Marsh

Renewable – The Broker's View

Marsh Malaysia

20 June 2023

A business of Marsh McLennan

Agenda

1. The Energy Transition
2. Solar PV
3. Onshore Wind
4. Battery Energy Storage Systems
5. Hydrogen Energy Storage
6. Hydroelectric
7. Biofuels / Waste to Energy
8. Carbon Capture, Utilization & Storage (CCUS)
9. Geo Thermal
10. Conclusion and Q&A

The Energy Transition

ENERGY GENERATION OVERVIEW
RENEWABLE ENERGY: BACKGROUND AND DRIVERS

Driving forces that will further accelerate the growth of Renewable Energy:

- **Hurricane Ian, Katrina, Irma, Maria, Florence, Michael (in the US), Typhoon Haiyan, Hato, Jebi, Mangkhut (Asia), Vongfong, Amphan, Iota, Filomena– Stronger, Larger and Deadlier**
- **Wildfire in Canada, Australia & USA; Flooding in Europe, Australia, Kerala**
- **UN report said renewable energy would need to supply 70-85 percent of electricity by 2050 to stay within a 1.5 degrees Celsius limit, compared with about 25 per cent now.**
- **UN report estimates that in order to limit global warming to 1.5 degrees Celsius, the world would need to eliminate coal power and invest $2.4 trillion a year in green energy technologies.**
- **Multinational banks and investors reduce funding on coal power projects.**
- **Increasing economies of scale, more competitive supply chains and further technological improvements will continue reducing the costs of solar and wind power. The same factors will also boost the availability of these key renewable power sources at night and in varying weather conditions (with the advancement in Energy Storage technology).**

The Energy Transition

Competitiveness

THE PAST

- Renewable Energy had high LCOE compared to conventional electricity;
- Making it dependent on incentives and subsidies.

THE NOW

- Technological advances make wind and solar becoming economically competitive;
- Evolved into established and mature technology with competitive cost of generation;
- Proving they can replace conventional power.

Figure 1: Cheapest source of new bulk electricity generation on a LCOE basis, 2H 2019

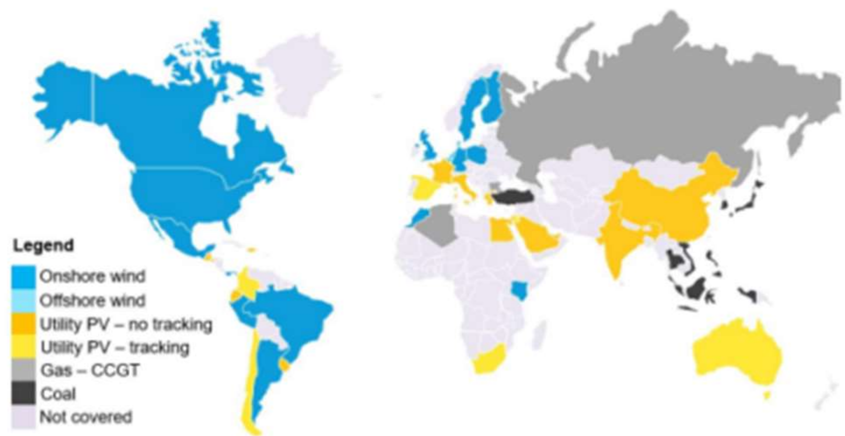
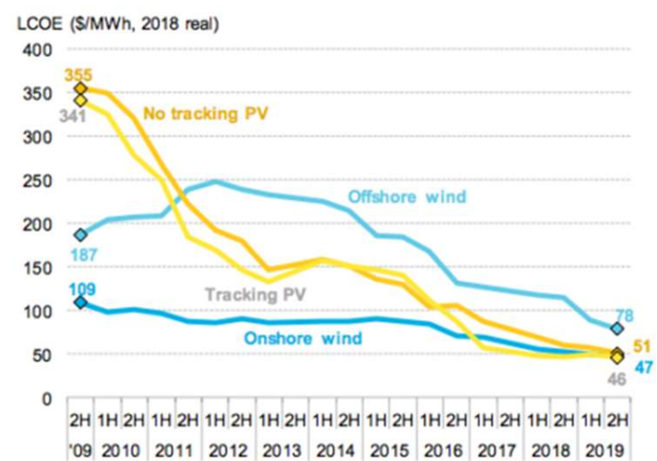


Figure 2: Global LCOE benchmarks

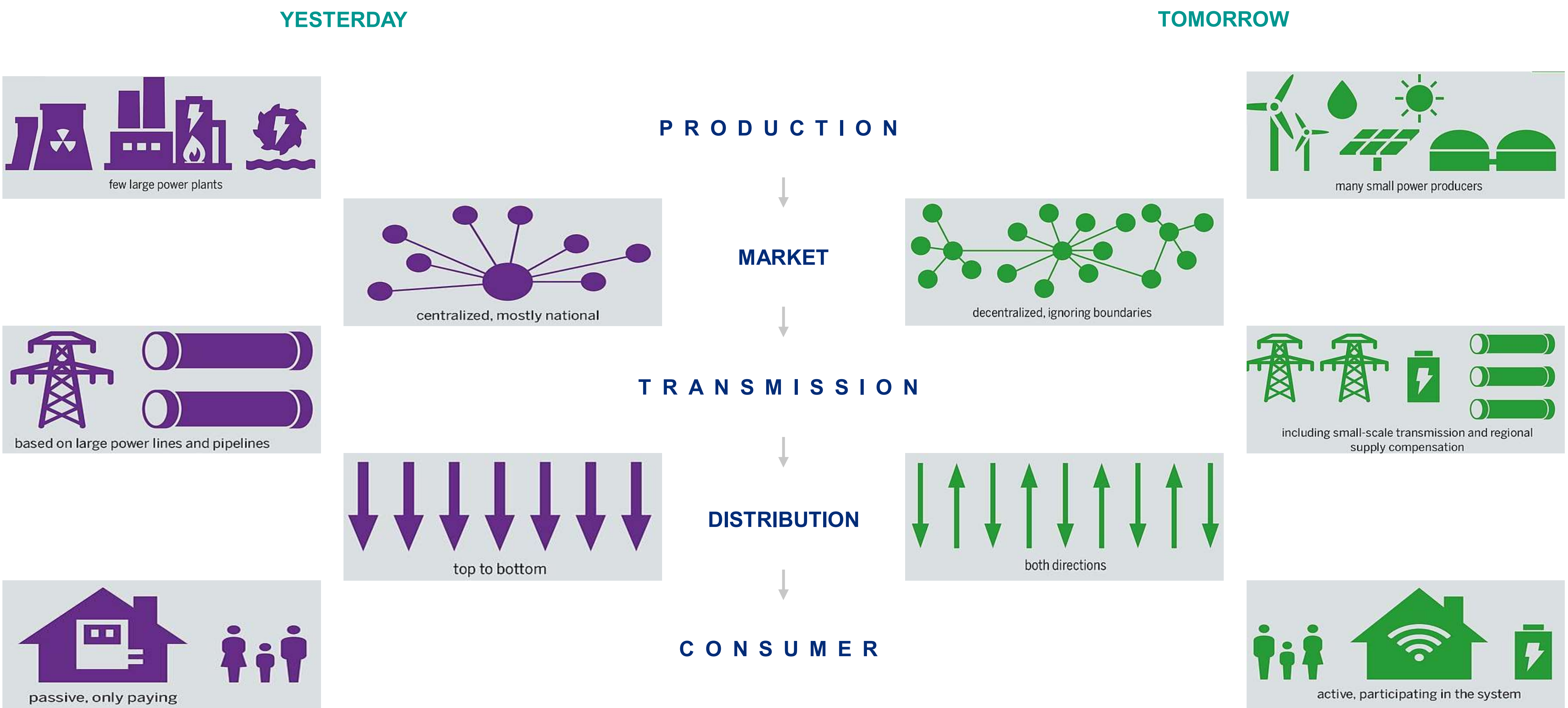


Source: BloombergNEF

Note: the top map shows the technology with the lowest benchmark LCOE in each market, excl. subsidies or tax credits.

