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 hour** of credit toward **Building Officials and Residential Contractors** continuing education requirements."

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


RREAL
Rural Renewable Energy Alliance
Jason Edens
MN BC 629837
NABCEP Certified
www.rreal.org

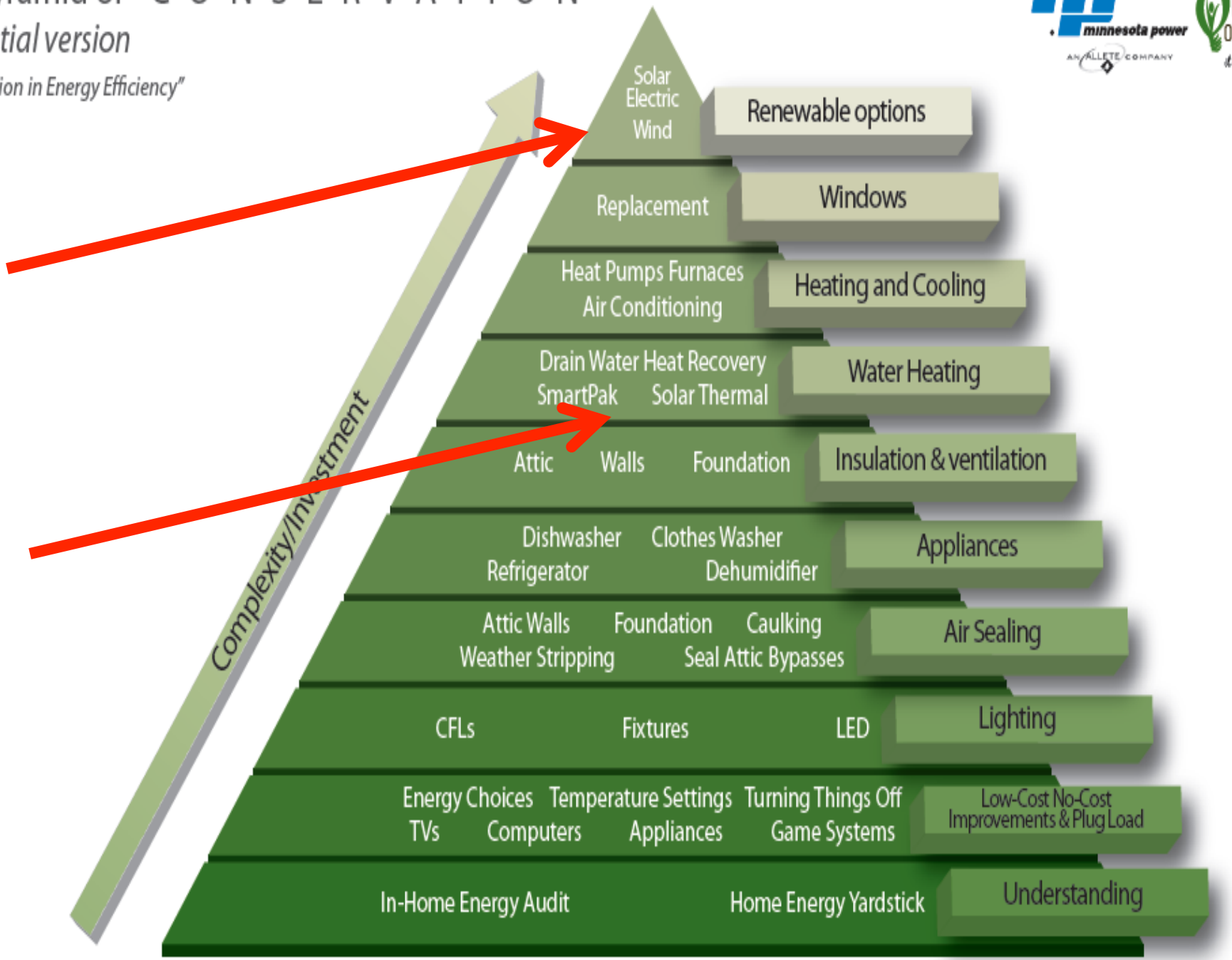
Form and Function: Solar Energy in Cold Climates

What about energy efficiency?

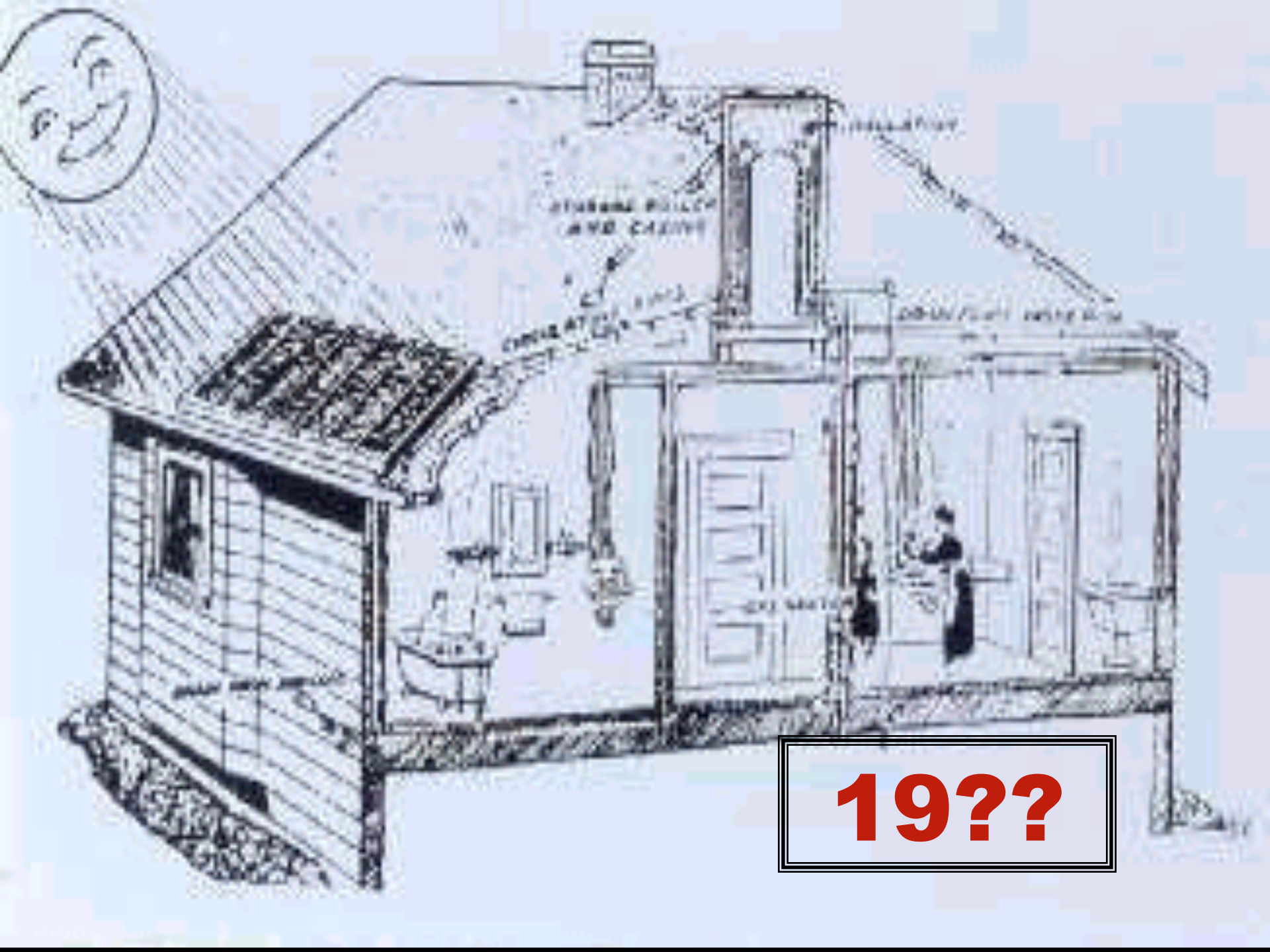
The Pyramid of CONSERVATION

residential version

"A Foundation in Energy Efficiency"




Nothing New...

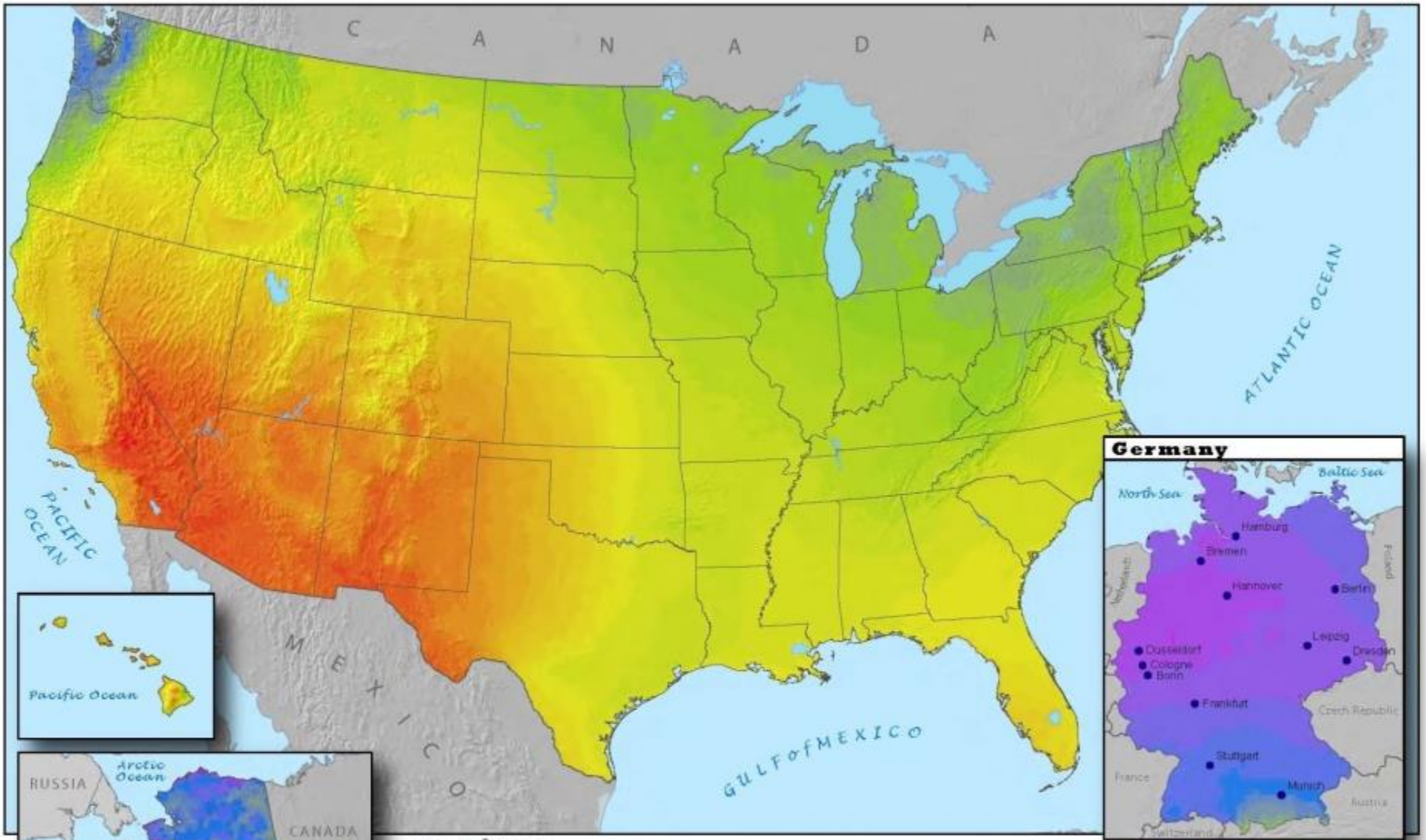

19??

Is Solar Energy an Appropriate Technology?

MAYBE!

1.Regional Solar Resource
2.Site-based Solar Resource
3.Site-based needs, opportunities and limitations

Photovoltaic Solar Resource : United States and Germany



kWh/m^2/Year

1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500

Annual average solar resource data are for a solar collector oriented toward the south at a tilt = local latitude. The data for Hawaii and the 48 contiguous states are derived from a model developed at SUNY/Albany using geostationary weather satellite data for the period 1998-2005. The data for Alaska are derived from a 40-km satellite and surface cloud cover database for the period 1985-1991 (NREL, 2003). The data for Germany were acquired from the Joint Research Centre of the European Commission and is the yearly sum of global irradiation on an optimally-inclined surface for the period 1981-1990.

