In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors code/energy** continuing education requirements."

For additional continuing education approvals, please see your credit tracking card.

Solar Ready Building

Jack Kluempke
Solar Business Advisor
Made in Minnesota Solar Incentive Program
Department of Commerce
Division of Energy Resources
Jack.Kluempke@state.mn.us

4811 Miller Trunk Highway
Duluth, MN 55811
218-722-9003

Doug Manthey

Conservation Technologies / Energy Plus

218-722-9003

doug@energy-plus.com

www.conservtech.com

Overview

- The Solar Market
- Types of Solar Systems
- Why Build Solar Ready?
- What is Solar Ready?
- Solar Ready Guidelines
- Resources

Feel free to ask questions as we go.

As a contractor, architect, or building official, why should you be interested in solar?

1. It is becoming more and more common.
2. Given the usable life of a building, it is very likely buildings erected today will have solar installed at some point in the future.
3. Increasingly your customers want it.
4. Add value.
5. Increase your bottom line.

Conservation First

- Well Built – Energy Eff Design
- Appliances – Energy Star at a Minimum
- Lights – LED's

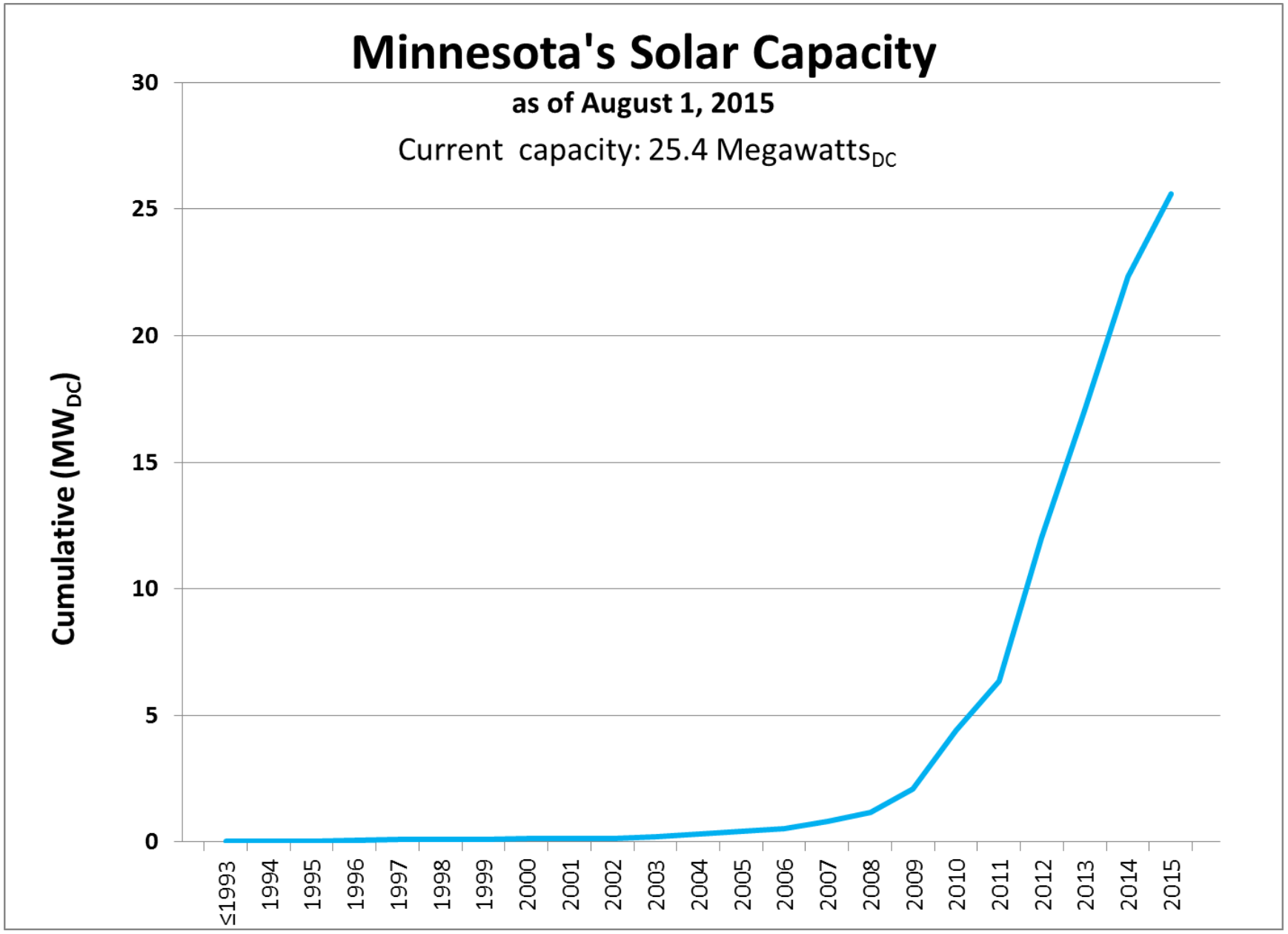
Table 2

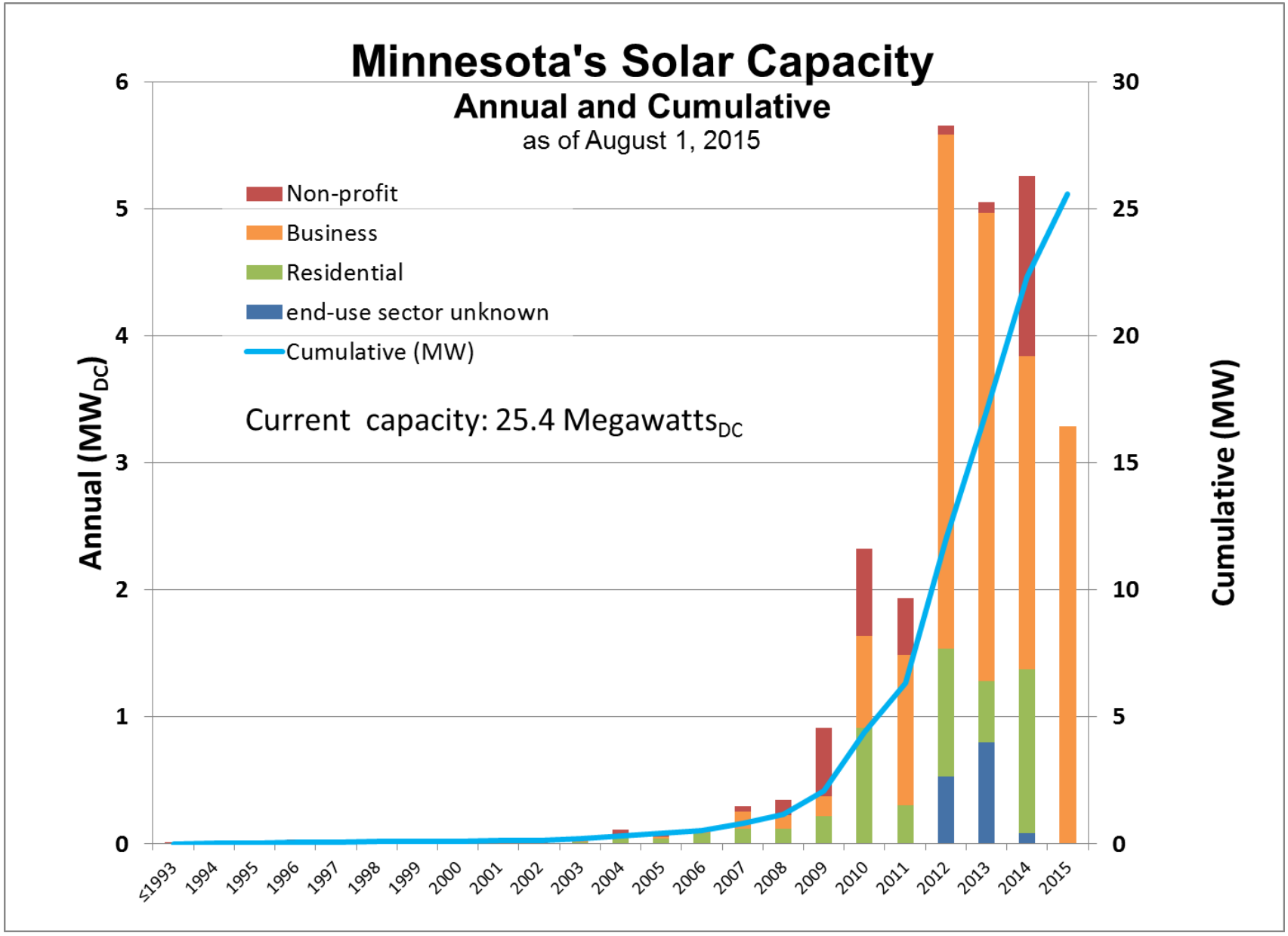
COMPARISON OF CLEAN ENERGY MARKET DEVELOPMENT
Minnesota, 2000-2012

