

# **INTRODUCTION TO SOLAR: TECHNOLOGY, RESOURCES, AND POLICIES**

Energy Design Conference 2019

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By

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# AGENDA

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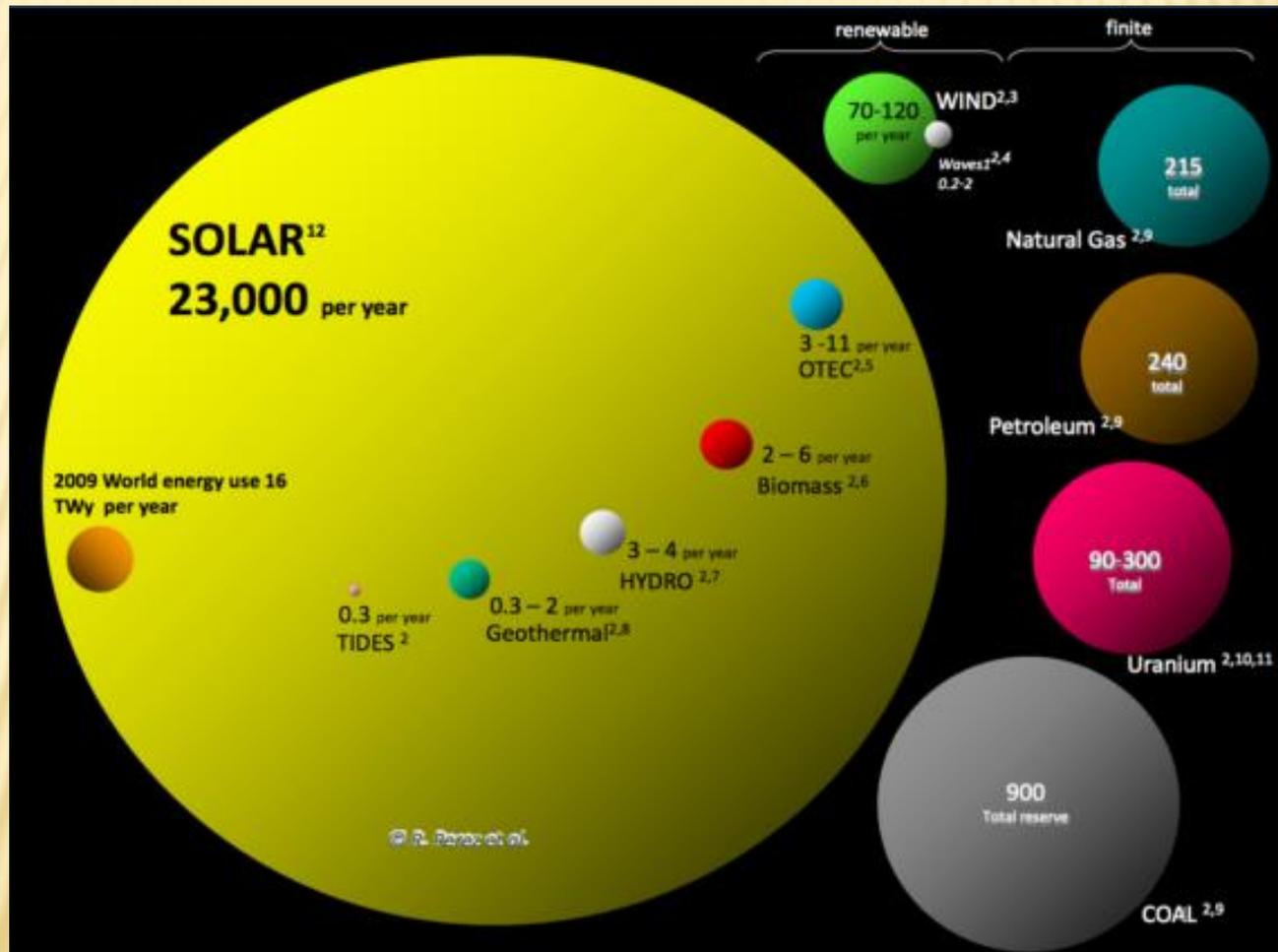
- ✘ Introduction:
- ✘ Overview: Solar Resource, Technologies, and policies
- ✘ Solar Technologies
- ✘ Market drivers and status
- ✘ Policies, Rules, and Regulations

**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.”**

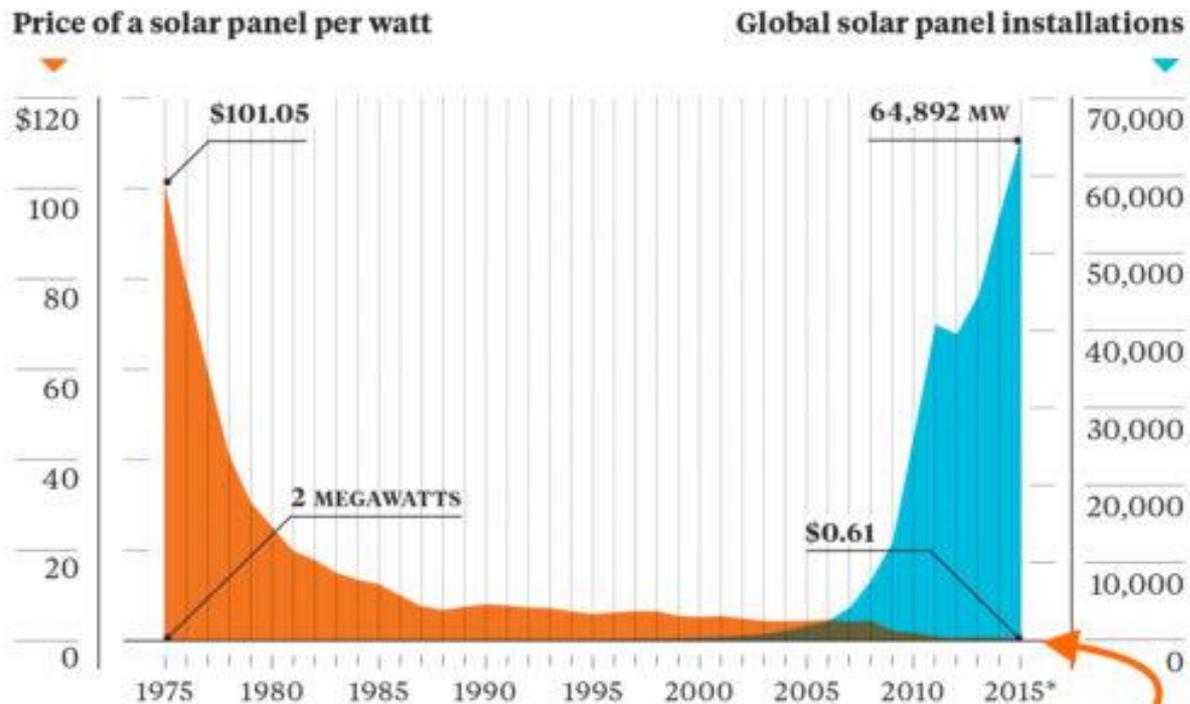
**FOR ADDITIONAL CONTINUING EDUCATION  
APPROVALS, PLEASE SEE YOUR CREDIT  
TRACKING CARD.**

# SOLAR AS A RESOURCE



# Solar on Fire

As prices have dropped, installations have skyrocketed.

