L’innovazione tecnologica nell’eolico e nel solare

Webinar Technology Watch, April 2023

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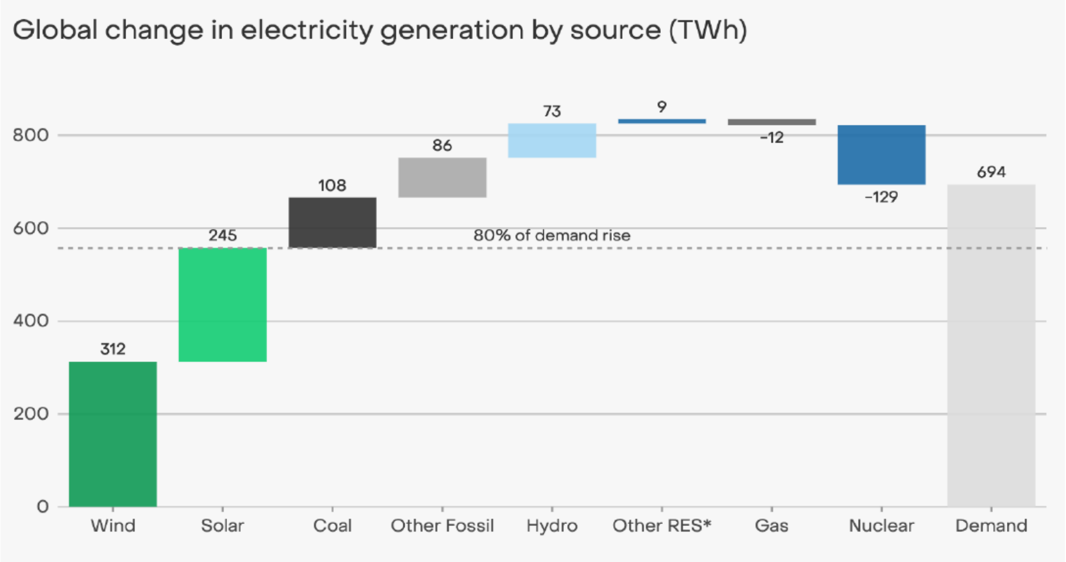
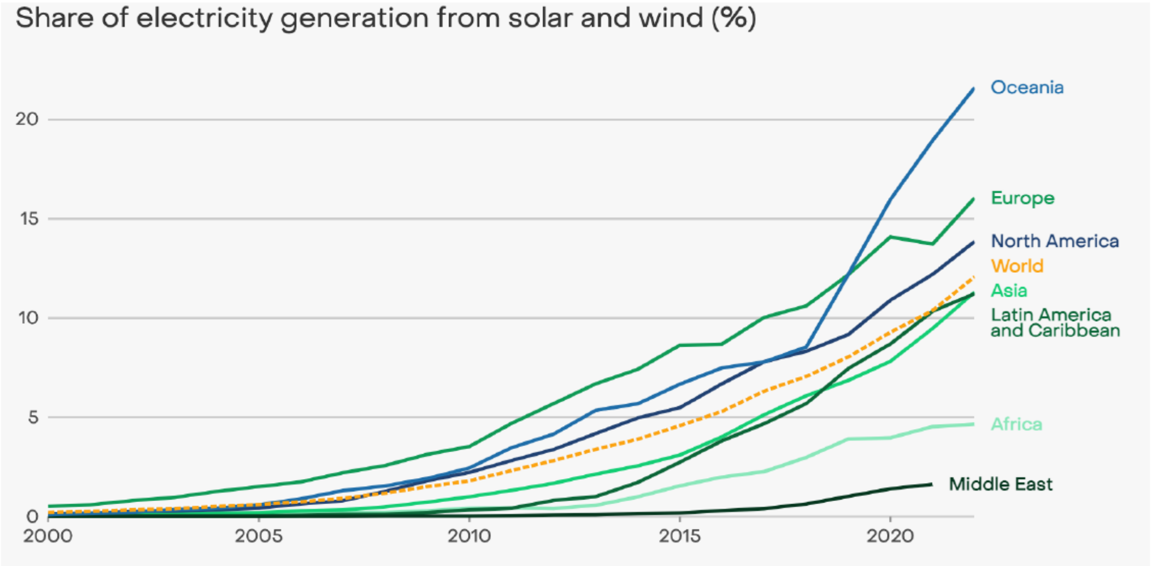
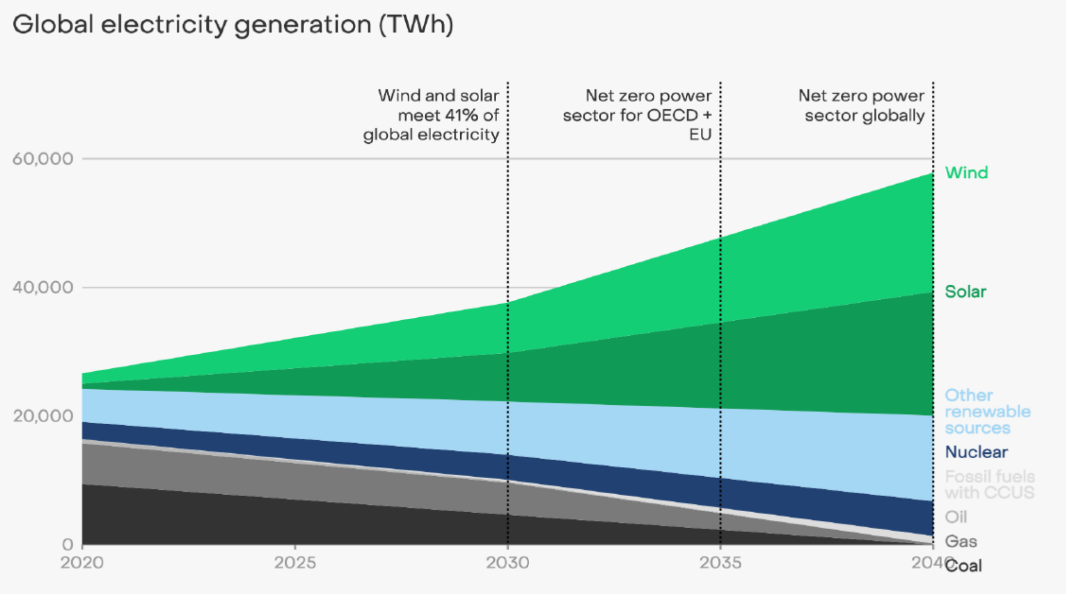
Solar and Wind – Global Electricity