	2000	2012	2000-2012 percent change
Energy Efficiency cumulative savings	9 trillion BTU	56.5 trillion BTU	524%
Bioenergy electricity production	1,320 Thou MWh	1,838 Thou MWh	40%
Installed wind energy capacity	290 MW	3,004 MW	935%
Installed solar energy capacity	118 kW	11,550 kW	9670%
Biofuel (Ethanol) production capacity	220 millions of gallons	1,117 millions of gallons	408%

Comparison of Clean Energy Market Development

	2000	2012	Today
Energy Efficiency Cumulative savings	9 Trillon BTU	56.5 Trillon BTU	
Bioenergy Electricity Production	1,320 Thou MWh	1,838 Thou MWh	
Installed Wind Energy Capacity	290 MW	3,004 MW	3,252 MW
Installed Solar Energy Capacity	118 kW	11,550 kW	25,400 kW
Biofuel (Ethanol) Production Capacity	220 Million gallons	1,117 Million gallons	1000 Million gallons


Minnesota's Solar Capacity
as of August 1, 2015
Current capacity: 25.4 Megawatts$_{DC}$
Cumulative (MW$_{DC}$)
30
25
20
15
10
5
0
≤1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

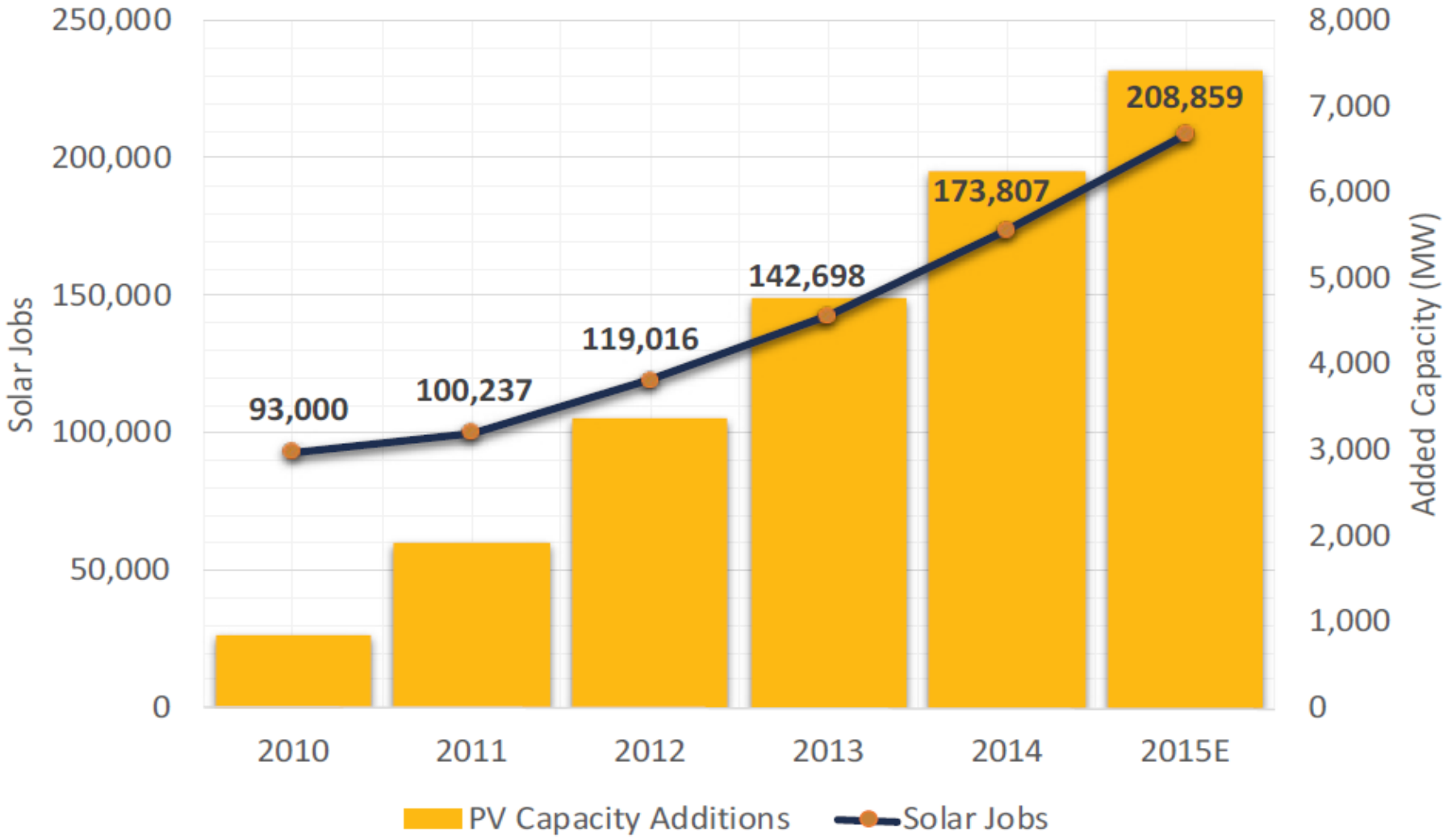

Minnesota's Solar Capacity
Annual and Cumulative
as of August 1, 2015
Non-profit
Business
Residential
end-use sector unknown
Cumulative (MW)
Current capacity: 25.4 Megawatts$_{DC}$
Annual (MW$_{DC}$)
Cumulative (MW)
0
1
2
3
4
5
6
0
5
10
15
20
25
30
≤1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

2020: How many residential systems?

