EuroGEO

# ENERGY

## Analysing the pattern dynamics in Earth Observation Research & Innovation

#OneEuroGEO

COMBINE, COORDINATE, COOPERATE

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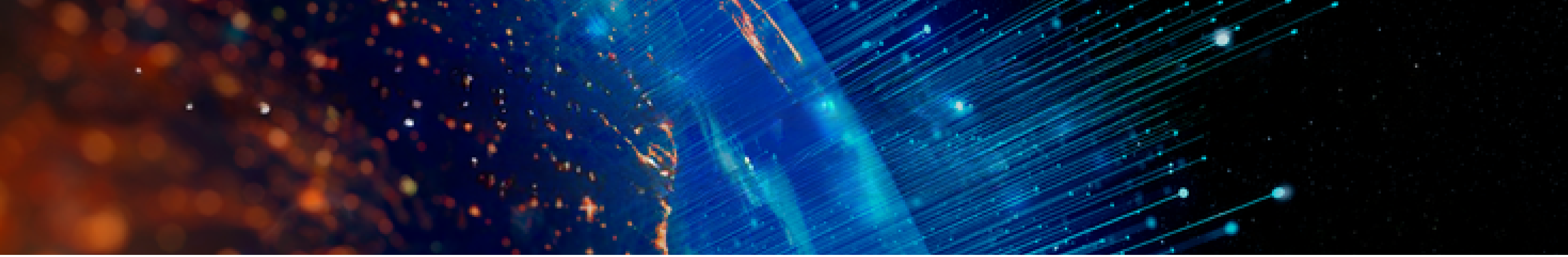


# Introduction

In recent years, there has been an **increasing uptake of Earth Observation** (EO) as a tool in support of the implementation of various policies and the execution of a wide range of operational tasks. Users across the value chains of different sectors can utilise EO-based solutions in support of their work, **realising significant benefits** (economic, environmental, societal, etc.). Market demand for such solutions is driven by policies and sector-specific needs. Technological advances have the potential to enable solutions that match the specific needs.

**EuroGEO**, Europe's part of the Group on Earth Observation, stands at the intersection of research, policy, and markets. This **strategic position** allows it to identify and monitor relevant developments and trends, to engage stakeholders, and to assess the evolving EO landscape in Europe and beyond. Capturing insights relevant for the different stakeholders allows EuroGEO to document the current state of play of EO, its trajectory, and the required steps for broader adoption and increased benefits.

With the support of the ***EuroGEOSec* project**, and with the aim of **maximising the impact of Research and Innovation** (R&I), a dedicated effort has been made to establish the **R&I Observatory for Earth Observation** (RIO). This includes a team of analysts and an online tool to monitor and analyse past and ongoing R&I in EO in order to identify trends and support strategic decisions on future R&I activities. Relying on the RIO, the so-called **R&I State-of-Play Reports** are created presenting a concise overview of the policy context, technological perspectives, and market trends within the thematic areas covered by the **EuroGEO Action Groups** (AG). This present report focuses on analysing patterns in the **energy segment**. Research has been complemented by multiple other reports and studies, including studies performed by and for EuroGEO's Energy AG.

The aim of this report is to **support EuroGEO and its stakeholders in decision-making** regarding future work programmes and strategic innovation agendas (such as those of the Knowledge Centre on Earth Observation – KCEO), inform the review of the **EuroGEO Implementation Plan**, and contribute to the production of institutional outputs.

The following EuroGEO **Action Groups** develop application pilots/conduct other actions foreseen in the EuroGEO roadmap: Agriculture, Land Cover and Land Intelligence (LC&LI), Urban, Disaster Resilience and Health, Energy, Biodiversity, ecosystems and geodiversity (BEG), Marine, Climate, and Green Deal Data Spaces.

# Methodology

The browser-based tool of the **R&I Observatory for Earth Observation** (RIO) allows retrieving relevant information from a variety of sources, including project information (e.g., descriptions, partners, budgets, results, timelines) for the majority of relevant European R&I programmes. Sources include information related to e.g., Horizon Europe (HE) and its predecessors, the LIFE programme, the Connecting Europe Facility, Eurostars, COSME, the European Defence Fund, and the European Defence Industrial Development Programme. Additional sources are being incorporated as part of the continuous development of the RIO.

The RIO structures the information into a standardised format for the uniform documentation of R&I activities. Functions of search, bookmarking, filtering, visualisation, and export allow the processing and analysis of the pre-curated information.

The focus of the analysis is on **mapping R&I efforts across segments** by analysing data on projects, core applications, budgets, and timelines. The full list of the analysed projects, filtered from the database of projects and mapped against segment-specific EO applications can be found in the original deliverable . The segment's **core applications** have been identified and mapped based on the most prominent and important themes, as determined by the Action Group and tits leads. They are derived from **AG expert studies** and further validated by sector experts such as AG leads. See the classification below:

- Solar Radiation Mapping
- Wind Resource Mapping
- Blue Power Resource Assessment
- Forecasting and Nowcasting
- Grid Management
- Weather Forecasting

To address the research questions – i.e., to identify trends in EO-related R&I for energy applications and the drivers behind them – the following **limitations or simplifications** were applied:

## Data Processing

- Project information sourced from the RIO (including acronym, title, coordinators, topic, programme, pillar, objectives, work programme, status, start and end dates, budget, grant, and links) has been filtered using segment-specific keywords to ensure that only relevant projects are included and no projects are overlooked. This relies on full-text search in existing descriptions and meta data, along with the use of consistent terminology. Where data might be missing or unexpected terminology is used, certain projects may have been missed.
- The filtered list of projects considered relevant has been extracted (i.e., exported into a spreadsheet) for processing.
- Data has been manually checked for relevance and further cleaned accordingly, then augmented by segment-specific categorisation for more detailed analysis. This categorisation aligns with EUSPA's definition of segment-specific EO applications.