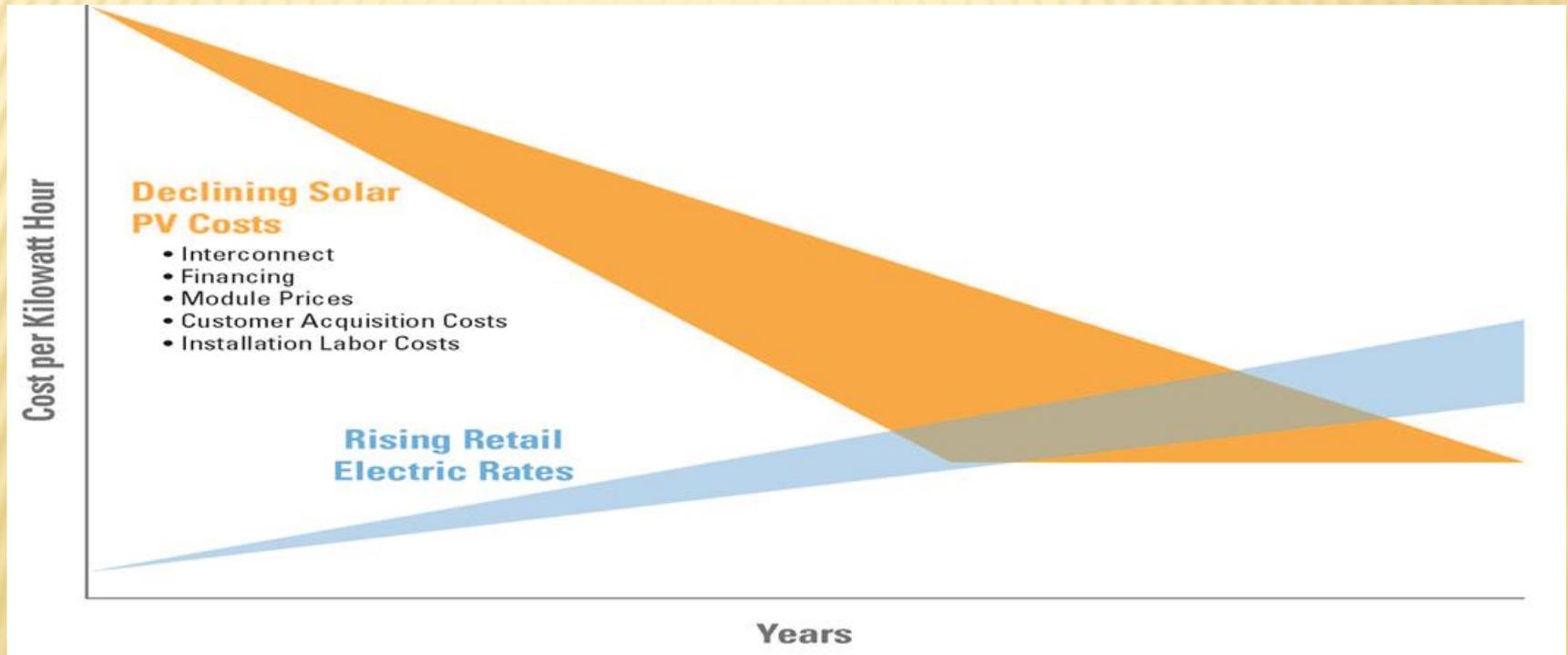


*\*Estimate. Sources: Bloomberg, Earth Policy Institute, [www.earth-policy.org](http://www.earth-policy.org)*

**Down to \$0.447 in August 2016**

# COST OF SOLAR

- ✘ Historic- 1950's \$300/w, 1970's \$50/w, 1990's \$10/w, today <\$1/w





# POLICIES DRIVING SOLAR

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- ✘ Global:
  - + Germany: EnergieWende
  - + China: 5 Year plans
  - + USA: state level RPSs
  - + Others
- ✘ Public Utilities Regulatory Policies Act 1978
- ✘ Net Metering



# MINNESOTA RENEWABLE ENERGY

- ✘ Next Generation Energy Act
  - + Passed in 2007 (§216C.05)
  - + 25% by 2025
  - + Accomplished or on target
- ✘ Solar Energy Standard



# 2013 Minnesota Solar Legislation

Renewable Energy Standard (RES)

Unchanged

Solar Energy Standard (SES)

**1.5% of Retail Sales by 2020**

*(excludes mining & paper industry)*

Net Meter

**1 MW Limit**

*(not to exceed 120% of usage)*

Solar Value Rate

**Value of Solar (VOS)**

*(Optional for IOU's)*

Community Solar Gardens

**Xcel Required, Other IOU's Optional**

Made in MN Subsidy

**5% of CIP\$**



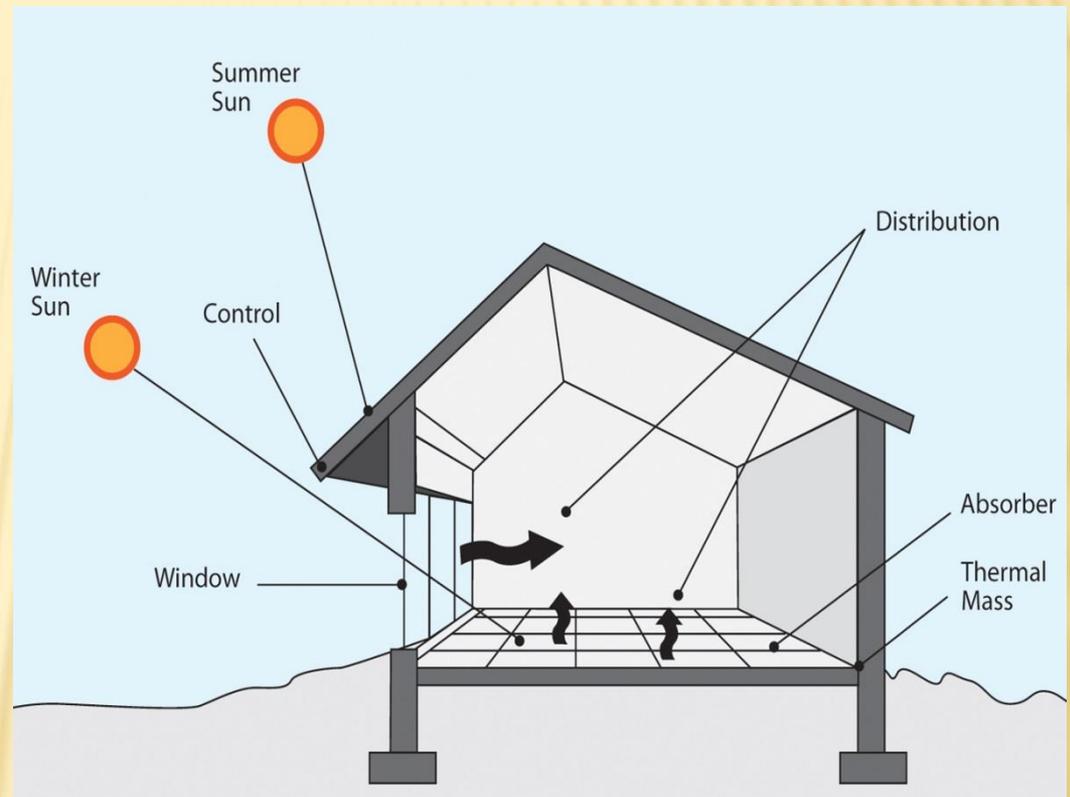
# TECHNOLOGY

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- ✗ Passive
  - + Heating, cooling, Lighting
- ✗ Heating and Cooling
  - + Systems and collector types
  - + Hot water
  - + Hot air
- ✗ Electricity
  - + Thermal
  - + Photovoltaic (PV)

