What is solar power?

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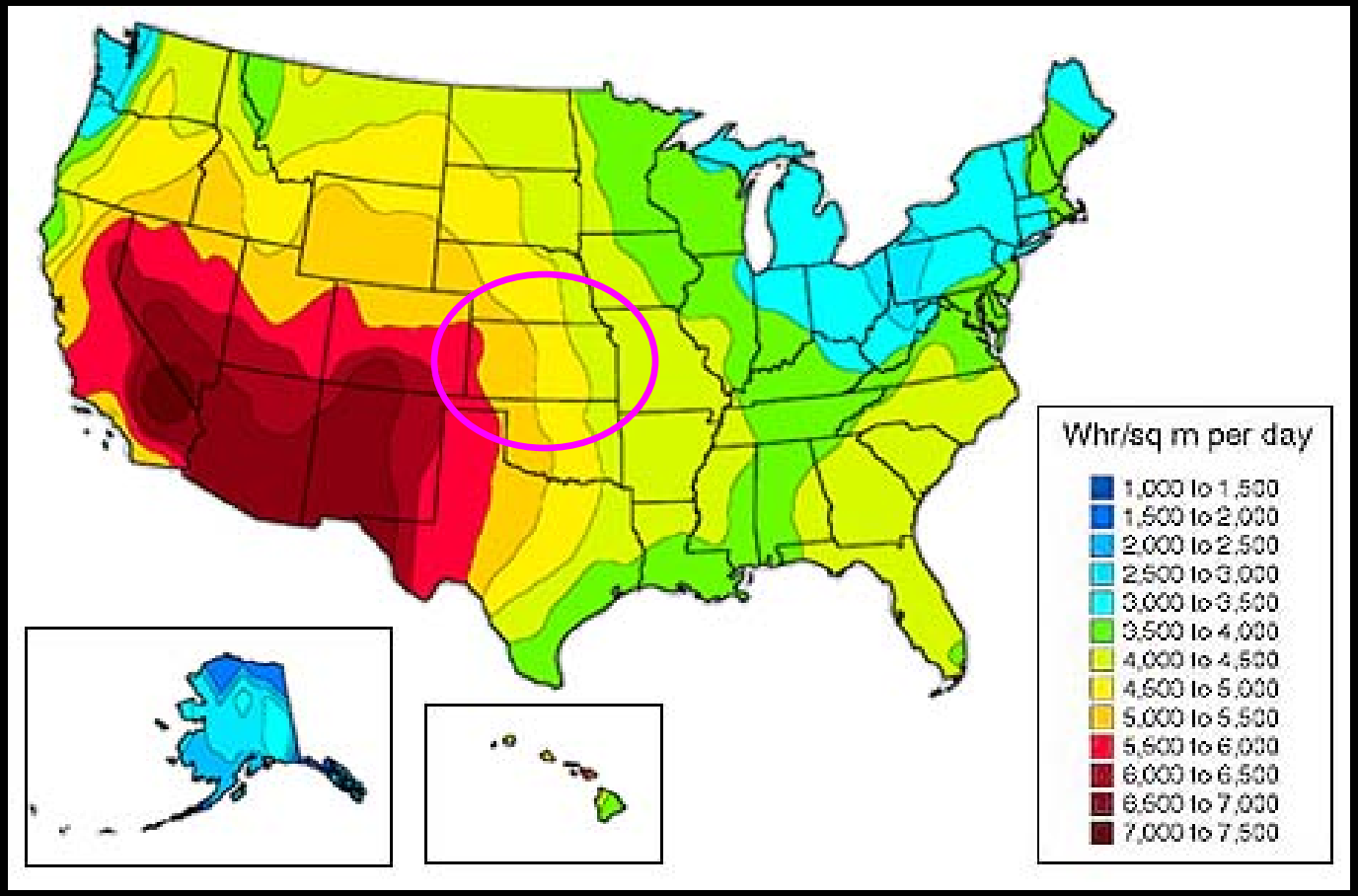
What is solar power?

- Electrical flow derived from solar radiation.

Advantages

- Solar power is…
  - Renewable

Solar Energy Incident in US



Kansas – about 5,000Whrs per square meter per day

Advantages

- Solar power is…
  - Renewable
  - Environmentally Sound

Advantages

- Solar power is…
  - Renewable
  - Environmentally Sound
  - Versatile

Disadvantages – the four Ds

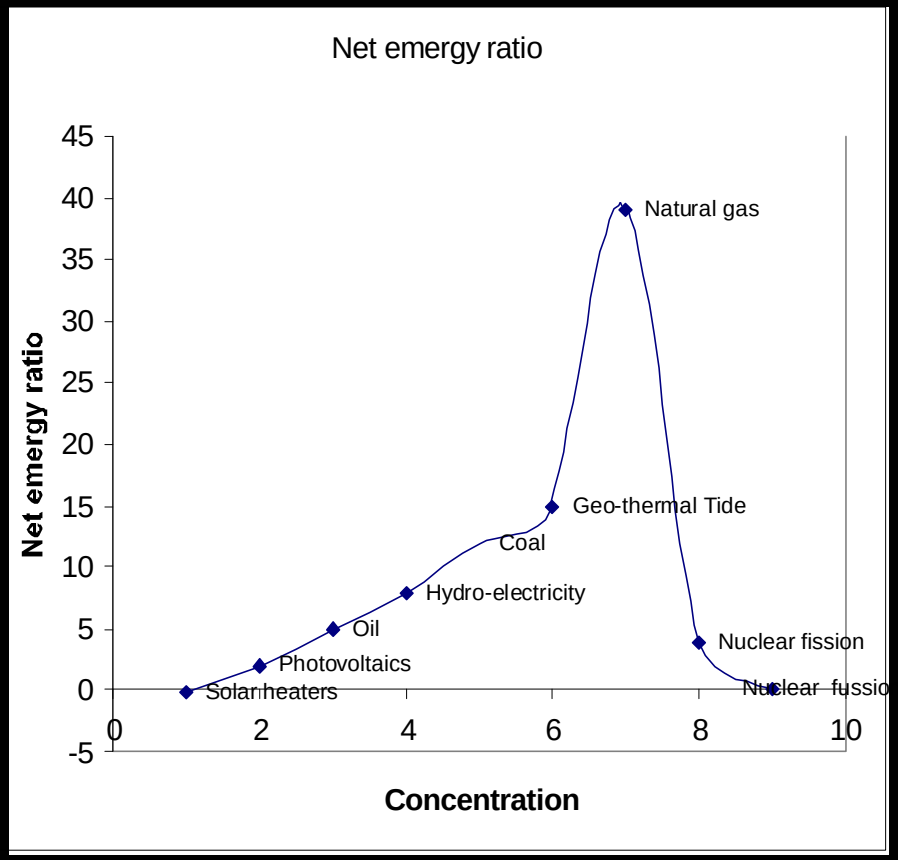
- Solar power is…

Disadvantages – the four Ds

- Solar power is…
  - Diurnal

Disadvantages – the four Ds

- Solar power is…
  - Diurnal
  - Diffuse



Disadvantages – the four Ds

- Solar power is…
  - Diurnal
  - Diffuse
  - Dis-efficient
  - De-inexpensive

Disadvantages – the four Ds

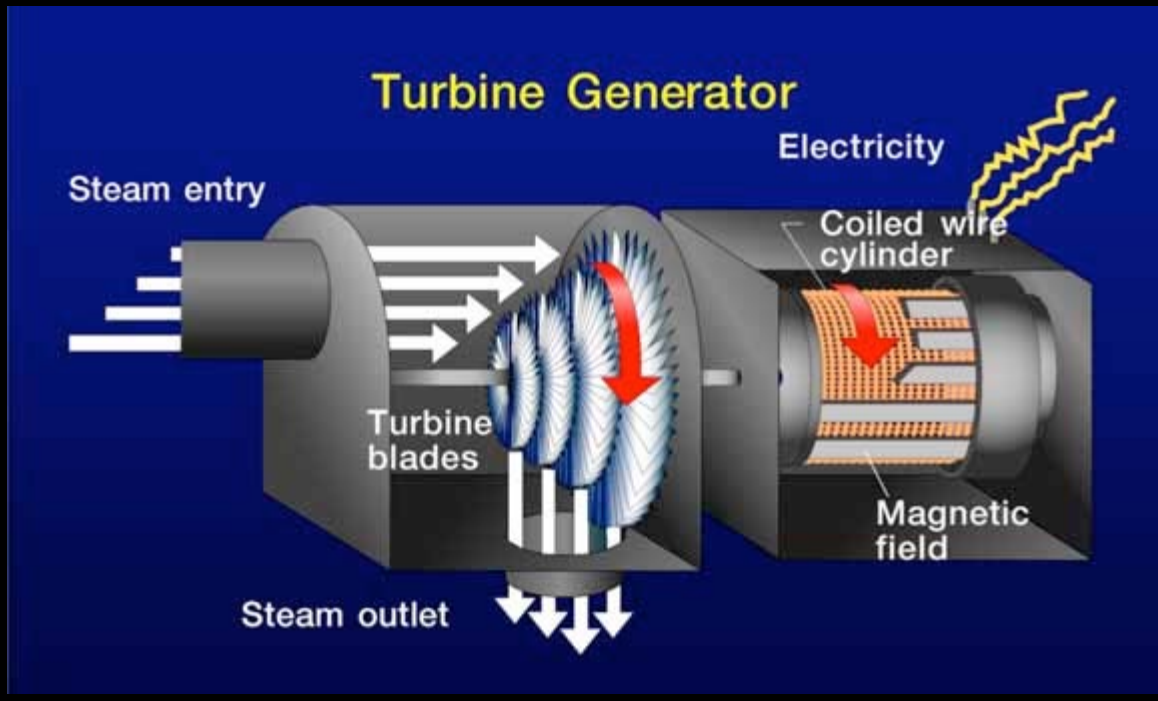
- Solar power is…
  - Diurnal
  - Diffuse
  - (Dis)efficient ??
  - (Dis)inexpensive ??