# Methodology

### Timeframe

In order to restrict the analysis to relevant activities while drawing from a significant enough sample size, a (roughly) **10-year timeframe** is used, covering the period **from 2014 to 2024** (i.e., only projects that have started before 2025 and have not ended before 2014 have been analysed). This timeframe is used to capture long-term trends, technological developments, and measurable outcomes of concluded projects. It also ensures that typical project lifecycles, such as those in Horizon Europe, are included. It coincides with the launch of the first Sentinel-1 satellite in 2014, the free and open data of Copernicus being considered as one driver of EO-related R&I, which has been attempted to confirm through the analysis.

### Sample Size

The sample data is limited to the sources **currently included in the RIO**, expected to cover relevant European R&I projects to a large extent, but with further potentially relevant projects not included in the analysis where the data source has not been included yet. It is further limited to the keywords and queries applied (see data processing above) and timeframe selected (see timeframe above).

### Budget allocations per application

Breaking down budgets of projects that address more than one segment-specific application and dividing them across these applications has been done following a simplified approach assuming an (unlikely) even distribution. Therefore, budget sizes per application can only **reflect trends** and may not be fully accurate.

To interpret and complement the findings from the RIO tool, **desk research** has been conducted across reports and studies, including:

- European Space Agency (ESA) application or industry articles
- European Commission (EC) documents, e.g., Climate factsheets, Reports on uptake barriers of EU space services
- EUSPA EO and Global Navigation Satellite System (GNSS) 2024 Market Report
- Stocktaking Reports from related Group on Earth Observations (GEO) initiatives
- Horizon Europe's Strategic Research and Innovation Agendas
- Segment-specific as well as EO-related strategic research and innovation agendas including outcomes of the Horizon 2020 (H2020) project *FIRE*
- EuroGEO Workshop Reports
- **EuroGEO Energy AG Expert Study**

These **sources** were carefully reviewed to extract relevant content that addressed the questions raised during the analysis. They were particularly useful in identifying gaps and barriers in each segment, as well as R&I trends and technologies that are (or can be) applied to address these issues.

The EuroGEO **Energy Action Group** has been involved in the review process and has contributed to complementing the findings with their expertise in the segment.

# Energy Overview

Given the pressing need to minimise the impact of **environmental change** and secure a **sustainable future**, the transition to **renewable energy** (RE) is critical, and Earth Observation (EO) technology plays an important role in this regard. In particular, EO facilitates the **planning**, **production**, **transmission**, maintenance and **consumption** of RE.

Despite significant progress, there are still many **barriers** that the EO research and commercial sectors face in supporting the energy transition, in relation to **user awareness**, **engagement**, and **adoption**. One key challenge is **gaining public support** for unfamiliar technologies like renewable energy installations. A possible way forward is to leverage EO data to create user-friendly visualisations or maps that present clear, unbiased information on environmental parameters like land use, land change, and available resources.

Geospatial technologies (i.e., EO and Global Navigation Satellite System – GNSS) are essential for **optimising RE sites** by assessing **solar and wind energy potential** . This, in turn, helps stakeholders such as governments and energy companies manage energy production, demand, and supply chain operations. Ultimately, these efforts aim to promote **energy independence** for Europe taking into account current geopolitical dynamics.

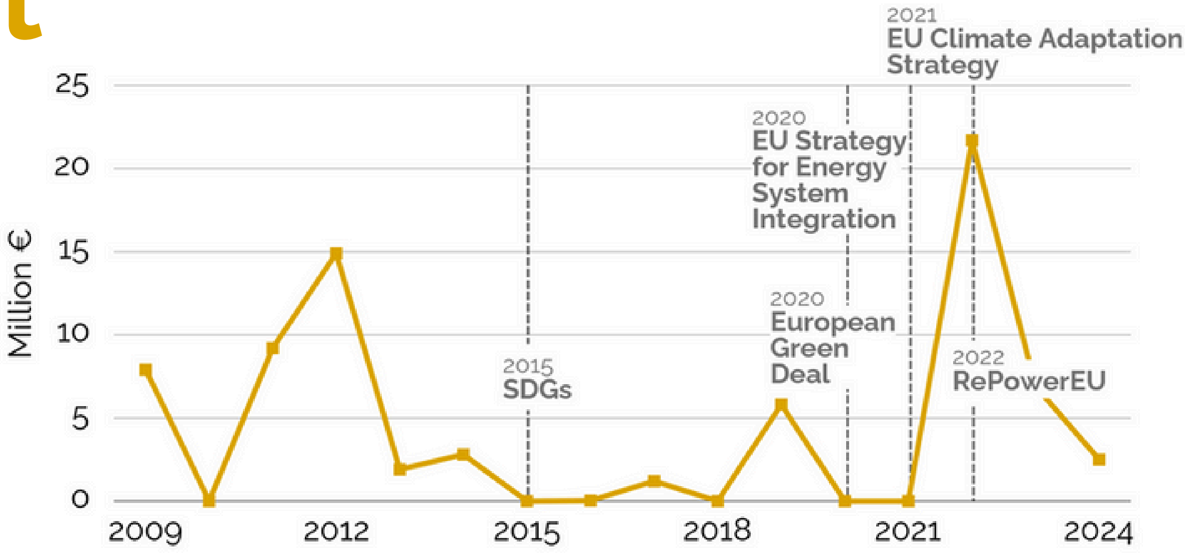
The main energy-related applications with the highest EO uptake and standardisation include **solar** **and wind resource mapping, energy forecasting and nowcasting**, and **grid management**. These are some of the core applications identified by the EuroGEO Energy Action Group (AG). **Ocean energy** (tidal, wave, thermal) is currently at a lower level of maturity but holds great potential – the International Renewable Energy Agency (IRENA) foresees that, aligned with the Paris Agreement central target, global ocean capacity could reach 72 GW by 2030, which represents more than a 14,000% increase since 2023. Among the more mature RE technologies, solar photovoltaic (PV) is projected to reach 5,457 GW (with an increase of over 280% since 2023), while wind energy (both onshore and offshore) is expected to grow to 3,534 GW, with a positive shift of almost 250%.