Today: 1,000 residential systems

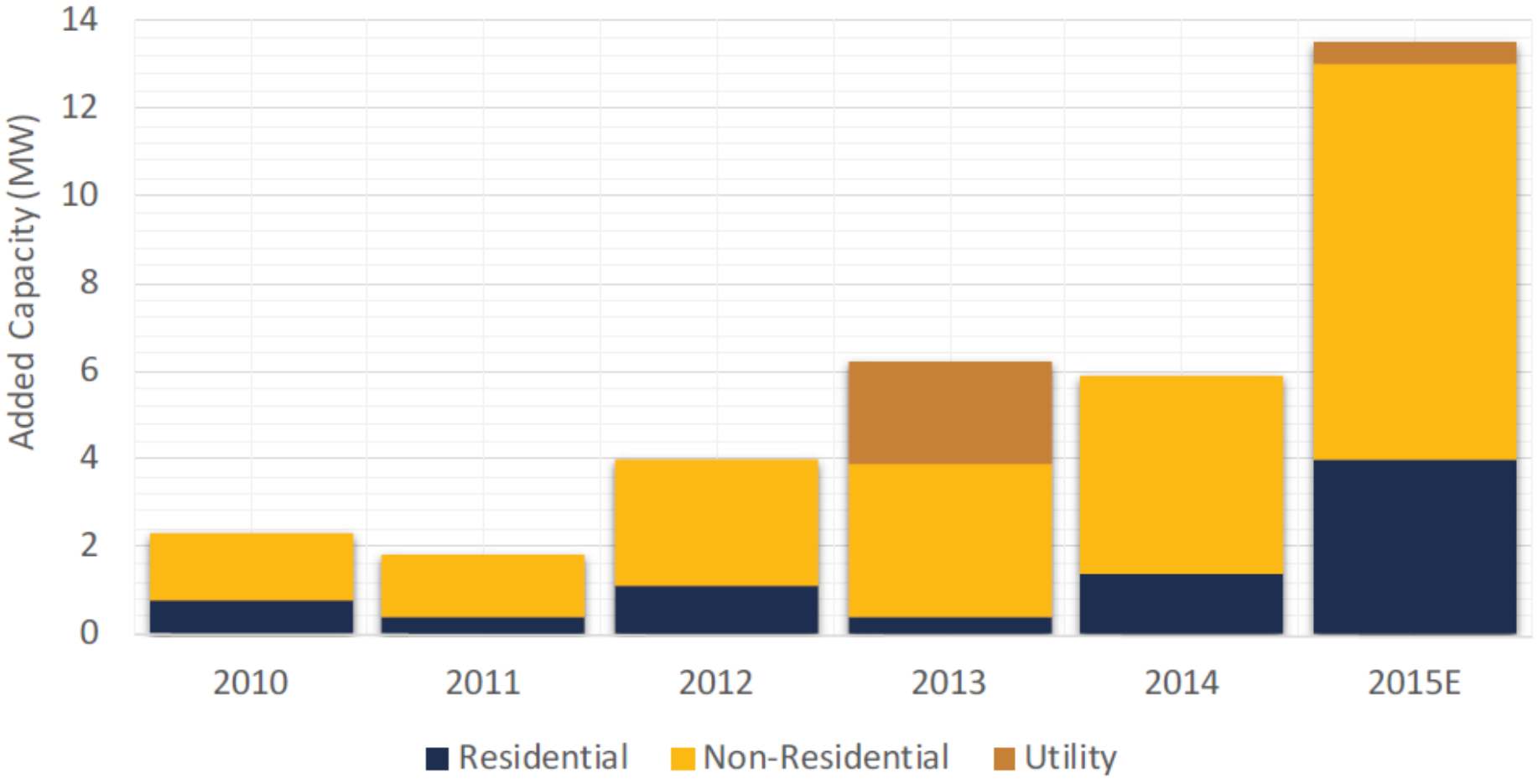
2020: 4,000 residential systems

U.S. PV Capacity Additions & Solar Jobs, 2010 - 2015E



Capacity Data Source: SEIA/GTM Research *Solar Market Insight Q3 2015*

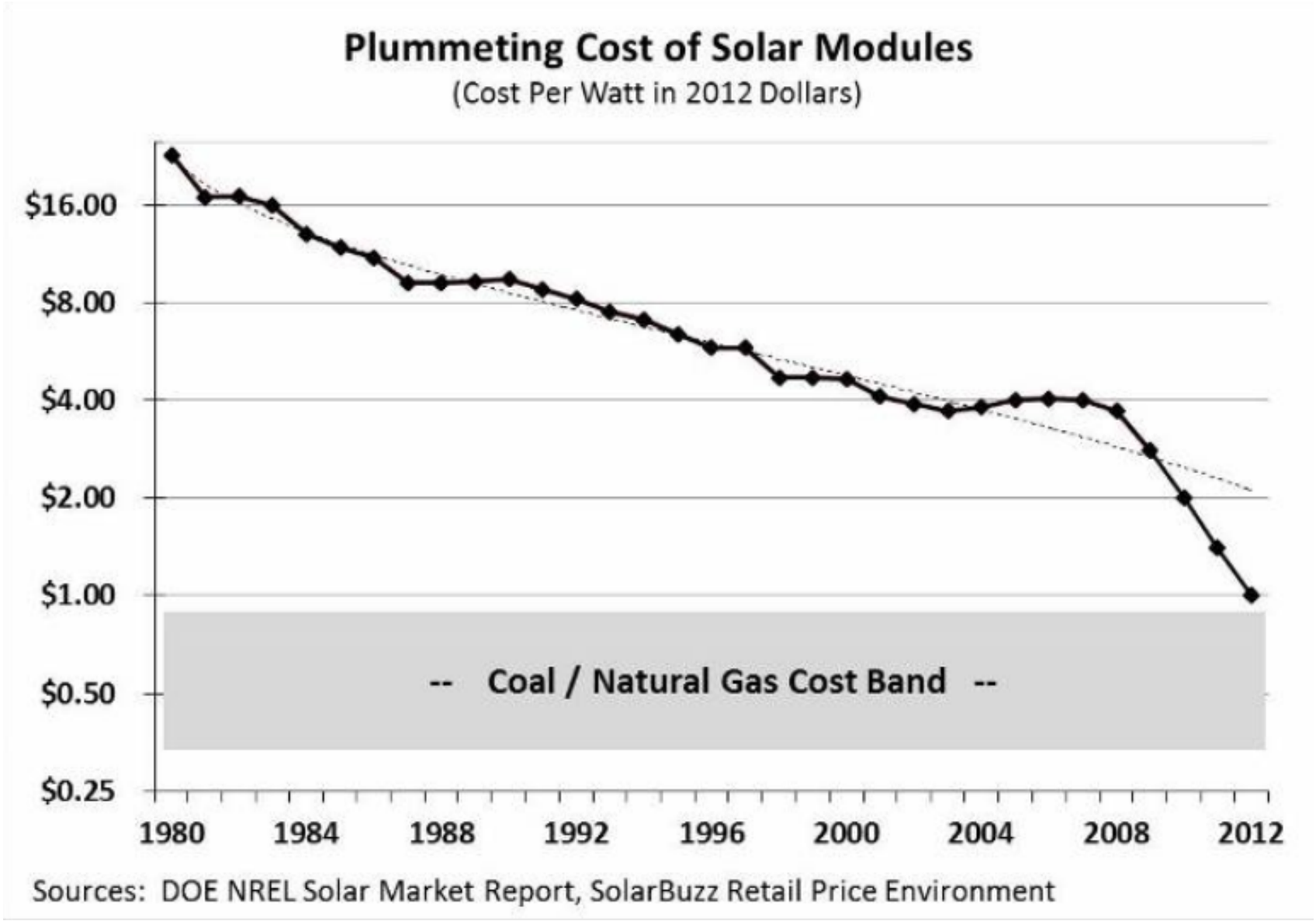
Minnesota Solar Capacity Additions, 2010 - 2015E



Source: SEIA/GTM Research *Solar Market Insight Q3 2015*

Data by Sector—Number of Solar Workers in Minnesota

Sector	2013 Jobs	2014 Jobs	2015 Jobs
Installation	394	508	347
Manufacturing	124	172	348
Sales and Distribution	96	109	949
Project Development	121	179	230
Other*	129	141	120
Total	864	1108	1995


Plummeting Cost of Solar Modules
(Cost Per Watt in 2012 Dollars)
$16.00
$8.00
$4.00
$2.00
$1.00
$0.50
$0.25
-- Coal / Natural Gas Cost Band --
1980
1984
1988
1992
1996
2000
2004
2008
2012
Sources: DOE NREL Solar Market Report, SolarBuzz Retail Price Environment

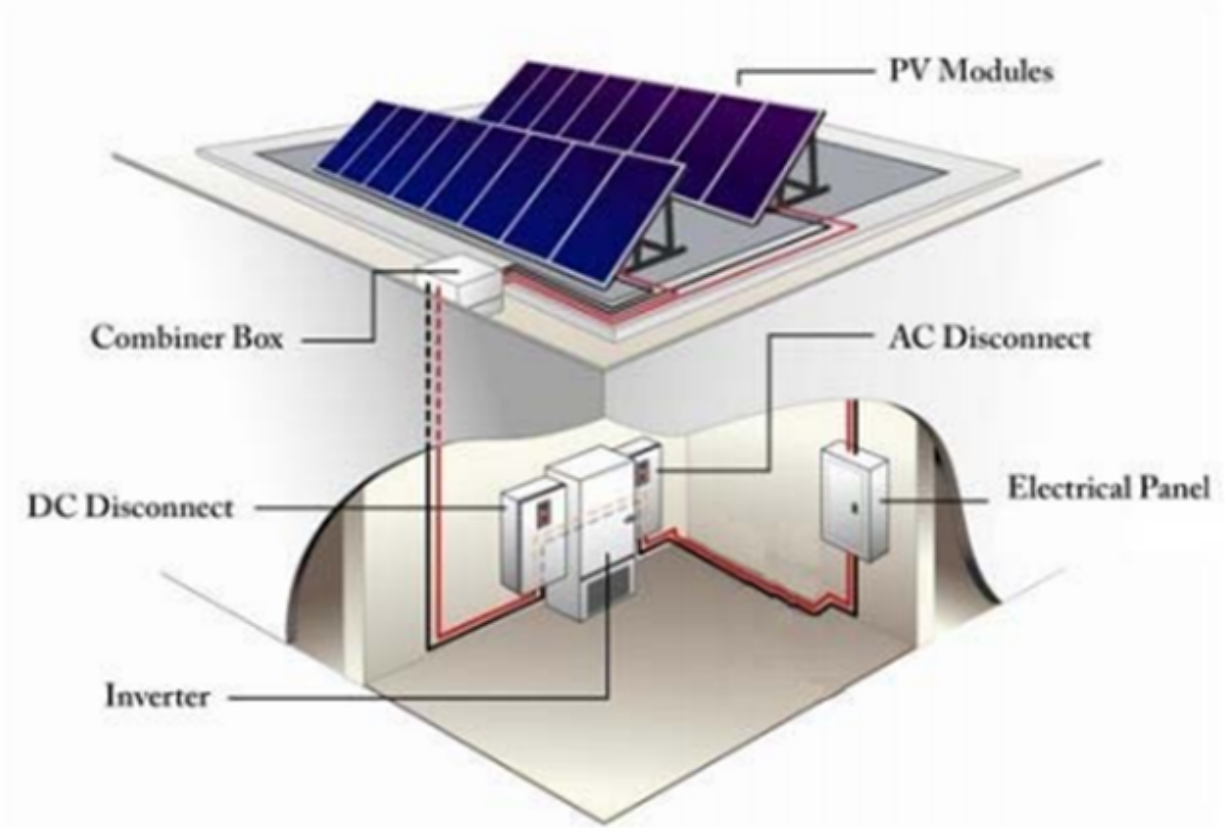
Types of Solar

- Designers and builders need to understand how to tailor a building project to accommodate solar.
- Solar energy systems include active and passive systems; solar electric (PV), solar hot water (SHW), and solar space heating (SHA) are active systems.
- These solar ready guidelines are directed at the solar technology options readily available to Minnesotans today, but keep in mind up and coming technologies.

