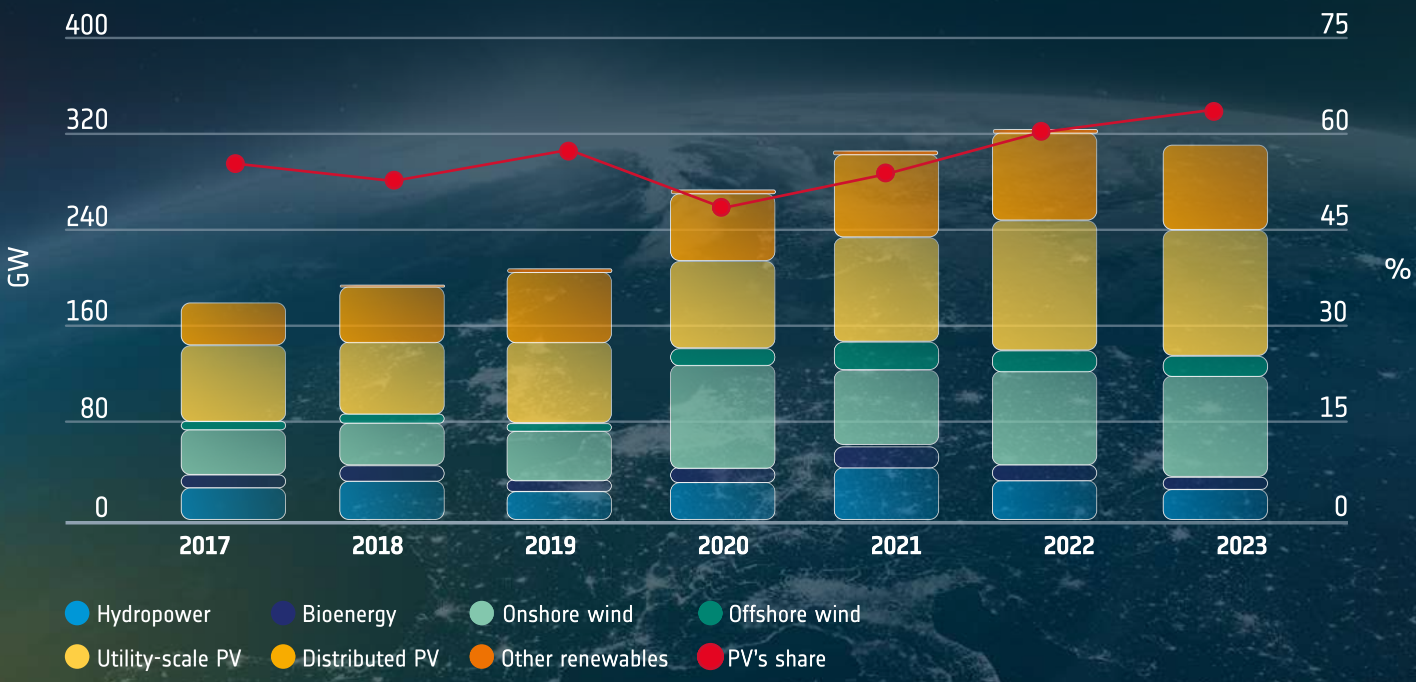
SPACE FOR RENEWABLE ENERGY: USE CASES AND COMMERCIAL OPPORTUNITIES

The rise of renewable energy

Against a backdrop of surging energy requirements, a growing awareness of the environmental impact of CO2 emissions, and an uptrend in the prices of raw materials, renewables are becoming the main source of electricity generation. Technological innovation and public policy have boosted the cost competitiveness of renewable energy sources, leading even greener impetus to their success story. Increasing environmental dependencies and new communication needs for hard-to-reach power generation facilities are opening up unique commercial opportunities for the space sector. This document gives an overview of the related use cases and opportunities, and can help both actors from the space and energy sector to identify synergies between the two markets.