# PASSIVE

- ✘ Using design to control energy from the sun entering the building
- ✘ Orientation, overhangs, and positioning of windows



# SOLAR THERMAL- HOT WATER

- ✘ Design types
  - + Batch
  - + Pressurized
  - + Drain back
- ✘ System components
  - + Collectors
  - + Pumps
  - + Pipes
  - + Storage tanks
  - + Controls
  - + Sensors

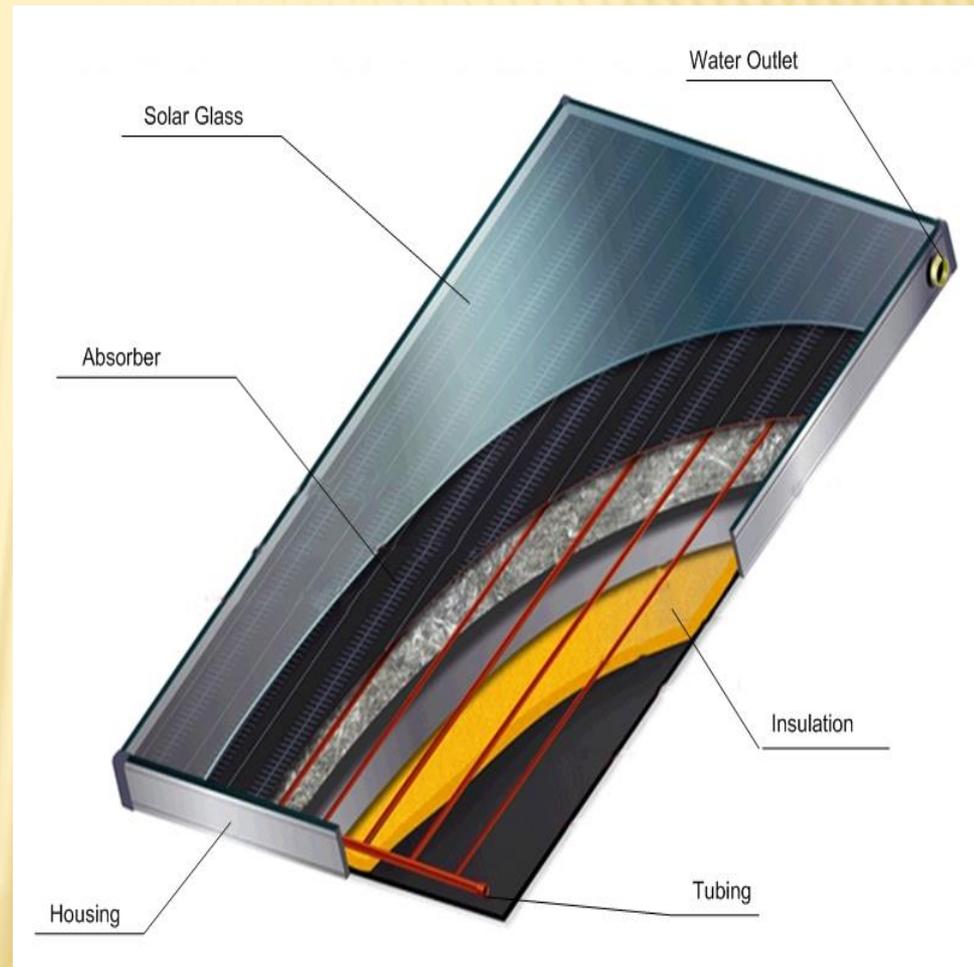
# BATCH SYSTEMS

- ✘ Used in warmer climates
- ✘ Small footprint



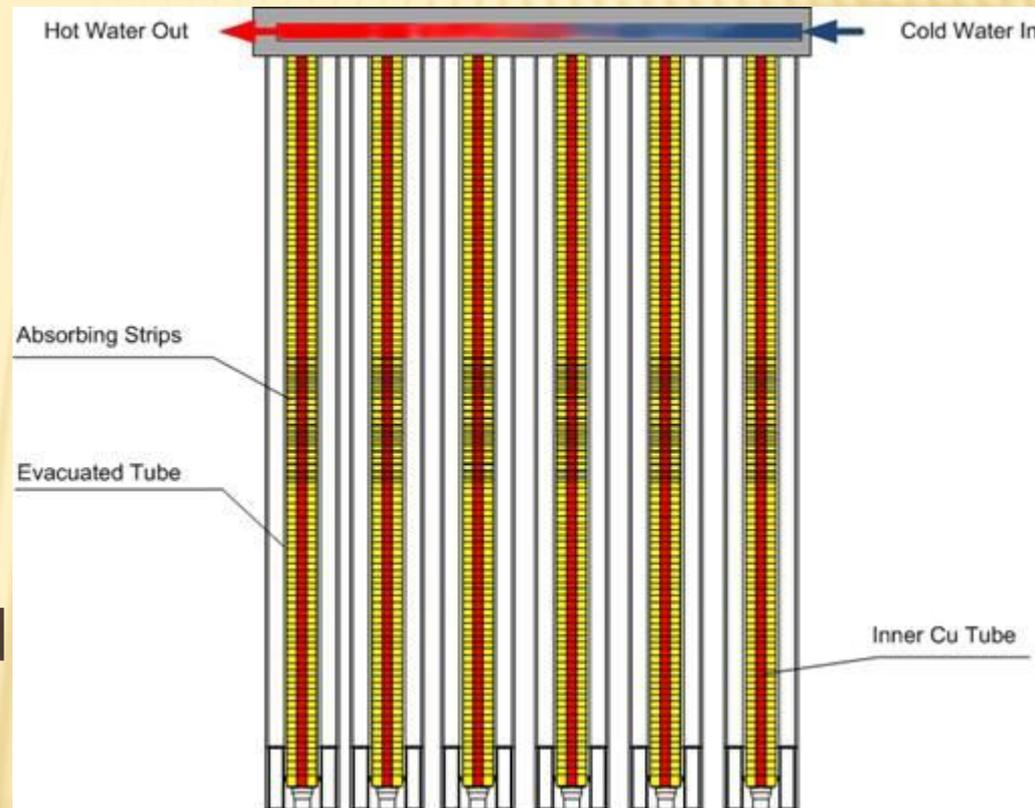
# FLAT PLATE

- ✘ Flat panels
- ✘ No internal moving parts
- ✘ Collectors, tubing, insulation, glazing, frame



# EVACUATED TUBES

- ✘ Vacuum sealed chamber around a specialized metal collector
- ✘ Top manifold to transfer heat to coolant loop
- ✘ Effective in very cold conditions
- ✘ Vacuum is key



