

Introduction of Renewable Energy

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Course Assessment

- 1 Total Achievement =
 - Course Presentation
 - Examination

Reference Books

- 1 程明，张建忠，王念春编著. 可再生能源发电技术. 机械工业出版社，2012 .
- 2 B. Wu, Y. Lang, Power Conversion and Control of Wind Energy Systems, 2011.
- 3 F. Blaabjerg, Z. Chen, Power Electronics for Modern Wind Turbines, 2006.
- 4 王长贵、崔容强、周篁主编. 新能源发电技术. 中国电力出版社，2003.

Overview

- **Why “Renewable Energy”?**
- **Wind Power**
- **Wind Turbine**
- **Wind Farms**
- **Wind Power Transmission**

Overview

- **Why “Renewable Energy”?**
- Wind Power
- Wind Turbine
- Wind Farms
- Wind Power Transmission

I. Why “Renewable Energy”?

■ Non-Renewable Energy?



I. Why “Renewable Energy”?

■ Non-Renewable Energy?

Coal



Gasoline



I. Why “Renewable Energy”?

■ Features of Non-Renewable Energy?



I. Why “Renewable Energy”?

■ Features of Non-Renewable Energy?

Fossil Fuel

- Non-renewable energy
- Not clean
- Air pollution
- Water pollution
- Climate change



Coal



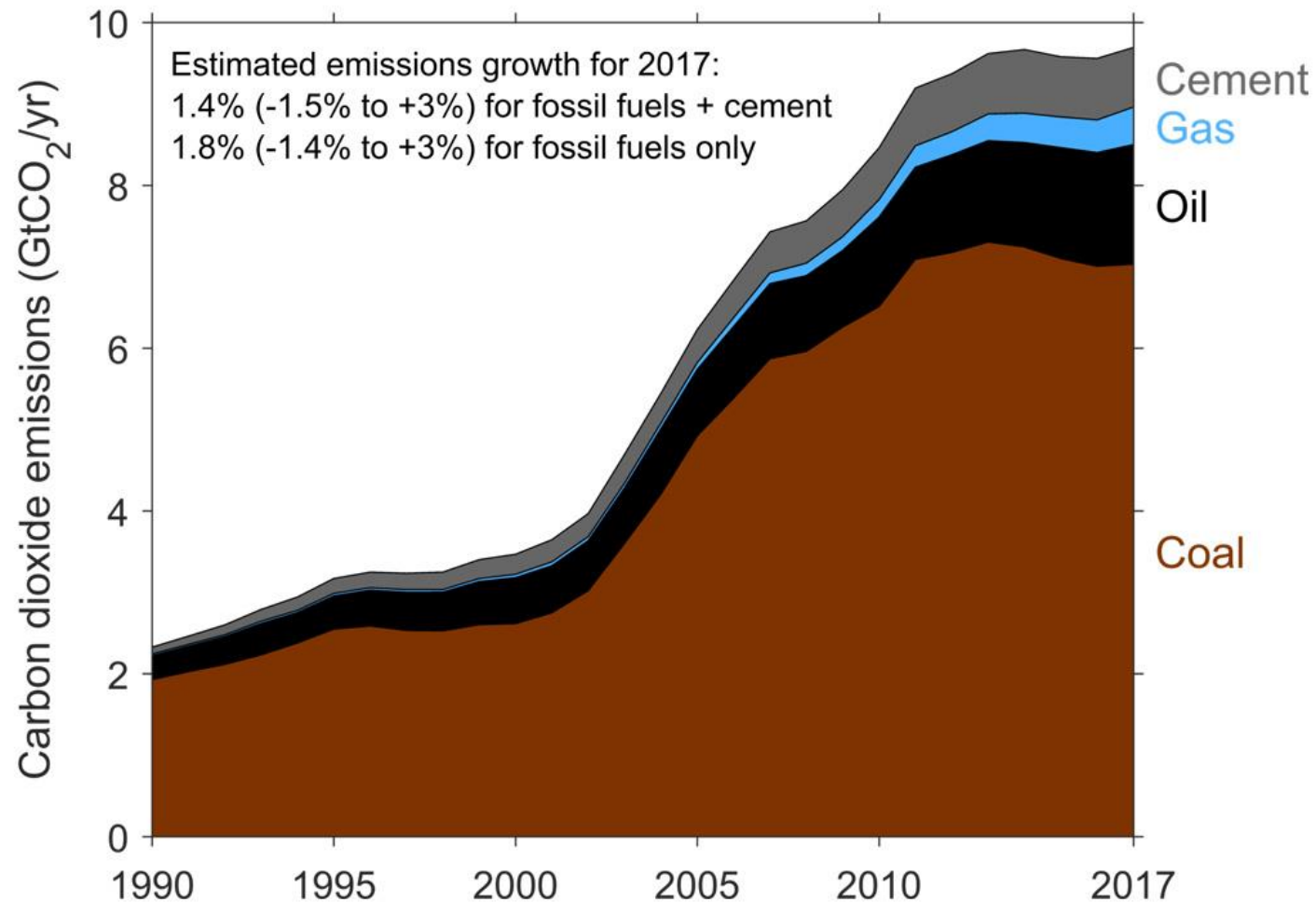
Gasoline

CO₂



I. Why “Renewable Energy”?

■ Carbon Dioxide Emission in China



I. Why “Renewable Energy”?

- What should we do?



I. Why “Renewable Energy”?



**Renewable
Energy!!!**



I. Why “Renewable Energy”?

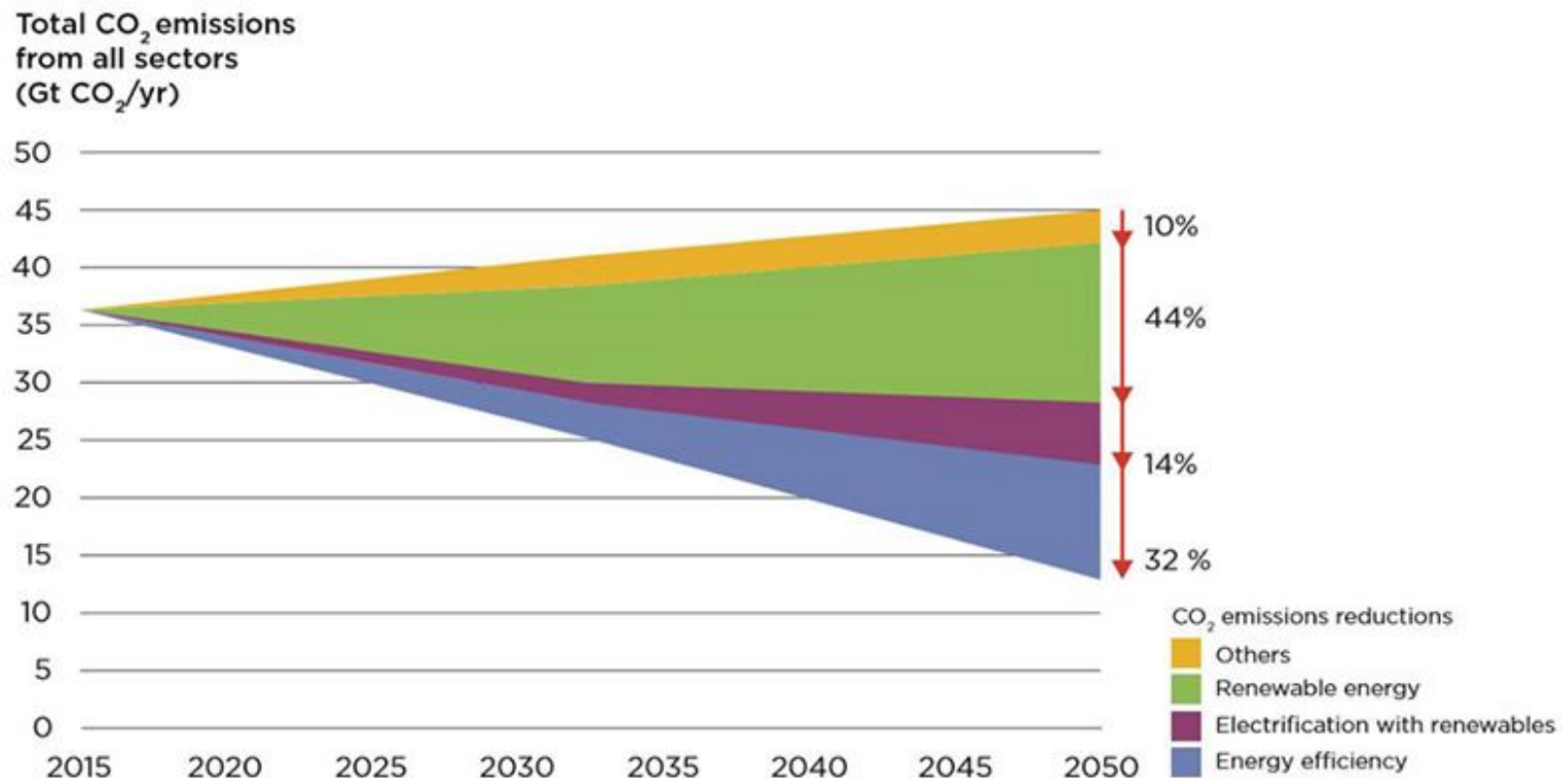
■ What is Renewable Energy?



I. Why “Renewable Energy”?

■ What is Renewable Energy?

The energy that is collected from renewable resources, which are naturally replenished on a human timescale.



I. Why “Renewable Energy”?

■ Why Renewable Energy?

Growth in energy demand

Demographic Dynamics



Security of energy supply

Resource Scarcity



Reduction of CO₂-emission

Environmental Focus



I. Why “Renewable Energy”?

■ Features of Renewable Energy?

- Sustainable
- Clean
- High quality at a competitive cost
- Reliable

I. Why “Renewable Energy”?

■ Renewable Energy?

