Unit 4:- Wind Energy

Syllabus…Unit 4

- **Wind Energy:** Wind characteristics, resource assessment, horizontal and vertical axis wind turbines, electricity generation and water pumping, Micro/Mini hydro power system, water pumping and conversion to electricity, hydraulic pump.

Books …

- Gilbert M. Masters, *Renewable and Efficient Electrical Power Systems*, Wiley - IEEE

Press, August 2004.

- Godfrey Boyle, *Renewable Energy*, Third edition, Oxford University Press, 2012.
- Chetan Singh Solanki, *Solar Photovoltaics-Fundamentals, Technologies and Applications*, PHI Third Edition, 2015.

Supplementary Reading:

- D.P.Kothari, K.C.Singal, Rakesh Rajan, *Renewable Energy Sources and Emerging Technologies*, PHI Second Edition, 2011.

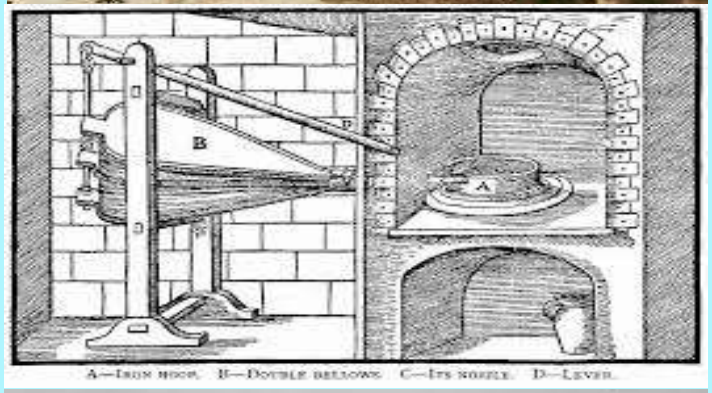
Lecture 1

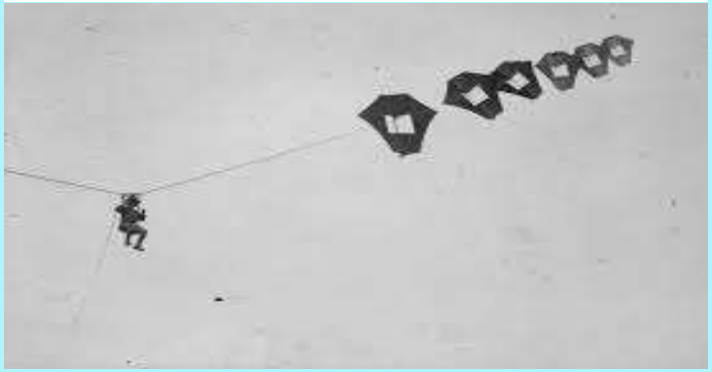
- Wind Energy Sailing
- Wind Energy Furnace, Bellows & Kites
- Wind Energy Windmills
- Wind Turbine History
- Wind Energy History
- Wind Electricity History
- Brief History
- Wind Energy Time Line
- Brief History to Modern Era
- OPEC Crises 1970-1973
- Modern Era
- Wind Energy Statistics as per IRENA(2019)

Wind Energy Sailing

- As early as about 4000 B.C., the ancient Chinese were the first to attach sails to their primitive rafts
- Approximately at 3400 BC, the ancient Egyptians launched their first sailing vessels initially to sail on the Nile River, and later along the coasts of the Mediterranean
- Around 1250 BC, Egyptians built fairly sophisticated ships to sail on the Red Sea
- The wind-powered ships had dominated water transport for a long time until the invention of steam engines in the 19th century

Wind Energy Furnace, Bellows & Kites





- About 300 BC, ancient Sinhalese had taken advantage of the strong monsoon winds to provide furnaces with sufficient air for raising the temperatures inside furnaces in excess of 1100°C in iron smelting processes. This technique was capable of producing high-carbon steel
- The double acting piston bellows was invented in China and was widely used in metallurgy in the fourth century BC
- Kites were invented in China as early as the fifth or fourth centuries BC