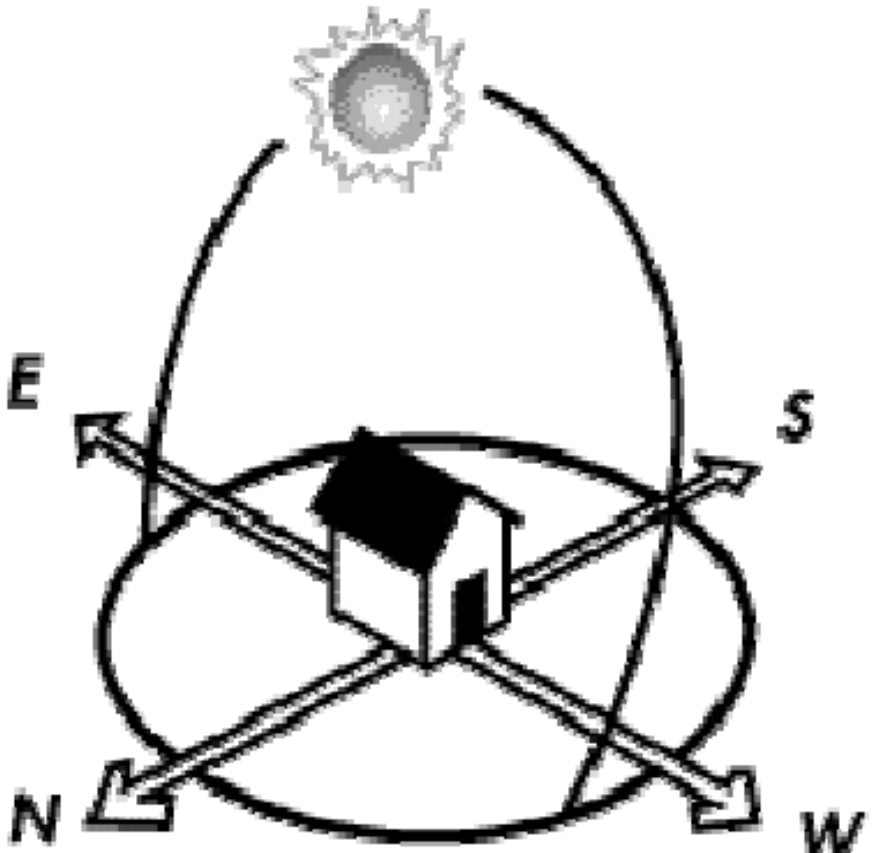
0 250 500 1,000 Miles

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy
May 30, 2008

NREL

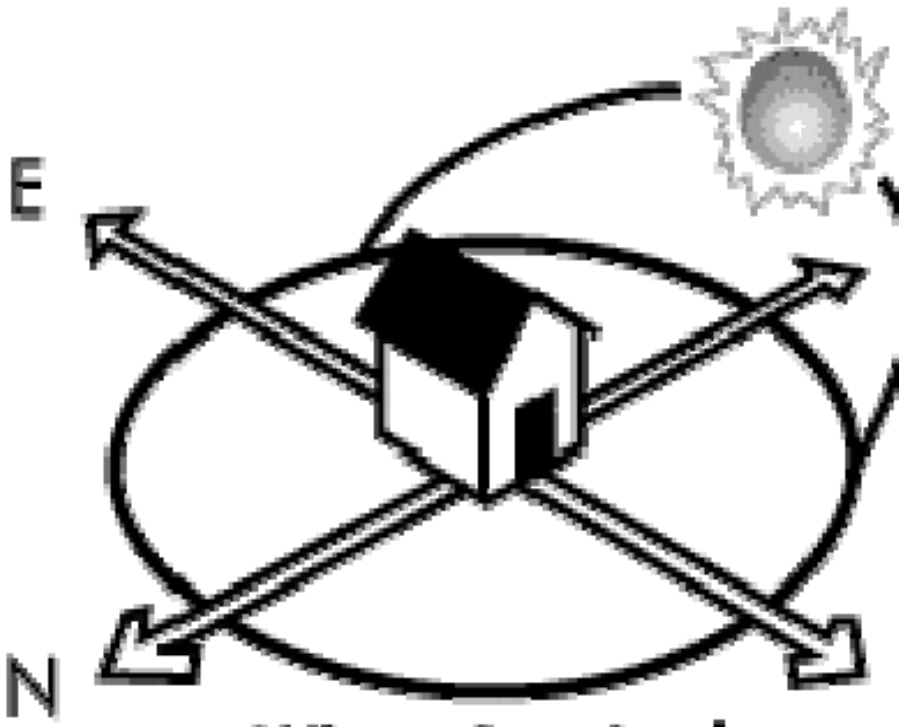

Is your place
solar compatible?

