Solar power: Social, environmental and economic concerns

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Introductory lecture – Energy commodities and technologies

Global trends

- Solar power: overview
- Economic concerns
- Environmental concerns
- Social concerns

Solar power: overview

- Solar-thermally generated electricity:
  - Complex collectors to gather solar radiation to produce temperatures high enough to drive steam turbines to produce electric power.
  - For example, a turbine fed from parabolic trough collectors might take steam at 750 K and eject heat into atmosphere at 300 K will have a ideal thermal (Carnot) efficiency of about 60%. Realistic overall conversion (system) efficiency of about 35% is feasible.
- Photovoltaic energy:
  - The direct conversion of sun's rays to electricity.
  - The efficiency (the ratio of the maximum power output and the incident radiation flux) of the best single-junction silicon solar cells has now reached 46% in laboratory test conditions. The best silicon commercially available PV modules have an efficiency of about 20%.

Solar power: overview

- Solar Thermal – Concentrating Solar Power
  - Trough
  - Linear fresnel
  - Dish
  - Tower

- Main types of PV's
  - Crystalline silicon solar cells
    - Monocrystalline Si or polycrystalline
    - > 90% market share
  - Thin film solar cells
    - Amorphous Si
    - Polycrystalline CdTe, CIGS
    - < 10% market share
  - Emerging technologies
    - Concentrating PV
    - Electrochemical (dye sensitized, aka Gräetzel cells)
    - Organic solar cells

Solar power: overview

- Theoretical: 1.76 x 105 TW striking Earth; 0.3 Global mean albedo.
- Practical: 600 TW.
- Intermittent source, reasonably predictable.
- Solar thermal performs better than PV but also requires higher initial investments.

Solar power: overview

Solar power: environmental concerns

- Use of toxic materials in cells & batteries
  - Cadmium
  - Arsenic
  - Hydrogen selenide gas
- Intensity of manufacturing process
  - Si purity requirements high
  - Consumption of ultrapure water ca 10 m3/kWp
- Fugitive losses of Heat Transfer Fluid (Solar thermal)
- Venting of light decomposition product of HTF

