




Wind power: Social, environmental and economic concerns

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Introductory lecture – Energy commodities and technologies

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Global trends

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



Wind power overview

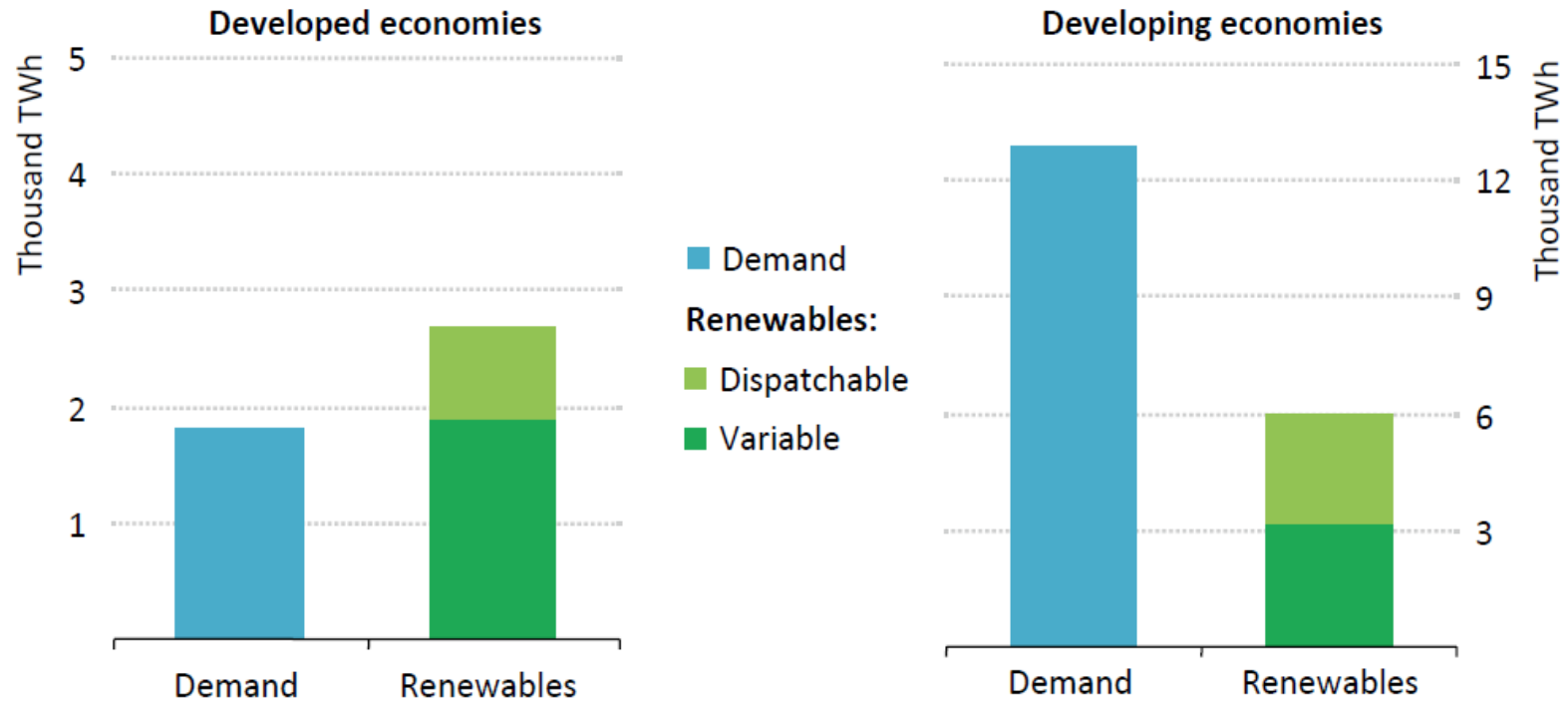


- Wind energy is conveyed by the uneven heating of the earth by the sun.
- Local topography (mountains) can enhance or restrict the natural wind flow.

$$P_{wind} = \dot{E} = \frac{1}{2} \dot{m} v^2 = \frac{1}{2} \rho A v^3$$

- A 10 % change in speed will result in a 33% change in energy.
- Turbulence Decreases the Effectiveness of a wind Turbine and imposes more wear and tear on the Wind Turbine.

Change in total electricity demand and renewable-based power supply in the New Policies Scenario 2014-2040



Source: IEA World Energy Outlook 2016.

Wind power overview



Onshore



Offshore



Wind power overview



- Output really depends on location characteristics.
- Higher performance but also higher investment cost in offshore.
- Intermittent output, not completely predictable.
- Betz limit: up to $16/27$ of the power in the wind can be converted to mechanical power by a turbine.