Sun Path



Summer Sun Angles

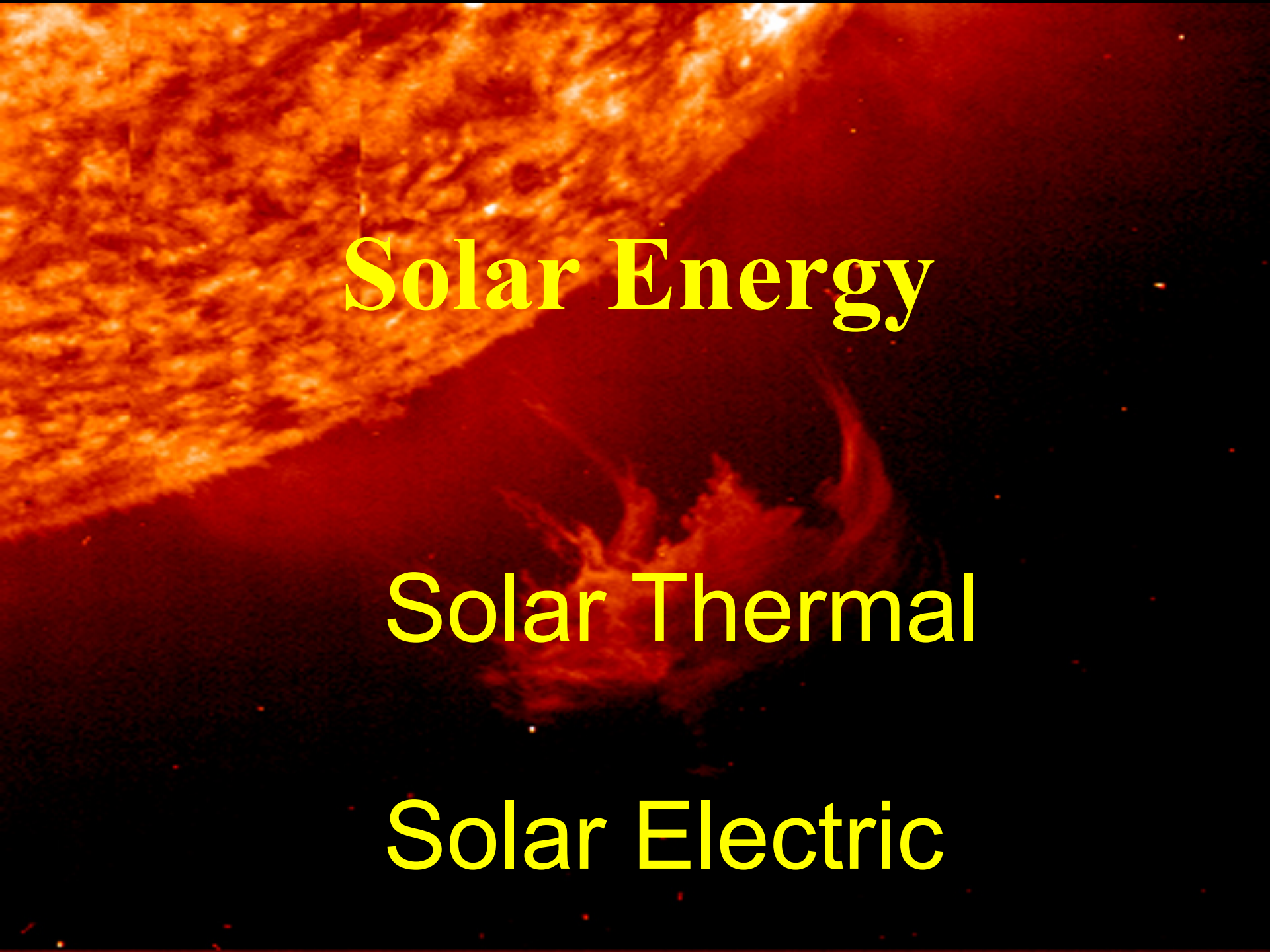
June 21st



Winter Sun Angle

December 21st


The
Site
Visit

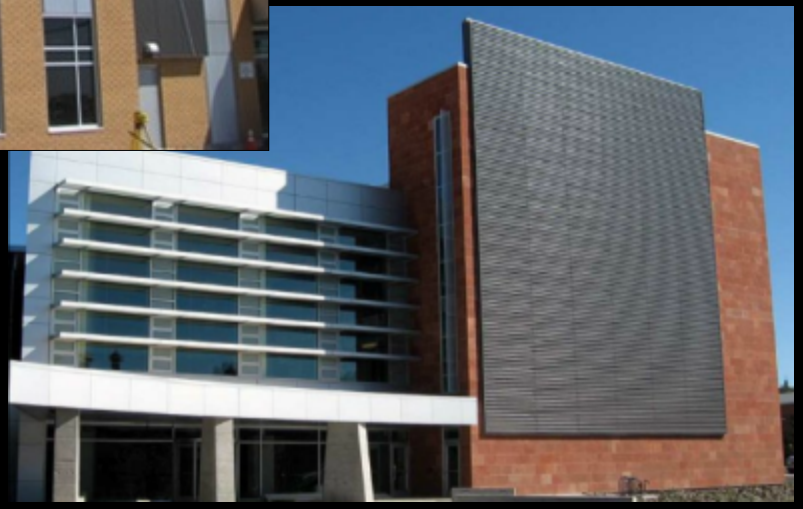

Solar Energy
Solar Thermal
Solar Electric

Appropriate Solar Air Heating Systems

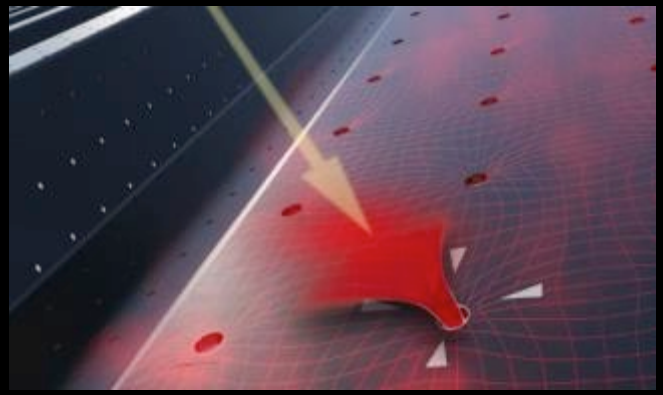
Transpired Air

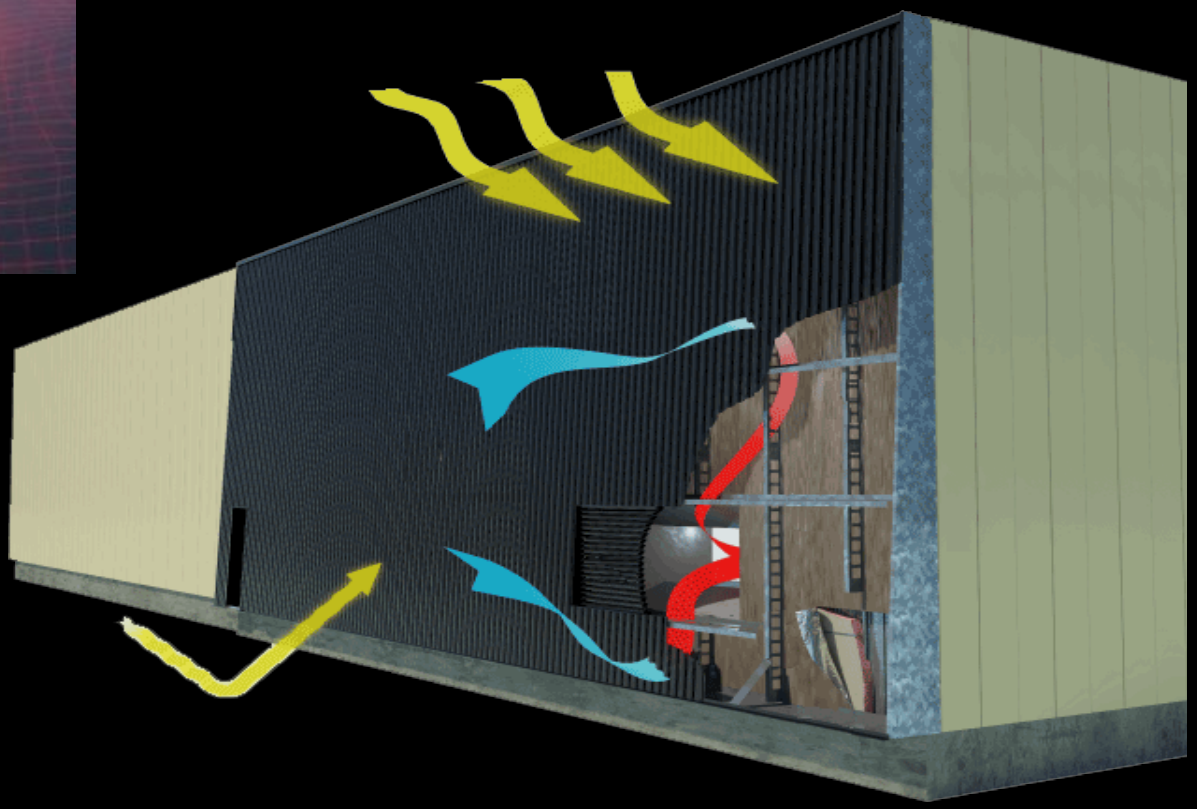
Recirculation Solar Air

Transpired Air



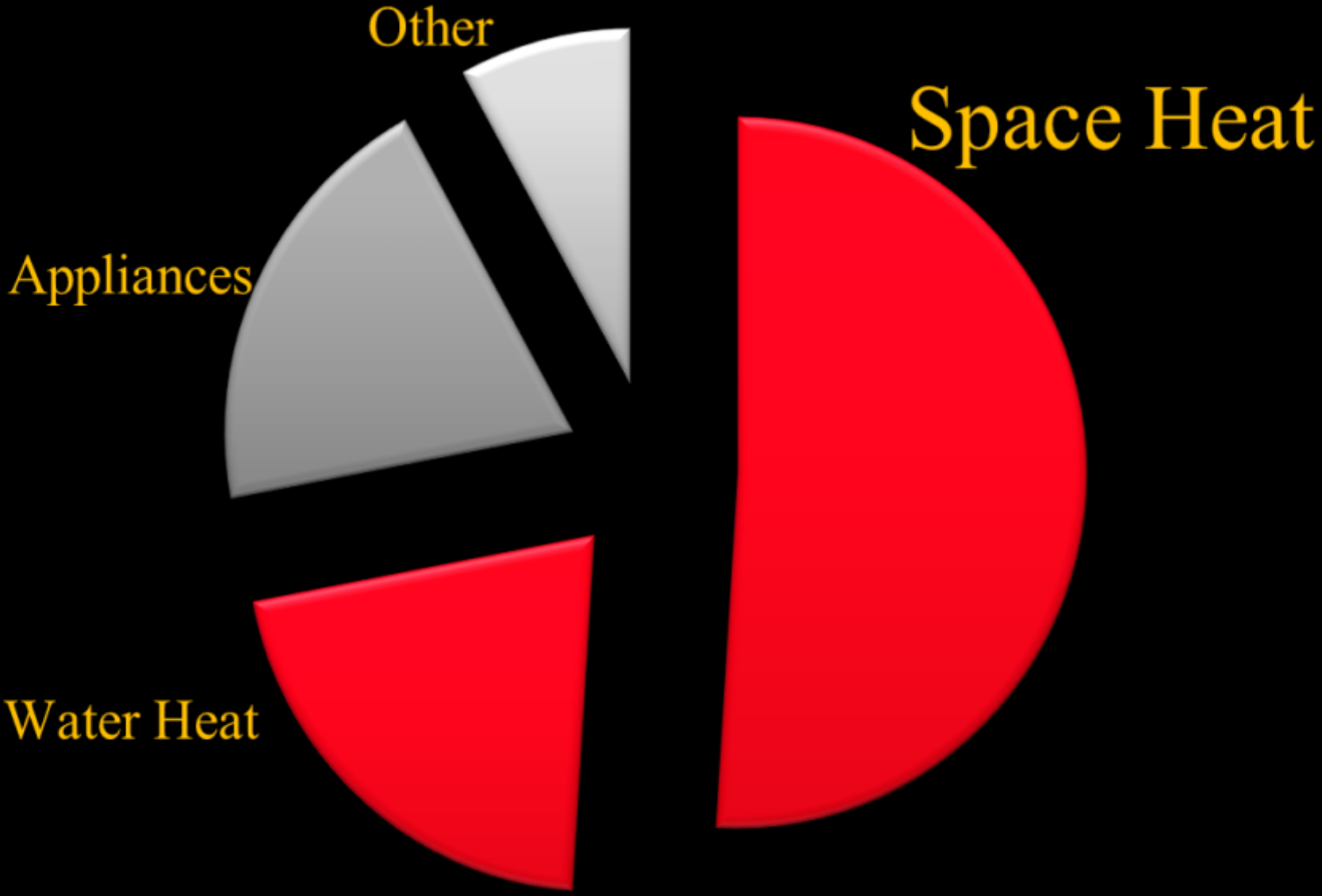
Pre-heating Ventilation Make-up Air with Solar Heat



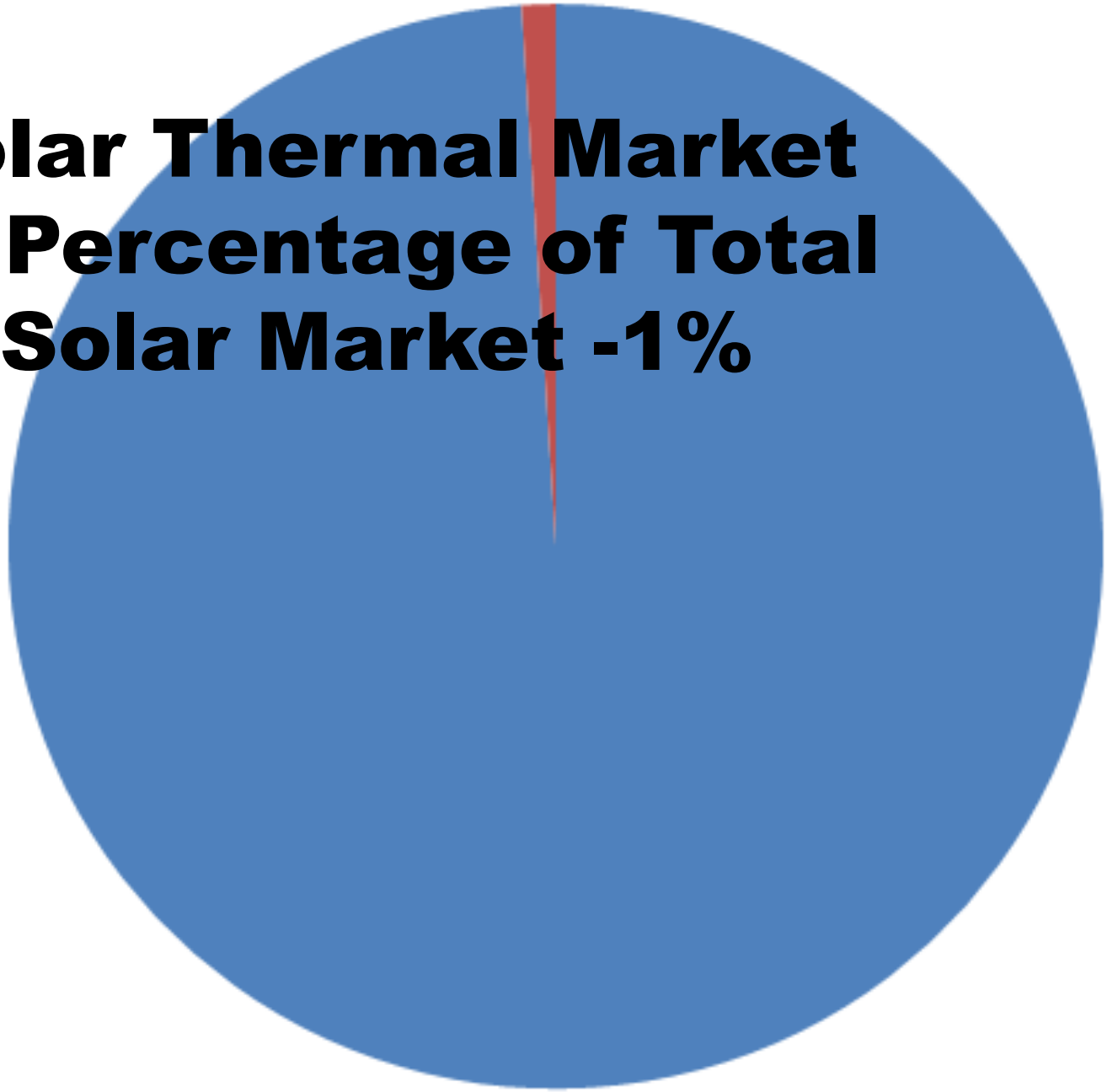


Transpired Air at Bemidji State

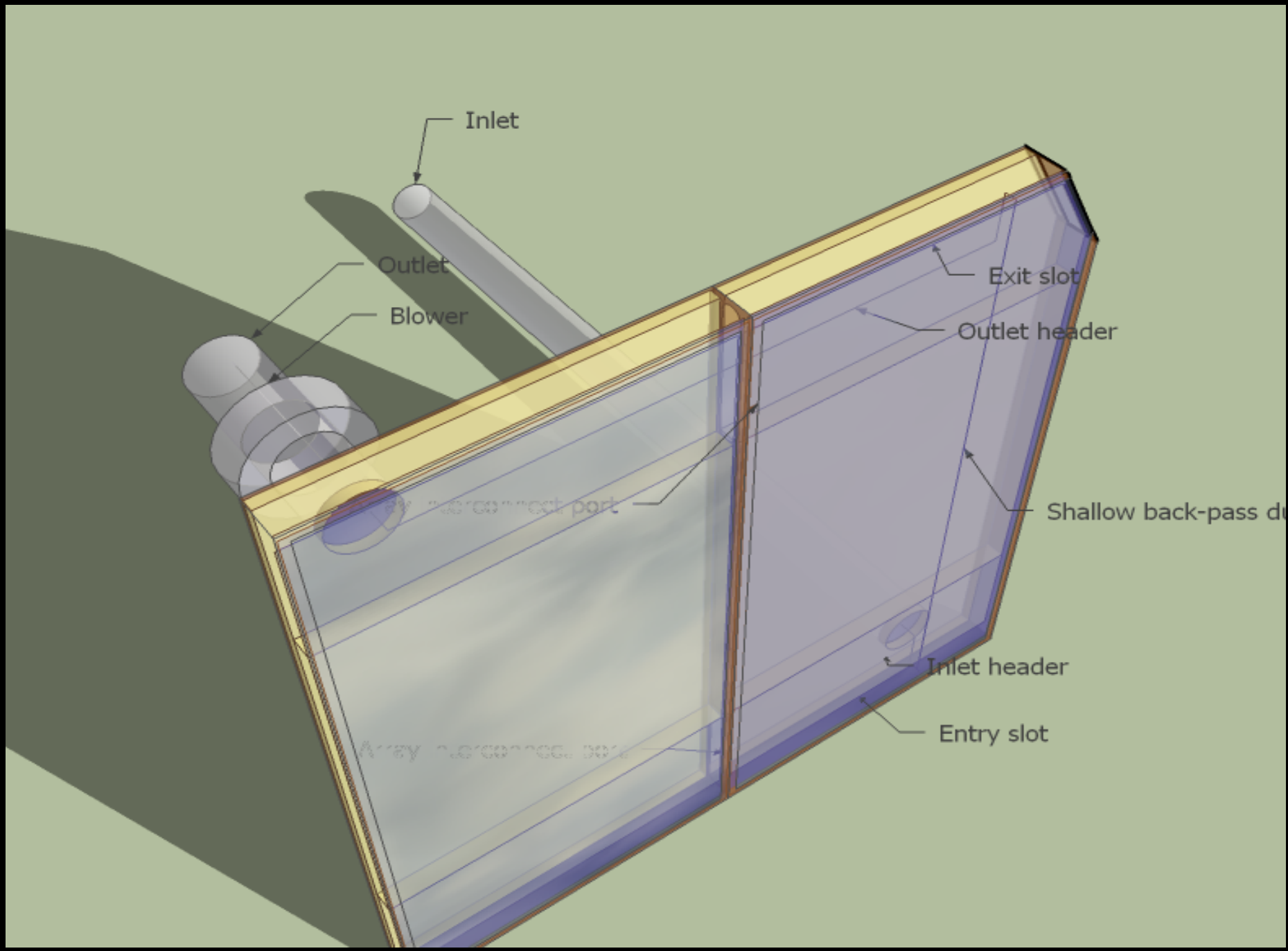
Why Solar Thermal?