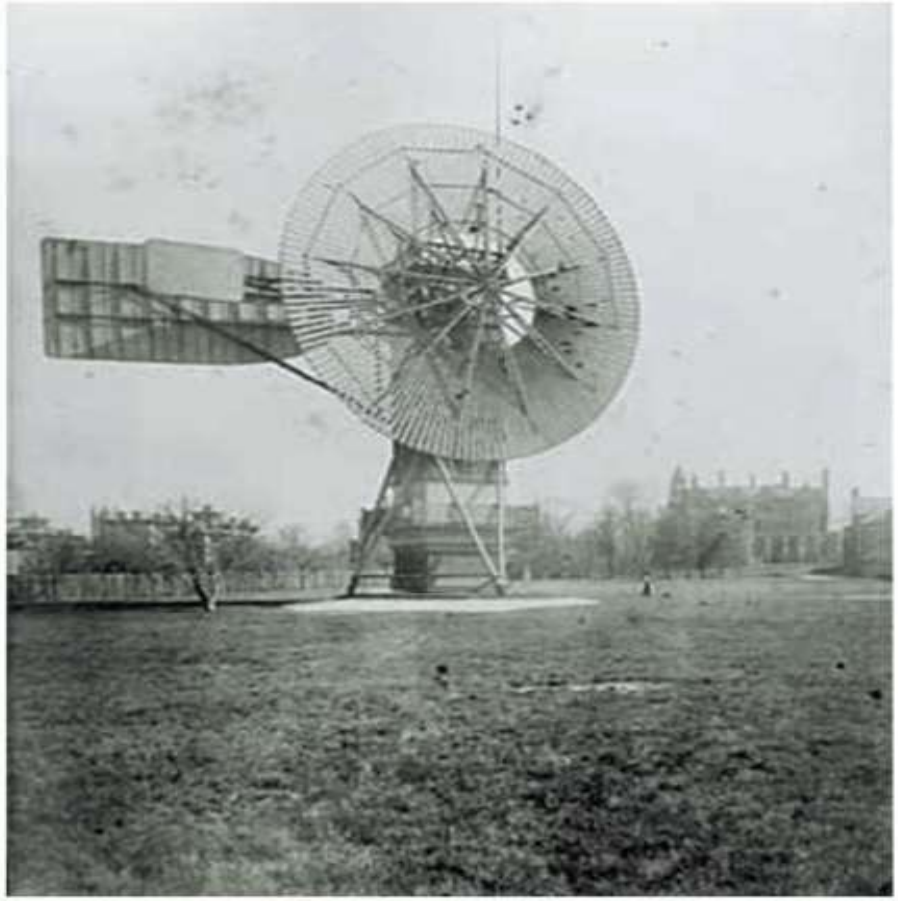
Wind Energy Windmills

- China has long history of using windmills. The unearthed mural paintings from the tombs of the late Eastern Han Dynasty (25–220 AD) at Sandaohao, Liaoyang City, have shown the exquisite images of windmills, evidencing the use of windmills in China for at least approximately 1800 years
- The practical vertical axis windmills were built in Sistan (Eastern Persia) for grain grinding and water pumping, as recorded by a Persian geographer in the ninth century

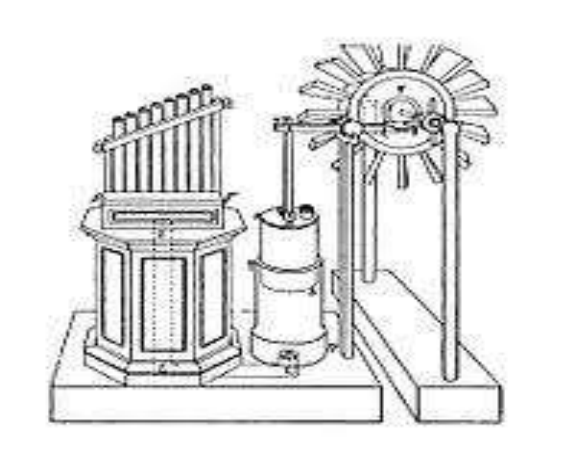
Practical Vertical Axis Windmills Were Built In Sistan (Eastern Persia)

Wind Turbine History

Charles Brush
(1887-1888, Cleveland, Ohio)
1st Automatically Operating
Wind Turbine Generator
12kW, 17m Rotor Diameter
Ran for 20 Years To Charge
Batteries in Mansion Cellar
www.windpower.org/en/pictures/brush.htm



Wind Energy History



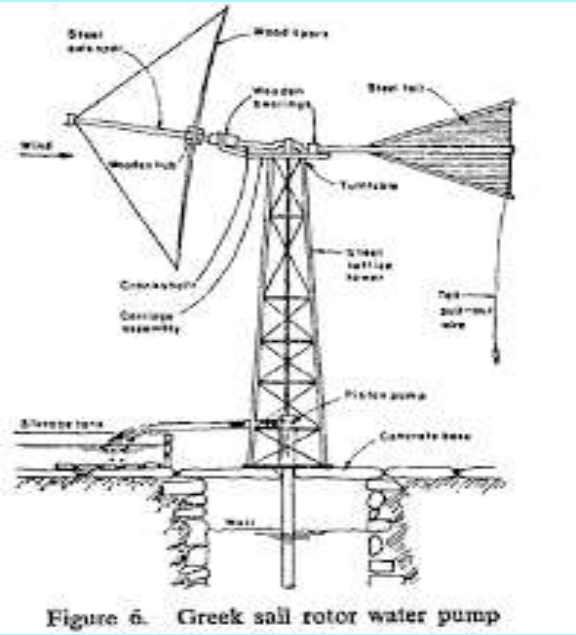


Figure 6. Greek sail rotor water pump

- In 1st Century A.D. Hero of Alexandria created wind driven wheel
- In 7th to 9th century wind mills were used in Sistan Region of Iran

- In 1000 A.D. wind mills were used for pumping sea water to make salt in China and Sicily.
- In 1180 vertical wind mills were used in Europe for grinding flour.
- **1st Known wind turbine was built in 1887in Scotland by Prof. James Blyth for charge accumulators to power lighting**

Wind Electricity History

- In 1st electricity generating turbine in 1891.
- In 1st electricity power plant in 1895 at village Askov.
- 2500 windmills with combined 30MW used for grinding in 1900.
- 1st MW size single wind turbine was connected to local grid in 1941 blade size was 76 feet
- Now over 7000 wind turbines produces 6.5GW
- Expected 20 GW in 2020…

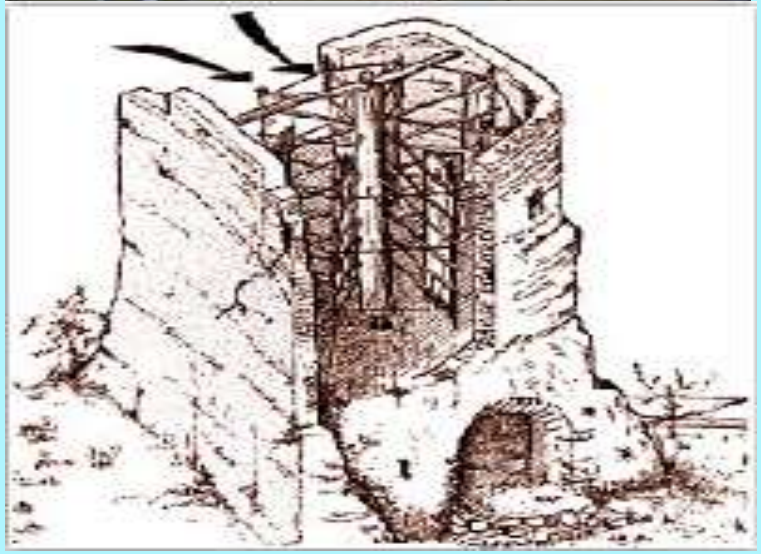
Brief History

1888: Charles Brush builds first large-size wind electricity generation turbine (17 m diameter wind rose configuration, 12 kW generator)

