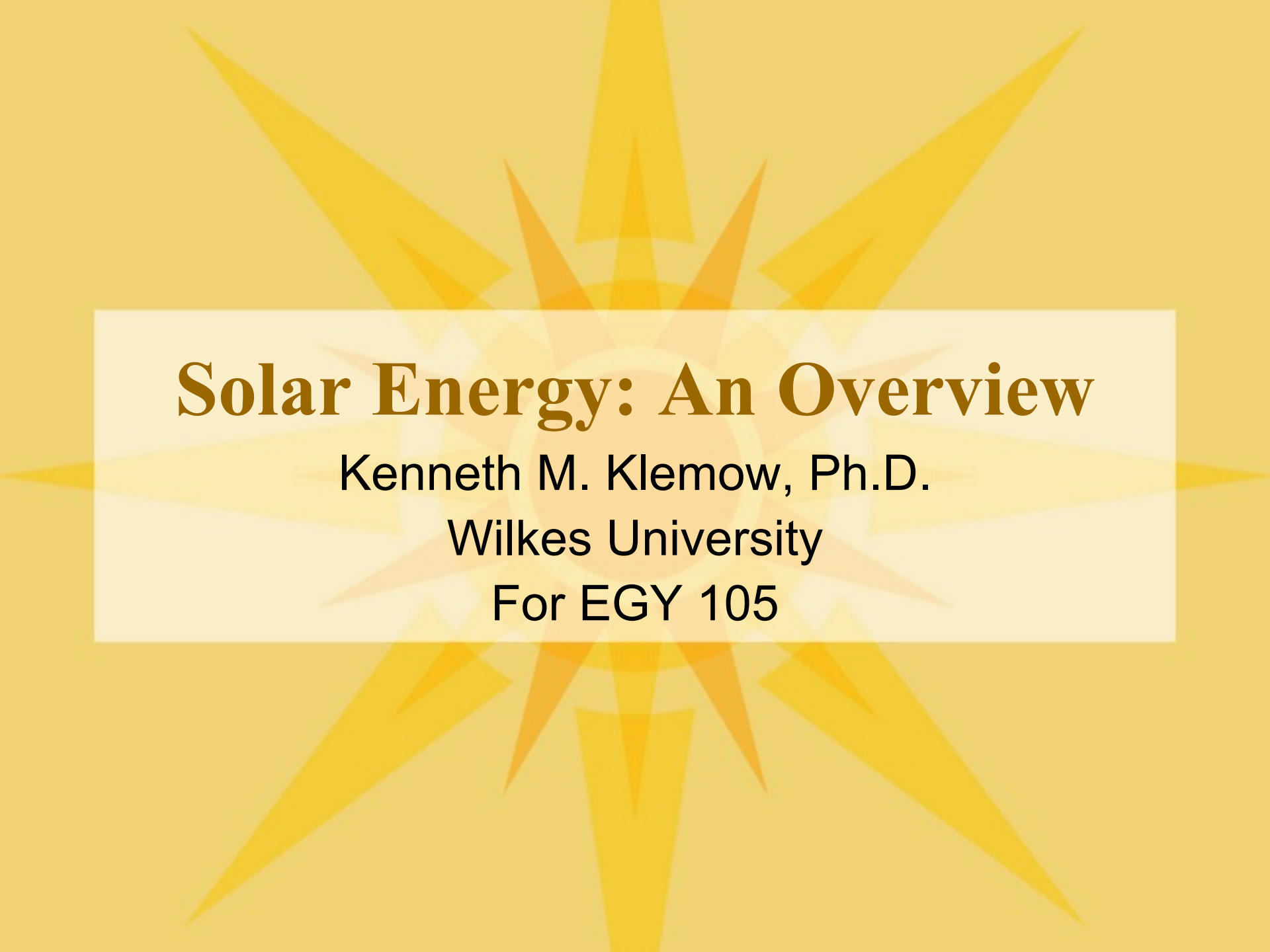




# **Solar Energy: An Overview**

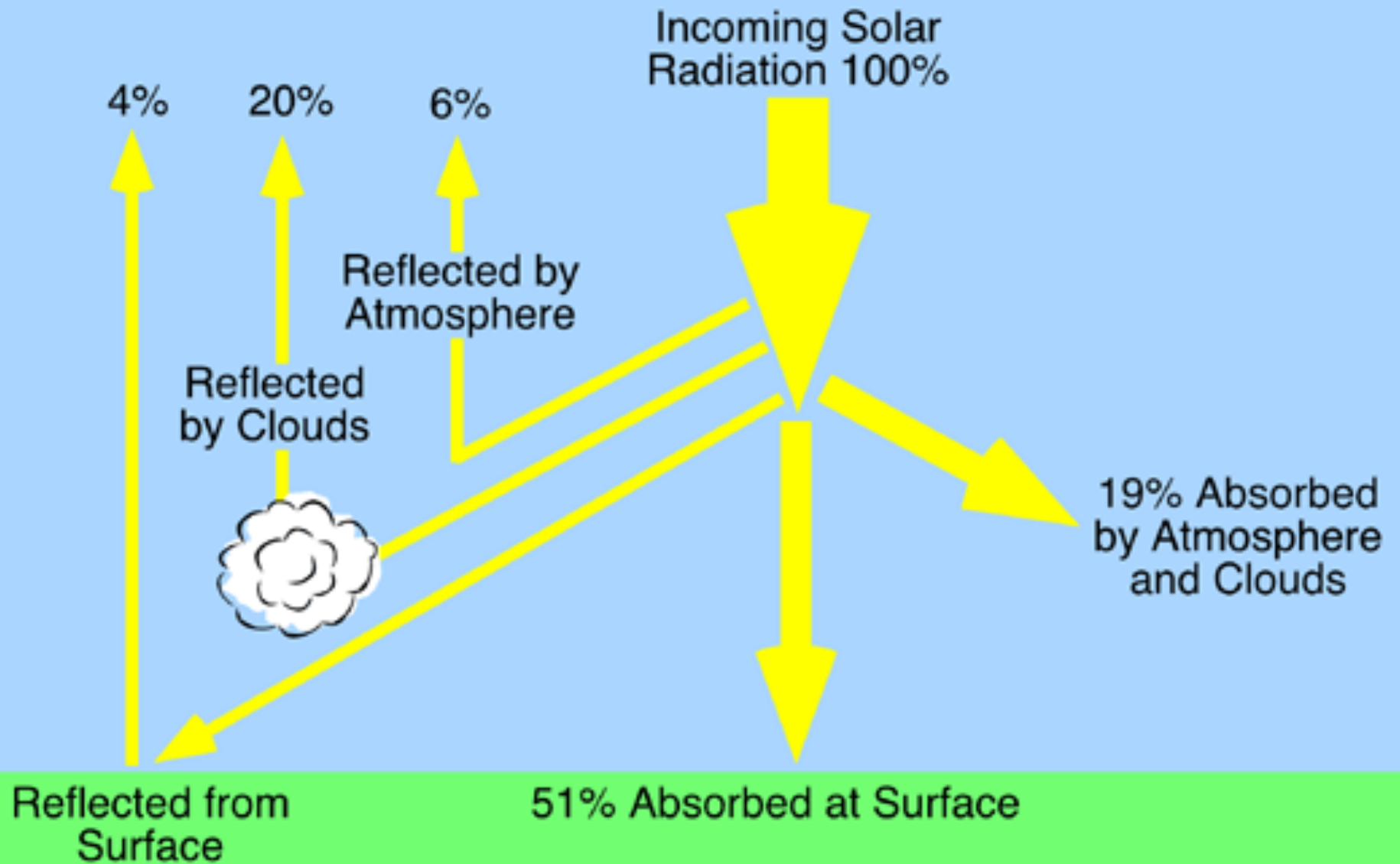
**Kenneth M. Klemow, Ph.D.**

**Wilkes University**

**For EGY 105**

# Points to be covered

- Energetics of sunlight at the earth's surface
- Direct uses of solar energy
- Types of solar electrical generation
- Current levels of solar electrical generation capacity worldwide and US.
- Benefits of solar power generation
- Disadvantages of solar



# Solar energy vs. demand

- Total solar = 3850 zettajoules (ZJ) per year
  - 1 ZJ =  $10^{21}$  J
- Oceans absorb approximately 285 ZJ of solar energy per year.
- Winds can theoretically supply 6 ZJ of energy per year.
- Biomass captures approximately 1.8 ZJ of solar energy per year.