Supported by the **Copernicus Marin**e (CMEMS ) and **Climate Change Services** (C3S ), future research and innovation (R&I) will focus on improving **forecasting and climatologic models** and applying Artificial Intelligence (**AI**) and Machine Learning (**ML**) technologies to expand EO systems and meet growing climate change and energy challenges . Produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) within C3S, **ERA5** is a fifth-generation reanalysis dataset offering global, hourly estimates of atmospheric, ocean-wave and land-surface variables from 1940 onwards. It is an invaluable resource for policymakers and researchers . The **Copernicus Atmosphere Monitoring Service** (CAMS) also plays a role in the energy transition as it most notably uses satellite information and atmosphere models to provide irradiance indicators for improved rooftop installation planning.

**Disclaimer:** Due to data limitations in the RIO tool, some projects may have been excluded from the analysis. Refer to the original deliverable for the dataset used. Improvements are forthcoming.

# Policy Context

Fig. 1: Evolution of EO R&I Energy Budget (€M) and Key Policy Shifts




EO-related technologies, particularly satellite-based remote sensing, play a crucial role in advancing renewable energy applications by providing **accurate, real-time data** on solar radiation, wind patterns, hydrological cycles, and land use changes. Such data enables more **efficient site selection** for solar farms, wind turbines, and hydropower plants, while also **improving forecasting** for energy production and grid integration. By monitoring environmental conditions and resource availability on a global scale, EO supports **sustainable energy planning**, optimises performance, and helps mitigate risks related to climate variability. Ultimately, it accelerates and maximises the transition to a cleaner and more resilient energy future.

In this context, relevant policies are increasingly encouraging the use of EO data, products, and services to support energy planning, management, and reporting. The growing uptake of EO in the energy sector is also evident in the scale and evolution of investment in related research and innovation activities, as illustrated in the graph below, generated with the help of the **R&I Observatory – RIO**.

Figure 1 depicts the fluctuations in budgets for EO-related R&I efforts in the energy segment, generated with the sampled data of 25 European-funded projects extracted from the R&I Observatory. This data has been mapped against specific EO applications and complemented with annotations of relevant policy implementations or changes to analyse the potential correlation between the two. Thus, there are indications of increased investment over time, and a potential **correlation** (here inconclusive) **of the investment with key policy drivers** discussed below.

European and international frameworks such as the **European Green Deal (EGD)** and the **United Nations Sustainable Development Goals (SDGs)** are playing a crucial role in reshaping the future of energy systems, driving a transition toward cleaner, more resilient, and sustainable solutions. As the EU's central strategy for reaching climate neutrality by 2050, the EGD underlines the need for accelerating **renewable energy** deployment, reinforcing **critical infrastructure**, and improving **climate adaptation**. This is directly addressed through the **RePowerEU** initiative, that supports efforts to **save energy**, **diversify** energy supply, and produce **clean** energy. In this landscape, Earth Observation has emerged as a key enabler, offering the high-resolution, real-time, and long-term geospatial data required to support **planning**, **monitoring**, and **resilience** in the energy sector.

The EGD is further supported by sector-specific initiatives such as the **EU Strategy on offshore renewable energy**, the **EU Solar Energy Strategy**, or the **Renewable Energy Directive (RED III)**, which set targets for expanding wind, solar, and marine energy. In the marine energy domain, policies such as the **EU Blue Growth Strategy** and the **EU Mission: Restore our Ocean and Waters** are advancing innovation in ocean energy. EO supports these efforts by delivering data on ocean currents, wave dynamics, and optimal time windows for operations and maintenance at offshore sites. These frameworks have fostered the uptake of EO technologies in energy resource assessment and infrastructure planning. For the analysed periods, considering only Horizon Europe (HE) and its predecessors, **seven EO R&I projects** related to **solar radiation** with a combined **budget of ca. €25M**, one project related to **wind resource mapping** with a **budget of ca. €4M**, and **four projects** related to **blue power resource assessment** (incl. e.g., offshore wind) with combined **budgets of €36M** have been identified.