Renewable Energy Technologies



Wind



Small Hydro



Biomass



Tidal



Wave



Solar energy
photovoltaic

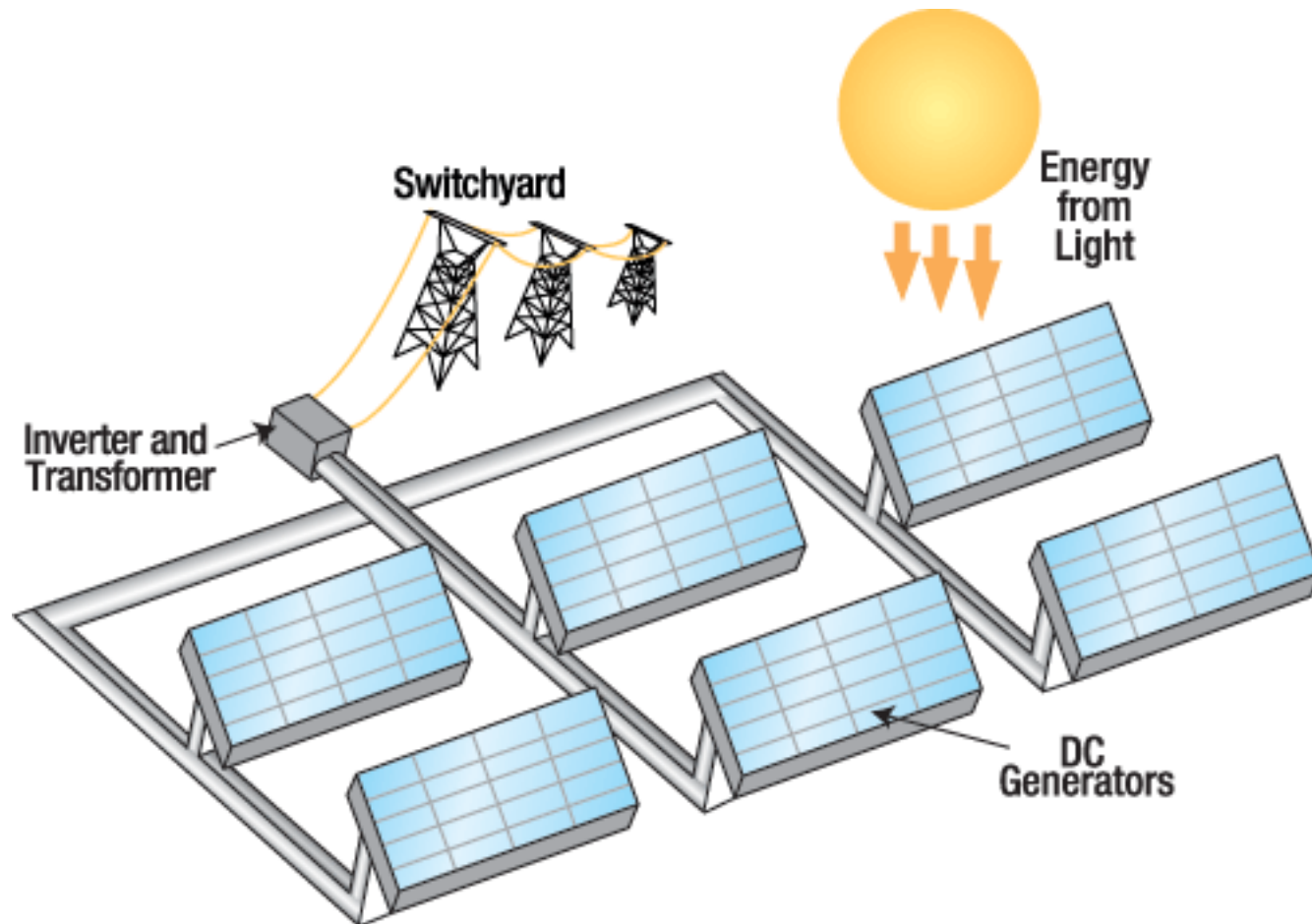
Wind Power

■ Wind power



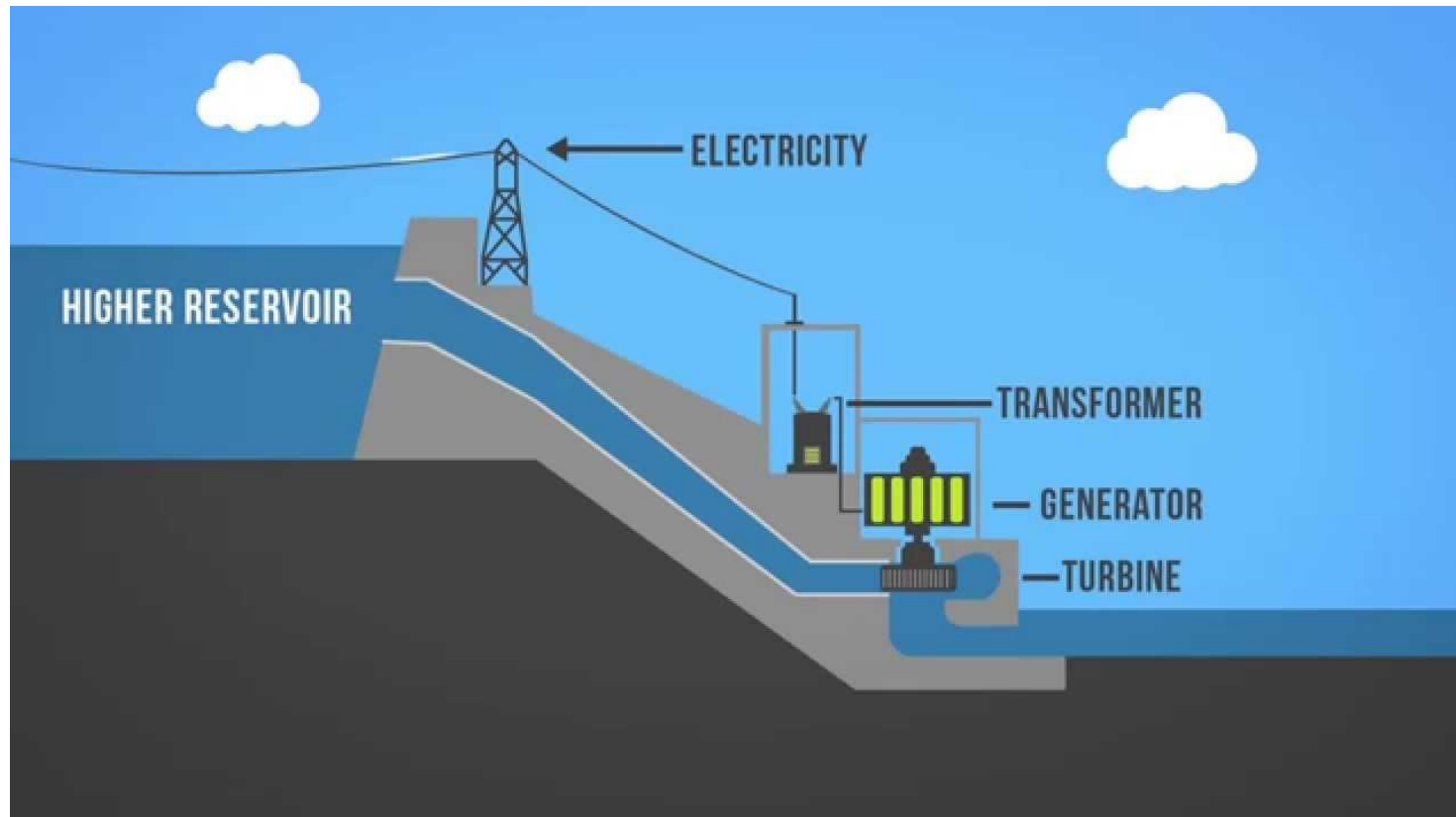
Solar Power

■ Solar Power



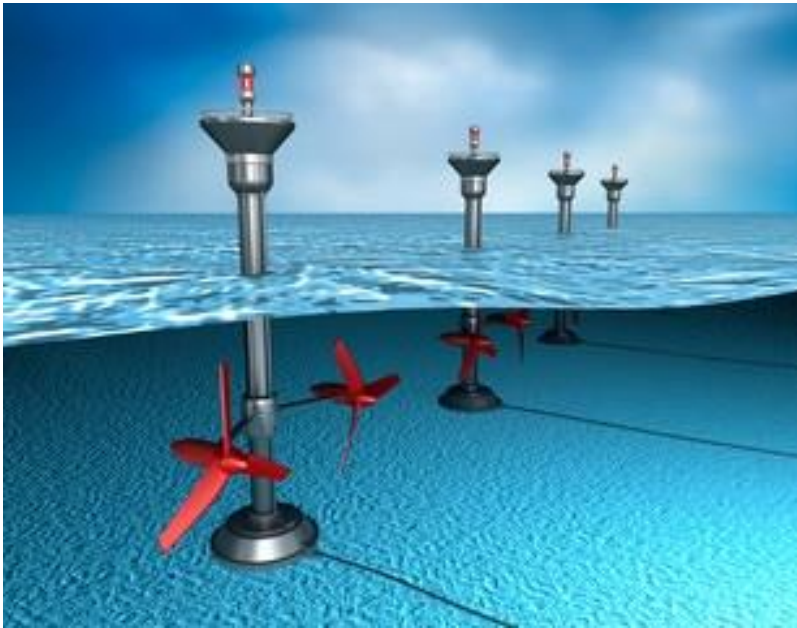
Hydro Power

■ Hydro Power



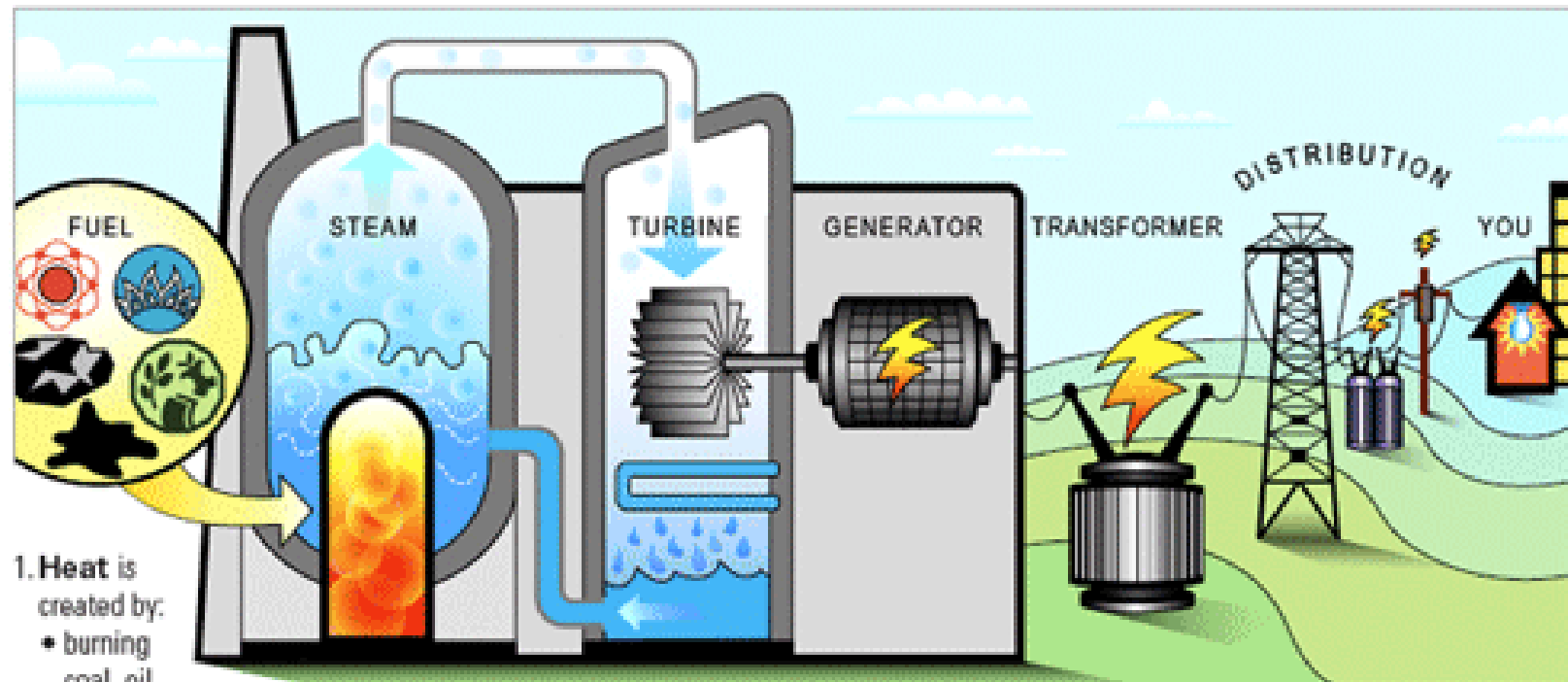
Ocean Power

■ Ocean Power



Biomass Power

■ Biomass Power



1. Heat is created by:

- burning coal, oil, natural gas, biomass trash,
- or splitting atoms in nuclear fission...

2. to boil water to make **steam**.

3. Steam turns the blades of huge **turbines**...

4. which spin **generators** to create electricity.

5. A **transformer** increases the voltage to send electricity over...

6. **distribution** lines. Then local transformers reduce the voltage...

7. for **you** to use.

Renewable Energy System



Overview

- Why “Renewable Energy”?
- **Wind Power**
- Wind Turbine
- Wind Farms
- Wind Power Transmission

Wind Power

Wind Power

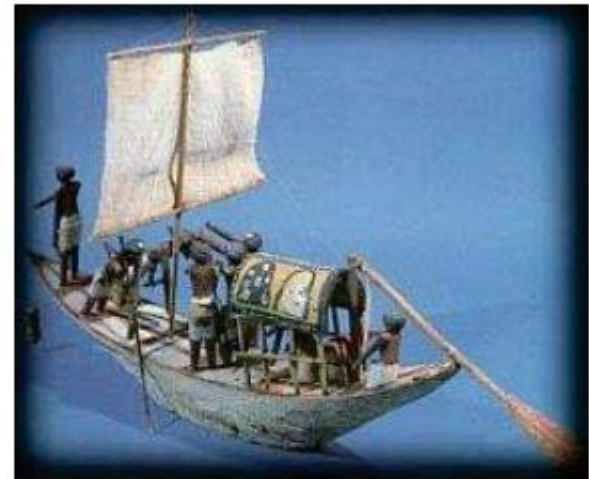
- Renewable energy
- Clean
- Almost no pollution
- Cost-effective



Wind Power

Early Wind Power Utilization

As early as 3000 B.C., people used wind energy for the first time in the form of sail boats in Egypt.



The earliest windmills, used to grind grain, came about in 2000 B.C.