Renewable energy sources play a key role in Europe's aim to be climate neutral by 2050. In the European Union, renewables accounted for nearly 40% of total electricity generated in 2022, with wind and solar power representing 22%. Compared to 2021, solar grew by 38TWh while wind rose 33TWh in Europe[1]. These developments place Europe and its industry in a position of leadership in the clean energy transition.

Beyond European borders, demand for clean energy is also increasing. Ensuring access to energy is part of Sustainable Development Goal[2] 7, as access to electricity is still out of reach for some 770 million people, mostly in Africa and Asia[3]. Innovative renewables and local off-the-grid systems (including hydro, solar photovoltaics or hybrid mini-grids) are on the rise worldwide, supporting access to green energy.



Net renewable worldwide capacity 2017-2023 (source: International Energy Agency)

1. EUROPE: RENEWABLES IN 2022 IN FIVE CHARTS – AND 2023...
2. THE 17 GOALS | SUSTAINABLE DEVELOPMENT...
3. ACCESS TO ELECTRICITY – SDG7: DATA AND PROJECTIONS

SOLAR

The most competitive renewable energy source. Innovative types are integrated photovoltaics (PV), agrophotovoltaics, floating PV, and road integrated PV, PV plus storage, and more[4]. Represents 62.3% of all renewable capacity worldwide in 2023[1].

WIND

Abundant and predictable. Innovative types include deep water, floating, hybrid and urban wind. Offshore wind is on the rise in Europe and is predicted to produce a total of between 240GW and 450GW by 2050[5]. Currently, net renewable capacity additions represent 81GW for onshore wind and 10GW for offshore worldwide[4].

HYDRO

Flexible, predictable and allows for energy storage. Growing trend for local and small-scale micro-hydro and pico-hydro systems. Now, Europe has nearly one quarter of worldwide hydropower capacity[6], making it a key pilar of the clean energy mix.

MARINE

Europe is leading the development and it is anticipated to produce 1GW of marine energy by 2030 and 40GW by 2050. Wave energy converters have 1.5MW currently operational in Europe. Tidal energy is expected to reach a deployment of 4.6GW in Europe by 2027. Thermal conversion, salinity gradient and current technologies have low Technology Readiness Levels (TRLs).

BIOENERGY

The source is usually fast-growning, energy- and biomass-rich crops. Usage includes transport and heating (mainly in Europe and America). Production of global biofuels is growing, mainly in ethanol and biodiesel.

HYDROGEN

Used as a feedstock, fuel, energy carrier and for storage. The European Commission predicts the share of hydrogen in Europe's energy mix to rise from less than 2% currently to 12-14% by 2050.

GEOTHERMAL

Reliable, low cost, and competitive with fossil fuels. Earth's geothermal reservoirs are near tectonic plates/volcanos. Mostly used for district heating, not energy production.

4. NET RENEWABLE CAPACITY ADDITIONS BY TECHNOLOGY...
5. WINDEUROPE-OUR-ENERGY-OUR-FUTURE.PDF...
6. JRC HYDROPOWER STORAGE IN THE EUROPEAN UNION – 2022...

Renewable energy in Europe

The renewable energy ecosystem is complex as it includes asset planning, financing, operations, transmission and distribution as well as consumption by end users. Governments and regions are heavily involved through tariffs, regulations and subsidies. Yet this slow-moving sector is experiencing disruption from start-ups.

In Europe, some of the 3 largest developers by assets include Enel Green Power (Italy), EDP Renovaveis (Spain) and Voltalia (France). Mostly, they focus on solar farms and wind parks. Other large players are BayWa (Germany), Scatec (Norway), and Iberia Solar (Spain)[7].

SOLAR

Germany, Spain, and Poland lead the sector[8]. Major companies are Iberdrola (Spain), Enerparc and Encavis (both from Germany), Octopus (through partnership with Lightsource BP) and the Foresight Group (both from the UK).

WIND

The leading European countries in terms of capacity are Germany, Poland, Denmark, Spain, and the UK[9]. Companies such as Siemens Gamesa (Spain), Vestas Wind Systems (Denmark), and Nordex (Germany) lead the wind sector.