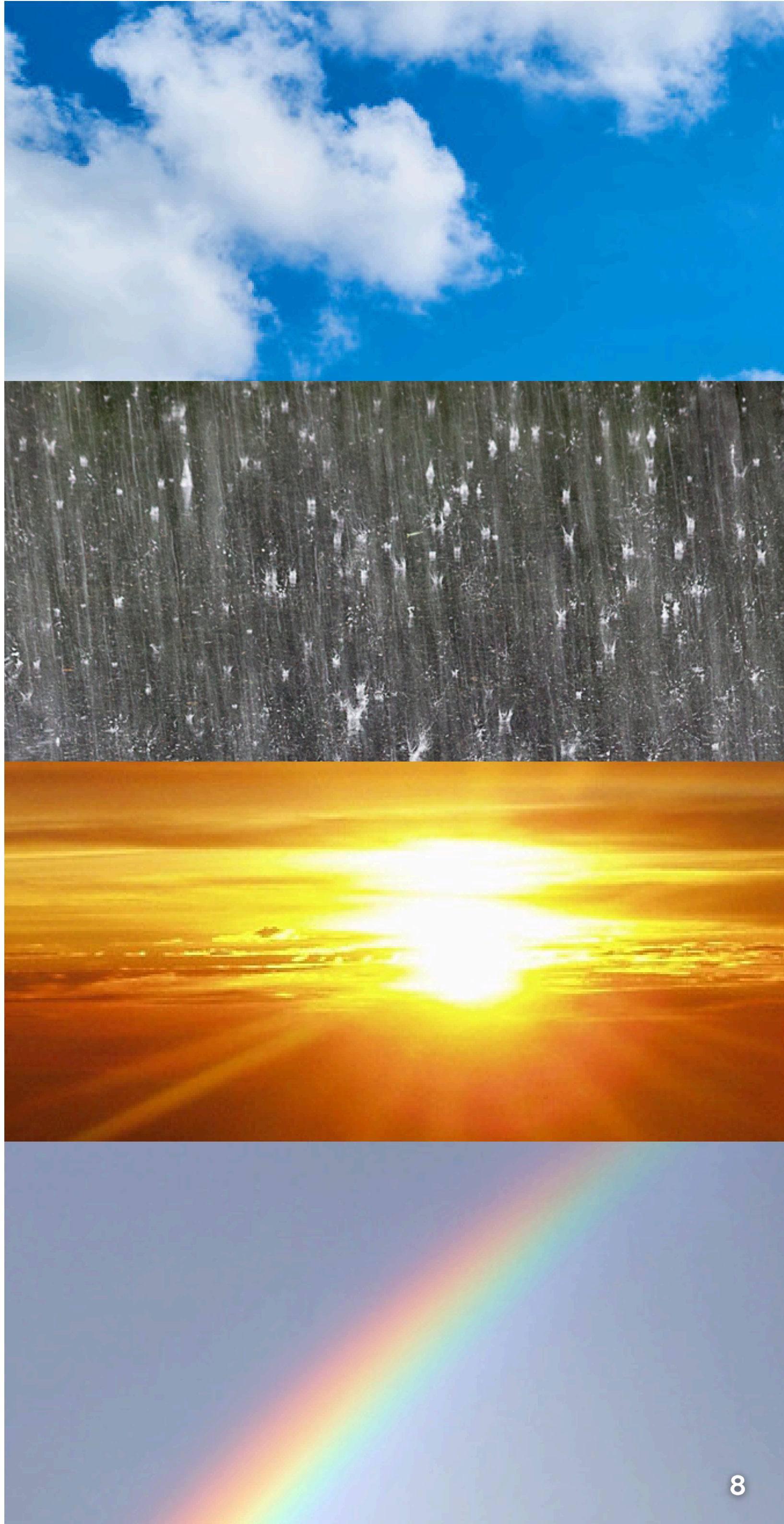
# Policy Context

The transformation of energy systems also implies improved resilience and digitalisation, as reflected by policies such as the **EU Strategy for Energy System Integration** (facilitated by the **Renewable Energy Directive**, **Electricity Market Design**, **Energy Efficiency Directive**, and **Energy Performance of Buildings Directive**, the latter mandating among other increased deployment of solar power, thus driving the need to monitor installations) and the **Clean Energy for All Europeans Package** (designed to meet EDG targets and **Paris Agreement** commitments to reduce greenhouse gas emissions). These require enhanced integration of **smart grids** and renewable sources, where EO supports e.g. infrastructure monitoring, risk assessment, or predictive analytics. During the analysed period, **five projects** focusing on EO-based **grid management** with combined **budgets of ca. €4.9M** were identified.

The growing importance of forecasting and operational resilience is further reinforced by overarching strategies such as the **EU Climate Adaptation Strategy**. EO data contributes to early warning systems and improved weather forecasting, which is critical for managing risks implied by extreme weather events to energy infrastructure, as well as to predict the load of the grid. **Seven projects** related to energy-related **weather forecasting** with combined **budgets of €18M**, and a total of **fifteen projects** addressing applications of **forecasting or nowcasting** with combined **budgets of €29.3M** have been identified to be running during the analysed period.