Solar power: social concerns

- Visual intrusion in rural and urban environments

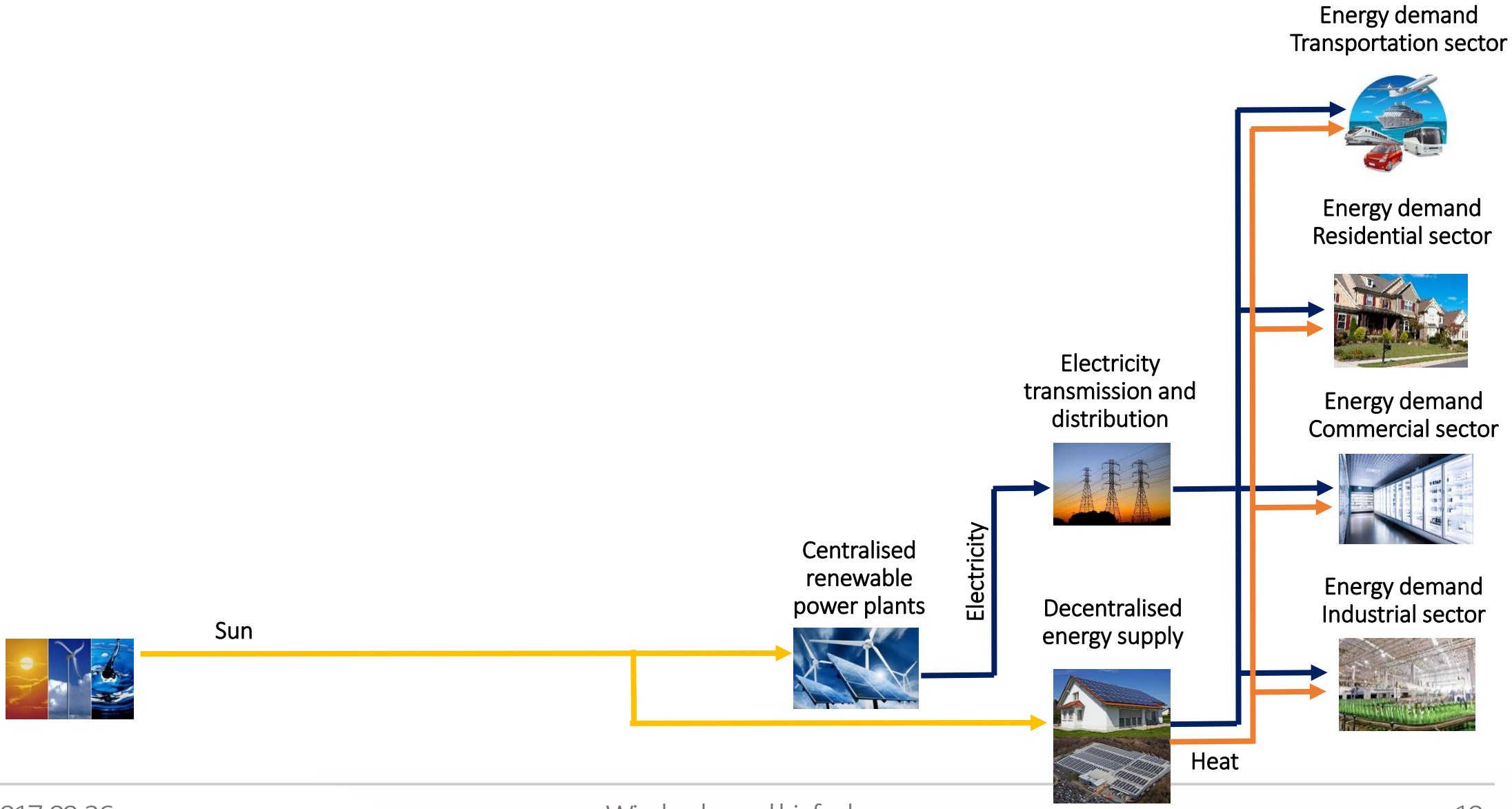
- Need for cooling installation/cooling water
  - Cooling water - scarce in regions where solar insolation is high (need for water conservation)

- Water use for solar thermal plants is similar to amounts needed for a comparably sized coal or nuclear plants, but depends on the type of cooling tower (wet, wet-dry, dry)

Technologies in the solar chain

- Photovoltaic (PV) and Concentrating Solar Power (CSP)

Sample Reference Energy System: solar



Centralised PV and CSP

- If the exact same (group of) solar power unit(s) is installed in different locations, the parameter that changes is the capacity factor.
- In countries with good solar resources, PV has reached the so called *grid-parity*. In others, not yet competitive.
- Most diffused commercial PV techs are wafer-based crystalline silicon and thin film. The latter is cheap (the production chain is similar to the one of LCD) but less efficient.
- CSP not yet competitive, but potential if market increases.

Key characteristics	
Utility PV	
Capital cost	1700-2100 $/kW
FOM cost	1% of capital / year
VOM cost	0 $/GJ
Life-cycle CO2 emission factor	12-25 gCO2/kWh
Avg. capacity factor	13%
Lifetime	25 years
CSP (no storage)	
Capital cost	4500-8000 $/kW
FOM cost	25-35 $/kW/a
VOM cost	0 $/GJ
Efficiency	13-15%
Avg. capacity factor	25-28%

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Key characteristics	
Residential PV	
Capital cost	2200-4500 $/kW
FOM cost	1% of capital / year
VOM cost	0 $/GJ
Life-cycle CO2 emission factor	12-25 gCO2/kWh
Avg. capacity factor	13%
Lifetime	25 years

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Sources for the RES pictures

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