- Worldwide energy consumption was 0.620 ZJ in 2023.

# Solar energy vs. demand

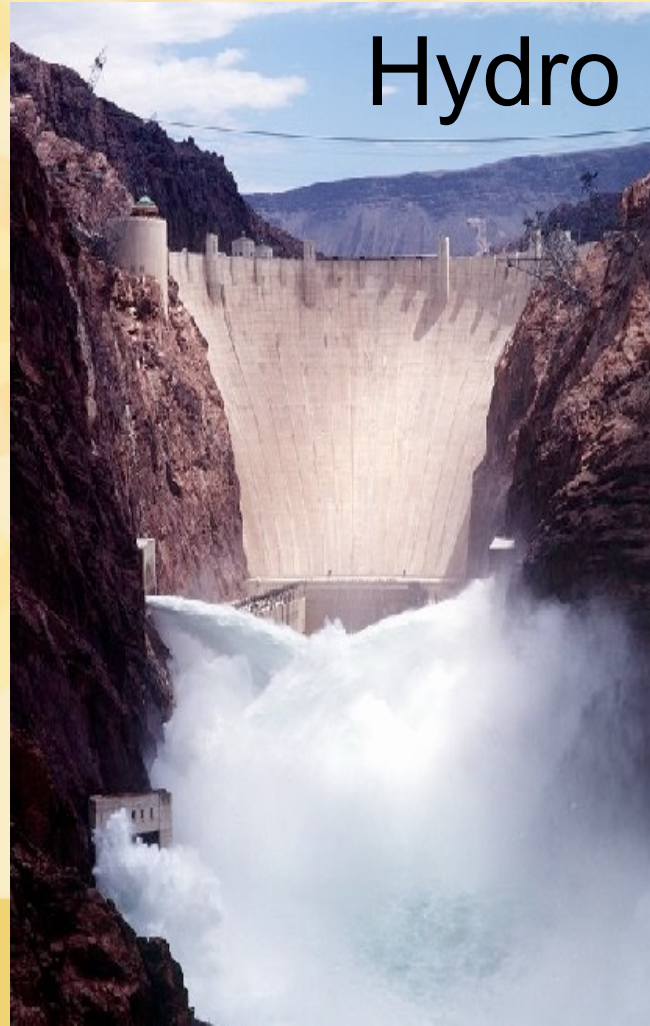
|                                     |                |
|-------------------------------------|----------------|
| <b>Total available</b>              | <b>3850 ZJ</b> |
| <b>Worldwide energy consumption</b> | <b>0.50 ZJ</b> |

# Indirect uses of solar energy

Wind



Hydro



Biomass



# Solar energy is used in two ways

Direct



[www.bestbuypoolsupply.com](http://www.bestbuypoolsupply.com)

Electrical generation

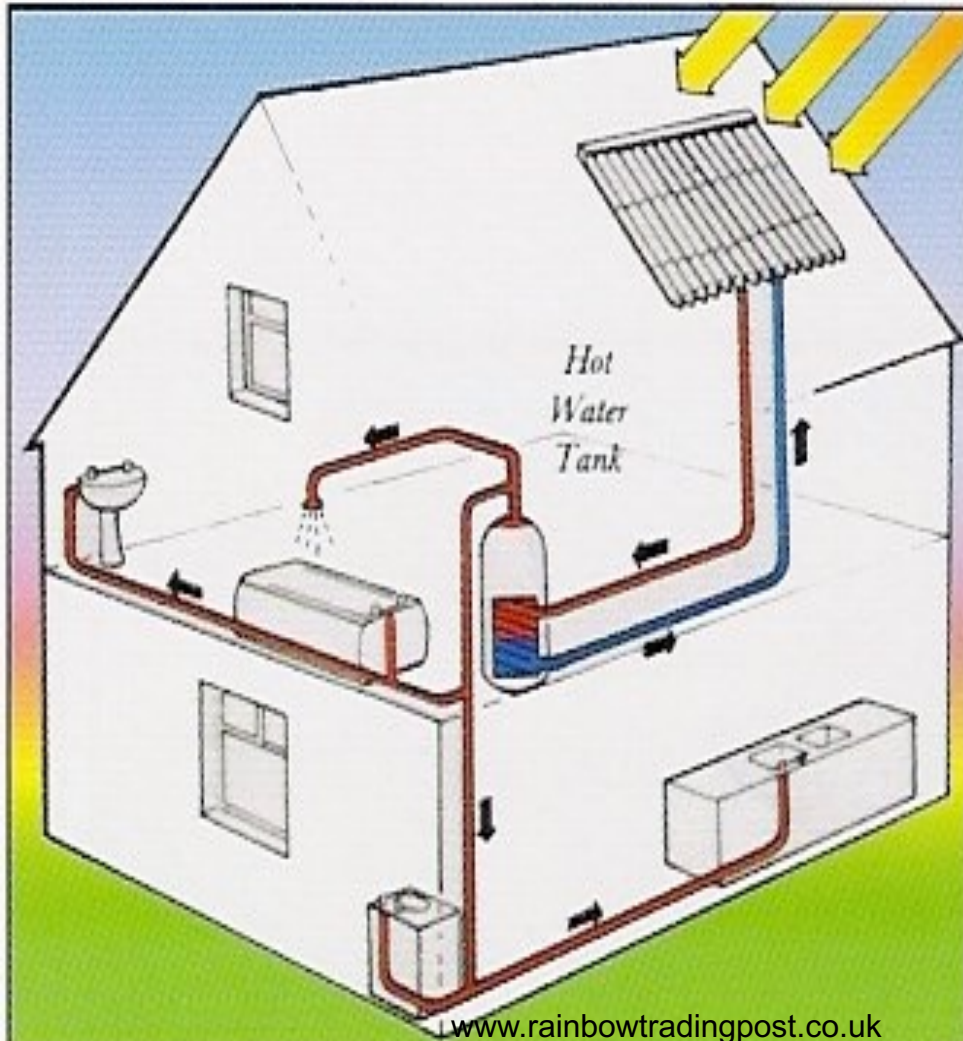


[http://static.flickr.com/28/95708914\\_9c915fb6f1.jpg](http://static.flickr.com/28/95708914_9c915fb6f1.jpg)