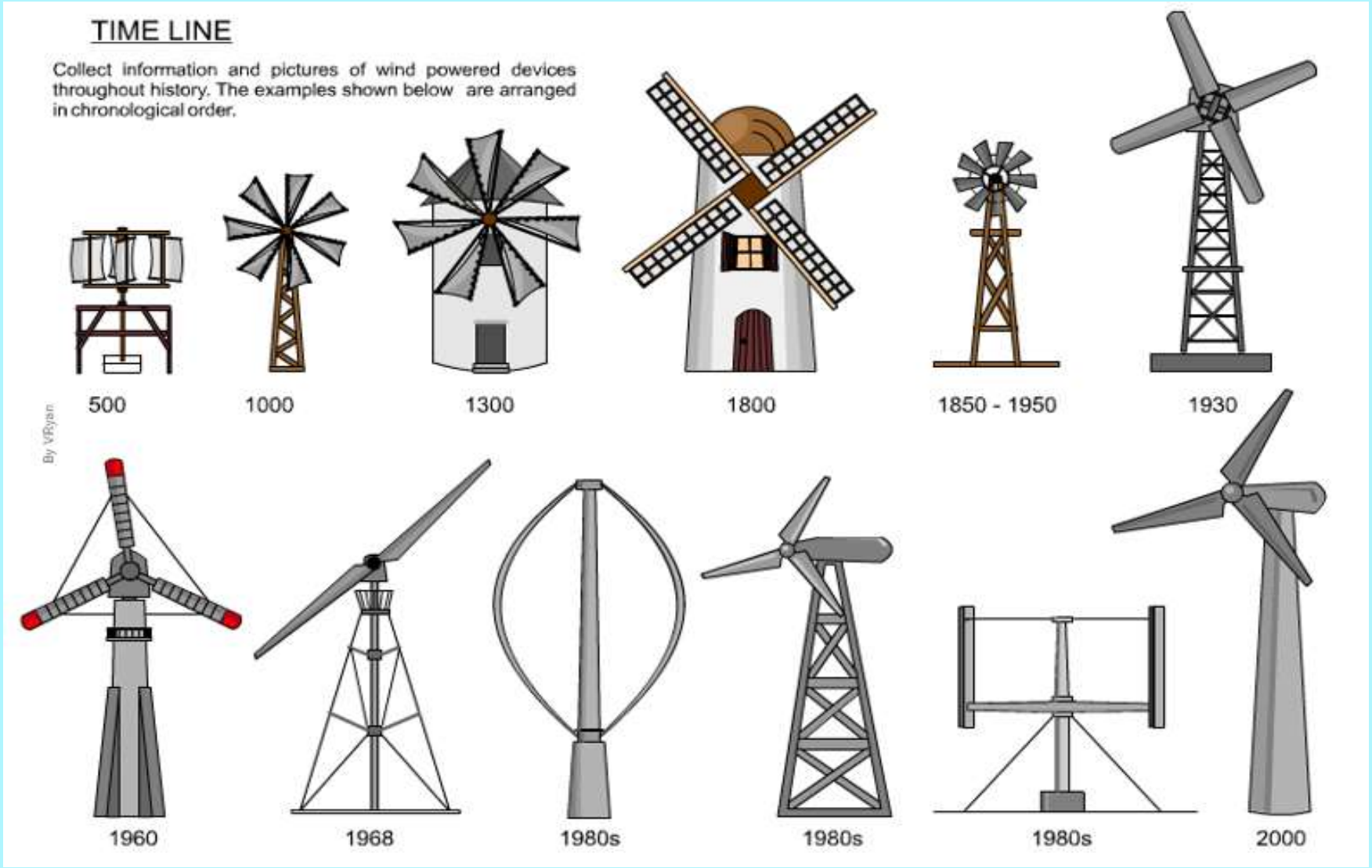
1890s: Lewis Electric Company of New York sells generators to retro-fit onto existing wind mills

1920s-1950s: Propeller-type 2 & 3-blade horizontal-axis **wind electricity conversion systems** (WECS)

1940s – 1960s: Rural Electrification in US and Europe leads to decline in WECS use



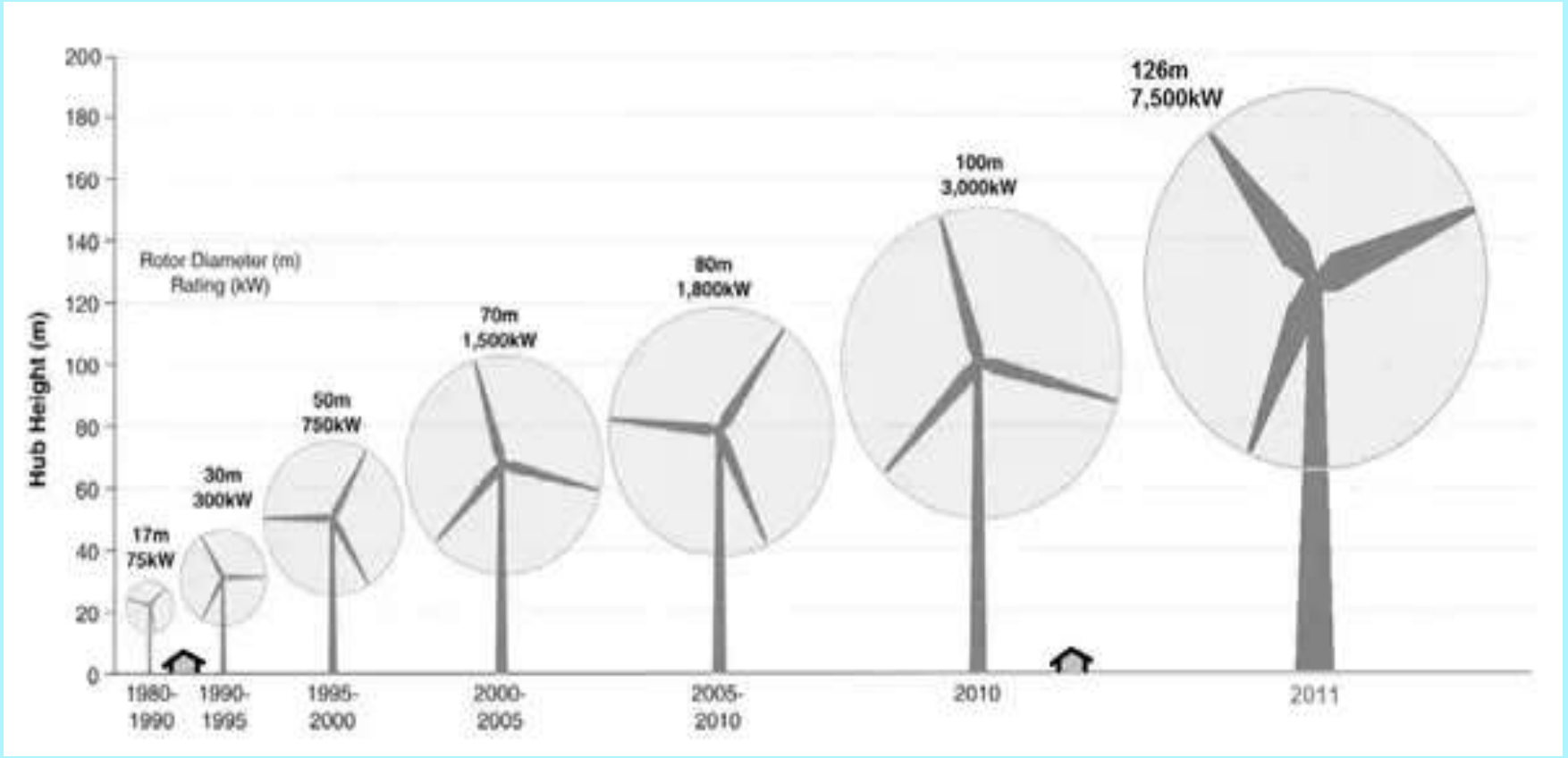
Wind Energy Time Line



Brief History to Modern Era

Key attributes of this period:

- Scale increase
- Commercialization
- Competitiveness
- Grid integration



Brief History to Modern Era

Catalyst for progress of wind energy: OPEC Crisis (1970s)

- Economics
- Energy independence
- Environmental benefits

OPEC Crises 1970-1973

1970 Oil Crisis

From 1970 the Organization of Oil Exporting Countries (OPEC) had steadily been expanding its share in the market, by 1973 OPEC was supplying 56% of the world's oil, up from 47% in 1965

1973 Oil Crisis...

Began on 17th October, 1973 when OPEC announced that they would not ship oil to US, European & Dutch Nations.

Netherlands supplied arms & Americans used Dutch airfields to supply guns.

The Arab oil embargo.

Price increase to reduce demand to the new lower level of supply.