On a global level, the SDGs provide a complementary policy framework that reinforces EO uptake in the energy sector. **SDG 7: Affordable and Clean Energy** calls for increased access to renewables, supported by EO-based mapping and monitoring tools to help increase the global share of renewable energy and ensure access to reliable, sustainable, and modern energy for all. **SDG 13: Climate Action** highlights the need for resilient infrastructure and emissions reduction with renewable energy playing a crucial role on combating climate change and supporting mitigation strategies. **SDG 9: Industry, Innovation and Infrastructure** underscores the importance of smart planning and sustainable development, both areas where EO can contribute. **SDG 11: Sustainable Cities and Communities** focuses on making cities and human settlements inclusive, safe, resilient and sustainable – a goal that can be promoted through urban energy solutions such as solar-powered transport and smart grids.

In conclusion, European and international energy policies are **key drivers for the adoption of EO-based solutions**. They encourage **data-driven planning** and promote the integration of EO into **energy system transformation**. As the policy landscape continues to evolve in response to **climate and energy challenges**, EO technologies are set to play an even more prominent role in supporting a **secure, decarbonised, and climate-resilient** energy future.



# Technological Perspectives

Europe's **Copernicus Climate Change Service** (C3S) and **Atmosphere Monitoring Service** (CAMS) are major contributors to EO technologic capabilities in the energy sector for renewable energy planning and demand forecasting, as well as solar radiation and air quality data. The relevance of atmospheric forecasting for energy applications can be illustrated by the *AI-METHOD* project (2019-2020), which focused on developing a platform using self-learning modelling techniques for this purpose. Additionally, the **Copernicus Land Monitoring Service** (CLMS) is very useful for grid management and hydropower applications, while the **Copernicus Marine Service** (CMEMS) provides ocean and weather data for offshore wind and wave energy.

In addition, the **Destination Earth** (DestinE) initiative (2022-2030), led by the European Union, aims to create a **highly accurate digital twin** of the Earth, harnessing **advanced modelling**, **big EO data**, and **high-performance computing** to simulate and predict environmental changes with unprecedented accuracy. For renewable energy, this initiative offers transformative potential by providing detailed, real-time insights into climate dynamics, weather patterns, and natural resource availability. Such capabilities can potentially empower policymakers, energy planners, and industry leaders to optimise the placement and operation of solar panels, wind farms, and hydroelectric facilities, while enhancing forecasting for variable energy sources. More generally, such initiatives also support urban planning through simulation-based decision making for traffic, air quality, heat adaptation, etc.. Destination Earth supports the acceleration of clean energy transitions, resilience building, and strategic investments, aligning closely with Europe's Green Deal and global climate objectives.

Sentinel-1 is equipped with a **Synthetic Aperture Radar** (SAR) system that can provide high-resolution, all-weather, day and night imagery for land and ocean monitoring, particularly relevant for mapping and assessing **wind**, **blue energy resources**, as well as for **grid management** and **weather forecasting**.
The Sentinel-2 mission has high-resolution multispectral imaging across 13 spectral bands, and user-generated high-level products from Sentinel-2 data can deliver, among other things, the **energy budget**, which will allow systematic monitoring. Other applications supported by use cases include **weather and seasonal forecasting** and **climate analysis**. Similarly, Sentinel-3's instruments e.g., the **Ocean and Land Colour Instrument** (OLCI) and the **Sea and Land Surface Temperature Radiometer** (SLSTR) support the monitoring of sea and land surface, which is crucial for **solar, wind and weather forecasting**.
The Sentinel-5 Precursor satellite (5P) carries the **TROPOspheric Monitoring Instrument** (TROPOMI), which continuously orbits the Earth and allows for the creation of daily global maps of atmospheric species relevant for **air quality and climate monitoring**, with implications for **wind resource** assessment.
Finally, the Sentinel-6 mission, with its constellation of sequentially launched identical satellites, provides high-precision and timely observations of ocean topography, which is highly relevant for **ocean energy monitoring and planning** and, thus for optimising **offshore wind farms**. Sentinel-6 also provides relevant data for **weather forecasting**.

It should be noted that geostationary satellites from the European Organisation for the Exploitation of Meteorological Satellites (**EUMETSAT**) – specifically the Meteosat Second Generation (MSG-SEVIRI) and the next-generation Meteosat Third Generation (MTG-FCI) – are at the core of the CAMS Radiation and CAMS McClear products. These combine cloud and atmospheric data to deliver high-resolution estimates of surface solar irradiance (global, direct and diffuse) for solar-energy applications. MSG-based products have been available since about 2004, and MTG is now being integrated to further enhance spatial and temporal resolution.

**NB:** The projects mentioned in this section are non-exhaustive and serve only as examples of how the technologies are being deployed.

# Technological Perspectives

**Fig. 2:** Energy Project Count Timelines by Application & Sentinel Missions

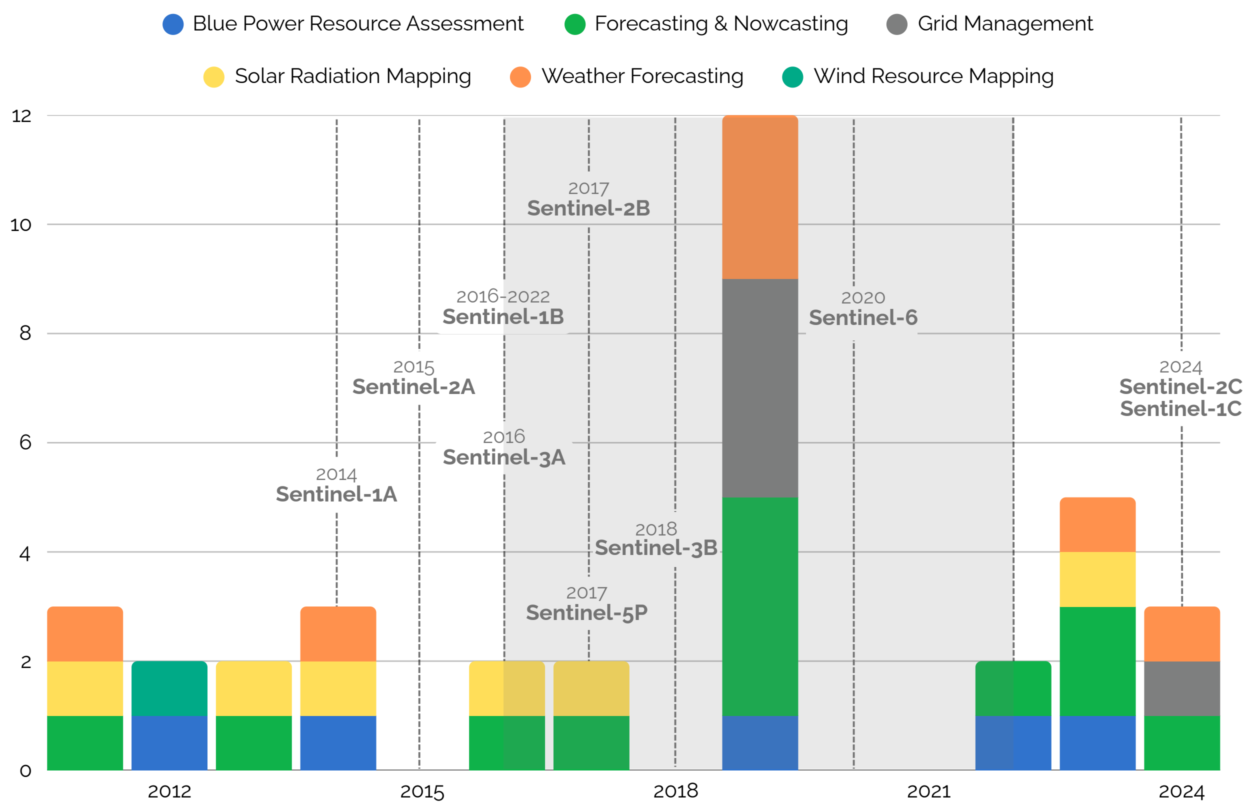



Figure 2 shows a significant **increase in R&I projects** from 2019 onwards, following the launch of Sentinels-2B and -3B. The addition of the second satellite in each mission, significantly boosted research in the areas of **grid management** and **weather forecasting**, and increased it in the **forecasting and nowcasting** domain.

The *GEO-CRADLE* project (2016-2018) supported the **integration** of EO into **renewable energy assessments**, especially in regions like North Africa, the Middle East, and the Balkans. It worked on solar energy mapping and climate services to improve energy infrastructure resilience.

Complementing remote-sensing observations, EO also takes into account data gathered with in-situ instruments to validate and calibrate the observed data, and for standalone meteorological observations.

The *Smart4RES* (2019-2023) project focused on optimising the **synergies** between **storage and power system operation** to improve RE forecasting. It utilised remote sensing and **meteorological measurements** for high quality and accurate forecasting through a platform designed to support decision-making and optimise RE applications.

EO is key for optimal **renewable energy site planning** by making available key **environmental parameters** such as solar irradiance, wind speed, cloud cover, digital elevation models and surface albedo (sunlight reflectivity). These insights help identify the best locations for **solar and wind power generation**. **SAR** and **InSAR** technologies, such as those used by Sentinel-1, are often **more accurate** or provide additional insights compared to traditional meteorological models in estimating wind speed and direction.

*e-shape* (2019-2023) developed pilots that deployed EO data for energy assessment and aimed to provide concrete, actionable services. One pilot combined EO data from different sources (e.g., HelioClim-3v5, McClear, CAMS, Sentinel) for **solar nowcasting** and **Short-Term Forecasting** (STF) and tailored it to local needs. Another focused on the unprecedented merging of offshore wind products into a **single wind product**, while promoting the use of EO data.

N*extGEOSS* (2016-2020) focused on building a **European data hub and platform** for EO. It developed services for renewable energy by integrating solar and wind resource assessment tools. Looking ahead, EO technologies for **wave and tidal resource mapping** are still at an early stage and taking place at testbed installations. *HYPOS* (2019-2022) developed an EO-based **decision support tool** that integrated satellite data and hydrological modelling to monitor environmental factors, which enabled more sustainable and informed planning of hydropower. Conversely, EO has long been used for **meteorological assessment**, and the integration of EO data in other fields is steadily growing.

**Fig. 3:** Budget Distribution for EO-Related R&I in Energy


In the context of **growing energy demand** and **climate change**, accelerating the deployment of **renewable** energy is key to meeting **sustainability** goals while minimising environmental impact. EO plays a crucial role in addressing critical challenges related to **resource assessment**, **infrastructure planning**, and **climate resilience**.

**Global revenues** from EO data and service sales across renewable energy applications are **expected to increase** from approximately €83M in 2023 to around **€114M** in 2033. This market is dominated by applications such as **solar radiation mapping**, **wind resource assessment**, and **site suitability analysis** for renewable infrastructure. This is partly confirmed by the analysed EO-related R&I activities, where projects active during the past 10 years have been mapped against key EO applications in the area of renewable energy.