# Direct uses of solar energy

- Home heating and cooling
- Cooking
- Lighting

# Home heating and cooling



# Rooftop solar heating unit at California College of Arts San Francisco Campus



# Cooking



# Solar Lighting (Daylighting)

Clerestories



[www.greatbuildings.com](http://www.greatbuildings.com)

Fiber Optics



[architecture.myninjablog.com](http://architecture.myninjablog.com)

# Skylights



# Solar Tubes

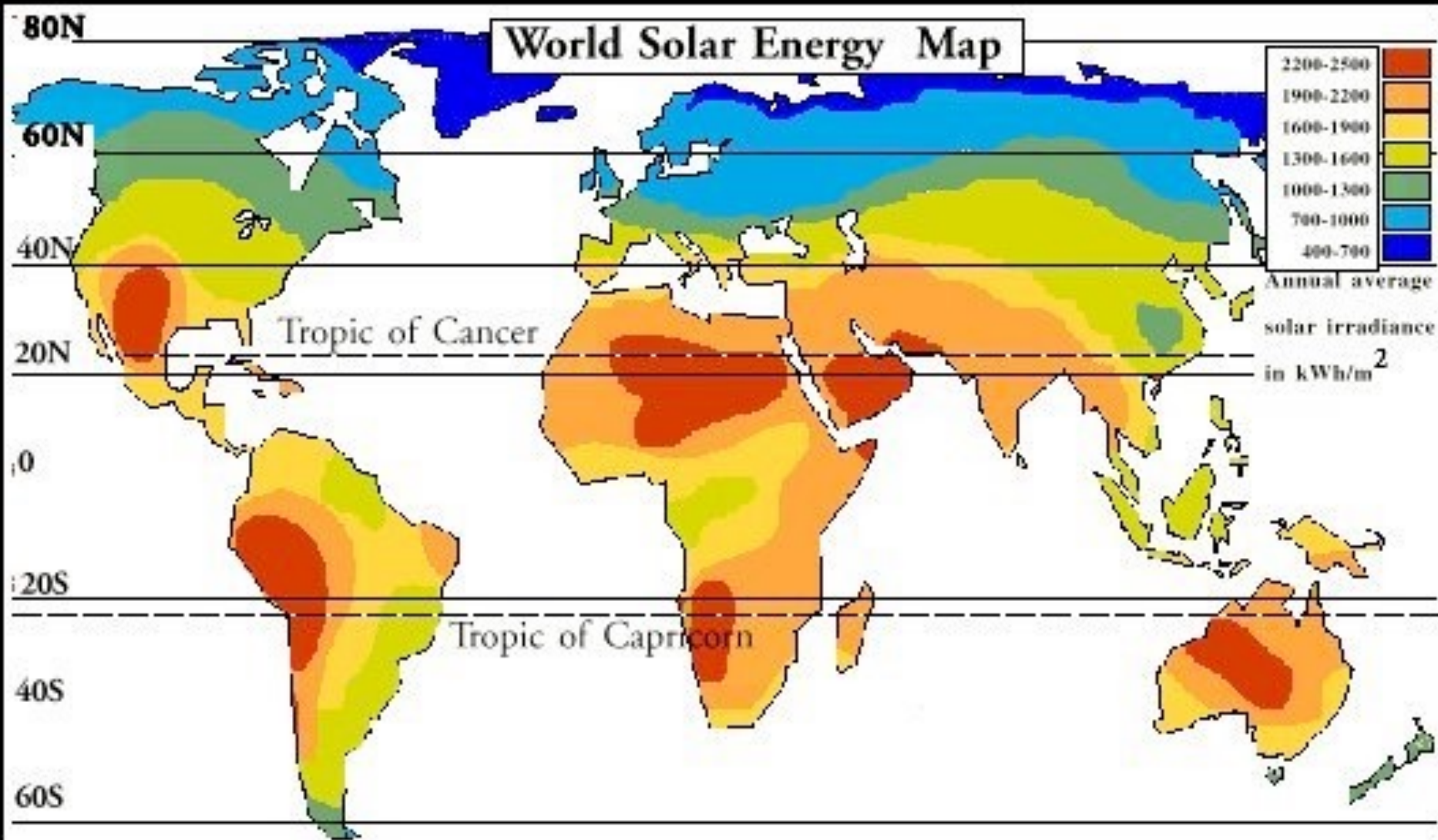


[www.woodheatstoves.com](http://www.woodheatstoves.com)



[www.luminessencelighting.com](http://www.luminessencelighting.com)