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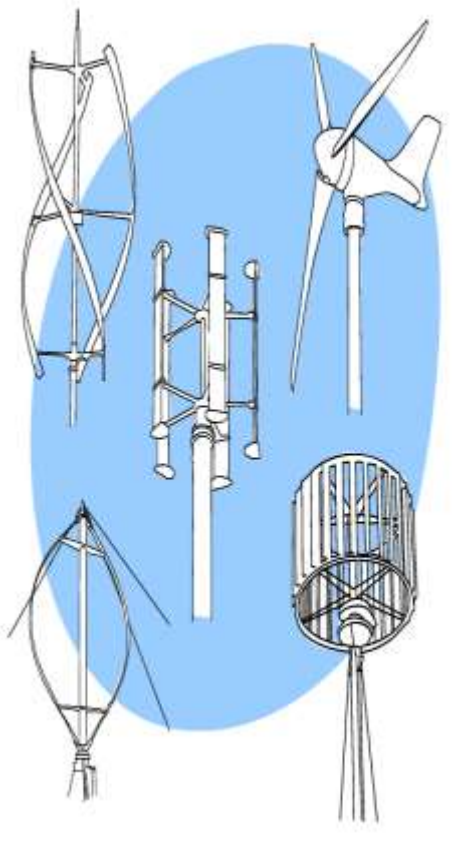
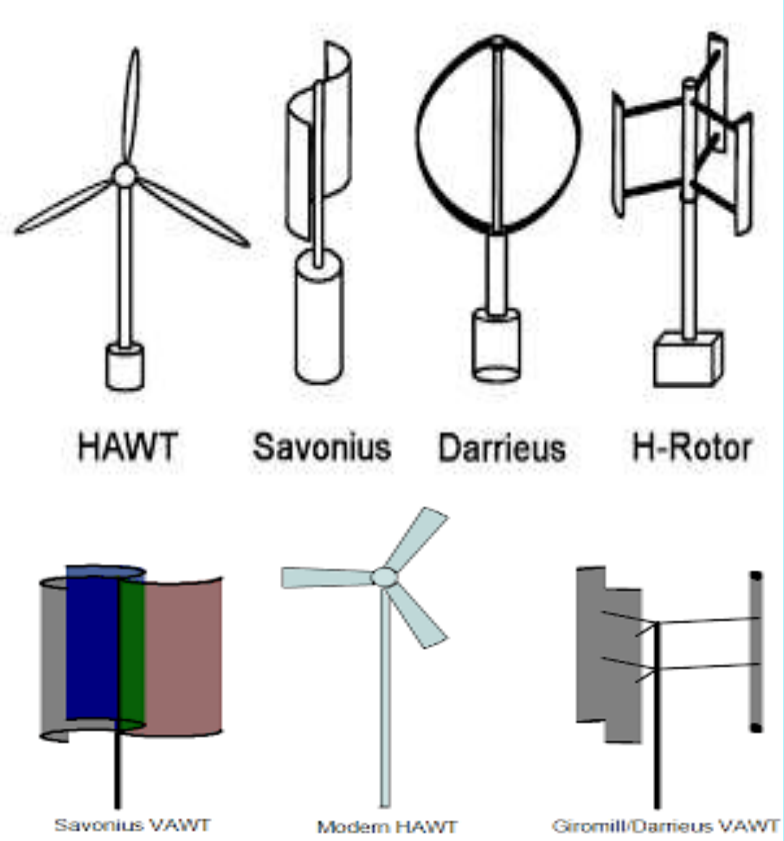
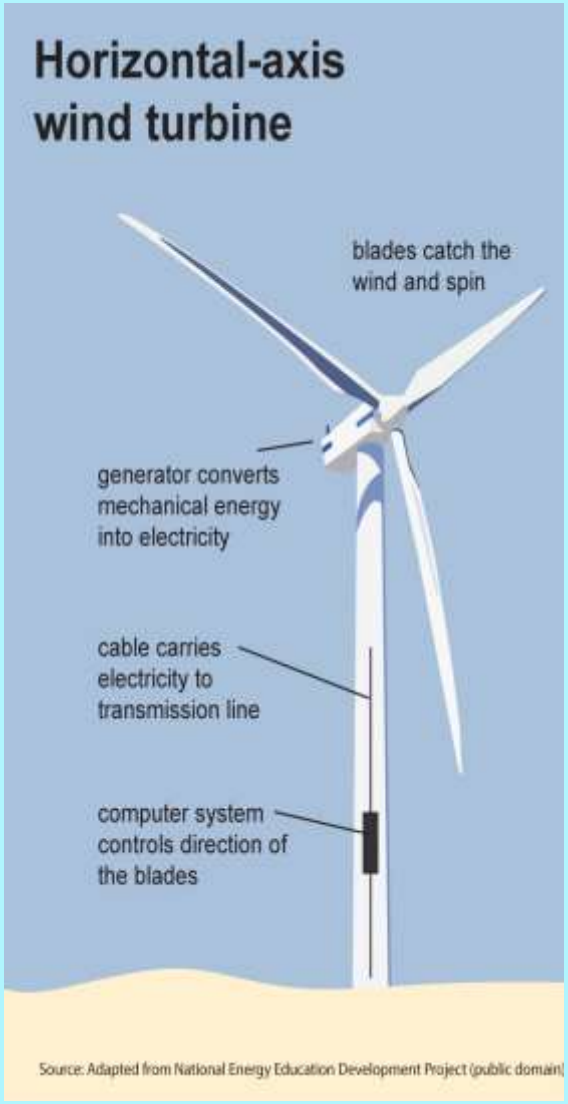
Modern Era

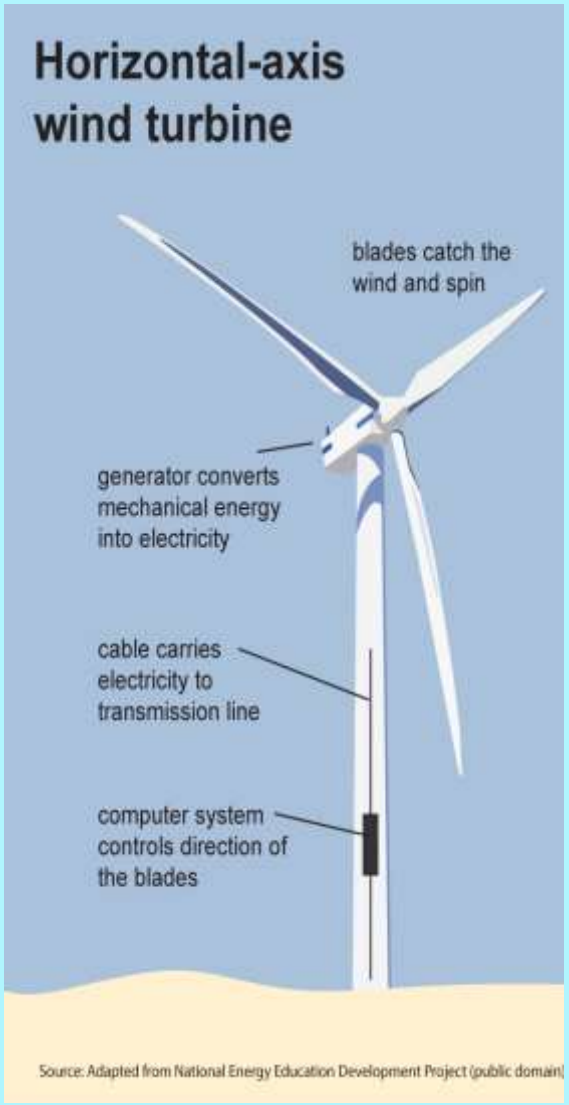
Turbine Standardization:
3-blade Upwind
Horizontal-Axis







Wind Energy Statistics as per IRENA(2019)



IRENA (International Renewable Energy Agency)

Decarbonisation Of The Energy Sector And The Reduction Of Carbon Emissions To Limit Climate Change Is At The Heart Of The International Renewable Energy Agency (Irena)'s Energy Transformation Roadmaps.