Key Facts 2022

- Solar and Wind reached 12% share in the Global Electricity mix(from 10% in 2021)
- Solar generation rose by 24%, wind generation grew by 17%
- The carbon intensity fell to a record low of 436 gCO_2/kWh



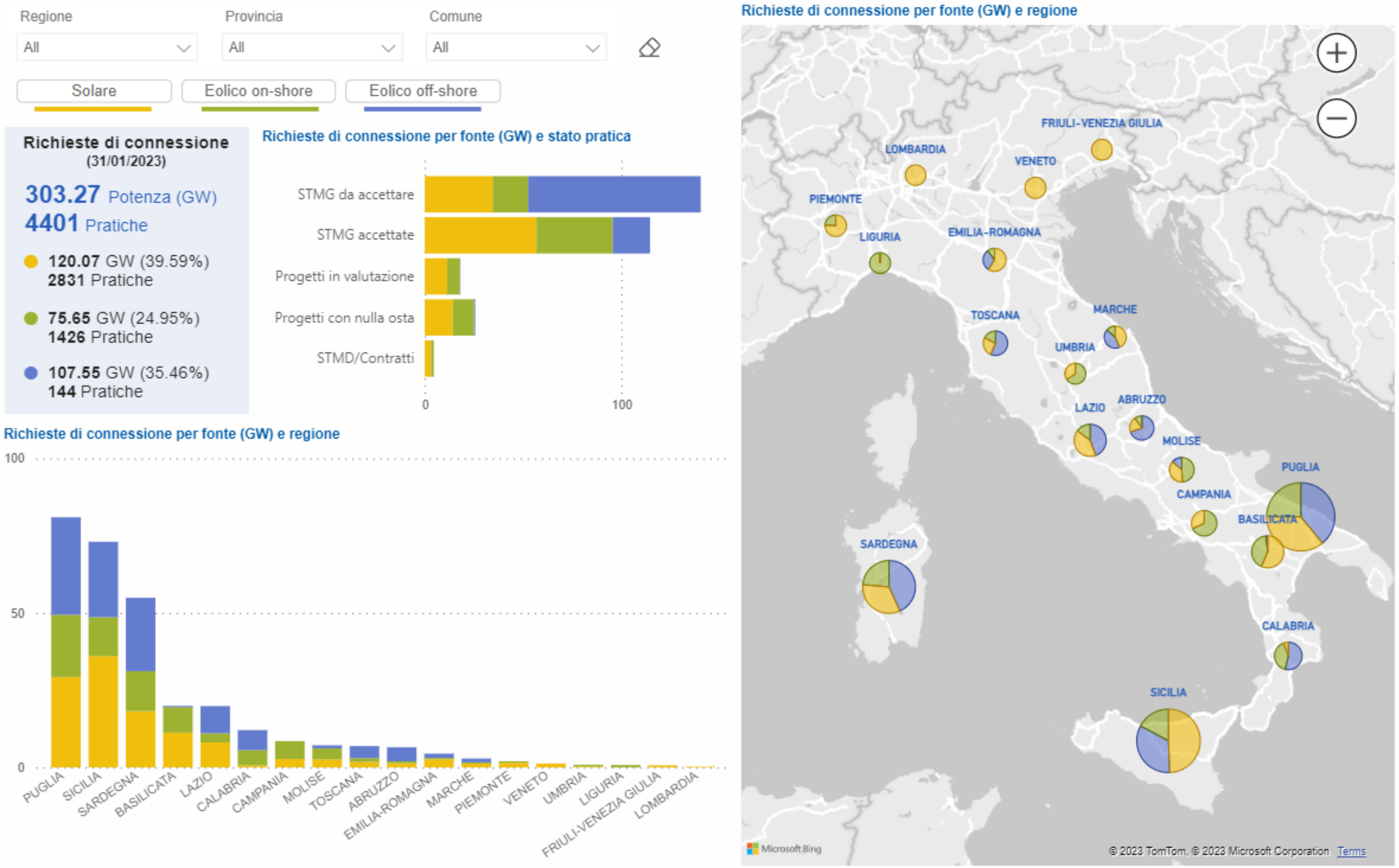




Source: EMBER Global Electricity Review 2023

Solar and Wind – Italian developments

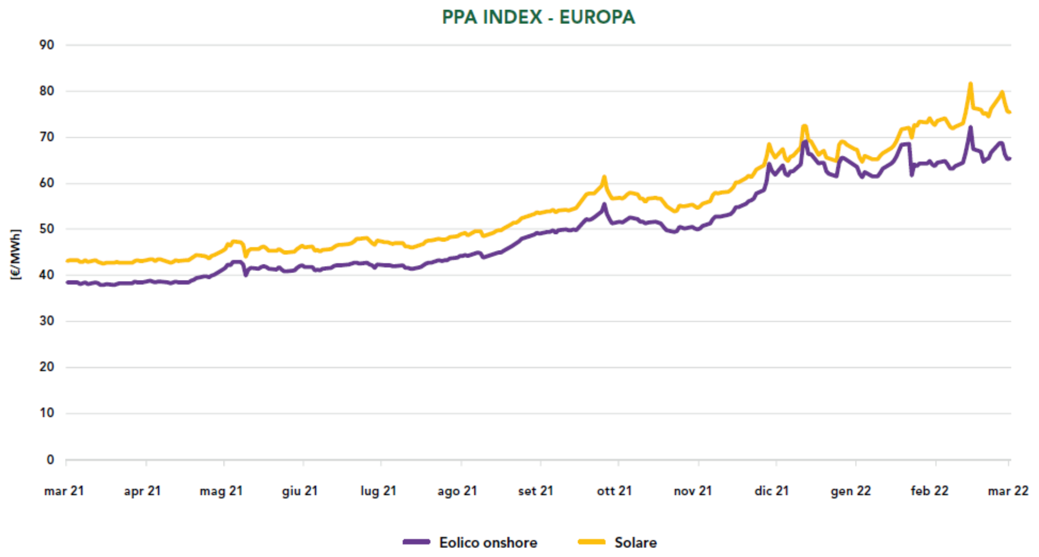
- + 85 GW of renewable power to be installed by 2030, according to Elettricità Futura 2030 Plan (83 GW of which being solar and wind)
- >300 GW of connection request (+100 GW Off-shore wind)
- Most of the projects concentrated in the South and in the Islands