Wind Power

Early Wind Turbine Utilization



Dutch wind turbines, in the Middle Ages, 16. Century

Wind Power

Early Wind Turbine Utilization



America wind turbines around 1900

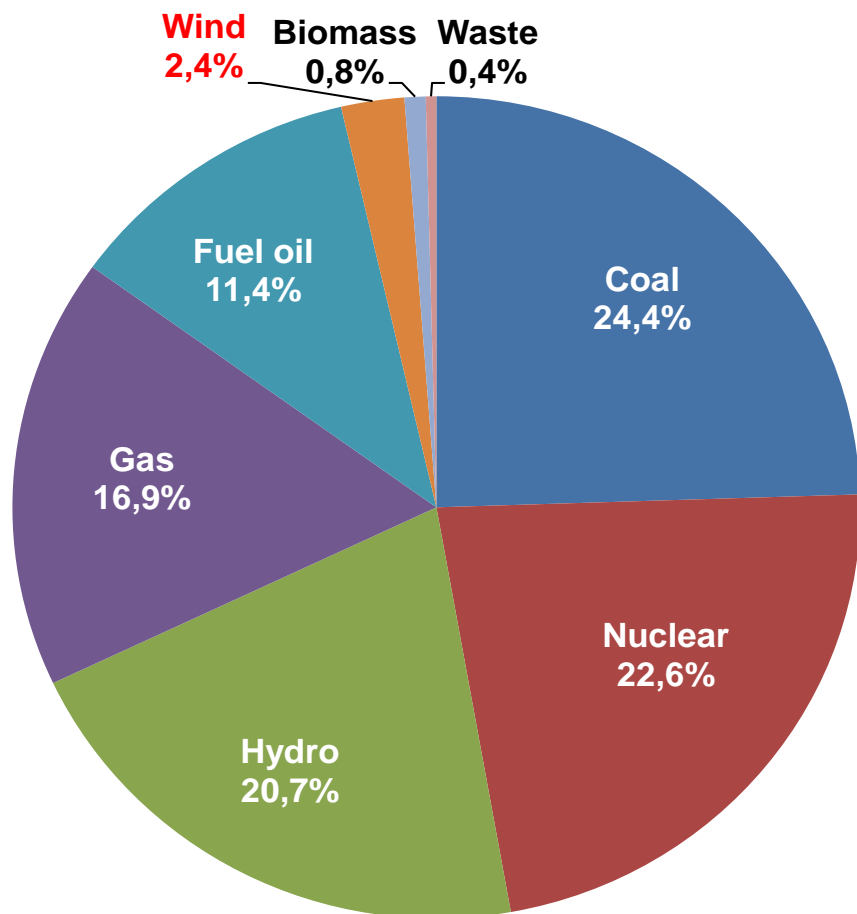
Wind Power

Modern Wind Turbines

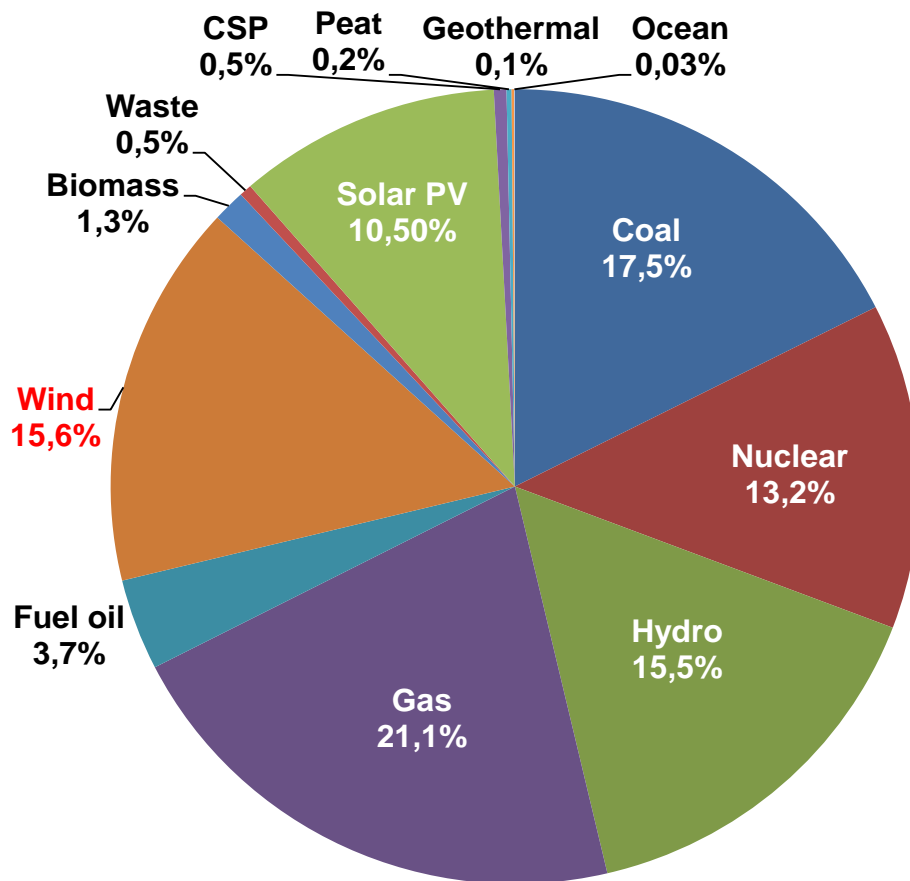


European Union (EU) Power

EU Power Mix in 2000

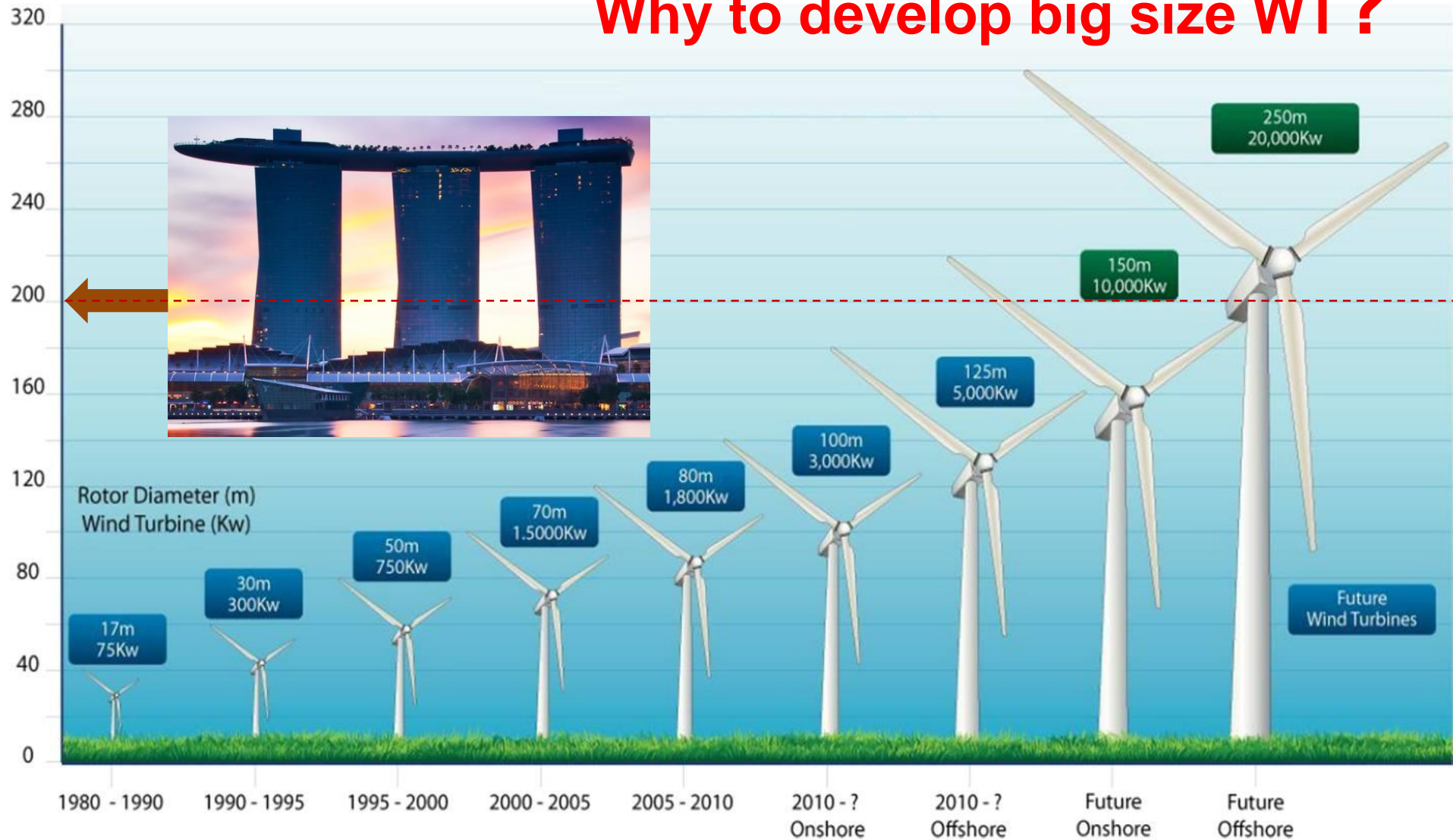


EU Power Mix in 2015



Growth of Wind Turbine Size

Why to develop big size WT?



Development in Wind Energy Technology

Current developments, Vestas A/S Denmark



- | | | | |
|--|-------------------------------------|-----------------------|-------------------|
| 1 Wind sensors and lightning connectors | 6 VPP-Top controller with Converter | 11 Gearbox | 16 Blade bearing |
| 2 Cooler for gearbox, generator and hydraulics | 7 Optispeed generator | 12 Machine foundation | 17 Blade hub |
| 3 Converter cooler | 8 Composite disc coupling | 13 Main shaft | 18 Hub controller |
| 4 Helicopter platform (Option) | 9 Service crane | 14 Voe gear | 19 Pitch cylinder |
| 5 Retraction rope (Option) | 10 Mechanical disc brake | 15 Main bearing | 20 Blade |

Vestas off-shore turbine

Rated power: 4,500 kW

Rotor diameter: 120 m

Hub height: 90 m

Turbine concept: Gearbox, variable speed, variable pitch

Generator: HV DFIG

Haliade™ 150-6MW

New generation offshore wind turbine



6MW offshore wind turbine with 150m rotor

- **Robust:** ALSTOM PURE TORQUE®
- **Simple:** Direct Drive PMG
- **Efficient:** Large rotor gives higher yield



E126/ 7,580 kW

Rated power:	7,580 kW
Rotor diameter:	127 m
Hub height:	135 m