HYDRO

Norway, Sweden, and France generate the most hydropower in Europe[10]. Europe is home to several leading commercial players. The major technology providers are Andritz Hydro (Austria), Voith (Germany) and GE Renewable Energy which acquired Alstom's power grid businesses (France).

MARINE

Europe is leading the development of marine energy. The UK, France and Portugal especially are driving the sector. Key firms include Nova Innovation (UK), Wave Energy Scotland and Seabased (Ireland).

BIOENERGY

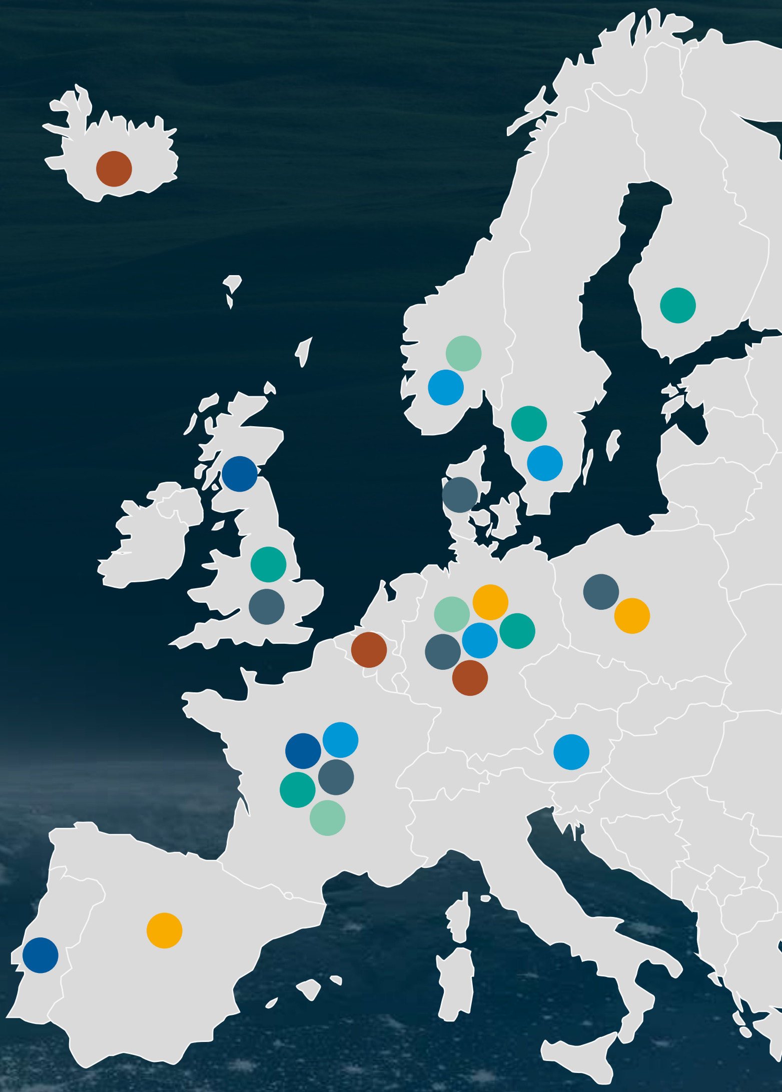
Germany, France and Sweden are leaders in biomass production in the EU. The main companies in the production of wood-based energy sources in Europe include Drax Group (UK) and Stora Enso (Finland), and Poet is a major player for biofuels in the US.

HYDROGEN

Germany is a leading player and has consequently established a National Hydrogen Strategy. The main European companies are Air Liquide (France), Nel Hydrogen (Norway) and Linde (Germany).

GEOTHERMAL

Iceland is a leader in the sector, covering 90% of its household heating needs with geothermal energy[11]. The main European companies include Enel (Italian), Tractebel Geothermal (Belgium), Geothermal Group (Germany), and Iceland Geothermal (Iceland).