Solar Power Systems

- Concentrating Solar Power
  - Thermic (heat driven)
- Photovoltaics
  - Photic (light driven)

Solar Concentration Systems

- Harness heat to generate electricity.
  - Heat used to create steam to turn turbine
    - turbine makes electricity



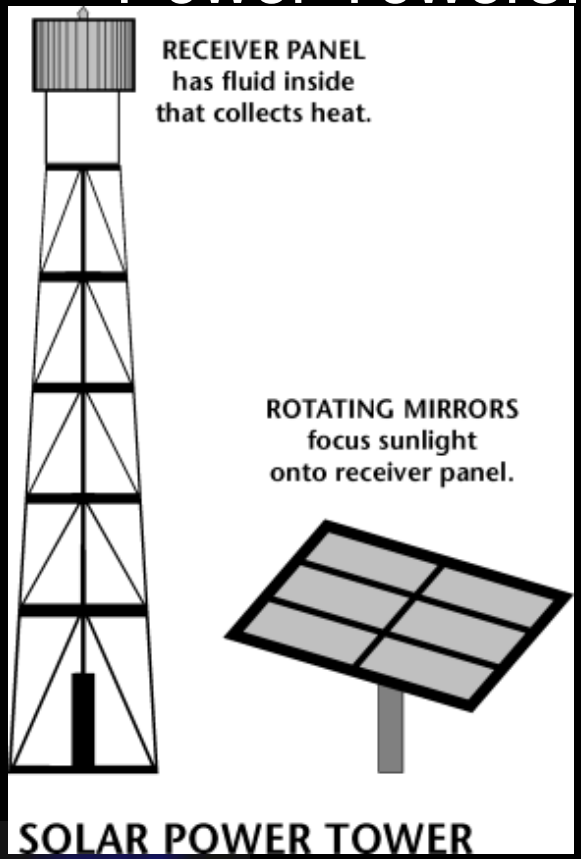
Concentration Systems

- Troughs.

Kramer Junction Facility, CA

Concentration Systems

- Power Towers.



Solar Two Facility, 10 MW

Concentration Systems

- Parabolic Dishes.

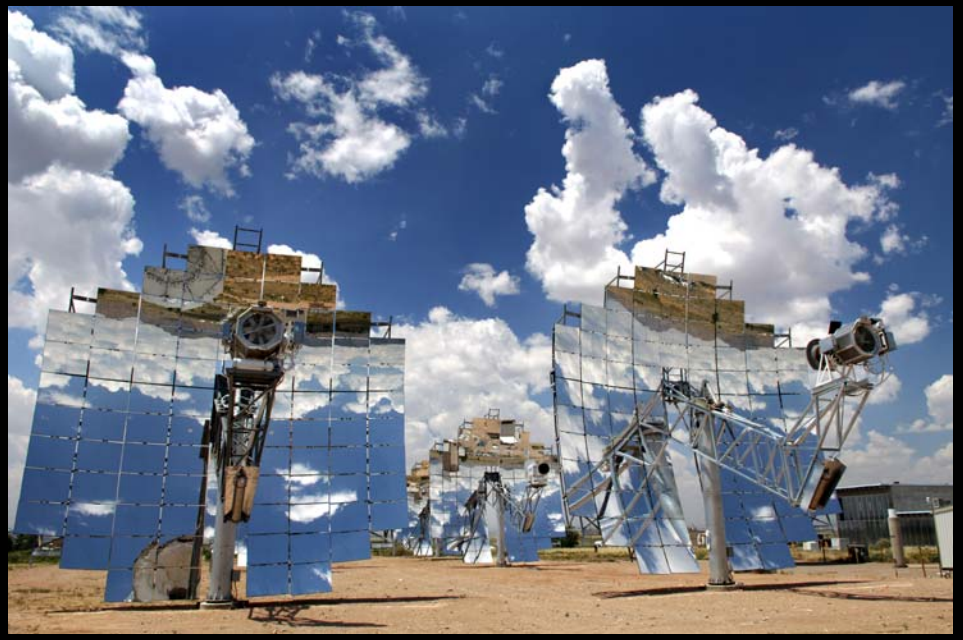
The ANU 400m2 solar concentrator dish

Solar Concentration Systems

- Harness heat to generate electricity.
  - Heat used to run engine.

Solar Concentration Systems

- Dish Stirling (Stirling Energy Systems)
  - Heat used for engine (Stirling Engine) that makes electricity.



Solar Concentration Systems

SES Dish Sterling.

Peak production:

25 kW

Solar Power: Types, Capacities, Potential

Concentration Systems - Applications

- Power Plants.

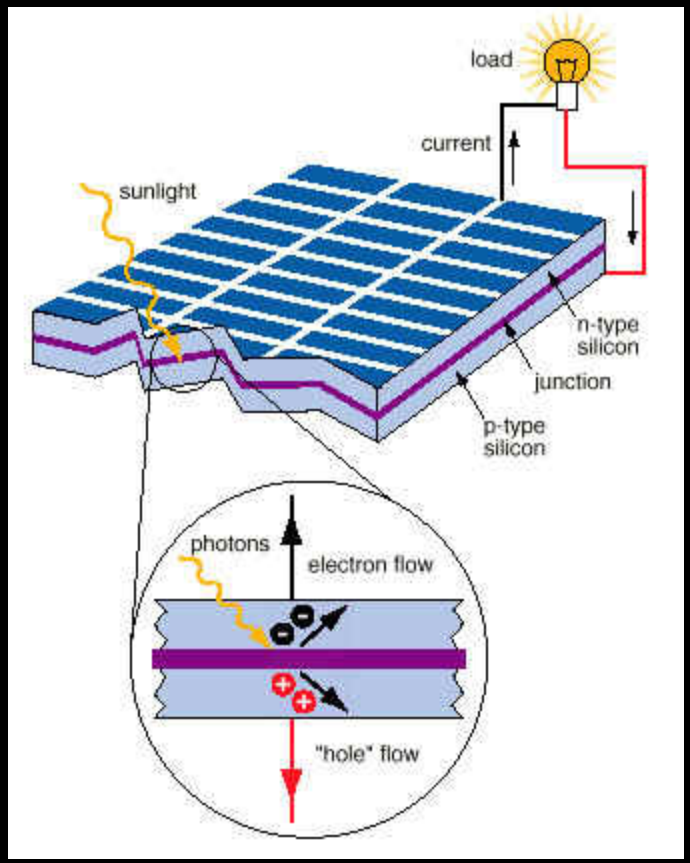
Kramer Junction Trough Plant

Seville, Spain Power Tower Facility

Model Dish Stirling Plant

Photovoltaics

- Light energy converted to electrical energy.
  - based on properties of silicon.



Photovoltaics - Applications

- Power plants.

Serpa Power Plant, Portugal.

Peak production: 11 mW

Photovoltaics - Applications

- Power plants.
- Building-scale (distributed)