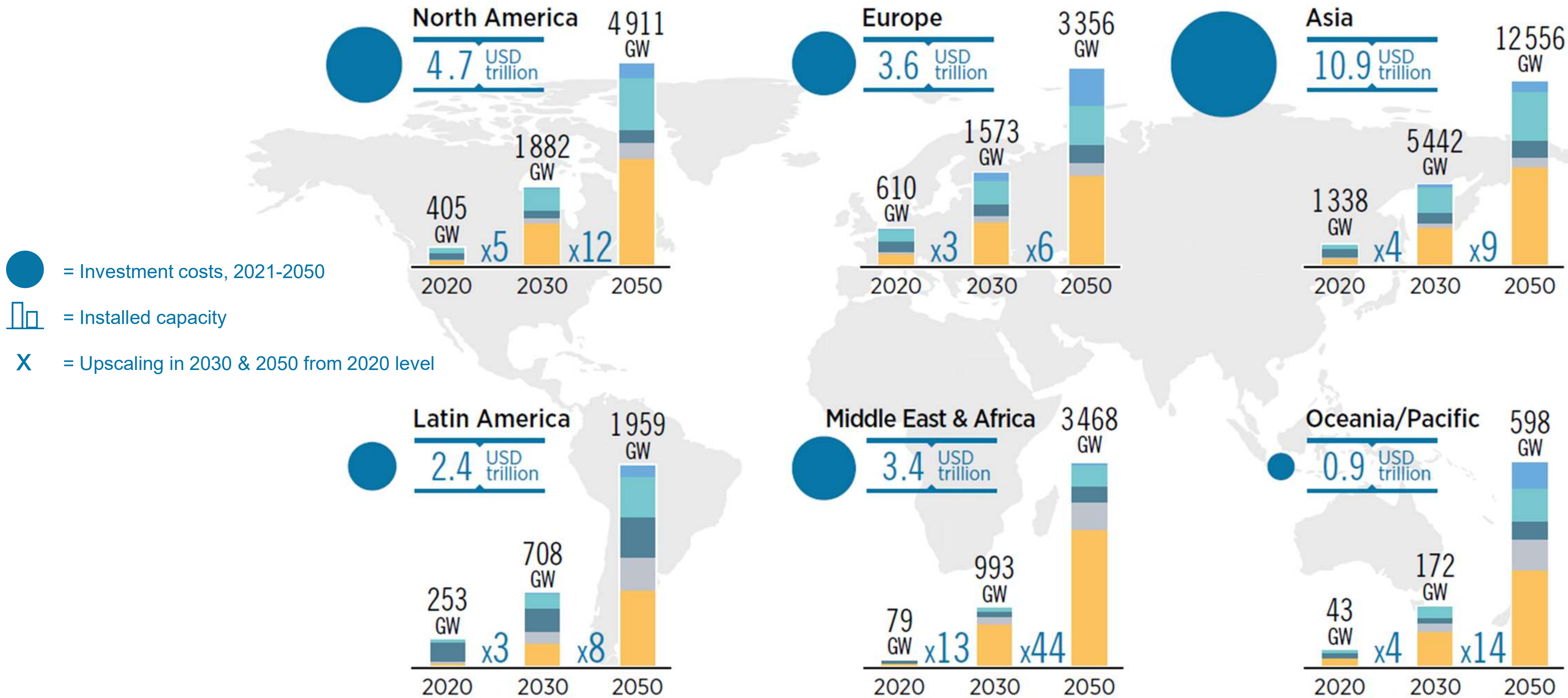
The Energy Transition

Future Generation



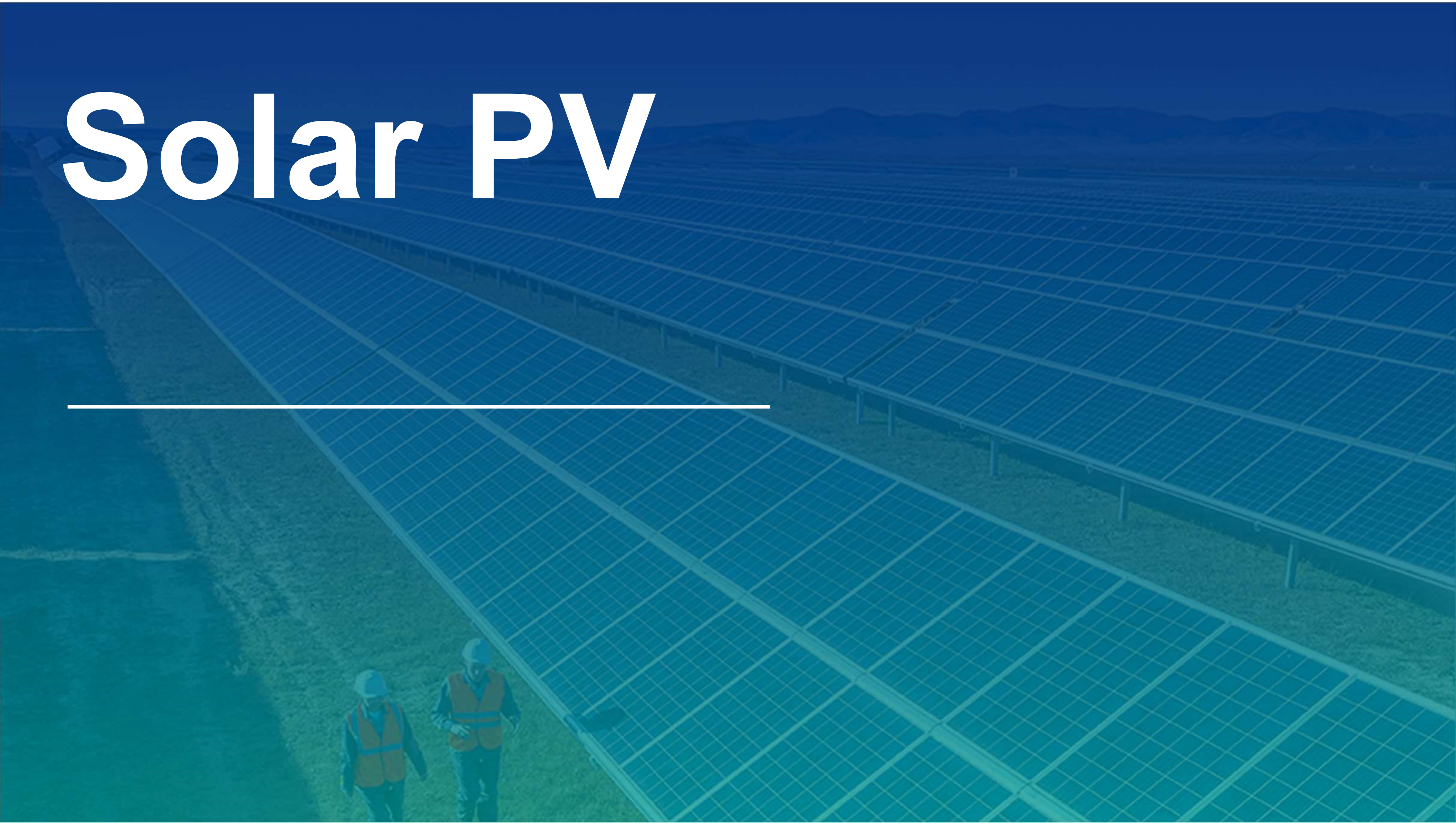
2023+

Why Asia



Source: *IRENA World Energy Transitions Outlook 2022*

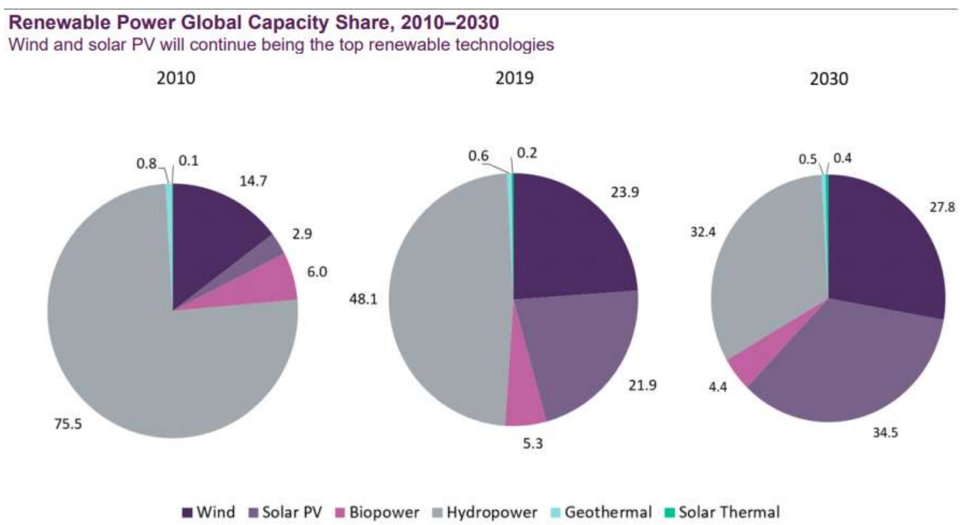
Solar PV

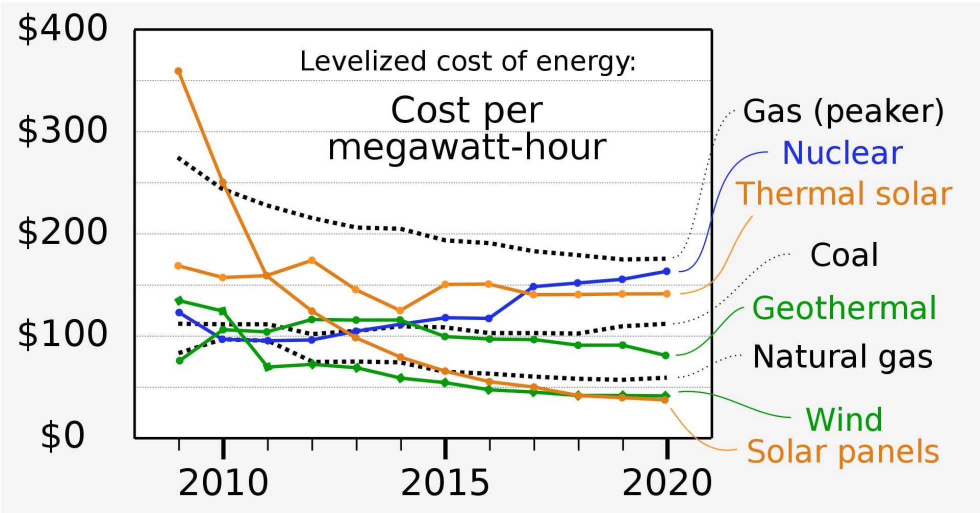


Solar PV

The rise of Solar

- Now cheapest ever in terms of both installation cost and off-taking;
- Fastest growing renewable energy source worldwide;
- Renewable energy adoption to continue its upward trend expected;





Solar PV

Limitations

Space: see visual

Efficiency:

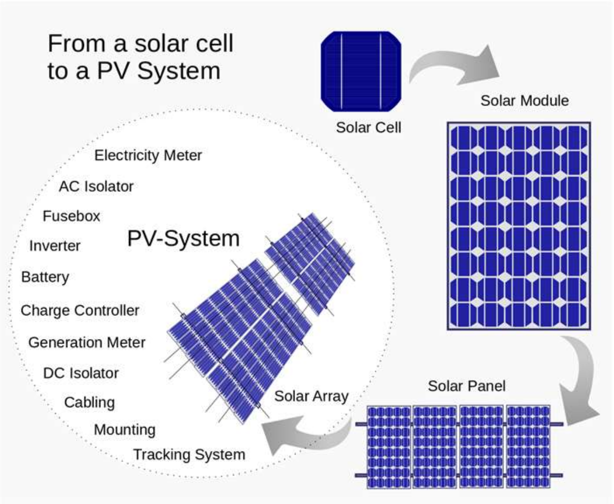
- 95% of the global market share is crystalline silicon solar panel type, ultra-thin layers as thin as a few nanometers;
- Expected maximum efficiency estimated to be around 26%, via developing and applying functional layers to the silicon wafers.

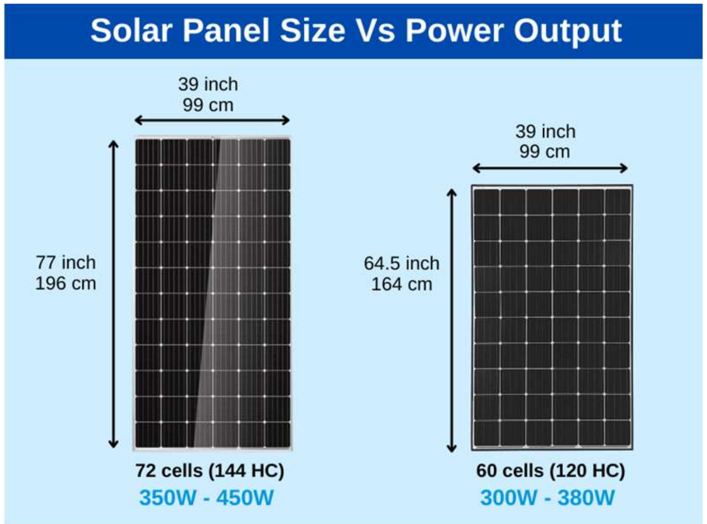
MW output:

- Solar cells use only the high-frequency part of solar radiation, while the low-frequency heat energy is wasted;