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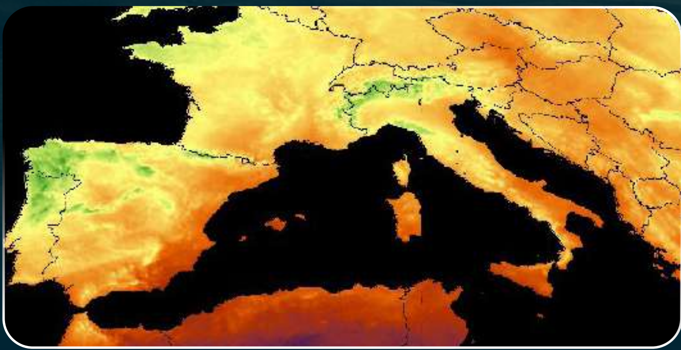
8. EU MARKET OUTLOOK FOR SOLAR POWER 2022-2026...
9. WIND POWER NUMBERS | WINDEUROPE...
10. EUROPE (HYDROPOWER.ORG)...
11. GEOTHERMAL ENERGY | ICELAND RENEWABLE ENERGY CLUSTER...

Energy sector needs and space related use cases

The energy sector is undergoing a major transformation, providing space-based companies with new commercial opportunities in fields ranging from Earth observation to telecommunication and technology transfers. The ever more complex and decentralised systems are increasingly dependent on their natural environment and are often located in remote areas. They also require forecasting, connectivity and a multidirectional flow of energy and information. The general role of data is increasing and energy-as-a-service as well as energy-data-as-a-service business models are emerging. Active "prosumers" (producers and consumers), increasing electrification and the need for planning and storage are further revolutionising the energy sector, with even financially conscious investors now attentive to how clean assets are. The requirements most relevant to space-based services and applications are the following:

1. Due diligence and location scouting

Selecting locations with the highest potential for energy generation is a key success factor for renewable energies, and especially relevant for solar, wind and marine assets. The sector needs renewable energy resource mapping through detailed and long-term statistics on solar irradiance, wind speed and direction, run-off due to snow cover, geothermal anomalies, biomass crops, etc. This is true of areas that are not easily accessible, or of larger areas that need to be scanned and where in situ approaches are not suitable, as, for instance, is the case with wave and offshore wind power.



Solar irradiance map of Europe

2. System planning

There is a need for selecting production and transmission infrastructure sites based on a combination of resource information with data on the local or regional environment, existing land and infrastructure characteristics, natural hazards, etc. In solar energy, for instance, this process would include the assessment of the PV (photovoltaic) potential that can be harvested from rooftops (including in urban areas), water bodies, etc. In transmission infrastructure, this involves the deployment of least-cost solutions through grid expansion/intensification/densification and mini-grids. Energy demand can be characterised by mapping settlements, important public infrastructure, potential irrigation areas and other indicators of economic activity where electricity consumption is high.

Given the increasing number of prosumers, creating inventories of existing energy infrastructure is important, especially in regions where available data is limited. These inventories are created by mapping features such as high-voltage and, more importantly, medium- and low-voltage power infrastructure and networks, etc. Space can also help in monitoring progress in electrification.