Zero-Energy Home

Photovoltaics - Applications

- Power plants.
- Building-scale (distributed)
  - Can be on or off grid

Zero-Energy Home

Photovoltaics - Applications

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Project Solar House

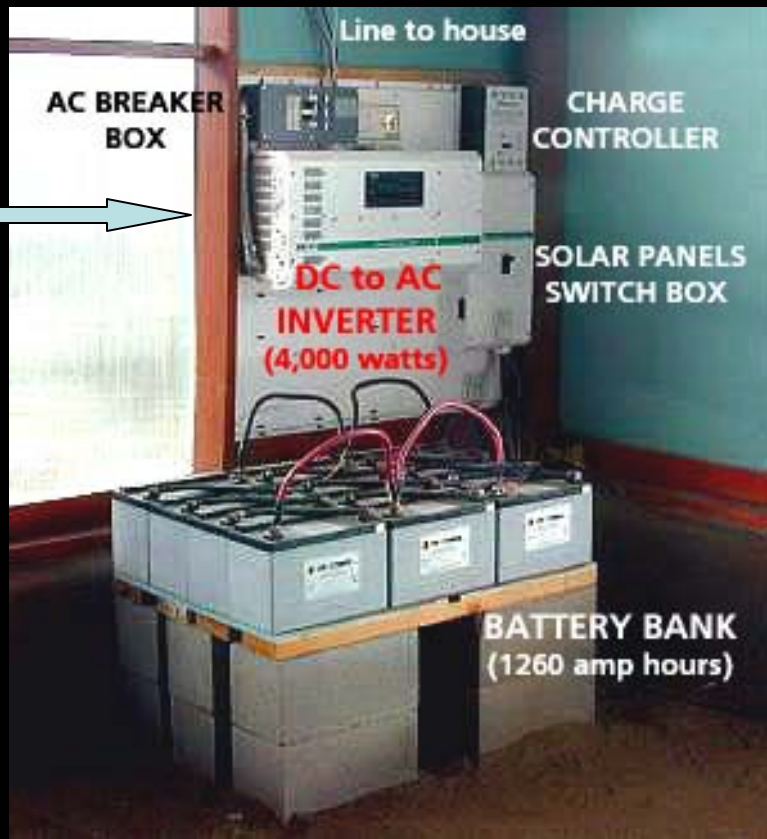
Photovoltaics – Building Scale

- Array

Zero-Energy Home

Photovoltaics – Building Scale

- Array
- Inverter system

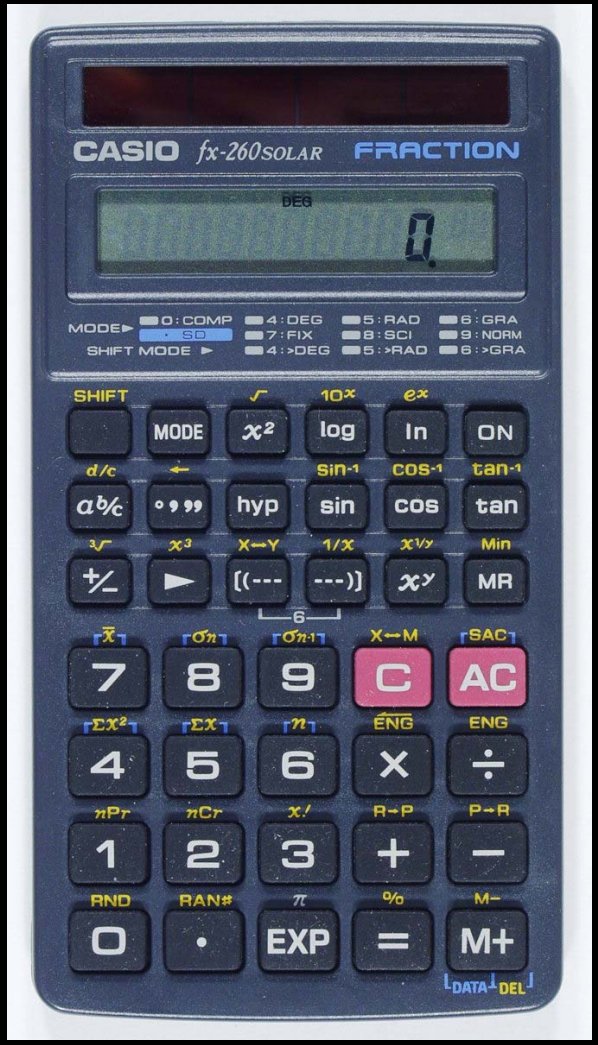


Photovoltaics – Building Scale

- Array
- Inverter system
- Storage System

Photovoltaics - Applications

- Power plants.
- Building-scale (distributed)
- Point-of-Use



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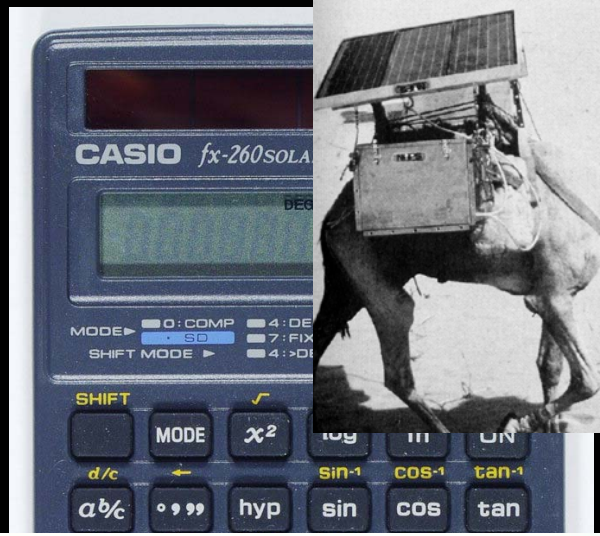

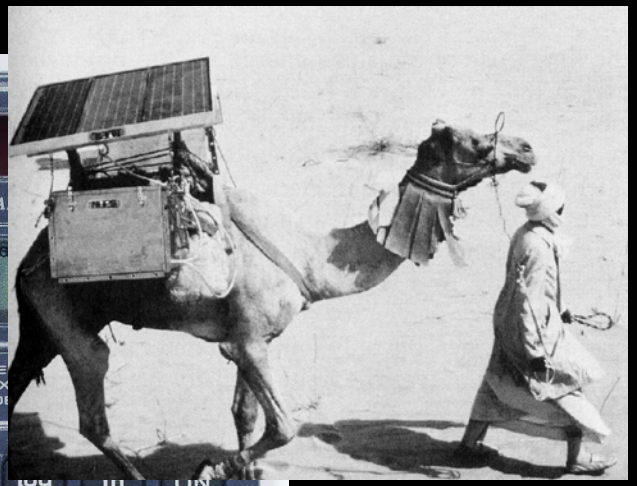

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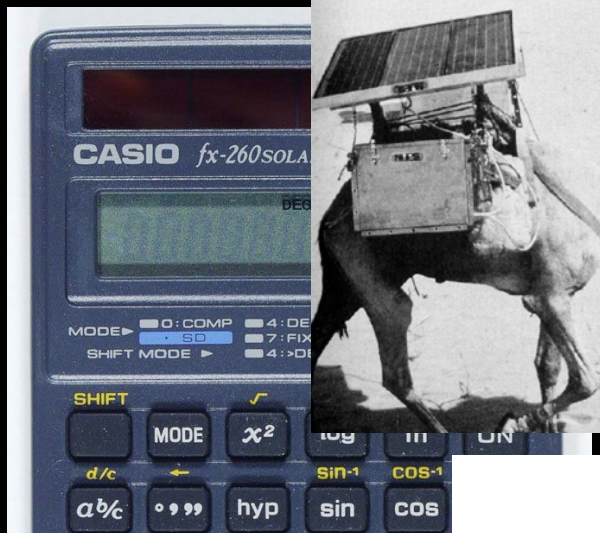

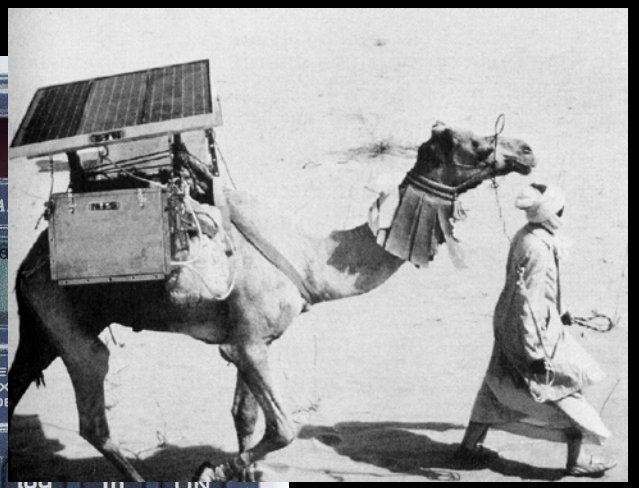

Photovoltaics - Applications

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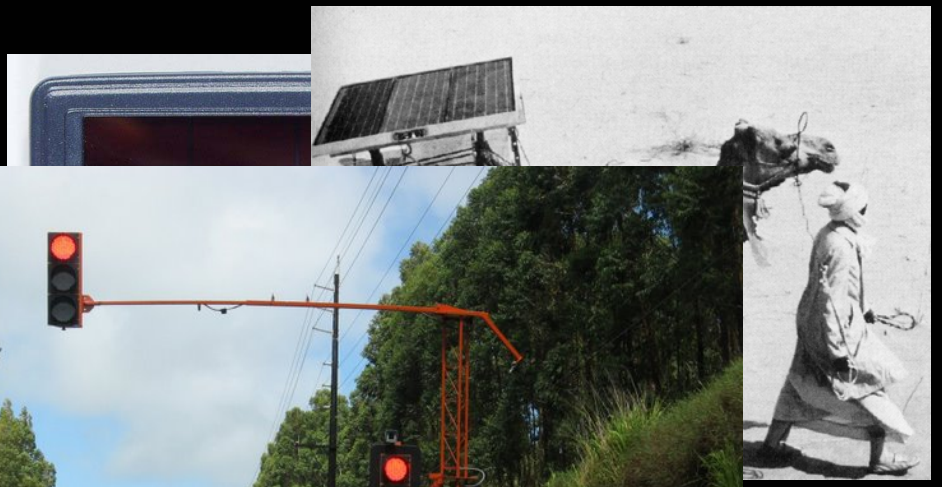
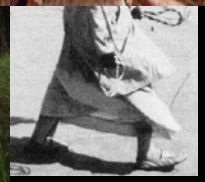


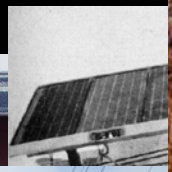
- Point-of-Use

Photovoltaics - Applications



- Point-of-Use

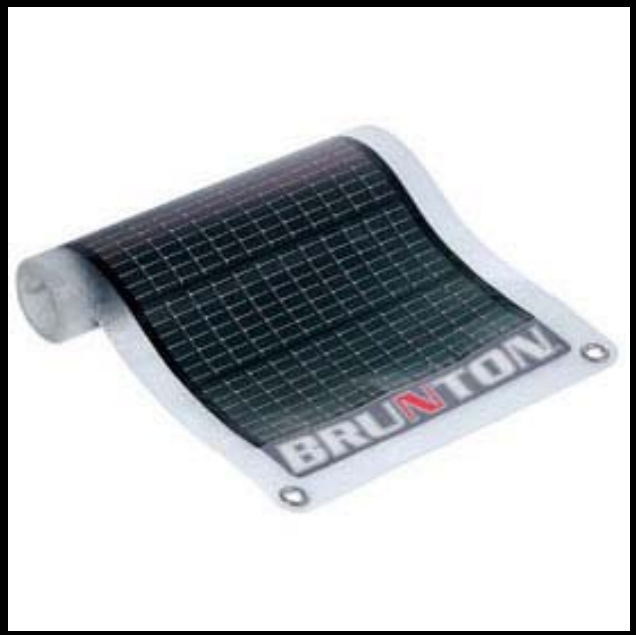
Photovoltaics - Applications



- Point-of-Use

Photovoltaics - Innovations

- Amorphous Silicon



Photovoltaics - Innovations

- Amorphous Silicon
- Thin Film

Photovoltaics - Innovations

- Amorphous Silicon
- Thin Film
- Translucent PV
- Organic PVs

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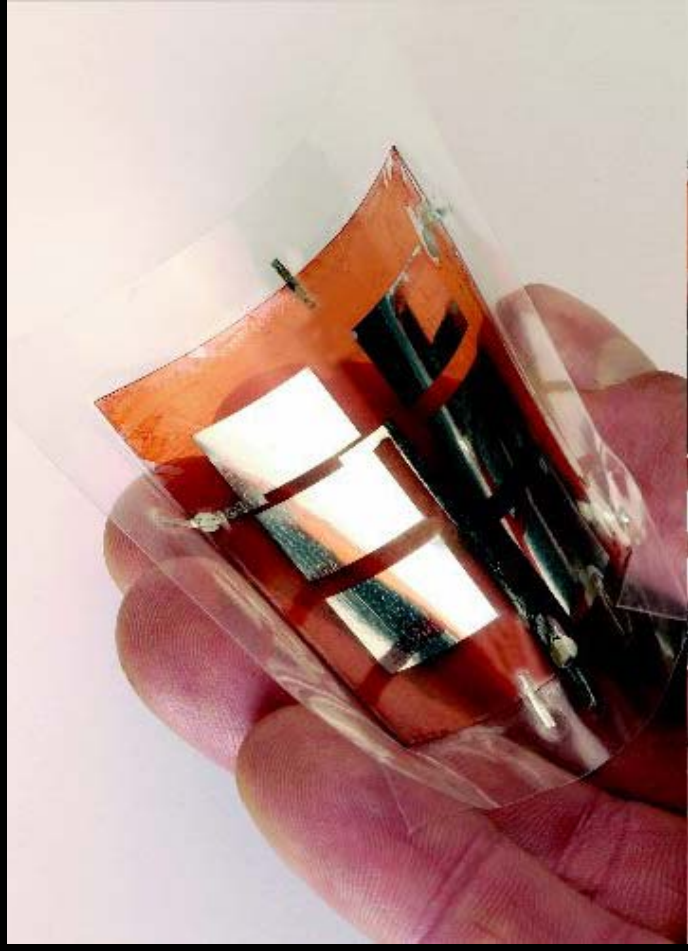
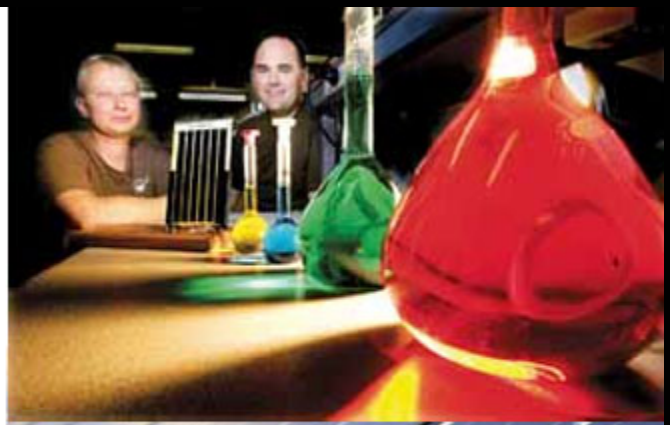
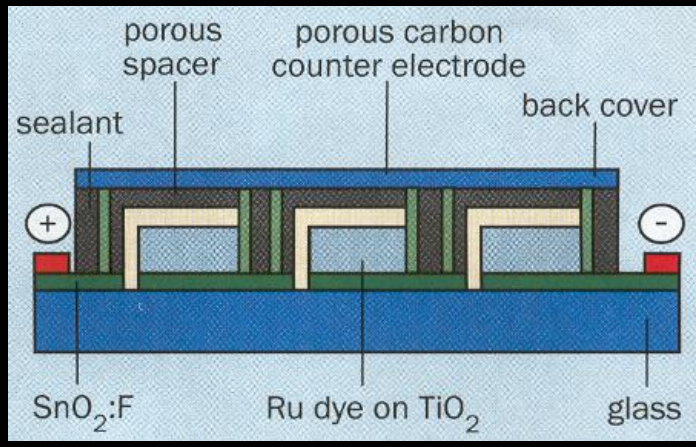
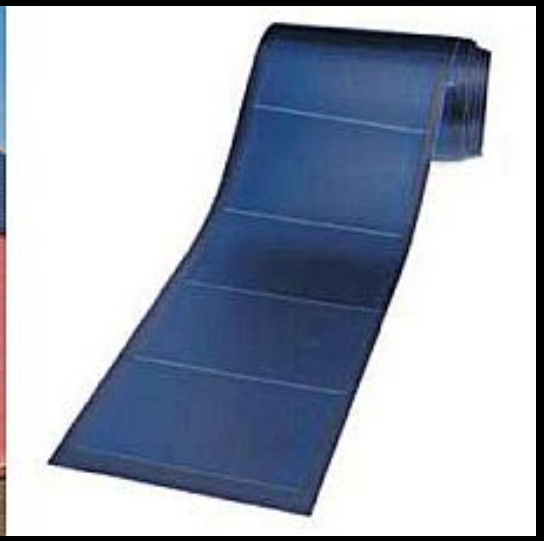


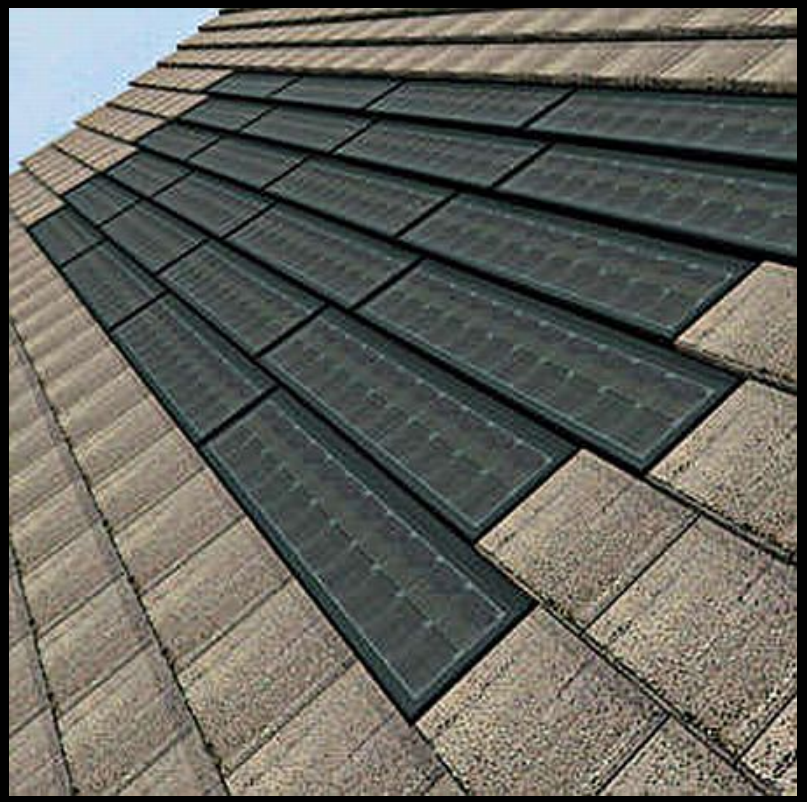




Photovoltaics - BIPVs

Rooftop applications





solar shingles

Photovoltaics - BIPVs

Rooftop applications

solar laminate

Photovoltaics - BIPVs

Rooftop applications

horizontal lights

Photovoltaics - BIPVs

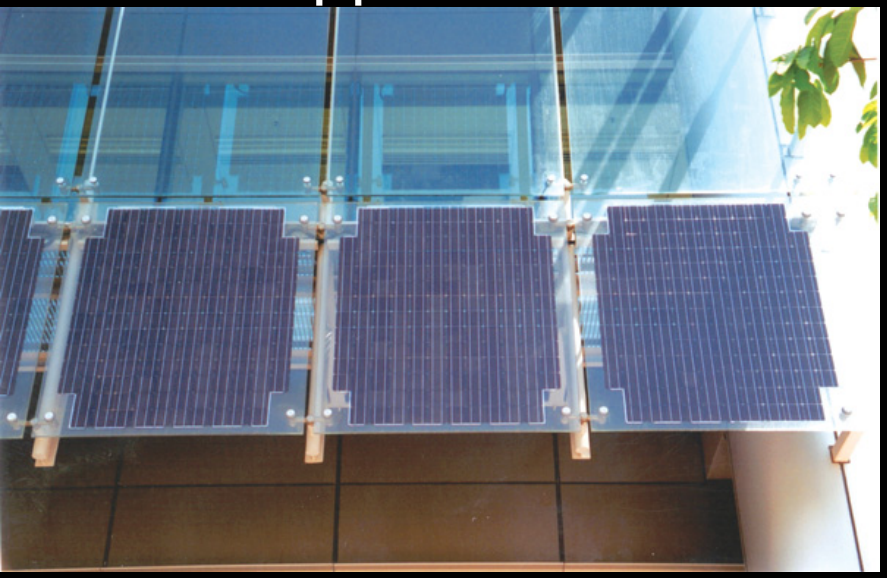
Facade applications

Hong Kong
Science Park

200 kW peak
production

Photovoltaics - BIPVs

Facade applications



Hong Kong Science Park

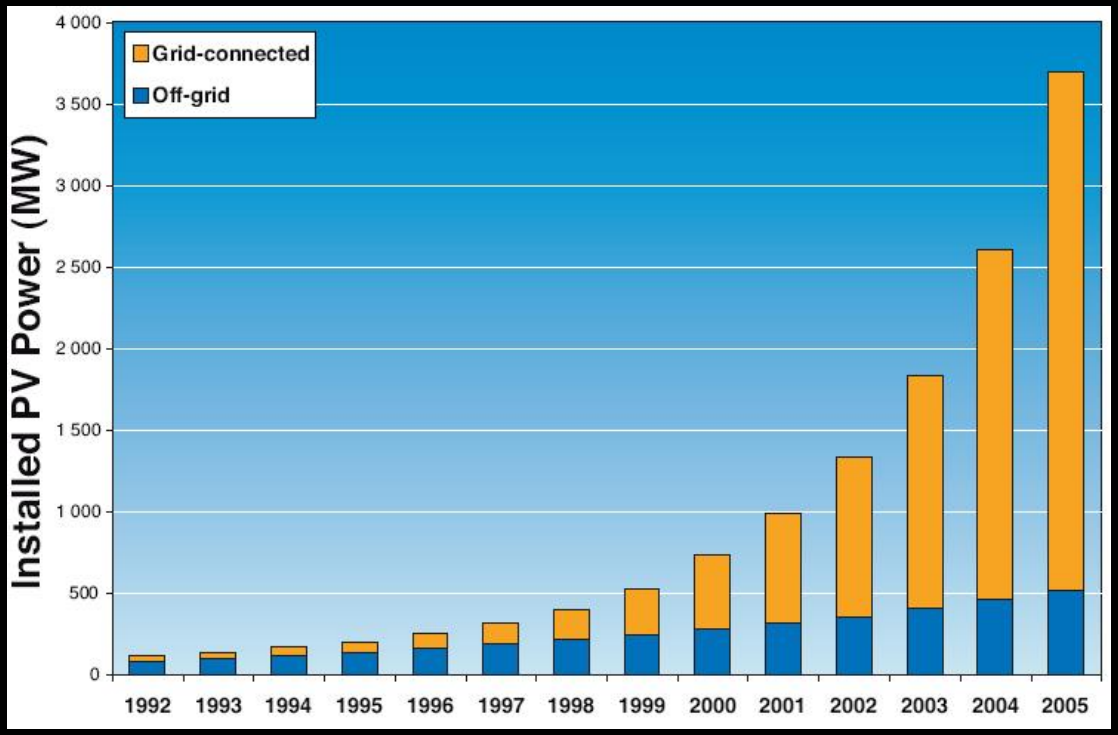
200 kW peak production

Solar Power Systems - Capacities

- In Use (as of 2006).
  - Photovoltaics
  - Concentrator Systems

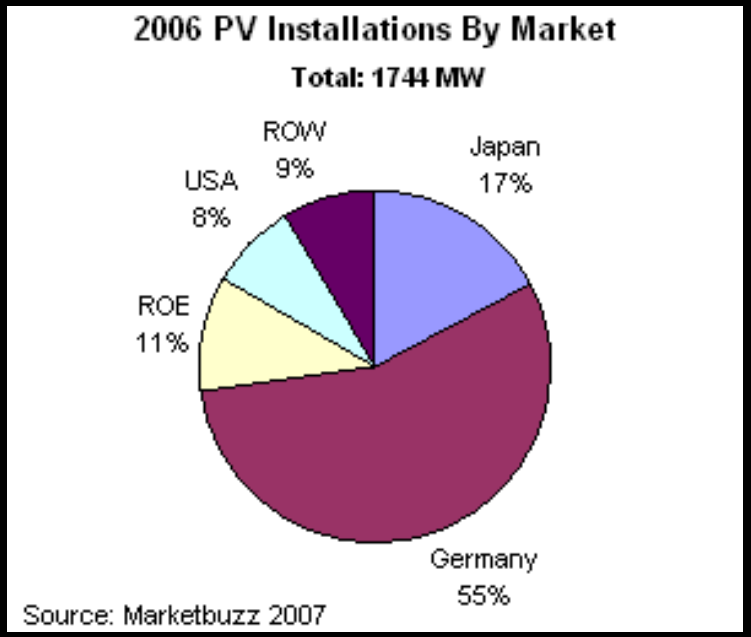
Solar Power Systems - Capacities

- Photovoltaics In Use (as of 2006).
  - 8,800 MW in use.



Solar Power Systems - Capacities

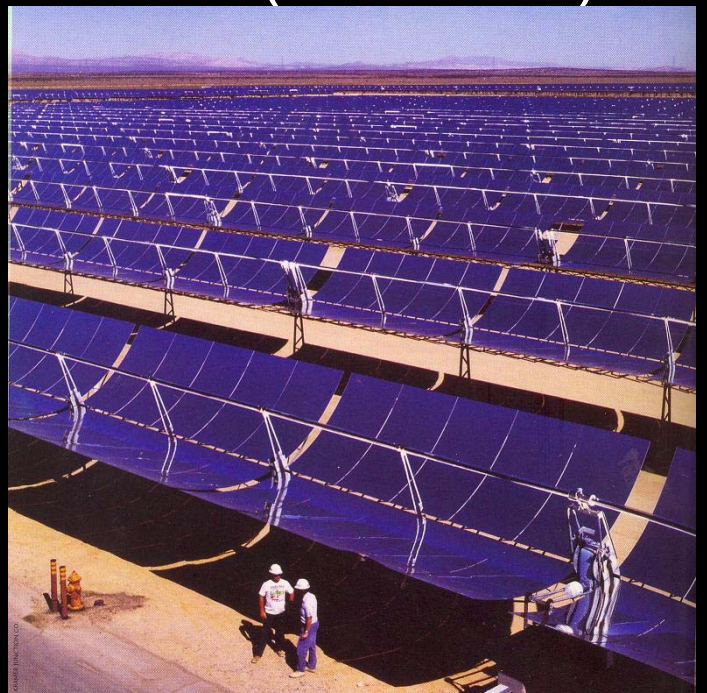
- Photovoltaics Installed (in 2006).
  - Photovoltaics 1,744 MW



(mostly distributed installations)

Solar Power Systems - Capacities

- Installed (by 2006).
  - Photovoltaics 8,800 MW
  - Concentrator Systems 524 MW (most in US)



Solar Power Systems - Capacities

- Under Construction.
  - Photovoltaics 3,800 MW produced in 2007 (mostly distributed installations)
  - Concentrator Systems 115 MW (all in Spain)

Solar Power Systems - Capacities

- Over 13,000 MW power installed or under construction.
  - Enough to power 2.5 million US homes

Solar Power Systems - Capacities

- Announced.
  - Photovoltaics Lots.
    California: 3,000 MW by 2010
    Japan: 5,000 MW by 2010
    Germany: 20% renewable by 2020
  - Concentrator Systems 4,000 MW
    (2300 MW are US installations)

Solar Power Systems - Capacities

Photovoltaic

Japan: World leader in PV use and manufacture

1992 – 32 MW of PV power installed

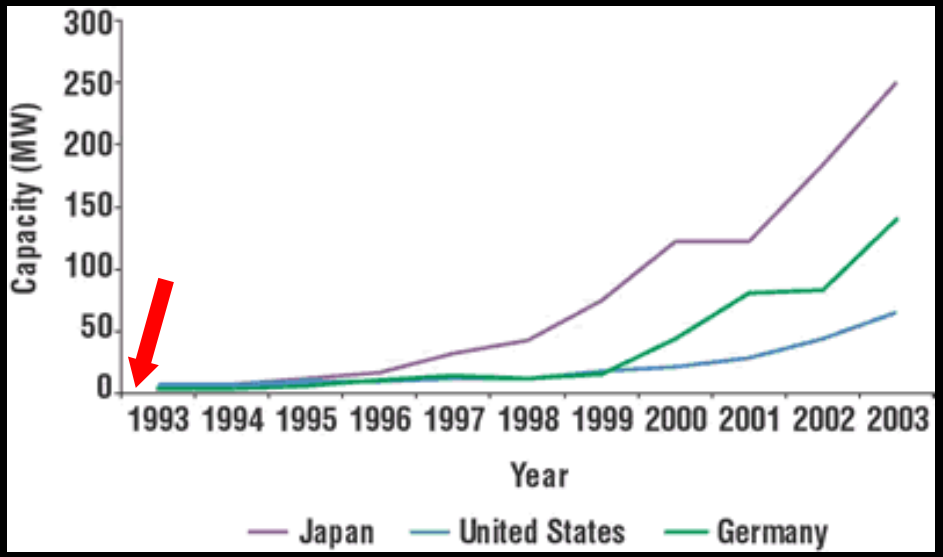
1997 – 70,000 Roofs plan begins

Government subsidizes PV installation, promotes massive publicity campaign, encourages developer participation

2002 – 70,000 Roofs plan terminated; net result: 144,000 Solar Roofs installed

2003 – 887 MW PV power in use

2010 – 4810 MW (projected)



New manufacture of PV per year, in MW

Solar Power Systems - Capacities

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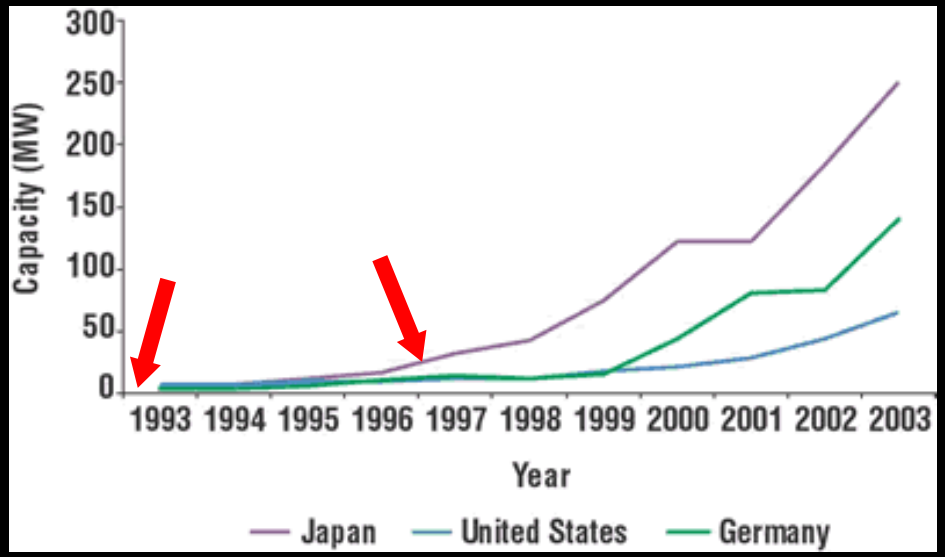

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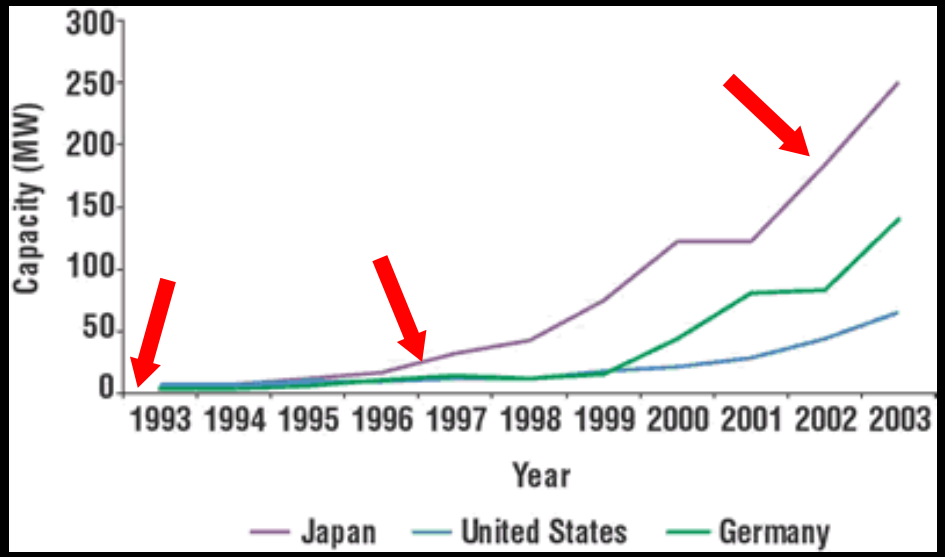

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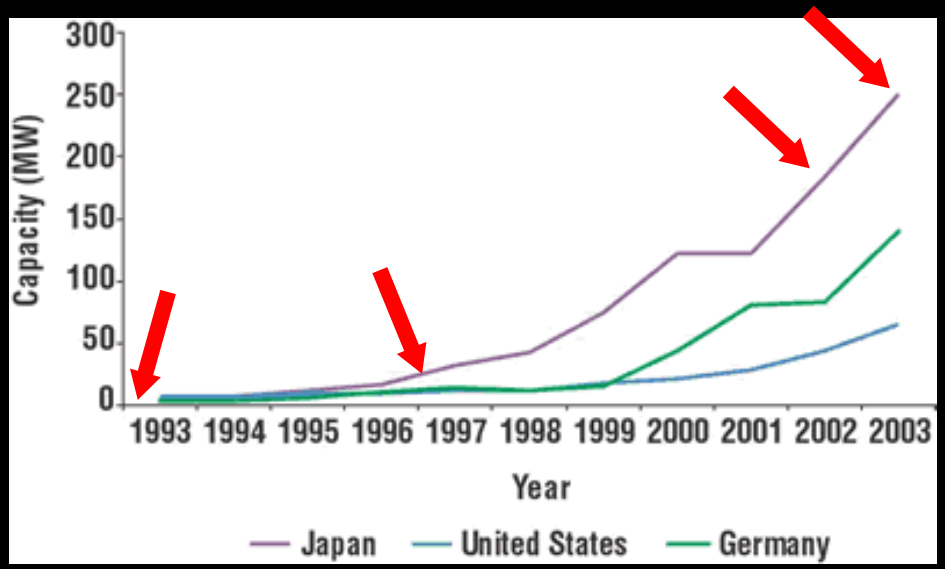

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Solar Power Systems - Capacities

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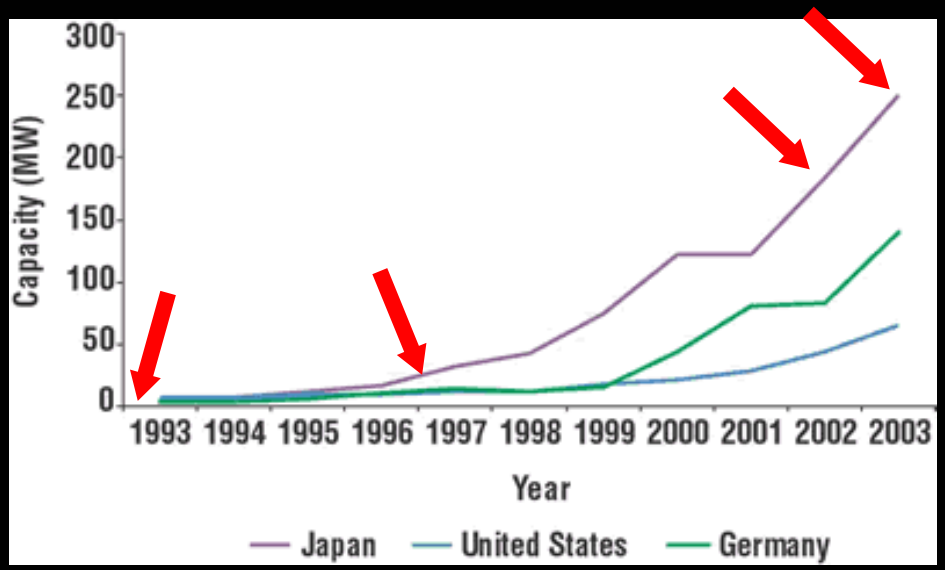

New manufacture of PV per year, in MW

Efficiency & Expense

- Efficiency – how much fuel energy is converted to electrical energy

Efficiency & Expense

- How efficient is solar energy?

Efficiency & Expense

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  - Photovoltaics: 10-15% on average (high as 22%)

Efficiency & Expense

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Gen-2 cell.
22% efficient

Efficiency & Expense

- How efficient is solar energy?
  - Photovoltaics: 10-15% on average (high as 20%)
    - Monocrystalline limit: 25%
    - Polycrystalline limit: 20%
    - Amorphous/thin film: 10%

SunPower's SPR-315.
19.3% efficient

Efficiency & Expense

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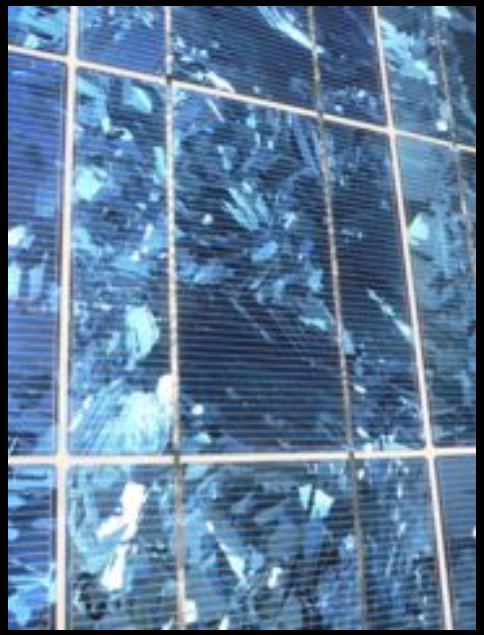
  - Parabolic troughs: 21%
  - Power towers: 23%
  - Dish engines: 29.4%



Kyocera's SPR-315.
18.4% efficient

Efficiency & Expense

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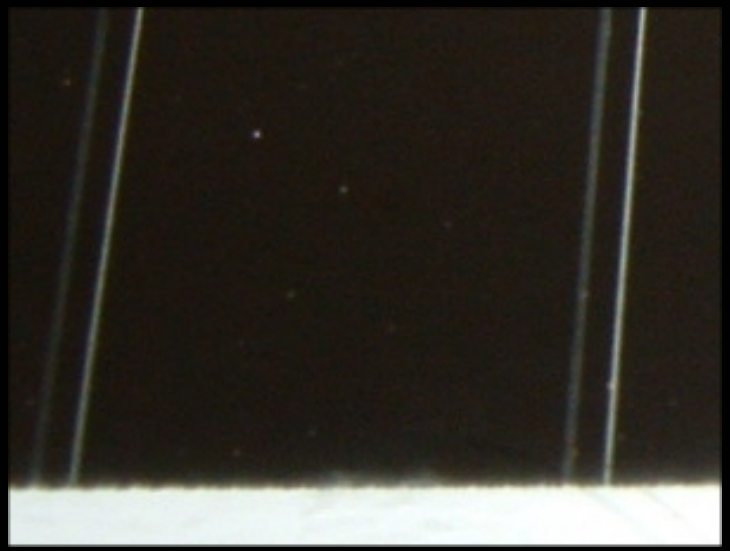

Uni-solar Membrane.

9.3% efficient

Efficiency & Expense

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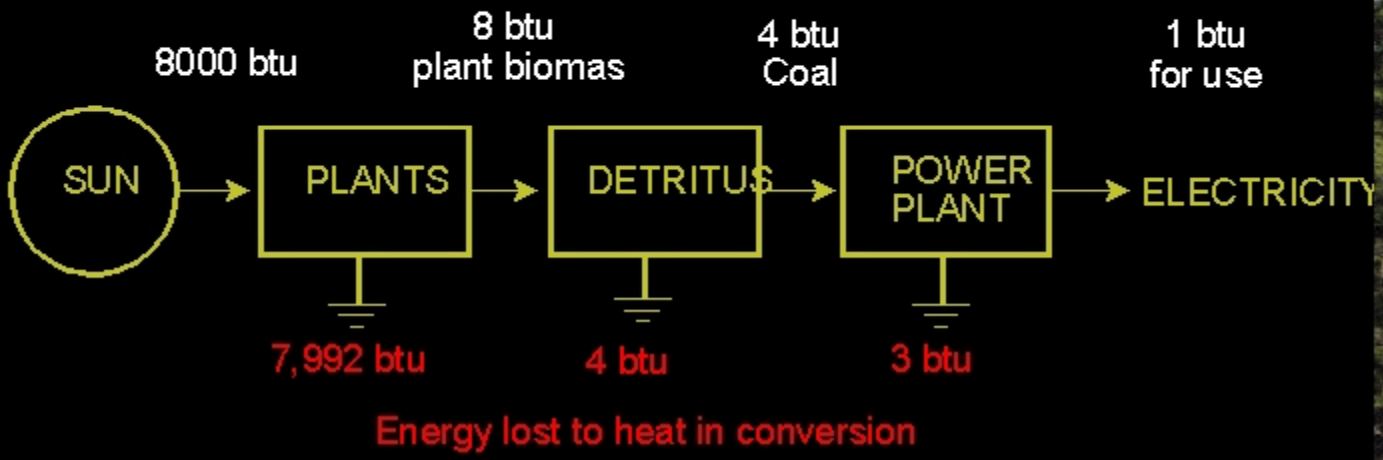
Efficiency & Expense

- How efficient are conventional power plants?

Coal efficiency



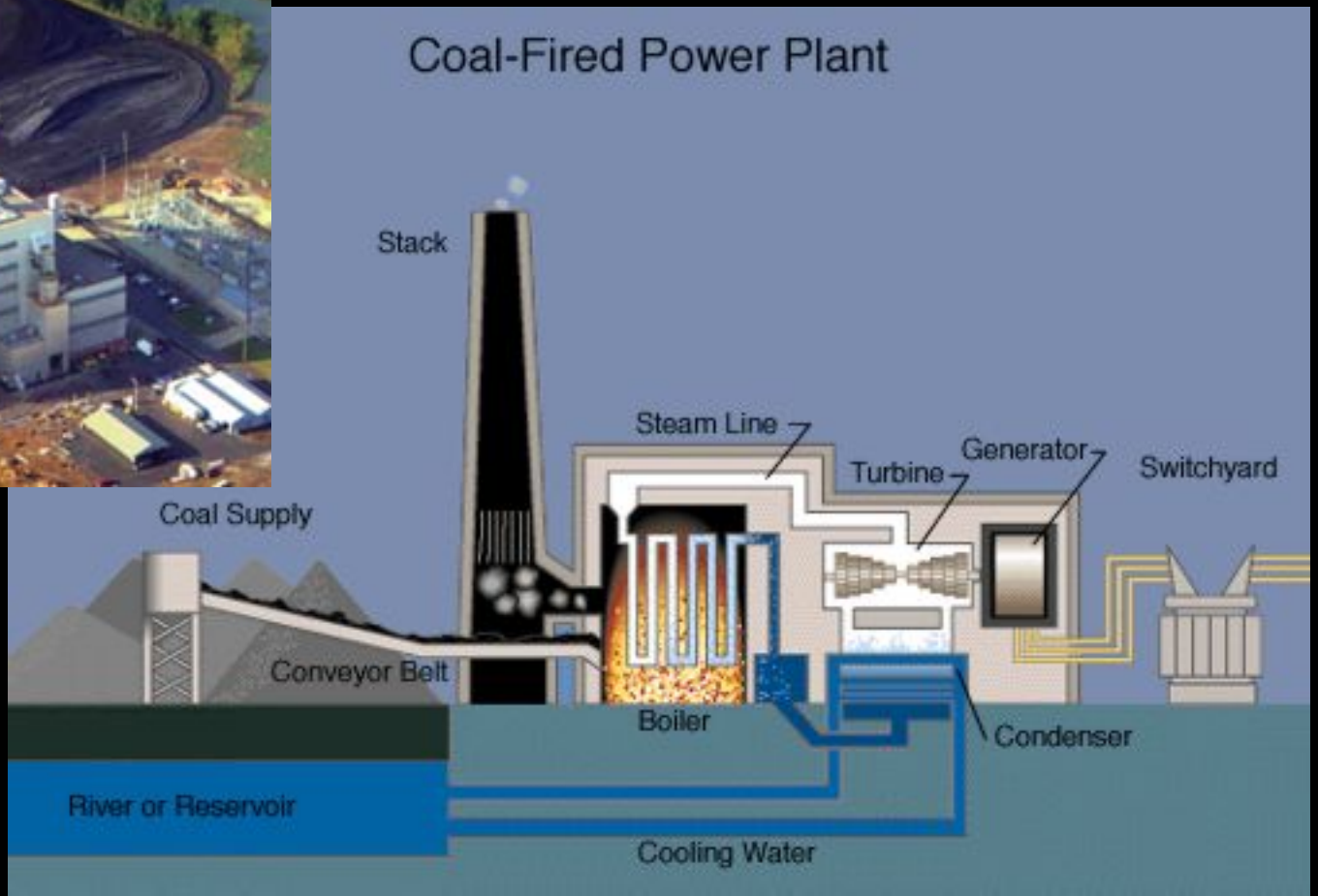
Total process - 0.01% efficient

Redfish Lake, Utah

8000 btu's strike the earth
1 Btu of electricity is produced (coal)

Efficiency & Expense

- How efficient are conventional power plants?