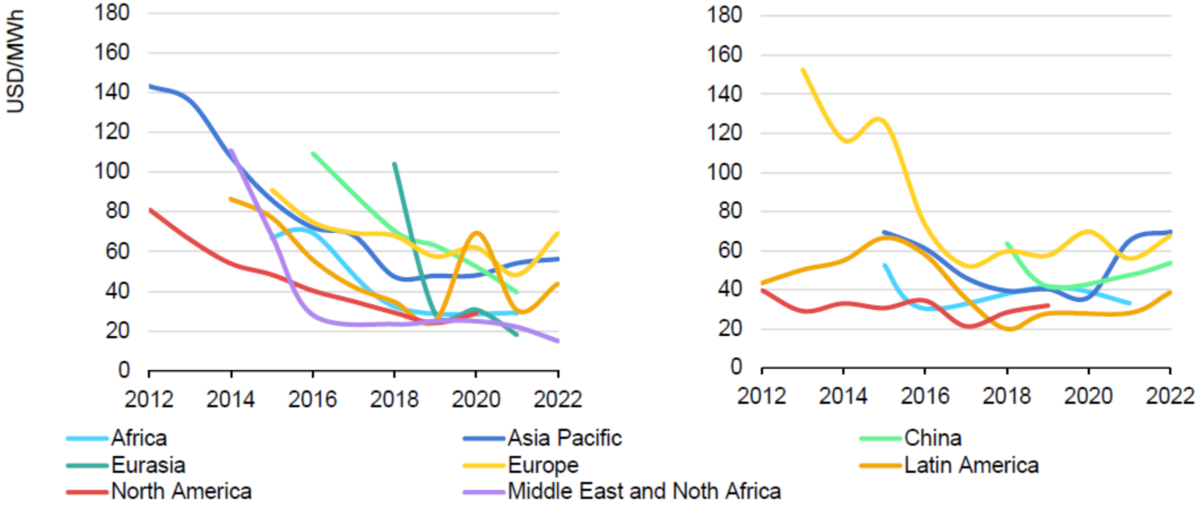
Source: TERNA Econnextion platform

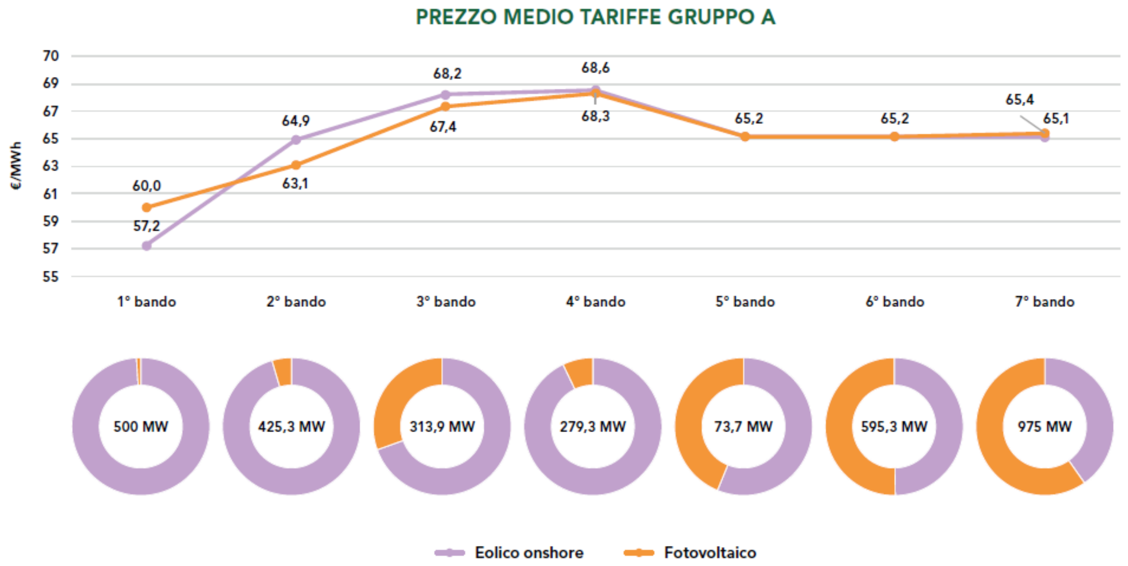
Solar and Wind – Latest Auction/PPA Prices

- After the progressive decrease of both Wind and Solar LCOE over the last 10 years prices have reached a certain “plateau”, with some geographical areas seeing LCOEs increase due to “greenflation”.
- Geographical heterogeneity



Auction contract prices for utility-scale solar PV (left) and onshore wind (right) by region