Type:	Upwind rotor with active pitch control
Rotational direction:	Clockwise
No. of blades:	3
Swept area:	12,668 m ²
Blade material:	GRP (epoxy resin); integrated lightning protection
Rotational speed:	variable, 5 – 11.7 rpm





Vestas V164-8.0



Technical Specifications Operational data

Rated power: 8,000 kW

Cut-in wind speed: 4 m/s

Operational rotor speed: 4.8 - 12.1 rpm

Nominal rotor speed: 10.5 rpm

Operational temperature range: -10 to +25°C

Extreme temperature range: -15 to +35°C

Rotor

Rotor diameter: 164 m

Swept area: 21,124 m²

Electrical

Frequency: 50 Hz

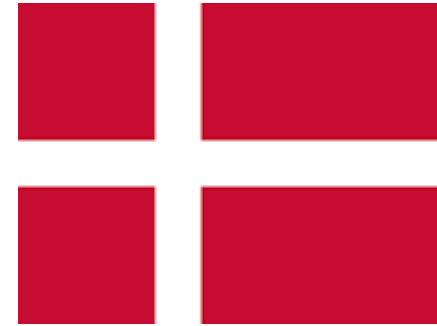
Converter type: Full scale converter

Generator type: Permanent magnet

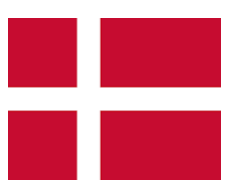
Nominal voltage: 33 - 35 and 66 kV

Danish Energy Industry

- Denmark is one of the earliest wind power developers
- Denmark produces **47%** of electricity consumption from wind source in **2019**
- Aims for a **50%** wind share by **2020**
- Denmark also has large number of CHP installations which supply both heat and electricity load with a high efficiency.

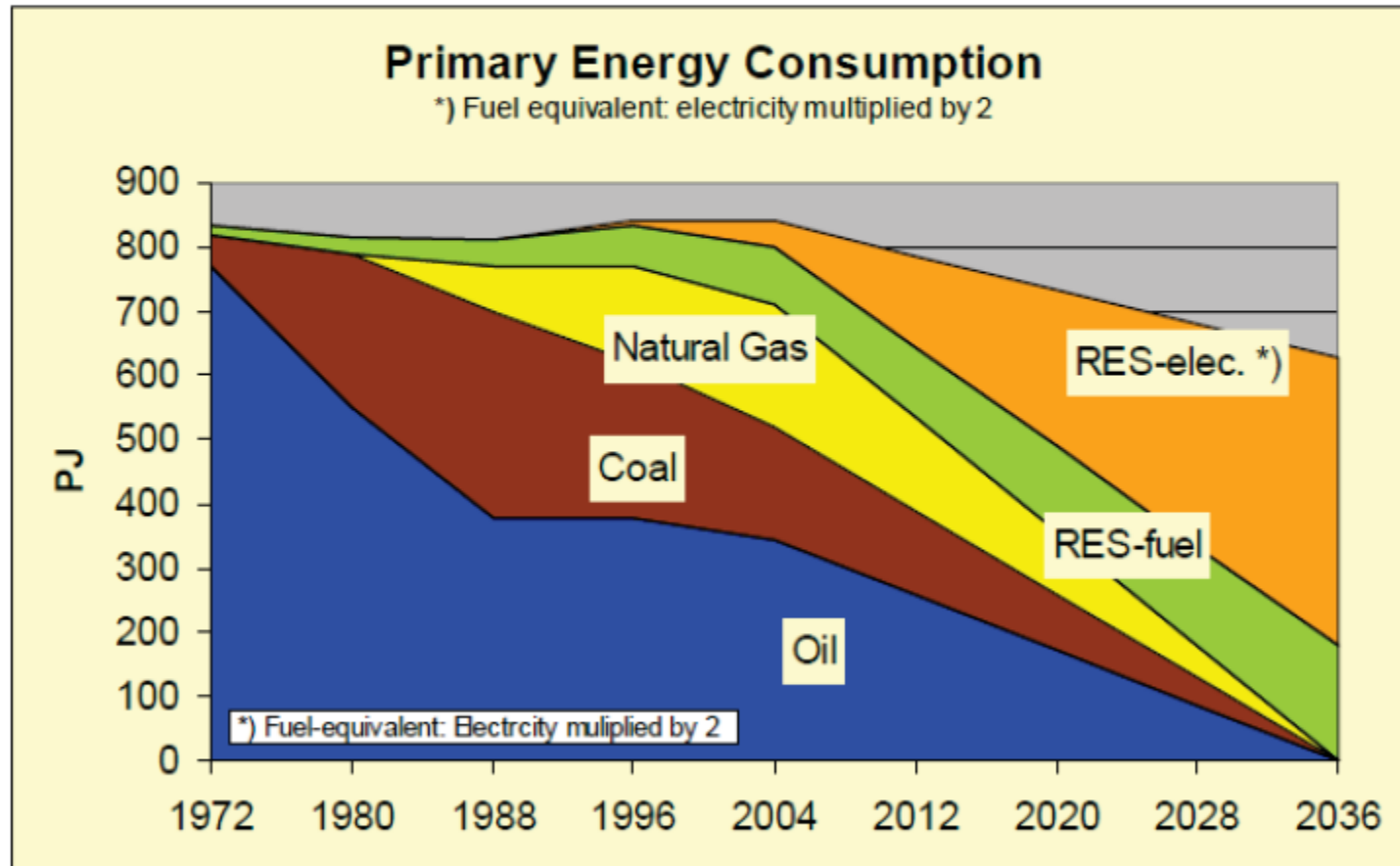


Future: A fossil fuel free energy society



Danish Energy Development

Primary energy consumption if Danish energy system is converted into 100 percent RES .



Henrik Lund, Renewable energy strategies³⁵ for sustainable development.

Wind Power to Households

One 5 MW
Wind Turbine



Average wind speed
 $v = 12$ (mile/hour)



Image
Normally, how many households can be
supported by one 5 MW wind turbine

?

(10? 50? 100? 500? 1000? 2000? 5000?)