Growing global demand for clean energy, combined with **constraints on land use** and **grid integration**, are driving the need for precision planning in wind energy development, especially given the spatial variability of wind resources. EO technologies support wind project developers in early stages by helping them **narrow their focus** for site selection. This results in **more efficient** in-situ measurement campaigns (onshore or offshore), reducing the number of campaigns needed and **lowering costs**. By **mapping** wind resources, **assessing terrain and land cover**, and **monitoring** environmental conditions EO improves site suitability analysis and **infrastructure planning**, creating significant market potential. However, only **one project** has been identified for the analysed period to address wind resource mapping with a budget of close to **€4M**.

The rapid growth of **solar energy** brings challenges related to spatial variability of solar resources, efficiency of land use, and uncertainty related to weather. This is increasing the demand for precise solar potential assessment. EO technologies provide continuous, high-resolution data on solar radiation, cloud cover, and atmospheric conditions, enabling accurate **solar radiation mapping** across diverse geographies. This supports, among other, optimal **site selection**, **performance forecasting**, and **live monitoring** to continuously track the state of the infrastructure. For the analysed period, seven projects were identified that address solar radiation mapping, with combined budgets around **€25M**. The *e-SPACE monitoring* project (2016-2017) used ground-based solar irradiance measurement sensors and data analysis algorithms to provide PV operators with a permanent, online solar performance assessment service.

# Market Trends

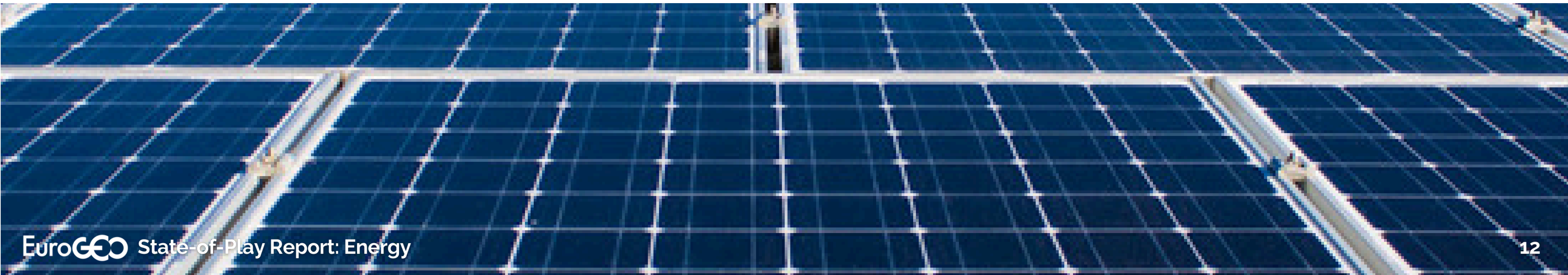
With renewable energy sources being highly dependent on weather conditions, more accurate and timely **weather forecasting** is required. EO technologies enhance weather models by providing high-resolution atmospheric, oceanic, and land-surface data. This enables better short- and long-term forecasts, supporting grid management, energy trading, and operational planning. **Seven projects** were identified for the analysed period to address weather forecasting specifically, with combined budgets of about **€18M**. This goes hand in hand with **forecasting & nowcasting** applications. Beyond weather forecasting, challenges such as **intermittency**, **demand-supply balancing**, and climate-driven **weather extremes** drive the need for high-resolution forecasting and nowcasting capabilities. Renewable energy applications play a critical role in supporting the **intraday and day-to-day energy markets** by enhancing forecasting accuracy and operational flexibility. Variability of sources like solar and wind, advanced forecasting tools powered by satellite data, AI, and real-time monitoring enable grid operators and energy traders to better predict **short-term generation fluctuations**.

This improves market responsiveness, allowing for more efficient bidding strategies, balancing supply and demand, and reducing reliance on costly reserve power. By integrating precise, near-real-time data into market operations, greater **grid stability**, increased market liquidity, and smoother integration of clean energy into competitive electricity markets are enabled, ultimately driving down costs and accelerating the energy transition. EO provides real-time and near-real-time atmospheric and environmental data that can enhance short-term (nowcasting) and medium-term forecasting models. This enables more accurate **prediction** of renewable energy generation, optimised grid operations, and improved energy market participation.

For the analysed period, **thirteen projects** have been identified to address **forecasting & nowcasting** with combined budgets of **€29.3M**. In the same context, EO technologies support grid operators by providing insights into environmental conditions, vegetation encroachment, and extreme weather risks in near real-time. This enhances grid reliability, maintenance planning, and disaster preparedness. Applications such as risk mapping, asset monitoring, and environmental impact assessment represent market potential for grid management. **Five projects** related to **grid management** have been identified for the analysed period, with combined budgets of **€4.9M**. The *3DEPLAN* project (2019) created an interactive, cloud-based platform to facilitate faster, cheaper, and socially responsible planning of powerline infrastructure.

Further market potential lies in the area of **blue power resource assessment**, which includes e.g. offshore wind. While overcoming challenges such as land use and utilising higher wind resources, offshore wind adds other challenges such as site accessibility, marine spatial planning, and weather-related risks. This is driving demand for precise marine resource assessment. EO enables monitoring of ocean winds, wave patterns, and sea surface conditions, supporting offshore wind site selection, construction, maintenance, and energy yield forecasting. **Five projects** related to blue power resource assessment with combined budgets of **€36M** were identified for the analysed period.