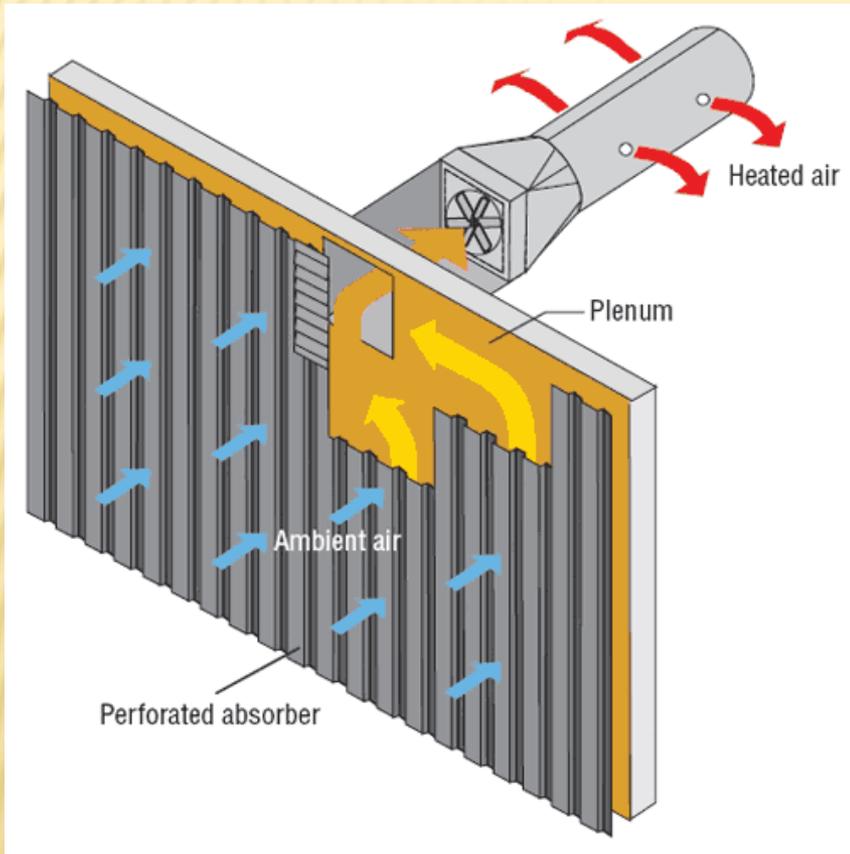


# SOLAR THERMAL- HOT AIR

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- ✘ Space heating
- ✘ Transpired air- pre conditioning

# SOLAR WALLS- TRANSPIRED AIR



# SOLAR THERMAL- GENERAL

- ✘ The current market is small
- ✘ Certifications for products through the Solar Rating and Certification Corporation (SRCC)



# SOLAR ELECTRIC- THERMAL

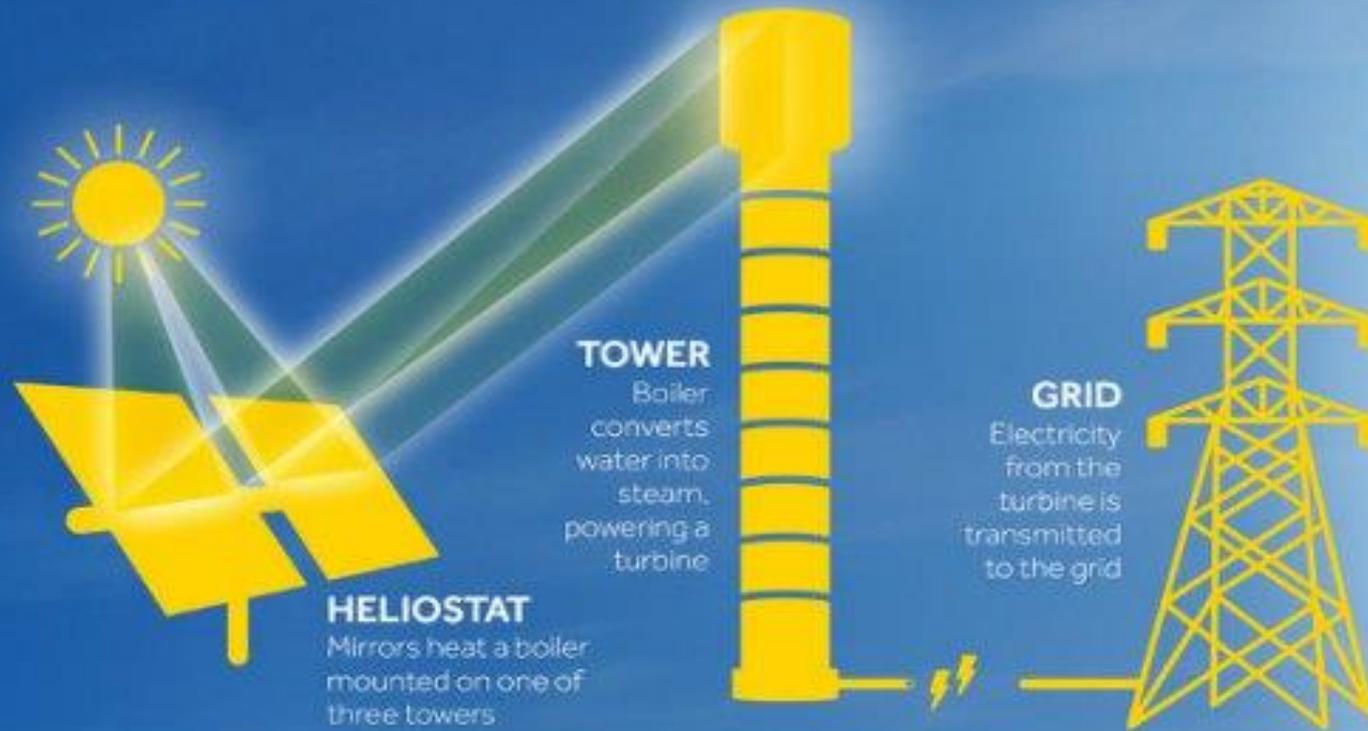
- ✘ Concentrating the sun to produce high levels of heat to create steam for power production
- ✘ Parabolic Trough and Power Towers



PO  
50

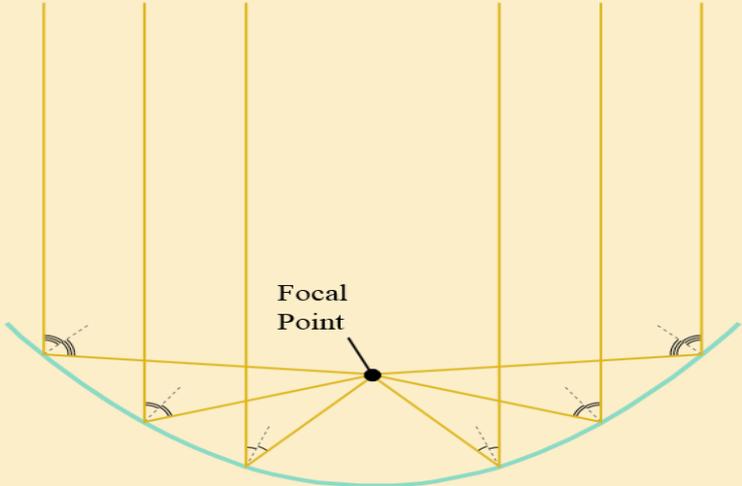
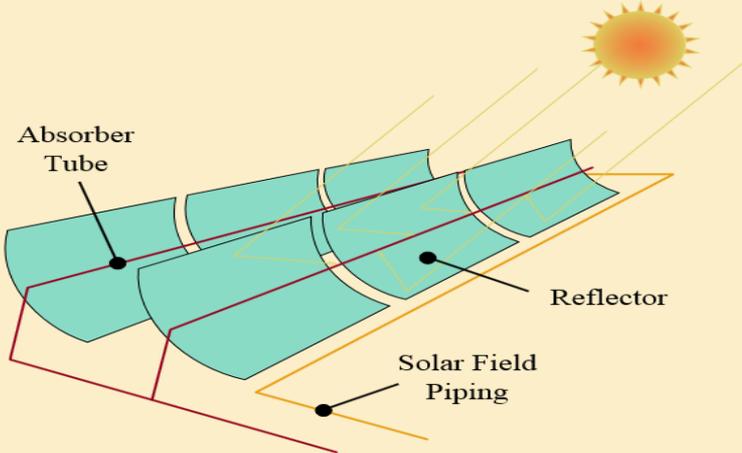
# Inside the innovation

Ivanpah is three separate plants on 3,500 acres in the Mojave Desert, California. But, size alone didn't make this project a big step toward our clean energy future; it required a smarter approach. We created a state-of-the-art solar power system that generates 392 MW from 347,000 garage door-sized mirrors.



100% of the steam turbine's water is recycled

# PARABOLIC TROUGH



# PHOTOVOLTAIC EFFECT

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- ✘ Britannica: “Process in which two dissimilar materials in close contact produce an electrical voltage when struck by light or other radiant energy.”
- ✘ First observed by French physicist A.E. Becquerel in 1839
- ✘ First solar cells made of gold and selenium in 1884 by Charles Fritts

# SOLAR ELECTRIC- PHOTOVOLTAICS (PV)

- ✘ Semiconductors exposed to light will create an electric current
- ✘ Scalable technology: from watches to utility scale system
- ✘ Dramatic improvements in technologies and costs has propelled PV into mainstream power production.
- ✘ First technology that allows homeowners to easily make their own electricity.

# MATERIALS AND APPLICATIONS

- ✘ Silicon solar cells

  - + Polycrystalline

  - + Monocrystalline

- ✘ Thin Film

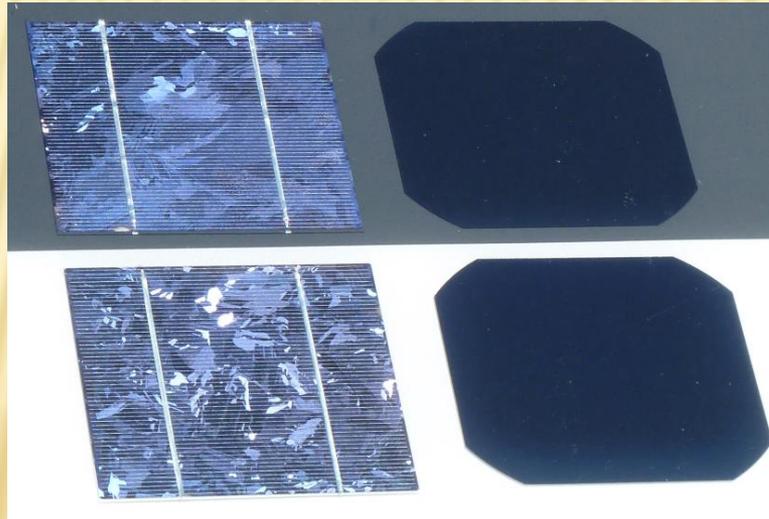
  - + CIGS- Cadmium Indium Gallium Selenide

  - + CdTe- Cadmium Telleride

- ✘ Others: Organic, Perovskites, Quantum Dots...

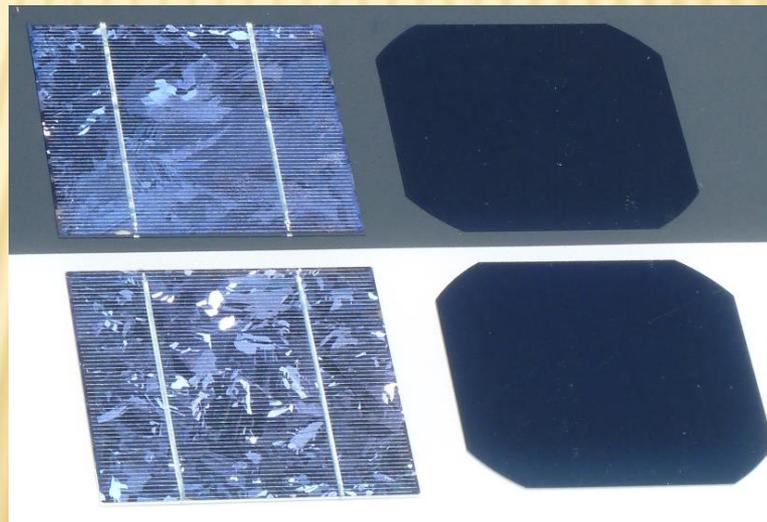
# SILICON CRYSTAL CELLS

- ✘ Polycrystalline: mottled appearance due to manufacturing technique.
- ✘ Less efficient than Monocrystalline cells due to cell structure. Less costly to produce.



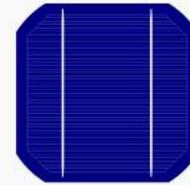
# SILICON CRYSTAL CELLS

- ✘ Monocrystalline: Uniform appearance due to single crystal structure
- ✘ More efficient than Polycrystalline
- ✘ More costly to produce



# FROM CELL TO SYSTEMS

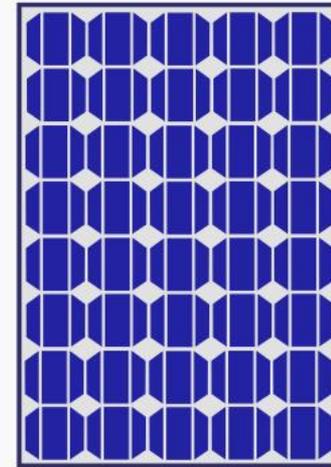
From a solar cell  
to a PV System



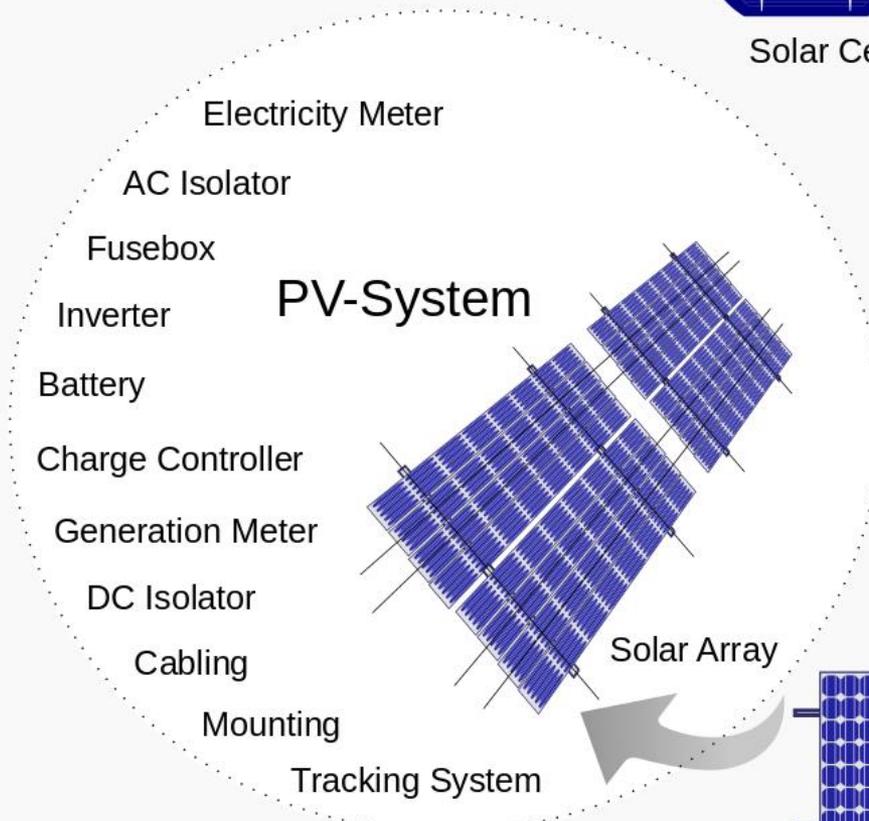
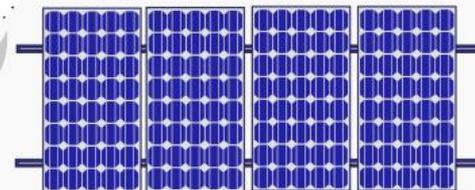
Solar Cell