Wind Power to Households

**One 5 MW
Wind Turbine**



**If average wind speed
 $v = 12$ (mile/hour)**



**Electricity
15,000,000 kWh/year**



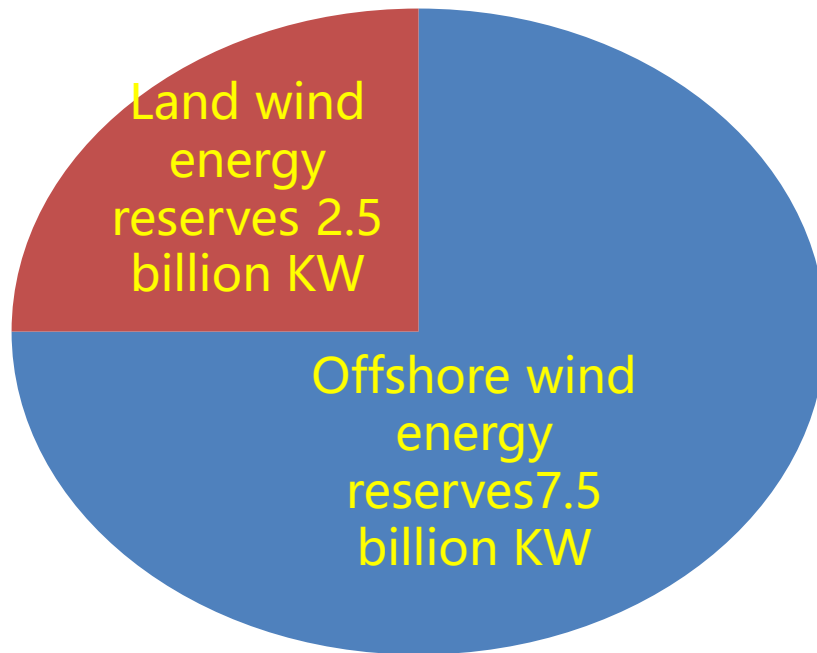
**Household
10,000 kWh/year**

1500 Households

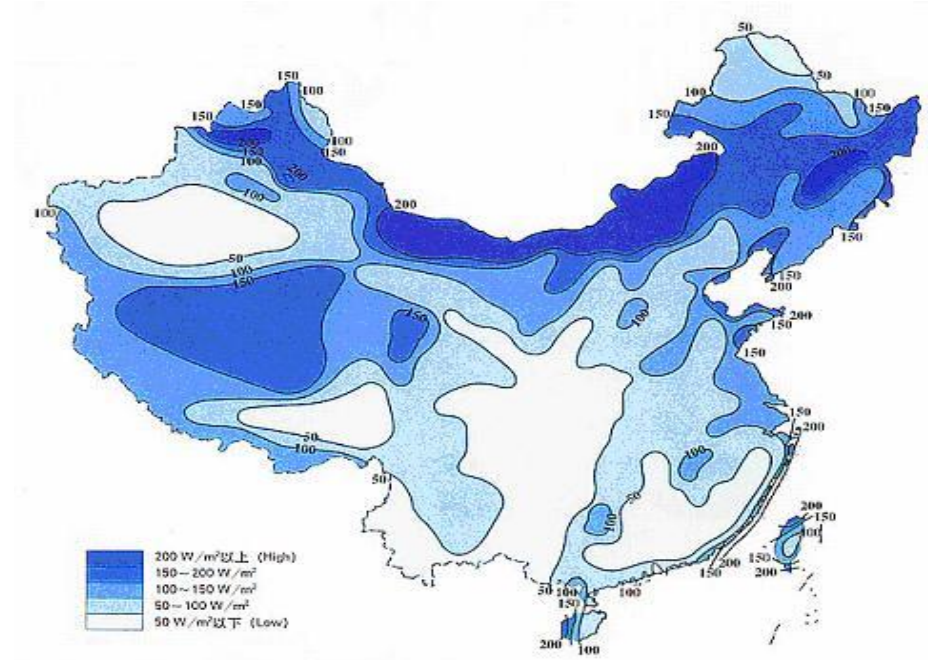


Chinese Wind Energy

- Wind Energy in China



The total amount of wind energy is **1 billion KW** available



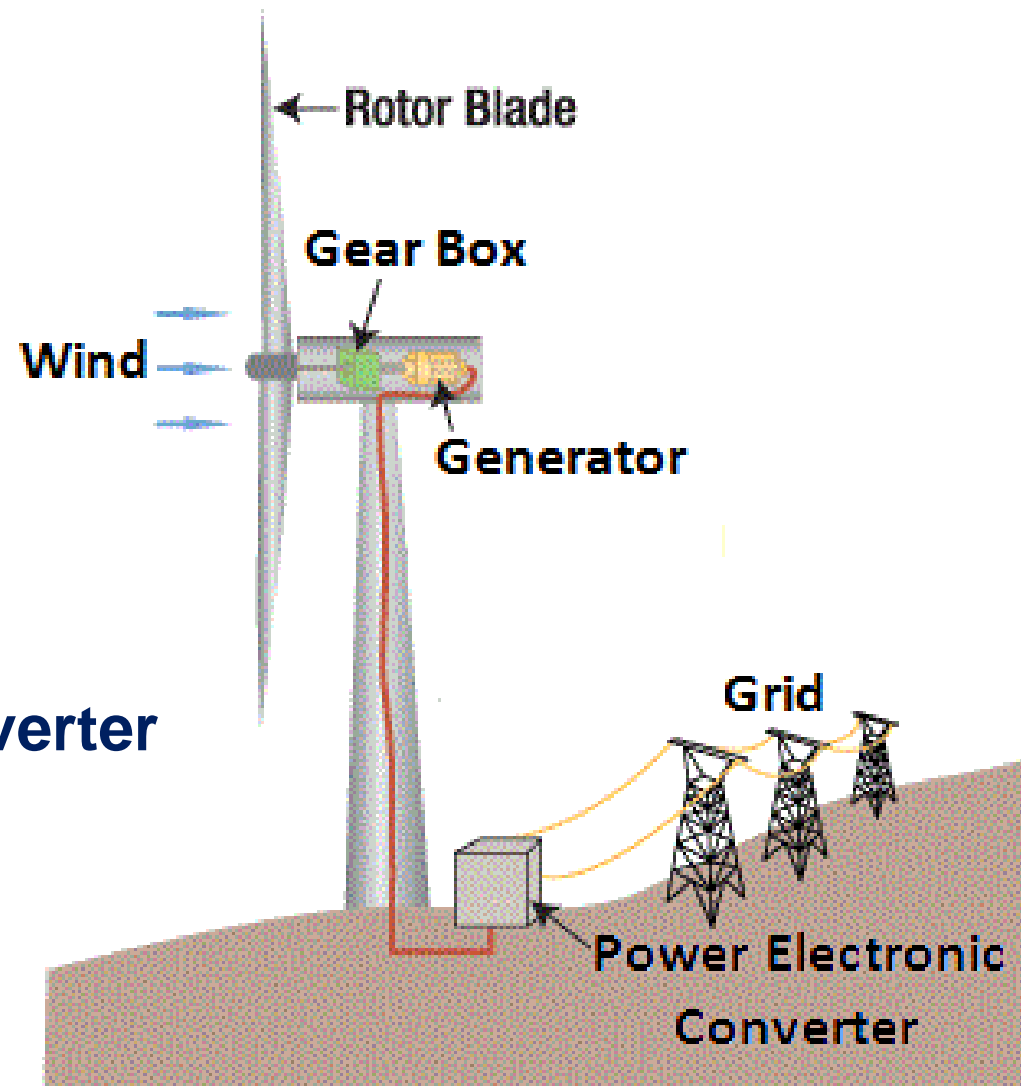
Wind energy is distributed **widely**

Overview

- Why “Renewable Energy”?
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- **Wind Turbine**
- Wind Farms
- Wind Power Transmission