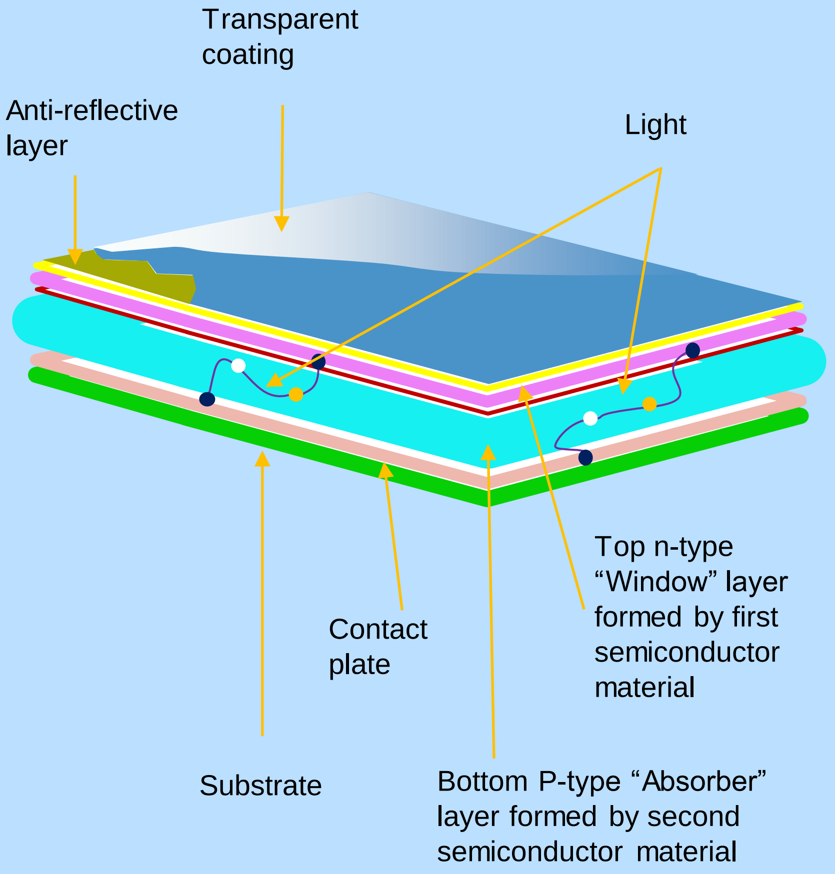




Source: EIA Renewables 2022, Energy Strategy RES Report 2022

Solar - Main innovations on cells

	Wafer-based		Thin-film			
	Crystalline silicon	**III-V compound**	**MJC**	**Conv. thin-film**	**Emerging Thin-film**	**Emerging tandems**
Market Share (2019)	95%	<0.1%	-	5%	-	-
Cost[1]	$	$$$	$$$$	$	$$	$$$
Efficiency & Eff. Increase (from 2010)	~25% (1-2%)	~30% (2-3%)	~40% (3-5%)	~22% (1-3%)	~25% (10-12%)	~30% (5-7%)
Remarks	*Mainstream but mature technology*	*High cost due to scarcity of material*	*High cost due to very complex manufact. process*	*Reduced wavelength absorption limits market adoption*	*Most promising tech. rapidly improving*	*Complex manufact. process but promising results achieved*

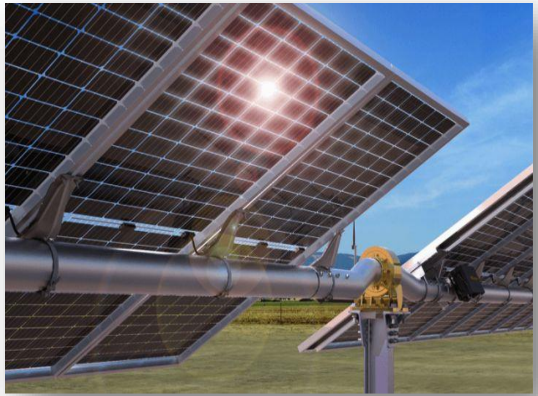


Third Generation Thin-Film Cells

Solar- Innovations on architecture and applications

Advanced module architecture technologies

Bifacial Solar Cells



Multi-busbars

Frame Type

Single axis tracking

Dual axis tracking

Innovative Application

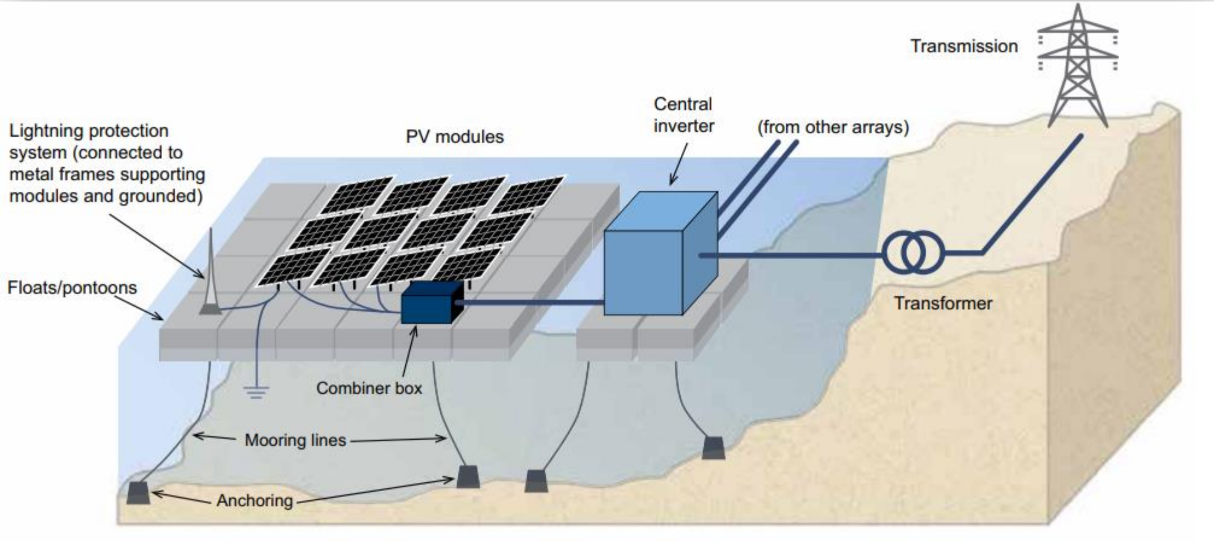
Floating Solar Farms

Agrivoltaics

Solar Trees

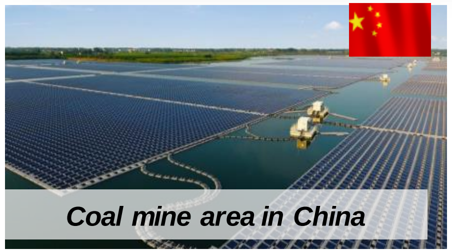
Solar Facades

Floating Solar




Sekdoorn farm in Netherlands


Nanatsujima Mega in Japan


Coal mine area in China


NTPC in India

Key Pros & Cons

+ Enable PV installation when land availability is a constraint
+ Preserves water resources (e.g., in lakes) through reduced evaporation in areas susceptible to droughts
+ Increased output by ~5–10% due to water cooling effect

− Requires ~20% additional CapEx for anchoring, mooring, and plant design
− Requires specialized equipment and installation knowledge
− Is harder to access and replace parts

Ideal conditions

- Zones with unutilized/abandoned water bodies
- Lack of available land for onshore PV

Agrivoltaics

- PV installations are blended with agricultural activities by sharing the land
- The system structure could not differ from a normal land-mounted PV installation, but depending on the agricultural activity, it might need to have a higher installation height
- In countries where the economy is agricultural-based, Agrivoltaics are considered a precursor technology for energy transition

Key Pros & Cons

+ No land competition between PV and agriculture
+ Larger energy and crops production yields by lowering the soil temperature

− High investment cost when structure is higher than standard PV
− Counterproductive effects on crops if not well-designed

Ideal conditions

- Existing agricultural activity in place
- Existent crops or animal herding not requiring the PV system to have a higher structure than a standard one

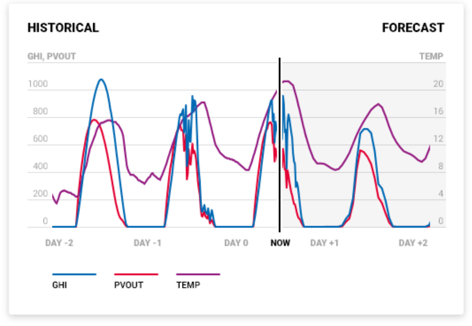
Solar - O&M innovation

Operations & maintenance systems of solar plants are also undergoing innovation, shifting towards data-driven solutions

1 DRONES FOR SOLAR PLANT MONITORING

Large-scale power plants require better tools for inspection and monitoring. **Manual inspections are thus being replaced by drone surveillance**, enabling **time efficiency and increased report accuracy for long-range inspections.**

2 SOLAR POWER OUTPUT FORECASTING



Machine Learning algorithms that are able to match weather predictions with PV solar plants' output are being developed worldwide, to enable better control of **electricity grid stability.**

3 ANTI-SOILING SOLUTIONS

Advanced panel-cleaning solutions to prevent loss of efficiency due to soiling, including **robotic panel cleaning technology**, and **sprinkler systems** that dispense water and soap to clean solar panels.

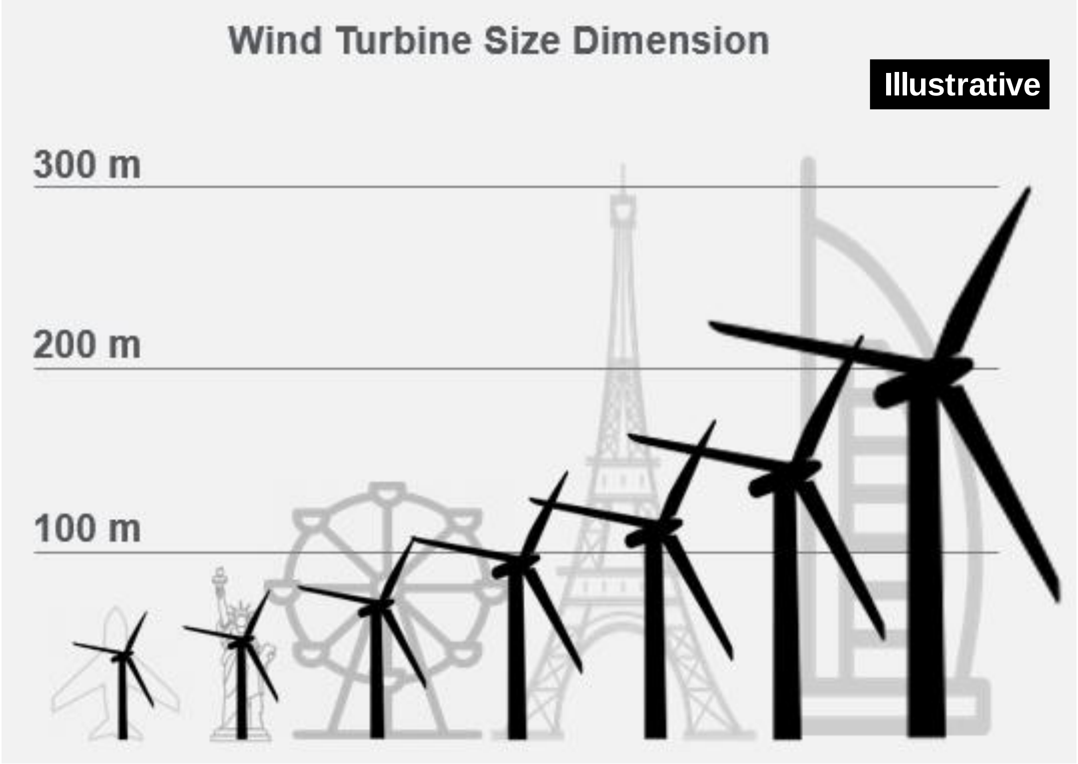
4 SOLAR POWER COOLANT

Solutions aimed to keep solar PV modules cool[1] and thus extend their performance. Most prominent is **Coolsheet system, heat exchanger panel that can be attached to the back of any brand of Solar PV panels.**

Wind - Turbine size, height and capacity

Advancements in turbine size and height are driving improved power output for wind power projects

- Continued trend towards taller and higher capacity turbines
- Over 40% projects in 2022 with over 150m height
- 15 MW turbine platforms in market
- 239% increase in avg. rated capacity since 1999



Output (MW)	0.5	1.2	2	3.6	4.2	6.6	13-15
Rotor Diameter (m)	40	70	90	117	136	170	236

Wind - Rotor & blade technological advancements

Increasing rotor diameter

- Significant **rotor scaling in past years**
- **85% of new turbines are more than 110 m diameter**, no turbine over 100 m in 2008

- Increased electricity generation with more wind kinetic energy harnessed

- High costs for >10 MW turbines (2.5% premium/MW)

Blade shape

- **Slightly curved blades** could capture 12% more wind
- Shape changes can help minimize mass with high strength

- Optimized wind capture
- Lighter blades with aeroelastic stability

- Increased manufacturing complexity

Blade material & design

- Blade made from **fiberglass-reinforced epoxy resin**
- **Siemens patented tech.**
- One integrated structure of blade

- Optimal aerodynamics
- Reduced exposure to cracking or water ingress

- Complex and patented manufacturing technology

Wind – innovative applications

Multi-Rotor Turbines

A test turbine in Roskilde, Denmark

A concept of a large-scale multi-rotor turbines with two or more rotors atop a single support structure

VWT in Open Spaces

VWT in a park, USA

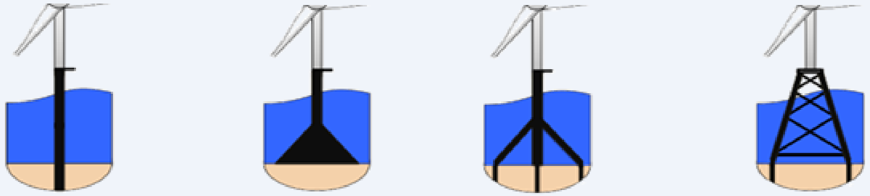
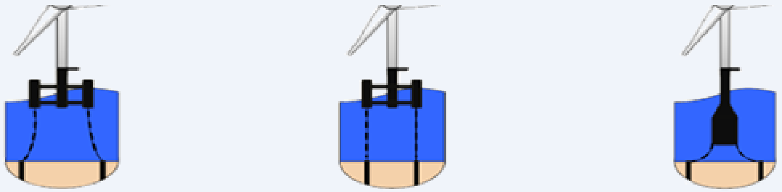
Vertical wind turbines installed in series in parks and open spaces that benefit surrounding communities

Skyscrapers with Wind Turbines

London Razor skyscraper

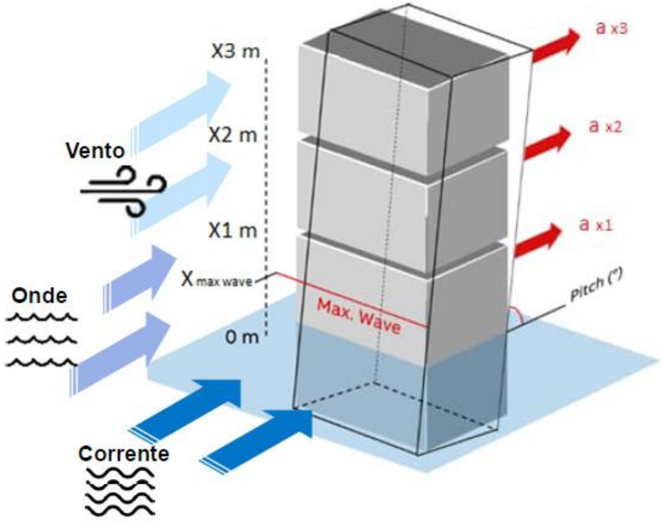
Wind turbines integrated into architecture of buildings, contributing to their energy needs

