esa

SPACE SOLUTIONS

ENERGY
DOSSIER

ABOUT THIS REPORT

Today's society depends on a wide range of energy sources for vital infrastructure. Global climate and resilience challenges are hastening the arrival of innovative energy solutions and accelerating plans for the modernisation and decarbonisation of the energy industry.

Space-based applications are at the forefront of this transformation, playing an ever more crucial role in the advancement and digitisation of the sector at every stage of the energy cycle, from generation and storage to operations and decommissioning.

Energy is central to ESA's mission on Earth. Through its Business Applications and Space Solutions (BASS) programme and the Task Force for Innovation in Energy Through Space (Energy Task Force), ESA is unlocking commercial potential in the sector and paving the way to a sustainable future.

This report demonstrates the crucial role ESA continues to play in bringing space and energy together and its ambitions for the future. It offers an overview of its wide-ranging BASS activities, the vital work of its specialist Energy Task Force and the international cooperation it has established across the energy sector.

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ENERGY

MARKET OVERVIEW

The global energy sector is going through a fundamental transformation.

Countries are undertaking clean energy transitions at varying extents and speeds, driven by the 2030 net-zero COP26 environmental targets.

Energy resilience is also at the forefront of today's policy agendas, as geopolitical events around the world affect oil and gas supplies and the post-pandemic economic recovery continues to have an impact.

Clean energy transitions in the period to 2030 will rely on variable renewables for electricity generation. Investments into green energy technology are currently at an all-time high of USD 1.3 trillion, with further growth to USD 2 trillion expected by 2030[1].

Digitalisation, satellite connectivity and space applications provide opportunities to enhance energy security and advance the green energy transition. They are set to play a large part in technological investment, facilitating exponential innovation in the energy sector.

1. Energy Technology Perspectives 2023 – Analysis – IEA

TRENDS AND OPPORTUNITIES

Clean/Green/Renewable Energy

The global demand for clean energy - including solar, wind, hydropower and bioenergy - is increasing rapidly, as the risks of climate change and the need to reduce our carbon footprint grow ever more real. The growth is driven by both public demand and government incentives.

Smart Grid Technology

Smart grid technology enables better energy management and improved efficiency. Utilities are turning to smart grids to manage electricity demand, reduce energy loss and improve reliability, while home energy management systems are allowing consumers to manage their energy usage.

Electric Vehicles

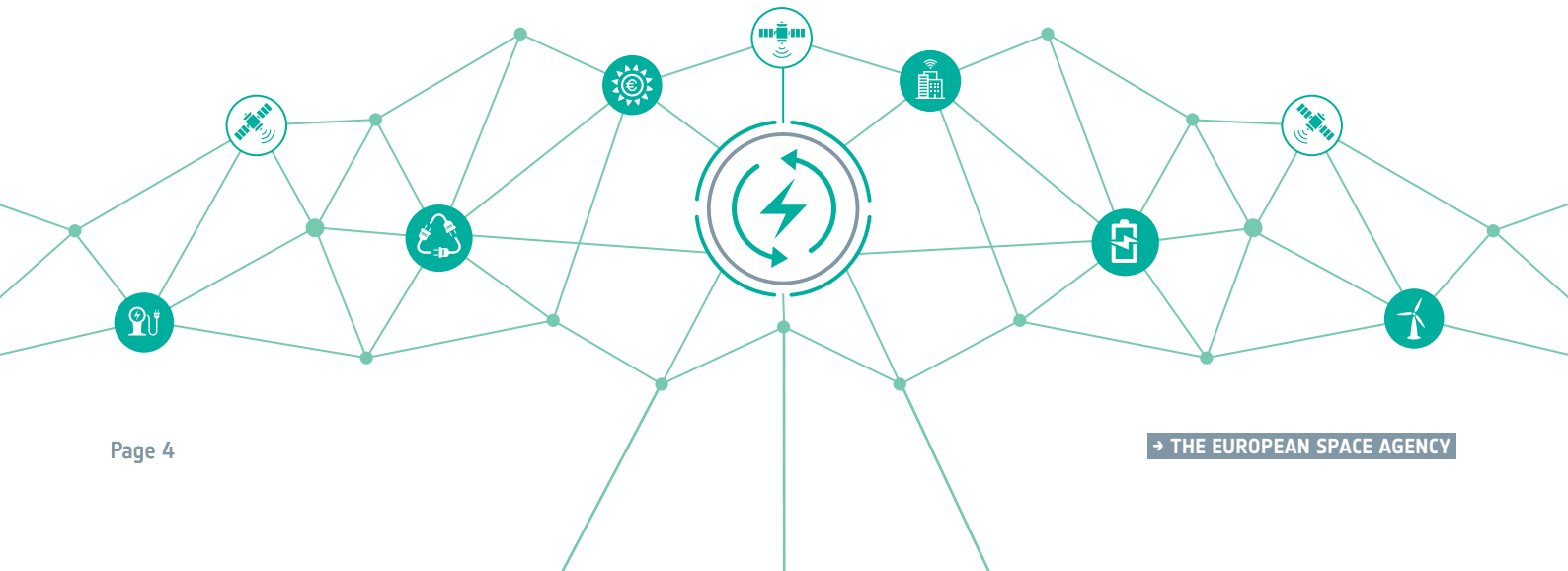
The ownership and usage of electric vehicles is increasing rapidly in Europe, as prices become more competitive and technology and charging infrastructure continue to improve. Emerging trends and technologies include wireless charging, V2G (Vehicle to Grid) and autonomous driving.