Photovoltaic (PV)

- PV systems generate direct current (DC) electricity when exposed to sunlight.
- An inverter converts the DC to AC matching the electricity supplied by the grid.
- They generally have no moving parts, require almost no maintenance, and last for decades.

Typical PV system



Solar water heating (SWH)

- These systems are designed to heat hot water for domestic or heating use.
- They can be designed to supply 75% of a household's hot water.
- Typically consist of collectors, a controller, storage tank, and freeze protection.

SHW

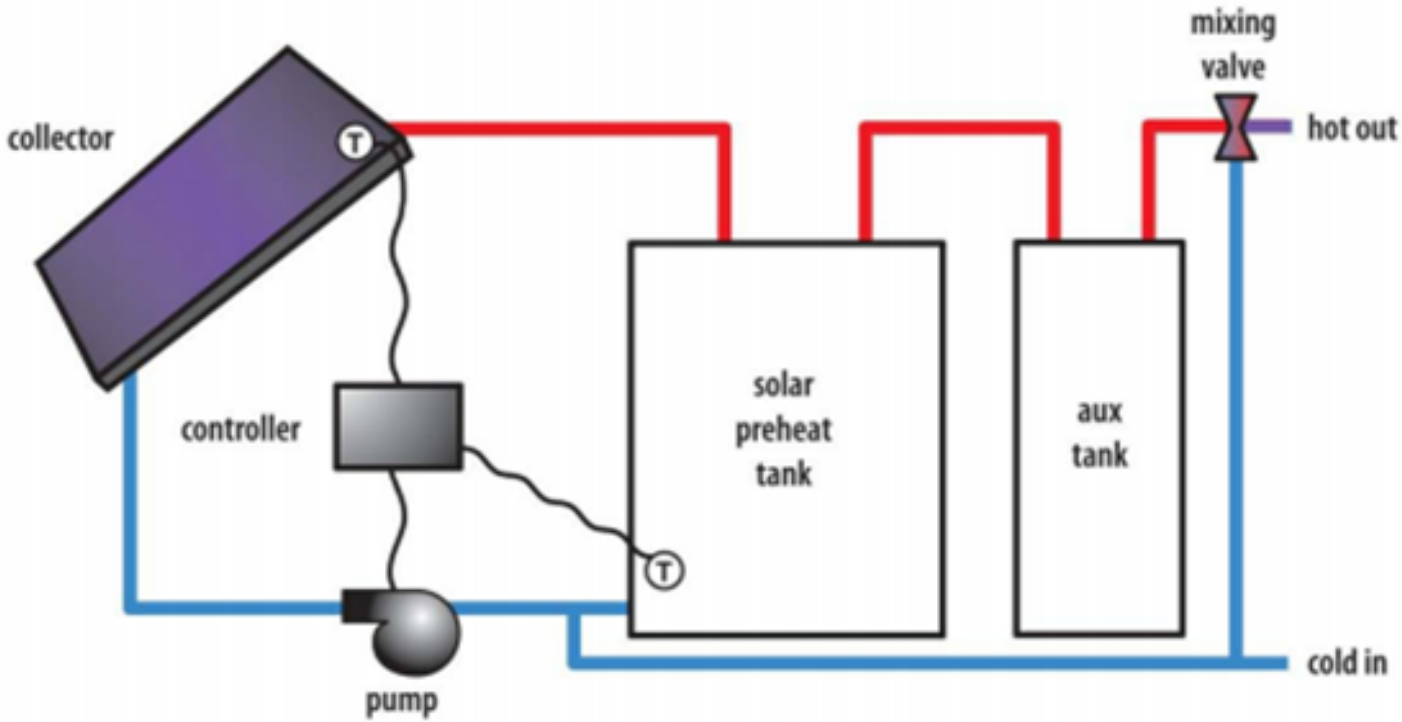
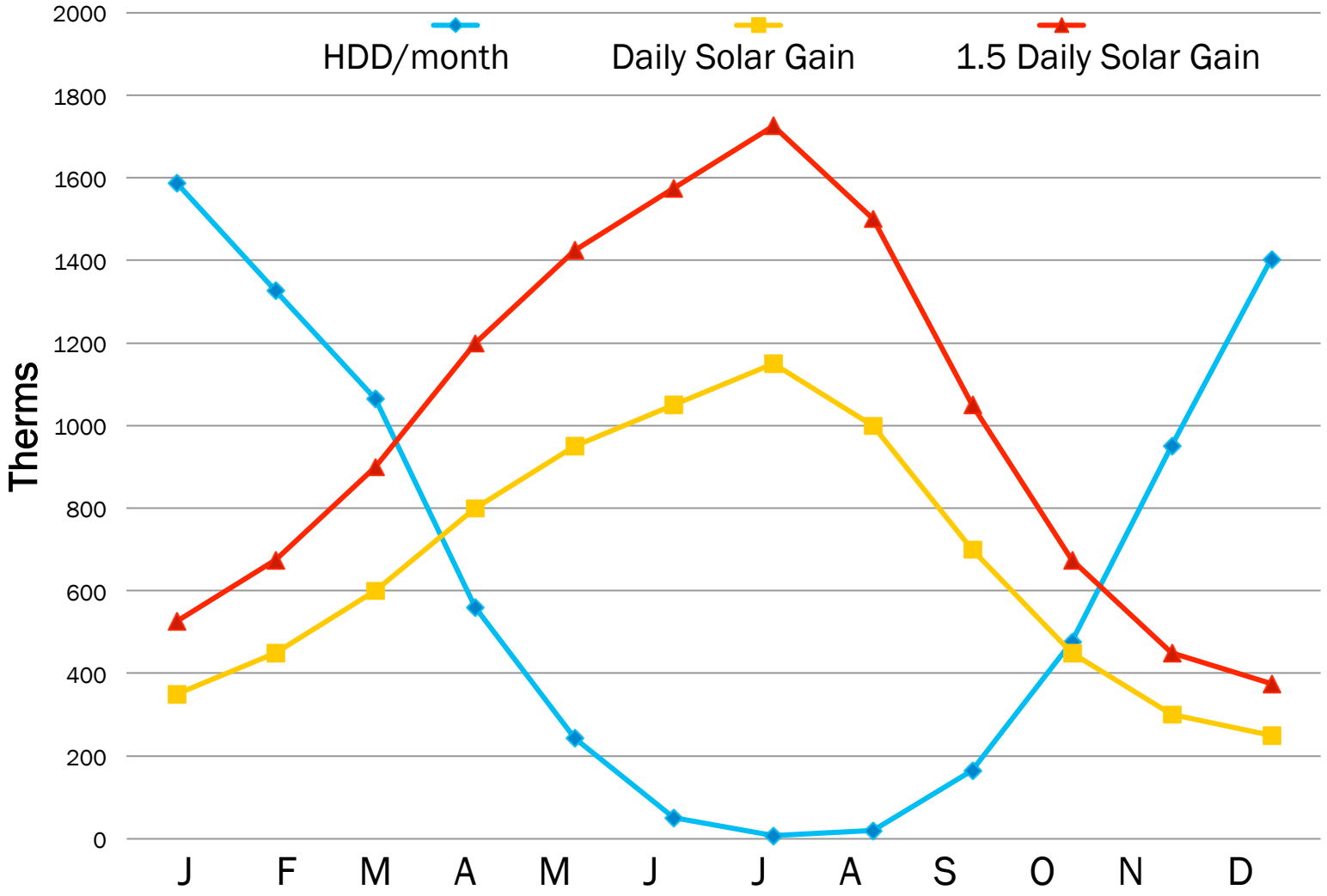
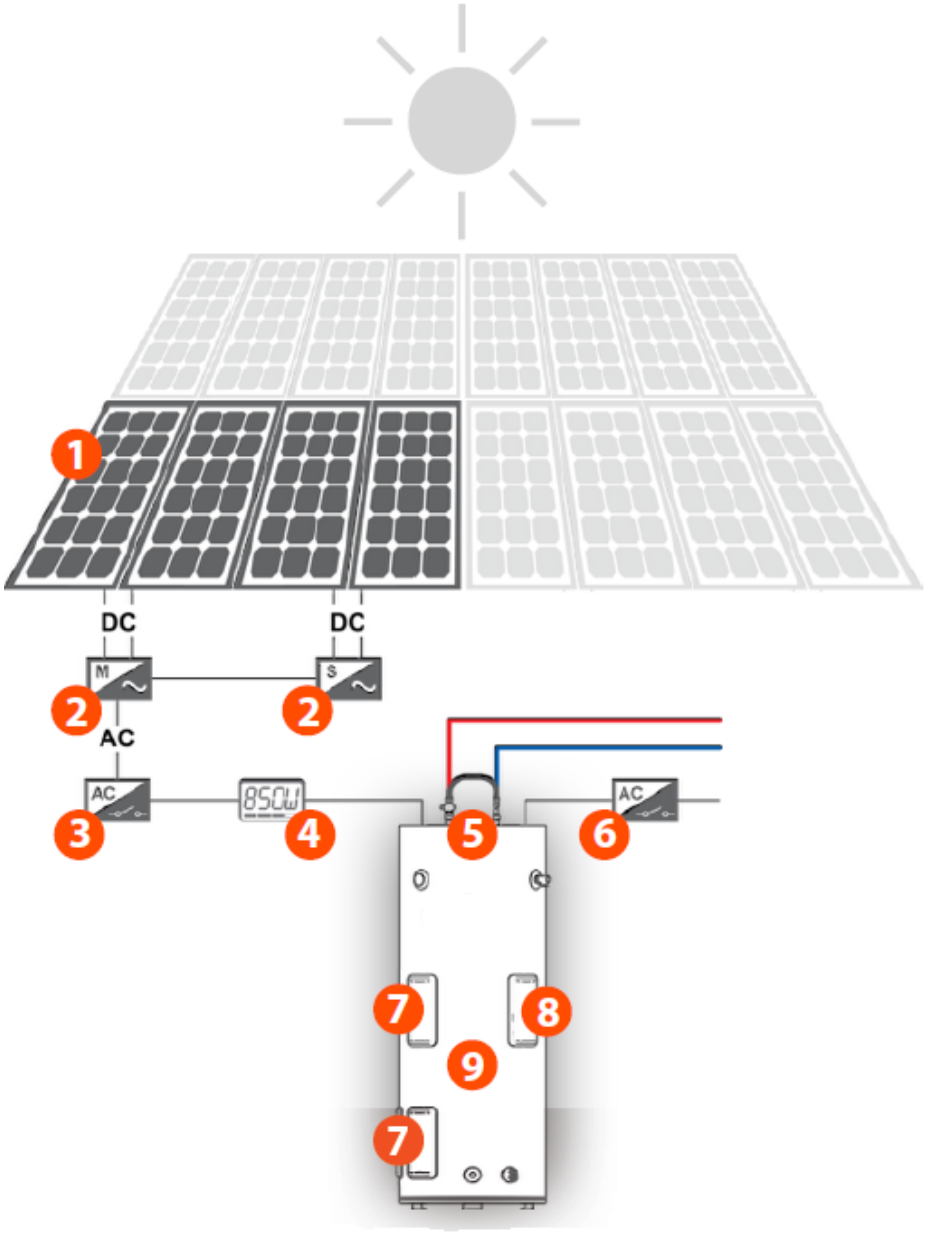


Figure 10. Direct system

Space-heat Mismatch

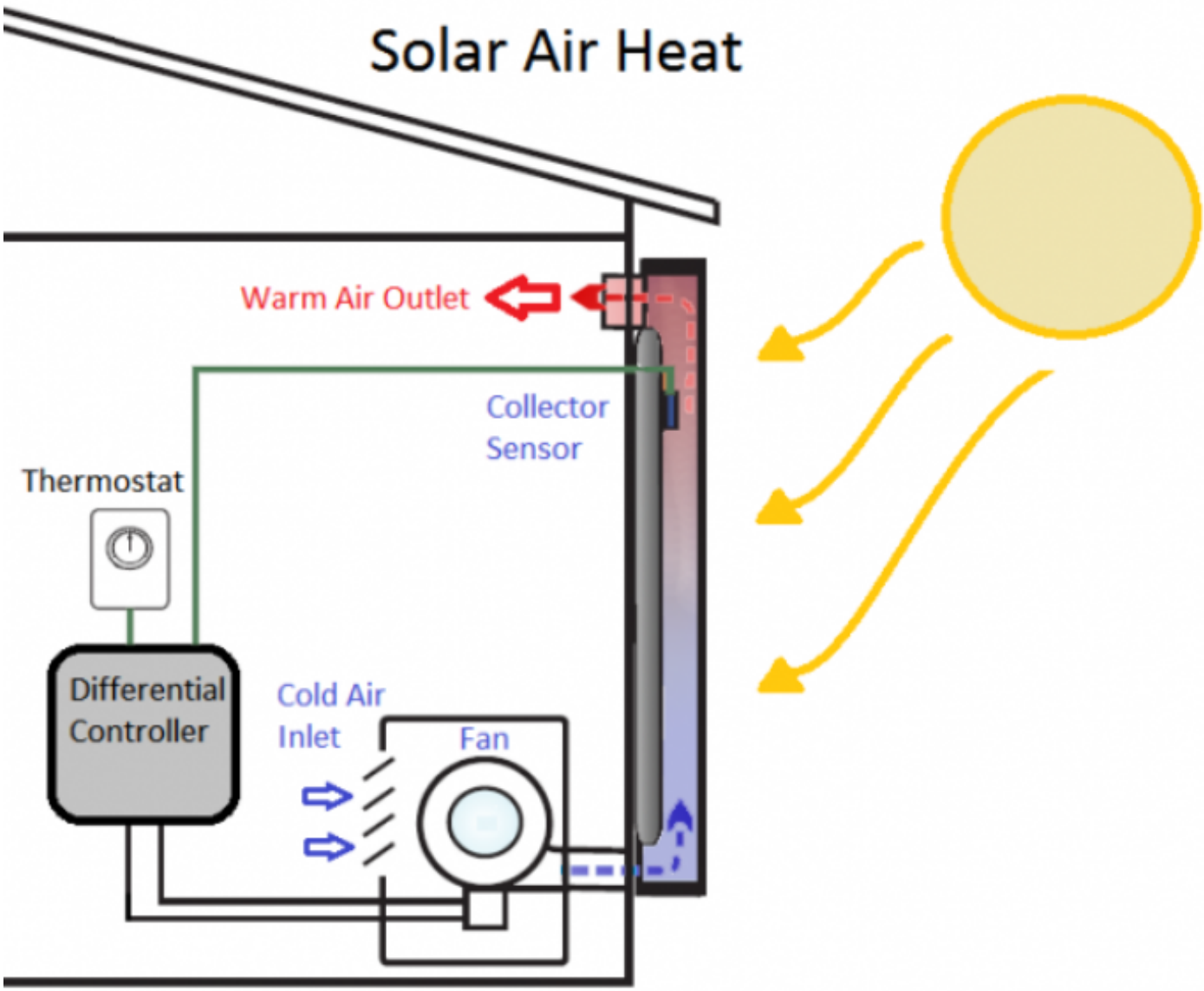


We also have available direct solar to hot water systems. These systems use PV to directly power an element in the hot water tank, no grid interconnection needed.



Solar Air Heating (SAH)

- These systems are designed to heat air for heating use.
- They can be designed to supply 15 to 30% of a household's heating load.
- Typically consist of collectors, a controller, and a fan.


Solar Air Heat
Warm Air Outlet
Collector Sensor
Thermostat
Differential Controller
Cold Air Inlet
Fan

Why Solar Ready?

The traditional design of our homes is one of the major barriers to the rapid development of solar in Minnesota. Homes were simply just not built for easy solar energy retrofits.

The concept of solar ready building sees buildings as infrastructure, multi-generational investments that consider not only today's market needs, but provide flexibility to meet the next generations' needs.

- The added expense to making a building solar ready is minimal if done during construction.

- Whereas, it can be cost prohibitive to do it on the back end.

- Structural or solar access barriers can prevent installations do to the insurmountable costs of building design.
  - Added load
  - Number of roof obstructions
- Reduced solar production from a poorly designed site creates a much less attractive financial picture.
  - Pitch
  - Orientation
  - Shading

Increasingly communities are requiring developers to build " Solar Ready" homes.

A growing number of communities are either requiring or incentivizing solar ready construction. Typically, when communities elect to require solar ready they add provisions to the local building code. Some are opting to incentivize solar ready construction, typically through a density bonus.

What is Solar Ready?

The National Renewable Energy Lab (NREL) defines a solar ready building as being designed and built:

"to enable installation of solar photovoltaic and heating systems at some time after the building is constructed."

Three basic components of a solar ready building:

1. Roof – Space & Structure
2. Connection between the roof and the mechanical area
3. Space assigned in the mechanical area

First basic component of a solar ready building:

1) Roof:

- Unrestricted solar access - free of obstructions such as rooftop equipment or plumbing vents.
- Structurally designed to accommodate the weight, wind, and drift loads that the system might impose.

Not so good sites!

This roof is too chopped up, no place to put an array. None of the slopes face south.

Way too much shade on this roof.

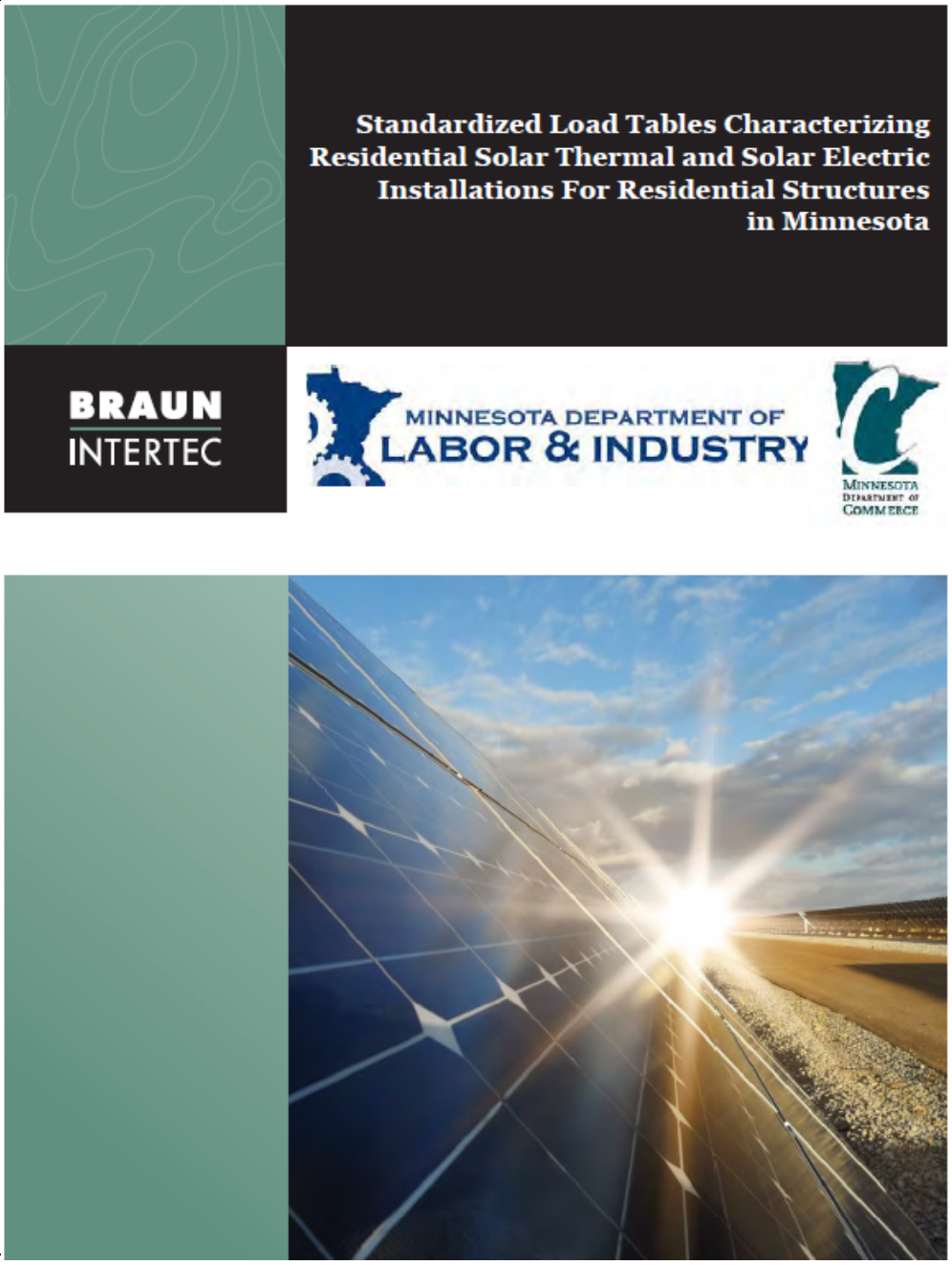
Structural Design Guidelines

This guide is available online at: [http:// mn.gov/commerce/energy/images/FINAL-Standardized-Load-Table-Report.pdf](http://)

Or just Google Standardized Load Tables.

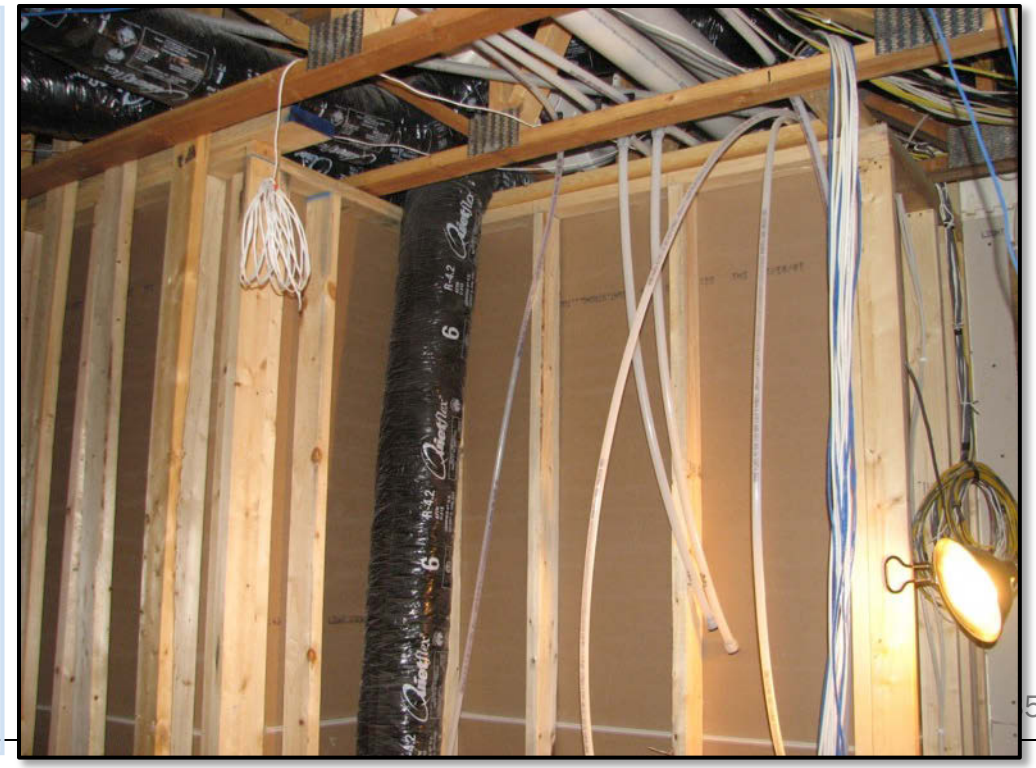
Can the roof handle the load?

Live Load vs. Dead Load



Second basic component of a solar ready building:

2) Connecting the solar system to the building's mechanical or electrical system.

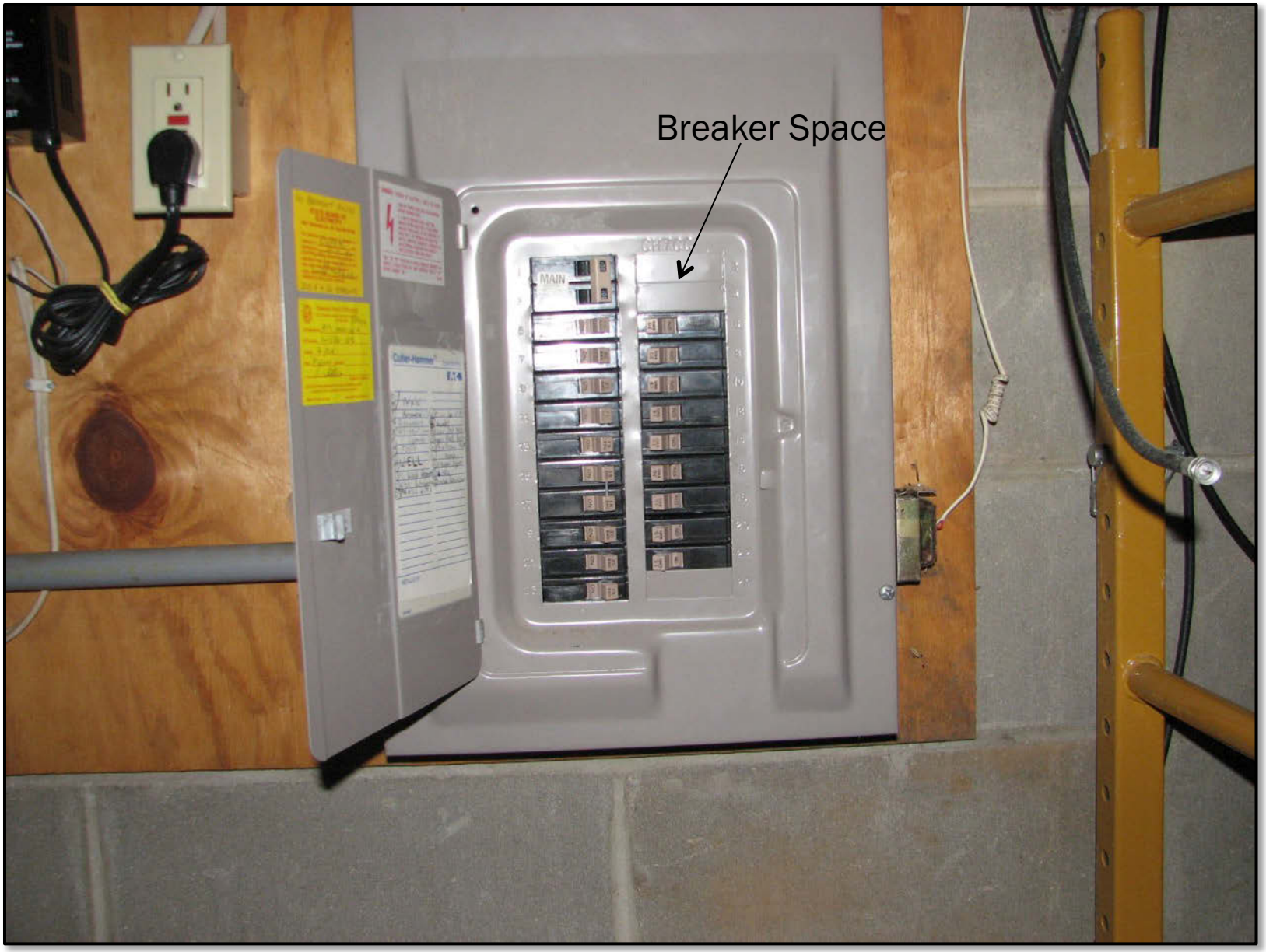


Third basic component of a solar ready building:

3) Space within the building that is readily available for the installation of controls and components.

Support for mounting the BOS

Space between the meter and a corner or from a window or door.


Breaker Space
MAIN

Solar Model

Budget Allowance for Solar Ready Construction

- ✓ $1000 for a two-story residential building
- ✓ $5000 to $7500 for a three-story mixed-use building
- ✓ Estimated cost for Retro-fitting Existing Structures to Incorporate Solar Ready Requirements
- ✓ $5000 for a two-story residential building
- ✓ $20-$30,000 for a three story mixed-use building


Before we discuss the Building Solar Ready Guidelines are there any questions about solar?

This presentation is taken from the Solar Ready Building Design Guidelines prepared for the Minneapolis Saint Paul Solar Cities Program
by Lunning Wende Associates, Inc., coordinated by CR Planning, Inc. and funded by National Renewable Energy Laboratory (NREL).

Solar Ready Building Design Guidelines

Solar Ready Building Design Guidelines for the Twin Cities, Minnesota

Available at www.nrel.gov

According to an NREL Study PV System

Table 3: Cost to Make a Building Solar Ready[5]

	During Construction			After Construction		
Measures	**Equipment**	**Labor**	**Total**	**Equipment**	**Labor**	**Total**
Increase size of electrical panel	$459	$480	$ 939	$459	$1,200	$1,659
Run conduit	$374	$416	$ 790	$374	$1,040	$1,414
Relocate vents	n/a	n/a	n/a	-	$ 300	$ 300
Install panels on multiple pitches	n/a	n/a	n/a	-	$1,000	$1,000
Total	**$833**	**$896**	**$1,729**	**$833**	**$3,540**	**$4,373**

60% Savings

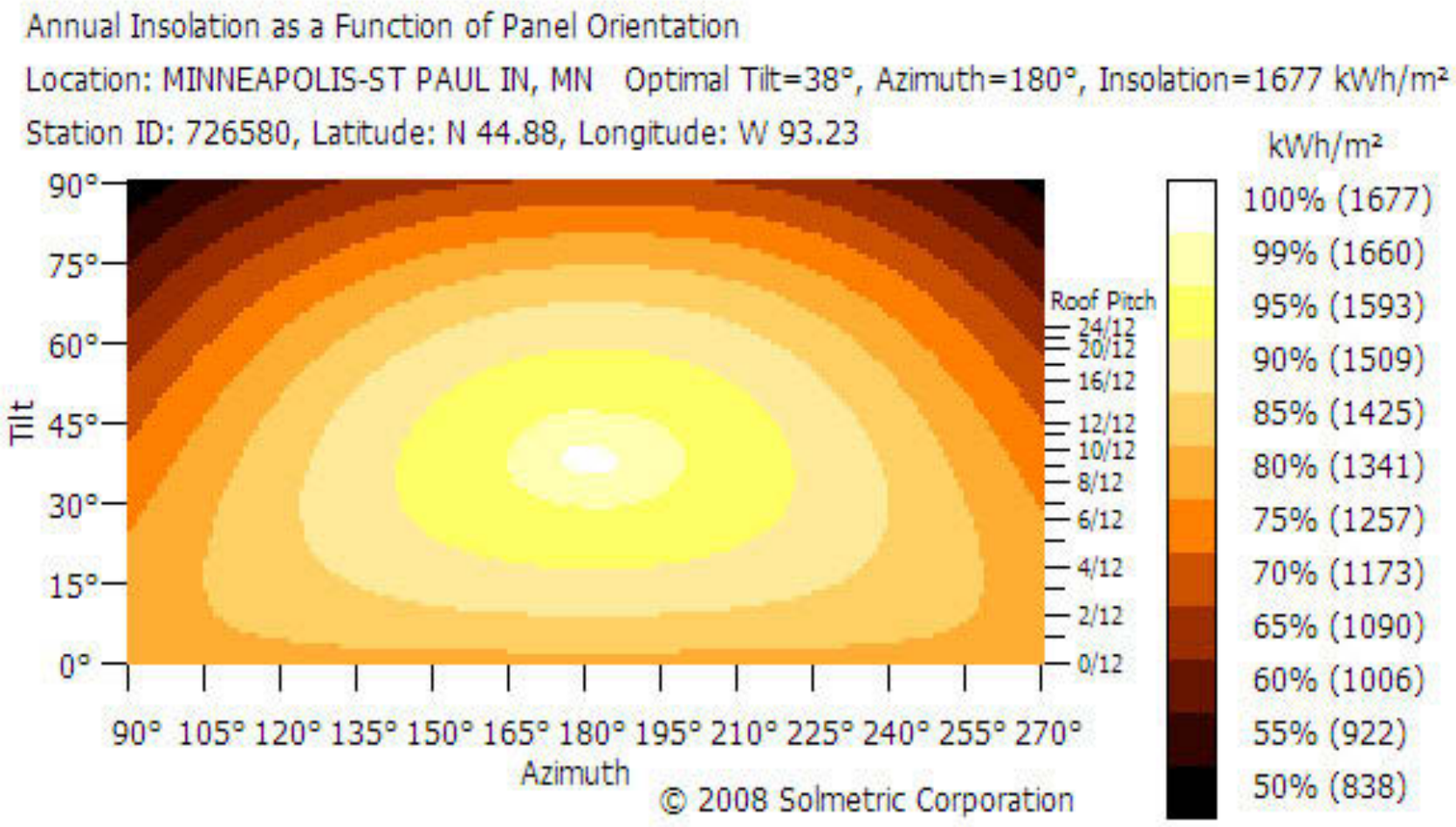
[5] Waier, P.R., ed. Green Building Cost Data. RSMeans. 1st Annual Edition, Norwell, MA: RSMeans. 2010

- Plan the building form - building height, roof projections, etc. – so that the roof area reserved for the solar array can receive the maximum amount of sun exposure.