- Idea: use of thermoelectric devices in tandem with solar cells to increase the efficiency of the combined solar/thermoelectric system to convert solar radiation into useful electricity.

Intermittency: lack of sunlight

Electrical storage: age old discussion





Solar PV

Solutions

Space: Floating PV placed on water bodies

Efficiency:

- Perovskite solar cells are cheap to produce and simple to manufacture; Perovskite solar cell efficiencies have increased from 3.8% (2009) to 25.5% (2020), exceeding the maximum efficiency of silicon solar cells;

- With the potential of achieving even higher efficiencies and very low production costs, they have become commercially attractive.

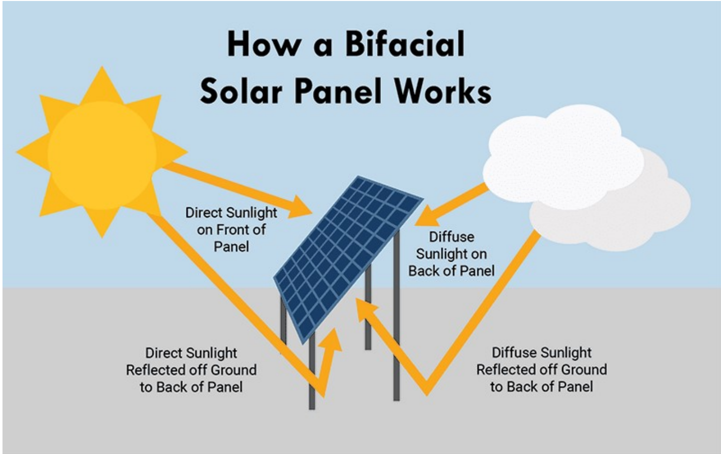
MW output:

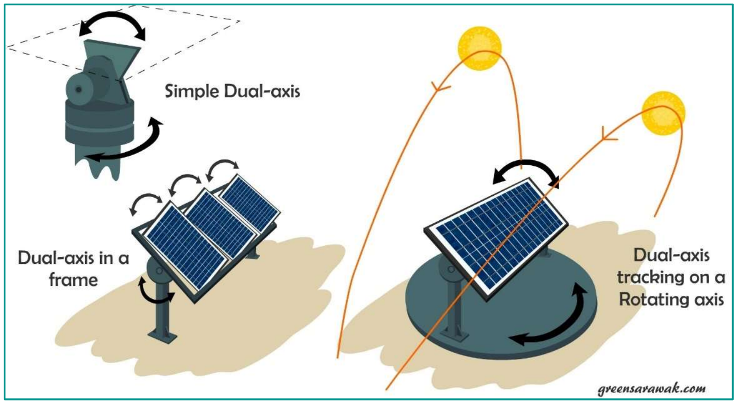
- Standard solar panels capture sunlight on one side; Bifacial panels can provide 10-20% higher energy yield. Higher yield and comparable production costs result in lower kWh costs.

- PV tracking systems replace fixed orientation. Dual axis systems further aim to capture max. sun rays by movement in four directions.