Wind power: economic concerns



- Land use
 - ❖ A modern wind farm uses only 1% of the land occupied and the towers only 0.2%
 - ❖ Access roads must be build for
- Land-based farms
 - ❖ The average wind farm requires 0.1 km² of unobstructed land per megawatt of design capacity
- High level of intermittency and unpredictability
 - Not a stand-alone source
 - To be coupled either with other generation technologies or storage



Wind power: environmental concerns



- Electromagnetic effects and increased sediment temperature along cables for direct current.
- Changed erosion and accumulation conditions.
- Physical encroachments on habitats.
- Barrier effects, e.g. at migration.
- Fragmentation of landscape.
- Visual appearance – light, shadows and reflexes – may be disturbing for both wild and domestic animals.



Wind power: social concerns



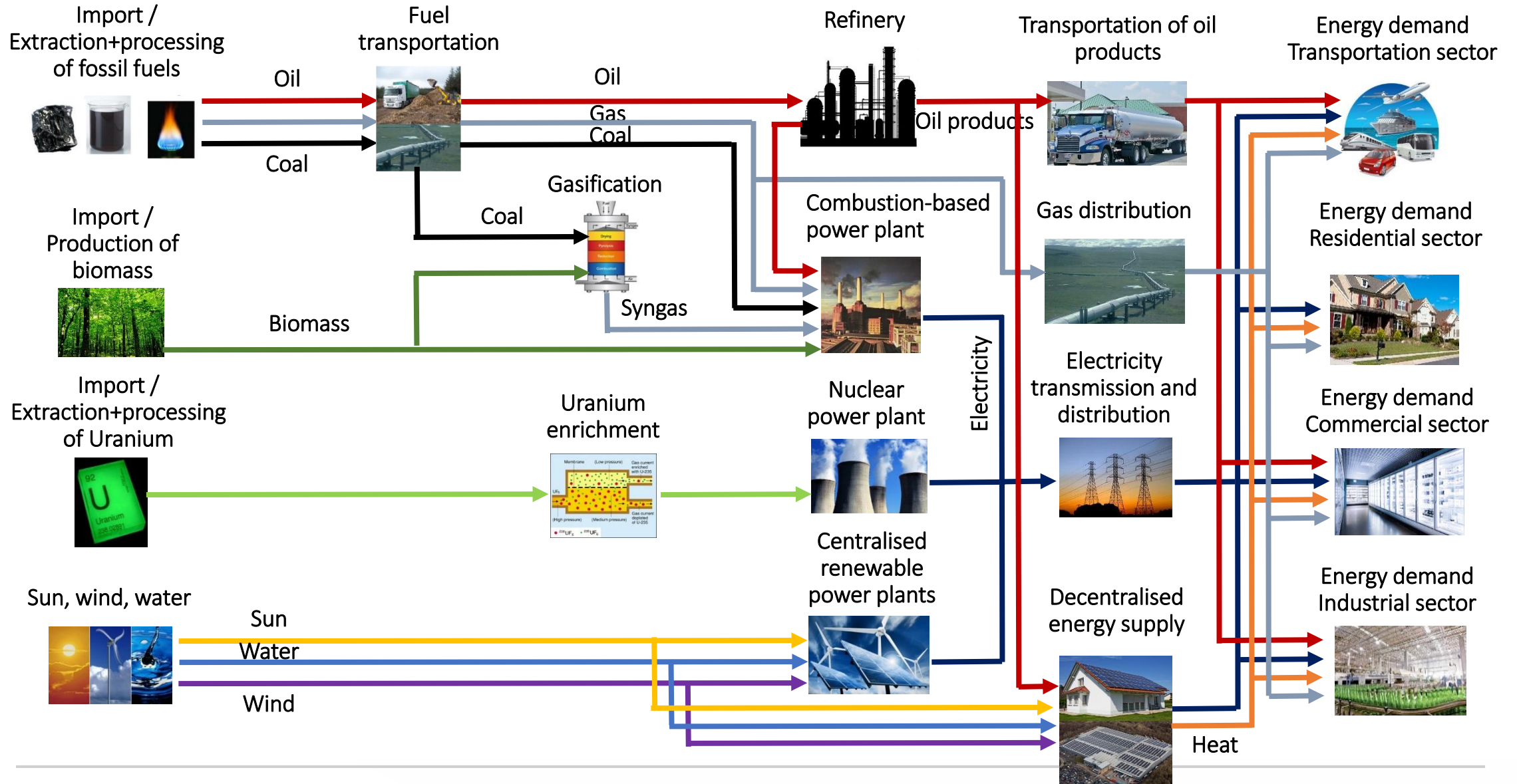
- Aesthetics
 - ❖ Visual perception
- Flickering
- Electromagnetic interference - Now minimized/eliminated with fiberglass blades
- Noise (mechanical and electrical equipment; aerodynamic)
 - ❖ 200 meters away from a wind turbine a normal noise level at wind speeds about 8m/s is 45 dBA
 - ❖ Denmark: minimum distance to households 200m
 - ❖ Sweden: wind turbines are usually not placed closer than 300-500 meter from nearest household