Nocturnal picture of Europe, exhibiting its light consumption

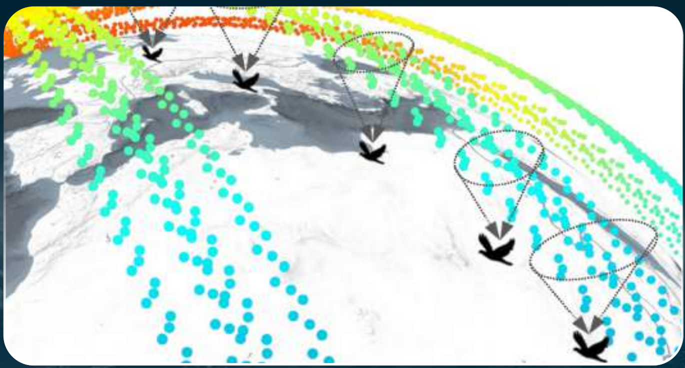
3. Bankability and efficiency

One of the main challenges that renewables face is reaching economic margins that allow them to compete with other energy sources. Specially, in a time of evolving feed-in tariffs as well as higher exposure to market prices. Currently, solar power has developed new financing options, such as solar leasing and power purchase agreements, resulting in wider adoption as it expands into developing countries. Wind is also becoming an attractive sector as the levelised cost of electricity of offshore wind decreases. Yet pressure is mounting to understand long- and short-term output generation, and to reduce and optimise maintenance cycles and approaches. For more efficient management of energy production operations using biomass, for instance, a wide range of information is needed, including on available and/ or forecast biomass crops, available solid fuel in the form of waste accumulated at managed waste sites and extreme weather events that would cause significant variations in the expected energy demand. In addition, offshore wind and other hard-to-reach-installations need predictive and automated maintenance control technologies (such as for cleaning solar panels from dust and repairing turbines) along with long-range communication tools to improve efficiency and reduce costs. Drones may support inspection and cleaning.

Offshore Wind Farm

4. Environmental and social impact

To be recognised as "green", environmental preservation during the construction and operation of the facility where a particular form of energy is produced is key. To minimise the impact of wind power on sky wildlife (e.g. birds and bats) and the changes to river ecosystems caused by hydropower, Europe has reduced large-scale new projects. Marine energy must prove that any negative influence on fish routes, marine habitats and coastal ecosystems is limited, and also reduce harmful liquid spills. Bioenergy requires the capability to monitor the impact of biomass/ biofuel production on land use, in particular with respect to deforestation.



Data from Swarm overpasses with GPS tracking points of migratory animals

5. Protection from climate related hazards and risks

Renewables are highly susceptible to weather changes at remote natural sites. The vulnerability of energy infrastructure needs to be assessed by estimating climate and disaster risks in the zone (floods, landslides, erosion, etc.), and by monitoring external threats such as natural (vegetation) encroachment on transmission lines. Awareness of climate risks means that protection can be applied to lower the risk of damage to installations and avoid lower energy production. Some examples include extreme temperatures for PV cells, which operate better when cold, or the melting of glaciers due to climate change, which affects hydropower capacity.