Distributed Energy Resources (DERs)

DERs are small-scale clean energy sources, such as solar panels, wind turbines and microgrids, which are located close to their point of use. Gaining significant momentum, DERs can supplement or replace traditional sources and allow for flexibility and efficiency in the sector.

Energy Storage

Effective storage is a key growth area, as nations look to stabilise power grids, improve energy efficiency and integrate renewable energy sources. The use of batteries is rising too, with a variety of new electricity storage technologies also developing at a rapid pace.



SPACE APPLICATIONS FOR ENERGY

Space applications have a central role to play in developing the energy sector, tackling the challenges it faces and achieving global sustainability targets.

BASS has already published a wide range of successful energy-related calls for industry, with new focus areas in the pipeline. These are illustrated below.

ENERGY-RELATED ACTIVITIES

Past Calls

Space for Hydro Energy

Marine Energy

Decommissioning of Energy Assets

Waste to Energy

Space Acting for Decarbonisation

Space and Digital Transformation for Green Energy

Sustainable Digitally Connected Solutions for the Commodities Crisis

Current Calls

Commercial applications of space-enabled robotics

Space for Infrastructure

Maritime Decarbonisation

Future Focus Areas

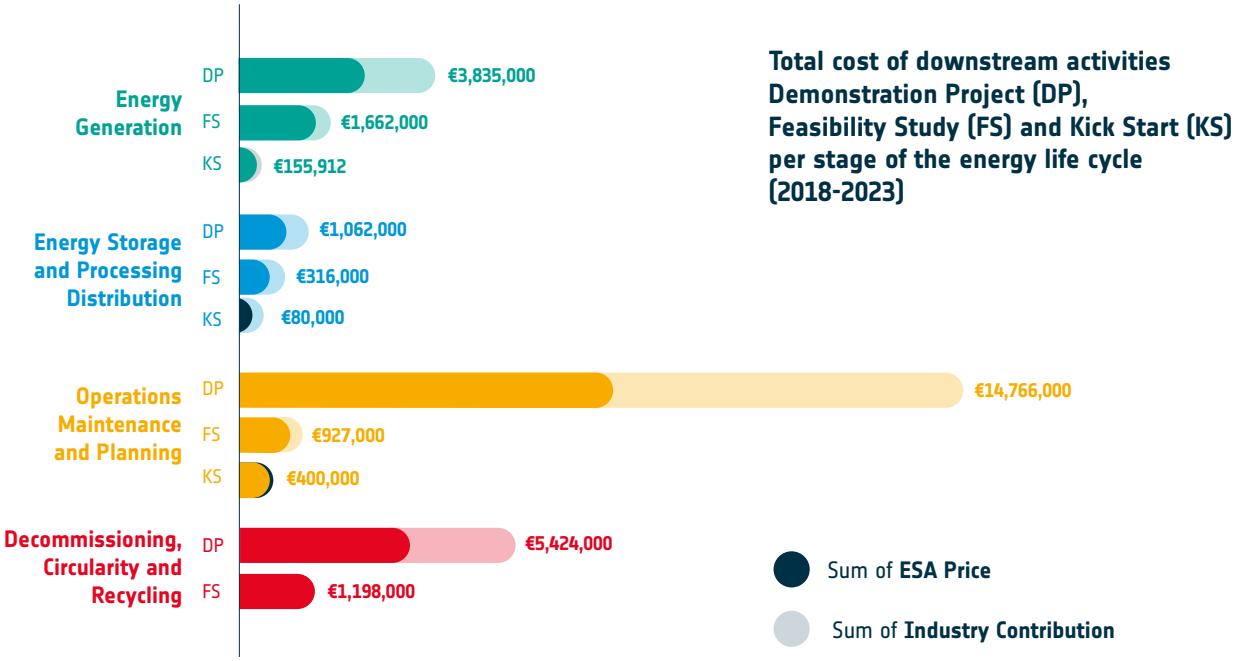
Advanced Batteries Integration / Recycling