By integrating EO data with advanced technologies, the renewable energy sector can accelerate its **transition toward cleaner, smarter, and more resilient** energy systems. Under a new EU Directive🔗, Member States must identify acceleration areas for RE deployment, which is a challenge due to limited data on suitable locations with low environmental impact. EO can bridge this gap and enable optimised planning and efficient operations as global initiatives increasingly prioritise climate neutrality, energy security, and sustainable development.



# Projections

Further integration of AI with EO tools is expected to **improve the precision of forecasting and nowcasting**. **AI** and **machine learning** have great potential to enhance weather prediction accuracy and decision-making tools for end users. The *PANORAMA* project (2025-2028) is using machine learning and AI for top-down emission estimations to improve EO product accuracy, supporting decision-making in climate action and aligning with the European Green Deal.

IRENA predicts a significant **increase in offshore wind capacity**, as the EU targets 240–450 GW by 2050. Meanwhile, in line with the EU's goal for greater internationalisation, investments in interconnections are expected to rise, driving **grid modernisation** and **increased digitalisation** in the electrical power sector.

In support of the objectives of recent directives, such as RePowerEU and the EU Climate Adaptation Strategy, EO technologies are becoming increasingly important for physical **risk assessments** due to extreme weather events, as **energy infrastructures** face growing exposure to **climate hazards**. This is expected to translate into a budget increase in applications like **forecasting and nowcasting** and **weather forecasting**.

Emerging **EO technologies for blue power** will become more mature due to advancements needed in wave and tidal resource mapping. Such advances will be necessary for accurate weather data and improved forecasting at national and regional levels to support policymaking. The *BLUE-X* project (2023-2026) is working on an innovative Copernicus-based solution for accelerating decision-making for blue renewable energy projects, contributing to the Green Deal's climate and energy objectives. Further, countries are planning to exploit offshore energy sources, and regional cooperation continues to be a driver for ocean energy development.

# EuroGEO Contribution

The Energy Action Group currently plays a key role in European research initiatives and solutions, which could be further leveraged through its **central position** among stakeholders. Particularly, the Energy AG works across policy, market and research to support **SDG7** and EO integration. It fosters **collaboration** via **co-designed projects** and **stakeholder networks**. In the energy sector, EuroGEO has contributed to **19 national initiatives** and supported the tailoring of EO tools for RE planning. Members of the group have led renewable energy research and applications in several previously mentioned projects, including *NextGEOSS*, *e-shape*, *GEO-CRADLE*, and *PANORAMA* 🔗.

However, there are a number of areas where further development is required to align with the Group's mission. Firstly, there needs to be a greater focus on the development of **tools for better decision making**, targeting regulatory benchmarks and **compliance requirements**. Another key area for improvement is the **integration** of EO tools with **existing energy systems** for better management of grid and other RE infrastructure. Given the relevance of demonstrating the benefits of EO through **pilot studies**, the AG should establish clear strategies for translating these into **large-scale applications**. Finally, there is a strong focus on increasing the **data accessibility** for smaller market actors to increase their contribution to the community, as well as in areas that lack the technology, infrastructure, or financial means to access or make use of such advanced data as EO.

Looking ahead, EuroGEO has the potential to contribute to the **energy transition** via dissemination, outreach, and the development of EO-based tools that respond to EU regulations. It aims to deepen collaboration across sectors and leverage diverse funding opportunities. By fostering stronger partnerships between research institutions, industry players, energy utilities, and policy-makers, the group seeks to co-develop targeted solutions for renewable energy integration and forecasting. Furthermore, aligning with private-sector investors and climate finance mechanisms could accelerate the development of market-ready applications. Increased engagement with global GEO initiatives and regional stakeholders can also amplify knowledge exchange, promote the uptake of EO data for energy planning, and ensure that EuroGEO remains at the forefront of enabling a sustainable, data-driven energy transition.

# Glossary

| | |
|---|---|
| AG | Action Group |
| AI | Artificial Intelligence |
| C3S | Copernicus Climate Change Service |
| CAMS | Copernicus Atmosphere Monitoring Service |
| CLMS | Copernicus Land Monitoring Service |
| CMEMS | Copernicus Marine Enviornment Monitoring Service |
| DestinE | Destination Earth |
| ECMWF | European Centre for Medium-Range Weather Forecasts |
| EGD | European Green Deal |
| EO | Earth Observation |
| EUMETSAT | European Organisation for the Exploitation of Meteorological Satellites |
| FCI | Flexible Combined Imager |
| GIS | Geographic Information System |
| GNSS | Global Navigation Satellite System |
| IRENA | International Renewable Energy Age |
| ML | Machine Learning |
| MSG | Meteosat Second Generation |
| MTG | Meteosat Third Generation |
| OLCI | Ocean and Land Colour Instrument |
| PV | Photovoltaic |
| R&I | Research and Innovation |
| RE | Renewable Energy |
| RED III | Renewable Energy Directive |
| RIO | R&I Observatory |
| SAR | Synthetic Aperture Radar |
| SDGs | United Nations Sustainable Development Goals |
| SEVIRI | Spinning Enhanced Visible and Infra-Red Imager |
| SLSTR | Sea and Land Surface Temperature Radiometer |
| TROPOMI | TROPOspheric Monitoring Instrument |

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