Renewable Energy Power Plant

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Disclaimer

My views and opinions are my own and do not represent financial or technical advice.

Why we are here

I'll keep it simple, Understanding WHY Renewable Energy (RE) . RE is undeniable move in the Energy sectors, Here's a simplified explanation of why it matters by "Supply and Demand":

DEMAND

Energy demand is increasing rapidly. With the rise of AI-driven technologies and data centers, this demand is expected to grow significantly.

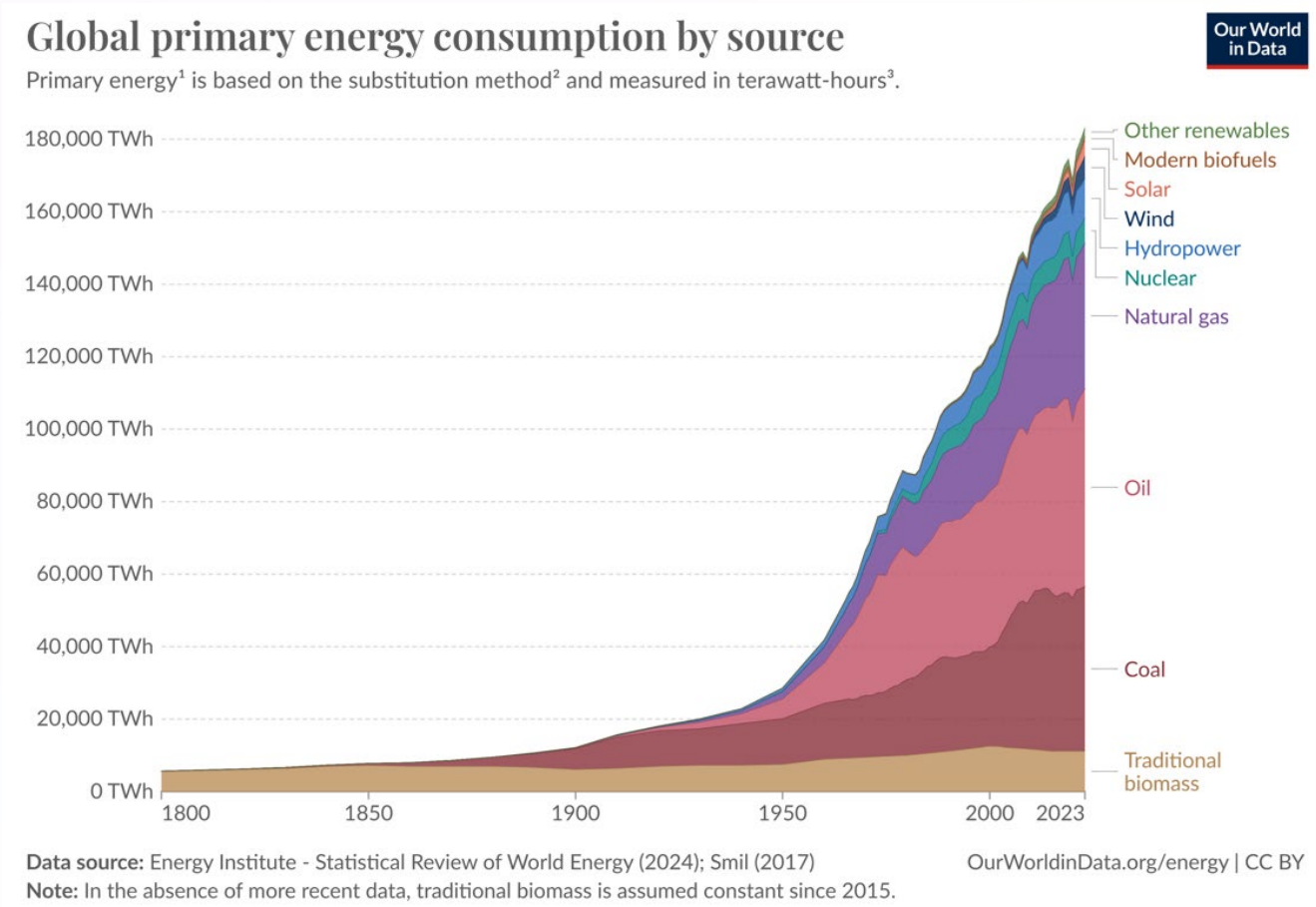
SUPPLY

Hydropower: Nearly fully utilized.

Coal and Fossil Fuels: Resources are depleting, contributing to global warming and pollution.

Nuclear Power: Heavily regulated and slow to develop.

Gas Plants: Expensive to operate with unpredictable gas prices.



Source: https://ourworldindata.org/energy

Why we are here

Shorter timeline

RE projects can be developed and constructed much faster than other technologies and benefit from favourable regulations.

Flexible Capacities

RE can be deployed on various scales—small (a few MW), medium (tens of MW), large (hundreds of MW), or very large (GW).

Energy Generation

Energy generation and cost of operation are much more predictable compared to fossil fuel resource thanks to renewable energy sources (free solar and wind primary resource)

Cost Reduction

Construction costs, especially for photovoltaic (PV) modules, have declined significantly.

So much more RE Plants to build in the future !!!

Intermittency Solutions

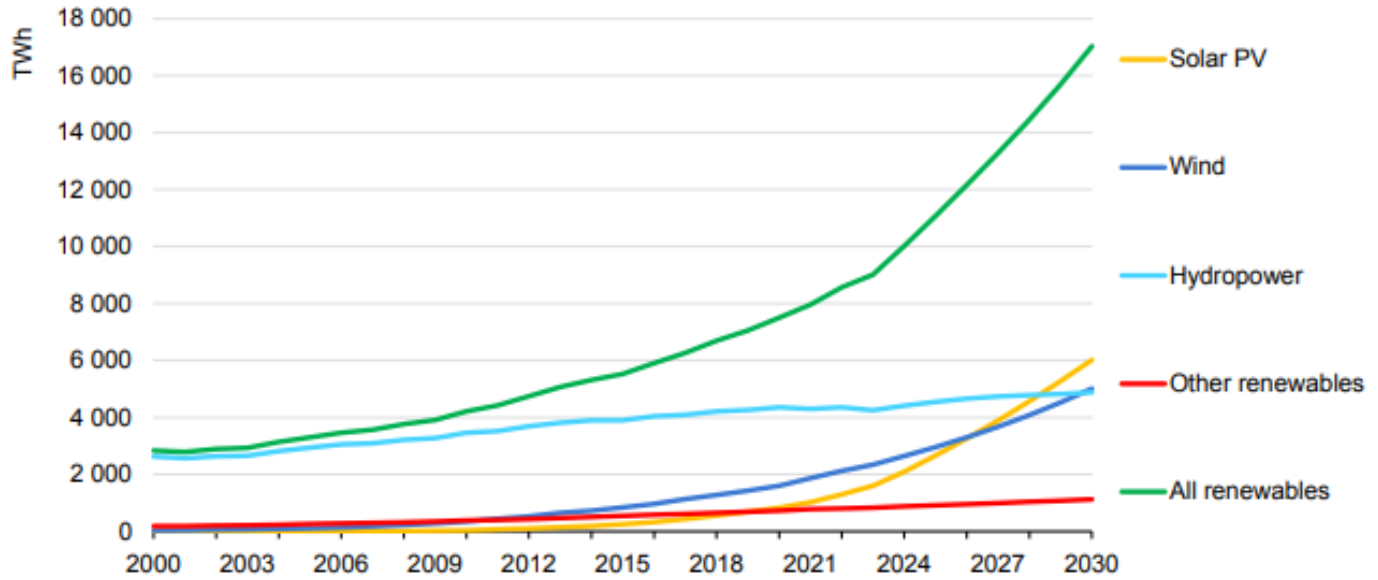
Challenges with RE intermittency are being addressed by advancements in Battery Energy Storage Systems (BESS), which are continually improving and becoming more cost-effective.

Why we are here

IEA forecast, In 2030, renewable energy sources are used for 46% of global electricity generation, with wind and solar PV together making up 30%.

By 2030, however, solar PV becomes the foremost renewable electricity source, followed by wind, both surpassing hydropower.

Global electricity generation by technology, 2000-2030



Notes: The electricity generation trajectories for wind and solar PV indicate potential generation, including current curtailment rates. However, they do not project future wind and solar PV curtailment, which may be significant in some countries by 2028. The "Increasing VRE Penetration Leads to Rising Curtailment" section in Chapter 2 discusses some recent trends.

Source: https://iea.blob.core.windows.net/assets/17033b62-07a5-4144-8dd0-651cdb6caa24/Renewables2024.pdf

Why we are here

So much more RE projects and plants to build in the future! What does this mean for all of us?

Investors and Developers

More opportunities for investment and development.