Solar Thermal Market as Percentage of Total Solar Market -1%




Solar Air
Heat


Inlet
Outlet
Blower
Exit slot
Outlet header
Shallow back-pass du
Inlet header
Entry slot

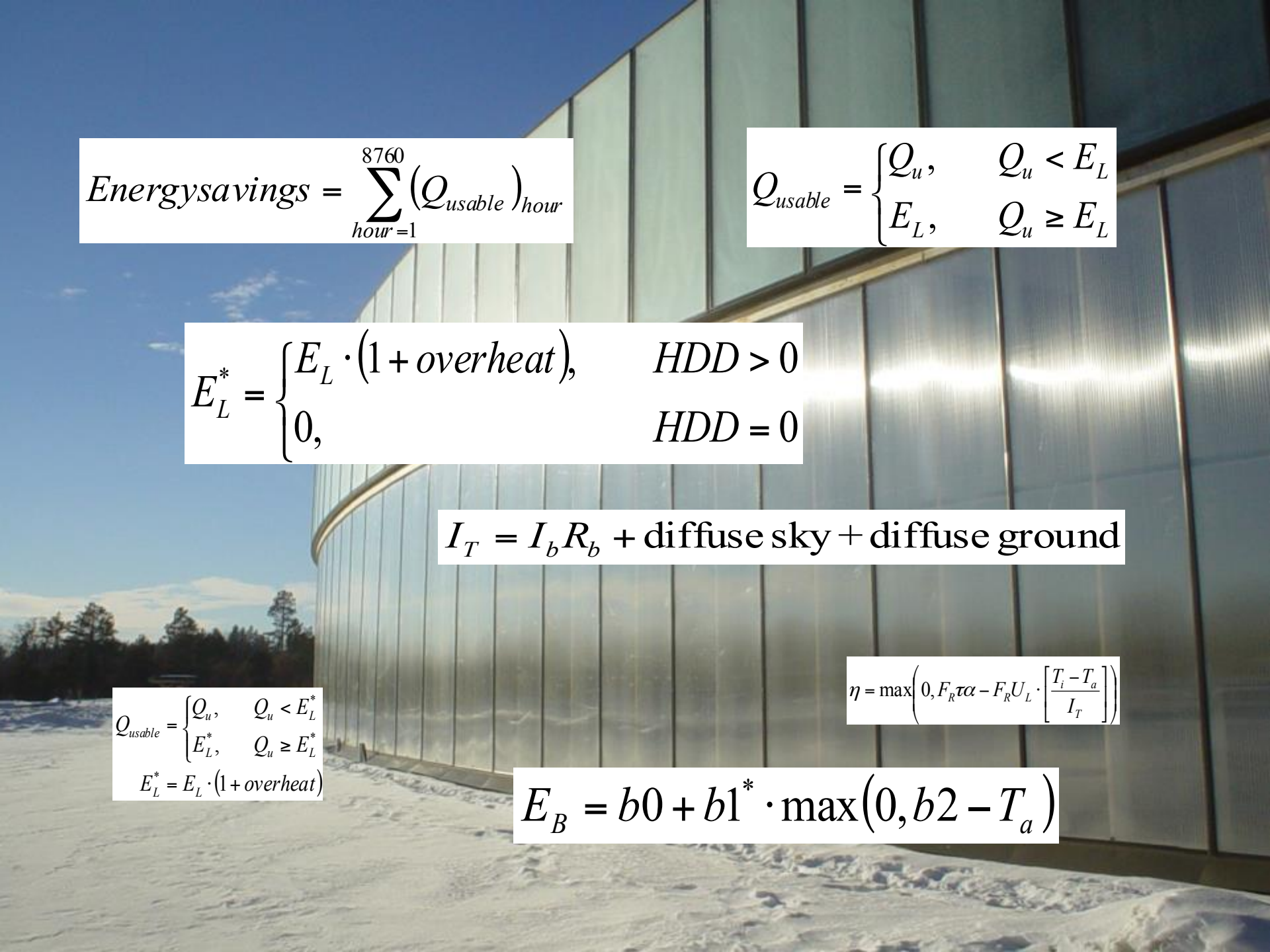
Site Selection

uel Source displaced	*Return on investment***
ropane	*0*
uel oil	
atural Gas	*5.0%*
lectricity	*6.0%*

Payback

Site Specific!

Solar Space Heating Systems



$$Energysavings = \sum_{hour=1}^{8760} \left(Q_{usable}\right)_{hour}$$

$$Q_{usable} = \begin{cases} Q_u, & Q_u < E_L \\ E_L, & Q_u \geq E_L \end{cases}$$

$$E_L^* = \begin{cases} E_L \cdot \left(1 + overheat\right), & HDD > 0 \\ 0, & HDD = 0 \end{cases}$$

$$I_T = I_b R_b + \text{diffuse sky} + \text{diffuse ground}$$

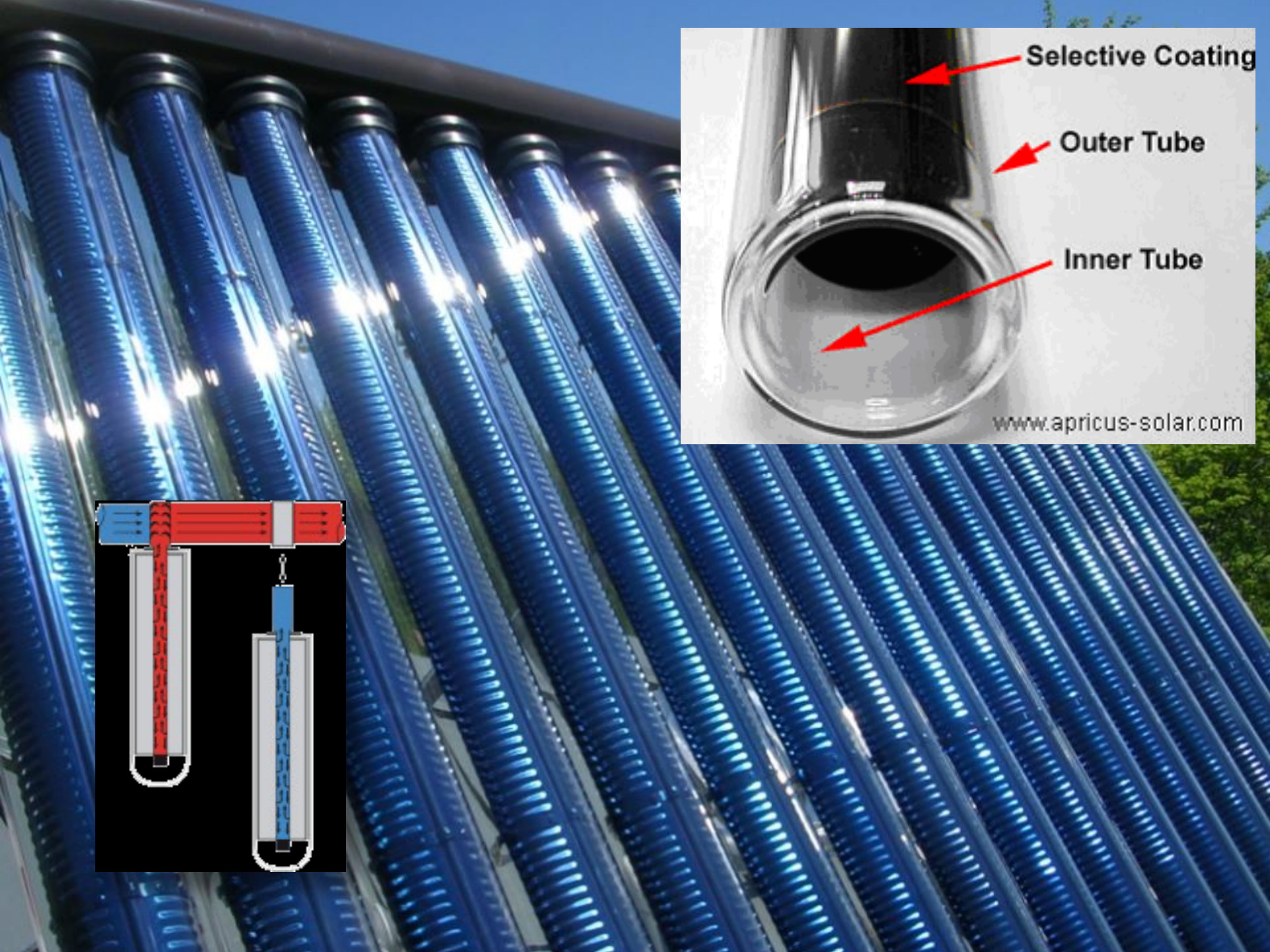
$$\eta = \max\left(0, F_R\tau\alpha - F_R U_L \cdot \left[\frac{T_i - T_a}{I_T}\right]\right)$$

$$Q_{usable} = \begin{cases} Q_u, & Q_u < E_L^* \\ E_L^*, & Q_u \geq E_L^* \end{cases}$$
$$E_L^* = E_L \cdot \left(1 + overheat\right)$$

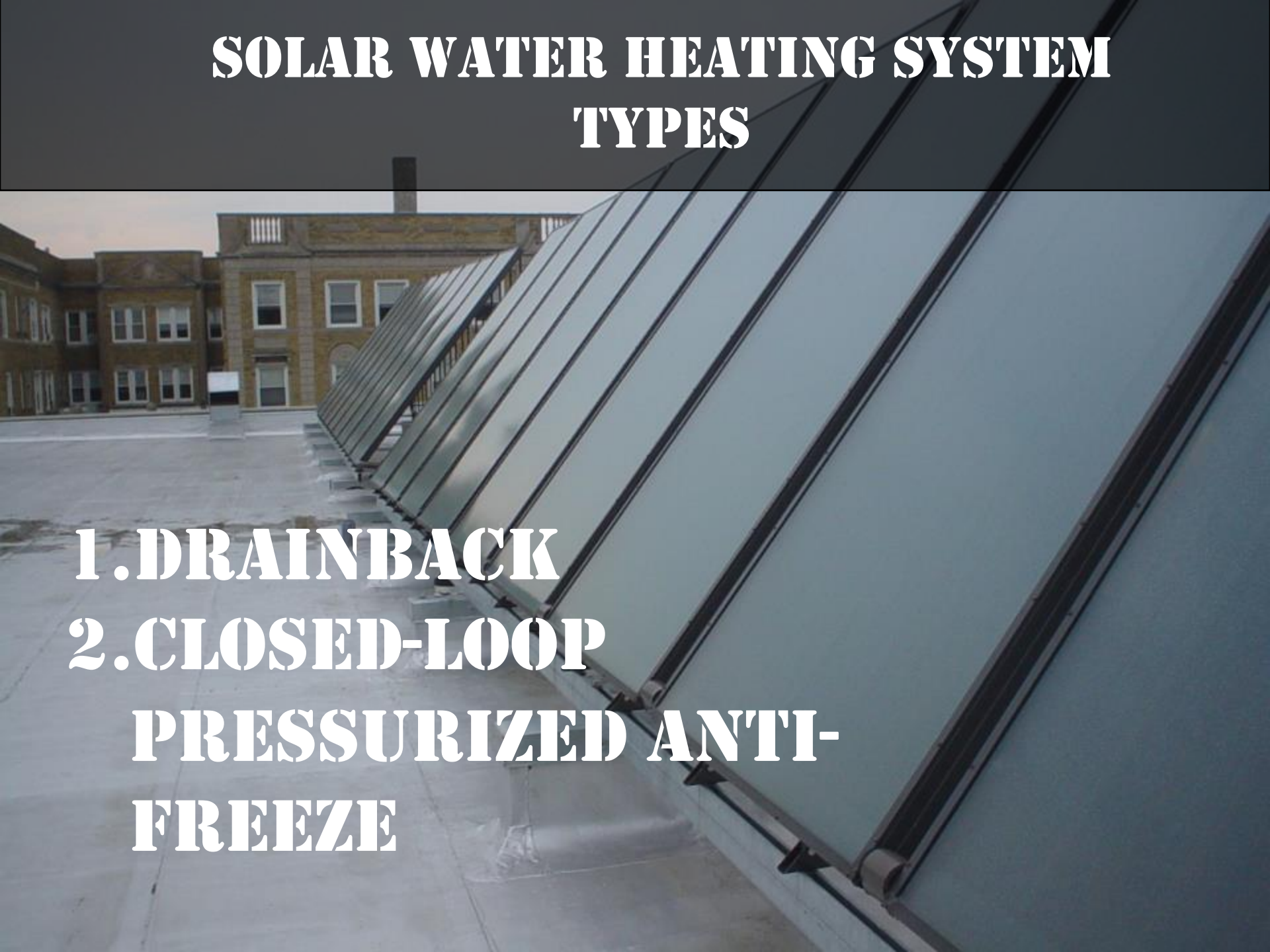
$$E_B = b0 + b1^* \cdot \max\left(0, b2 - T_a\right)$$


Solar Water Heat

Glazed Flat Plate Collectors

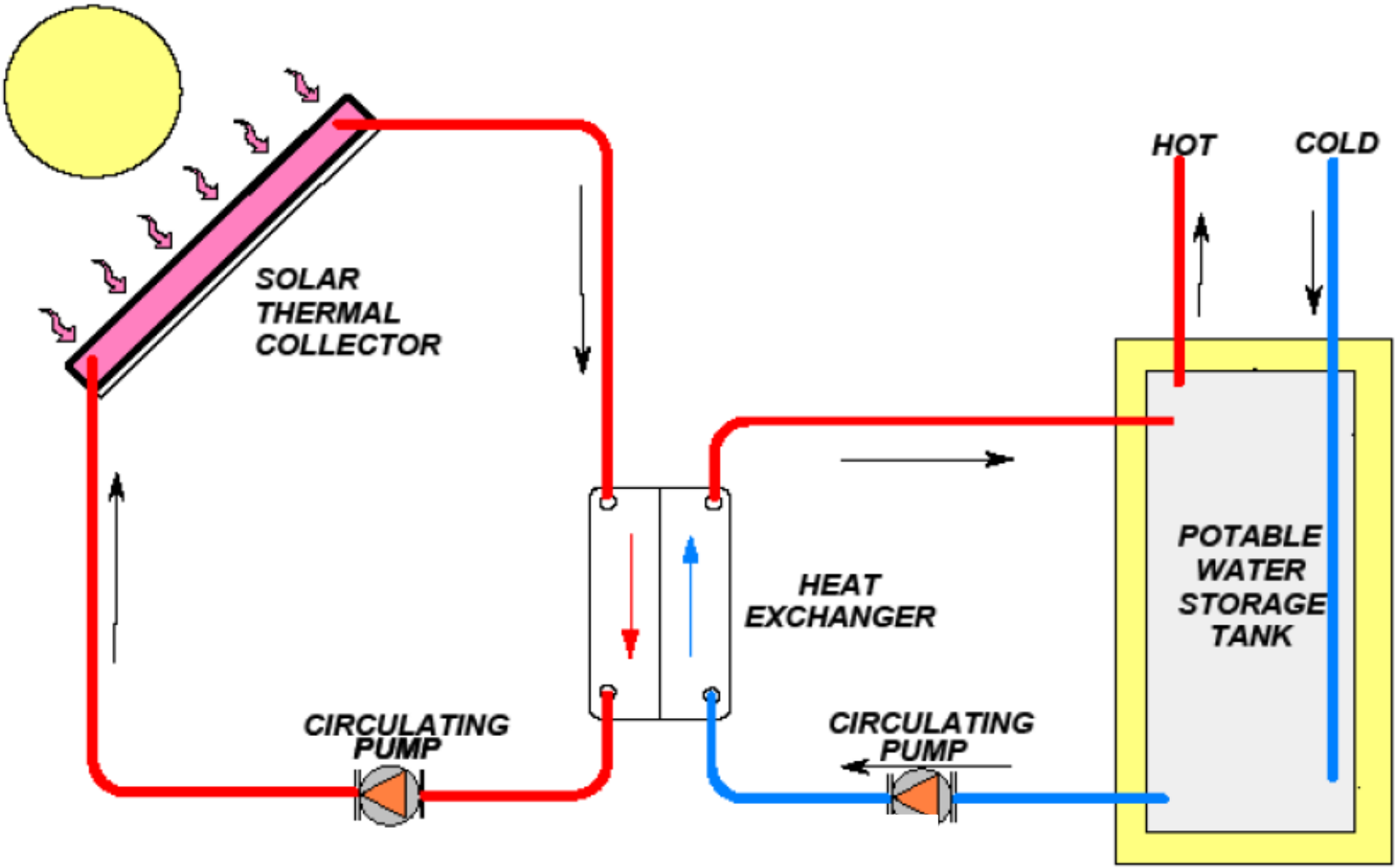

Selective Coating
Outer Tube
Inner Tube
www.apricus-solar.com

SOLAR WATER HEATING SYSTEM TYPES

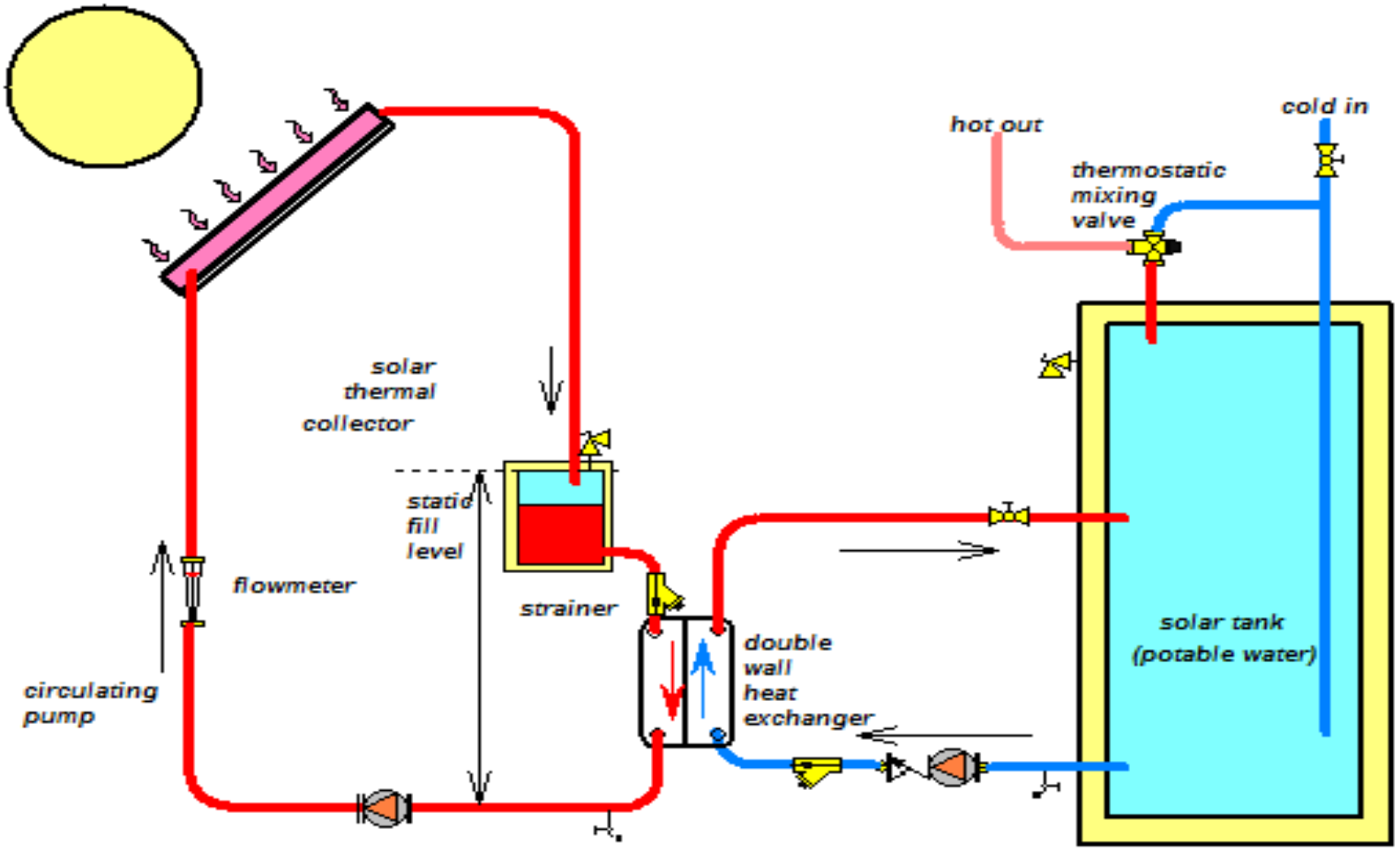


1. DRAINBACK
2. CLOSED-LOOP PRESSURIZED ANTI-FREEZE

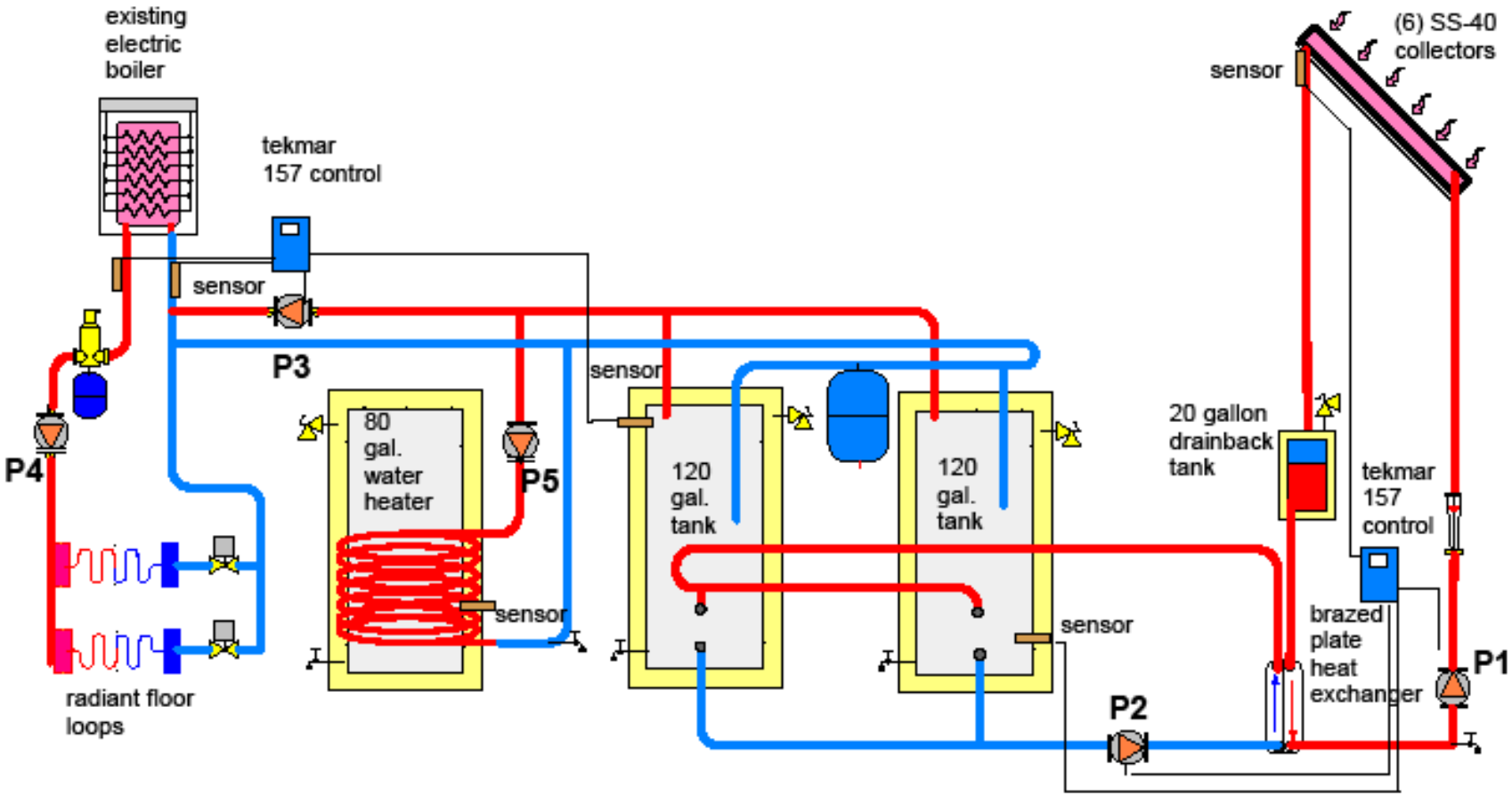
BASIC SOLAR THERMAL SYSTEM



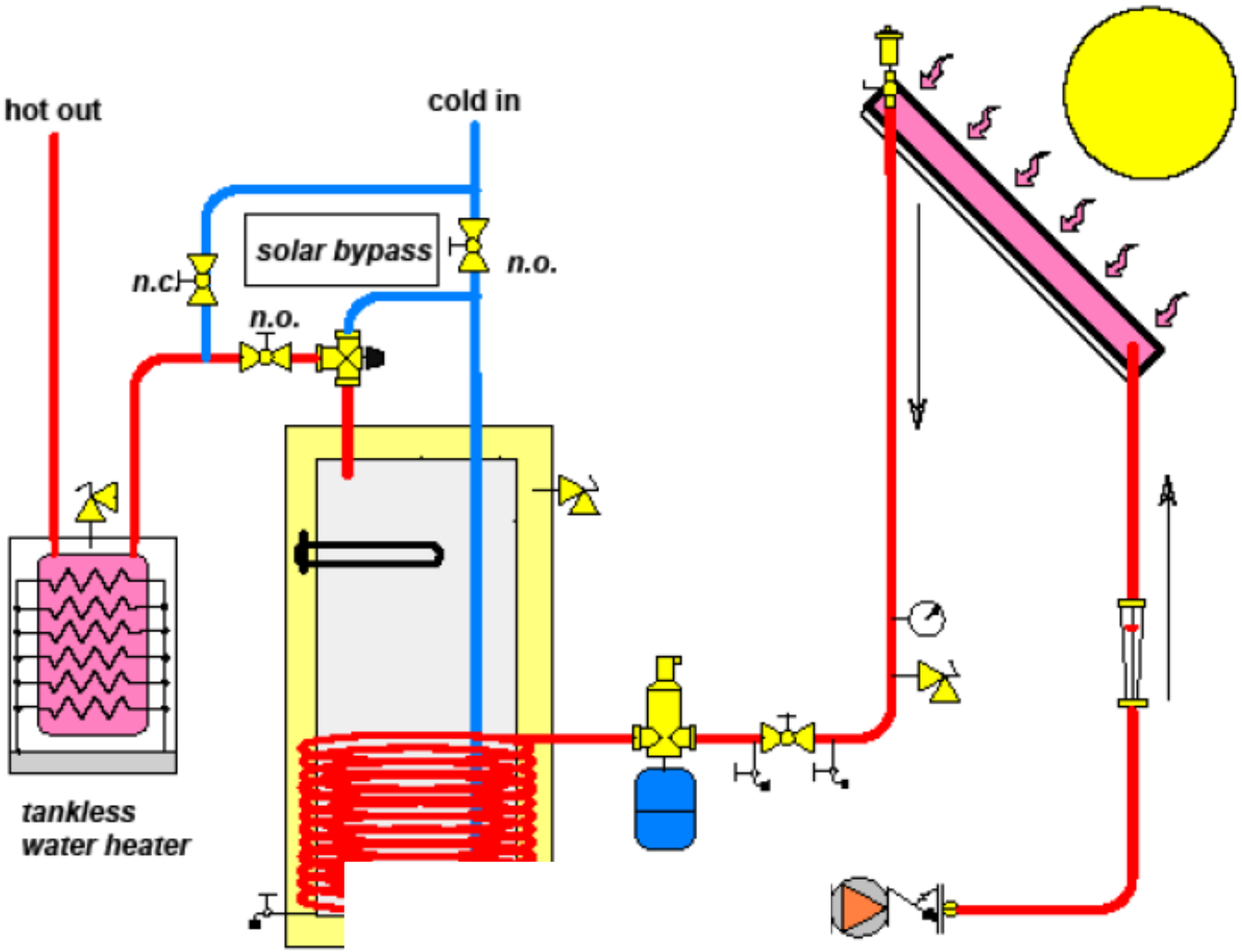
DRAINBACK CLOSED LOOP SYSTEM



DRAINBACK HEAT and DOMESTIC HOT WATER



SOLAR TANK W/ WRAP AROUND HEAT EXCHANGER PRESSURIZED SYSTEM



Solar Heat Sizing

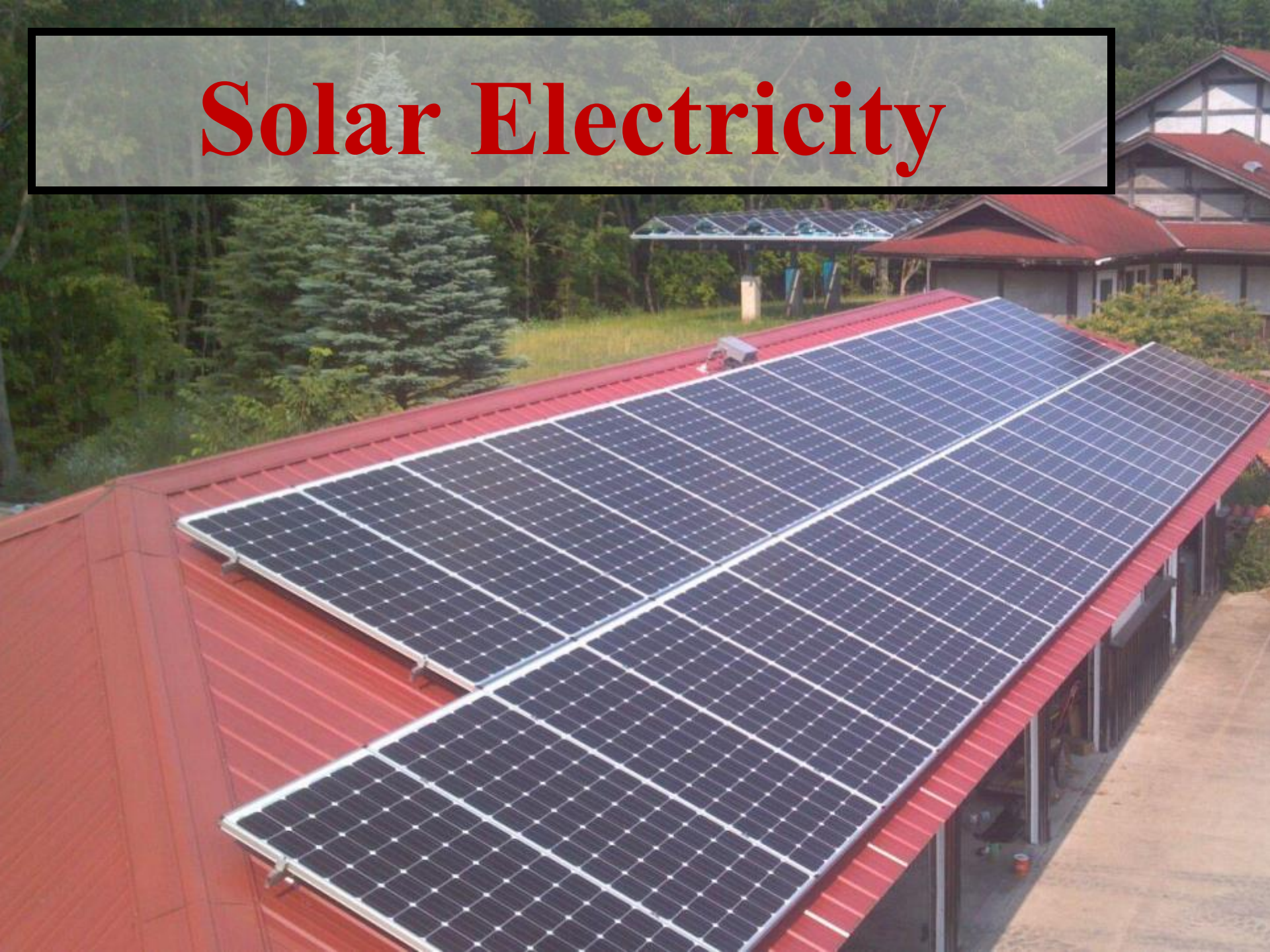
Method 1

- Load Analysis for SDHW - # of gallons hot water/ day
- .75-1.0 square foot collector surface area / gallon

Method 2

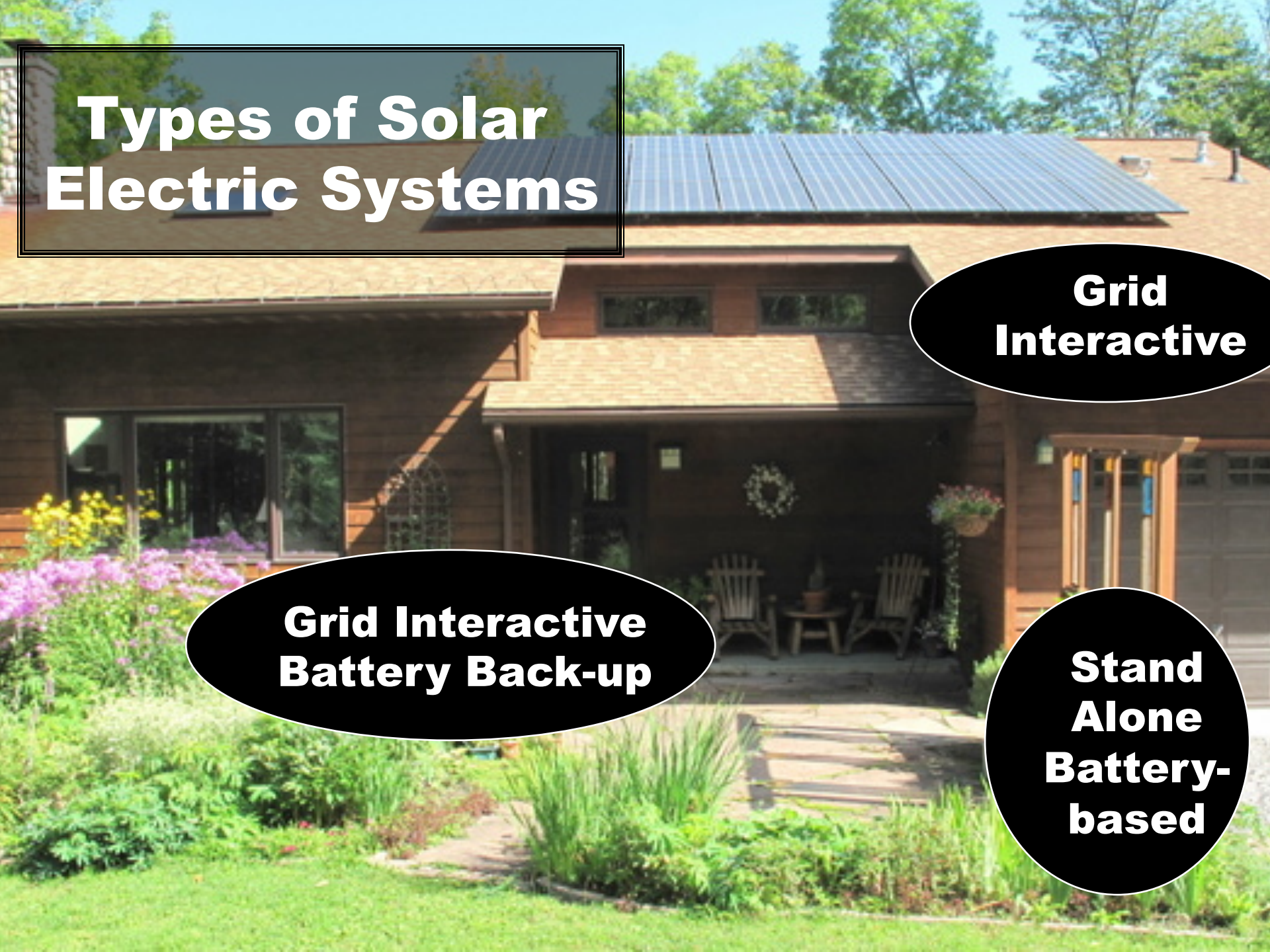
- Load Analysis
- (Wc) (Ts-Ti) (Cp) 8.33
- (65) (70) (1 BTU/lb. F) 8.33 = 37901.5 btus
- Array Sizing
- PSH (4.3) / 10.76 = .399 kWh / sq. ft. / day
- .399 x 3413 = 1361 BTUs / sq. ft. / day
- Match with thermal collector rating

Solar Electricity



Types of PV Modules

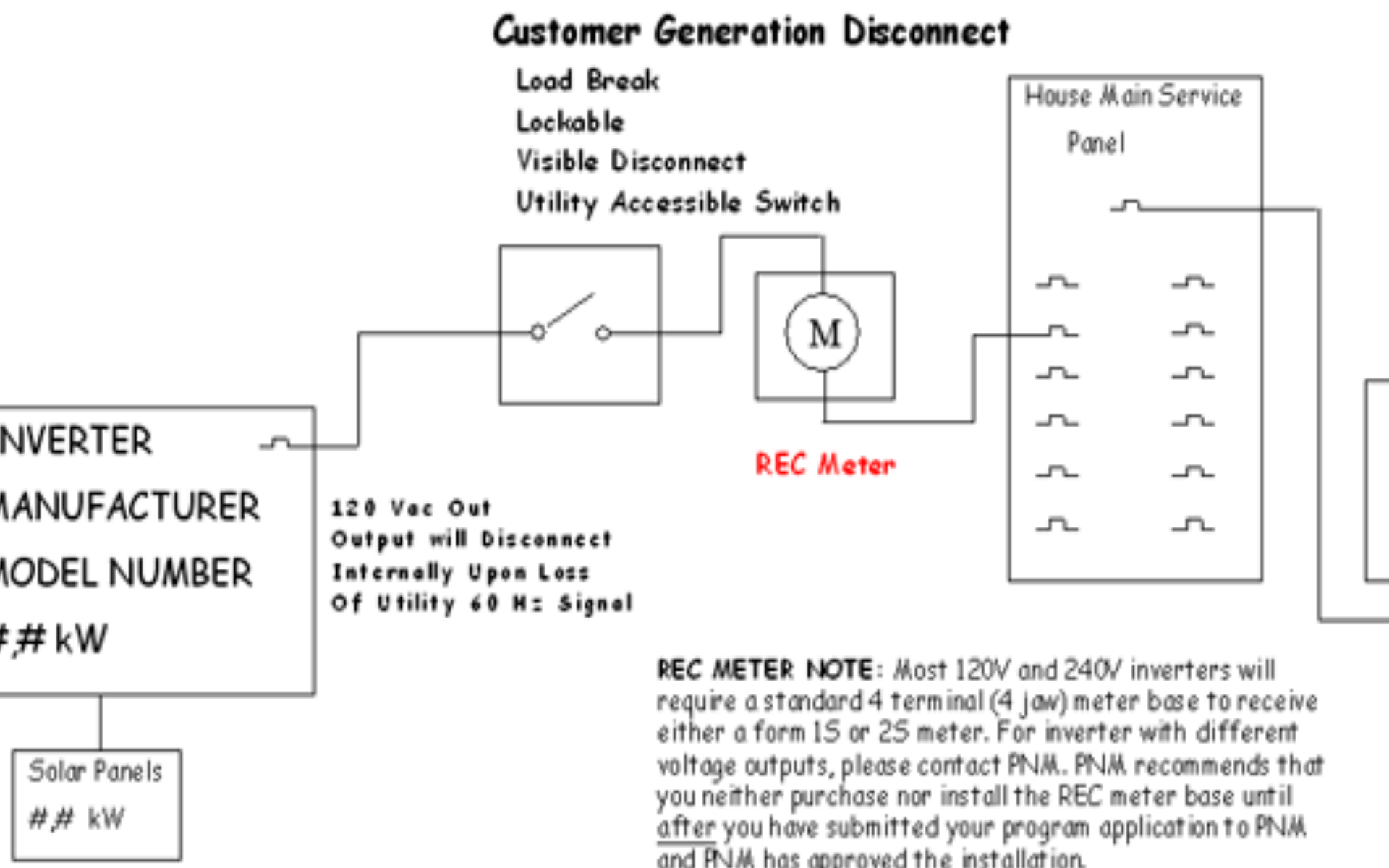
1. Mono-crystalline Si
2. Poly-crystalline Si
3. Amorphous Si
4. CIGS
5. CdTe