Green Hydrogen

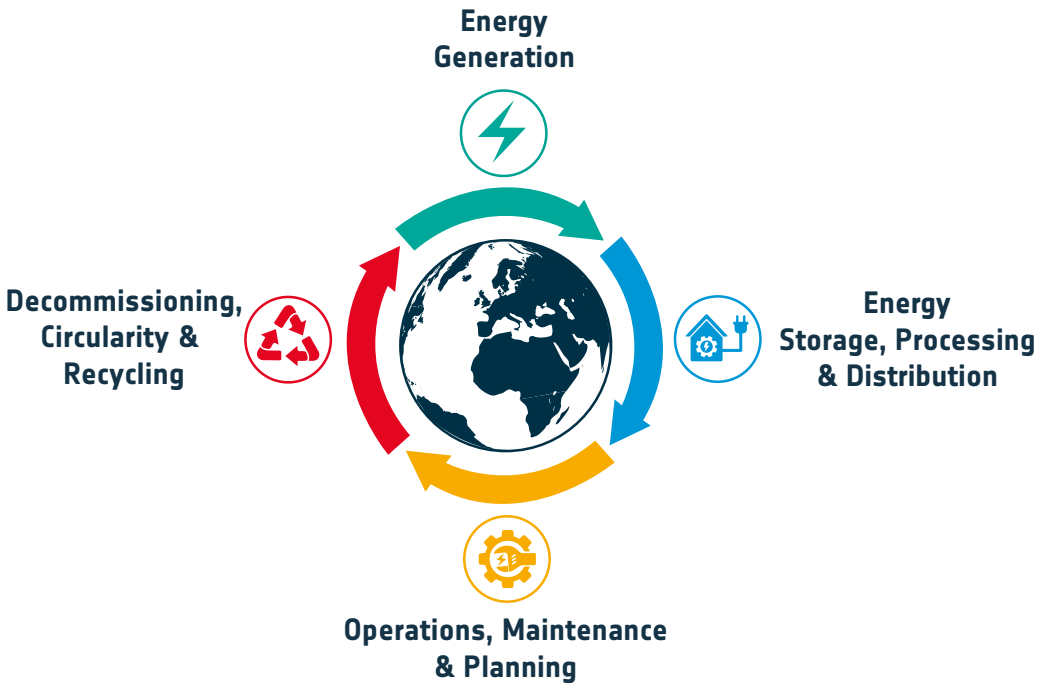
Heat Sector Decarbonisation

Space for Electromobility

This section provides an overview of ESA's BASS supported energy activites between 2018 and 2023, encompassing 61 projects and almost 30 million Euros in investment.



ESA's activities are segmented according to the key stages of the energy life cycle stage[2], highlighting the impact of the BASS-supported projects on the energy sector.



2. ISO 14040:2006 - Environmental management — Life cycle assessment — Principles and framework

ENERGY GENERATION

Today's electricity is generated from a wide range of energy sources, including fossil fuels, nuclear power, hydro power, geothermal systems, solar panels, biofuels and wind.

KEY CHALLENGES

- With an historical reliance on fossil fuels (80%), the energy sector continues to be the highest contributor to greenhouse gas emissions.
- With the carbon footprint of homes representing around 20% of all global CO2 emissions, new approaches to the consumption of energy are urgently required.
- Large-scale generation of electrical power by traditional centralised grids is less environmentally friendly and more costly than using small-scale renewable sources.

HOW CAN SPACE SUPPORT ENERGY GENERATION?

Monitoring pollution and heat efficiency:

- SatEO[3] can provide accurate data to help monitor emissions.
- SatEO and Satnav[4] can map the distribution of urban surface temperatures, identifying hotspots and measuring heat efficiency.

Resource assessment and impact assessment:

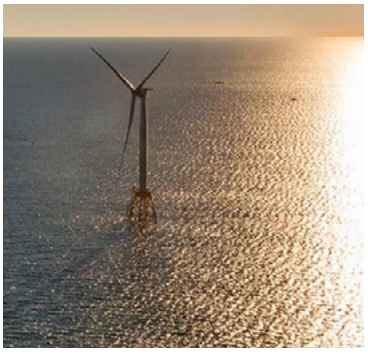
- SatEO data can assist in identifying sites to deploy renewable solutions.
- Satcom[5], SatEO and GNSS can forecast environmental conditions and monitor the impact of deployments.

Low carbon heat production:

- SatEO can identify greenspaces to harvest low carbon heat, providing greener and more flexible energy stores.
- Greenspaces use ground source heat pumps that are used to heat homes and businesses.

MESPAC

Italian company Wave for Energy developed MESPAC, an online platform that delivers highly accurate survey data to facilitate the development of offshore wind farm sites. Integrating with SatEO data sources, it uses advanced physical models and AI algorithms to inform the development of new ocean energy applications, without the need for time-consuming, expensive and hazardous offshore operations.