Contractors & Suppliers

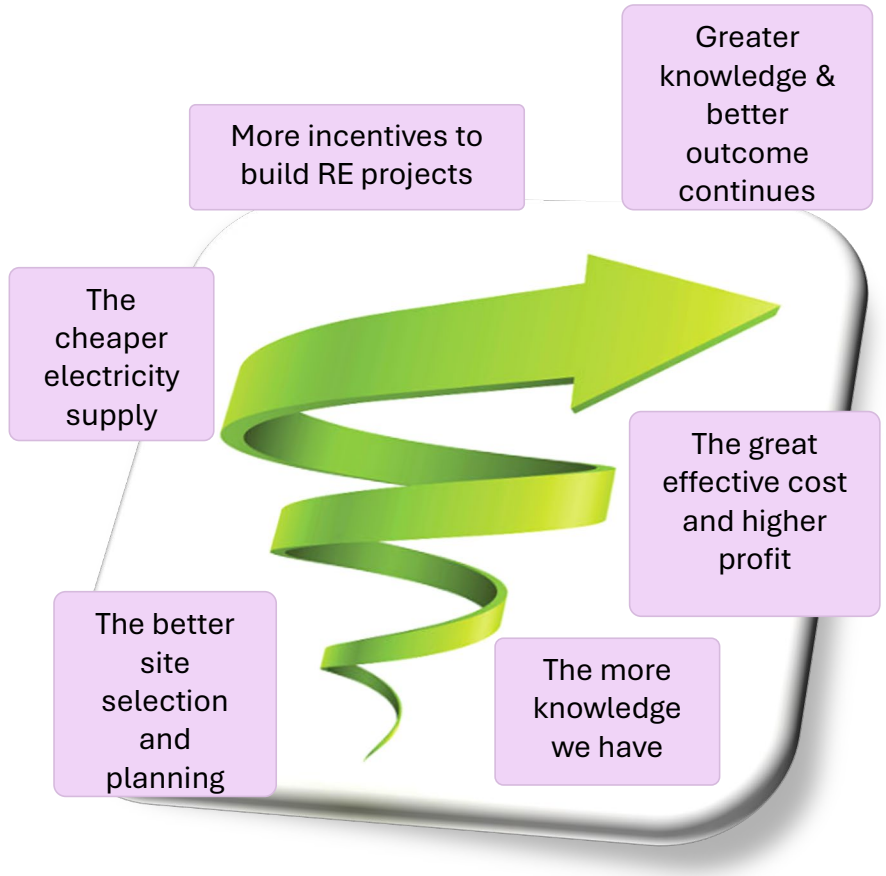
More opportunities with supply and construction contracts.

Consultants

More opportunities with Engineering, Owner Engineering, Project Management & Construction Management contracts.

Why we are here

- More importantly, we will be part of the meaningful journey, build the great power plants which bring cheap and suitability electricity our families, friends, factories, nations and especially for our sociality.
- (If you think it is not, think about your family is spending an entire day in your house without electricity during a scorching summer).
- Be proud to be part of this important energy sector.



The more we know, the smarter our site choices and plans become. This means better plants, lower costs, bigger profits, and cheaper electricity for everyone— eventually even more renewable energy projects as the upward spiral and compound of interest.

In the downturn, this is the best time ever to learn and gain knowledge about Renewable Energy.

Agenda of multiple workshops

The Agenda of multiple workshops will be covered as the following structure.

1. Introduction - Renewable Energy Power Plant
   - Solar PV Power Plant (Solar Farm)
   - Onshore/Nearshore Wind Power Plant
   - Offshore Wind Power Plant
2. Development of Solar PV Power Plant
3. Development of Onshore & Nearshore Wind Power Plant
4. Development of Offshore Wind Power Plant, Planning, Construction and Operation
5. Operation of Wind Farm
6. Procurement and Logistic
7. Project Management Professional (PMP)

Etc.… to be developed

Introduction - Renewable Energy Energy Power Plant

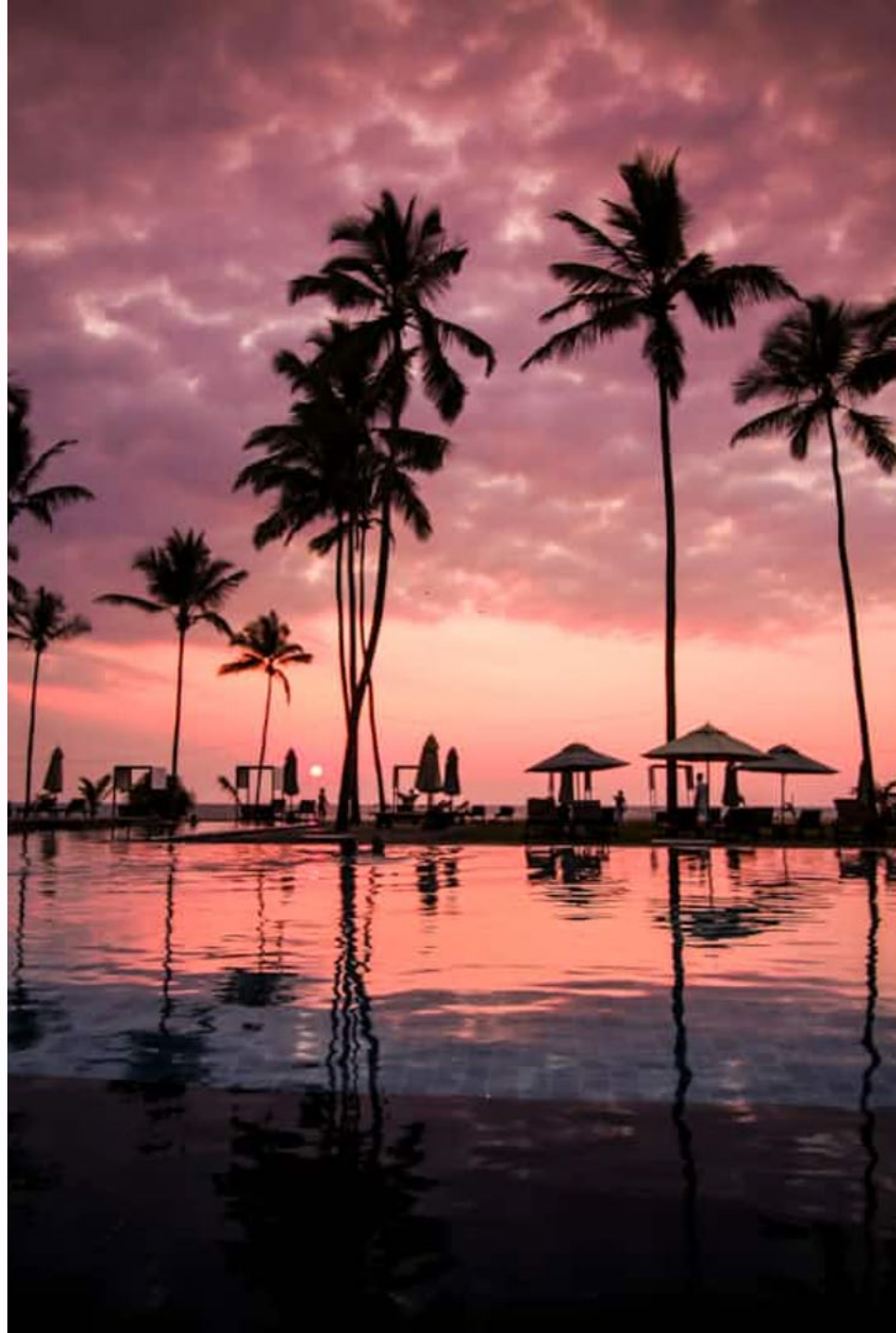
Renewable energy power plants harness natural resources such as sunlight, wind, water, geothermal heat, and biomass to generate electricity.

Solar PV

Wind Farm

Biomass

Hydropower



Introduction – Solar Power Plant

- Sun and Earth:
  - For billions of years now, the Sun has been producing energy via nuclear fusion, which converts hydrogen nuclei into helium nuclei. This process releases energy. Solar energy is in fact nuclear energy in that sense.
  - The Earth rotates around the Sun once a year and at the same time rotates around its own axis once a day. The Earth's axis is at an angle of 23.45 relative to the plane of the Earth's path around the Sun.
  - The solar energy hit the outer space of Atmosphere are approximately 1367kWh/m2 (solar constant)
- The Solar Irradiation
  - Direct Normal Irradiance: The beam energy component received on a unit area of surface directly
  - Diffuse Horizontal Irradiance: The energy received on a unit area of horizontal surface from radiation that is scattered off the atmosphere or surrounding area
  - Global Horizontal Irradiation: The total solar energy received on a unit area of a horizontal surface

  For fixed mounting structure, we will try to tilt the PV modules toward to maximize the DNI/GHI in the year (tilt angle optimization).