Types of Solar Electric Systems
Grid Interactive
Grid Interactive Battery Back-up
Stand Alone Battery-based

Grid-Interactive Solar Electric System

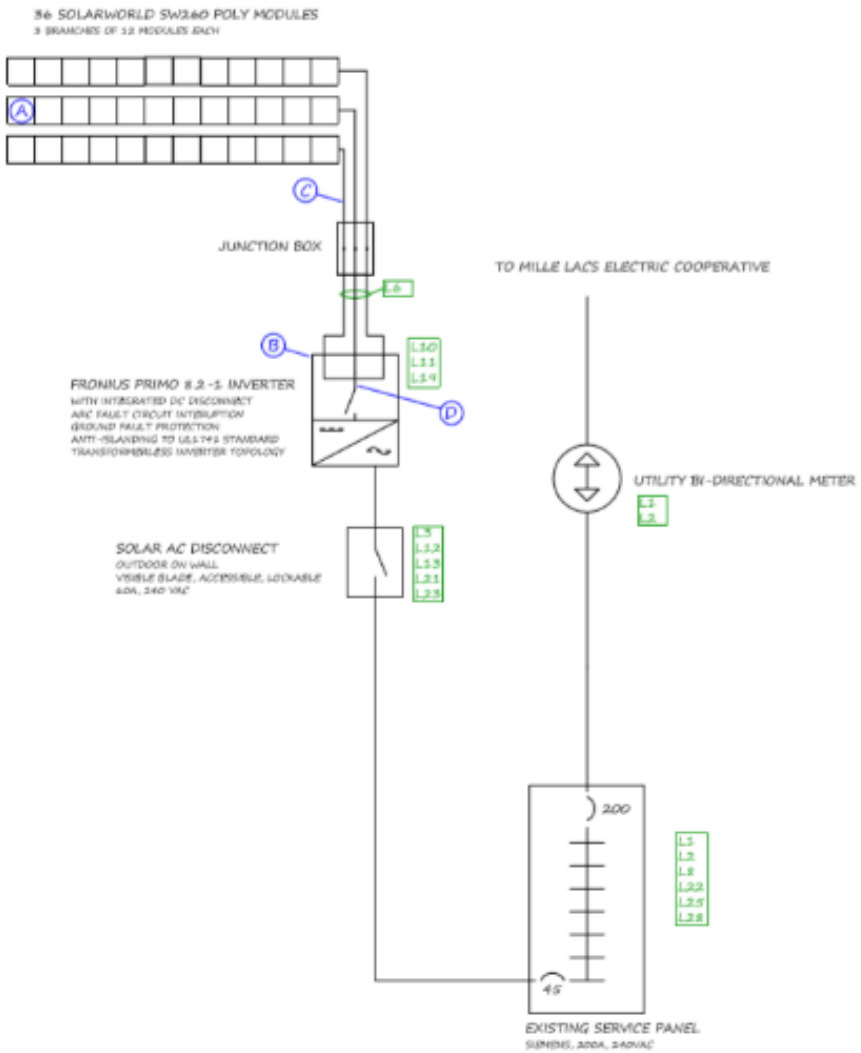
- Rebates
- Battery Free
- Flexible budgeting

SAMPLE ONE-LINE DIAGRAM: GRID-TIED SYSTEM



REC METER NOTE: Most 120V and 240V inverters will require a standard 4 terminal (4 jaw) meter base to receive either a form 1S or 2S meter. For inverter with different voltage outputs, please contact PNM. PNM recommends that you neither purchase nor install the REC meter base until after you have submitted your program application to PNM and PNM has approved the installation.

ONE LINE DIAGRAM



SPECIFICATIONS

(A) MODULE

SOLARWORLD SW360POLY 260W	Pmax	RATED	260 W
	Vmp	NAMEPLATE	31.4 VDC
	Imp	NAMEPLATE	8.37 A
	Voc @ -40C	CALCULATED	46.14 VDC
	Isc	NAMEPLATE	8.94 A

-DC VOLTAGE MAY BE PRESENT WHEN SOLAR MODULES ARE EXPOSED TO SUNLIGHT

(B) INVERTER

FRONIUS PRIMO 8.2-1 5.0 KW	WATTS, RATED	NOMINAL	8200 W
	OUTPUT VOLTAGE	NOMINAL	240 VAC
	OUTPUT CURRENT	MAX	34.2 A
	MAX EFFECIENCY	RATED	97.0%

-INVERTER IS UL1741 LISTED
-INVERTER HAS BUILT IN AFCI PER UL1998

(C) STRING

	Pmax	RATED	3120 W
	Vmp	NAMEPLATE	376.8 VDC
	Imp	NAMEPLATE	8.37 A
	Voc @ -40C	CALCULATED	553.7 VDC
	Isc	NAMEPLATE	8.94 A

(D) ARRAY

NOTE:

- GROUND WIRE NOT SHOWN
- SEE SHEET L.1 FOR LIST OF NEC AND UTILITY REQUIRED LABELS
- NOT ALL EXISTING ELECTRICAL EQUIPMENT SHOWN

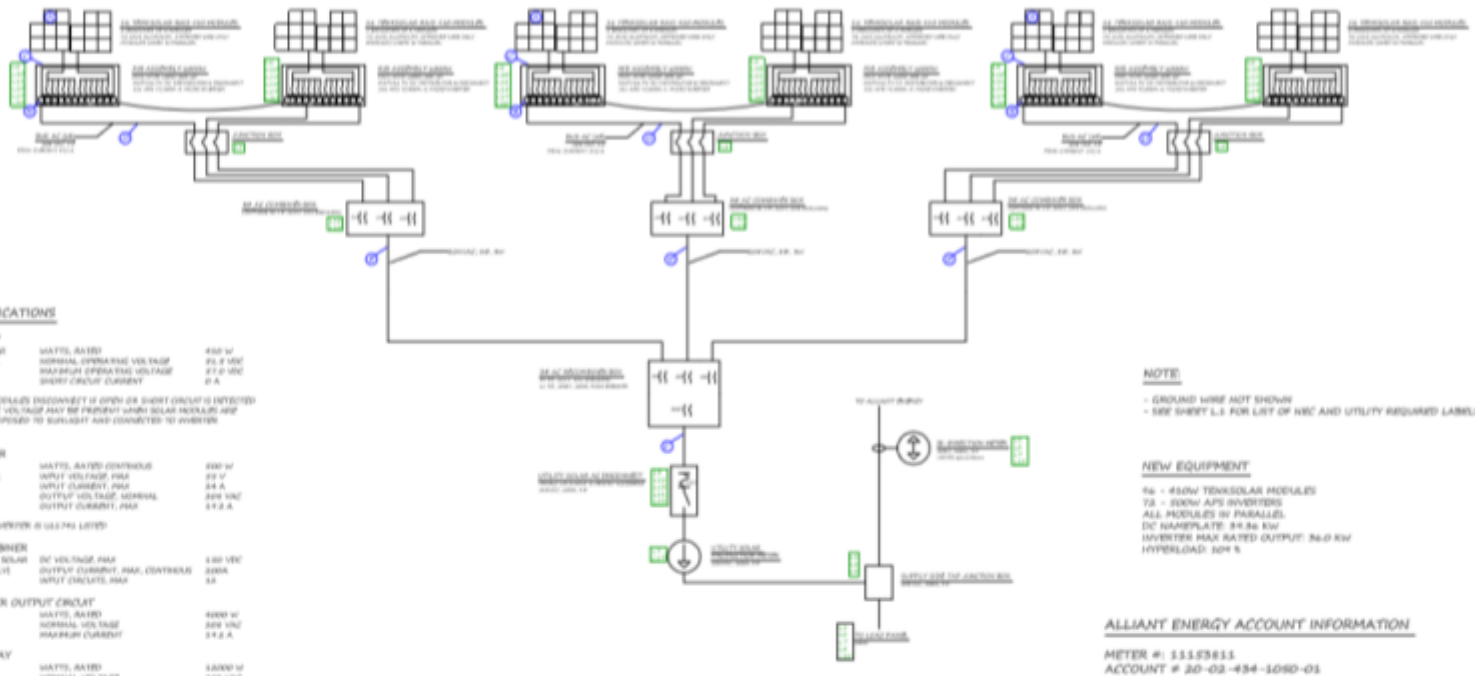
NEW EQUIPMENT

36 - 260W SOLARWORLD SW260POLY PHOTOVOLTAIC MODULES

GRID-TIE, BATTERY FREE

ELECTRIAL ONE LINE DIAGRAM

ONE LINE DRAWING



SPECIFICATIONS

A MODULE

TENKSOLAR	WATTS, RATED	410 W
BAS 3T-A	NOMINAL OPERATING VOLTAGE	35.3 VDC
410W	MAXIMUM OPERATING VOLTAGE	37.0 VDC
	SHORT CIRCUIT CURRENT	0 A

-MODULES DISCONNECT IF OPEN OR SHORT CIRCUIT IS DETECTED
-DC VOLTAGE MAY BE PRESENT WHEN SOLAR MODULES ARE EXPOSED TO SUNLIGHT AND CONNECTED TO INVERTER

B INVERTER

APS	WATTS, RATED CONTINOUS	600 W
YC600A-K	INPUT VOLTAGE, MAX	45 V
600W	INPUT CURRENT, MAX	14 A
	OUTPUT VOLTAGE, NOMINAL	208 VAC
	OUTPUT CURRENT, MAX	2.9 A

-INVERTER IS ULL741 LISTED

C DC COMBINER

MIDNIGHT SOLAR	DC VOLTAGE, MAX	150 VDC
MNPV16 (LY)	OUTPUT CURRENT, MAX, CONTINOUS	100A
	INPUT CIRCUITS, MAX	10

D INVERTER OUTPUT CIRCUIT

	WATTS, RATED	4000 W
	NOMINAL VOLTAGE	208 VAC
	MAXIMUM CURRENT	19.2 A

E SUBARRAY

	WATTS, RATED	14000 W
	NOMINAL VOLTAGE	208 VAC
	LINE CURRENT	33.9 A

F ARRAY

	WATTS, RATED	34000 W
	NOMINAL VOLTAGE	208 VAC
	LINE CURRENT	113 A

NOTE

- GROUND WIRE NOT SHOWN
- SEE SHEET E.1 FOR LIST OF NEC AND UTILITY REQUIRED LABELS

NEW EQUIPMENT

96 - 410W TENKSOLAR MODULES
73 - 600W APS INVERTERS
ALL MODULES IN PARALLEL
DC NAMEPLATE: 39.36 Kw
INVERTER MAX RATED OUTPUT: 36.0 Kw
HYPERLOAD: 109 %