## World Solar Energy Map

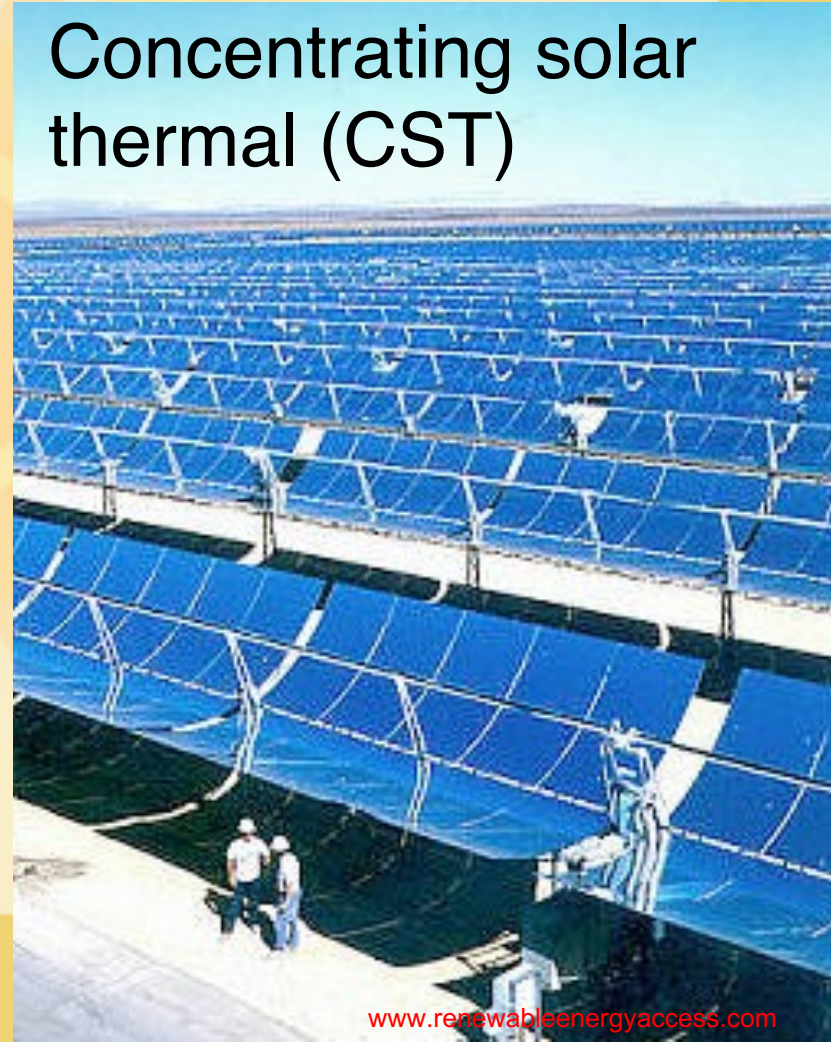


# Types of solar electrical generation

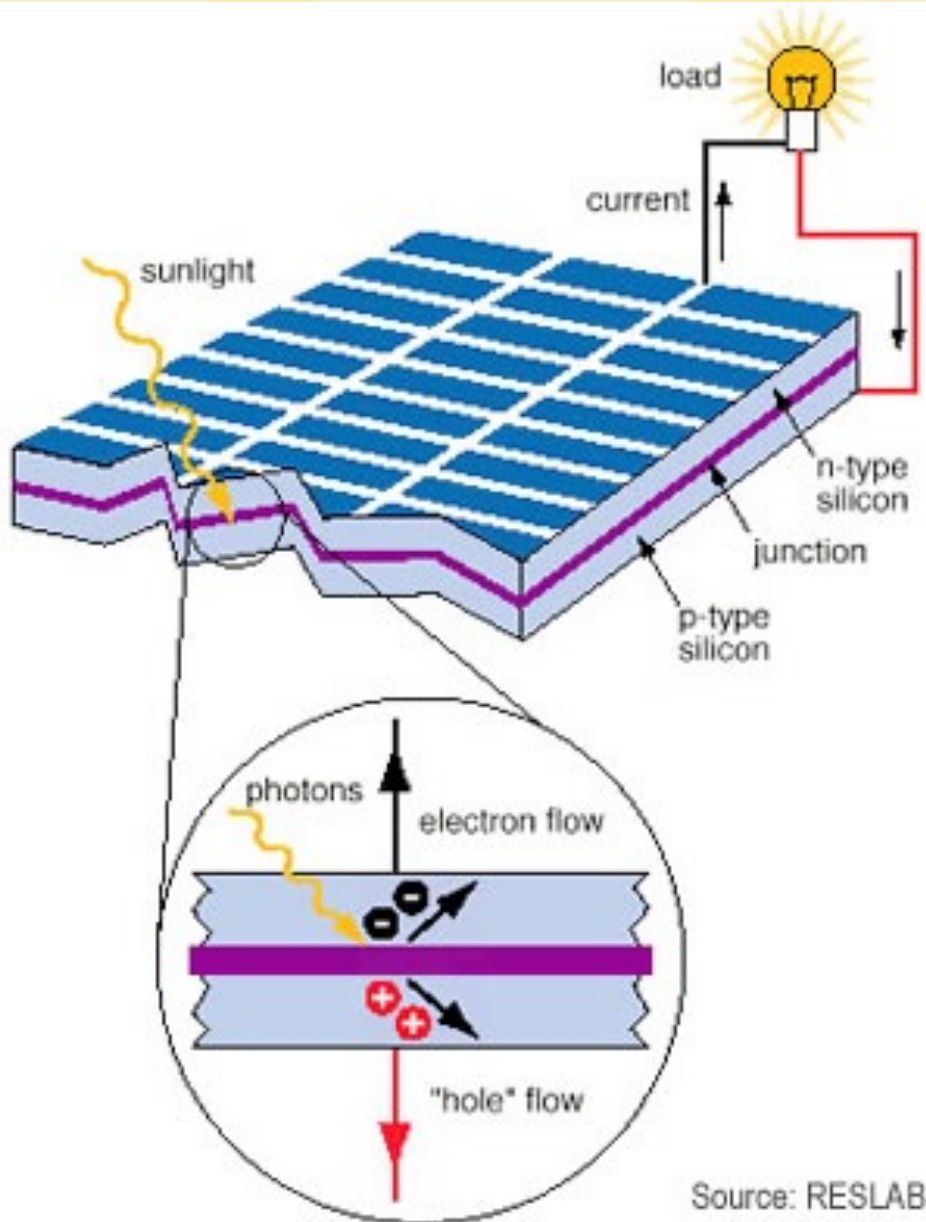
Photovoltaic (PV)



Concentrating solar thermal (CST)



# Photovoltaic cell



Check out this  
YouTube video  
for more  
information on  
PV cells.

# Forms of solar thermal electrical generation

## Concentrating Solar Power Tower



[www.trec-uk.org.uk](http://www.trec-uk.org.uk)

See DOE Video on Concentrating Solar Energy

# Forms of solar thermal electrical generation

## Solar parabolic collectors



# Solar powered transportation

Zephyr - solar airplane

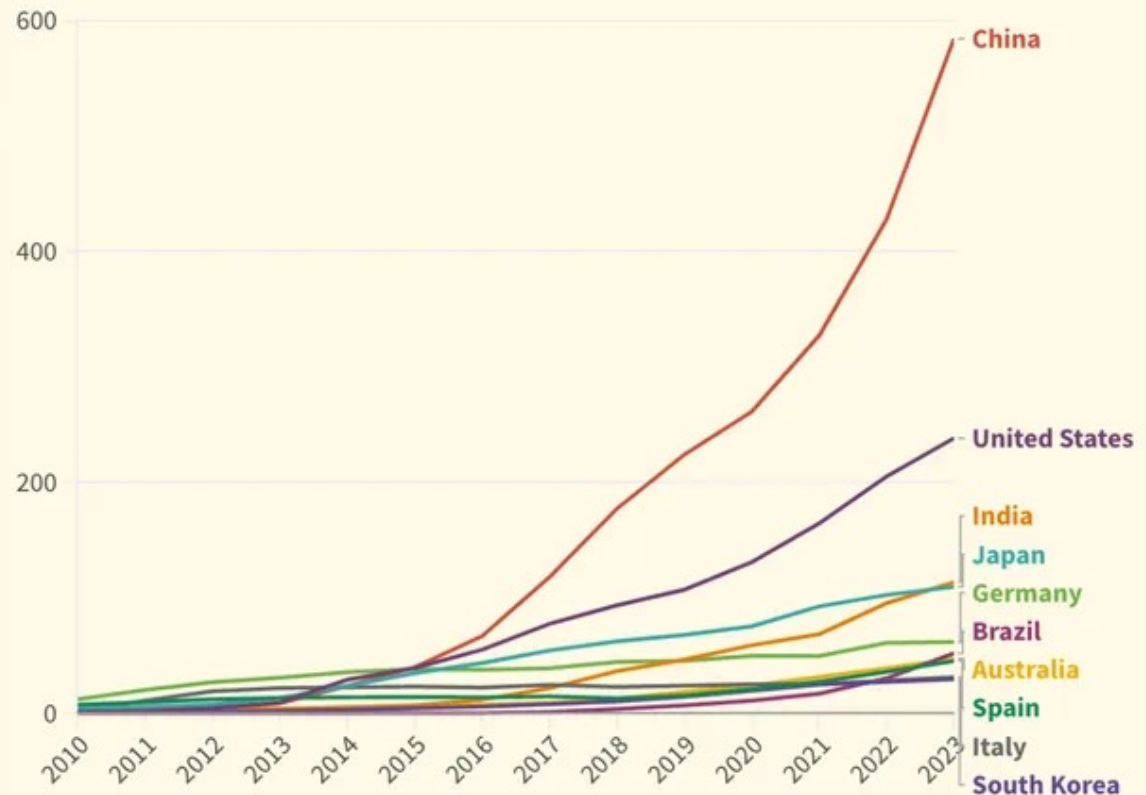


Solar powered car from Durham University



# Leading solar countries

## Top 10 solar-producing countries in 2023

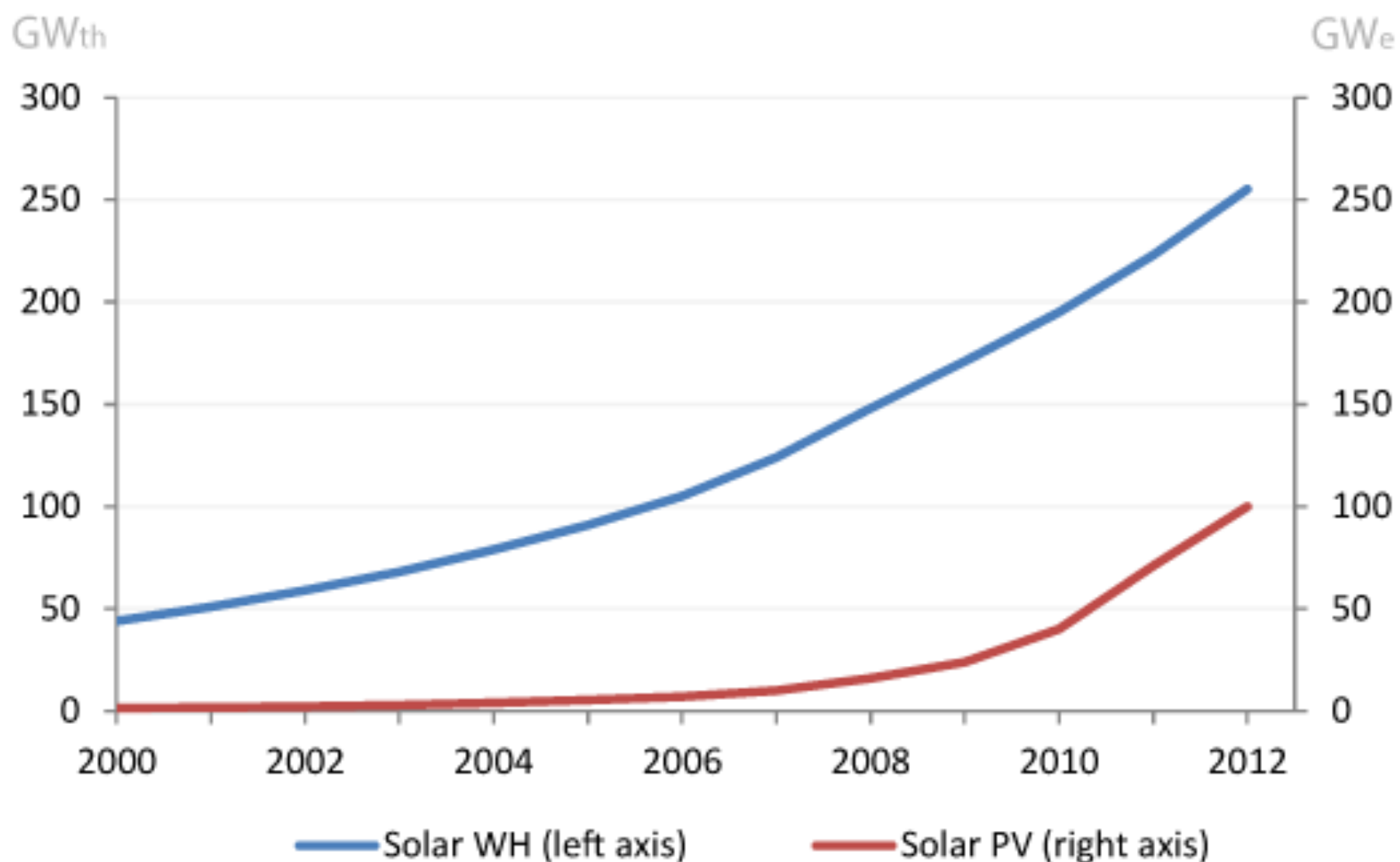


CANARY MEDIA | CHART OF THE WEEK

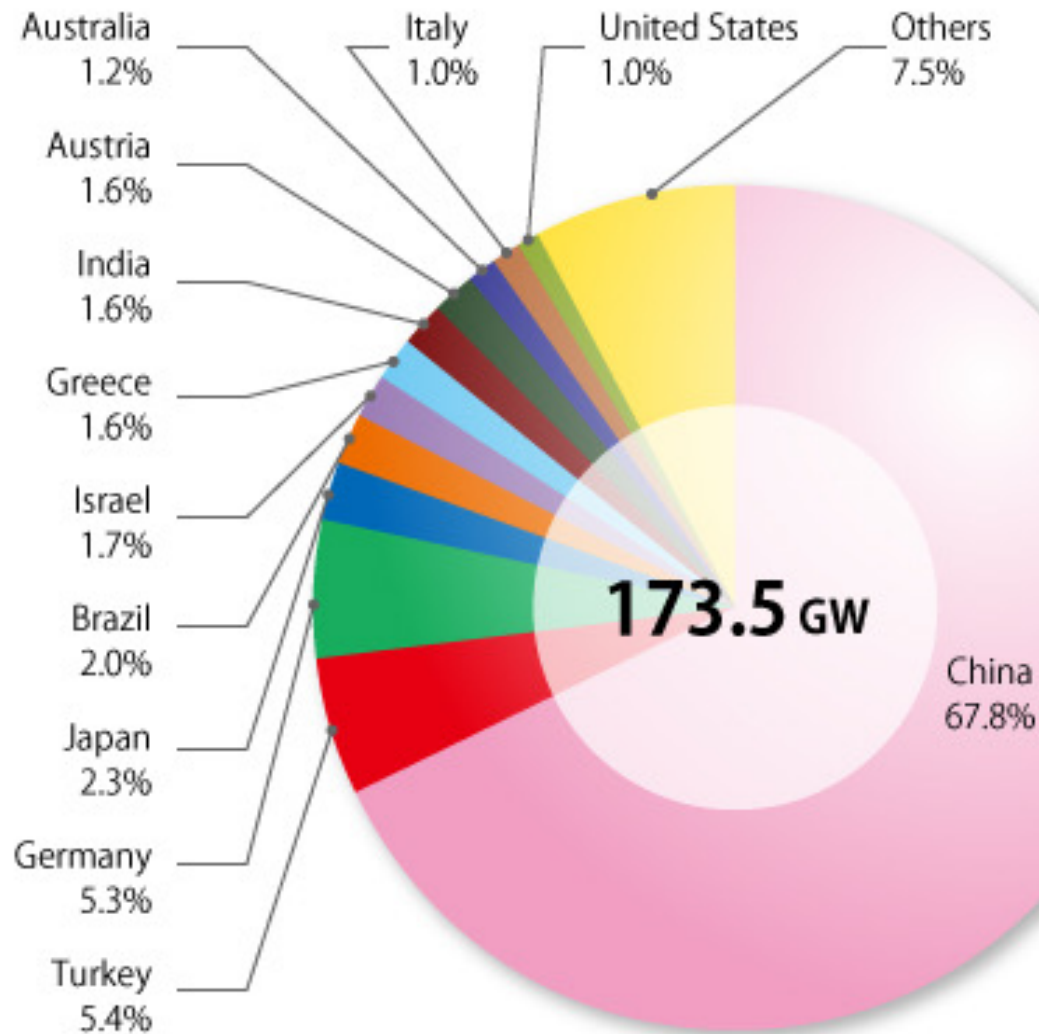
# Solar Thermal vs PV

- Advantages for thermal
  - No need to generate electricity
  - Higher efficiency / energy density
  - Can last for decades
- Disadvantages for thermal
  - High weight associated with water
  - Freezing water expand, can burst pipes
  - Minor failure can totally destroy system
  - Pose hazards to migratory birds

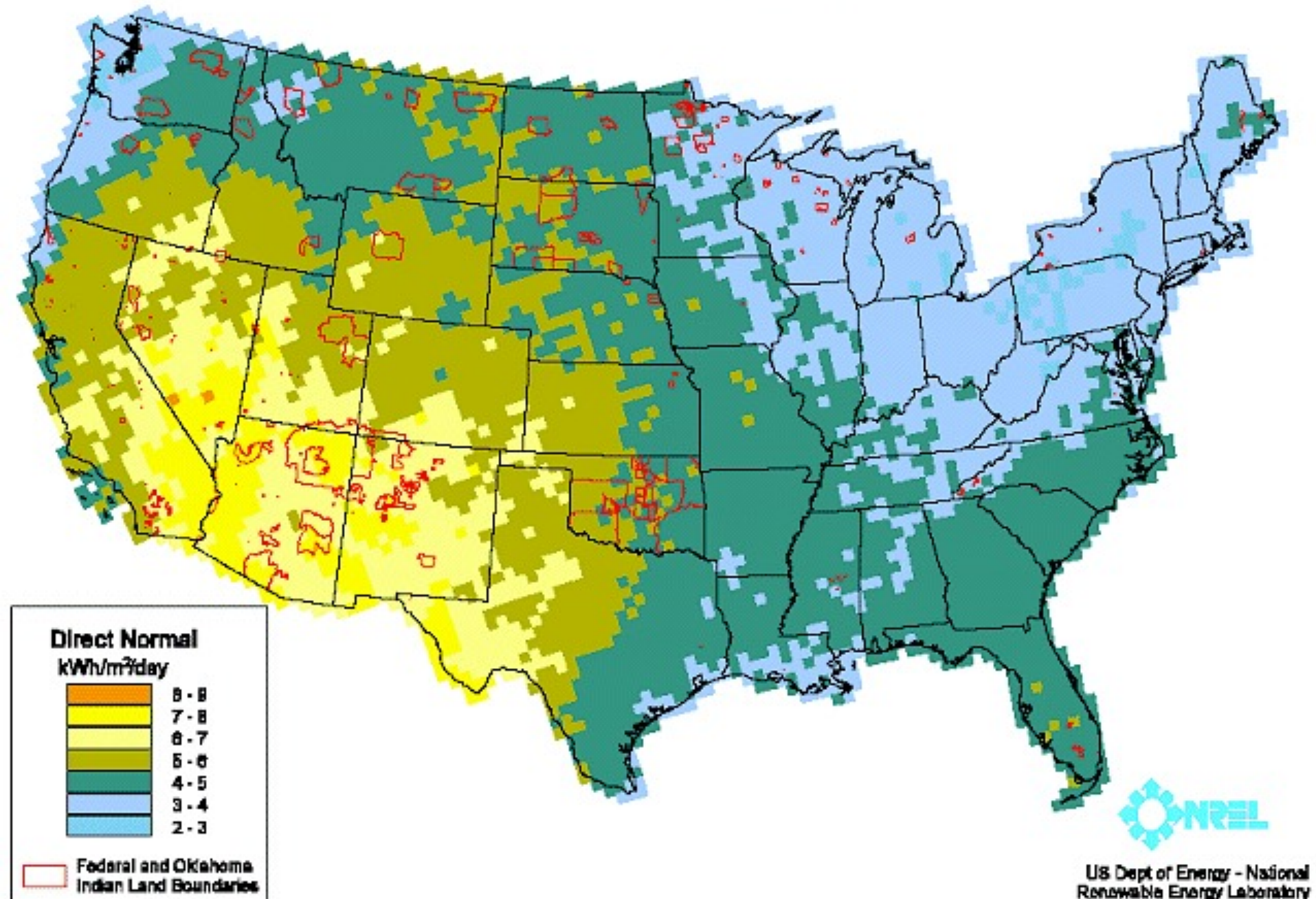
# Global Capacity for Solar Water Heating and Solar PV (GW)