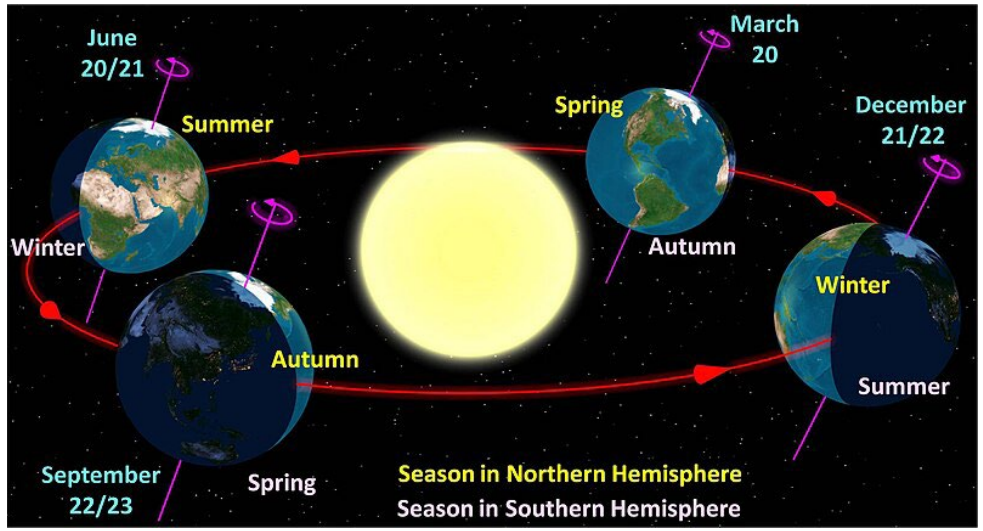


Photo source: https://en.wikipedia.org/wiki/File:North_season.jpg

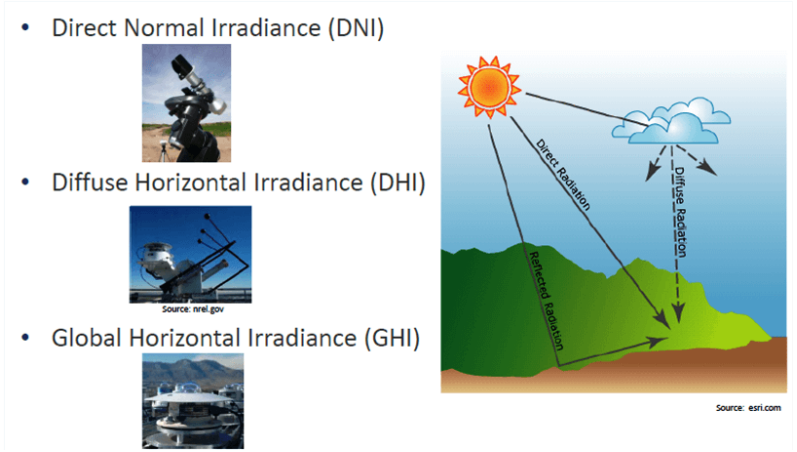


Photo source: https://yellowhaze.in/solar-irradiance/

Introduction – Solar Farm

- Solar Panels (PV Modules): These panels capture sunlight and convert it directly into DC electricity using the photovoltaic effect – a process where sunlight striking semiconductor material generates an electric current. Multiple cells form a module, and multiple modules are connected to create the desired power output.
- Inverters: The DC electricity from the panels is then converted into AC electricity by inverters. This AC power is what's compatible with the utility grid.
- Mounting/Tracking: To maximize energy capture, the panels are securely mounted, either at a fixed angle or on tracking systems that follow the sun's movement throughout the day.
- MV Transformers : MV transformers increase the voltage of the AC electricity from inverter level to medium voltage.
- Substations provide further voltage step-up to match the high-voltage transmission lines.
- Battery Storage (Optional): Excess energy generated can be stored in batteries for later use, providing power even when the sun isn't shining

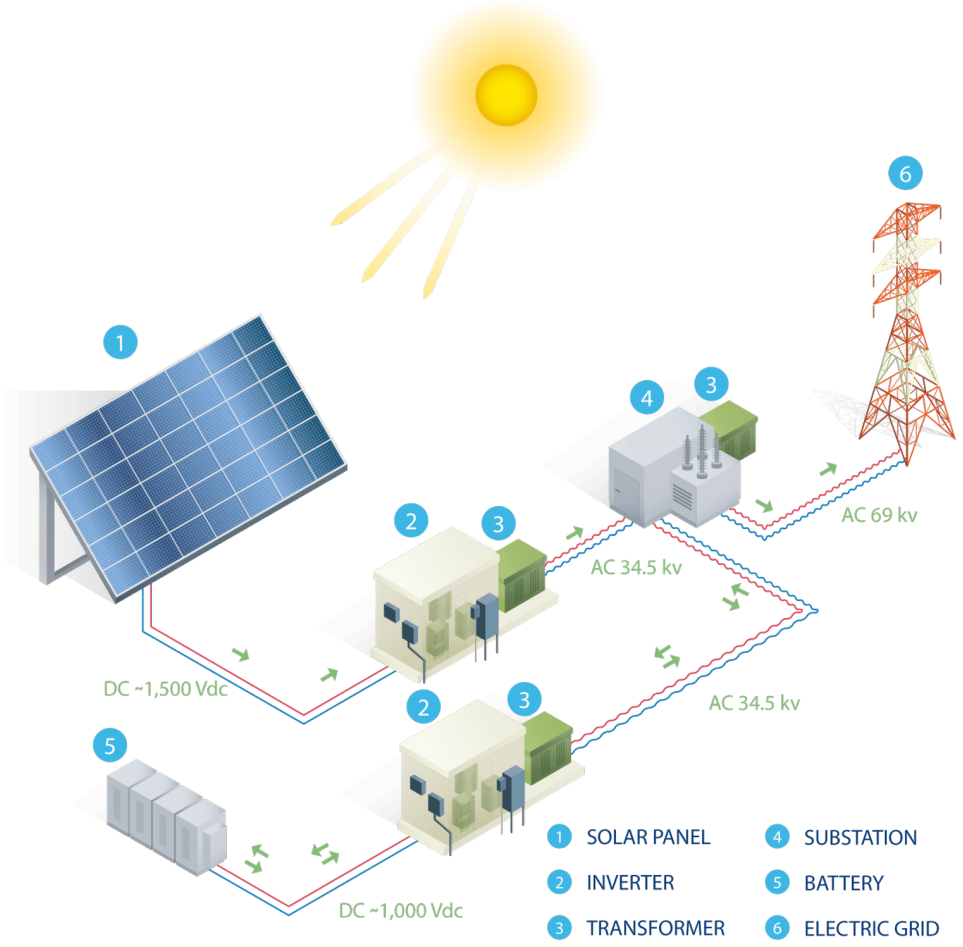


Photo source: https://avenston.com/en/services/commercial-pv/types/on-grid/

Introduction – Solar PV Power Plant

One example from the photo PV farm components consist of

- PV modules + Mounting structure or Tracker
- Combiner Box
- Inverters + MV Transformer
- BESS system
- HV substation and Transmission Line
- Other civil infrastructures (pilings, foundation, roads, powerhouse, etc…)

Photo source: https://www.energynewsbulletin.net/policy/news-articles/1421486/horizons-regional-wa-bess-blitz

Introduction – Solar Farm

- PV modules consist of multiple PV cells connecting in series:
- The PV cell have Crystalline Sillicone Cells (including Poly, Multi Crystalline and Monocrystalline) and Thin-film.
- The most popular PV technology recently use Monocrystalline for commercial use (PV solar farms, rooftops) thanks to its higher efficiency and cost effectiveness.
- The PV module are currently at 22%-23% efficiency (what does this mean for efficiency?)

Example to understand the peak capacity of PV module and its efficiency:

- Another example: One PV modules with the area 2.8m2, at the standard testing condition (STC) (Irradiation 1000W/m2, and cell temperature 25 degree C), the DC power of such PV module generated is 620Wp. Therefore, the PV module rating is claim as 620Wp PV module at STC condition. In addition The efficiency of PV module (at STC condition) is approx. 22.1%.

It is noted that in the real operating condition, the Irradiation might be lower than 1000W/m2 (due to impact of atmosphere, Sun angle through out the day), the cell temperature might be hotter than 25-degree C. Therefore, the real condition that such PV module might generate DC power normally lower than power of STC condition (except sometime if clear sky and favourable temperate).