Solar Module



Solar Panel



# SOLAR SYSTEMS

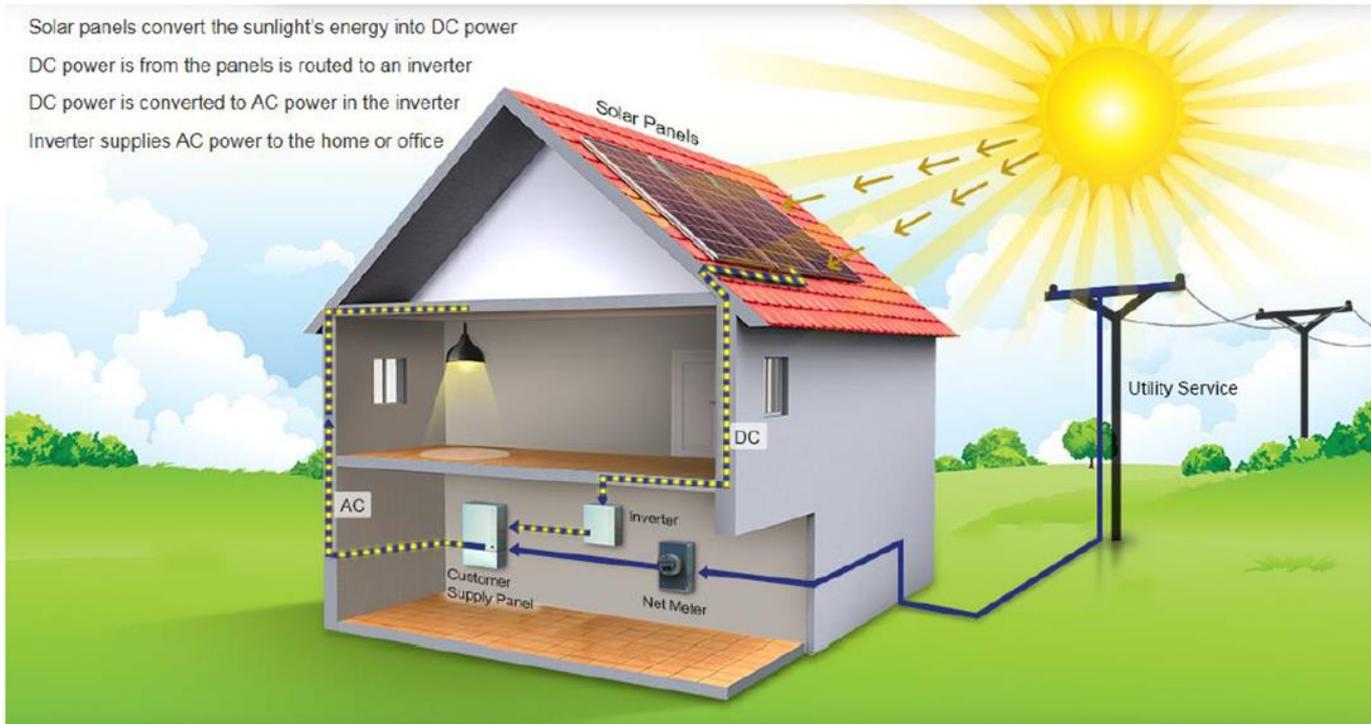
## Grid Connected Solar Photovoltaic System

Solar panels convert the sunlight's energy into DC power

DC power from the panels is routed to an inverter

DC power is converted to AC power in the inverter

Inverter supplies AC power to the home or office



# GRID TIED SYSTEM COMPONENTS



AC Disconnect  
With in 10' of  
utility meter



DC Disconnect

**DC**

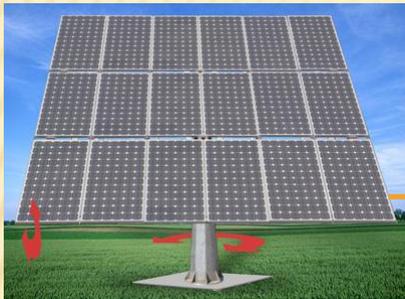


Inverter

**AC**



# GRID TIED BATTERY BACKUP



Main Panel



Charge Controller



Secure Loads panel

# SYSTEM COMPONENTS

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- ✘ Certifications under IEEE1547 for solar inverters
- ✘ UL1541 for inverters, and 1708 for modules
- ✘ New standards are emerging for inverters
  - + CA- Rule 21/ IEEE1547.
  - + Allow for more advance functions
    - ✘ Low voltage ride through
    - ✘ Dynamic controlling

# SOLAR MODULES

## Basic Elements

- Photovoltaic Panel
  - 250W-350W capacity each
  - 0-40V DC depending upon sunlight exposure
  - 5-10 Amps per panel
  - Produce power any time sunlight is on them
  - **Even with disconnect open, Voltage is present at panel**
  - Wired in series to increase DC Voltage and Amperage



# INVERTERS

## Basic Elements

- Inverter
  - Similar to vehicle inverter
  - Converts DC to AC sine wave
  - Sine wave created exactly matches utility (unity PF)
  - Acts like an amperage source providing the house with kwh
  - Integrated AC-DC disconnect barrel switch on most models
  - Multiple sizes and models can be combined at one site



# RACKING

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- ✘ Roof
  - + Mechanical attachments
  - + Ballasted
- ✘ Ground
  - + Multiple pole
  - + Single Pole
  - + Ballasted
- ✘ Trackers

# BALLASTED

- ✘ Flat roof or ground mounts
- ✘ Weighted to hold array in place
- ✘ No penetrations/ More Weight



# GROUND MOUNTS

- ✘ Need to know soil conditions
- ✘ Very flexible configurations



# ATTACHED

- ✘ Mechanical fasteners into structural members
- ✘ Flashed mounting points
- ✘ Rails to attach modules
- ✘ Integrated grounding features



# TRACKERS

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- ✘ Large scale installations
- ✘ Single or Dual Axis
- ✘ Increases capacity factor



# BALANCE OF SYSTEM

- ✘ Meters
- ✘ Disconnects
- ✘ Combiners
- ✘ Conduit
- ✘ Wire
- ✘ Etc.



# TRAINING, TOOLS, AND RULES

- ✘ Department of Labor and industry requires electrically trained persons to perform work associated with PV installation
- ✘ NEC codes guiding proper installation:
  - + 690
  - + 720
  - + Other associated sections
- ✘ NABCEP and UL certification
- ✘ State Interconnection Standards
  - + 2004 standards currently being updated
  - + Small Generator Interconnection Process

# SOLAR INSTALLER CERTIFICATION

- ✘ NABCEP- North American Board of Certified Energy Practitioners
- ✘ UL- Underwriter Laboratories

NABCEP™

Raising Standards. Promoting Confidence.