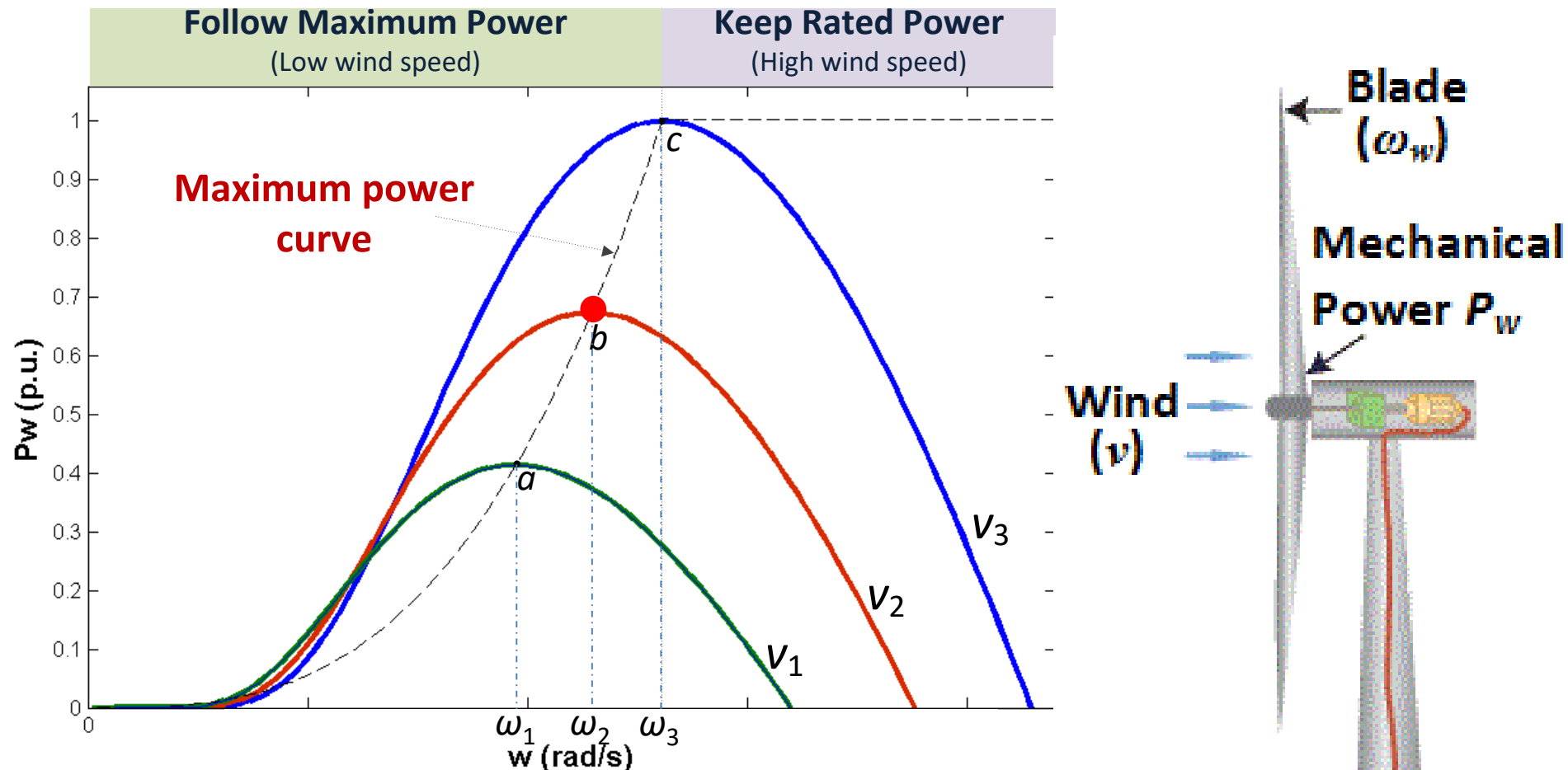
Wind Turbine

- ❑ Power capture
- ❑ Drive system
- ❑ Generator
- ❑ Power electronic converter

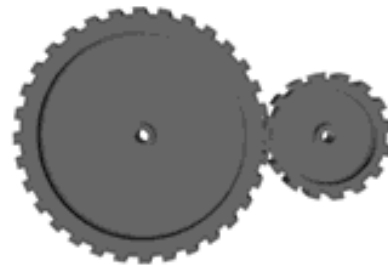
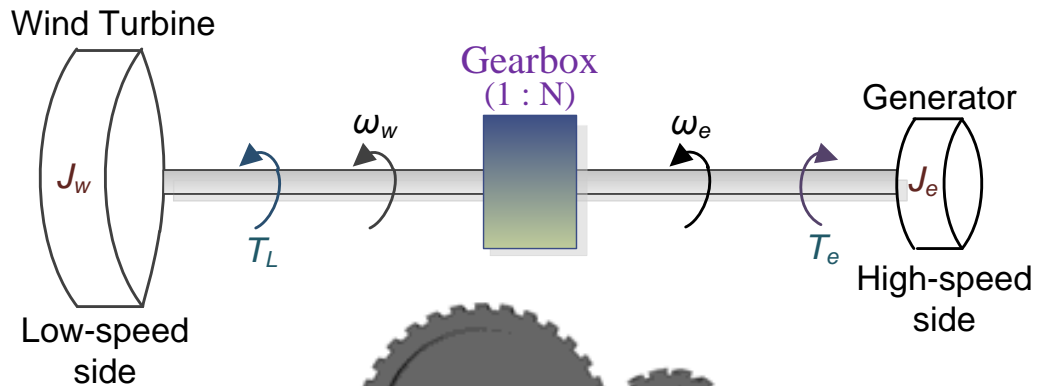


Captured Wind Turbine

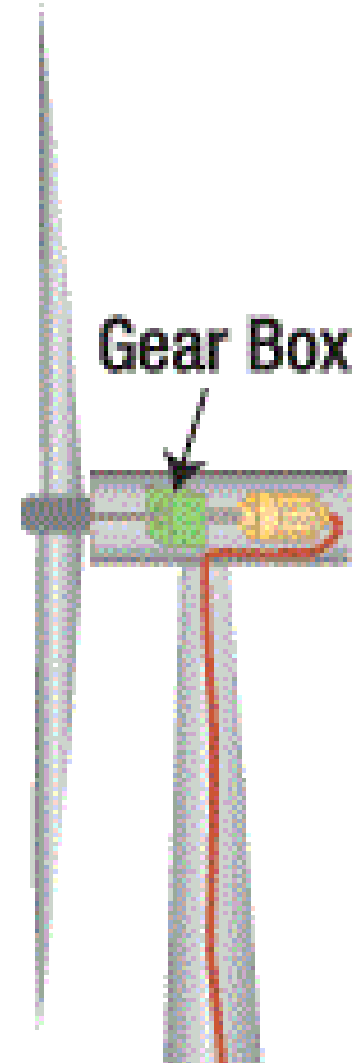
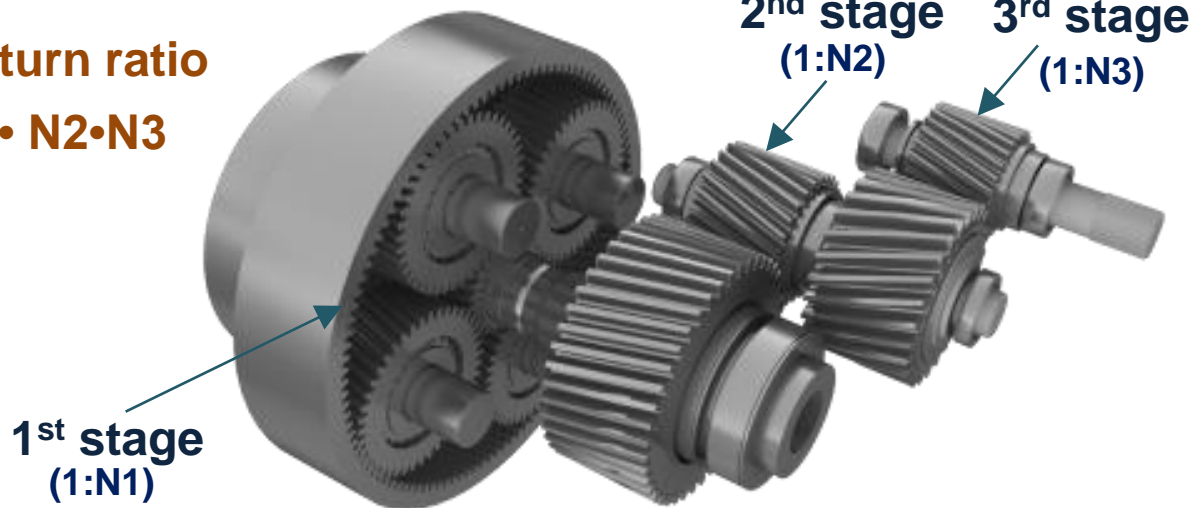
Does wind turbine with high speed ω_w lead to higher P_w ? (Yes or No)



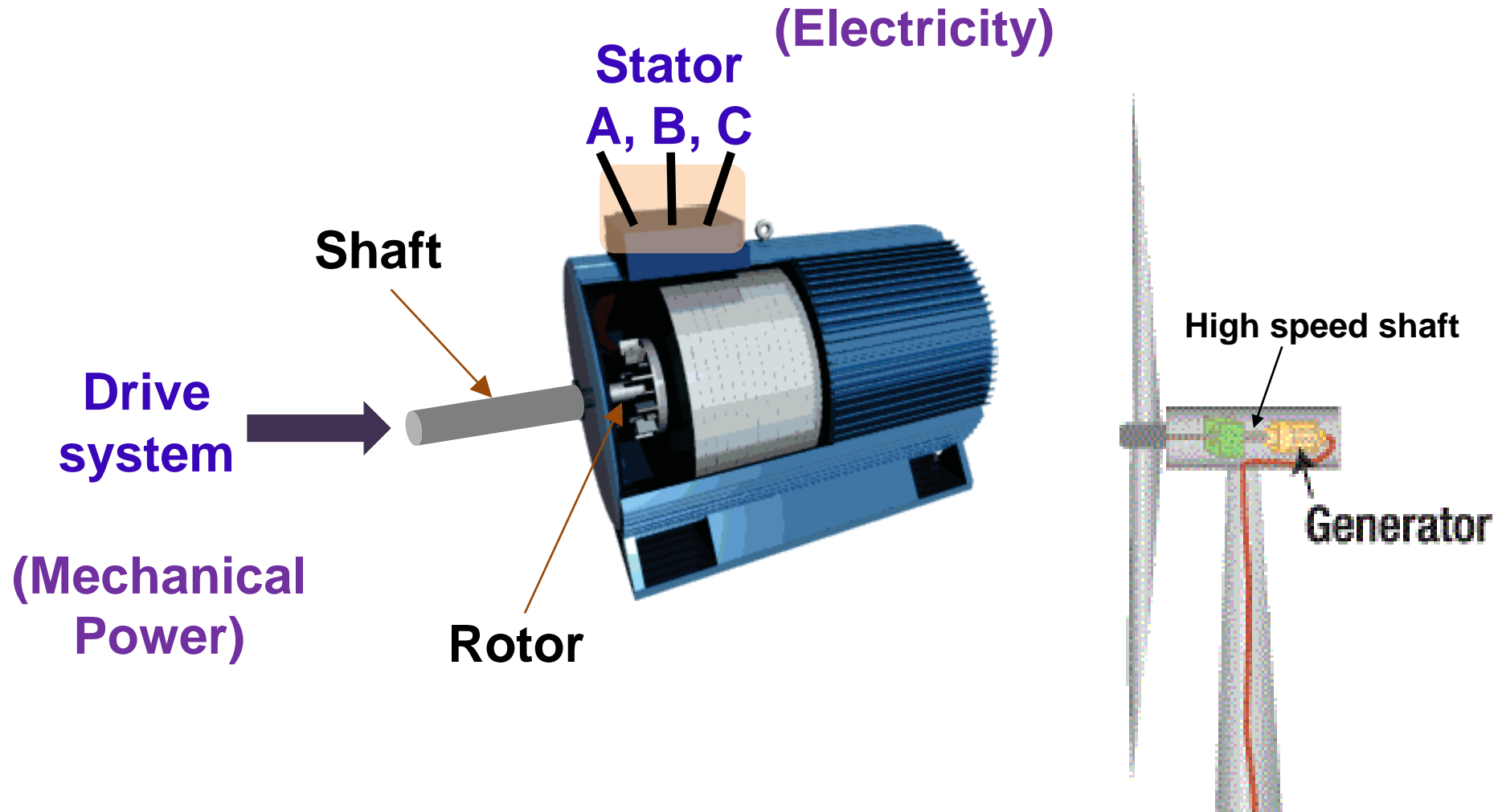
Drive System



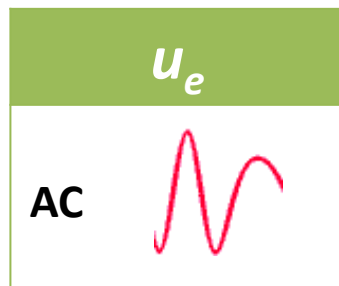
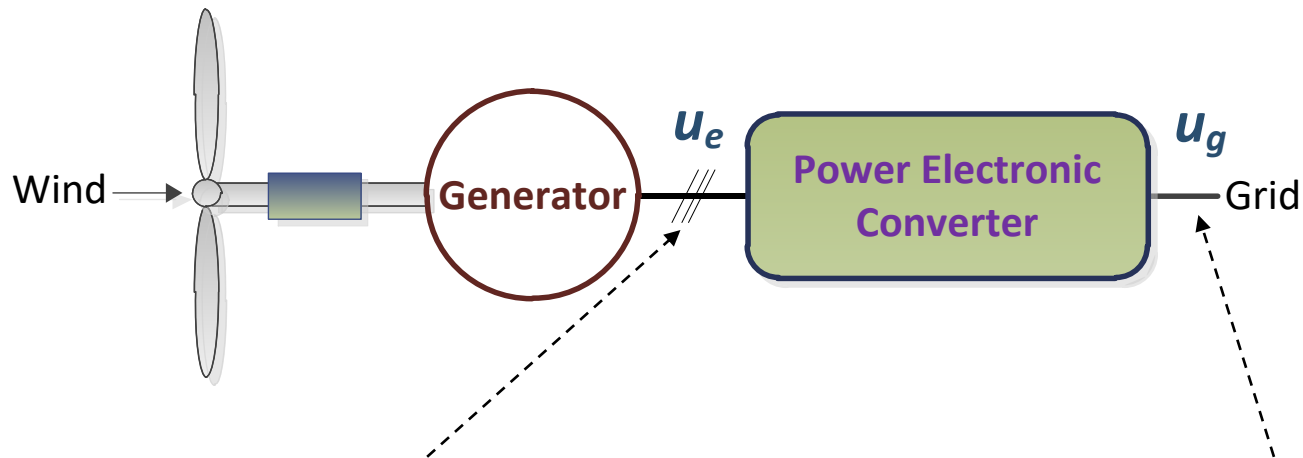
Total turn ratio
 $N = N_1 \cdot N_2 \cdot N_3$