Intermittency: hybrid grid structure

Electrical storage: technological advancements (see late slide)



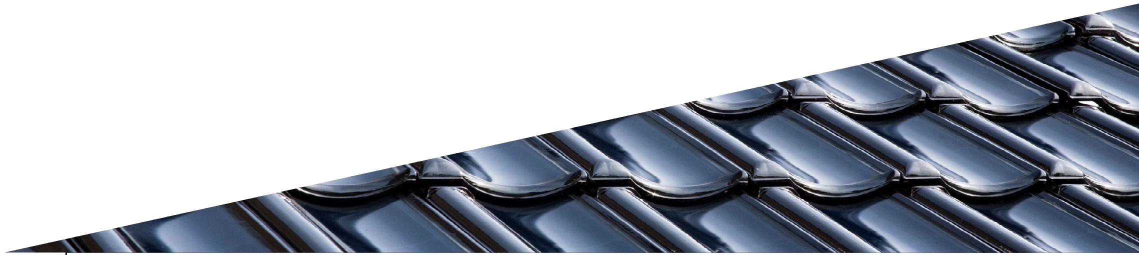


Solar PV

What’s next in solar?

Solar PV

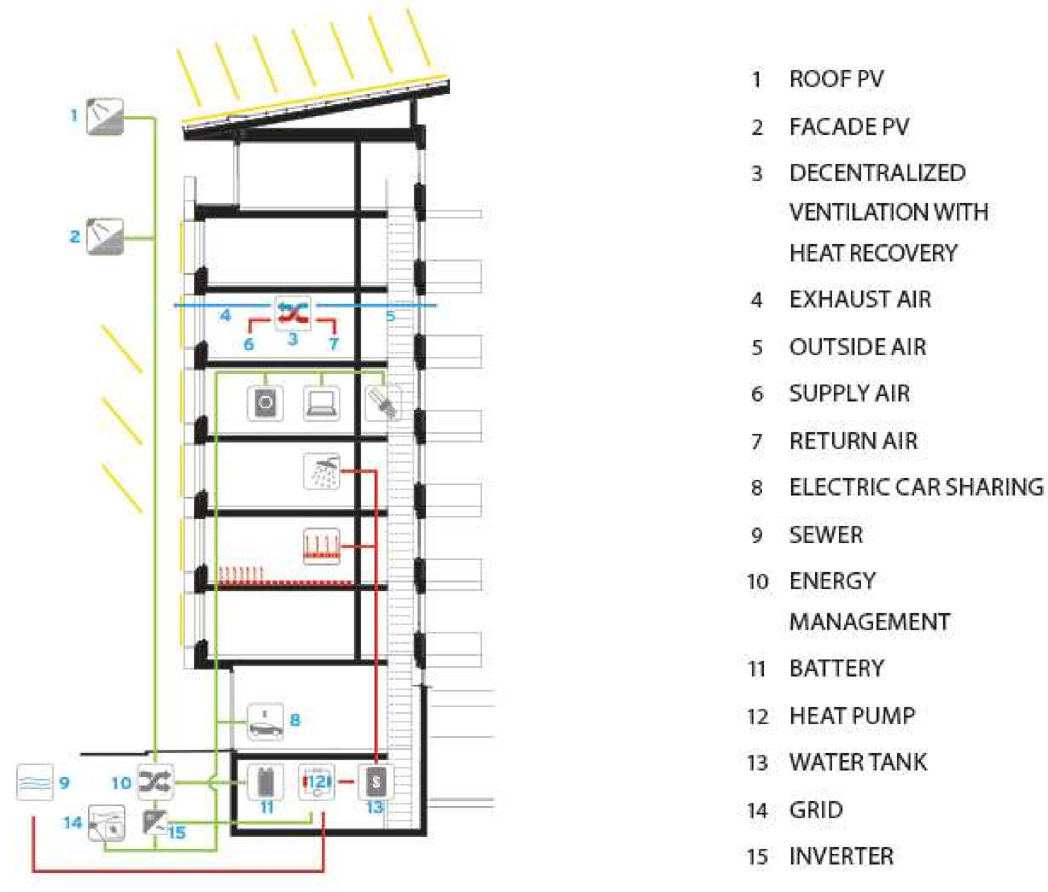
Building Integrated Photovoltaics (BIPV)



Purpose: dual, as outer layer of a structure and electricity generation.

Application: As retrofit, or included in initial building design (without costs and design issues for separate mounting systems).

- **Façade –** Integrated into the sides of buildings, replacing traditional glass windows with semi-transparent thin-film or crystalline solar panels. As retrofit to camouflage unattractive or degraded building exteriors.
- **Rooftops –** Replaces roofing material or the roof itself. Either an integrated, single-piece solar rooftop made with laminated glass or solar “shingles” instead of regular shingles.
- **Glazing –** Ultra-thin solar cells as semi-transparent surfaces, allow daylight to penetrate while simultaneously generating electricity. Often used to create PV skylights or greenhouses.



ENERGY CONCEPT DIAGRAM

Onshore Wind

Onshore Wind

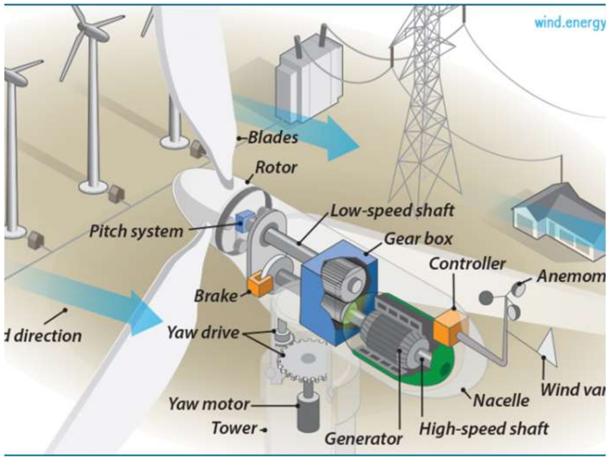
The rise of Wind

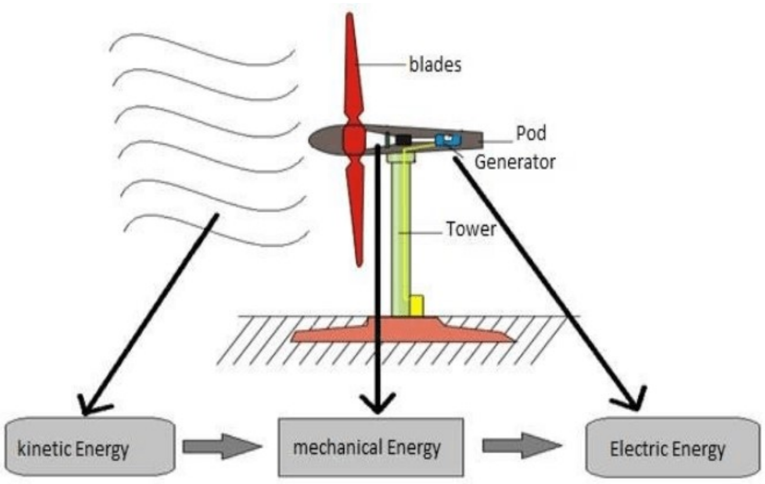
Humans have long harnessed the kinetic energy from wind to drive mechanical energy and subsequently to generate electrical energy.

3 blades take the kinetic energy into rotational power into the main shaft coming in to the turbine. Either gear box or direct drive technology applied to then generate electricity.

Escalation of size and output has been significant. Profile of the large scale onshore turbines:

- Today up to 6.5MW; rapidly increasing;
- One turbine can produce enough energy for 10,000 homes;
- One rotation = enough to power your house for a few days;
- Heights of 250m (at blade tip).





Onshore Wind

Limitations

Space:

- Direct land use is a measure of the area of such things as the concrete tower pad, the substations and access roads.
- In the US, the direct land use for wind turbines comes in at three-quarters of an acre per megawatt of rated capacity. That is, a 2MW wind turbine would require 1.5 acres of land.

Shelf life: Pace of advancements means the technology used in relatively new installations from 10 to 15 years ago is becoming increasingly redundant. Sound investment?

Maintenance & Access: Access to nacelle is a time and physically intensive task. Other maintenance considerations:

- 100m long blade inspection
- Suspended in the air

Intermittency: lack of wind

Electrical storage: age old discussion

Onshore Wind

Solutions

Space: offshore or even airborne turbines?

Shelf life:

- Repowering older projects;
- Reduces no. of turbines at a site and higher electricity production.

Maintenance & Access: Use of data driven solutions including integration of robotics to:

- assist with self-maintenance, remote monitoring; and
- cutting down on human servicing hours.

Intermittency: hybrid grid structures

Electrical storage: technological advancements (see later slides)

Battery Energy Storage Systems

Battery Energy Storage Systems

Solutions for electrical storage

Electricity cannot itself be stored on any scale, but it can be converted to other forms of energy which can be stored and later reconverted to electricity on demand.

Storage solutions include:

- Pumped hydroelectric: Electricity is used to pump water up to a reservoir.
- Compressed air: Electricity is used to compress air and store it, often in underground caverns.
- Flywheels: Maintaining energy in a system as rotational energy.
- Thermal energy storage: Molten salt or aluminium
- **Batteries:** Conversion of chemical energy to electrical energy requiring anodes and cathodes
  - Positively charged lithium ions shuffle from one electrode to the other
  - Negatively charged electrons flow through your device (phone, laptop) to power as you go

Battery Energy Storage Systems

Limitations

Supply: Competing interests (grid needs, domestic usage and a big electric vehicle push) may cause capacity issues.

Manufacturing capability: Limited owing to

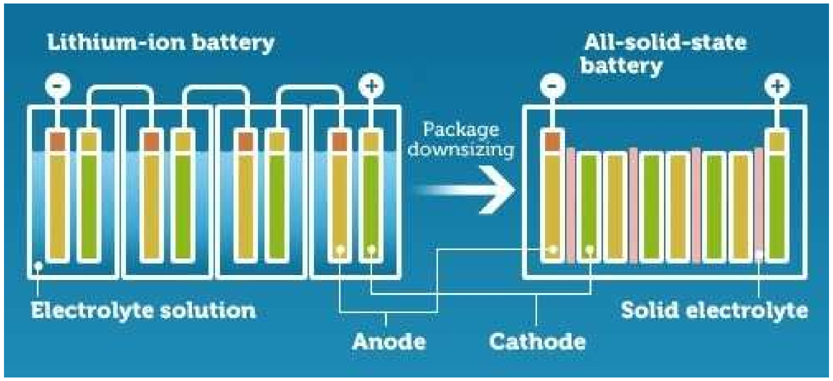
- Slow investment take up and
- Finite supplies of raw metals such nickel & lithium.

Shelf life: Average shelf life is between 3-6 years.

Storage conditions: Requires climate controlled storage in dry and cool conditions away from other batteries or metal objects.

Battery Energy Storage Systems

Solutions



Aims:

- Faster charging
- Safer (less flammable)
- Longer life
- Cheaper and smaller to produce

- The lithium-ion battery is the future of sustainable energy technology. Recently, researchers have found that changing the chemical compounds of the anodes is a simple and low-cost means of reducing volume expansion while improving the energy density of these batteries.

- Future technology**:** A solid-state battery is a battery technology that uses solid electrodes and a solid electrolyte, instead of the liquid electrolytes found in lithium-ion or lithium polymer batteries. They are potentially safer, with higher energy densities, but at a much higher cost. Challenges to widespread adoption include energy and power density, durability, material costs, sensitivity and stability.

Hydrogen

Energy Storage

Hydrogen Energy Storage

The rise of Hydrogen

The concept is to use Hydrogen as an energy carrier and transition solution to store renewable energy, with zero Co2 emissions.

Three different forms of hydrogen

Grey Hydrogen:
Made from hydrocarbons
CO_2 emitted

Carbon Emitting Sources, such as partial oxidation, hydro carbon reforming, coal gasification

Blue Hydrogen:
Made from natural gas + carbon capture, utilisation, storage (CCUS)

Steam-Methane Reforming is a form of syngas processing, produce hydrogen from methane. **CO_2 is captured**, not emitted

Green Hydrogen:
Made using renewable electricity, with zero CO_2 emissions

Electrolysis using renewable electricity. No carbon involved

Hydrogen Energy Storage

Limitations

Storage: Owing to its low density, H2 must be compressed to a liquid state & stored the same way at lower temperatures to ensure its effectiveness and efficiency.

Cost: Electrolysis and steam reforming, the two main processes of hydrogen extraction, are extremely expensive. This is the reason it's not heavily used across the world.

Safety: H2 is a highly flammable and volatile substance, it also lacks smell making leakage difficult to detect.

Transportation: For most of the above reasons, transportation of large batches of hydrogen is extremely challenging. The race is on to pioneer hydrogen shipping. The major challenge is to keep the hydrogen chilled at minus 253 degrees Celsius—only 20 degrees above absolute zero—so it stays in liquid form, while avoiding the risk that parts of a vessel could crack.

Infrastructure: The race is also on to develop or retrofit pipelines and grid infrastructure which is well established for conventional sources (oil, gas etc.)

Hydrogen Energy Storage

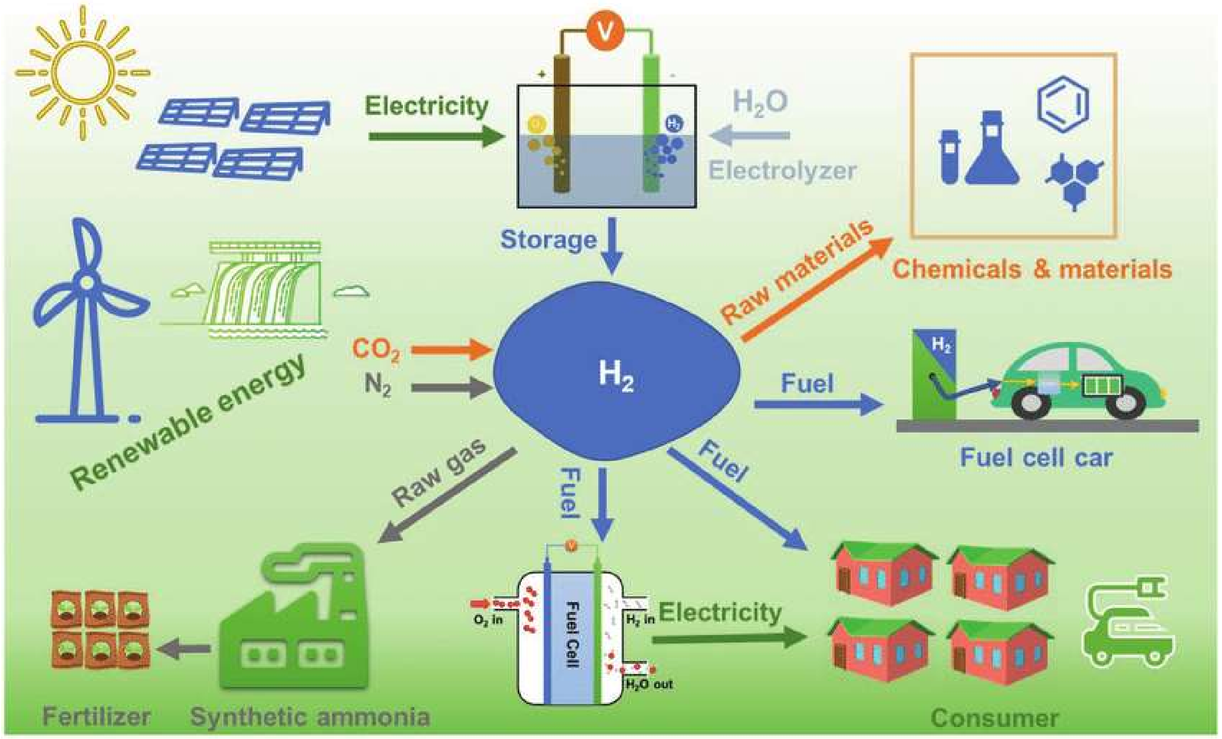
Solutions

Investment:

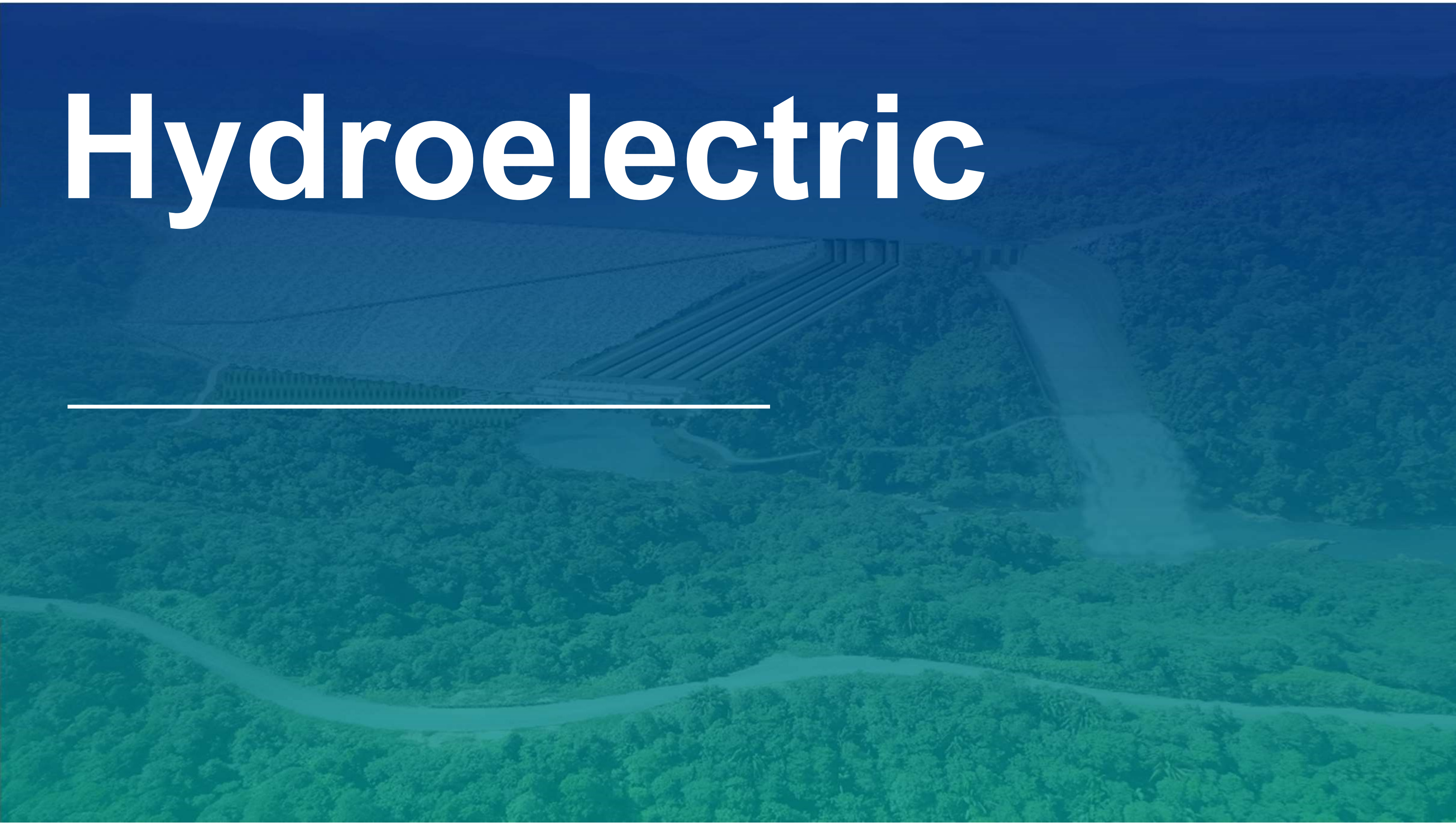
- By 2030, some USD 300bn is to be invested in the entire sector;
- Not just to the value chain but also to achieve economies of scale and to bring down costs;
- Only part of this sum will be financed by the public sector with USD 70bn announced to date which underscores the extent of private sector finance.

The Hydrogen Economy:

The hydrogen economy is an envisioned future in which hydrogen is used as a fuel for heat and hydrogen vehicles, for energy storage, and for long distance transport of energy.



Hydroelectric



HYDRO

Hydro Power

- **Today**
  - Mature technology, major energy generation capacity
  - Best large-scale sites already developed in many countries
- **Outlook**
  - Small-scale hydro and 'run-of-river' projects
    - ✓ Many suitable sites
    - ✓ Can meet local power requirements
    - ✓ Lower environmental impact

HYDRO

- Long-established technology, widely deployed, major energy generation capacity
- Drawbacks associated with some schemes (mainly large-scale):
  - Potential increased seismicity in vulnerable areas
  - Ecosystem impacts (e.g. downstream flood and sediment regime)
  - Displacement of communities
- Trends and future developments:
  - Best large-scale sites already developed in many countries or environmental concerns limit future deployment
  - Major projects still being proposed in some territories
  - Pumped storage projects
  - Major potential for small-scale hydro and 'run-of-river' projects:
    - Many suitable sites
    - Can meet local power requirements
    - Lower environmental impact

HYDRO

Insurance issues:

- Project sites tend to be in remote and hard to reach locations, leading to logistic problems in the event of a loss
- Hydro breakdown of key parts very common, leading to large claims
- Natural Peril risk very high, i.e. flood, landslide and snow slide in vicinity of project site
- Catastrophic losses can attract very high loss quantum i.e. 2009 Sayano–Shushenskaya hydro power station accident, Oroville Dam, Xepian-Xe Nam Noy, Kenyir

Hydro Power

Key Concerns

- Potential increased seismicity in vulnerable areas
- Ecosystem impacts (i.e. downstream flood and sediment regime)
- Displacement of communities
- Flood
- Remote locations
- Land slide and snow slide
- Hydro breakdown of key parts
- Turbine failure
- Bursting of the dam leading to people losing lives and homes

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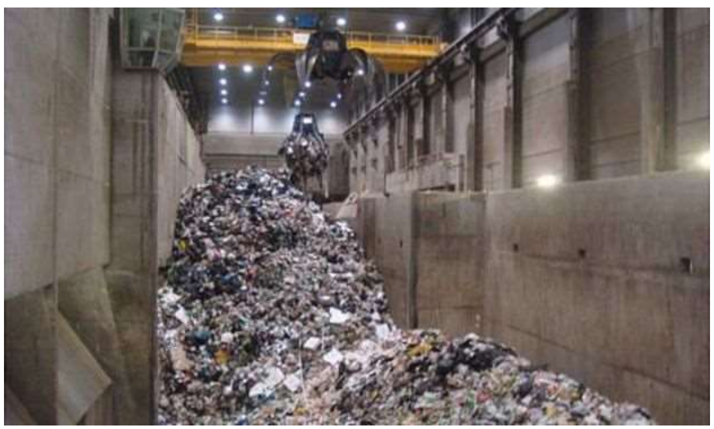
Biofuels / Waste to Energy

Waste to Energy (Biomass)

- **General**
  Broad term including production of heat, electricity or fuel from organic material
  - Biomass combustion for energy (‘Energy-from-Waste’)
  - Biomass digestion for energy (landfill gas, anaerobic digestion)
  - Biofuel – biomass conversion to bioethanol / biodiesel
- **Feed stocks**
  - Agricultural wastes (e.g. straw, crop residues)
  - Crops grown specifically for energy / fuel
    (e.g. oil seed rape, sugar cane)
  - Other wastes
    (e.g. food production, tires, wood)

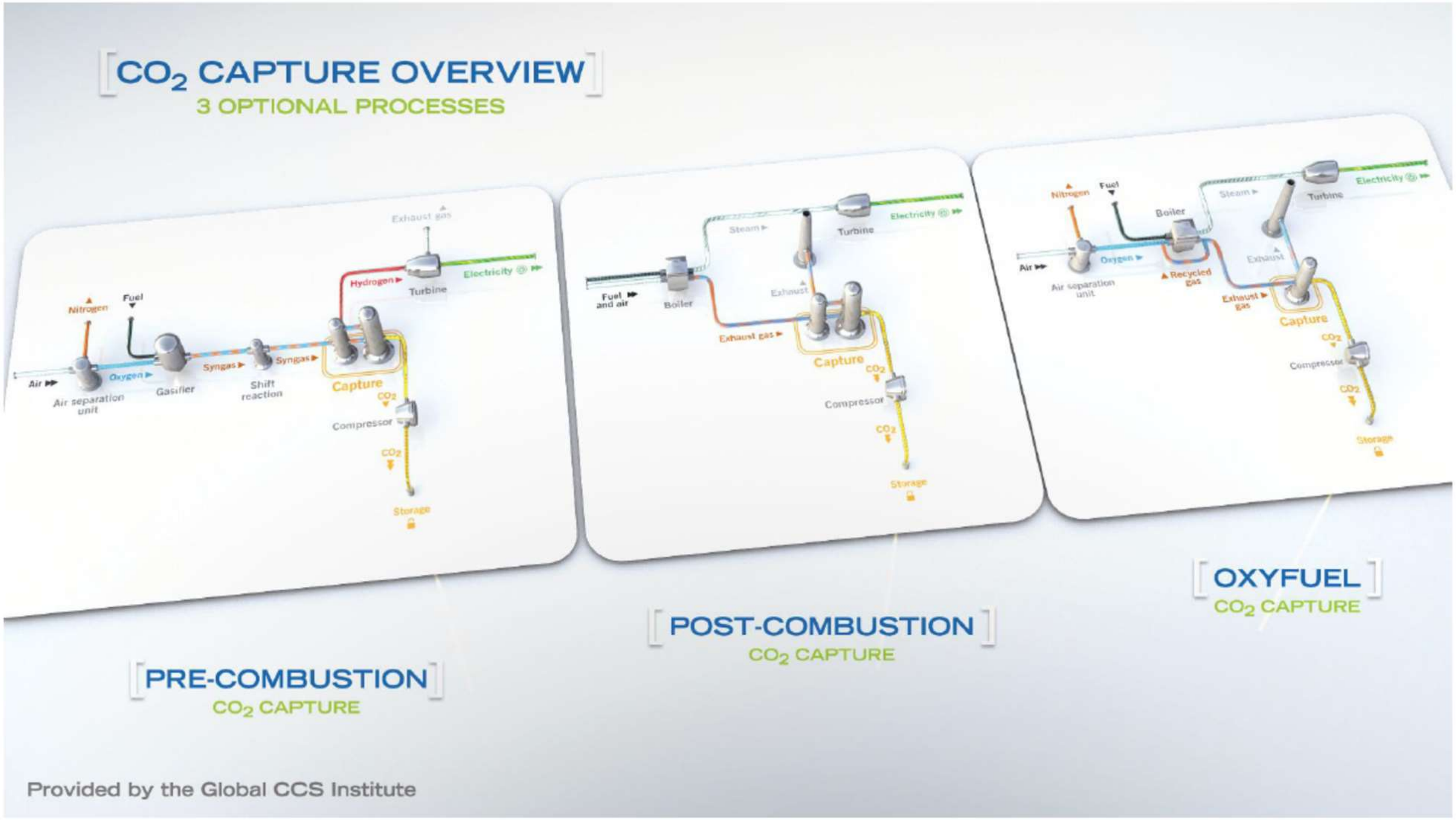
Waste to Energy (Biomass)

Key Concerns	
• Prototypical technology	• Fire Hot Spots
• Pollution	• Testing & commissioning
• Faulty design / non-performance	• Combustion



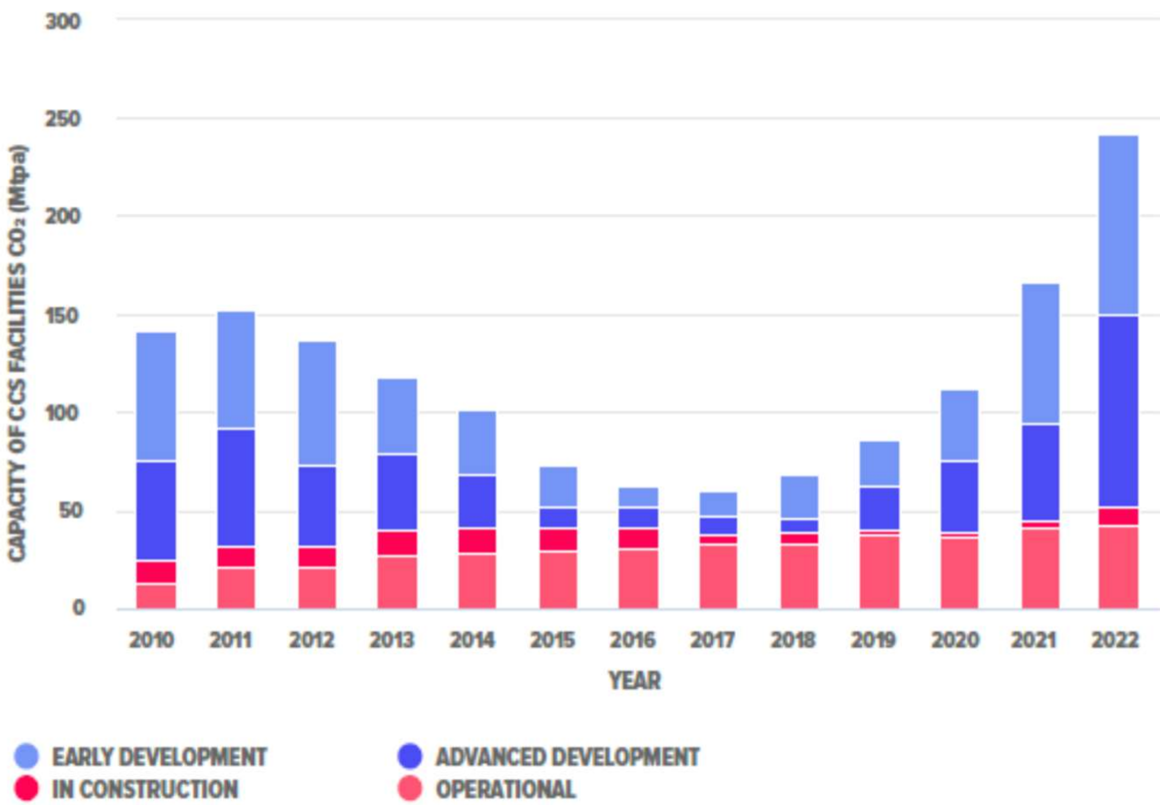
Carbon Capture, Utilization & Storage (CCUS)

Different approaches to capturing CO_2



CCUS 2010 - 2022

PIPELINE OF COMMERCIAL CCS FACILITIES BY CAPTURE CAPACITY



	OPERATIONAL	IN CONSTRUCTION	ADVANCED DEVELOPMENT	EARLY DEVELOPMENT	OPERATION SUSPENDED	TOTAL
NUMBER OF FACILITIES	30	11	78	75	2	196
CAPTURE CAPACITY (Mtpa)	42.5	9.6	97.6	91.8	2.3	243.9

Source : globalccsinstitute.com

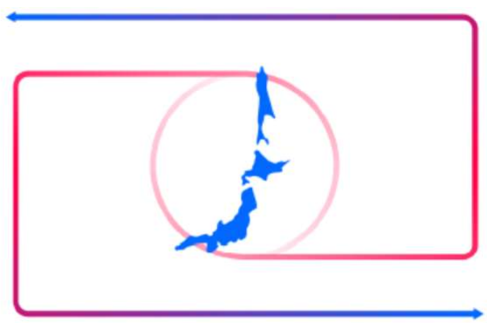
CCUS – Asia Pacific

The Australian Government has included CCS in the Emissions Reduction Fund, providing the first financial incentive scheme for CCS in the Asia Pacific region.

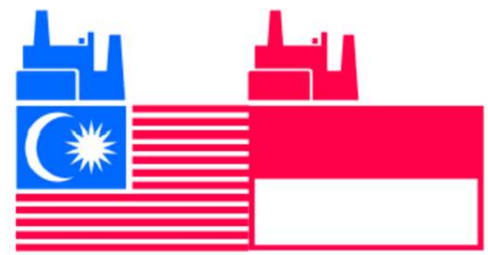
AUSTRALIA INCLUDES CCS IN EMISSIONS REDUCTION FUND

China launched its emissions trading system, covering 2,225 power plants, which collectively emit over 4,000 million tonnes of CO_2 per annum.

Japan continues to be a regional driver of CCS, promoting regional collaboration and exploring low-carbon energy exports.



The first commercial CCS projects were announced in both Indonesia and Malaysia.



FIRST COMMERCIAL PROJECTS FOR MALAYSIA & INDONESIA

CCUS Project Announcements

NEW COMMERCIAL CCS PROJECTS IN THE ASIA PACIFIC REGION

CCS FACILITY	COUNTRY	INDUSTRY	STAGE OF DEVELOPMENT	EXPECTED START OF OPERATION
Guodian Taizhou Power Station Carbon Capture	China	Power	In construction	2023
Petronas Kasawari Gas Field Development Project	Malaysia	Natural Gas Processing	Early development	2025
Repsol Sakakemang Carbon Capture and Injection	Indonesia	Natural Gas Processing	Early development	2026
Bridgeport Energy Moonie CCUS Project	Australia	Power	Advanced development	2028 or earlier
PAU Central Sulawesi Clean Fuel Ammonia Production with CCUS	Indonesia	Chemical/Ammonia	Early development	Late 2020s

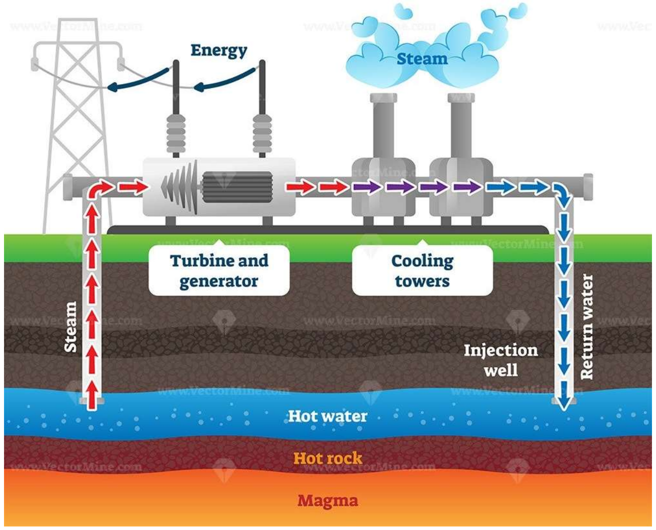
Company	Segment	CCS Target
BP Tangguh LNG	LNG Liquefaction CCS EOR	2.5 MT/year
Venture Global LNG	LNG Liquefaction (2) CCS EOR	1 MT/year
Santos Moomba	NG CCS	1.7 MT/year
Oxy (Low Carbon Ventures); USA*	Direct Air Capture	1 MT/year
Northern Lights; Norway (Project longship)	CCS Storage and Transportation	3 MT/year
Horizont Energi; Norway	Blue NH3 and CCS Storage and Transport	2 MT/year
Exxon	Houston CCS hub	Not estimated – but $100B Capex
Pertamina / Exxon	Gundih CCS Storage and Transportation	Not estimated – but $500MM Capex

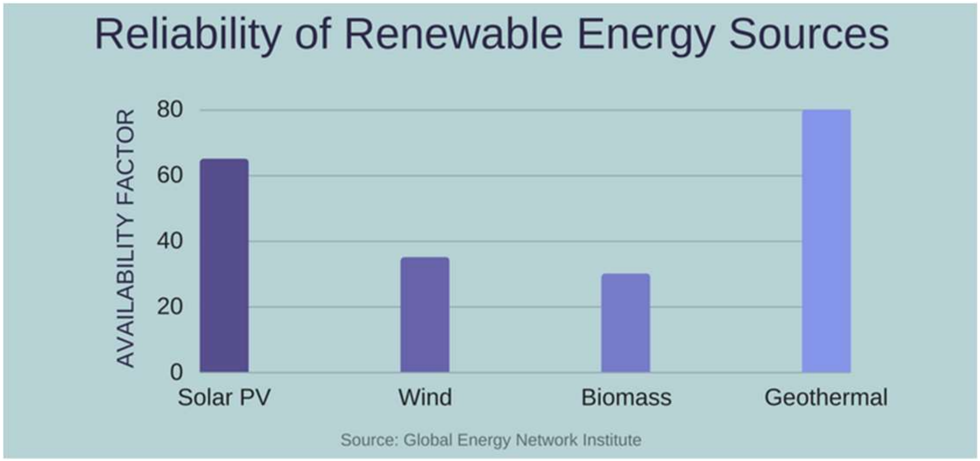
Geo thermal

Energy

GEOTHERMAL

- Well established but limited deployment (approx. 10 GW globally)
- Three main types of geothermal plant:
  - Dry steam – direct use of geothermal steam to generate electricity (old plant)
  - Flash steam – hot (>180°C) geothermal water flashed to steam in low pressure tank to drive generator (most plants)
  - Binary cycle – lower temp water (>60°C) used to flash secondary fluid with lower boiling point which used to drive generators (new plants)





GEOTHERMAL

- **Potential for wider deployment:**
  - Latest technology allows usage of much lower temperature water
  - Improved drilling technology (depth, horizontal drilling, stimulation)
  - Combination with district heating
  - Future hot rock geothermal – not dependent on tectonically active areas
- **Engineering / insurance issues:**
  - Pollution issues; drilling risks; resource development risk
  - General civil engineering construction issues
  - Control of Well Insurance requirement for drilling
- **Environmental concerns about Greenhouse Emissions:**
  - Extraction of geothermal energy leads to a release of greenhouse gases like hydrogen sulfide, carbon dioxide, methane and ammonia.
  - However, gas released is significantly lower of fossil fuels.

Geothermal Energy

Limitations

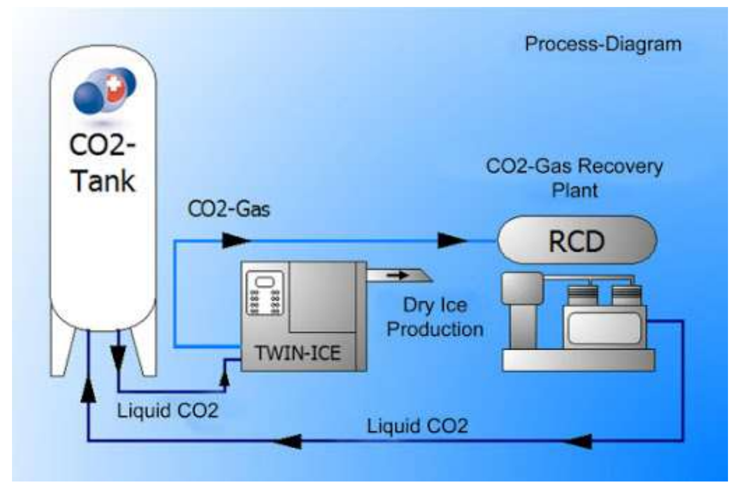
Space: land requirement.

High Investment Cost: The need for drilling and installing quite a complex system makes the price climb. Nevertheless, the return on such investment is promising.

Geology: Composition and properties of soil and rock can affect heat transfer rates and therefore need to be taken into consideration for designing geothermal systems.

Hydrology: Ground and surface water influence the type of ground loop, as well as groundwater can be used as a source for open-loop system, if the water quality is sufficient.

Environmental concerns about Greenhouse Emissions: The extraction of geothermal energy from the grounds leads to a release of greenhouse gases like hydrogen sulfide, carbon dioxide, methane and ammonia. However, the amount of gas released is significantly lower than in the case of fossil fuels.



Conclusion

And Q&A

Future of our energy mix

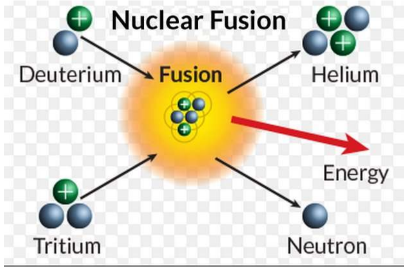
Looking further ahead – Nuclear Fusion?

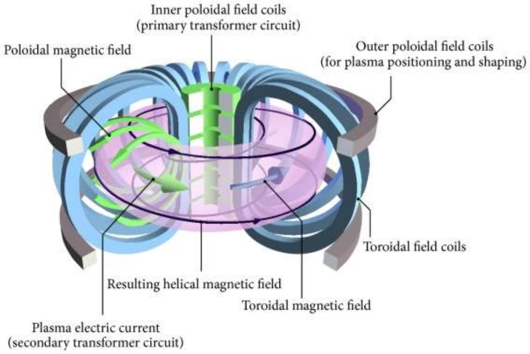
International Thermonuclear Experimental Reactor (ITER)

- International nuclear fusion research and engineering megaproject;
- Aimed at replicating the fusion processes of the sun to create energy on earth.
- Upon completion in 2026, it will be the world's largest magnetic confinement plasma physics experiment and the largest experimental tokamak nuclear fusion reactor.

ITER's thermonuclear fusion reactor will attempt to use 50 MW of heating power to create a plasma of 500 MW. This would mean a ten-fold gain of plasma heating power.

Commercial scale roll out??





Future generation

Smart Grids

Insurance solutions

ESG in Renewable Energy Construction

Environmental

Greenhouse gas emissions	Water consumption	Waste management	Resource management
Mineral extraction	Materials	Resource efficiency	Recycling

Social

Diversity and social inclusion	Health and well-being	Legacy planning
Community impact and integration	Education and skills	Emergency response planning

Governance

Strategies	Policies	Constitution of governing body	Procurement
Sales	Supply chain management	Stakeholder engagement	Diversity, equality, and ethics

Source: Marsh analysis

A business of Marsh McLennan