This Report Outlines The Role Of Wind Power In The Transformation Of The Global Energy System Based On Irena's Climate-resilient Pathway (Remap Case),

Wind Energy Statistics as per IRENA(2019)

IRENA Key Findings

- Deployment of wind power when coupled with deep electrification would contribute to more than one quarter of the total emissions reductions needed (nearly 6.3 Giga tonnes of carbon dioxide (Gt CO_2) annually) in 2050.
- Global cumulative installed capacity of *Onshore* wind power by 2030 to 1 787 GW and by 2050 to 5 044 GW compared to installed capacity in 2018 to 542 GW
- For offshore wind power, the global cumulative installed capacity would increase almost ten-fold by 2030 to 228 GW and substantially towards 2050, with total offshore installation nearing 1 000 GW by 2050

Wind Energy Statistics as per IRENA(2019)

IRENA Key Findings

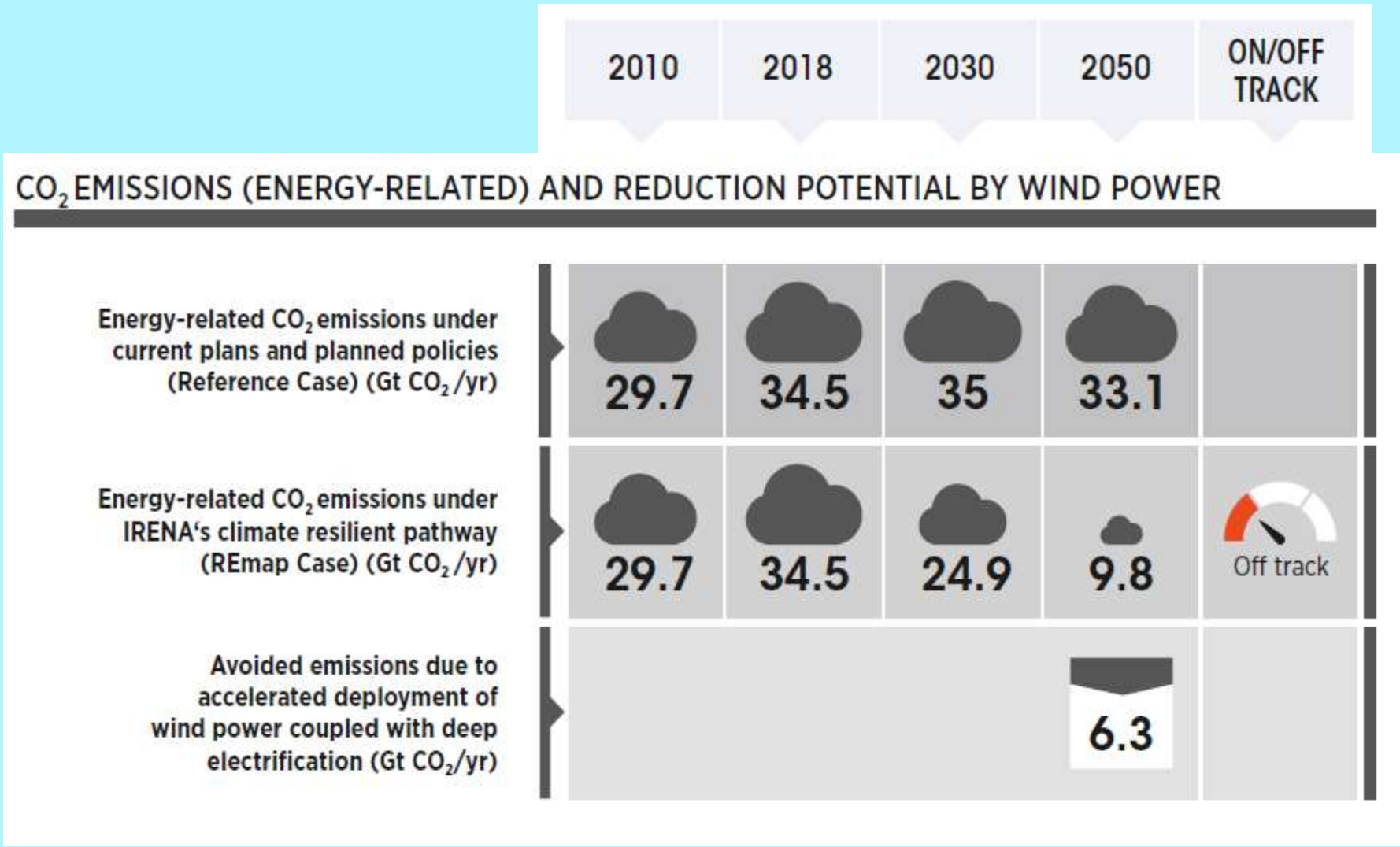
- Asia (mostly China) would continue to dominate the onshore wind power industry, with more than 50% of global installations by 2050, followed by North America (23%) and Europe (10%)
- For offshore wind, Asia would take the lead in the coming decades with more than 60% of global installations by 2050, followed by Europe (22%) and North America (16%).
- Increase in wind turbine size for onshore applications is set to continue, from an average of 2.6 megawatts (MW) in 2018 to 4 to 5 MW for turbines commissioned by 2025
- Offshore applications, the largest turbine size of around 9.5 MW to day will become 12 MW in 2025 and Research and development will likely lead to a potential to increase this to 15 to 20 MW in a decade or two.

Wind Energy Statistics as per IRENA(2019)

IRENA Key Findings

- improved wind turbine technologies, deployment of higher hub heights and longer blades with larger swept areas leads to increased capacity factors for a given wind resource.
- For onshore wind plants, global weighted average capacity factors would increase from 34% in 2018 to a range of 30% to 55% in 2030 and 32% to 58% in 2050. For offshore wind farms, even higher progress would be achieved, with capacity factors in the range of 36% to 58% in 2030 and 43% to 60% in 2050, compared to an average of 43% in 2018.

Wind Energy Statistics as per IRENA(2019)



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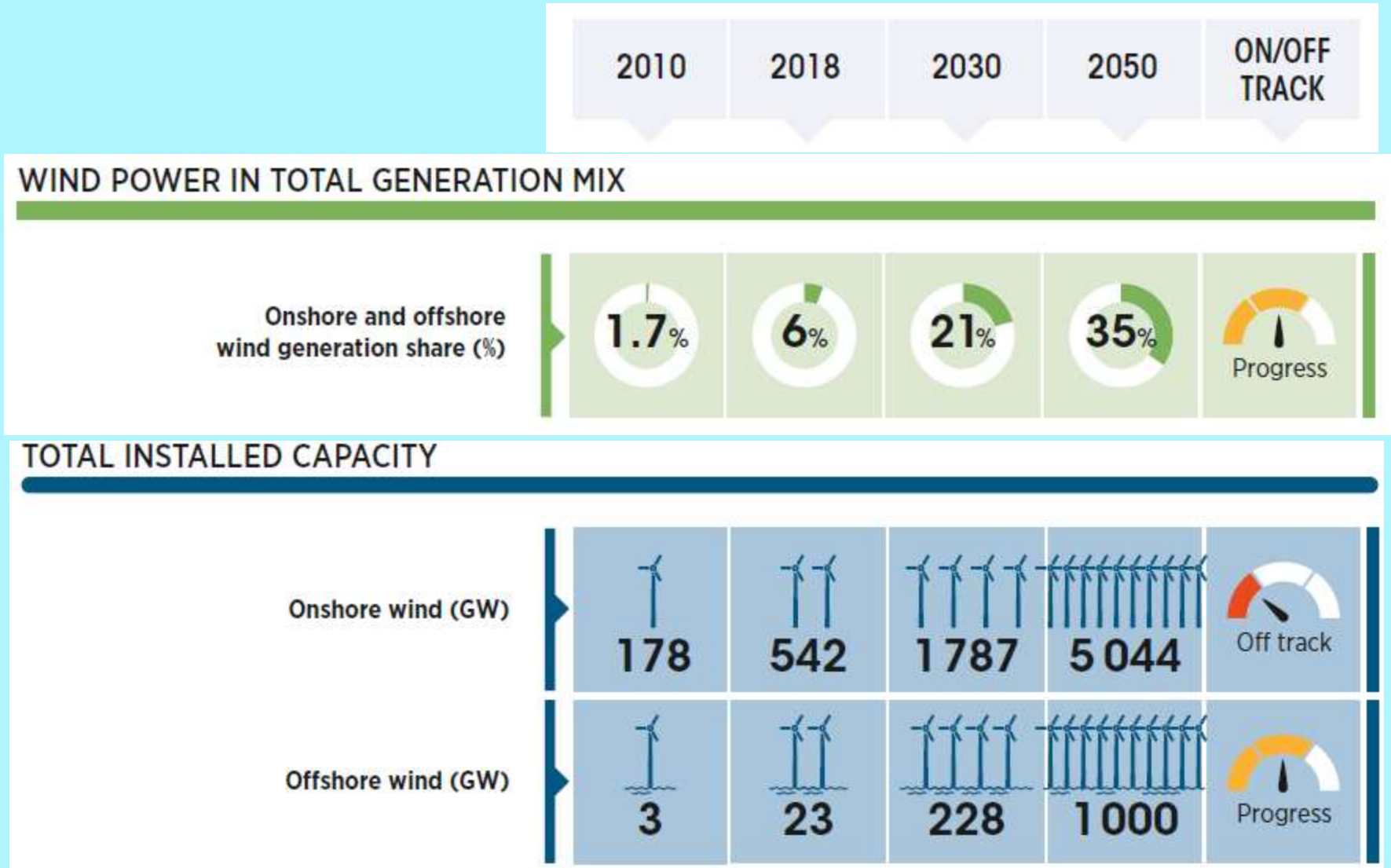

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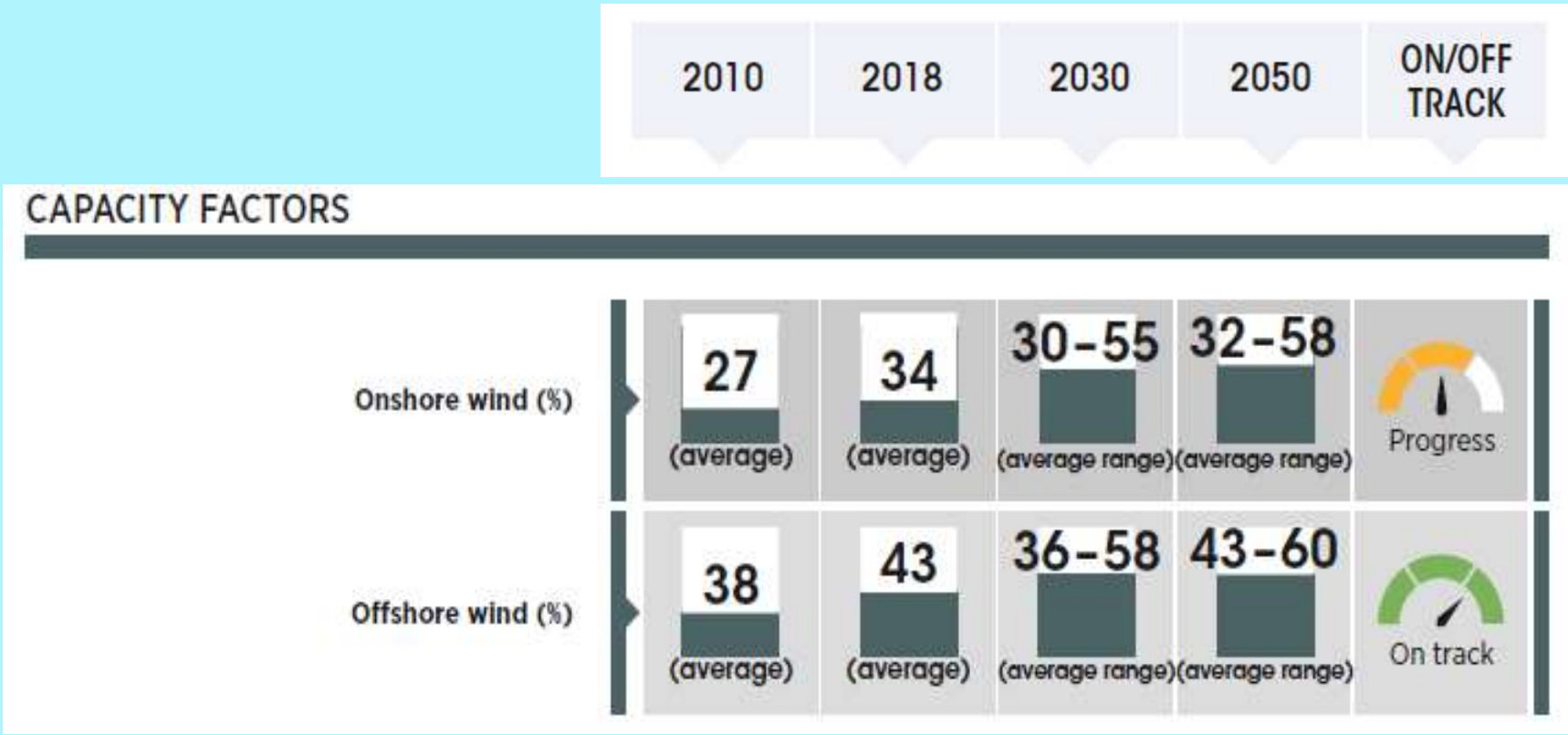

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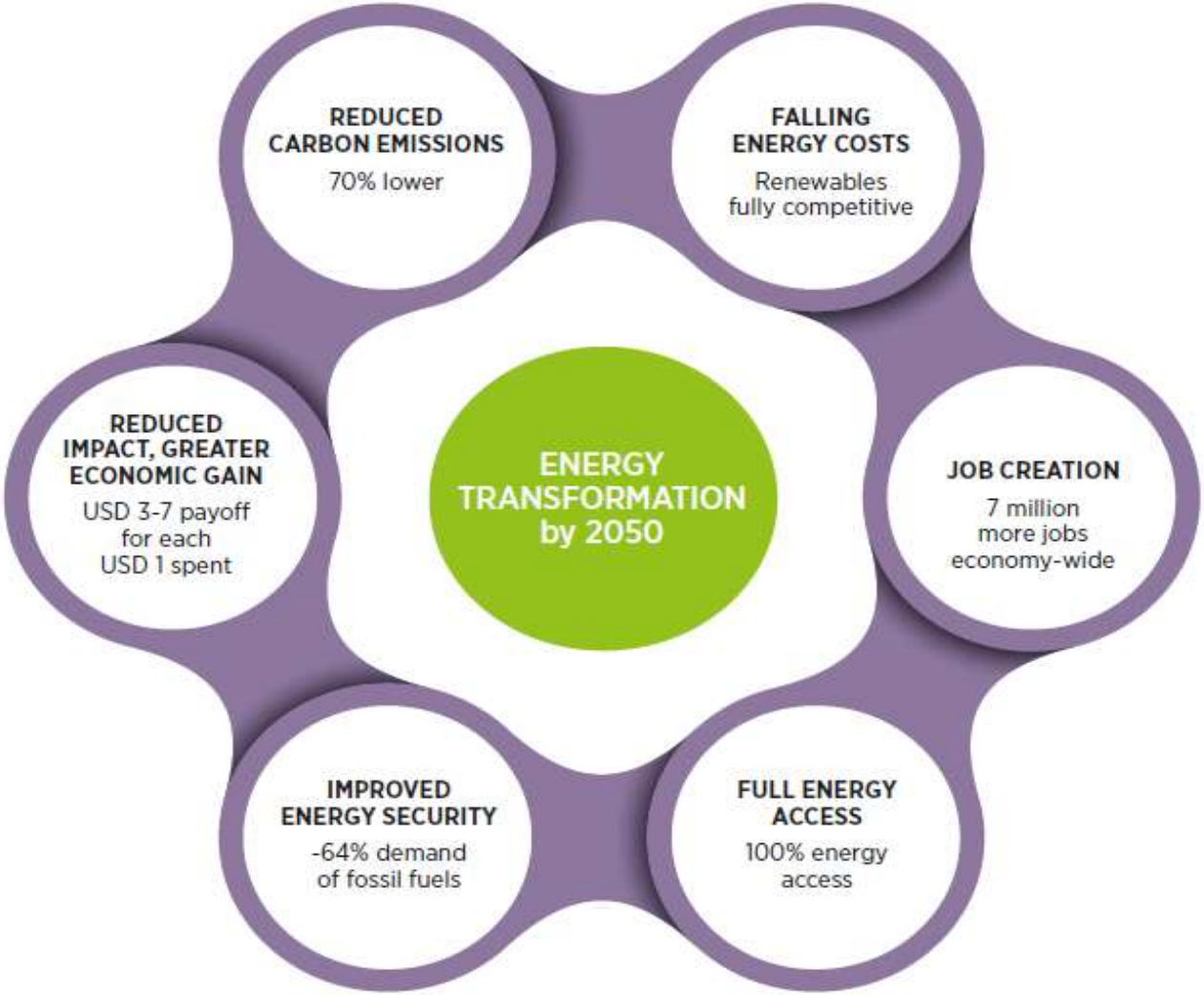

Thank You