboratory
- d. Building Code

7. What is the approximate maximum desirable temperature for the bottom of a glass lined steel Solar Hot Water storage tank?

- a. 220 degrees Fahrenheit
- b. 300 degrees Fahrenheit
- c. 180 degrees Fahrenheit ←
- d. 120 degrees Fahrenheit

8. Polysun is computer simulation software that does what mainly?

- a. Gives system pricing information for Domestic SH systems
- b. Calculates and estimates the solar fraction of Domestic SH systems in a given geographical location ←
- c. Compares various forms of renewable energy to one another and suggests the best option to the installer
- d. Presents Solar Hot Water to the consumer in a fun interactive video game format

9. Sunlight falling on the United States for what length of time transfers enough energy to power the nation for one year?

- a. one half day
- b. one week
- c. one day ←
- d. one month

10. The water in a solar storage tank can get very hot so it's important to regulate the hot water output temperature to prevent scalding. This valve can be set at different hot

water output temperatures and automatically mixes the hot solar water with the cold water inlet. Typical set temperature is between 120-140 degrees. What is the name of this valve?

- a. Tempering Valve ← (tempering, mixing or anti-scald)
- b. Temperature Valve
- c. Mixing Valve ← (tempering, mixing or anti-scald)
- d. Isolation Valve

11. The Solar Fraction is the ratio of energy supplied by the sun to the amount of energy needed to supply the total hot water demand. As an example a Solar Fraction of 20% is where only 1/5th of the energy needed to heat hot water is supplied by the sun. What is the most desirable solar fraction to achieve when designing a new Solar Heating system?

- a. at least 80% during winter months
- b. 100%
- c. 80% or greater
- d. 60% to 80% ←

12. The longest day of the year is:

- a. December 13
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- c. June 21 ←
- d. July 13

13. When calculating the optimal size Solar Heating systems what is the normal daily hot water consumption for one person in the United States?

- a. 50 gallons
- b. 40 gallons
- c. 30 gallons
- d. 20 gallons ←

14. Carrying the collector by the header is allowed when:

- a. You're actually on the roof and getting a grip on the collector is difficult
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- d. You need to attach straps to the collector to pull it onto the roof
- e. It's never okay to carry the collector by the headers ←

15. This system uses a glycol and water mixture circulating through the collectors to prevent freezing, corrosion, scaling and boiling.

- a. Closed Loop ←
- b. Open Loop
- c. Thermosyphon
- d. Prototype

16. The collector splice kit's main purpose is to:

- a. Connect collector rails at different angles to allow for unique roofs
- b. Connect collector rails to accommodate an array of more than 2 collectors ←
- c. Add seasoning to dishes for people who like their food spicy!
- d. Add strength to a single collector mounting

17. What is a "riser sleeve"?

- a. Pipe insulation for long pipe runs to and from the collector array
- b. Special insulation used to protect the collectors when not in use
- c. A type of insulation designed specifically to insulate DOS connections ←
- d. A convenient way to carry your peanut butter cup candies

18. A Schrader valve is located on the underside of the expansion tank. This is the same type of valve used to fill an automobile tire. When no pressure exists in the piping connecting the roof to the Helio-Pak how much pressure should exist in the expansion tank? (This is called a pre-charge pressure)

- a. 100 psi
- b. No pressure
- c. 50 psi
- d. 25 psi ←

19. Solar Heating storage tanks are normally tall and thin in order to keep the cold water entering the tank somewhat separated from the existing hot water in the tank. This feature causes allows hotter water to be drawn from the tank before it becomes cold. What is the name of the property this tank design feature promotes?

- a. isolation
- b. saturation
- c. layering
- d. stratification ←

20. What amount of water storage is recommended for every square foot of collector area? (Tricky question: How much hot water per square foot plus how much storage per gallon of production.)

- a. 2.5 to 3 gallons
- b. 1.5 to 3 gallons ← (varies w/geographic region)
- c. .5 to 1.5 gallons
- d. Any amount over 1.5 gallons

21. The expansion tank absorbs excess water pressure, and provides overpressure protection which could otherwise damage the plumbing structure or exhaust fluid through the pressure relief valve. Some tanks use a bladder instead of a diaphragm. Which of these choices is a feature of this type of tank that is especially beneficial to an installer?

- a. Mounts in any orientation ←
- b. Must be mounted in a vertical position.
- c. Larger simpler to install size
- d. Less sensitive to glycol

22. What was the name of the first commercial solar water heater designed by Clarence Kemp, sold in the United states in 1891?

- a. Solar Snapper
- b. Hot Box
- c. Solar Still
- d. Solar Climax ←

23. What type absorber surface produces the highest solar energy capture?

- a. Black Chrome
- b. Black Paint
- c. Acid Etched
- d. Blue Sputtered ←

24. Insulating the pipe runs on a system is primarily necessary because

- a. None of these reasons
- b. it reduces the amount of heat loss ←
- c. it looks nicer than copper pipes
- d. it keeps the moisture contained during condensation

25. Air valves are either manually operated or automatic and are mounted in the flow of glycol to allow excess air to escape. Air valves should be installed at the highest point in the solar loop. This prevents air locks which will restrict flow of the fluid and reduce the heat transfer in the solar loop. How should float type air vents be positioned?

- a. horizontally
- b. air valves are not sensitive to orientation
- c. 45 degrees from vertical
- d. vertically ←

26. Solar Heating is suitable for all regions of the United States.

- a. True ←
- b. False

Appendix B

Module 2: Supporting Materials

Component Identification Activity Sheet

Solar Heating System Scenarios Activity Sheet

Thread Identification Activity Sheet

Optional Slide Sequence

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE:	COMPONENT IDENTIFICATION
SH MODULE:	MODULE #2: SH SYSTEMS & COMPONENTS
OBJECTIVE:	Identification and understanding function of individual SH system components.
DURATION:	One hour, then possibly ongoing for many students. Individual parts and display boards may be used in on-going instruction and testing situations.
INTRODUCTION:	Solar heating installers must be able to identify and explain the function of individual component parts.
SEQUENCE:	<u>Without Display Board</u> 1. Collect individual component parts (check valve, vacuum breaker, air vent, expansion tank, ball valve, etc.). 2. Prepare each part for student identification (mark part with number or place each part on a numbered piece of paper). 3. Layout parts on tables. 4. Identify and explain each part to students. 5. Students circulate through table displays and identify (write name and/or function) on worksheet. <u>With Display Board</u> 1. Collect individual component parts (check valve, vacuum breaker, air vent, expansion tank, ball valve, etc.). 2. Prepare classroom display board(s) with parts attached and identified by number only. 3. Follow #4 and #5 above.
MATLS/EQUIP:	Individual component parts (check valve, vacuum breaker, air vent, expansion tank, ball valve, etc.).
RESOURCES:	Text and modules, plumbing parts/fittings web sites. NABCEP text: pages 28-32.

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE: **SH SYSTEM SCENARIOS**

SH MODULE: **MODULE #2: SH SYSTEMS AND COMPONENTS**

OBJECTIVE: Understanding system design, function, and component parts.

DURATION: One half to one hour.

INTRODUCTION: Solar heating installers must understand fundamental system design, function, and component parts. Students will design a system for a specific application and defend their design to the class – all based on what has been studied to date.

SEQUENCE:

1. Use one or more scenarios to describe a system(s) that student crews must design.
Example: *"You have been assigned by your contractor to design a passive solar heating system for a remote off-grid hunting cabin. During hunting season the cabin supports two-to-four adult hunters for multiple periods of two-to three weeks each. The existing cabin water supply is a reliable solar (PV) powered well pump supplying unheated water to a single kitchen sink at four gallons per minute. A slightly used eighty gallon electric water heater is on site but is not operational due to the absence of sufficient power. Also on site is a slightly used, no-name, four-by-eight flat plate collector. Design a system and a parts list for this job".*
2. Students work together in "crews" to develop a plan. Plan diagrams are drawn on large format sheets (easel paper) or on white boards.
3. Student crews introduce, explain and defend their designs. Instructor and other students ask questions/comment.

MATLS/EQUIP: White boards, white board markers, and/or easel sheets and markers, masking tape.

RESOURCES: Text, modules.

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE: **THREAD IDENTIFICATION**

SH MODULE: **MODULE #2: SH SYSTEMS & COMPONENTS**

OBJECTIVE: Identification and understanding function of pipe and other threads.

DURATION: One hour, then possibly ongoing for many students. Individual parts and display boards may be used in on-going instruction and testing situations.

INTRODUCTION: Solar heating installers must be able to identify specific thread types. Many “probie” errors and potentially expensive mistakes occur when dissimilar threads are forced together. Many proprietary threads also exist, in addition to standard SAE, pipe, and metric threads in solar heating, which can complicate an installation if not properly recognized and addressed.

SEQUENCE: Without Display Board

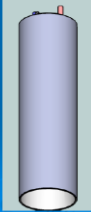
6. Collect individual thread examples (SAE fine bolt SAE course bolt, metric bolt, two inch pipe nipple, three inch lag bolt, etc.).
7. Prepare each example for student identification (mark part with number or place each example on a numbered piece of paper).
8. Layout examples on tables.
9. Identify and explain each example to students.
10. Students circulate through table displays and identify (write name) on worksheet.

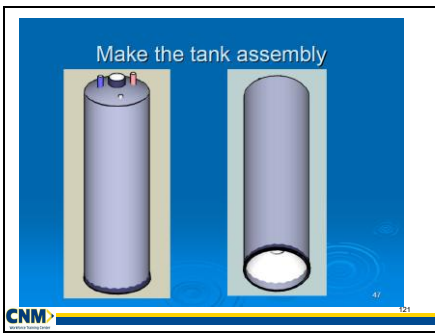
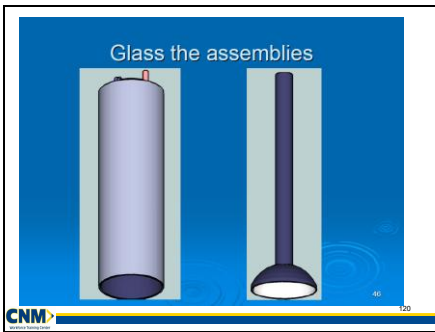
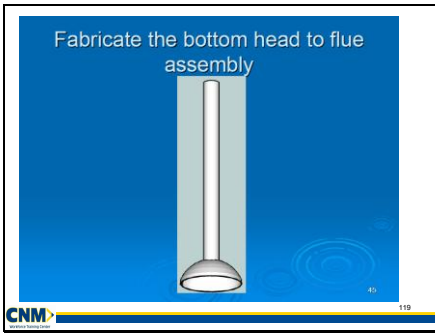
With Display Board

4. Collect individual thread examples (check valve, vacuum breaker, air vent, expansion tank, ball valve, etc.).
5. Prepare classroom display board(s) with examples attached and identified by number only.
6. Follow #4 and #5 above.

MATLS/EQUIP: Individual thread examples (SAE fine bolt SAE course bolt, metric bolt, two inch pipe nipple, three inch lag bolt, etc.).

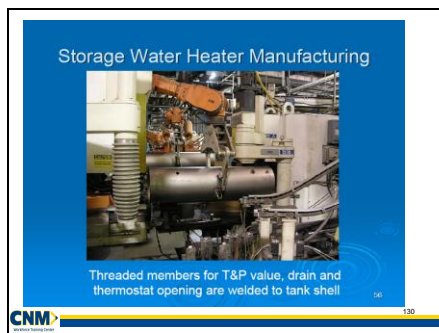
RESOURCES: Hardware web sites.

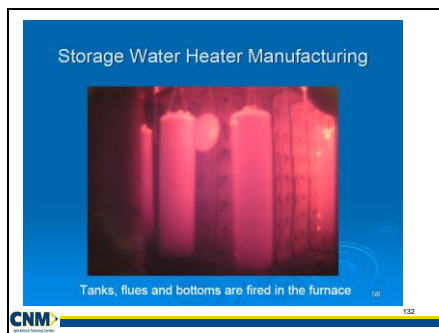
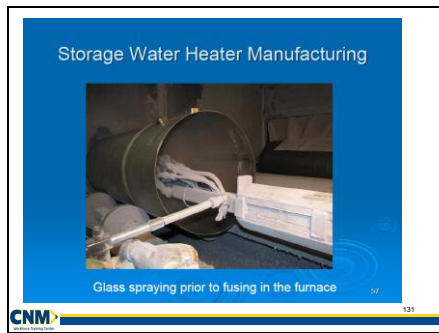
WATER HEATER MANUFACTURING OPTIONAL SLIDE SEQUENCE WATER HEATER MANUFACTURE AND RELATED TOPICS. CNM ©2013	
Gas Water Heater Fabrication ➤ All manufacturers use basically the same process. ➤ Tanks are welded and glassed ➤ Tank assemblies are put into the jackets and foamed in place ➤ Burners, T & P valve, etc. added ➤ Boxed and Shipped CNM ©2013	
Fabricate top head to tank shell assembly  CNM ©2013	

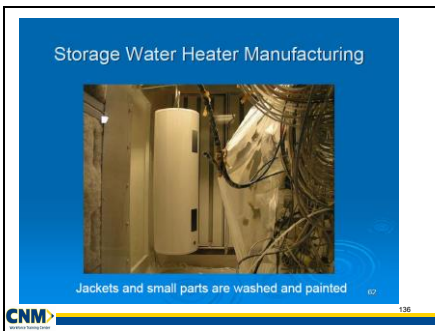
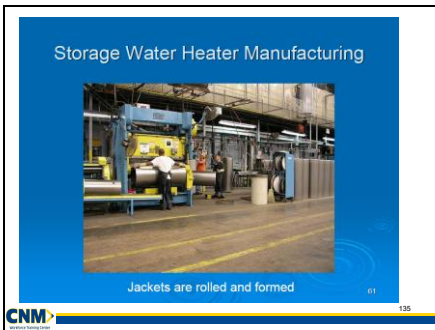


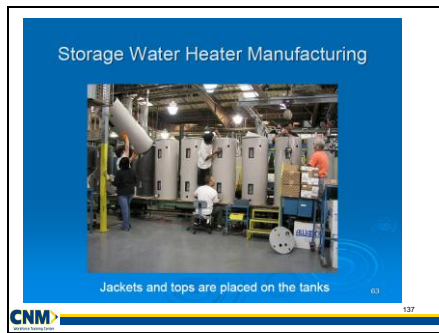














Appendix C

Module 3: Supporting Materials

Solar Heating Calculations Activity Sheet

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE: SH CALCULATIONS

SH MODULE: MODULES #3, 4, 5: SH SYSTEMS & COMPONENTS, SH SITE & SIZE ANALYSIS, SH OPERATION, MAINTENANCE, TROUBLESHOOTING

OBJECTIVE: Understanding solar heating related calculations.

DURATION: Half hour reviewing formulas and examples, then potential referral in on-going instruction and testing situations.

INTRODUCTION: Solar heating installers must be able to perform mathematical calculations including volume, lag bolt embedment, friction head losses, insolation, collector ratings, irradiation, and collector to storage ratio. A selection of calculations will likely appear on the NABCEP entry level examination.

SEQUENCE:

1. Determine if you will (a) individually present calculations in context, using examples/exercises to reinforce practical applications, or (b) present an overview of the solar heating calculations found in this activity.
2. Explain purpose of a calculation(s) on white board, posing a problem/question, and walking through a calculation.
3. Use formula sheet as handout. Refer to text references and web site examples as applicable.
4. Have students individually work through additional problems. Then discuss problem solving steps and solutions in class.

MATLS/EQUIP: Paper, pencil, white board or paper-easel and pens.
Optional: instructor computer/projector/Internet access. Overhead projector, cells, marking pens.

RESOURCES: Attached calculation and problem/example sheets.
NABCEP text.
Internet examples (identified with calculations).
Collector Capacities:
ProgressiveTube <http://www.tctsolar.com/> (go to "Spec Guide")
Heliodyne <http://www.heliodyne.com/> (go to "Industry Professionals", then "Product & Technical Downloads", then "Product Specifications", then "DOWNLOAD - GOBI Specifications")

CALCULATIONS: **STORAGE TANK VOLUME,**
(Following pages-
useful handouts) **STORAGE TANK WEIGHT**
LAG BOLT EMBEDMENT
Btu and kWh
COPPER PIPE EXPANSION
HEAD LOSS
STORAGE TANK VOLUME (Refer to NABCEP text page 103)

Installers calculate the volume of water/solar fluid in a tank.

Volume of cylindrical tank:

$$V = \pi r^2 h$$

V = volume of tank

$$\pi = \text{pi} = 3.14$$

r = radius of tank

h = height of tank

Example: Calculate the volume of a tank* measuring two-and-a-half feet in diameter, and five-and-a-half feet tall.

Hint: convert feet-inches to inches: 2-1/2 feet = 30", 5-1/2 feet = 66"

Step One: Determine area of the tank:

$$V = \pi r^2 h$$

$$V = 3.14 \times 15''^2 \times 66''$$

$$V = 3.14 \times 225'' \times 66''$$

$$V = 46,629 \text{ in}^3 \quad (\text{answer is in cubic inches})$$

Step Two: You can continue in one of two directions here. Either (a) you calculate the volume (gallon capacity) of the tank using cubic inches, or (b) you convert cubic inches to cubic feet and then calculate volume (gallon capacity) of the tank.

Option A: Calculation using cubic inches.

First you must know there are **231** cubic inches in one gallon (something you memorize).

$$V = 46,629 \text{ in}^3 \times 231 \text{ gal/in}^3$$

$$V = 201.86 \text{ U.S. gallons (or 202 gal)}$$

Option B: Calculation using cubic feet.

First convert from cubic inches to cubic feet. Divide the cubic inch answer above by **1724** (memorize).

$$V = 46,629 \text{ in}^3 / 1724 \text{ in}^3/\text{ft}^3$$

$$V = 27.05 \text{ ft}^3$$

Second, you must know there are approximately **7.5** gallons in one cubic foot (memorize).

$$V = 27.05 \text{ ft}^3 \times 7.5 \text{ gal/ft}^3$$

$$V = 202.88 \text{ U.S. gallons (or 203 gal. Note the term "approximately" in reference to 7.5 gal/cu}^3)$$

SOLVE FOR:

1. Five foot tall, two foot diameter tank.
2. Seven and a half foot tall, two-and-three-quarter foot diameter tank.
3. Seventy five feet of three-quarter inch copper tubing.
4. Forty-eight feet of one-inch stainless line set.
5. Amount of propylene glycol required for a 50/50 mix, or 50% glycol to water ratio, in a system including one 4x8 foot flat plate collector, 150 feet of 3/4 inch copper tubing, a 2-1/2 foot diameter by 7 foot tall storage tank, and an 80 gallon water heater.

*Dimensions of actual tank, not including insulation, outer shell, etc.

STORAGE TANK WEIGHT (Refer to NABCEP text page 103)

Installers calculate the weight of water/solar fluid in a tank.

Q. Why would it be important for a system designer or installer to calculate weight of water/solar fluid in a tank?

A. Discuss ICS, thermosyphon, and other batch systems wherein the tank is roof mounted (in consideration of roof loading).

B. Discuss using weight of water/solar fluid in system to determine amount of propylene glycol required to meet 50/50 mix (ratio of glycol to water), 46/60 mix, 30/70 mix.

Weight of water or solar fluid in a tank:

$$W = V \times 8.3$$

W = weight of fluid in tank

V = volume

8.3 weight of one gallon of water (memorize)

Step One: Determine volume of the tank (see tank volume calculation).

Example: Use 202 gallons.

$$W = 202 \times 8.3$$

$$W = 167.60 \text{ lbs (pounds)}$$

REMINDER. If you are calculating a roof or other structural load, remember to add the weight of the dry tank and tank hardware to the calculated water/solar fluid weight.

SOLVE FOR (use results from volume calculations for problems #1 and #2):

1. Five foot tall, two foot diameter tank.
2. Seven and a half foot tall, two-and-three-quarter foot diameter tank.
3. Seventy five feet of three-quarter inch copper tubing.
4. Forty-eight feet of one-inch stainless line set.
5. 4x8 Progressive Tube collector.

LAG BOLT EMBEDMENT (Refer to NABCEP text pages 79-80)

Lag bolts are commonly used to secure collectors to roof structural members. An installer must ensure that lag bolts of the proper size have been selected to secure collectors and collector mounting hardware from effects of wind loading, racking geometry, and collector weight.

The installer should consider:

1. The wood used for the roof rafters.
2. The diameter and length (of thread) of the lag bolt chosen.
3. The diameter of the drill bit used to drill a lag bolt pilot hole.

Rafter wood. Typically an installer will not be certain what type of wood has been used to construct the roof rafters. The writer has seen both fir and redwood rafters, while spruce or pine rafters are as also common.

Lag bolt. The manufacturer typically determines the withdrawal force that lag bolts must withstand. This force, measured in pounds, is used to calculate the length of the lag bolt thread that must be embedded in each rafter (in the center of the rafter).

The example and reference chart provided in the NABCEP text, page 80, provide an example:

- A. Manufacturer specifies each foot ("foot", "boot", "leg", different terms used by manufacturers) must withstand a withdrawal force of 650 pounds.
- B. A mounting "foot" design typically calls for two lag bolts.
- C. Lag bolt calculation requires lag bolt pull-out capacity chart (page 80). Charts are provided by manufacturers (installation guides) and/or found on manufacturer web sites.
- D. Example given:
$$d_{min} = (650lb)/(205lb/in) = 3.17 \text{ in}$$

Where d_{min} = withdrawal strength
650lb = manufacturer's spec
205lb/in = chart reference for 3/16" lag in Spruce, Pine, Fir
3.17 = required depth of lag screw into rafter (not sheathing, roofing material)
- E. As two lags will be used for each foot, the installer can safely install each lag at a minimum depth of 1.59 inches.

Diameter of pilot drill. A commonly misunderstood element of lag bolt installation is the choice of pilot drill. Consider that the lag bolt has a "core" or "root" or "body" – a solid diameter underneath the threaded segment of the bolt. This "root" diameter has a tendency to split rafters, particularly older rafters, as if the installer were driving a large spike into the wood. The installer pilot drills holes in the rafters to hopefully eliminate this splitting tendency. Pilot holes also provide the added bonus of helping to prevent bolt heads from splitting off of the bolt when torquing in place.

The ROT (Rule of Thumb) used to select a pilot drill is to choose a drill diameter at 50% to 75% of the screw diameter. Pilot charts are also available on line. Example: <http://www.renovation-headquarters.com/lag-bolt-pilot-hole.htm>

BTU – BRITISH THERMAL UNIT and kWh – KILOWATT HOUR
(Refer to NABCEP text pages 7, 10, 47, 145)

Q. Insolation is commonly presented in units of:

- a. kWh/m²/day
- b. W/m²
- c. BTU/ft²/day
- d. Photons/ft²

A. Insolation is the solar radiation that reaches the earth's surface over a given period of time. Insolation is measured in units of kWh/m²/day (kilowatt-hours per square meter per day).

Insolation may also be presented in the unit of sun hours. One sun equals 1000W/m². This equals 317 BTU/ft².

Q. Irradiance is commonly presented in units of:

- a. kWh/m²/day
- b. W/m²
- c. BTU/ft²/day
- d. Photons/ft²

A. Irradiance is the power of the sun (electromagnetic radiation) at a given moment and is commonly presented in units of W/m² (watts per square meter). Irradiance varies during the day, typically ranging from 700W/m² to 900W/m².

SRCC tests collectors (OG-100) and reports irradiance in both megajoules per square meter per day and in Btu per square foot per day. "Clear sky" collector performance ratings are measured at irradiance units of 23 MJ/m² d and 2,000 Btu/ft² day.

SRCC collector ratings (OG-100) (see <http://www.solar-rating.org/ratings/index.html>) provides "Average Daily Total Solar Radiation for U.S. Cities", listing irradiance for collectors in Albuquerque, New Mexico tilted at 23° as 2076 Btu/ft²/day , and 2062 Btu/ft²/day tilted at 45°.

Q. Solar heating ratings are commonly presented in

- a. kWh/m²/day
- b. W/m²
- c. BTU/ft²/day
- d. Photons/ft²

A. BTU/ft²/day

Q. Can you compare two or more collectors by purchase price and energy output?

A. Yes, divide the energy output by the cost of each. Example: using SRCC OG-100 ratings, compare one collector with an output of 20,000 Btu against another collector with an output of 30,000 Btu. The first collector sells for \$450, the second sells for \$650. Then:

First collector: 20,000 Btu divided by \$450 = 44 Btu/\$

Second collector: 30,000 Btu divided by \$650 = 46 Btu/\$

Generally speaking, the higher the Btu/\$ the more cost-effective the collector.

COPPER PIPE EXPANSION (Refer to NABCEP text page 87)

Q. The recommended compensation strategy for one inch copper pipe expansion concerns in long pipe runs is:

- a. Install an expansion tank
- b. Install a flexible tubing loop
- c. Install a U bend
- d. Install an in-line air column

A. Install a U bend. The U bend allows the pipe to expand without damaging joints and fittings.

Copper pipe expansion is not a typical problem in systems with short runs of ½ and ¾ inch copper pipe. Pipe expansion, however, should be appreciated in the design of roof penetrations.

See NABCEP text page 87 for an explanation and examples of plumbing configurations that mitigate expansion concerns.

HEAD LOSS (Refer to NABCEP text page 99)

Head loss, or pressure loss, due to friction to water/solar fluid velocity along a length of copper pipe is a system design consideration. Head loss is associated with energy loss for a given length of pipe and bends, fittings, valves, etc.

One common equation used to calculate major head loss is the Hazen-Williams equation. On-line head loss calculators: http://www.engineeringtoolbox.com/hazen-williams-water-d_797.html System designers may also refer to tables designed to assist in head loss calculations.

Short pipe systems with a large number of bends and fittings, can suffer significant head loss, but SH system installers of residential systems – while they should be aware of head losses – typically install three-speed circulators capable of overcoming head loss concerns. (See NABCEP page 146).

Appendix D

Module 4: Supporting Materials

Hampden Trainers Activity Sheet

Heliodyne Trainer Activity Sheet

Knots Bend Hitches Activity Sheet

Pipe Sweating Activity Sheet

System Dry Fitting Activity Sheet

System Installation Activity Sheet

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE: **HAMPDEN TRAINERS**

SH MODULE: **MODULE #4: SH SYSTEMS & INSTALLATION**

OBJECTIVE: Understanding SH systems.

DURATION: One to three hours per trainer, depending on the number of individual student “crews” and the number of trainers employed.

INTRODUCTION: **SOLAR SYSTEM TRAINER.** A solar hot water heating system. Components include a solar collector, circulation pumps, storage tank, heat exchanger, air separator, air handler, solar heating coil, automatic air vents, thermostat, and a control panel with sensors. Gauges, thermometers, and flow meters permit students to observe pressures, temperatures, and flow rate while the system is in operation.

MOBILE SOLAR TRAINER. Provides hands-on practice in studying a wide variety of solar concepts. Can be used to build space heating, domestic hot water, water-to-air heat exchange, heat storage and other systems.

SOLAR HEAT SERVICE TRAINER. Contains the actual control components of a solar heating system, including: sensors, relays and thermostats. Each component terminates at binding posts for easy interconnection into several configurations. Up to 21 faults may be inserted from the panel on the side.

SOLAR HYDRONICS TRAINER. Contains the plumbing components typically found on most active solar-heated circulating hot water heating systems. It includes both the storage (open) loop and the exchange (closed) loop.

SEQUENCE: Students follow Hampden trainer manuals, complete exercises/worksheets. Trainers also useful in initial Q&A component and function discussions.

MATLS/EQUIP: Hampden trainers. Hampden trainer workbooks.
Model # H-SST-1A Solar System Trainer
Model H-SST-2 Mobile Solar Trainer
Model H-SHST-1 Solar Heat Service Trainer
Model H-HYD-1A Solar Hydronics Trainer

RESOURCES: Hampden trainer workbooks. Hampden web site. <http://www.hampden.com/>

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE:	HELIODYNE TRAINER
SH MODULE:	MODULE #4: SH SYSTEMS & INSTALLATION
OBJECTIVE:	Understanding SH systems.
DURATION:	One to three hours, depending on specific use, the number of individual student “crews” and the number of trainers employed.
INTRODUCTION:	The HLAB is a compact, mobile, fully working closed loop SHW system. Its main function is to serve as a portable system for educational or product demonstration purposes.
SEQUENCE:	Various possible sequences including but not necessarily limited to: <u>Introduction to system components:</u> Point to component and ask, what is this? (valve/sensor/pump/etc.) Ask student to describe and trace closed (solar) loop and component parts. Ask student to describe and trace open (domestic) loop and component parts. <u>Commissioning:</u> Ask student crew to describe pressure testing procedure. P-Test. Ask student crew to describe flushing procedure. Flush Ask student crew to describe system filling procedure. Fill Ask student crew to describe system startup procedure. Startup Ask student crew to describe system test procedure. Test Students manually take time/temperature/ ambient/weather readings to rate system performance. Students monitor system performance via WiFi. <u>Collector installation:</u> With careful planning, spare parts, proper tools, and a separate collector with mounting hardware, the HLAB can also be used by disconnecting the 4x4 collector and providing a student crew with plans to install a separate (rooftop) collector, plumbing it to the HLAB. Students then pressure test, flush, fill, startup, and test – taking measurements over time to rate performance.
MATLS/EQUIP:	Heliodyne trainer. HLAB HLAB 000 000.
RESOURCES:	Heliodyne installation guide. Pages 18, 20, 21 http://www.heliodyne.com/industry_professionals/downloads/guides.html DOWNLOAD - <u>HPAK System Installation Guide</u> or http://www.heliodyne.com/industry_professionals/downloads/HPAKSystemInstallation.pdf

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE: **KNOTS, BENDS, HITCHES**

SH MODULE: **MODULE #4: SH SYSTEMS & INSTALLATION**

OBJECTIVE: Learning to tie basic knots used in solar heating installations.

DURATION: Thirty minutes

INTRODUCTION: Solar heating installers often use rope to tie off and lift tools and equipment. They need to be able to correctly tie a variety of knots, hitches, and bends when using rope on the job.

SEQUENCE:

1. Introduce students to knot tying; asking them what it is that defines a “good” knot. A “good” knot is a properly tied knot that may be untied as easily as it was tied – even knots subject to loads.
2. Demonstrate proper tying techniques for selected knots. Explain common uses.
Square knot - simple binding knot used to secure a rope or line around an object. AKA “Reef knot”.
Clove hitch - two successive half-hitches, typically around an cylindrical object.
Two half hitches – useful binding knot, an extension of the half hitch.
Sheet bend – a “bend” or a knot that ties two ropes together. AKA “Weaver’s knot”.
Bowline – used to form a fixed loop on the end of a rope. AKA “King of the knots”.

MATL/EQUIP: A length (five feet is useful) of half-inch rope per student.

RESOURCES: Numerous good web sites describe background and tying of knots. Wiki sites are available for each knot listed above.

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE:	PIPE SWEATING
SH MODULE:	MODULE #4: SH SYSTEMS & INSTALLATION
OBJECTIVE:	Successful copper pipe soldering
DURATION:	One to two hours, then possibly ongoing practice for some students.
INTRODUCTION:	“Pipe sweating” is a craft/trade term for soldering copper pipe. Solar heating installers must be skilled at sweating copper pipe.
SEQUENCE:	1. Prepare pipe sweating stations prior to class session. 2. Carefully explain all safety concerns and practices associated with sweating copper pipe. Everyone should be wearing safety eyewear, gloves, and hard hats. 3. Identify tools and materials, identifying functions and alternatives. 4. Demonstrate and explain sweating steps prior to actual demonstration. 5. Demonstrate sweating of pipe/fitting. Explain further. 6. Allow student to sweat pipe/fitting. Ask them to first explain what they will do – step-by-step. Ask them to explain safe practices. 7. Allow all students to successfully sweat. Discussion. Further demonstrations as needed. 8. Clean up.
MATLS/EQUIP:	Appropriate work bench(es), torches, solder, flux, fire extinguisher, pipe sections, selection of pipe fittings, abrasive cloth, inside/outside reamers, inside/outside wire brushes, wet rags, pipe cutters, reamers (inside/outside), student work-station jigs. Work-station jigs to hold a section of copper pipe for sweating may be as simple as a four-by-four with pipe diameter holes drilled in to it.
RESOURCES:	Text and on-line step-by-step and video web sites. NABCEP text: pages 90-93.

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE: **SYSTEM DRY FITTING**

SH MODULE: **MODULE #4: SH SYSTEMS & INSTALLATION**

OBJECTIVES: Understanding selected direct system circuits and components.
Building a system using a drawing/diagram as a reference.

DURATION: Hour.

INTRODUCTION: Solar heating installers must understand system (piping) circuits and related component parts. Also, while many installations today involve “plug-and-play” systems, installers must be familiar with installations built from individual component parts. Installers must be able to interpret a system diagram (drawing).

SEQUENCE:

1. Review system diagrams in texts, references, solar heating modules. Review plumbing symbols in text. Discuss differences between pictorial (pictograph) drawings and those using ASHREE/other plumbing symbols (logograph).
2. Organize students into crews, including crew leader.
3. Provide crews with separate and different direct system diagrams.
4. Instruct students to dry fit systems using supplied pipe and component parts.
5. Crews describe completed systems to class, discussing over function and purposes of component parts.

MATLS/EQUIP: Selection of drawings/diagrams of selected direct systems.
Pipe lengths and component parts (ball valves, check valves, bends, tees, etc.) organized by crew for dry fitting.

RESOURCES: “Progressivetube” diagrams are useful and available on various websites: “Progressive Tube Plumbing Diagrams” at <http://www.tctsolar.com/> under “Technical Resources: Spec Guide”,
Also at <http://www.contractorsinstitute.com/> under “Files, Forms, and Templates Download Section”, then click on “Solar” file, then open “Contractor’s Domestic Hot Water Educational PDF’s, lastly open “Solar Domestic Hot Water”.

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE:	SYSTEM INSTALLATION INDIRECT - PRESSURIZED SYSTEM INSTALLATION DRAIN BACK SYSTEM INSTALLATION THERMOSYPHON SYSTEM INSTALLATION
SH MODULE:	MODULE #4: SH SYSTEMS AND INSTALLATION
OBJECTIVE:	Participate in the installation of a working SH closed loop, pressurized system. Additional or alternative participation in the installation of a working SH drain back system, and/or thermosyphon system.
DURATION:	Fifteen hours per install, approximately
INTRODUCTION:	Engaging students in an actual install requires hours of advance organization. Everything must be in place, safe, and at ready. Short course (weekend) instructors may opt to work with solar heating trainers (Heliodyne, Lab-Volt, Hampden, etc.). 40-to-50 hour course instructors may opt to use both trainers and actual installations – often depending on overall student experience. An installation with 70%-30% inexperienced to experienced student crews of 4 to 8 should take approximately 15 hours. This timeline allows for short, on-the-spot instructor demonstrations and discussions. Three-unit semester (105-135 hour classes) should be organized for students to experience 2 to 4 different installations. This activity calls for a complete kit of system parts and a “roof” suitable for the installation of the system, hard hats, tool bags and carts – everything necessary for a working installation. It is important that the instructor have the support of a laboratory technician and/or co-teacher. Students working above 6 feet should have passed OSHA 10, but the solar instructor must provide safety/procedural instructions regarding ladders, personal fall protection (nets, railings, harnesses, etc) prior to installations. Short term courses may use a “roof” less than 6 feet tall – it poses plumbing problems on systems such as drain backs, but effective learning can result if organized properly.
SEQUENCE:	Actual installations follow instruction on system types and component parts, tool use/safety, fall protection, and advisedly hands-on experience (collector tilt analysis, system pressure testing, etc)using trainers. Internet/manufacture installation videos are very helpful in terms of establishing a process of work or

sequence of events (example: locate rafters, layout roof penetrations, etc).

Adult students are typically quick to understand safety concerns and installation sequences. They should already be familiar with the installation laboratory setting, where equipment, components, and tools are stored. They form crews, hold “tailgate meetings” to discuss installation plans and manuals. Time to setup ladders and get to work.

MATLS/EQUIP:

Class Structure: Class size will determine the number of complete system “kits” necessary to conduct this exercise. Large class instructors may have students install two systems (alike or different), or assign a set of students to do the install and other students to engage in a separate activity (examples: sweating pipe, tying knots, constructing roof modules – locating rafters, roof penetration/flashing practice, designing a complete system proposal [three-ring binder] ready for building department [AHJ] approval).

Kits: SH system kits must be established in advance of student installs. Some manufacturers provide comprehensive system kits, largely “plug-and-play” operations. Other manufacturers provide matched collectors, pump stations (or separate pumps and exchangers – like the side-arm heat exchanger), and tanks – but you must organize the balance of the system.

When organizing systems for student installation the instructor must be sure to have more than enough copper tubing and/or line-set on hand. She/he must be certain to have all the necessary “small parts” such as valves, tees, bends, flow gauges, pressure gauges, check valves, clips, and so on. Small items get lost easily. Always have spare compression rings, o-rings, etc. on hand – remember these systems were designed to be installed, period. Students will install/uninstall these systems repeatedly.

Student Crews: Students may be organized in crews, each with a foreperson, etc. The instructor is responsible for organizing crews and advantageously blends experienced and inexperienced students. A single install can have two crews – one to install the collector and related plumbing, the other installs the tank, heat exchanger, pump, etc. Crews switch “roof and basement” assignments on another installation.

RESOURCES:

Text, module, system manufacturer web site and installation publications.
Attachment: “SOLAR THERMAL TRAINING BRIEF: BEST PRACTICES - THE BAG AND THE TRUCK” – ideas from the field on classroom organization.

SOLAR THERMAL TRAINING BRIEF:

BEST PRACTICES -

THE BAG AND THE TRUCK

Tom Chatagnier, Diablo Valley College*
Curt Bradley, Solar Winds
Roger Coghlan, Solar Pirate
Robert Cooley, Heliodyne Inc.
Richard Dahl, Diablo Valley College

The experience of building rooftop solar collector systems, offered to student installers in our first Solar Thermal course offerings, taught us many valuable lessons in tool, equipment, and system component handling.

Our original classroom management discussions included the organization and management of the many hand tools, corded and battery-powered tools, ladders, pipe, pipe fittings, assorted types of mounting rails and associated hardware, safety harnesses, hard hats, and that longer list of tools, materials and supplies called for in code-aligned roof mounted systems.

- Do we develop individual tool sets or team toolboxes?
- Do we inventory (tool/material control) and establish a tool-room (checkout) procedure?
- Do we shadow-mount hand and powered tools on boards or carts?
- Do we number and assign hard hats and harnesses to individual students?

The list of questions grew longer as we closed in on the first day of class, but our confidence level was high and we knew that many best practices would reveal themselves as laboratory and roof-top classes got underway.

The first few rooftop installs proved to be both enjoyable and valuable learning experiences - even exceeding our curricular expectations. Our student groups proved to be highly motivated learners, and understood our first-course management dilemma. Different organizational schemas were attempted, each meeting with mixed results. During our third roof-top install the answer became crystal clear.

The answer was not only clear but staring right at us – in the parking lot.

Ask yourself the question, “What does a solar collector installer take with her/him to the job site?” Answer, “He/she drives to the site in a service/field truck, loaded with equipment and supplies.” And, when the installer leaves the truck to walk onto the site, she/he carries a tool bag with commonly required tools and component parts.

THE BAG. The tool bag contains all hand and power tools required to minimize time and energy wasting trips up and down the ladder, and to-and-from the truck. Depending on its size, the bag, or a second bag, contains all mounting and system installation hardware and supplies required by the job.

Currently, our tool bag contains all commonly used tools required for the installation of the day. We provide one tool bag for each group of student installers (four-to-six people per bag). Why a tool “bag”? A hard plastic or metal tool box may slide off of a steep roof, and we prefer that inexperienced student-installers not wear a tool belt – from which heavy metal objects may fall and hit glazed collectors. Bags come in many styles (some installers prefer “alligator mouth” bags that “balloon-out and stick” on sloped roofs). We are using an electrician’s style bag as it has many individual “slots” built-in, making the missing tool stand out upon bag check-in.

THE TRUCK. The field truck carries ladders, personal safety equipment, hand and power tools, equipment and supplies for the installation job, and everything else that experience - largely built upon things gone wrong and unexpected install requirements – has proven necessary to get the job done on-time and on-budget.

The “truck” in our classroom setting is morphing into a variety of four-wheeled carts with various sized steel bins and drawers. Initial plans call for separate photovoltaic (PV) and solar thermal “trucks”. The PV truck will clearly carry items required in collector mounting, combiner box, inverter, meter, switch and breaker installations. Similarly the solar thermal truck will carry items required in collector mounting, plumbing, storage and expansion tank, heat exchanger, and controller installations. Clearly all trucks will be in use on one of our combined photovoltaic and solar thermal installation days.

“Trucks” will be inventoried and stocked with parts and supplies by staff prior to a class installation. Student installers will be responsible for checking consumables against the day’s assignment, and fitting out their truck with required equipment (ladders, extension cords, drill motors, fill hose, torches, etc.). Requiring students to carefully review all tools, equipment and supplies against installation requirements develops job-specific critical thinking skills and establishes a skill-set/habit clearly embraced by employers in the field.

Our end-of-semester analysis of bags and trucks highlights two wins. First, we have a clear classroom management system that meets our inventory control needs. Second, we are using a management strategy which emulates site installation parameters for the student-installer. Bags and trucks serve to prepare solar system installers with easily transferable skills to the workplace.

* Diablo Valley College, Pleasant Hill, California, offers associate degree and certificate courses in photovoltaics, solar thermal, and photovoltaics and solar thermal installation. Photovoltaic courses are NABCEP approved.

Appendix E

Module 5: Supporting Materials

Multimeter Applications Activity Sheet

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE:	MULTIMETER APPLICATIONS
SH MODULE:	MODULE #5: SH OPERATION, MAINTENANCE & TROUBLESHOOTING
OBJECTIVE:	Understand solar heating applications of the multimeter for testing and troubleshooting.
DURATION:	Half hour demonstration, then ongoing student use.
INTRODUCTION:	Multimeters measure alternating current (AC) and direct current (DC) voltages and resistance – two features important to SH installers. Both analog (meter) and digital (display) multimeters are available. Installers commonly use multimeters to test line voltage (AC pumps & controllers) and resistance in ohms (DC sensor/thermistor resistance).
SEQUENCE:	Installers must be able to use a multimeter to perform a minimum of three functions: (1) test for voltage, (2) test for continuity, and (3) test for resistance. Begin with explanation of electricity safety, meter care, meter settings, internal battery, leads, and zeroing-out meters for resistance function. 1. Test for Voltage. Select AC or DC voltage setting and range. Low voltage: Touch negative probe to known ground, touch positive lead to wire you are testing. Note reading. High voltage: Touch negative probe to neutral wire – carefully. Touch positive lead to hot wire – safely. Note reading. 2. Test for Continuity. A “closed circuit” allows electricity to flow through it. This circuit has “continuity”. An “open circuit” has a break or very high resistance in the circuit. This circuit has no continuity. Installers test for continuity to know if a circuit is open or closed. Test begins by turning power off to the circuit – power in a circuit when testing for continuity can ruin the meter. Select resistance setting. Zero out analog meter. Touch probes across component or section of circuit to be tested. Read meter. Low resistance (low meter reading) = continuity. High resistance or “infinity” reading = no continuity. 3. Test for Resistance. Resistance, “ohms”, indicates how much the component or circuit resists current (flow of electrons). Test begins by turning power off to the circuit – power in a circuit when testing for continuity can ruin the meter. Select resistance setting. Zero out analog meter. Touch probes across component or section of circuit to be tested. Read meter. Compare to expected and/or manufacturer spec. If a thermistor, compare reading to expected resistance and/or thermistor resistance chart. Note: When testing keep fingers away from probes (increases resistance). If a component, disconnect from circuit whenever possible prior to testing.

MATLS/EQUIP: Multimeter, leads, thermistor selection, solid and multi-strand copper wire selection, SH trainers.

RESOURCES: Text, various web sites.
 NABCEP pages: 109-110, 120-122, 132-133
 Nice two-page multimeter handout on web (Crutchfield Corp)
 <http://a248.e.akamai.net/pix.crutchfield.com/ca/learningcenter/car/pdfs/000MULTI2.pdf>

Appendix F

Module 6: Supporting Materials

Solar Heating Design Project Activity Sheet

SOLAR HEATING ACTIVITY SHEET

Hands on learning activities related to the solar heating curriculum.

TITLE: **SH DESIGN PROJECT**

SH MODULE: **ADVANCED PROJECT: RELATES TO ALL MODULES**

OBJECTIVE: Activity for the advanced student to prepare a comprehensive, Authority Having Jurisdiction – ready solar heating design proposal. This activity is optional only, and not a normal activity in the forty-eight hour introductory course.

DURATION: Out-of-class time activity. Course project in long-term class (semester).

INTRODUCTION: A comprehensive report must be completed as a prerequisite to obtaining a solar heating building permit from the Authority Having Jurisdiction (AHJ). While report organization and contents may vary amongst AHJ's in different geographical regions, the elements of this assignment should cover the majority of AHJ requirements.

SEQUENCE: Assignment. Consultations.

1. Estimate hot water use in your/subject home. Estimate KWH/Therms used to heat water used. **CALCULATE SOLAR FRACTION. SIZE your/subject system. USE SOLAR FRACTION TO ESTIMATE KWH/THERM DIFFERENTIAL/SAVINGS.**
2. Make a **BASIC SITE DIAGRAM** of the property. Include trees and other objects that would shade the collector/array. Include a **GOOGLE EARTH PRINTOUT** of your/subject property.
3. Do a **SITE EVALUATION** incorporating the Solar Path Finder. Determine **ROOF ORIENTATION AND SLOPE.**
4. **SELECT AN OG-300 SYSTEM TYPE** (drain back, closed-loop glycol, other).
5. **SELECT AND LIST COLLECTOR TYPE AND MAJOR B.O.S. COMPONENTS.**
6. Complete a **BASIC SITE DIAGRAM.** Include locations of collector, tank, heat exchanger (if included), and drain back tank (if included).
7. Complete a **SINGLE LINE DRAWING** (logograph or pictograph) including all equipment, plumbing components, pipe, and wire for your/subject S.H.W. system.
8. Include a **SYSTEM OG-300 SHEET AND MANUFACTURER CUT SHEETS** for the collector(s), controller, storage tank(s), pump (if separate from appliance), heat exchanger/appliance, expansion tank (if used), and drain back tank (if used). Include **MSDS SHEETS** for glycol (if used) and roof calking.

MATLS/EQUIP: Computer with Internet access, printer, etc. Prerequisite: Completed introductory SH course or equivalent. Solar PV and/or SH experience desirable.

RESOURCES:

Internet access key to assignment. Draws on student learning from entire course. End product typically presented in binder. Includes everything required by AHJ (permitting) and more.

Appendix G

Module 7: Optional Module

Module 7: Solar Incentives and Marketing

SOLAR INCENTIVES AND MARKETING

Time: 120 minutes

Learning Activity 1

Discussion Points

Logistics



PowerPoint Presentation

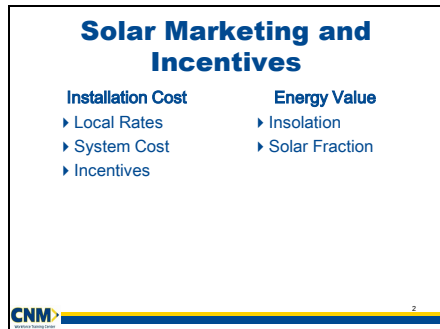


Slide 1

Instructor/Trainee Activities

This module is designed for the use of an accompanying PowerPoint presentation. If you choose not to use PowerPoint, then please have facilitator information charts ready for some activities.

Slide 1 should be available to view prior to participants entering the room.



Slide 2

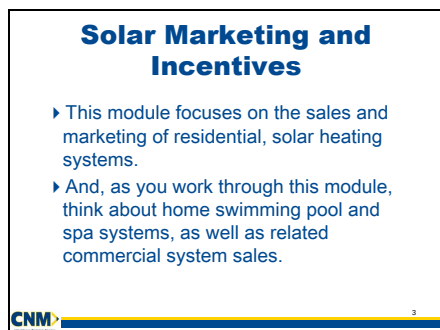
Reveal Slide 2.

Explain that sales and marketing topics are not indicated as a part of the NABCEP entry level solar heating examination. Students interested in sales and marketing, however, are often enrolled in entry level solar heating classes.

Note that this module should only be considered as a very basic overview of solar sales and marketing. It may be used in all or part at the instructor's discretion.

The decision to purchase and install a solar heating system is a multifaceted decision. The “balancing act” between cost and return, or return on investment (ROI) involves factors such as those listed on this slide.

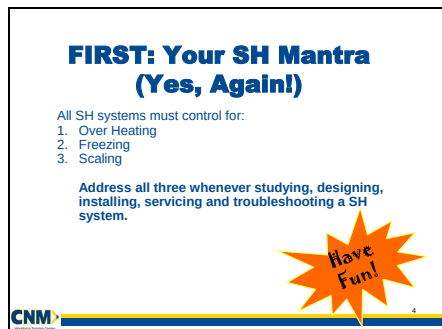
Ask: Can you identify additional ROI factors?



Slide 3

Reveal Slide 3.

Explain that sales and marketing topics are not indicated as a part of the NABCEP entry level solar heating examination. Students interested in sales and marketing, however, are often enrolled in entry level solar heating classes. This module should only be considered as a very basic overview of solar sales and marketing. It may be used in all or part at the instructor's discretion.



Slide 4

Reveal Slide 4.



Slide 5

Reveal Slide 5.

Explain that "Financial Incentives" cover a huge amount of territory, vary by state, vary by regions within the state, vary by utility, and vary by system type.

Review DSIRE web site in class.

Provide Additional Examples:

Corporate Tax Credit Advanced Energy Tax Credit (Corporate)

Agricultural Biomass Income Tax Credit (Corporate)

Geothermal Heat Pump Tax Credit (Corporate)

Renewable Energy Production Tax Credit (Corporate)

Sustainable Building Tax Credit (Corporate)

Industry Recruitment/Support Alternative Energy Product Manufacturers Tax Credit

PACE Financing Local Option - Renewable Energy Financing District/Solar Energy Improvement Special Assessments

Performance-Based Incentive El Paso Electric Company - Small and Medium System Renewable Energy Certificate Purchase Program

	<u>PNM - Performance-Based Solar PV Program</u> <u>Xcel Energy - Solar*Rewards Program</u> Personal Tax Credit <u>Advanced Energy Tax Credit (Personal)</u> <u>Agricultural Biomass Income Tax Credit (Personal)</u> <u>Geothermal Heat Pump Tax Credit (Personal)</u> <u>Renewable Energy Production Tax Credit (Personal)</u> <u>Solar Market Development Tax Credit</u> <u>Sustainable Building Tax Credit (Personal)</u> Property Tax Incentive <u>Property Tax Exemption for Residential Solar Systems</u> Sales Tax Incentive <u>Advanced Energy Gross Receipts Tax Deduction</u> <u>Biomass Equipment & Materials Compensating Tax Deduction</u> <u>Gross Receipts Tax Exemption for Sales of Wind and Solar Systems to Government Entities</u> <u>Solar Energy Gross Receipts Tax Deduction</u> State Bond Program <u>Energy Efficiency & Renewable Energy Bond Program</u> State Loan Program <u>Drinking Water State Revolving Loan Fund</u> Utility Rebate Program <u>Central New Mexico Electric Cooperative - Residential Energy Efficiency Rebate Program</u> <u>El Paso Electric Company - Commercial Efficiency Program</u> <u>El Paso Electric Company - Residential Efficiency Program</u> <u>El Paso Electric Company - SCORE Plus Standard Offer Program</u> <u>New Mexico Gas Company - Commercial Efficiency Programs</u> <u>New Mexico Gas Company - Residential Efficiency Programs</u> <u>PNM - Commercial Energy Efficiency Rebate Program</u> <u>PNM - Energy Star Home Builder Rebate Program</u> <u>PNM - Residential Energy Efficiency Rebate Program</u> <u>Xcel Energy (Electric) - Commercial Energy Efficiency Rebate Program</u>
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	<u>Xcel Energy - Residential and Low Income Home Energy Service</u>
MODULE #7 : TOPICS - Solar Marketing and Incentives ▶ Tax Credits and Utility Incentives ▶ Solar Funding ▶ Solar Marketing and Sales ▶ This module focuses on residential flat plate systems. CNM Slide 6	Reveal Slide 6. Review Energy Savers (government) web site in class. http://www.energy savers.gov/your_home/water_heating/index.cfm/mytopic=13230w.harveysph.com/solar-thermal.php
Tax Credits and Utility Incentives ▶ NREL: Technical Report ▶ "Break-even Cost for Residential Solar Water Heating in the United States" ▶ This paper examines the break-even cost for residential rooftop solar water heating (SWH) technology, defined as the point where the cost of the energy saved with a SWH system equals the cost of a conventional heating fuel purchased from the grid (either electricity or natural gas). ▶ http://www.nrel.gov/docs/fy11osti/48986.pdf CNM Slide 7	Reveal Slide 7. Review NREL Technical Report NREL/TP-6A20-48986 February 2011 (NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.) http://www.nrel.gov/docs/fy11osti/48986.pdf Explain that BREAKING EVEN is often a huge consideration for solar heating system buyers. This NREL report is significant in scope and definitely worth a close look as it includes a review of solar incentives, tax breaks, utility costs, geographical features, and the like.. Many nice graphic illustrations. The Southwest 'resource' noted above is solar fraction.

	Review conclusion from “Break-even Cost for Residential Solar Water Heating in the United States: Key Drivers and Sensitivities” <i>“We evaluated the break-even price for residential SWH customers in the United States and found that the current break-even price varies by more than a factor of five even though the amount of energy produced varies by less than a factor of two. This difference is largely driven by incentives, which can exceed \$3,000/system, and the difference in electricity or natural gas prices, which can vary by a factor of four. Even without incentives, large variations in break-even cost will remain given the range of hot water usage and solar energy available. The general trend observed in this analysis is that SWH systems that replace conventional electric systems are more likely to achieve break-even costs than SWH systems replacing conventional natural gas systems. Break-even conditions appear first in the Southwest where they are driven by resource and in the Northeast where they are driven by high electricity prices. As SWH system prices continue to decline, break-even conditions begin to occur in the Southeast and Midwest. Very low electricity and natural gas prices will preclude break-even conditions in certain areas in the Northwest and Midwest even with SWH prices at \$3,000/system and a continuation of the federal ITC.</i> <i>Overall, the scenarios evaluated represent a market entry point for SWH. However, the scenarios do not consider the potential for a deep, sustained market. Therefore, caution must be used when considering this analysis. SWH break-even does not imply that customers will necessarily adopt SWH, and only a fraction of customers in each utility will have the necessary combination of good solar access and attractive financing options. A true depth or market analysis is required to determine a “demand curve” for SWH at various price points. This must be combined with analysis of commercial buildings to provide an estimate for the market potential of rooftop SWH. “</i>
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Tax Credits and Utility Incentives

- ▶ Federal Technology Alert (FTA)
- ▶ U.S. Department of Energy, Federal Energy Management Program
- ▶ New Technology Demonstration Program
- ▶ "Solar Water Heating"

http://www1.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf

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Reveal Slide 8.

Review the Federal Technology Alert.

The U.S. Department of Energy's Federal Energy Management Program (FEMP) is sponsoring a series of programs to reduce energy consumption at Federal installations nationwide. One of these programs, the New Technology Demonstration Program (NTDP),

Explain that this is another nice example of justifying the installation of a solar heating system based on a cost-benefit analysis.

Pages 34 -35 provide a nice example of a system design worksheet.

"Solar Water Heating"

This FTA describes the main types of solar water-heating systems available and discusses some of the factors that make the various types more or less appropriate for particular situations. It also points out the types of situations where solar water heating is most likely to be cost effective and gives examples for each of those situations.

http://www1.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf

Reveal Slide 9.

Explain:

MAJOR SOURCE FOR NM SOLAR TAX CREDITS
By statute (Sections 9-5A-1 through 7, NMSA 1978), the New Mexico Energy Conservation and Management Division (ECMD) "shall plan, administer,

New Mexico Tax Credit

- ▶ **New Mexico's Solar Tax Credit**
- ▶ Solar Market Development Tax Credit
- ▶ Frequently Asked Questions

- ▶ Federal Tax Credits for Consumer Energy Efficiency

- ▶ Solar Statutes
- ▶ Solar Rights Act [Sections 47-3-1 to -5 NMSA 1978]

- 2007 Legislative Amendments to the Solar Rights Act of 1978
 - Solar Rights Act brochure
 - Solar Rights Declaration form
 - Solar collector definitions and restrictions



<http://www.emnrd.state.nm.us/main/index.htm>

<http://www.emnrd.state.nm.us/ECMD/RenewableEnergy/solar.htm>

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review, provide technical assistance, maintain records and monitor state and federal energy conservation and alternative energy technology programs." Included are programs related to the development and use of solar, wind, geothermal, and biomass resources as well as alternative fuels and transportation. In addition, this division provides technical assistance and information in these areas to government agencies, Indian tribes and pueblos, educational institutions, and the general public. ECMD receives U.S. Department of Energy funding support through its State Energy Program (SEP) to accomplish our division's clean energy goals.

Review:

<http://www.emnrd.state.nm.us/ECMD/RenewableEnergy/solar.htm>

New Mexico's Solar Tax Credit

Solar Market Development Tax Credit

Solar Gross Receipts Tax Exemption

Frequently Asked Questions

Testimonials from several who have benefited from New Mexico's Solar Tax Credit

Federal Tax Credits for Consumer Energy Efficiency

Solar for Schools - ARRA-funded \$4.5 million initiative

Solar Statutes

Solar Rights Act [Sections 47-3-1 to -5 NMSA 1978]

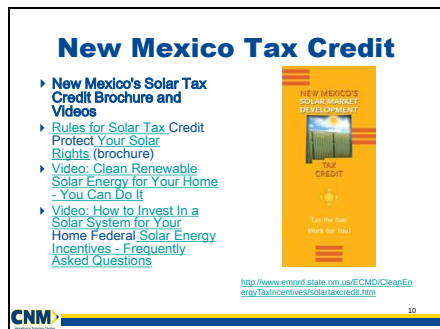
2007 Legislative Amendments to the Solar Rights Act of 1978

Solar Rights Act brochure

Solar Rights Declaration form

Solar collector definitions and restrictions

<http://www.emnrd.state.nm.us/main/index.htm>



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Reveal Slide 10.

Review brochure:

<http://www.emnrd.state.nm.us/ecmd/Multimedia/images/STC-1.jpg>

Show videos

(“buttons” listed on web site under subheading “Additional Information”)

<http://www.emnrd.state.nm.us/ecmd/Multimedia/images/STC-1.jpg>



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Reveal Slide 11.

Explain that DSIRE is a comprehensive source of information on state, local, utility and federal incentives and policies that promote renewable energy and energy efficiency. Established in 1995 and funded by the U.S. Department of Energy, DSIRE is an ongoing project of the N.C. Solar Center and the Interstate Renewable Energy Council.