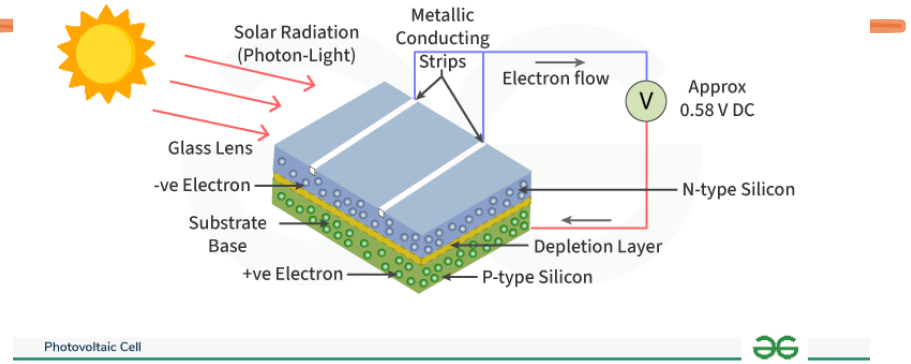


Photo source: https://talklikesm.best/product_tag/91784432_.html/

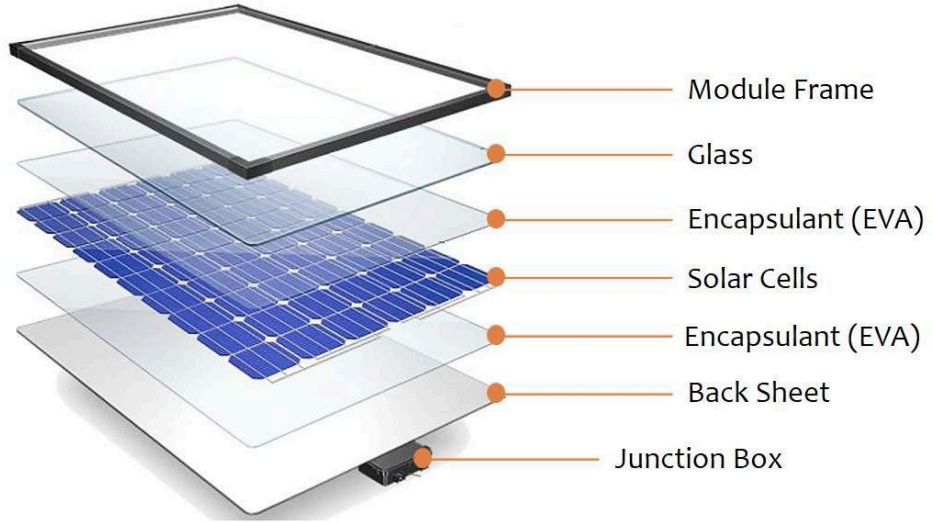


Photo source: https: //arka360.com/ros/photovoltaic-modules/

Introduction – Solar Farm

PV substructure common:

- Fixed Tilt
- Tracking (most common is 1 axis tracker)

Fixed Tilt allowed to build the power plant quicker and lower cost but have the energy yield production lower than Tracker.

General requirement of the Tracker is the

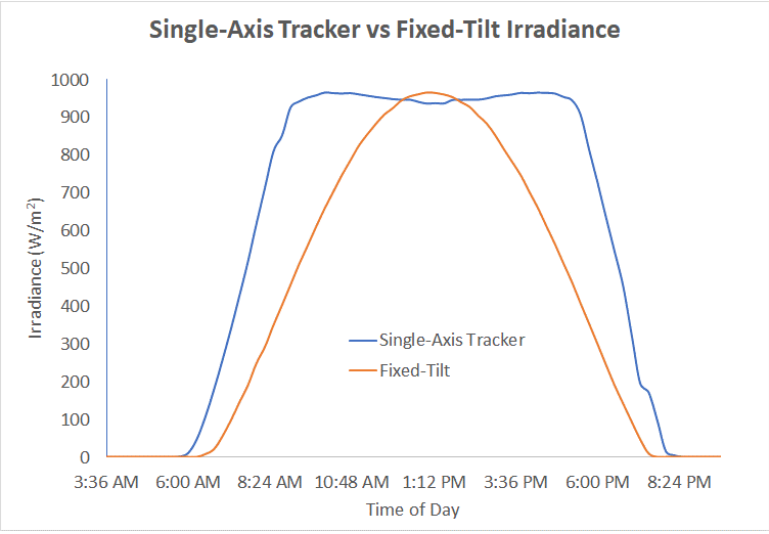


Photo source: https://www.solsystems.com/solar-eclipses-effect-on-pv-system/

Photo source: https: //arka360.com/ros/photovoltaic-modules/

Introduction – Solar Farm

Main purpose of Inverter:

- Convert DC to AC
- Control the power to the Grid
- Maximum Power Point Tracking

Two main types of Inverter

- Central Inverter
- String Inverter

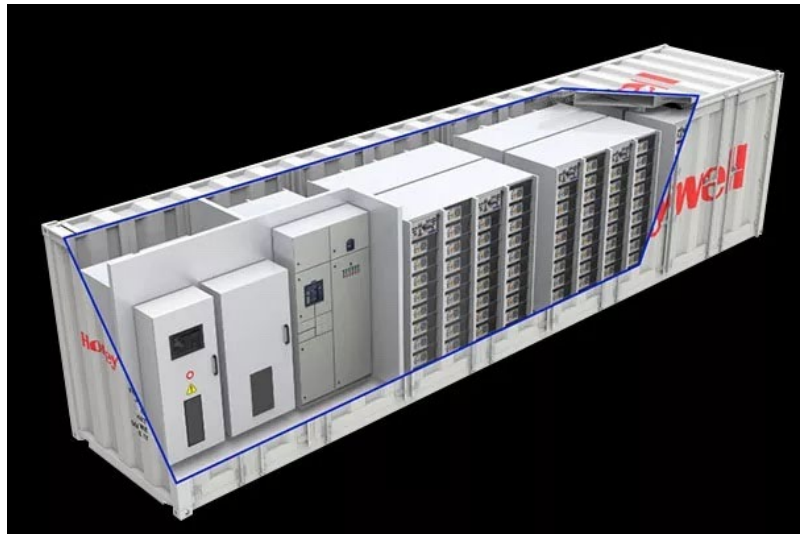
Central Inverter

String Inverter

Photo source: Internet

Introduction – Solar Farm

- Utility Batter Storage normally packaged in container type
- The main purpose of battery is load smoothing and avoiding intermittent from solar source
- Shift the energy loads (for example from noon to evening)



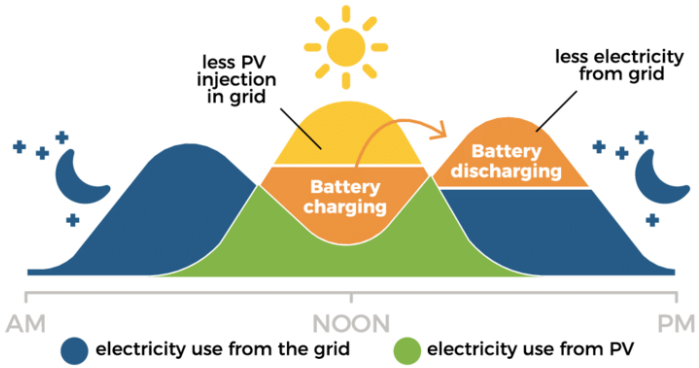
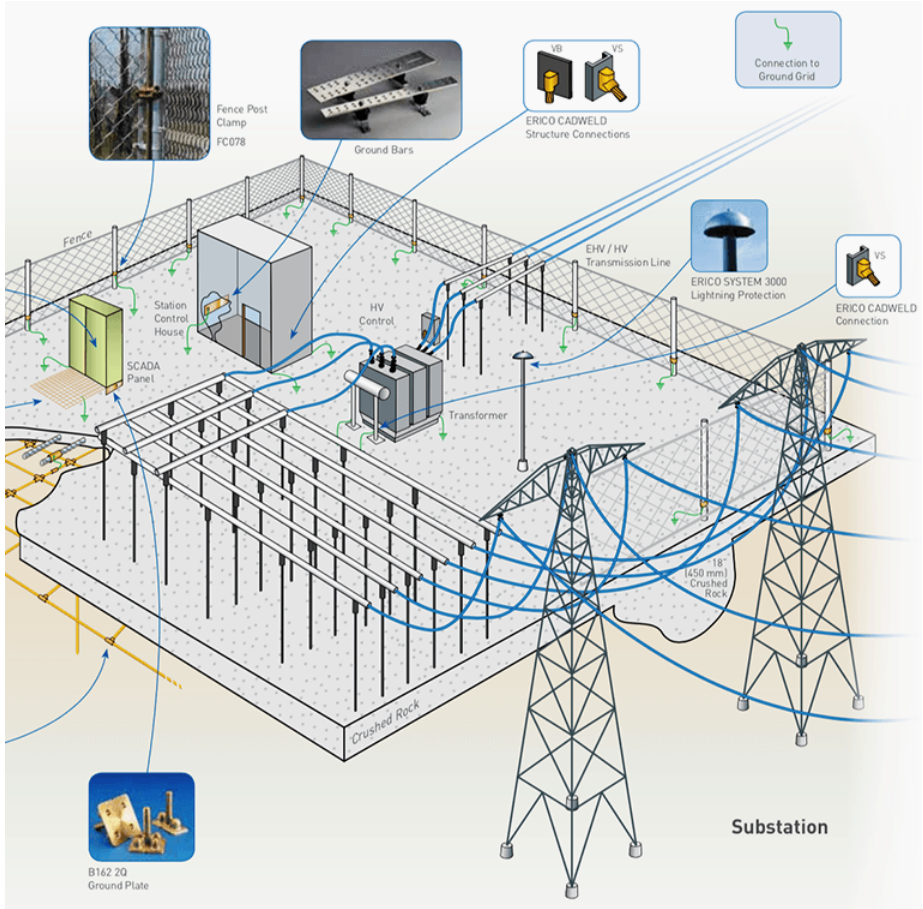


Photo source: Internet

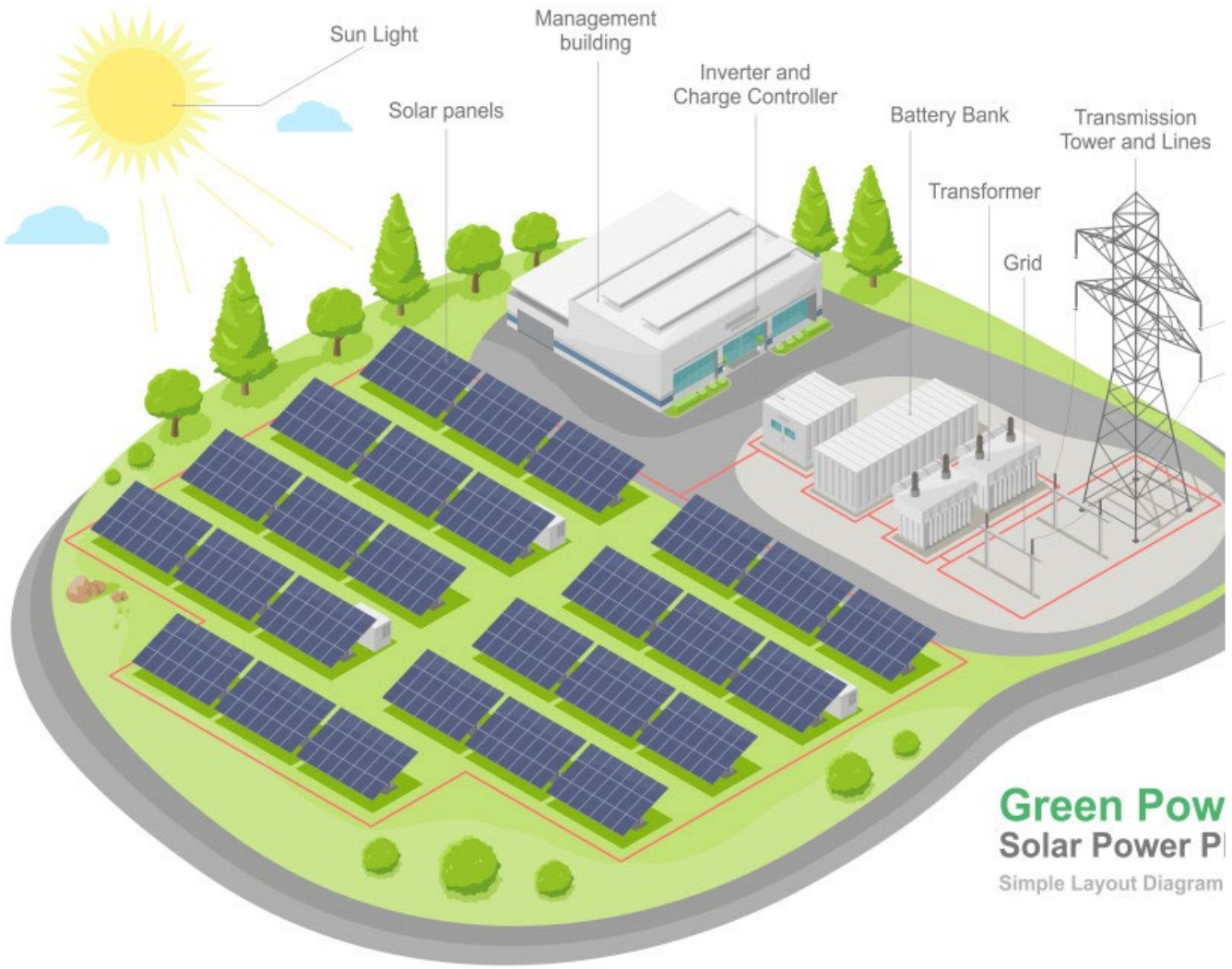
Transformer and Transmission Line

- MV Transformer: Step up Voltage from Low Voltage (normally 600V) to Medium Voltage 22k to 35kV
- HV Transformer: Step up the Medium Voltage to High Voltage (110KV, 230kV, 400kV, 500kV)
- Transmission Line: To Transmit the energy from the Solar Farm to to Point of Connection for Grid connection.



Summary of Solar Farm

In the next workshop, we will have one dedicated workshop to deep dive and discuss more detail the development of the Solar farm

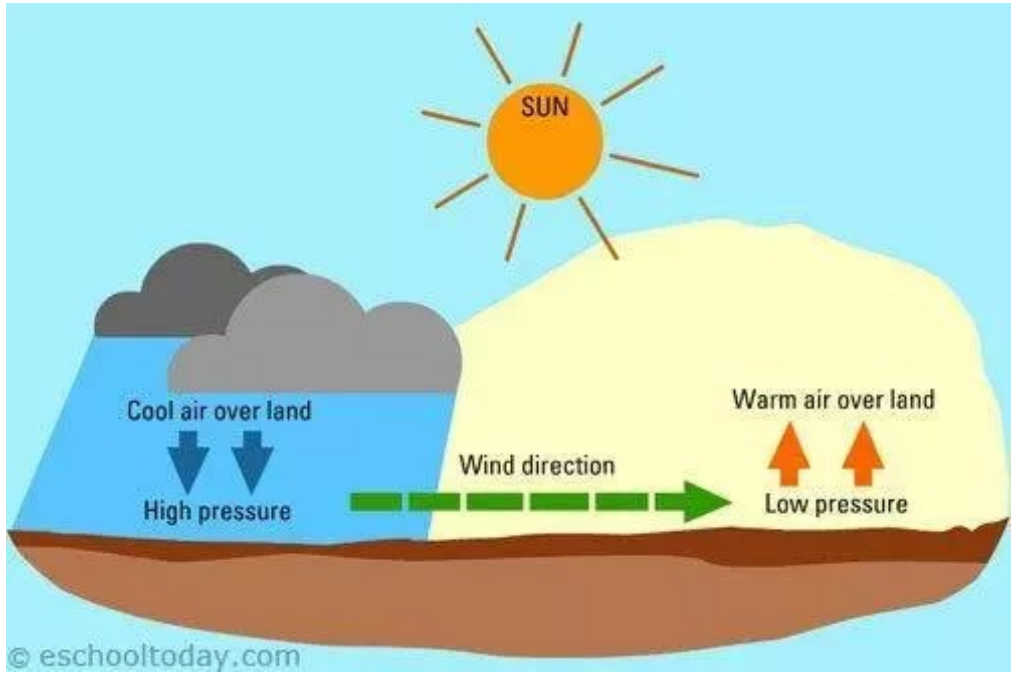


Introduction - Wind Power Plant

- Wind Energy:

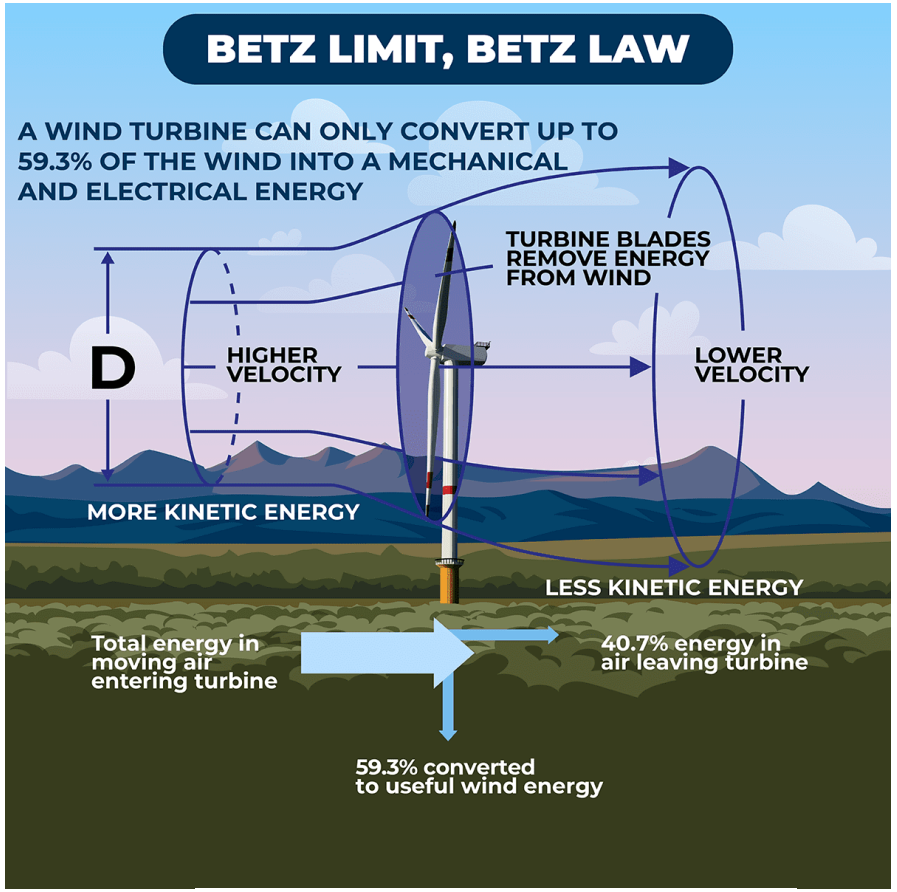
Wind energy is actually a byproduct of the sun. The sun’s uneven heating of the atmosphere, the earth’s irregular surfaces (mountains and valleys), and the planet's revolution around the sun all combine to create wind.

Since wind is in plentiful supply, it’s a renewable resource for as long as the sun’s rays heat the planet.



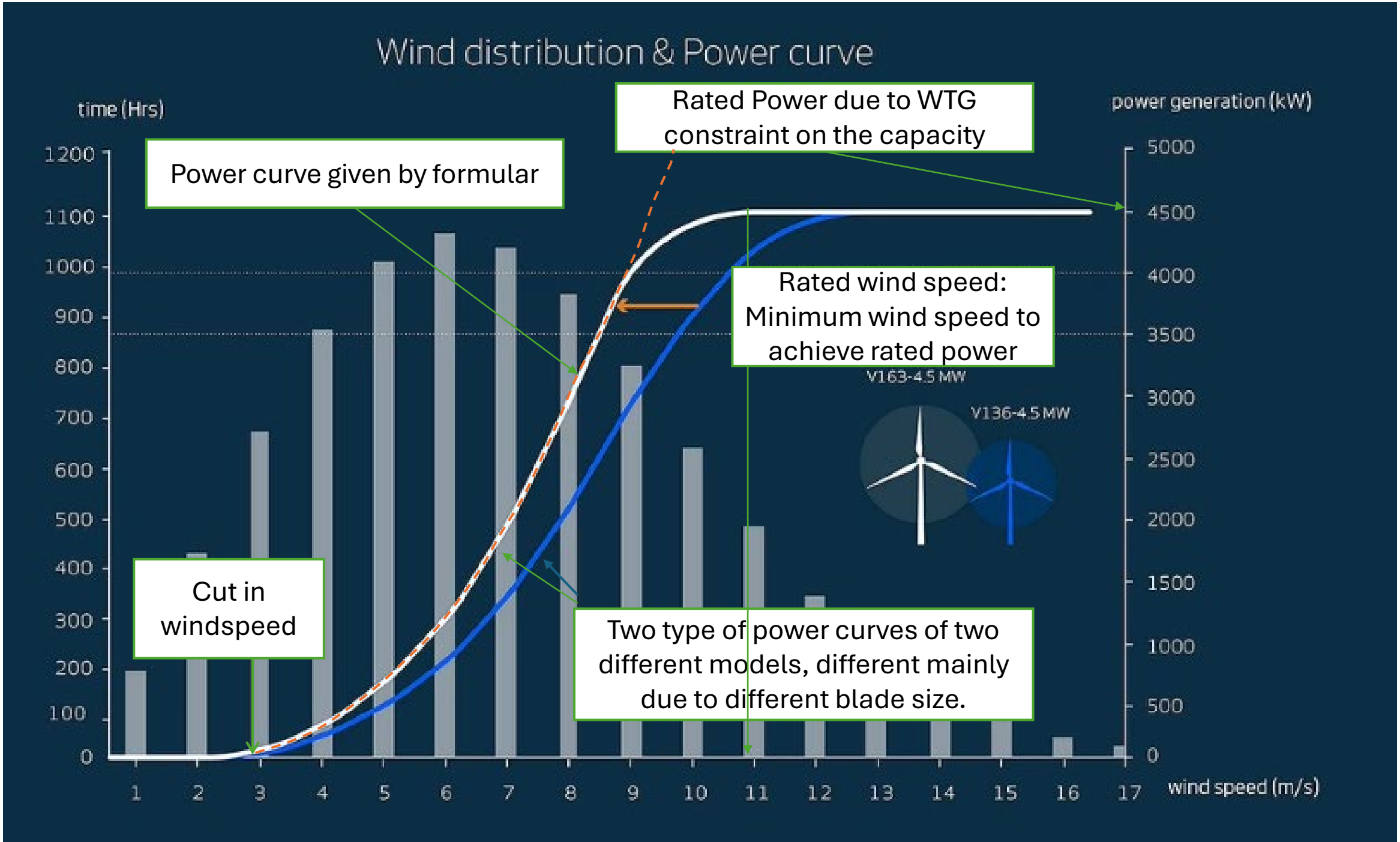
Introduction - Wind Power Plant

- Wind turbines capture the kinetic energy of the wind. This process slows the wind down because energy is extracted. However, only the air passing through the turbine's rotor is directly impacted.
- According to Betz law, only 59.3 percent of the kinetic energy entering from the wind can be used to generate electricity.
- The modern Wind turbine efficiency is around 35% to 50%
- Power output from a wind turbine is given by the well-known formular
  - ρ is the density of air (1.25kg/m3)
  - Cp is the power coefficient
  - A is the rotor swept area
  - U is the free wind speed
- Wind speed affect the Power generation the most,
- following by the swept area (given by the length of blade).
- Air density is also factor affect to the power, it is depending on the altitude, environment and temperature)
- power coefficient describes that fraction of the power in the wind that may be converted by the turbine into mechanical work/useful power (or we can consider as Turbine efficiency). The Cp will be never exceeding Betz limit.



$$P = \frac{1}{2} C_p \rho A U^3$$

Photo source: Internet


Wind distribution & Power curve
time (Hrs)
power generation (kW)
Rated Power due to WTG constraint on the capacity
Power curve given by formular
Rated wind speed: Minimum wind speed to achieve rated power
V163-4.5 MW
V136-4.5 MW
Cut in windspeed
Two type of power curves of two different models, different mainly due to different blade size.
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
wind speed (m/s)

Wind farm Introduction

- Given above explanation, significant increases in output power can only be achieved by expanding the rotor's swept area or placing wind turbines in areas with higher wind speeds.
- However, it is noted that given the rapid increase of the wind turbine size which is also affect negatively to the supply chain and logistics for the wind farm development also, especially
  - Pressure for the manufacturing of the other component (for example foundation) which fit for the larger turbine
  - Pressure for the transportation and logistics for heavy transportation and installation for example: larger trucks for transportation, large cranes, larger vessel, etc…
  - Pressure on the infrastructure like the road/bridge, port for transportation and storage

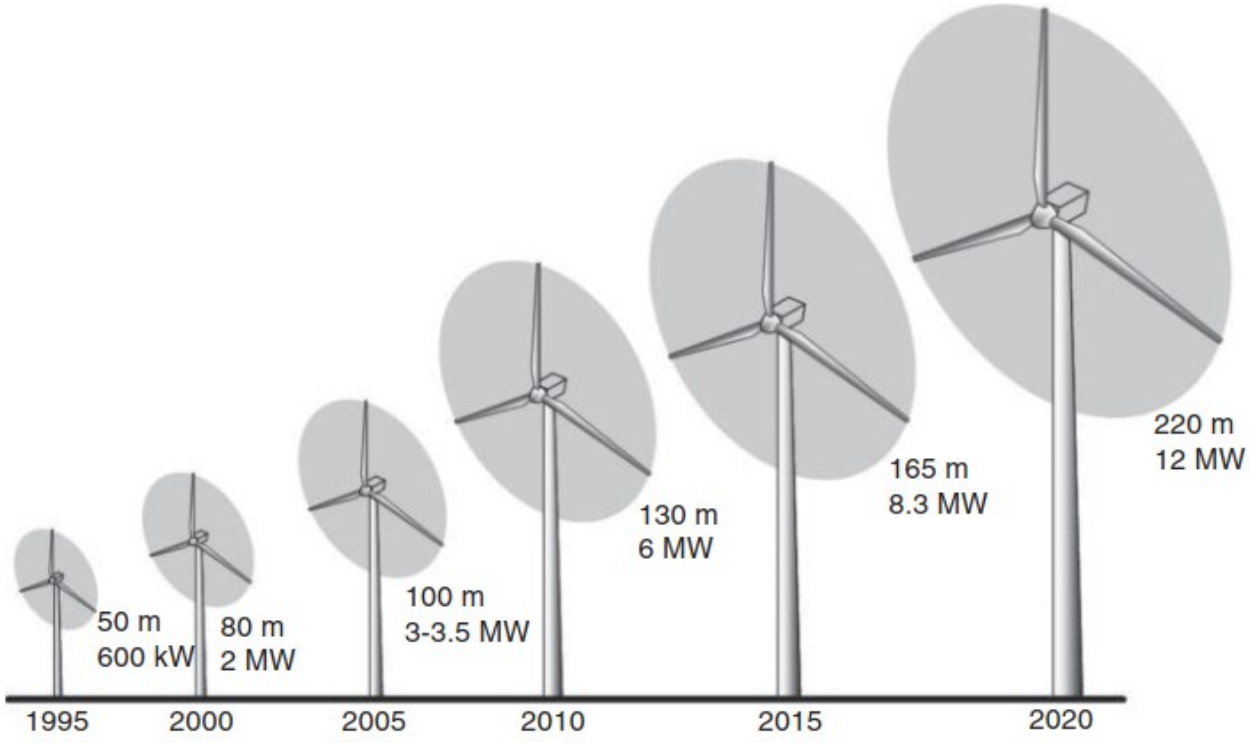


Photo source: Internet

Wind farm Introduction – Onshore Wind farm

- The onshore wind farm components are consisting of
  - Wind Turbine Generators
    - Nacelle
    - Blade
    - Towers
    - Other auxiliary (anchor cages)
  - Balance of plant
    - Foundation
    - Road
    - Crane pad (hardstand)
    - HV substation and transmission lines
    - Linkbridge (/subsea cable

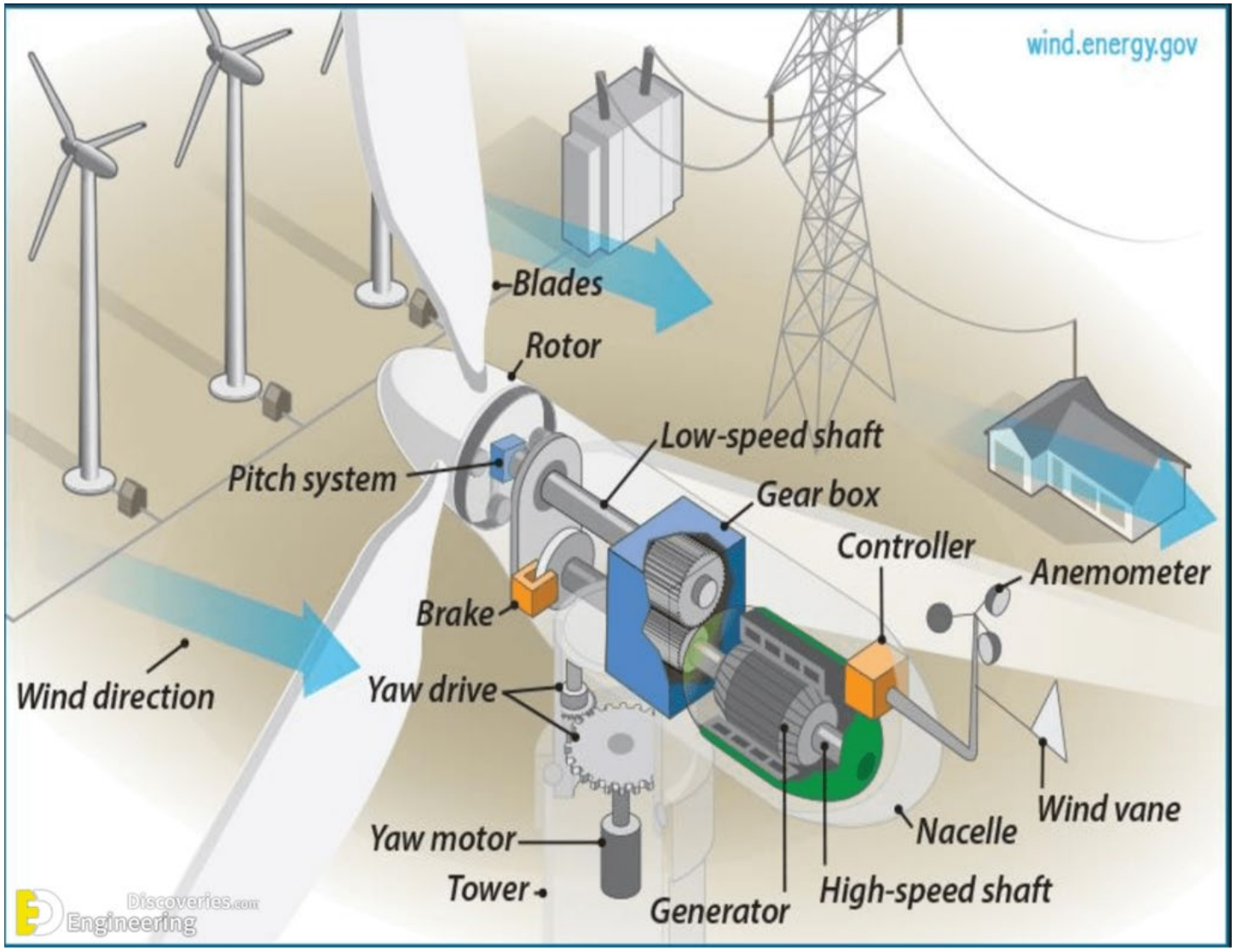


Photo source: Internet

Dam Nai Wind Farm
(source: Internet)

Wind farm Introduction – Nearshore Wind farm

- The Nearshore wind farm components are quite similar to Onshore wind farm (but might be quite unique in Vietnam nearshore condition), instead of positioning wind turbines on land, they are positioned in the nearshore, shallow sea water.
- The turbines are still onshore type by adapted with sea condition.
- However, in the other hand, the foundation is likely the pile cap foundation (or monopiles) raised up above the sea water level.
- The link-bridge connecting all the turbine together housing MV cables inside and facilitate operation & maintenance.
- The construction of foundation (pile caps) are quite similar with the construction of the port and bridge.
- The installation of turbines may involve the cranes and barges for the installation.

Photo source: https://khangducconst.com/en/news/industry-news/wind-turbine-installation-in-vietnam/

Wind farm Introduction – Nearshore Wind farm

Nearshore construction example (Vietnam)

- Construction the monopile raising up above the sea water. The construction of pile caps and pile foundation for Nearshore wind project are similar type of marine construction, bridge construction which can leverage the traditional method of construction, utilizing the local contractors and skills.
- Installation of turbine also using the crawler crane sitting on the barge for the installation of the Nearshore wind farm

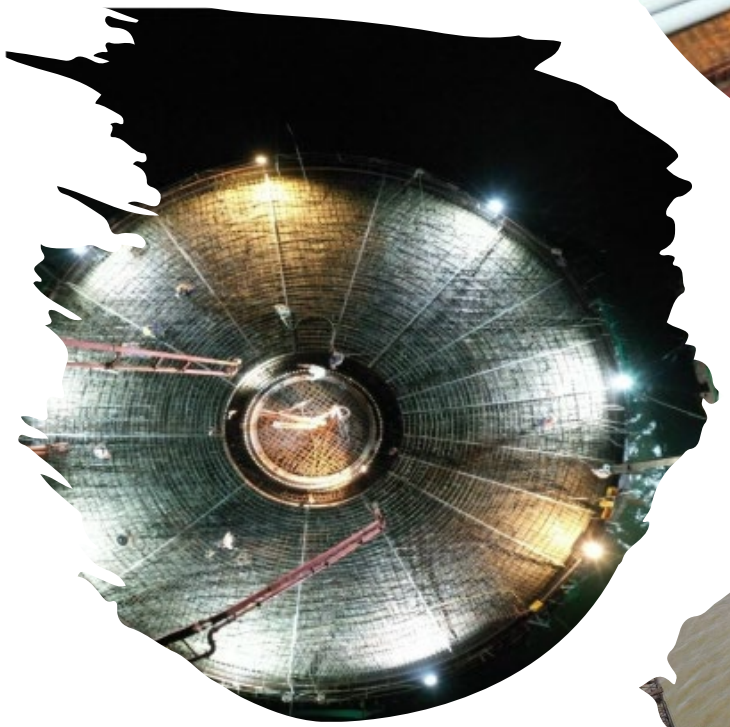


Photo source: Khang Duc & Soc Trang 7 (internet)

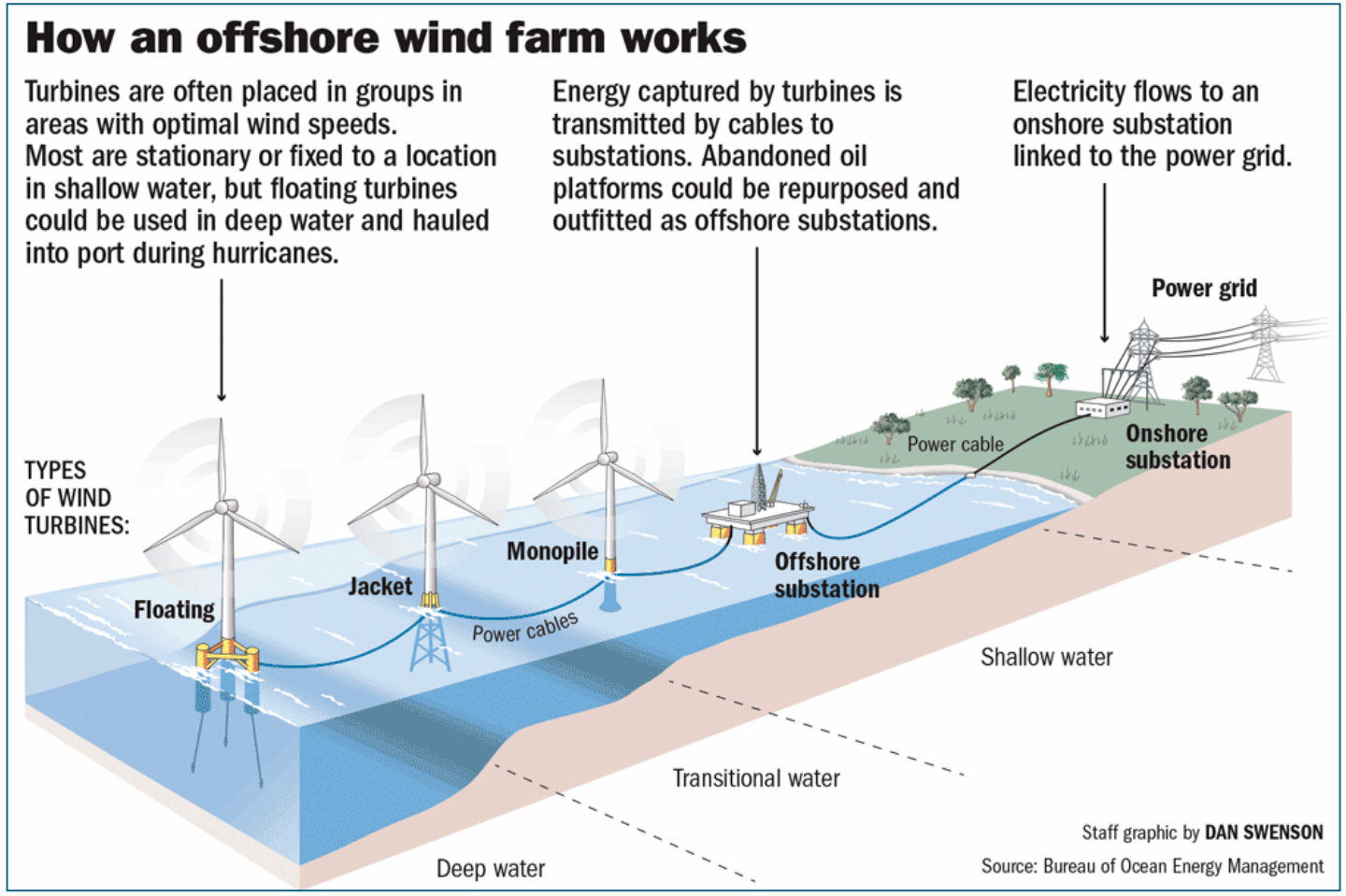
Tra Vinh V1-1 (source: Internet)

Offshore Wind Farm

- Offshore wind turbines capture the ocean's wind energy and transform it into renewable electricity.
- The offshore wind turbines generate electricity and transfer to the offshore substation via inter-array subsea cables. The electricity is then transmitted from offshore
- substation to an onshore substation via the export subsea cables where it is transferred to the existing power grid network as presented

The main components of the Offshore Wind Farm are including

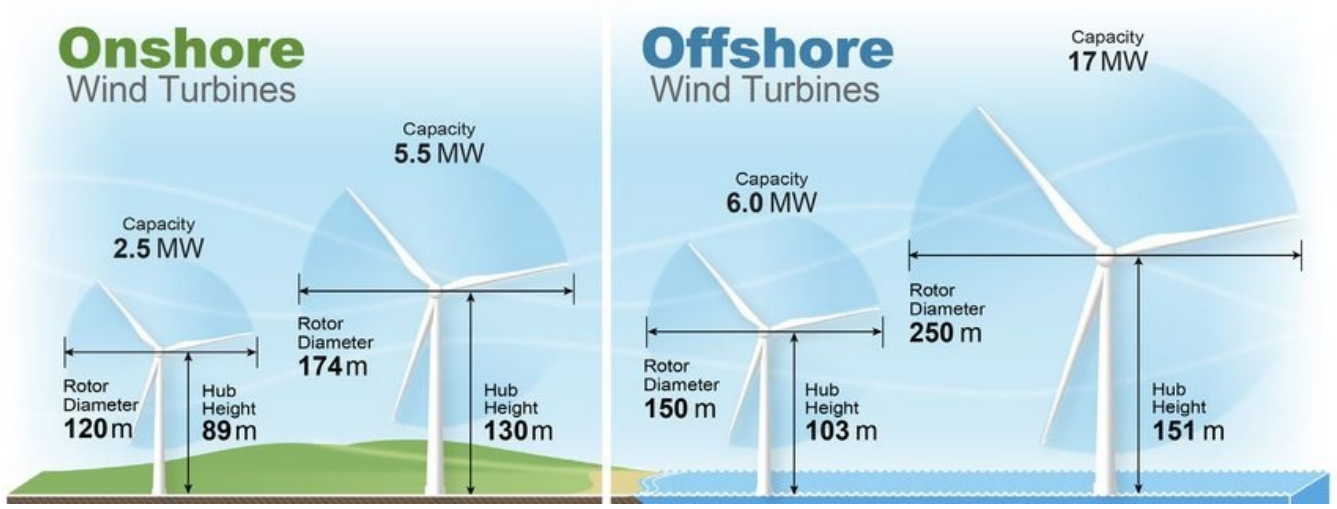
- Wind Turbine
- Offshore inter-array cables
- Offshore substations
- Offshore Export cables
- Landfall
- Onshore substations
- Transmission Line




MOSES & SACS
SPAR
SEMI-
SUBMERSIBLE
TENSION
LEG
PLATFORM
SACS
JACKET
SACS & PLAXIS
SUCTION
BUCKET
MONOPILE

Offshore Wind typically offers:

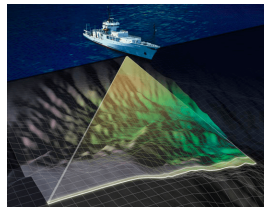
- Much larger turbines
  - Higher wind speed
  - More consistent wind
  - Lower visual impact
  - Lower noise impact
- Larger projects
  - Availability of sea-area

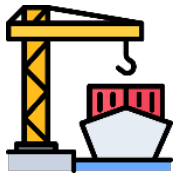
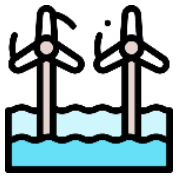


Source: Internet

Ultimately these factors lead to an overall higher capacities and energy yields

Offshore Wind Development


Site selection, pre-feasibility study

- **Approx 1 year**

Later-stage Development

Pre – construction

- **Approx 4 years**

Fabrication and Construction

- **Approx 3 years**

Operation & Decommissioning

- **25 years to 30 years**

Approximately 8 years to build an offshore wind project.

Source: Internet

Q&A section