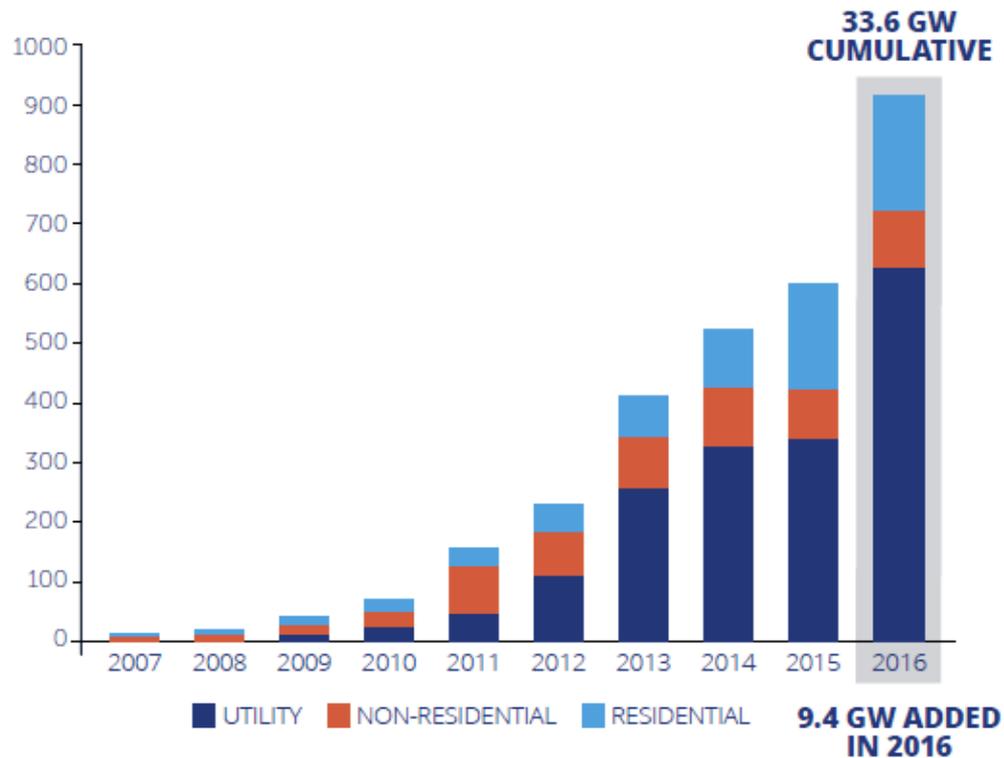


# THE SOLAR MARKETPLACE TODAY

- ✘ Global demand is growing rapidly
- ✘ US demand is about 10 GW per year
- ✘ Challenges of an intermittent resource
- ✘ Falling prices bringing a competitive edge
- ✘ Solar still remains higher cost energy in many areas
- ✘ Incentives are available for consumers

# SOLAR IS GROWING

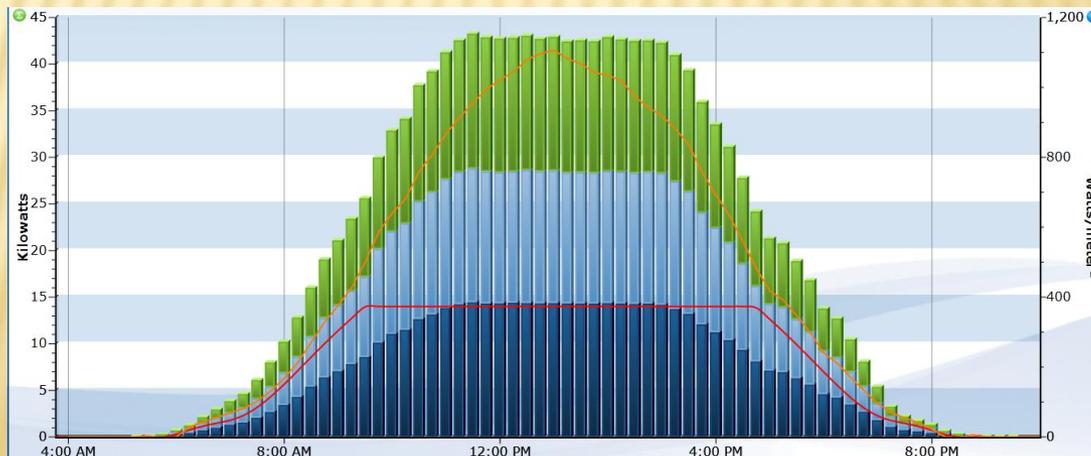
FIGURE 1: ANNUAL SOLAR CAPACITY (MW)

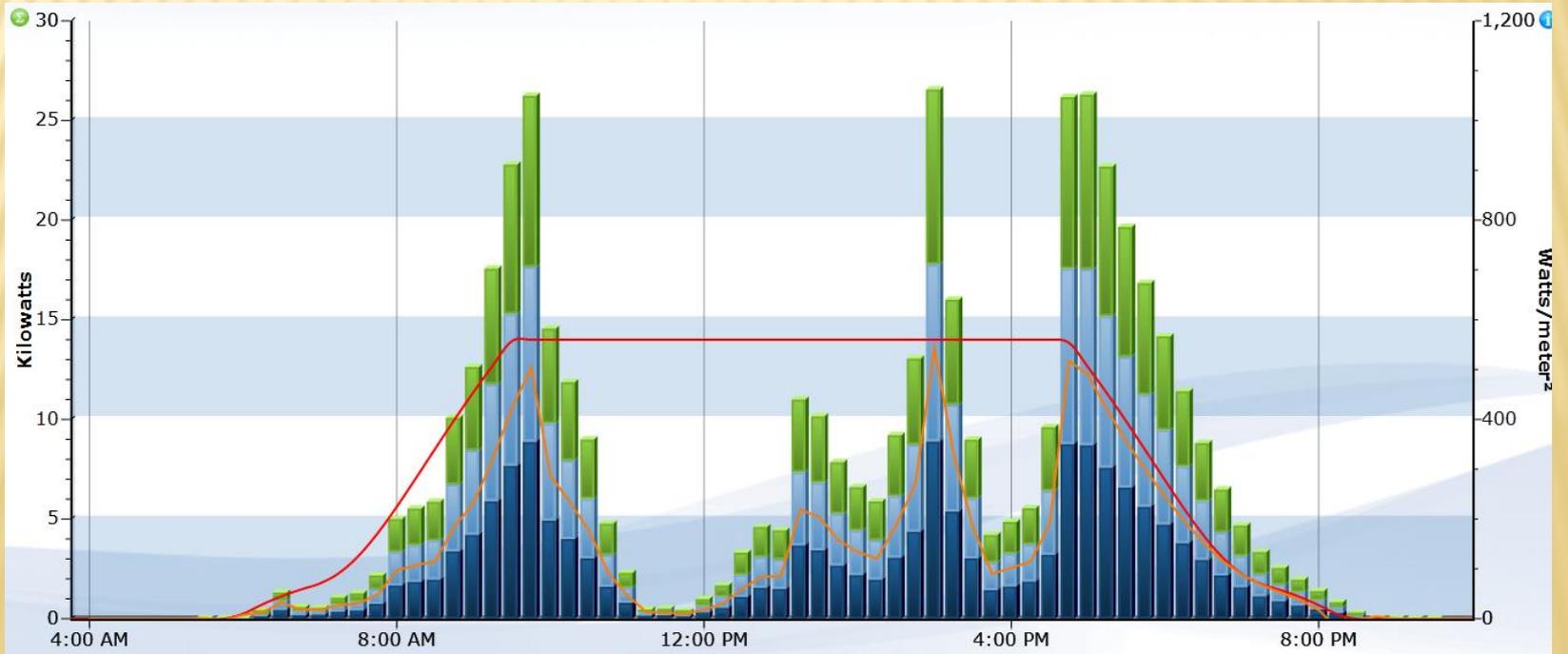
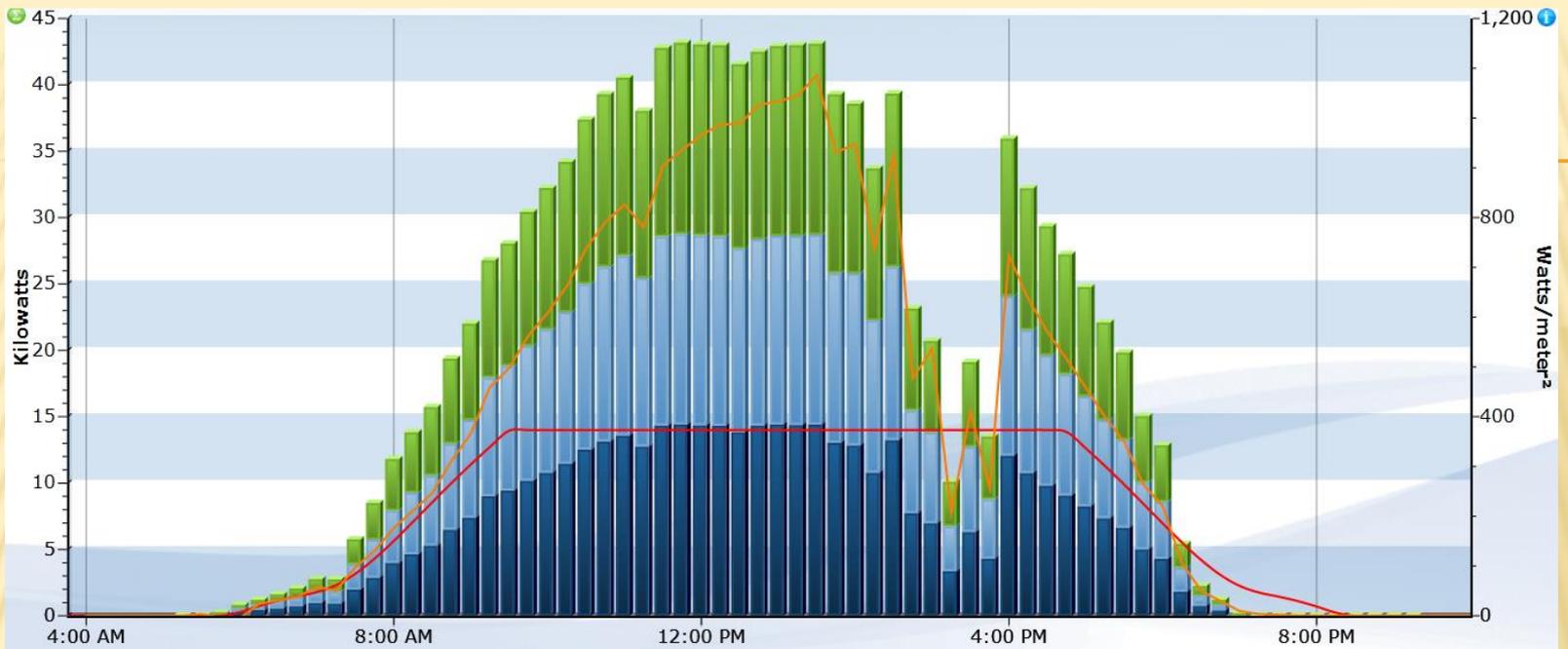


Source: Smart Electric Power Alliance, 2007-2017.

# INTERMITTANT RESOURCE

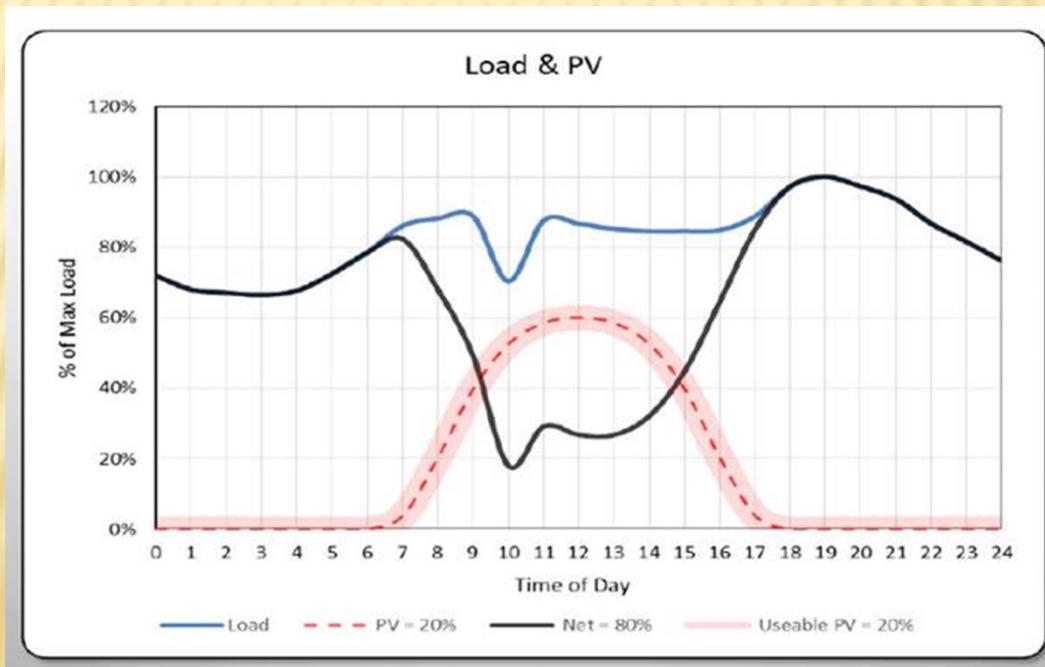
- ✘ Power is produced when the sun is up, and not when it is down
- ✘ Power curves can be erratic
- ✘ As penetration of solar increases, there can be concerning effects





# PEAK POWER MATCHING

- ✘ Solar may or may not coincide with the peak power demands
- ✘ Different across states and utility territories



# STORAGE AND PEAKER PLANTS

- ✘ Peaker Plants: Natural Gas can help to overcome 'Duck' curve type scenarios
- ✘ Energy storage will help alleviate intermittency issues as well.



# FEDERAL TAX CREDIT

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- ✘ 30% of the cost of installed systems through 2019
- ✘ 26% in 2020, 22% in 2021
- ✘ 10% thereafter for businesses
- ✘ Accelerated depreciation (MACRS) for commercial
- ✘ Storage systems may also apply with stipulations on charging source.

# SOLARSENSE PROGRAM

- ✘ 3 year program cycle
  - + Current cycle through 2019
- ✘ Increasing yearly budget
- ✘ Estimated production based incentive
- ✘ Max \$20,000
- ✘ 120% cap of previous 12 months usage
- ✘ 20 kW max system size (AC)



# XCEL SOLAR\* REWARDS

- ✘ Production based incentive: payments based on production of systems
- ✘ 10 years of annual payments
- ✘ \$0.07/kWh
- ✘ \$9.8 Milion available in 2019
  - + 8.4 available 2/8/19







# NEXUS OF TECH- EVS - STORAGE

# THANK YOU!

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✘ Questions and Answers

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