<http://www.dsireusa.org/>

New Mexico Tax Credit

- ▶ **State Bond Program**
- ▶ **State Loan Program**
- ▶ **Utility Rebate Program**
 - Central New Mexico Electric Cooperative - Residential Energy Efficiency Rebate Program
 - El Paso Electric Company - Commercial Efficiency Program
 - El Paso Electric Company - Residential Efficiency Program
 - El Paso Electric Company - SCORE Plus Standard Offer Program
 - New Mexico Gas Company - Commercial Efficiency Programs
 - New Mexico Gas Company - Residential Efficiency Programs
 - PNM - Commercial Energy Efficiency Rebate Program
 - PNM - Energy Star Home Builder Rebate Program
 - PNM - Residential Energy Efficiency Rebate Program
 - Xcel Energy (Electric) - Commercial Energy Efficiency Rebate Program
 - Xcel Energy - Residential and Low Income Home Energy Service

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Show <http://www.dsireusa.org/>

Federal Tax Credit

- ▶ A federal tax question and answer link:
http://www.emnrd.state.nm.us/ECMD/CleanEnergyTaxIncentives/documents/SEIATaxManual_v3-0_FAQ.pdf
- ▶ Addition federal tax credit information:
<http://energy.gov/>
- ▶ Interactive tool:
<http://energy.gov/savings>

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Reveal Slide 13.

Discuss

A convenient link to federal tax incentive information -
http://www.emnrd.state.nm.us/ECMD/CleanEnergyTaxIncentives/documents/SEIATaxManual_v3-0_FAQ.pdf

Demonstrate interactive tool.

<http://energy.gov/>

<http://energy.gov/savings>

State and Federal Tax Credit Processing

- ▶ A "Checklist" is included in the "Solar System Certification Application" on the New Mexico Energy Conservation and Management Division web site
 - [Solar System Certification Application](#)
 - [Solar System Installation Form](#)
 - [Taxpayer and Contractor Statement of Understanding](#)
 - [Photovoltaic List Form](#)
 - [Solar Thermal List Form](#)
 - [Solar Market Development Income Tax Credit Claim Form RPD 41317](#)
 - [Solar Federal Form 5695 - Residential Energy Credits](#)



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Reveal Slide 14.

Review forms. The following forms are available at <http://www.emnrd.state.nm.us/ecmd/Multimedia/images/STC-1.jpg>

PACE Financing

- ▶ PACE (Property-Assessed Clean Energy) Financing Property-Assessed Clean Energy (PACE) financing effectively allows property owners to borrow money to pay for energy improvements.
- ▶ The amount borrowed is typically repaid via a special assessment on the property over a period of years.
- ▶ In 2009 New Mexico enacted two separate bills -- S.B. 647 and H.B. 572 -- authorizing local governments to offer these types of programs.



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Reveal Slide 15.

Explain that Property-Assessed Clean Energy (PACE) financing effectively allows property owners to borrow money to pay for renewable energy and/or energy-efficiency improvements. The amount borrowed is typically repaid via a special assessment on the property over a period of years. In general, local governments (such as cities and counties) that choose to offer PACE financing must be authorized to do so by state law.

PACE (Property-Assessed Clean Energy) financing is worthy of mention as it is available in some areas of New Mexico.

http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NM28F

Review: http://en.openei.org/wiki/PACE_Financing (Scroll down through list to review New Mexico listing) The original PACE model began in Berkeley, California, allowing property owners to "borrow" against their property taxes to finance a solar system. The loan is repaid annually via an increase in individual property taxes. The increased tax stays with the property (even if the owner/buyer sells the property and moves on) until the loan is paid in full.

Solar Funding

Paying for Your New Solar System – Examples:

- ▶ Lease
- ▶ Power Purchase Agreement (PPA) Monthly
- ▶ Power Purchase Agreement (PPA) Prepay
- ▶ Lines of Credit and Loans

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Reveal Slide 16.

Explain that similarly to housing finance options, solar systems are financed in a variety of ways – some obvious, others maybe not so obvious.

Lease

The homeowner leases the solar PV equipment—making a low monthly payment for the length of the contract term.

Power Purchase Agreement (PPA) Monthly

The homeowner simply pays each month for electricity generated by the solar system for the length of the contract term.

Power Purchase Agreement (PPA) Prepay

This option on a PPA allows the homeowner to pay the total amount of the contract up front, effectively paying for the energy the system will produce over the course of the contract term.

Lines of Credit and Loans

Solar Home Equity Line of Credit (HELOC) and home improvement loan for homeowners who prefer to own their solar systems.

A few companies offer solar sales professionals, integrators, and installers' access to consumer financing and essential services through easy-to-use software, online solar sales solutions, and tools to help you efficiently manage the entire sales process and offer consumer financing to successfully close more deals.

Stated advantages:

Create branded, custom, signature-ready proposals in minutes

Access continuously-updated utility rates, incentives, and approved solar equipment

Offer multiple competitive consumer financing options

Manage and measure the sales process in real-time

Share and collaborate on proposals, project design, and finance documents.

Solar Funding

► System buyers are often interested in
"The Bottom Line"

Proprietary software programs.
Some siting/sizing tools offer system design
software and cost analysis features.
System manufacturers often include "how much will
it cost" calculators on their web sites,
"F-Chart": comprehensive system analysis and
design software tools used to design solar heating
systems and calculate system costs.

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Example:

Proprietary software programs are available.
Available programs range from free to expensive with
an expectedly wide range of analysis tools.

Some siting/sizing tools (Sun Eye, Pathfinder, etc.)
offer system design software and cost analysis
features.

System manufacturers often include "how much will it
cost" calculators on their web sites.

F-Chart Software has been producing thermal energy
analysis software since 1975. The principals of the
company are faculty members at the University of
Wisconsin. The unusual name of the company is
based on a method developed by the principals that
is widely used for estimating the thermal performance
of solar space and water heating systems. F-Chart
Software has a commitment to education and has
made its software available to the educational
community through academic licenses.

Some online details are available for viewing without
charge at <http://www.fchart.com>
At last look the software was selling for \$400
(individual) and \$600 (academic license).

Solar Marketing and Sales

The Internet is resplendent with colorful and well-
designed examples of solar heating marketing
plied by contractors, solar heating distributors,
and solar marketing companies.

- On-line coupons
- Seasonal sales
- Solar leasing, lease-to-buy, incentive discounts
- Presentation portfolios
- Equipment cut sheets

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Reveal Slide 18.

Explain that a variety of web sites with nice solar
heating marketing examples are listed below.

Explain to students that the examples are for
illustrative purposes only and do not in any way
suggest a company/product preference or
endorsement.

Solar Marketing and Sales

The Internet additionally provides a valuable variety of solar heating sales tools.

- On-line siting and sizing calculators
- Forms: Site evaluation, system check-off sheets, return-on-investment worksheets, system designs (plot-plans, etc.)
- Marketing and sales videos
- Schools, seminars, workshops
- NABCEP “PV Technical Sales: Job Task Analysis”

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Reveal Slide 19.

Explain that a variety of web sites with nice solar heating marketing and sales examples are listed below. Explain to students that the examples are for illustrative purposes only and do not in any way suggest a company/product preference or endorsement.

Heliodyne:

http://www.youtube.com/watch?v=PQm_2lpLUqk

Transsen:

<http://www.youtube.com/watch?v=G28oCvCHZGE>

One example of extensive marketing and sales presentation:

<http://www.slideshare.net/OnGridSolar/solar-sales-marketing>

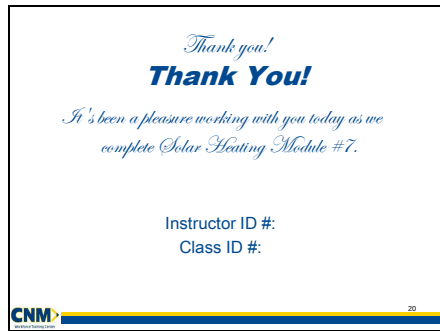
Additionally, while there is no NABCEP Solar Heating certification, the NABCEP “PV Technical Sales: Job Task Analysis” document prepared for PV Technical Sales Certification is available for review at the NABCEP web site.

<http://www.nabcep.org/certification/pv-technical-sales-certification>

The job task analysis, should prove instructive at least in part for individuals seeking direction in Solar Heating sales. It is described as:

“The NABCEP PV Technical Sales Job Task Analysis defines a set of knowledge, skills and abilities typically required of solar PV sales personnel who are responsible for site analysis, system design, ethical presentation, accurate analyses and projections of electrical and financial performance of PV systems.

The JTA is broken into eight major topic areas: Qualify the Customer; Site Analysis; Conceptual Design; Financial Costs, Incentives, and Savings; Financial Benefit Analysis and Financing; Non-financial Benefit Analysis; Performance Analysis; Prepare Proposals”



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Reveal Slide 20.