3. Earth Observation Satellites (SatEO) monitor conditions on Earth, such as weather patterns, the effects of climate change and all manner of natural activity around the world. ESA leads and supports a number of Earth Observation Missions to better understand the complexity of our planet.
4. Satellite Navigation (Satnav) refers to a system that uses satellites for geopositioning. These networks of satellites communicate with ground stations on Earth. Satnav systems with global coverage are referred to as global navigation satellite systems (GNSS).
5. Satellite Communications (Satcom) enables the exchange of data anywhere across the globe from the network of communication satellites orbiting the Earth. Satcom provides connectivity even when ground telecommunication structures are unavailable or damaged.

ENERGY STORAGE, PROCESSING AND DISTRIBUTION

Effective storage, processing and distribution systems maximise the performance of energy networks, increasing efficiency and minimising emissions.

KEY CHALLENGES

- As the world strives to cut greenhouse gas emissions, energy-intensive sectors such as transport and industry, shipping, and aviation present major environmental challenges.
- After transport and industry, the energy supply system is the main emitter of greenhouse gases, accounting for more than 1/3 of total emissions.
- Decarbonisation of the energy sector requires fundamental changes towards more sustainable, bio-based and alternative green energy carriers.

HOW CAN SPACE SUPPORT ENERGY STORAGE, PROCESSING AND DISTRIBUTION?

Monitoring renewable capacity:

- Satcom can monitor the distribution of renewable energy, increasing efficiency and enhancing safety.

Smart grid and energy systems:

- Satcom can accelerate modernisation towards smarter grids with real-time monitoring and control of infrastructure.

Assessing energy usage and infrastructure planning:

- Satcom and GNSS can assess demand and supply, assisting infrastructure planning and storage.

Energy outage detection and prediction:

- SatEO can be used for predicting the influence of environmental factors and weather conditions on the power grid.

Resources assessment for green hydrogen:

- SatEO, Satcom and GNSS can assess the regional resources and capacity for producing green hydrogen.

Sustainably fuelled mobility monitoring:

- SatEO, Satcom and GNSS can monitor green hydrogen power emissions and provide data to mitigate them.

CRESS FEASIBILILTY STUDY

CRESS is a Feasibility Study by Bennamann Energy in the UK which looks at capturing, processing, storing and distributing fugitive methane that is produced by micro-scale biomethane producers during their day-to-day operations, in order to generate added value for those organisations. When storage is at capacity, excess biogas is processed to produce liquid methane for offsite heat, power and fuel use. The proposed solution covers the entire value chain.

OPERATIONS, MAINTENANCE AND PLANNING

Modernisation of the energy sector requires a focus on system-operating parameters and limits, maintenance procedures and schedules, and documentation methods.

KEY CHALLENGES

- Timely and effective maintenance of an ageing energy infrastructure is vital for the efficient operation of energy systems and the safety and longevity of assets.
- There is an urgent need for electricity grid modernisation to accommodate a growing share of renewable energy sources and local power generation.
- Energy security requires resilience against unforeseeable threats such as cyber-attacks, geopolitical tensions, physical sabotage and natural disaster.
- The supply of certain renewable energy sources such as wind and solar is not fully predictable, leading to unexpected surges or losses of power.
- With over three quarters of passenger vehicles expected to be powered by electricity by 2030, planning for electromobility is of paramount importance.

HOW CAN SPACE SUPPORT OPERATIONS, MAINTENANCE AND PLANNING?

Operational planning:

- Satcom, SatEO and GNSS can help to establish robust communications and forecast environmental factors for operational planning.

Green energy supply:

- SatEO can provide accurate and fast evaluation of green energy sources, assessing their impact, and monitoring their efficiency.

Micro-mobility vehicles:

- SatEO data can enhance town planning to improve charging infrastructure and enhance safety and vehicle life spans.

Remote monitoring:

- Satnav can monitor the structural integrity of energy assets, reducing the time and risks associated with manual inspections.

Supporting maintenance activities:

- Satcom and Satnav can aid the analysis of assets in real-time, allowing maintenance to be performed remotely.

Geo-hazards:

- SatEO, Satnav and Satcom can help detect and monitor geo-hazards, extreme weather conditions and environmental change patterns.

MOWGLI

MOWGLI is a satellite-based solution that provides a range of services for optimal microgrid planning, design, operations and maintenance in urban and rural areas of developing countries. The solution supports the tailoring and sizing of micro-grid components based on electricity demand and the availability of renewable energies. It also provides monitoring, load balance, disaster recovery and smart services.

DECOMMISSIONING, CIRCULARITY AND RECYCLING

Withdrawing a facility from service, its deconstruction, and the removal of components for recycling, storage and disposal is an essential element of the energy life cycle.

KEY CHALLENGES

- Circularity of operations and materials and the re-use of infrastructure play a crucial role in reducing the carbon footprint of the electric power industry.
- The decommissioning of oil and gas platforms involves potentially hazardous activities such as the removal of underwater structures and topside platforms.
- Offshore decommissioning, repair and maintenance is traditionally time and labour-intensive, requiring large vessels and crews.
- Although it carries a lower environmental risk, the decommissioning of wind farms requires complex logistical processes to remove and dispose of parts.

HOW CAN SPACE SUPPORT DECOMMISSIONING, CIRCULARITY AND RECYCLING?

Monitoring of environmental impact:

SatEO can be used to support services for environmental monitoring, such as:

- High-resolution imagery for the detection of spills
- assessment of the environmental impact of energy installations

Logistics and automation:

Satnav can be used to help with:

- Positioning and automation of vessels and assets
- Improving logistical efficiency

SatEO can provide weather forecasts to help plan and optimise decommissioning.

Safety and end-to-end business support:

Satcom-based services can provide a communication link between platforms and actors offshore and onshore, including:

- Machine to machine (M2M)
- Voice
- Data

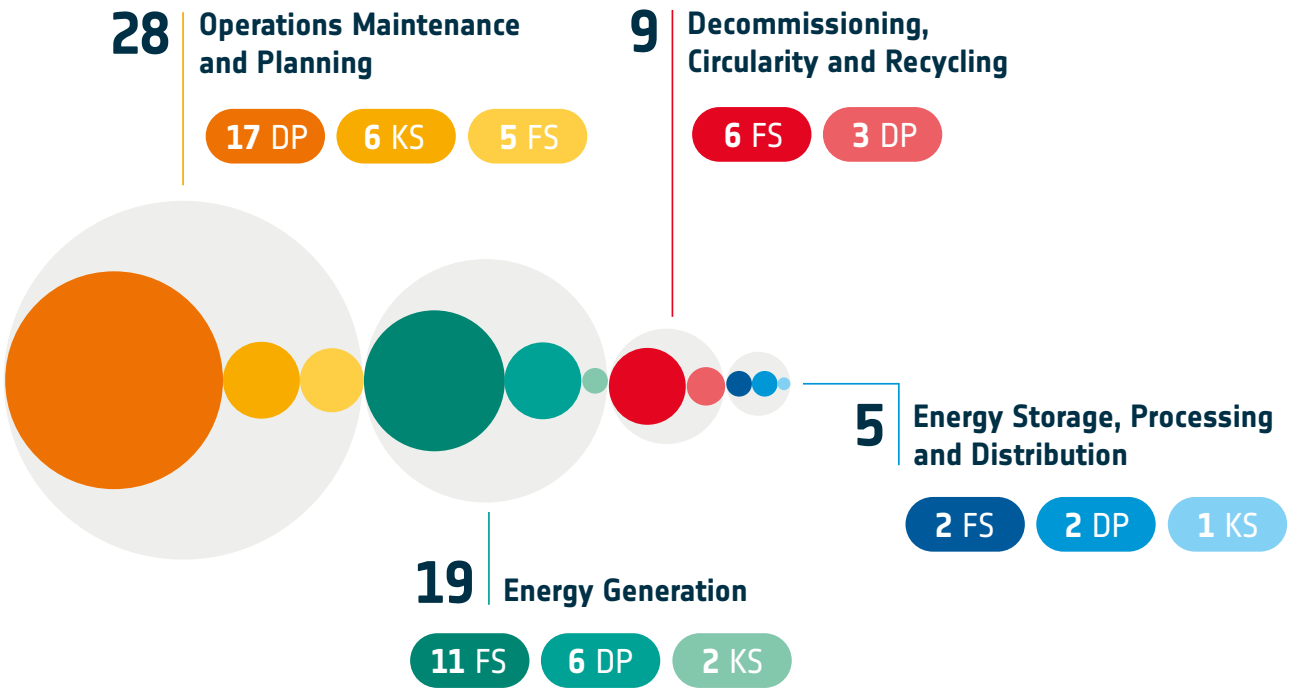
SULMARA SUBSEA

In this Feasibility Study by UK-based Sulmara, satellite-connected uncrewed maritime systems (UMS) were able to undertake the offshore decommissioning and subsea inspection, repair and maintenance processes. Using Satcom and Satnav, the UMS were controlled from an operations centre on land. Usually carried out by large vessels with big crews, the process reduces costs, carbon footprint and safety risks.

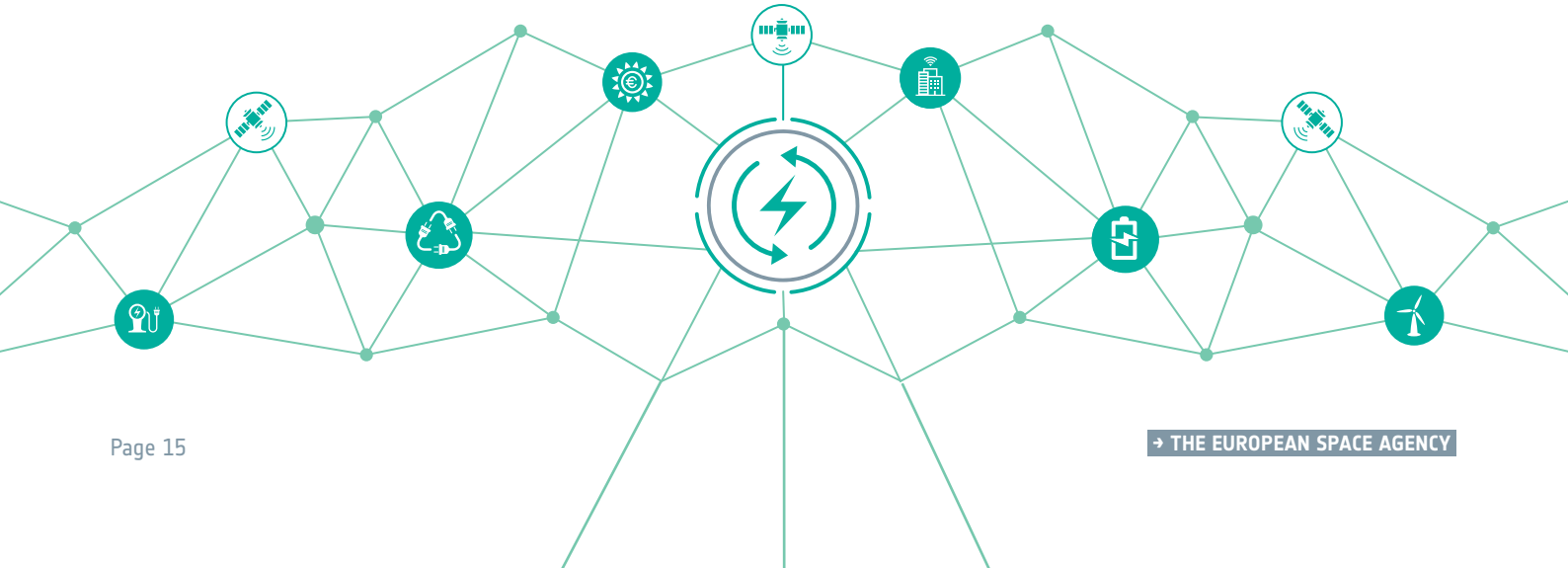
ENERGY ACTIVITIES BY AREA

Between 2018 and 2023, ESA BASS supported 61 energy-related activities which are now at various stages of implementation:

There were in total 7 Kick Start and 13 Feasibility Study initiatives:



DP = Demonstration Project **FS** = Feasibility Study **KS** = Kick Start



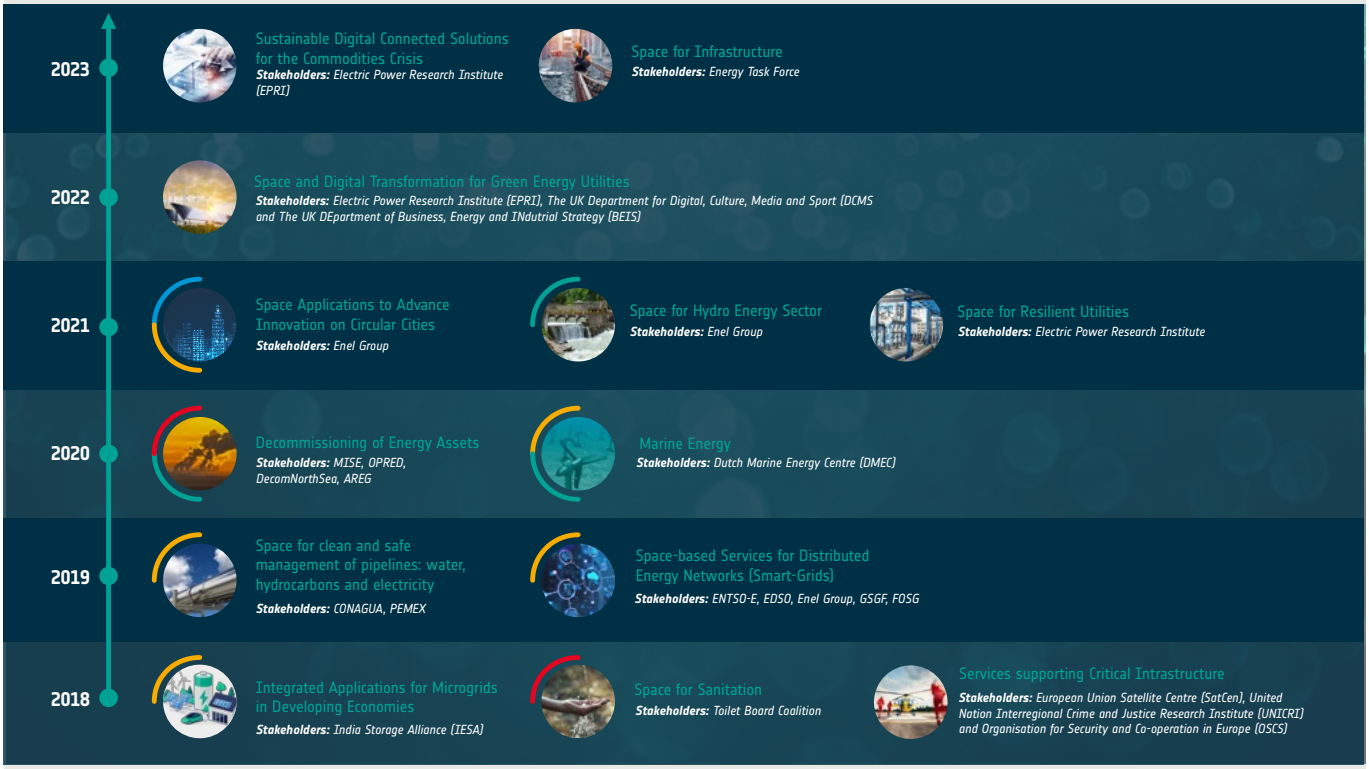
INTERNATIONAL COOPERATION

ESA BASS collaborates with major stakeholders across the energy sector in Europe and beyond, including energy distribution and transmission operators, energy associations and innovation clusters.

Since 2018 a range of Feasibility Studies have been carried out across multiple Member States and all stages of the energy life cycle to identify potential areas for innovation and collaboration as part of the BASS.

These co-operations have resulted in the creation of international initiatives in areas such as offshore wind, rural electrification and microgrid management, electricity network maintenance, and the decommissioning of oil and gas facilities.

Funding calls across the energy life cycle supported by stakeholders



TASK FORCE FOR INNOVATION IN ENERGY THROUGH SPACE

ESA's activities with leading energy stakeholders paved the way for the launch of the Task Force for Innovation in Energy Through Space in October 2022.

The Task Force is focused on generating green and economic impacts across society, in partnership with the private sector and funded by ESA initiatives.

The Task Force objectives include:

- Leveraging space applications in innovative, sustainable services which address the priorities of the green energy ecosystem and support the growth of a sustainable green economy
- Combining expertise from across the sector to develop and deliver innovative products
- Helping institutions, space agencies and industry demonstrate the potential of space technologies for the energy sector

CURRENT MEMBERS – MORE TO COME

Aberdeen Renewable Energy Group (AREG)
An association of 250 members based in the UK

Decom Mission
A not-for-profit, membership-based trade organisation based in the UK

European Distribution System Operators (E.EDSO)
Represents 41 electricity distribution systems operators in 24 countries

European Network of Transmission System Operators for Electricity (ENTSO-E)
Represents 39 electricity transmission system operators (TSOs) from 35 coutries across Europe

Electric Power Research Institute (EPRI)
A not-for-profit organisation funded by the electricity industry

Global Alliance for Sustainable Energy
An independent, multi-stakeholder alliance including members from the energy industry, civil society and academia

India Energy Storage Alliance (IESA)
An industry alliance focused on the development of advanced energy storage, green hydrogen and e-mobility technologies

Net Zero Technology Centre (NZTC)
A not-for-profit organisation funded by the UK and Scottish government

PRIORITY TOPICS AND APPLICATION AREAS

Renewable Energy (Net Positive)

Going beyond net-zero carbon footprint aims by removing additional carbon dioxide from the atmosphere.

- Logistics, operation and durability of energy installations
- Resource and environmental impact assessments
- Monitoring renewable capacity and Smart Energy systems

Small-Scale Generation of Renewable Electricity

Using small-scale renewable sources as a strategic alternative to the traditional large-scale generation of electrical power by a centralised grid.

- Smart energy systems
- Green Financing

Green Hydrogen and Alternative Green Carriers

Determining sustainable, bio-based and alternative green energy carriers to reduce emissions.

- Resource assessment and site selection for Green Hydrogen
- Sustainably-fuelled mobility monitoring for maritime, aviation and land

Ensuring Energy Supply Security

Assessing resilience to unforeseeable events that threaten energy flow or lead to irregular energy price rises.

- Security of energy supply in commodities crisis
- Assessment of energy usage
- Energy outage detection and prediction

Electric Mobility Planning

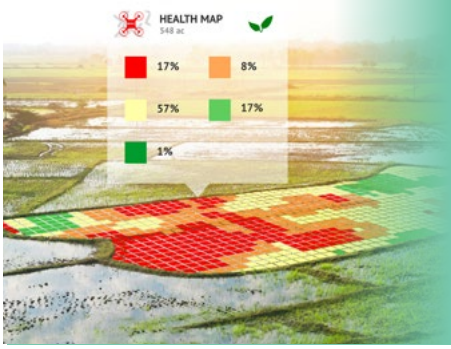
Reinventing infrastructure for the growing number of electric vehicles, addressing energy logistics and sources.

- Assessment of energy usage and infrastructure planning
- Management of micro-mobility vehicles

Circularity and Decommissioning

Assessing the decommissioning of oil and gas platforms and removal of structures to minimise environmental impact.

- Monitoring of environmental impact
- Logistics and automation
- Safety of workers and end-to-end business support



Decarbonisation

Focusing on reducing the carbon intensity of the power sector and emissions per unit of electricity generated.

- Mapping and monitoring of pollution
- Thermal mapping for heat efficiency
- Low carbon heat production
- Smart Grid monitoring

Energy Asset Operation and Maintenance

Determining the effective maintenance of assets to ensure the safety and longevity of traditional and green energies.

- Remote monitoring
- Supporting maintenance activities
- Geo-hazards

ENERGY TASK FORCE NEXT STEPS

From these eight topic areas, the Task Force has identified priorities for the short and medium term as follows:

- Decarbonisation, circularity and decommissioning
- Electromobility planning
- Asset operation and maintenance

In line with these priority areas, the Task Force is supporting the following initiatives:

- Call for Proposals "Space for Infrastructure"
- Call for Proposals "Commercial Applications of Space-Enabled Robotics"
- Call for Proposals "Space for Electromobility"

More information about these and other calls can be found at business.esa.net

SOCIO-ECONOMIC IMPACT

The figures below show the impressive socio-economic impact of 16 energy-related BASS Demonstration Projects, which received a combined ESA investment of EUR 9 million.

ESA's commercially-focused approach has generated international market success and broad socio-economic benefits through sales and the creation of jobs across Europe. The BASS projects have unlocked market opportunities, driving the development of European space-based solutions in the energy sector and promoting collaboration with a wide range of partners.

16 Energy Projects From **10** Countries Received **€9m** ESA Investment

50%
of projects generate sales
during the demonstration project

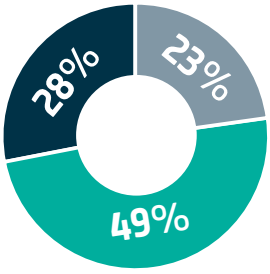
Exporting to 9 countries
across 3 continents during demonstration projects

<2 years to commercial return
Average, 12-50 months range

58 Jobs
Full time employment generated within the companies resulting from the project

5.2 x sales multiplier
€1 of ESA investment in the Demonstration Projects is forecast* to generate €5.2 in industry revenues within 3 years of completion

** Industry estimates*



47 Stakeholders

- Rest of World
- Other Europe
- Home

ENVIRONMENTAL IMPACT AND GREEN TRANSITION

The energy sector is the highest contributor to Green House Gas (GHG) emissions, with energy supply accounting for approximately 34% of anthropogenic GHG emissions.

ESA is working with a wide range of partners to develop innovative cost-effective space-based solutions to combat the environmental impact of the energy sector.

CONCLUSION

With a growing interest from industry and energy stakeholders, space applications are playing a vital role in the modernisation and digitalisation of the energy sector. Through innovation and collaboration, ESA is leading the way towards a more sustainable future.

ESA's energy initiatives across the energy life cycle provide the platform for the development of innovative, market-driven, space-based applications that address global markets and contribute to the fundamental changes that are required to ensure a safer, cleaner world.

Market analysis confirms the strong and wide-ranging socio-economic benefits of ESA's energy initiatives, while ESA's Energy Task Force leverages investment in green energy technology and forges opportunities for industry to advance space-enabled solutions.

ESA is set to launch several new green initiatives offering European companies the opportunity for funding and support to develop new energy services, technologies and products.

FIND OUT MORE

To find out more about these initiatives and to apply, please visit business.esa.int/energy and scroll down to 'Funding Opportunities'.

Register for the Energy Bulletin for the latest updates.

To follow us on LinkedIn – scan the code on the right and join us for more specialised content.