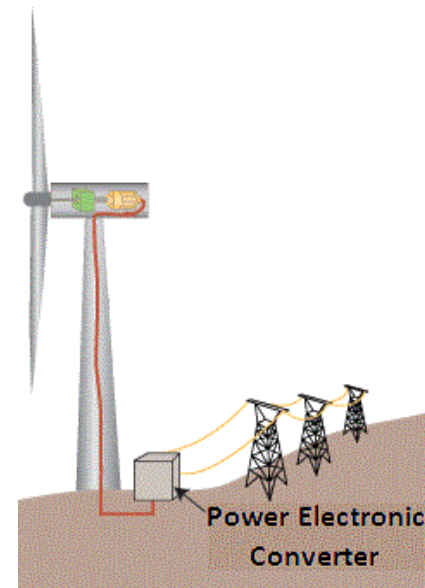
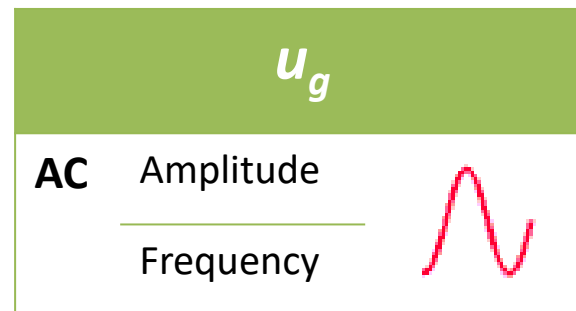
Generators



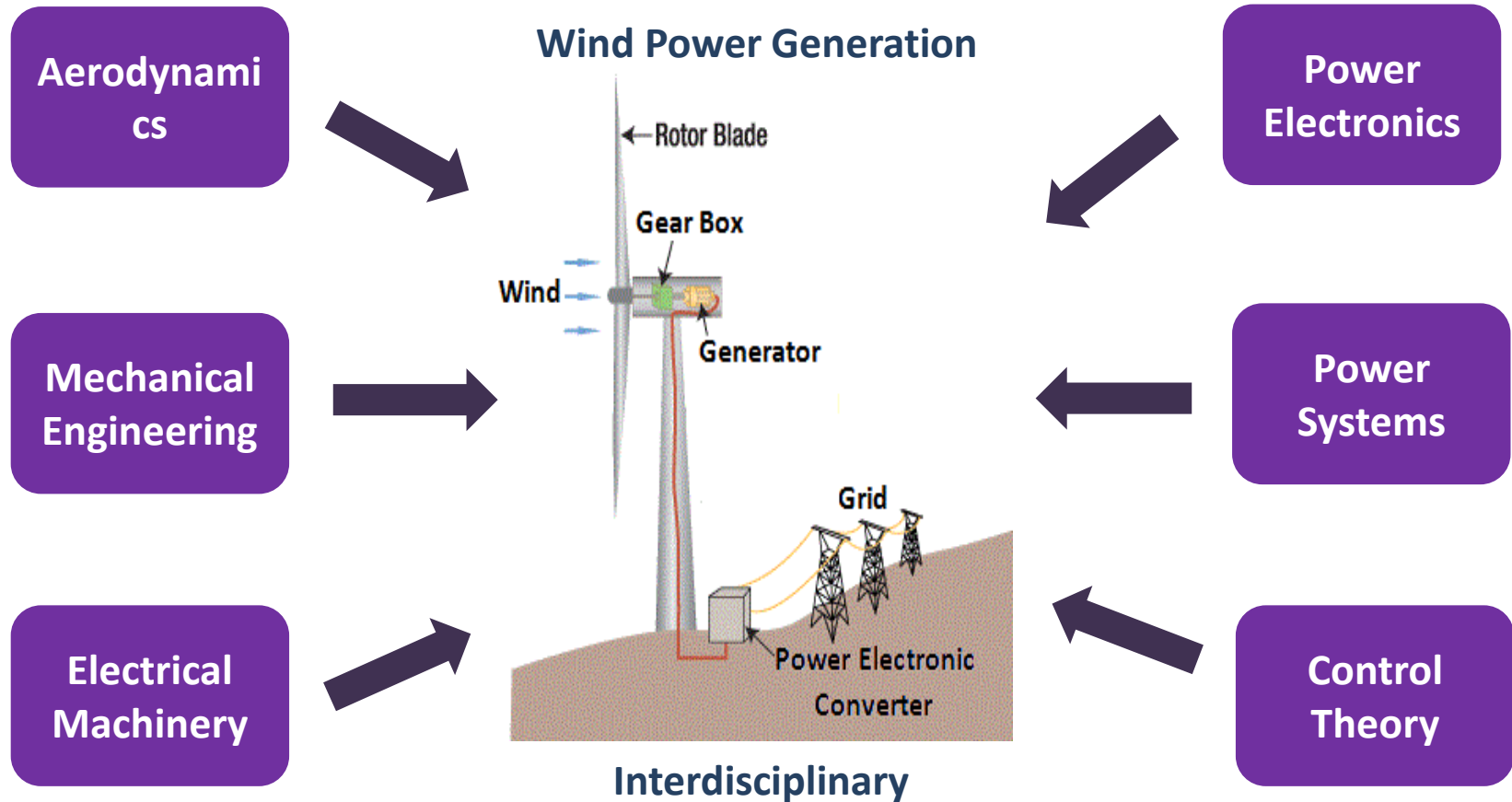
Power Electronic Converters



Power
converter



Conclusions



Overview

- Why “Renewable Energy”?
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- **Wind Farms**
- Wind Power Transmission

Wind Farm

	Offshore Wind Farm		Land Wind Farm
Wind Source	Better	>	Normal
Wind speed	Higher	>	Normal
Electricity	More	>	Normal