Efficiency & Expense

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Efficiency & Expense

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  - Photovoltaics: 10-15% on average (high as 20%)
  - Parabolic troughs: 21%
  - Power towers: 23%
  - Dish engines: 29.4%
  - Coal plants: 32%

Efficiency & Expense

- How expensive is solar energy?
  - capital costs
  - operating costs
  - maintenance costs

Efficiency & Expense

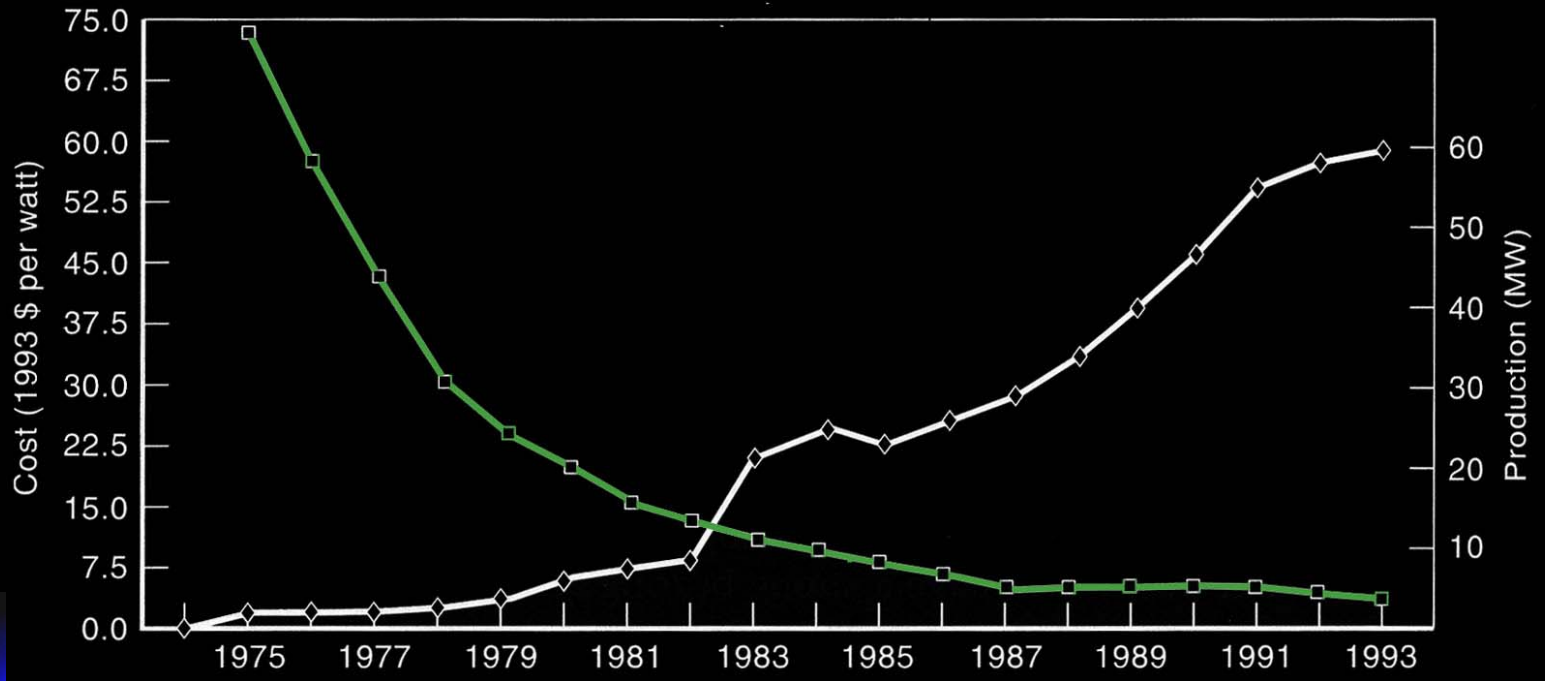
- Capital cost – how much to start generating power
  - Coal fired power plant
    - Highwood Generating Station– Southern Montana Electric. 250 MW Plant estimated to cost $720 million - $2.88 per watt

Efficiency & Expense

- Photovoltaics - $8-10 per watt
- Solar Concentrator Systems – $4-10 per watt
  - Stirling Energy System – roughly $250k for 25kW system
  - they anticipate that the dish could be made for $100k or less
  - Parabolic troughs $4-5 per watt

Efficiency & Expense

- Capital costs for Solar Power Systems are on the decline
  - Photovoltaics

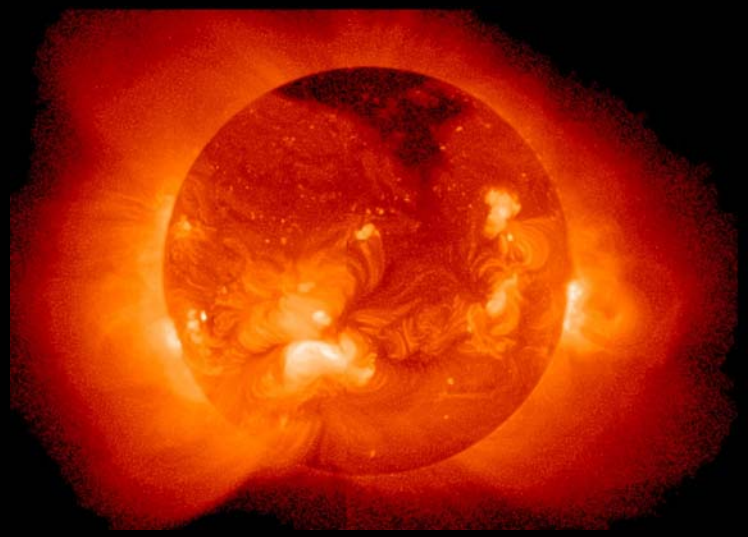


Efficiency & Expense

- Solar Concentrator Systems
  - Dish Stirling could be made for $100k or less
  - Simply doubling size of plant reduces cost per watt by 15%
  - If power plant sizes reach 100-200MW, plant costs are projected to be comparable to coal plants.
    - Dish Stirling - $2.65/watt
    - Parabolic Troughs - $2.88/watt
    - Power Tower - $2.73/watt

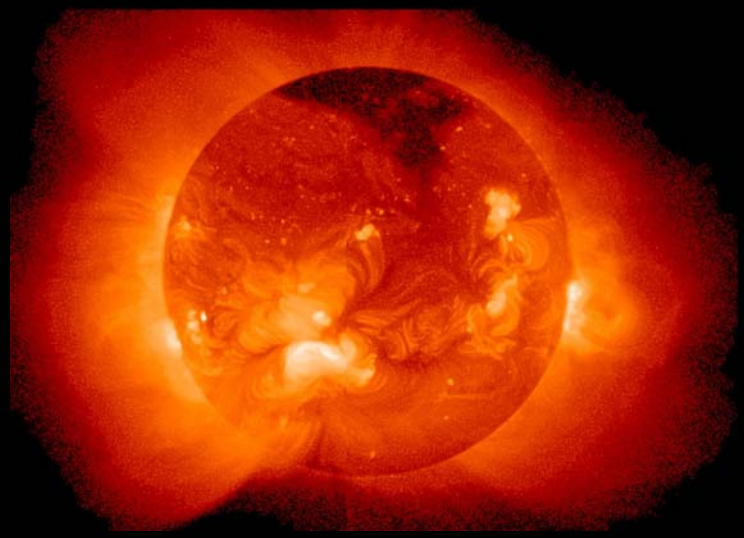
Efficiency & Expense

- Operating costs
  - Coal plants: fuel
  - Solar power systems: no fuel



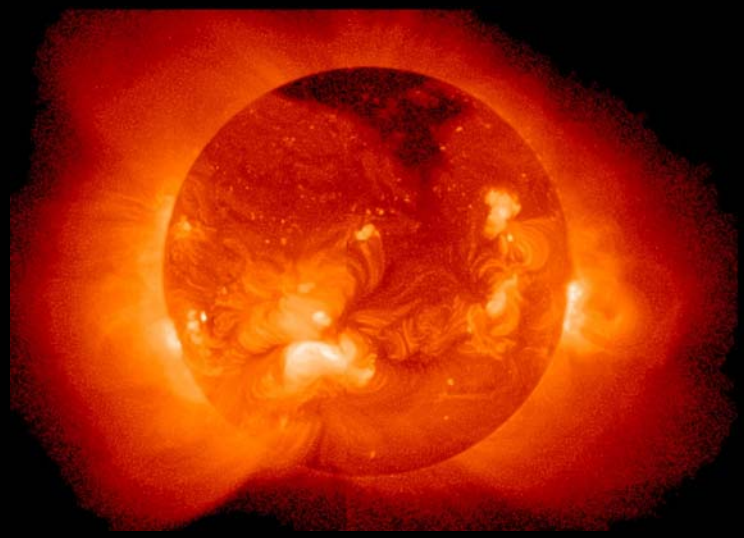
Efficiency & Expense

- Cost figures for PVs include cost of system
  - Coal plants: fuel – costs from 2.5-4 cents per kWh
    - 8-14 cents to consumer in US
  - PVs: 20-30 cents per kWh



Efficiency & Expense

- Why so different?
  - Solar power includes capital costs



How do we increase solar power use?

- Rebates for installations
- Net metering laws – electric companies buy excess electricity at market prices
- Set policy
  - Ohio, Colorado – 2.5% solar “carve-out”
  - Germany
  - KU – student referendum

What is solar power?

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