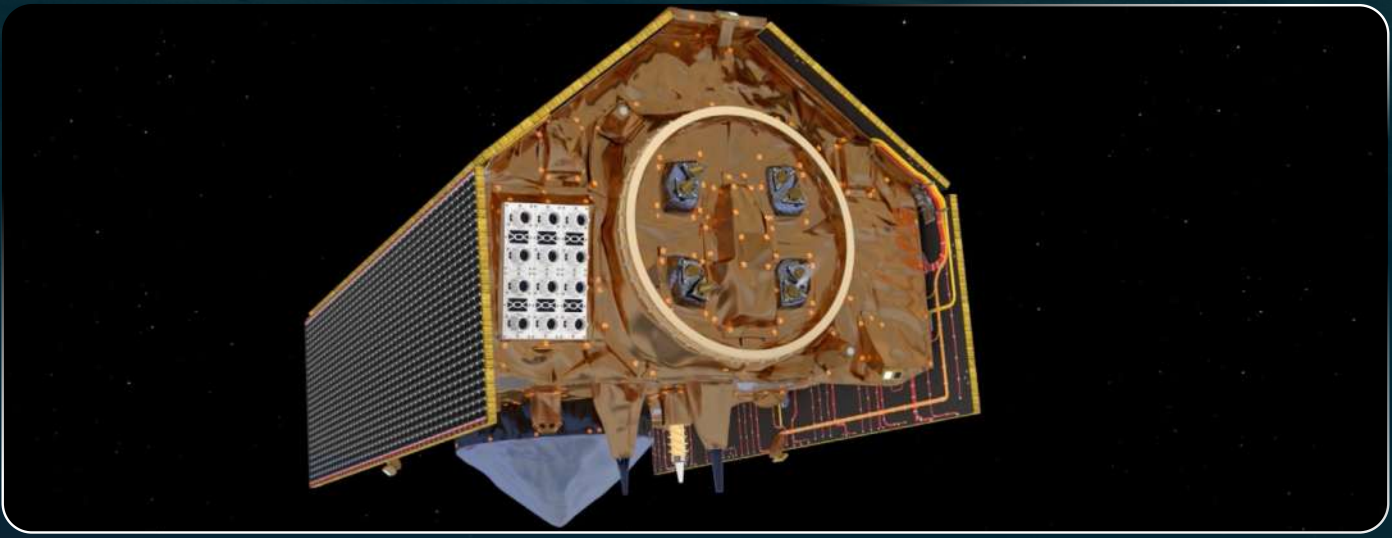
Flooding caused by heavy rains

Public and commercial space added value

The space and energy sectors intersected for the first time over 60 years ago with the technological development of solar cells. As renewable energy assets rise worldwide, space is becoming indispensable.

Renewable energies will drive the energy agenda further thanks to favourable conditions from a technological, policy and financial perspective. It can be assumed that this development will have a highly positive impact on the use of weather and other satellite-based data due to increasing dependency on environmental conditions, digitalisation (energy-as-a-service) and the need for forecasting (owing to changes in feed-in-tariffs).

Solar and wind energy especially are set to be deployed on an even larger scale over the future years and decade. The increase in renewables heightens the energy sector's volatility proportionally, and therefore the need for climate information. Copernicus is an Earth observation programme headed by the European Commission in partnership with ESA, that provides a wealth of data, both recent and historical, and services. Small subsets of all the data available is featured in the following examples per service:



Copernicus Sentinel-6 solar panel deployment

Copernicus Atmosphere Monitoring Service (CAMS)	Monitors air quality for the operational efficiency of PV and wind turbines. Supports localised solar energy potential estimates, based on retrievals and modelling of solar irradiance parameters. Its meteorological services (wind, cloud cover, etc.) can assess the potential risks of low variable renewable energy supply.
Copernicus Climate Change Service (C3S)	Predicts weather patterns to manage risks efficiently for planning and forecasting. Through optical and radar sensors, shows snow cover, runoff estimates, land surface temperatures, soil moisture, and other EO-derived parameters relevant for river basin management, hydropower potential estimation and operations. The data is freely accessible in the Climate Data Store.
Copericus Marine Environment Monitoring Service (CMEMS)	Uses scatterometer and synthetic aperture radar (SAR) data to provide information on marine surface wind speed and direction, allowing offshore wind energy potential estimates to be calculated.
Copernicus Land Monitoring Service (CLMS)	Provides data on land cover, land use, and vegetation, useful for location scouting and environmental impact. Uses various satellite data sources, including optical and radar sensors, to provide information on biomass, such as crop acreages, yield estimates, irrigated crop acreages and irrigation potential mapping, which is based on a combination of climate, soil, and crop type data.