Off-Shore Wind - Traditional vs. floating

	Fixed-bottom Wind Turbines	Floating Wind Turbines
Description	Wind turbines are attached **directly to the seabed in water depth less than around 80 m**	Wind turbines are **mounted on a floating structure in water depth up to 1km**
Water Depth	*< 30 m* (Gravity-based, Monopile); *30 to 80 m* (Tripod, Jacket)	*80 m to 1 km*
Types	 *Gravity-based*, *Monopile*, *Tripod*, *Jacket*	 *Semi-submersible*, *Tension leg platform*, *Floating spar buoy*
Prevalence	**12%** (Gravity-based), **76%** (Monopile), **5%** (Tripod), **6%** (Jacket)	**Early-stage development**
Advantages	• **Still cost-superior** as a mature technology • **Easier to install** as it doesn't require extra-heavy-duty cables	• **Access to stronger winds** as it's further from the shore • **Easier maintenance** compared to fixed-bottom turbines

Off-Shore Wind – technological challenges

Off-shore Wind share is expected to increase exponentially to constitute ~17% of global market by 2050



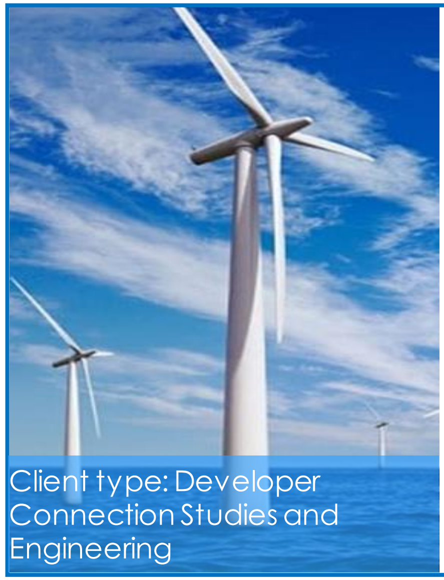
Source: TERNA, Hitachi Energy

CESI support to Off-Shore Wind developments

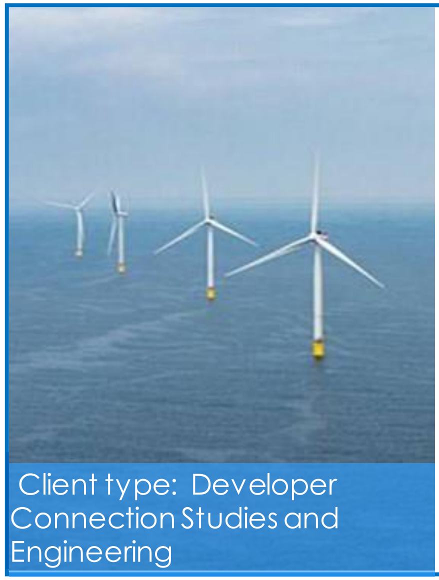
- Technical and Technological advisory
- Production/storage optimization (Green Electricity/Green Hydrogen)
- Grid Connection studies / optimal PP location
- Electrical and Civil Engineering for the connection
- Environmental Permitting
- Components Testing and Qualifications


Client type: Government
Feasibility study

The scope of the project is to perform **pre-feasibility and feasibility studies for the implementation of off-shore wind farms** in the Bay of Bengal, including site selection, the analysis of the implementation cost, the identification of key requirements, the definition of technical and logistic details, the study of the power system and of proper solutions to connect the wind farms to the grid and the suggestion of technical and regulatory support.


Client type: Developer
Connection Studies and Engineering

The scope of the project is the preparation of the final plan for the authorisation of the **connection to the grid of an Offshore Wind Farm** to be built in Sardinia, including the design of the electrical connection of the plant and the preparation of the documentation required for the approval of the grid facility for the connection and for the decommissioning of the existing 220kV lines.


Client type: Developer
Connection Studies and Engineering

CESI is supporting a project located in the stretch of sea in front of the Ravenna coast, with an installed capacity of up to 1,100 MW. The project consists of two wind farms, a floating photovoltaic system, a storage system and, in subsequent phases, onshore and offshore systems for the production of green hydrogen. The focus of CESI activity concerns the design of the **electrical connection of the plant to the Italian grid**.

CESI

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