ALLIANT ENERGY ACCOUNT INFORMATION

METER #: 11153811
ACCOUNT # 30-02-434-1050-01

PROJECT TITLE
GRID-TIE, BATTERY FREE PV INSTALLATION
ALBERT LEA SEED HOUSE
1414 WEST MAIN STREET
ALBERT LEA, MN 56007

REVISION SCHEDULE

NO.	DATE	BY

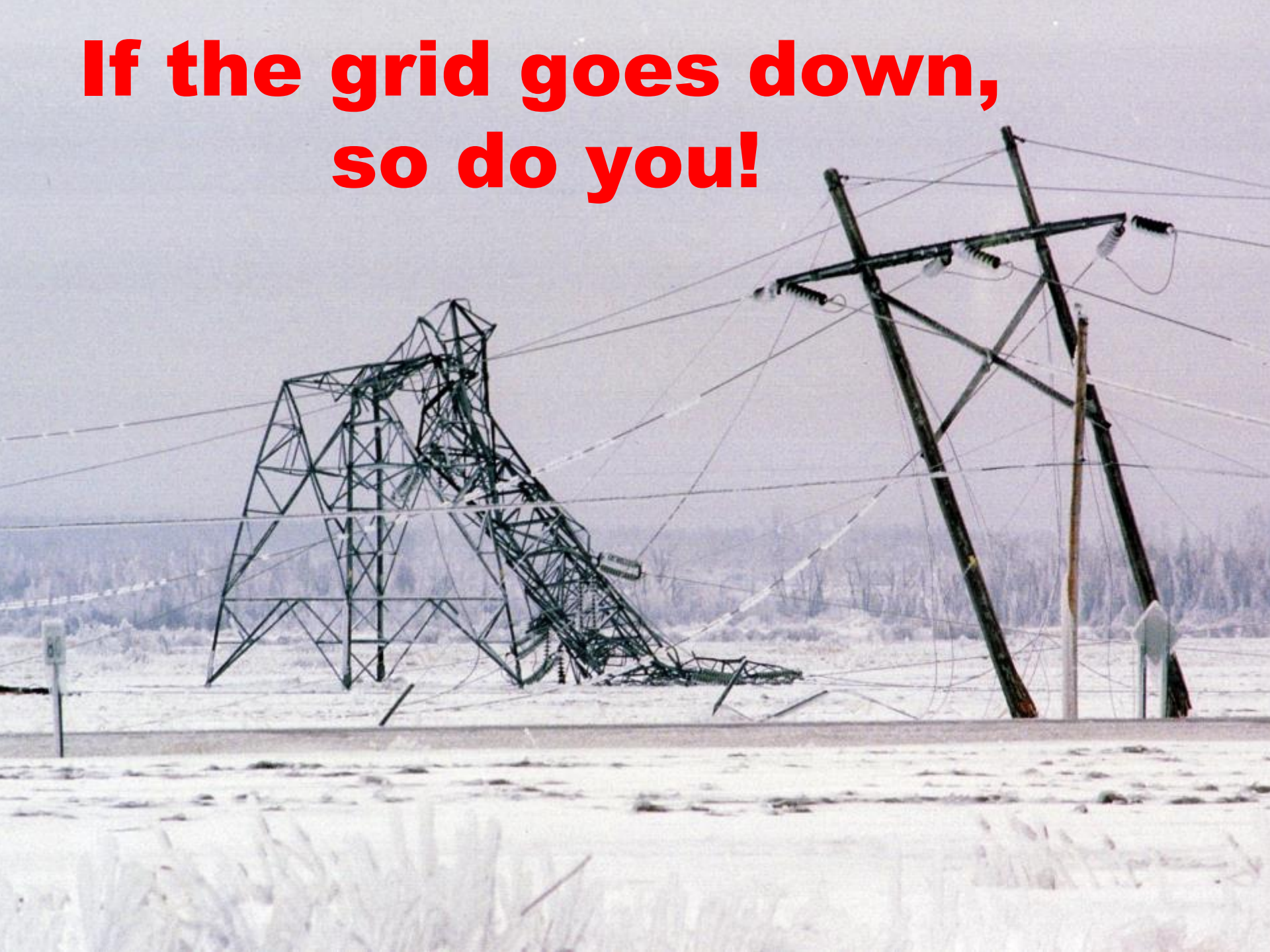
REALSOLAR Solar Design-Build
www.REALsolar.org 218-557-4739 info@REALsolar.org

DRAWN BY: RSO | DATE: 3/6/15 | CHECKED BY: JSL | PAGE: NTS

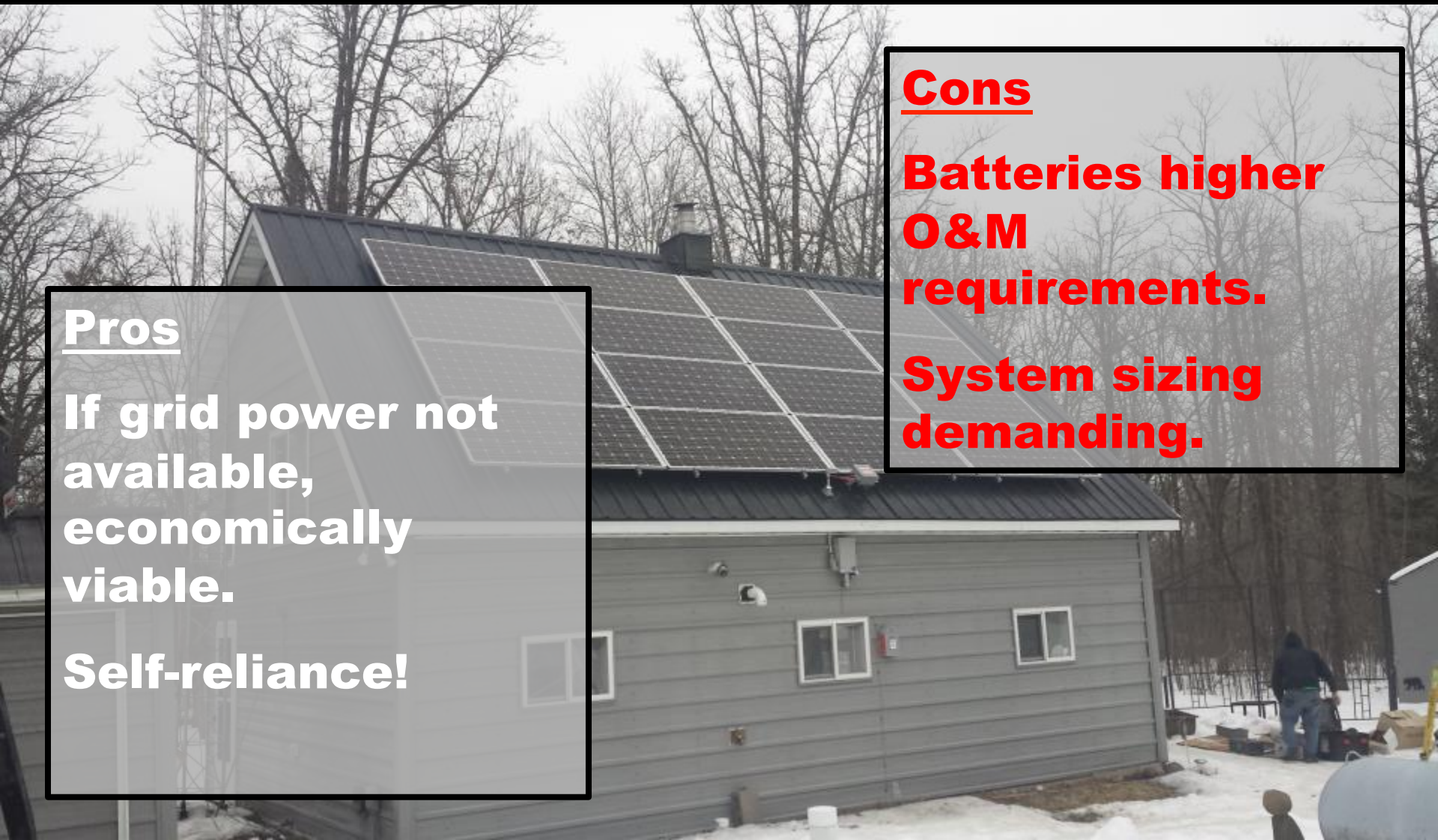
SHEET TITLE
ELECTRIAL ONE LINE DIAGRAM

PROJECT NUMBER
GTBF-39360

SHEET NUMBER
E.1


If the grid goes down,
so do you!

Stand-alone Battery- Based System



Pros

If grid power not available, economically viable.

Self-reliance!

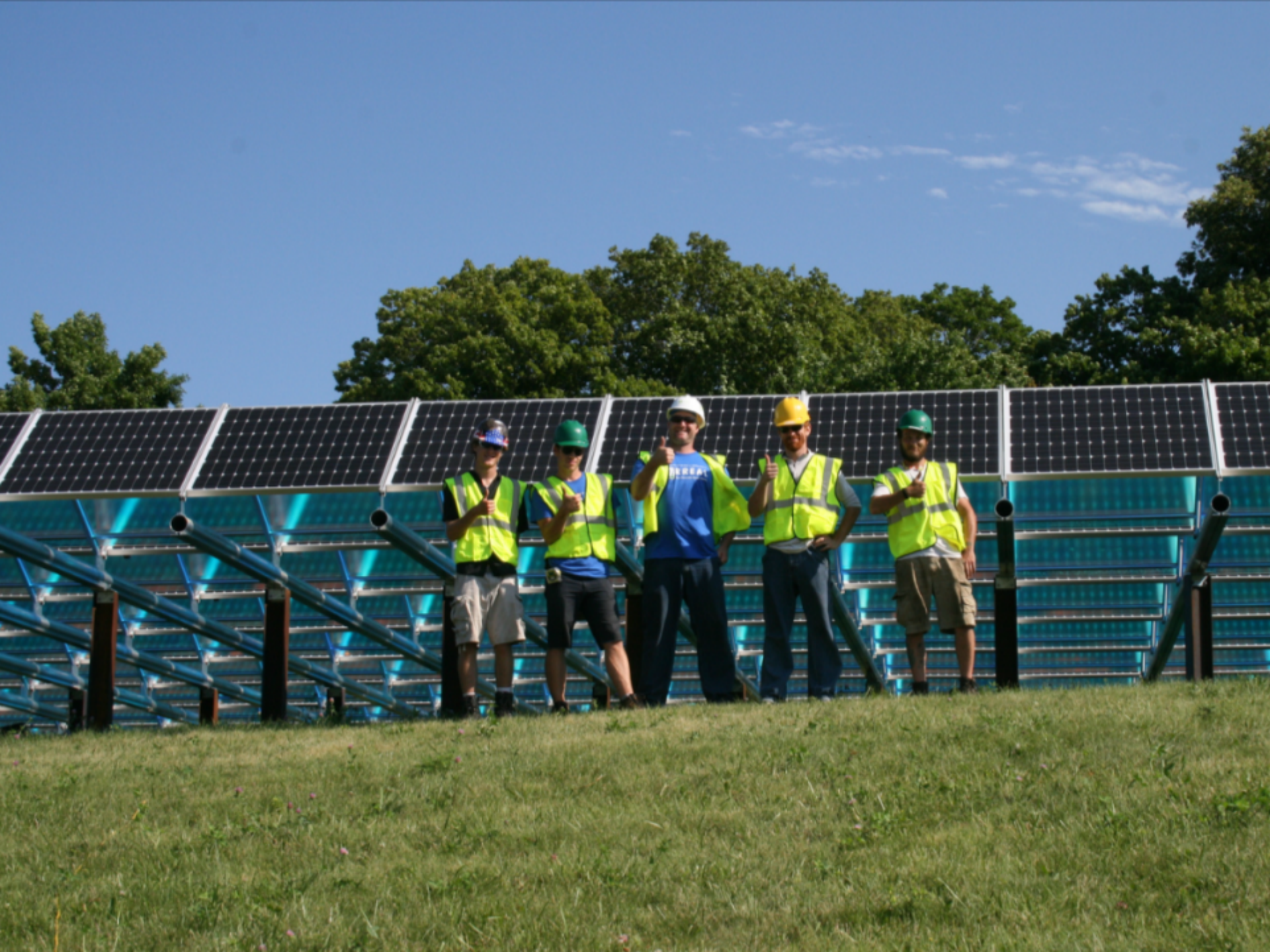
Cons

Batteries higher O&M requirements.

System sizing demanding.

Reality Check: Flush Mount and Snow


1
2
3
4
5




Royalton

Solar Electric Sizing

- Load Analysis - Determine ADC (Average Daily Consumption)
- Site Analysis - Determine PSH (Peak Sun Hours)
- ADC / PSH = PV Array Size
- Determine PV Make and Model
- De-rate PV module for real world application (.7 multiplier)
- Determine # of modules necessary to meet array size

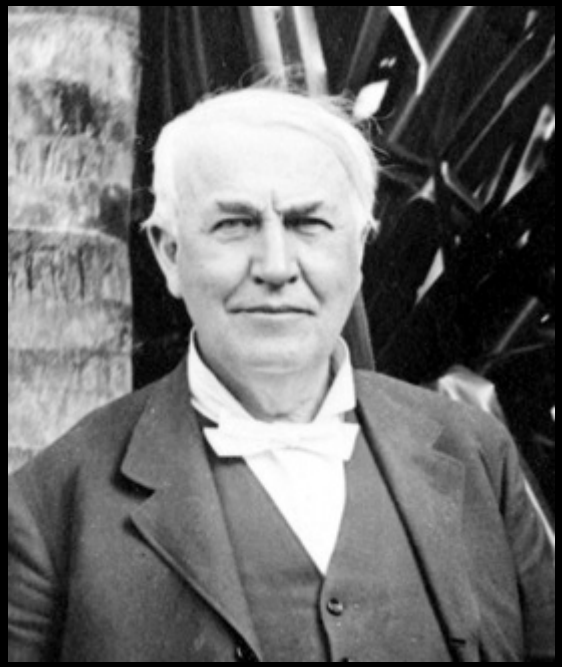
Incentives for Solar

http://mn.gov/commerce/energy/topics/resources/energy-legislation-initiatives/made-in-minnesota/

Incentives for Solar

www.dsireusa.org

Database of State Incentives for Renewable Energy



“I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that.”

Thomas Edison 1931


Thank you and
sunny regards.