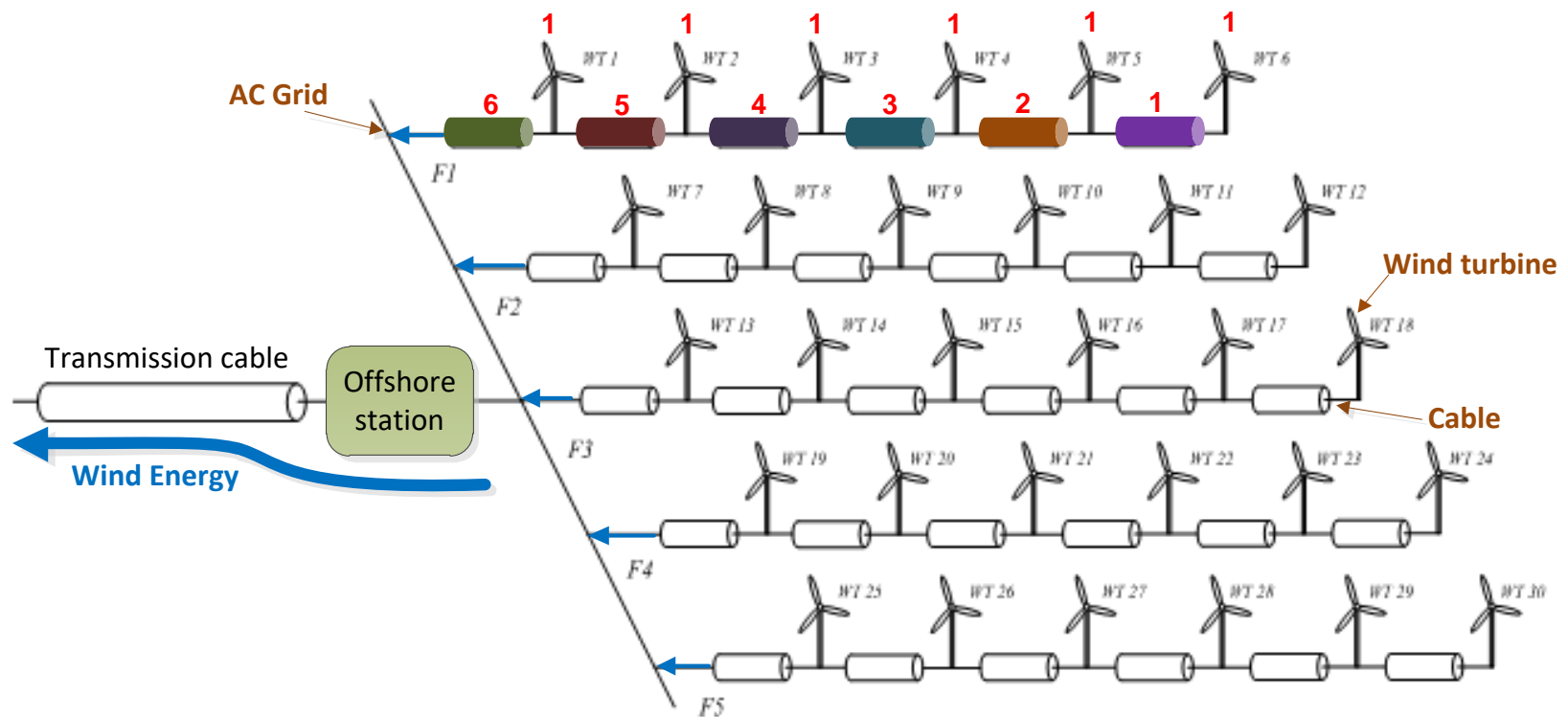


Typical Offshore Wind Farm

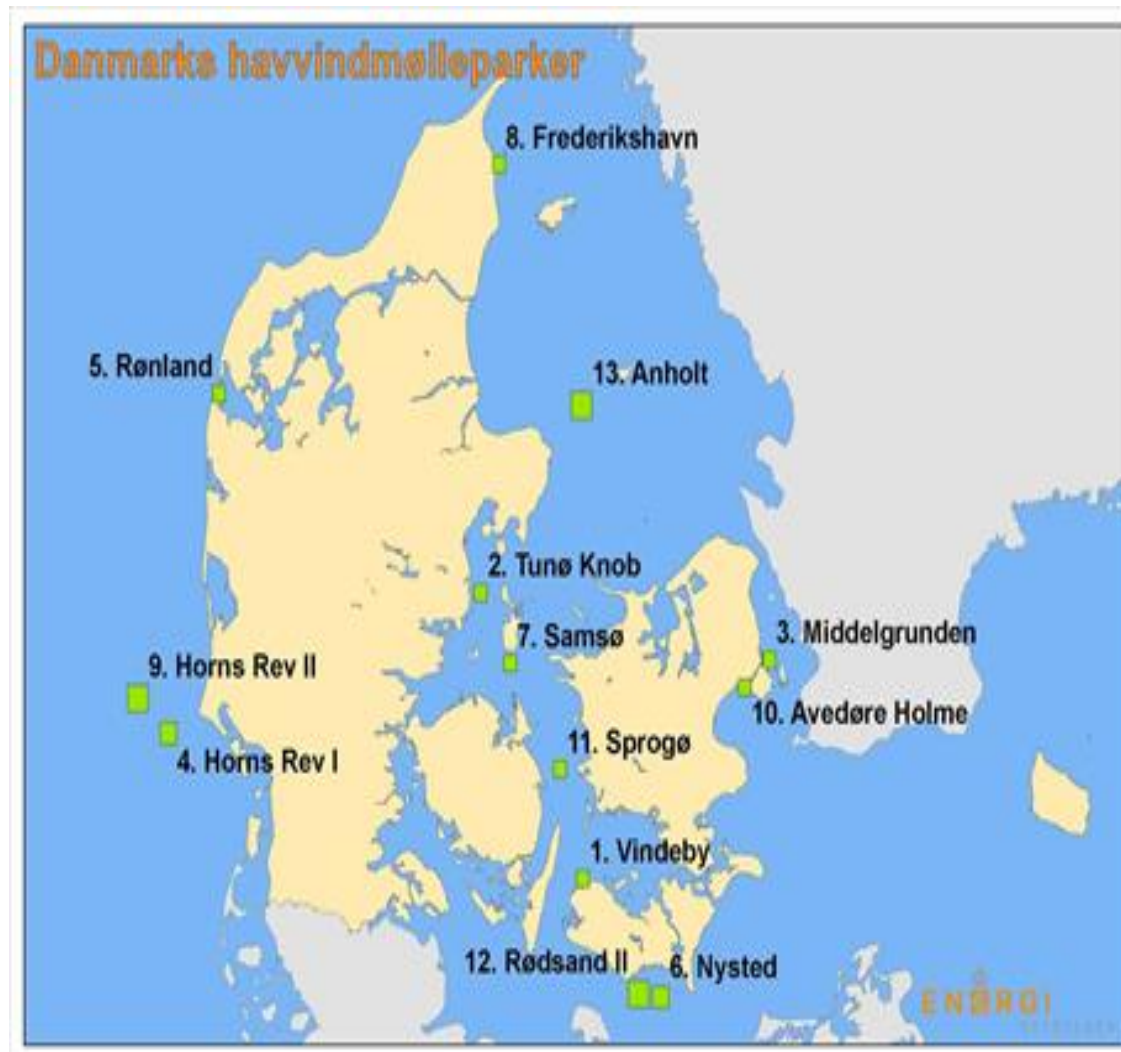
Mature AC Technology

- 33 kV collection AC voltage
- 50 Hz transformer at offshore station

Capacity of cable?



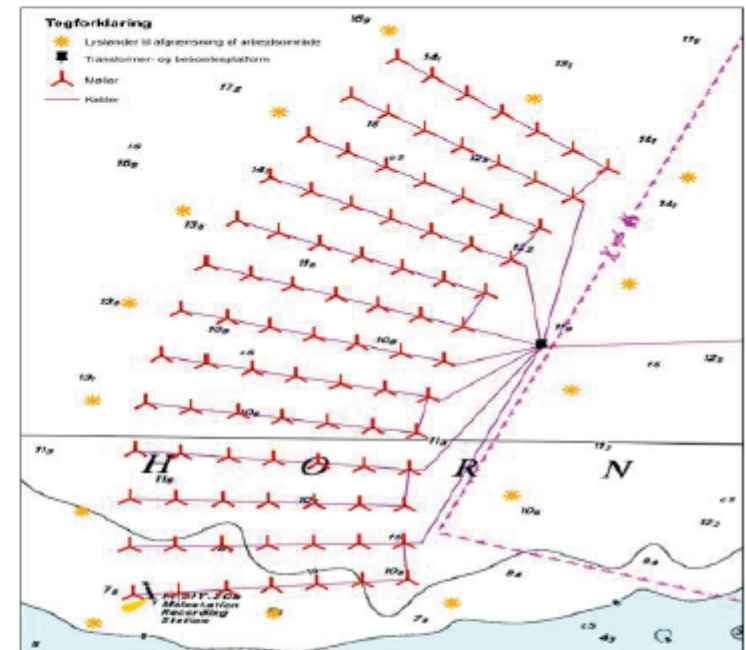
Danish Offshore Wind Farms



Developments in Wind Energy Technology

Developments –off-shore wind farms

Official Name:	Horns Rev 2
Alternative Name:	Horns Reef 2
Development Status:	Commissioned
Area of Wind Farm:	33 km ²
Number of Rows/Turbines:	13 x 7 turbines
Location:	Blåvandshuk
Region:	Esbjerg, Vestjylland
Country:	Denmark
Sea Name:	North Sea
GPS Latitude:	55.6008
GPS Longitude:	7.5825
Distance From Shore:	30 km
Water Depth:	9-17 m



Total Installed Capacity:	209.3 MW
Total Number of Turbines:	91
Annual Production:	956.03 GWh in 2012
Capacity Factor:	52.14 % in 2012

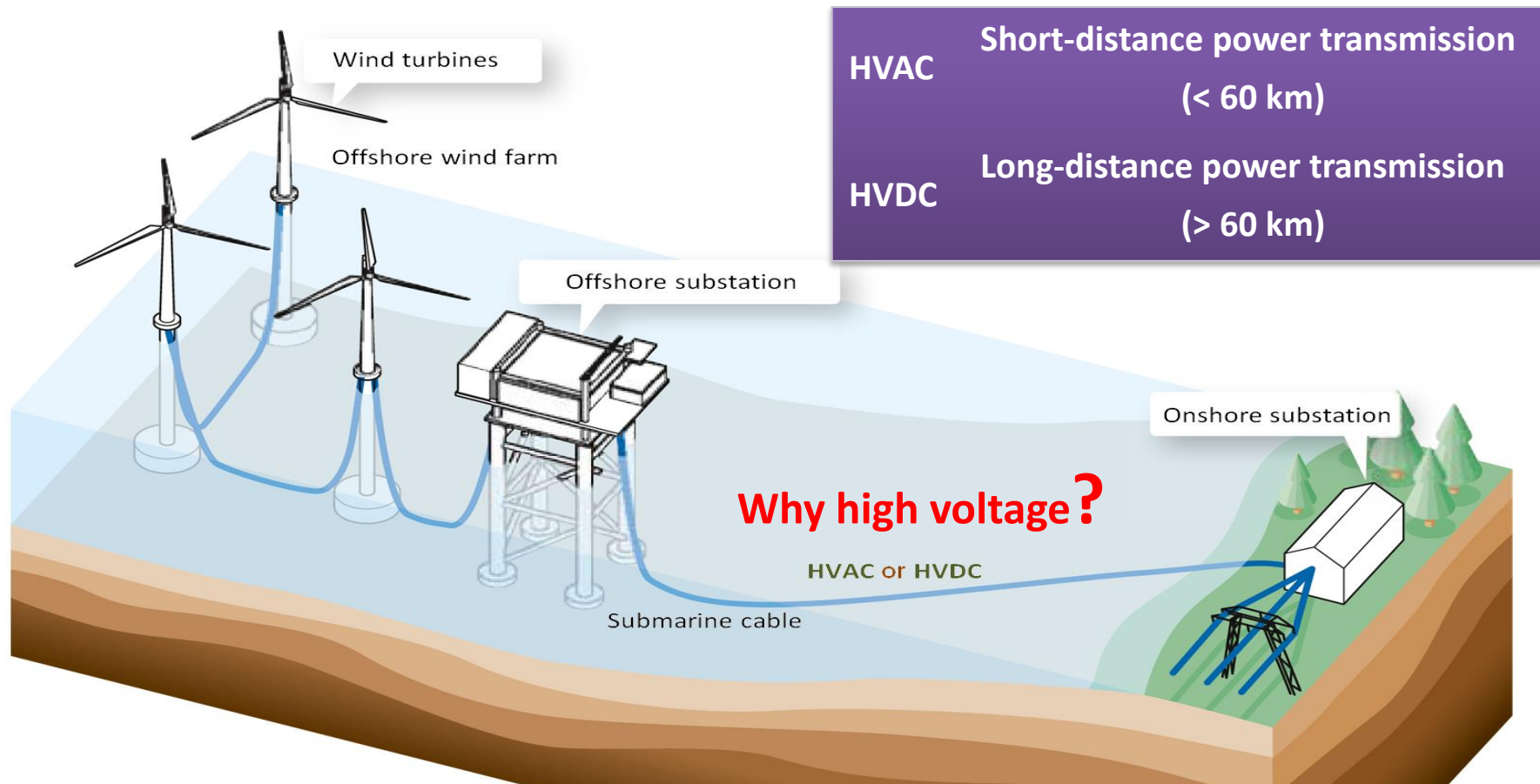


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Wind Power Transmission

- ❑ High Voltage Alternative Current (HVAC) Technology
- ❑ High Voltage Direct Current (HVDC) Technology



Thanks !