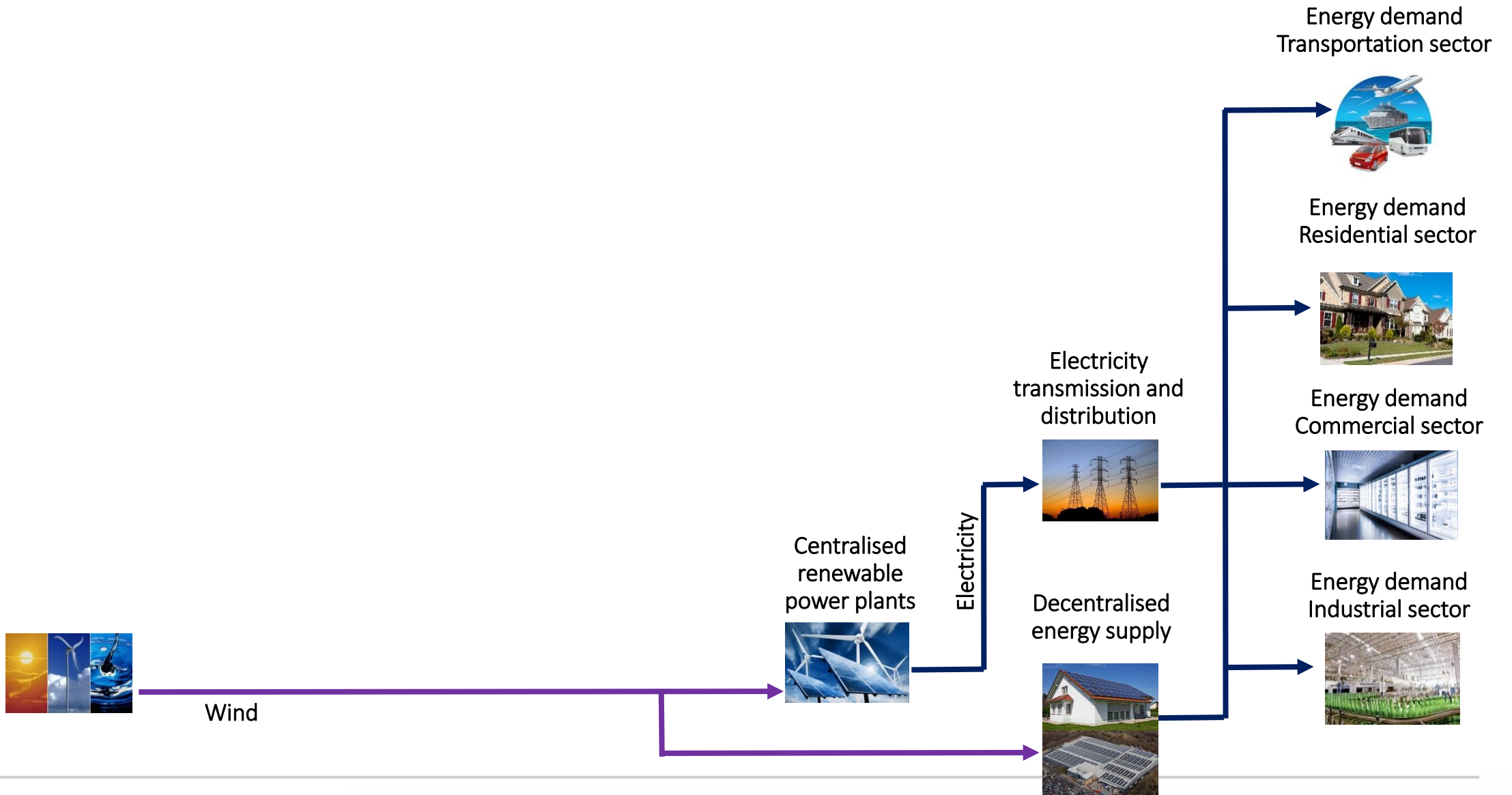
Technologies in the wind chain

- On-shore wind
- Off-shore wind

Sample Reference Energy System



Sample Reference Energy System: Wind





Onshore wind



- Mature technology, lowest costs in the United States and China.
- The overall performance of wind power depends on the specific characteristics of each location.
- The capacity of a wind turbine can vary from a few kW to 9MW.
- If the exact same (group of) wind turbine(s) is installed in different locations, the parameter that changes is the capacity factor.

Key characteristics	
<i>Onshore wind</i>	
Capital cost onshore	1400 €/kW
FOM cost	2.7% of capital
Avg. capacity factor	23%
Indirect GHG emission factor	10 tCO ₂ eq/GWh
Lifetime	20 years



Offshore wind



- Mature technology in Northern Europe, but experience still limited elsewhere.
- In general, higher costs than onshore, but also higher performance (especially in terms of capacity factors).
- Higher capacity factors due among others to lower disturbance of the flow.

Key characteristics	
<i>Offshore wind</i>	
Capital cost onshore	3470 €/kW
FOM cost	3.7% of capital
Avg. capacity factor	34%
Indirect GHG emission factor	16 tCO ₂ eq/GWh
Lifetime	20 years



References and reading material



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Sources for the RES pictures



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Sources for the RES pictures



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Changelog and attribution



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Available at: <http://www.osemosys.org/understanding-the-energy-system.html>. [Access date]