Orientation

- Keep in mind that solar is just one aspect of a building's design. Southern orientation is necessary in almost all cases, but tilt is more forgiving.
- In Minnesota a 38° tilt is optimal for PV, but anything between 20° & 45° is good. 10:12 pitch = 39.81° 6:12 pitch = 26.57°
- Thermal is between 90° & 90°

The Tilt Effect:



At Tilt: 37 º and Azimuth: 179 º, Annual Insolation: 1677 kWh/m^2 (TOF: 100.0%)

www.solmetric.com

Space Planning

- PV systems need an inverter, AC & DC disconnects, and monitoring equipment.
- Designate a 3’ x 3’ space with a 3’ wide clearance next to the service panel.
- Best to locate the service area directly below the array area.

PV Equipment

PV on Exterior

Basic PV Planning

- Meter on the house
- Roof
  - Clear south face.
  - Pitch 10/12 or 12/12
- Standing Seam Metal Roof
- 2” EMT from Mechanical to Attic
  - No more than 360 degrees (4 elbows)

Metal Roof Fasteners

Shingle Fasteners

Thermal Systems

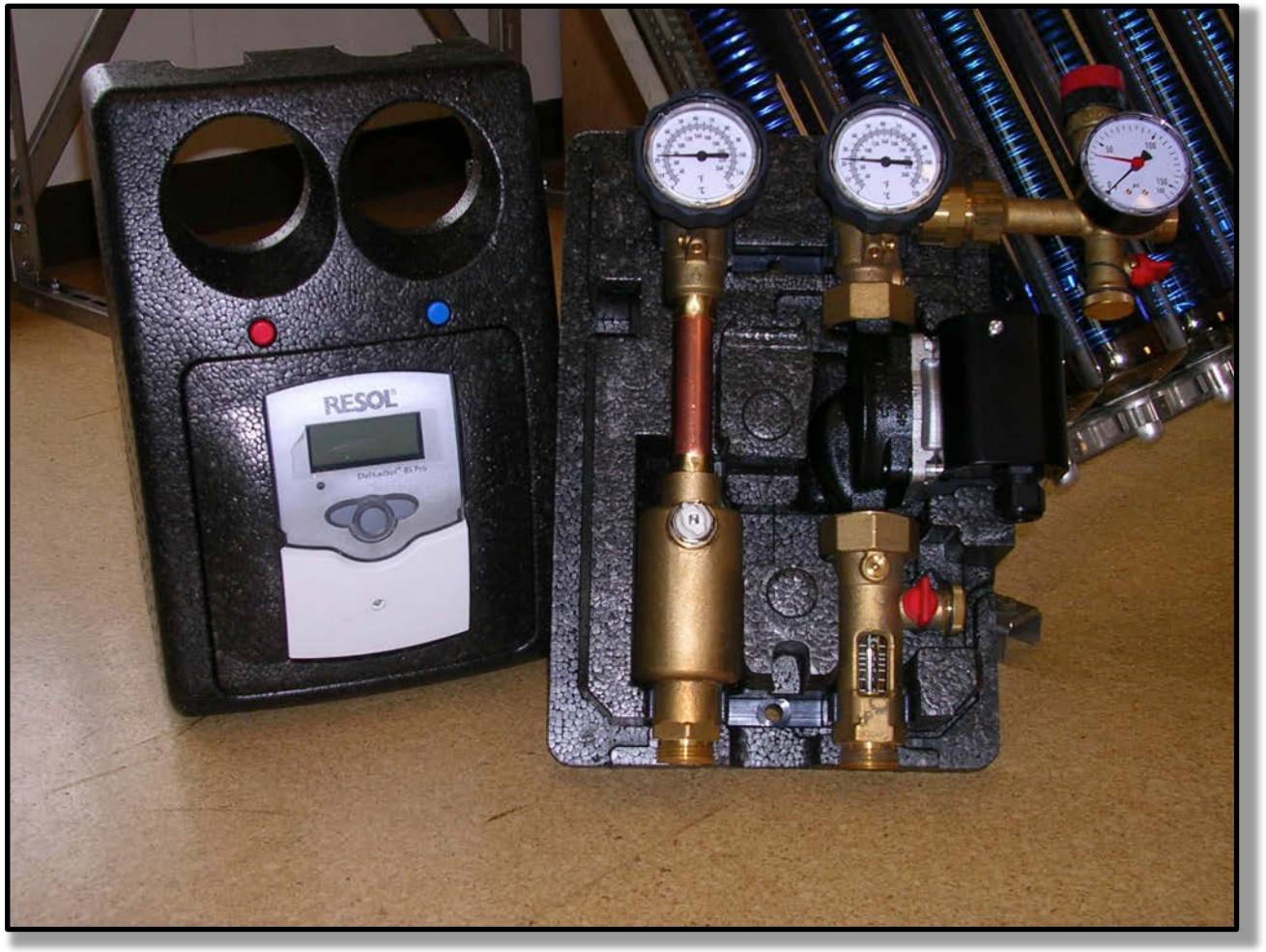
- Thermal systems need space for storage tanks, pressure tank, pumps, and controls.
- Locate a continuous shaft in the floor plans for supply and return from the collectors to the storage tanks.
- Determine the amount of storage needed, Typically 80 to 120 gallons.

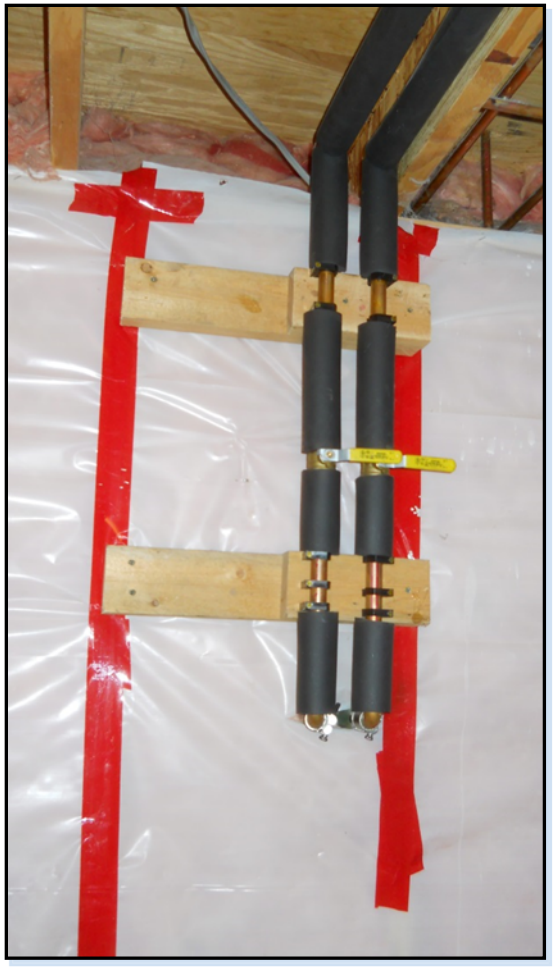
Typically copper will be used for the hot and cold runs from the attic to the storage tanks. This is a pre-insulated flexible tubing that can be used for that run. The simplest method is to install it before the sheetrock.

DO NOT USE PEX!!!!

Notice the control wire. Always run a low voltage wire for controls.

Thermal controller






By-pass valve
Tie in for Solar
Power Supply
PDV

Basic SHW Planning

- Roof
  - Clear south face.
  - Pitch is 90 degrees.
- Standing Seam Metal Roof
- Two ¾” insulated pipes from Mechanical to Attic (color coded for hot and cold)
- Sensor wire

Roof Planning

- Location and size of the area with solar access depicted on the roof plan.
- Structural design that addresses the loads imposed by the future solar array.
- Description of roofing material and system.
- Inform the trades of the location of the array and the intention.

Flat roof standoff

Roof Vent Placement

Mechanical & Electrical

- A 2” metal conduit is needed to house the wiring.
- Provide sufficient space in the electrical panel. (Bottom left corner)
- Location for production meter next to main meter.
- For Thermal a ¾” insulated copper supply and return along with a sensor wire.

Resale Value

- A study by Lawrence Berkeley National Laboratory found solar not only saves money on electric bills, but also provide a boost to homes at resale.
- The study found that solar added about $5.50 per watt to the resale value of a home.

Resources for Building Companies & Their Customers

- **Department of Commerce Solar Helpline**
  - (651) 539-1848
  - Solar.Help@state.mn.us

- **Solar America Communities**

National Renewable Energy Laboratory
  - (303) 275-3000
  - www.nrel.gov

- **CR Planning, Inc.**
  - (612) 558-4904
  - www.crplanning.com

Thank You

Jack.Kluempke@State.mn.us

651-539-1676

Minnesota Department of Commerce

Division of Energy Resources

energy.mn.gov
mn.gov/made-in-minnesota