# Global Solar Thermal Capacity



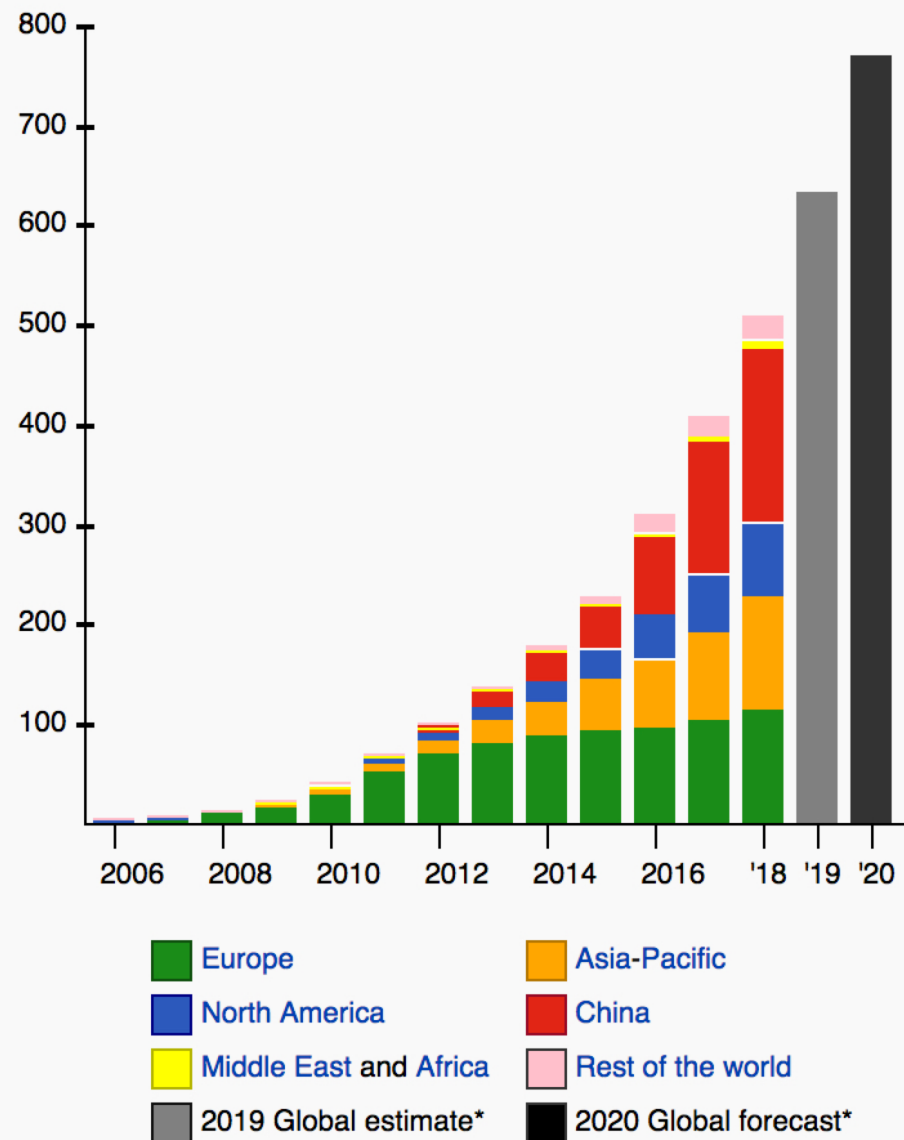
**Figure 12. Concentrated Solar Power (CSP) Resource Potential**



# Trends in Global PV Solar

## Worldwide growth of photovoltaics

Global growth of cumulative PV capacity in gigawatts (GW<sub>p</sub>)<sup>[1][2][3][4][5]</sup> with regional shares (IEA estimates).<sup>[6]</sup>



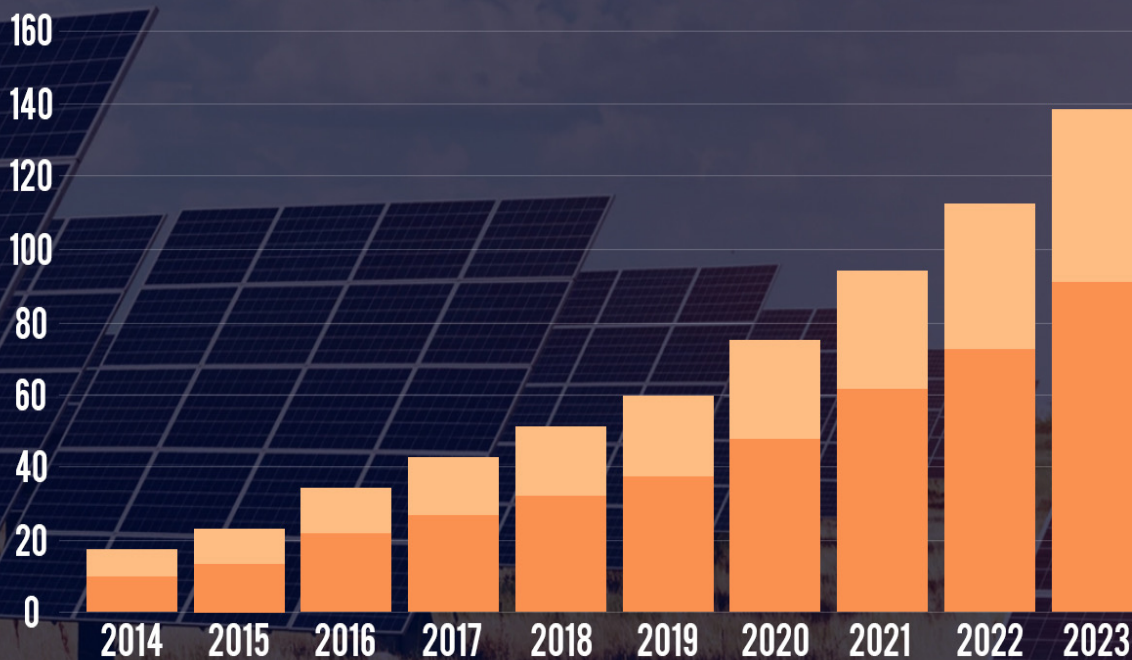
\*(2019/20 tentative figures, no regional split-up)<sup>[7]</sup>

# US Solar PV Energy Capacity

## U.S. SOLAR CAPACITY

Utility-scale Small-scale

Gigawatts



Annual solar (utility- and small-scale) summer capacity.  
Source: U.S. Energy Information Administration (EIA)

CLIMATE CO CENTRAL

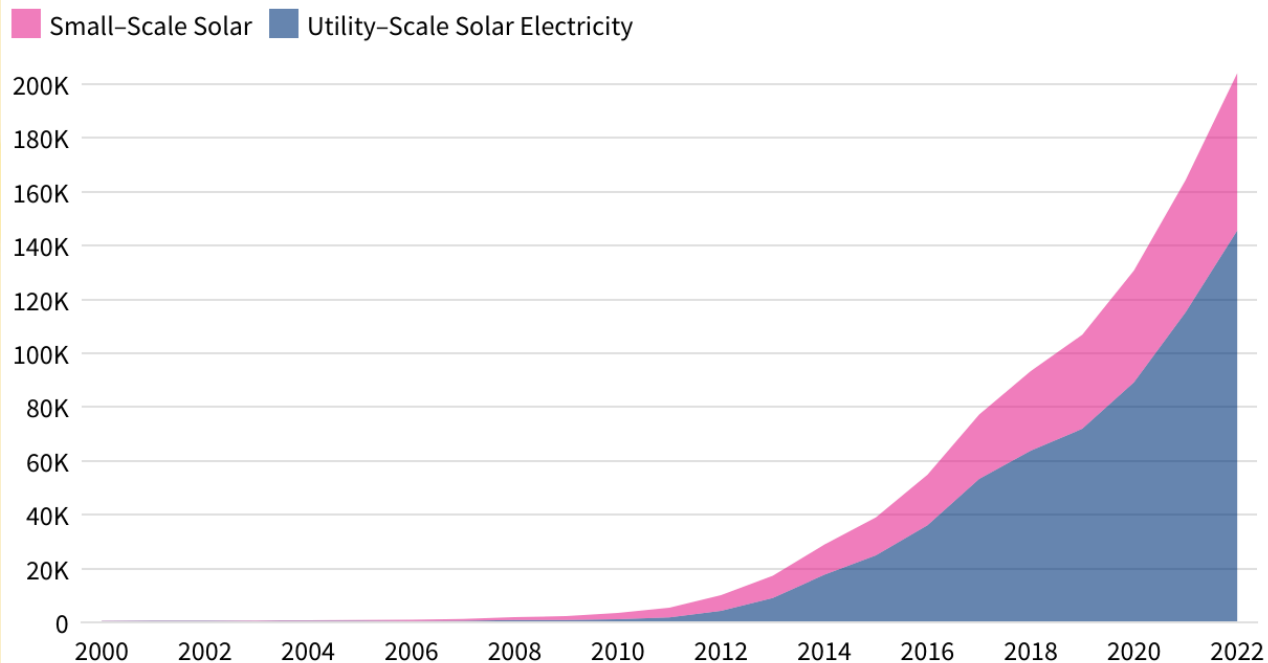
# Small-scale vs large-scale solar



# U.S. solar electricity by scale

**Over the past five years, solar electricity generation has nearly tripled.**

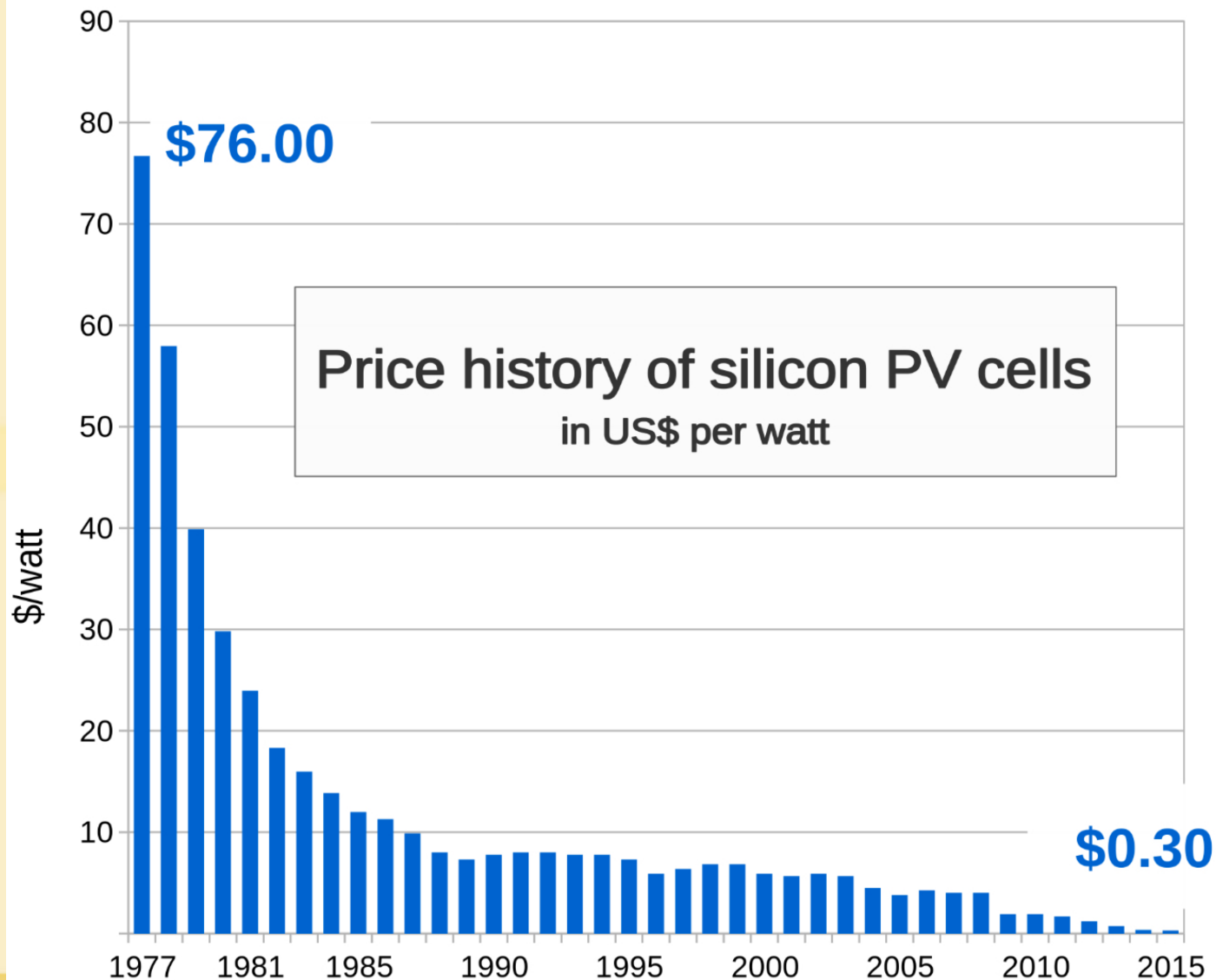
Solar electricity generation in million kilowatt-hours by scale, 2000–2022



Small-scale solar installations include ones found at homes, businesses, and non-utility industrial sites. Small-scale estimates are from small-scale PV units less than 1 MW and utility-scale are from units with 1 MW or more. 2022 data is preliminary.

Source: [Energy Information Administration](#)

# Price of solar cells



# Costs to consider if switching to solar power

- Purchasing / leasing land
- Installation labor
- Cost of hardware
- Battery costs

# Benefits of solar power

- Renewable and sustainable
- Generally quiet to operate
- Conserves fossil fuels
- Can be implemented remotely
- Can be scaled from tiny applications (solar calculators) to very large (solar powered communities)
- Can prevent pollution caused by fossil fuels
- Jobs in solar industry
  - 264,000 jobs in U.S. in 2022
  - 3.5% annual growth
  - Various job categories

# Comparative life-cycle CO<sub>2</sub> emissions

| Energy source | CO <sub>2</sub> / kWe |
|---------------|-----------------------|
| Coal          | 1.4 – 3.6             |
| Natural gas   | 0.6 – 2.0             |
| PV solar      | 0.07 – 0.18           |
| Thermal solar | 0.08 – 0.20           |

# Existing and potential solar energy development

- >1 million Americans use solar water heaters
- >4.2 million homes use photovoltaic systems.
- Enough electrical power could be generated in 100 mi<sup>2</sup> area of desert southwest to supply US energy needs.

# Drawbacks to solar power

- Heavy investment.
- High-latitude areas receive relatively little sunshine.
- Solar unreliable at night, during winter, and during cloudy periods.
- Storage difficult; relies on batteries that may leak chemicals.
- Some PV cells use heavy metals - toxic and difficult to recycle.
- Solar farms require much land, currently between 5 and 10 acres / megawatt.
  - Is it wise to use farmland or productive forest for solar?

# Community Resistance to Solar

- Some community solar power in rural areas criticized on basis of:
  - Destroying habitat
  - Industrializing rural areas
  - Enhanced fire risk
- Locally, proposed solar projects in Lehman and Nanticoke defeated.
- See Reference 1 and Reference 2
- One proposed solution: Brightfields on grayfields