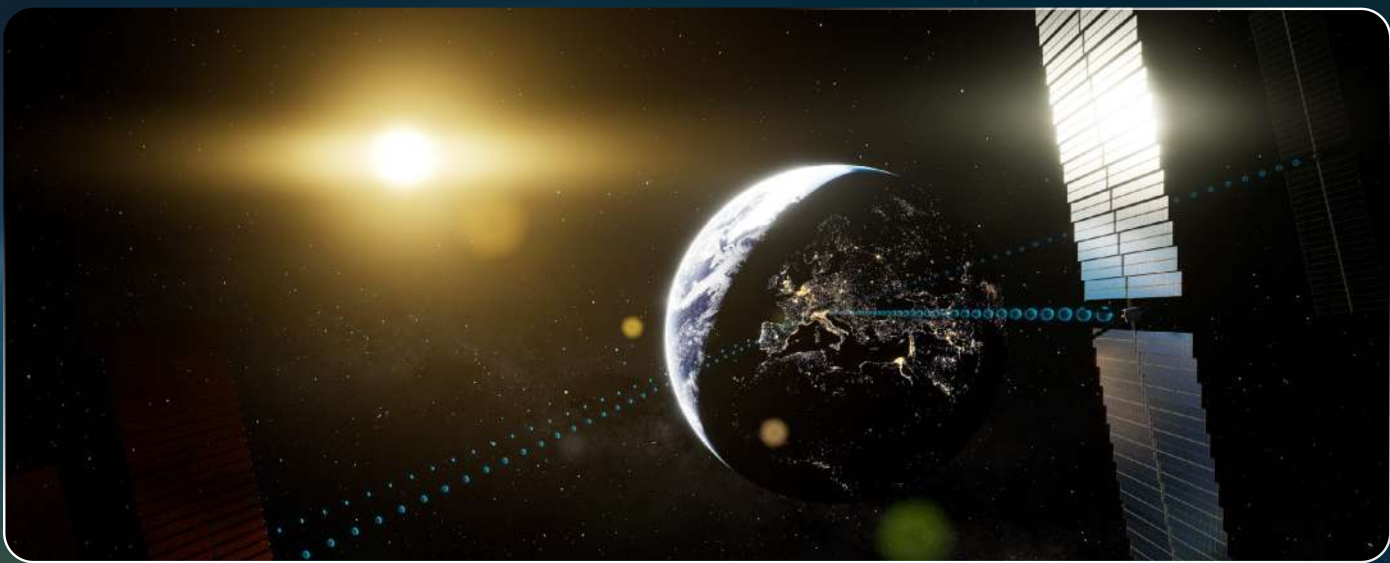
Based on public space infrastructure, new commercial models have been emerging. For example, LAUTEC'S ESOX tool uses wind and wave information from SAR sensors to support wind farms, and Vortex maps wind resources and provides location assessment. Larger private renewable companies using space applications include 3TIER (Finland, forecasting), and Clir Renewables (Canada, monitoring and optimising wind power).

The European Space Agency contributes to commercial approaches to supporting the growing renewable energy sector. ESA operates Business Incubation Centres (BIC)[12] across its Member States and these have helped a variety of energy-related companies by providing access to funding, networks and business support.
BIC-supported firms include Polar and Sobolt in the field of solar energy, Farwind Energy and Eolion Energia for wind power and Alphaedge GmbH in the hydro energy sector. TIA BASS[13] supports demonstration projects in the field of energy. FUTURE EO[14], for example, supports offshore and marine renewables through the Atlantic Regional Initiative[15]. InCubed[16] supports companies using Earth observation data, and Global Development Assistance (GDA)[17] works with international financial institutions such as the World Bank to improve access to energy in developing countries.

With a view to increasing the role of space in directly mitigating the climate crisis, ESA has kicked-off a preparatory R&D initiative, known as SOLARIS[18], to mature the feasibility of space-based solar power as a potential game-changing source of clean, affordable, continuous, abundant and secure energy. Sunlight is on average more than ten times as intense at the top of the atmosphere as it is down at the surface of the Earth. At a sufficiently high orbit sunlight would be available on a continuous basis. Solar power could therefore be collected 24/7 by huge solar farms in space and beamed to receiving stations across the planet, wherever it is needed. SOLARIS will prepare a decision by 2025 on whether Europe should embark on a full development programme towards delivering commercially-viable, clean energy from space in the 2030's.

Technology transfers are taking place through spin-ins and spin-offs. Moreover, the Micro-Ecological Life Support System Alternative (MELiSSA)[19] is an initiative aiming to develop the technology for a future regenerative life support system for long-term human space missions. Additionally, ESA's Space for a Green Future Accelerator responds to the global climate and environmental crisis, in support of a sustainable green transition.

In conclusion, renewables are a booming industry with emerging needs and high institutional economic support, resulting in promising commercial opportunities for space-based companies over the years to come.



Space-Based Solar Power for Earth's energy needs

12. BUSINESS INCUBATION CENTERS (BIC)...
13. TIA BASS...
14. FUTURE EO...
15. ATLANTIC REGIONAL INITIATIVE...
16. INCUBED...
17. GLOBAL DEVELOPMENT ASSISTANCE (GDA)...
18. SOLARIS...
19. MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE...