"SPACE AND DIGITAL TRANSFORMATION FOR GREEN ENERGY UTILITIES" THEMATIC CALL - ANNEXES

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ANNEXES

This call for proposals results from the cooperation between the European Space Agency (ESA) and key stakeholders of the energy sector. It aims at developing sustainable services leveraging space assets to address the needs for greener energy utilities.

The objectives identified at a global level have been defined in cooperation with the Electric Power Research Institute (EPRI).

The objectives related to the UK Government priorities have been identified by ESA in coordination with teams from the UK Department for Digital, Culture, Media and Sport (DCMS) and from the UK Department for Business, Energy & Industrial Strategy (BEIS).

1. ANNEX A: EPRI USE CASES

1.1. Decarbonisation and Sustainability

The world is on a path to decarbonise and the electric power industry is leading the charge. Since 2005, the US reduced its carbon footprint by one gigaton, primarily by switching to cleaner fuels, expanding renewables, and driving efficiencies. To get the next gigaton, we need solutions to integrate and manage more low-carbon energy generation: from distributed to utility-scale solutions covering wind, solar, hydro, and low-carbon fuels; to systems that help us optimize their output. Circularity in our operations and materials also are critical. As we deploy these solutions, controls, financing, accounting systems, and materials technology options will help society better track environmental impacts and support a shift to zero carbon. Our path to deep decarbonization also includes a focus on low-carbon hydrogen technologies.
Applications can address topics among the following:

- Sector-coupling clean energy fuel programs
- Green energy finance

- Circularity and low-carbon materials (vegetation waste, plastics, concrete, SF6 replacement, etc.)
- Satellite imagery for environmental resource monitoring (water, air, habitat, vegetation, etc.)
- Identification of aquatic and terrestrial species of concern for planning, compliance monitoring, and reduction of impacts in real time
- Offshore wind solutions
- Green hydrogen solutions
- Hydrogen storage systems
- Renewables integration
- Low-carbon fuels generation, distribution, and storage

1.2. Predictive and Prescriptive Operations

With the growth in renewables, distributed energy systems and electrification, modelling, and managing our grid is more important than ever. Digital overlays and AI/ML are fundamentally transforming the electric power system, and we seek solutions that provide more intelligent and autonomous power plants. We also seek automated, data-driven, and optimized operations, maintenance, and planning technologies for building a safer, more efficient, equitable, decentralized, secure, and decarbonized grid that better serves our customers.

Applications can address topics among the following:

- Predictive asset monitoring, maintenance, prognostics, planning and management
- Grid flexibility and automated management for distributed energy resources and baseload generation
- Dynamic degradation and failure prediction on renewable generation assets
- Unmanned systems and digital imagery capture and analytics
- Advanced atmospheric and weather modelling
- AI-enhanced IT/OT hardening and cyber threat mitigation
- Resilient, secure communications to support ubiquitous connectivity
- Internet of things (IoT) for grid monitoring

- Digital twins

1.3. Fixed Premise Electrification

Building systems and commercial/industrial processes represent significant opportunities for decarbonization. Utilities have long been active in innovations around building envelope, device efficiencies, and demand response programs. As we add intelligence, load disaggregation and flexible load solutions, we help match energy consumption to grid availability without sacrificing comfort or performance. As these solutions become more integrated and complex, there also is a need for comprehensive Electrification-as-a-Service solutions that guide customers through the design, deployment, and operation of solutions. Applications can address topics among the following:

- Advanced HVAC systems
- Load disaggregation, monitoring, and control
- Flexible load control solutions
- VPP and virtual battery solutions
- Standards and solutions for behind-the-meter interoperability
- Comprehensive Electrification-as-a-Service
- Low-and-moderate-income (LMI) & disadvantaged communities (DAC) targeted programs
- Industrial heat pumps

1.4. Robotics

Technological advances have led to rapid growth of opportunities in the robotics industry. As utilities manage the aging of existing assets and develop new advanced power plants, industry will need robotic platforms and integrated data analysis tools to safely and reliably reduce the cost of operations, inspections, and maintenance of power generation assets. We expect the next generation of these platforms to operate autonomously in difficult land, sea, and air environments, while sharing space safely with human workers and high-value assets.

Applications can address topics among the following:

- Physical security of critical assets
- Solutions for operating in inaccessible areas, such as ladders and heavy doors
- Operating robotic emergency response in difficult weather conditions
- Collaborative robots (“cobots”) for assisting human workers
- Onboard machine vision, automated analysis, and decision-making to facilitate handoffs from human-controlled to autonomous
- Advanced sensor payloads for radiation, audio, visual, and chemical detection
- Payloads and systems for monitoring equipment condition
- Advanced submersibles for maintenance diving tasks

2. ANNEX B: UK GOVERNMENT USE CASES

2.1. The UK strategy and priorities regarding renewable energy

A special focus of this call is devoted to the United Kingdom’s strategy and priorities regarding renewable energy. As a first remark, delivering the renewable electricity generation capacity necessary to meet the country’s decarbonisation targets is a key priority and an area where the UK is making progress. In 2020, renewable share of electricity generation accounted for 43% per cent of total electricity generation, setting a new record, and exceeding the generation from fossil fuels for the first time.

Wind and solar photovoltaic (PV) technologies will play a key role in delivering net zero, which is why the UK Government:

- Set an ambitious target to deliver 40GW of offshore wind capacity by 2030, including 1GW via floating offshore wind;
- Released the 2021 Contracts for Difference (CfD) auction round (AR4) to support up to double the renewable capacity that was delivered in 2019’s successful round, and;
- To include a pot for established renewable technologies, such as solar PV and onshore wind in CfD AR4 to ensure these technologies can play their full role in meeting net zero.

Both solar PV and onshore wind are key parts of the government's strategy to decarbonise the energy sector and will play key roles in helping us achieve our ambitious Net Zero and Carbon budget 6 (CB6) targets. The Energy White Paper, published in December 2020, committed to 'sustained growth' in solar PV and onshore wind across the next decade.

Solar PV is an established low-cost versatile technology that can be deployed in a variety of locations and contexts including roofs of domestic, commercial, and industrial properties, and on the ground in brownfield and greenfield sites. It has been a UK success story, with rapid deployment over the last 10 years. Since May 2010, over 99% of the UK's solar PV capacity has been deployed and over a million homes have installed solar PV. As of July 2021, the UK has around 13.51GW of installed solar capacity - enough to power around 3 million homes.

Onshore wind is a mature, low-cost and quick-to-deploy technology that plays a significant role in our energy mix. Latest figures indicate we now have over 14GW of onshore wind capacity installed in the UK, enough to power over 10 million UK homes. Most of the installed capacity is in Scotland, as is the majority of projects in the planning pipeline.

The UK Government is investing in the potential benefit of digitalisation in the Energy sector already for some years, and it has investigated how the use of data could be transformed across the energy system through the Energy Data Taskforce[2].

The optimisation is achieved also through the transition to Smart Energy Grid, a key objective of the UK plan, which has defined the roadmap in the Smart Systems and Flexibility Plan 2021[3].

Among other technologies, hybrid terrestrial-satellite 5G (and prospectively 6G) networks have a strong potential to support such green transformation for the energy utility sector and beyond, enabling green transition in key vertical markets.

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[1] https://www.gov.uk/government/statistics/solar-photovoltaics-deployment
[2] Energy Data Taskforce - GOV.UK (www.gov.uk)
[3] Transitioning to a net zero energy system: smart systems and flexibility plan 2021 - GOV.UK (www.gov.uk)

2.2. Delivering Net Zero: satellites for energy assets control

2.2.1. Background

Meeting a 2050 net-zero carbon dioxide emissions target will require changes to existing passive electricity distribution and transmission networks worldwide to turn what are now largely passive networks into 'smart networks' that use distributed intelligence to actively control the flow of energy. This is essential to better control the flow of renewable generation onto the grid and to manage the potential doubling of peak electrical load needed for the electrification of transport and heating. As a result, there is now a need for a novel communications network that can reach assets such as transformers and offshore wind farms that are outside the range of conventional terrestrial cellular coverage and that can still function when the power fails in order to control the re-starting of supply. The purpose of this piece of work is to explore whether satellites could provide such a dedicated communication network to support the energy smart grid and hence assist in the effort to achieve net zero emissions by 2050.

2.2.2. The Requirements

The UK Government recently published the recommendations from The Energy Data Taskforce[1] which shows how data can assist with unlocking opportunities provided by a modern, decarbonised and decentralised Energy System to achieve the best value for consumers. This identified the important characteristics of the communication system that could achieve these benefits:

- The communications network should be able to communicate to a variety of electrical assets on the network, distributed across wide areas and frequently in remote areas.
- The communications network should be able to still operate when the power is down in an area so that data from sensors on the grid can assist with fault determination and the restoration of service. This implies the transceivers need to be able to operate with battery power for some time after power is lost- up to two weeks would be ideal.
- The data rates from individual assets are low. A transformer current sensor may only send a reading every few seconds and a circuit breaker may only be required to be

switched once or time a year. Latency requirements means that data needs to be sent in a timely fashion however (<1s latency).

- The system will need to be highly reliable since many assets are difficult to access for maintenance and they will be expected to work instantly when required. For example, in a thunderstorm where lightning strikes have switched protective circuit devices which then need to be reset remotely.
- Cybersecurity and denial of service protection are critical since the electricity network is critical national infrastructure. So, for example, the system should have substantial immunity from jamming.
- There are over 40,000 low voltage transformers on the UK electricity grid alone. To be applicable to as many electricity assets as possible, the cost of the ground station should be as low as possible.

With the rapid change in the electricity networks as more renewable energy comes online, industry representatives have expressed a view that this increase in monitoring, control and data cannot be met with existing terrestrial communication technologies and require new methods. They have particularly identified issues with use of cellular mobile networks, specifically in relation to coverage and particularly power resilience, which they state does not give the necessary control of the energy networks in a power outage scenario. In response, the UK Government recently procured a piece of work (Spectrum Strategy project[2]) with the purpose of assessing the risks of the new energy demand not being met from existing connectivity solutions.

The purpose of this work is therefore to understand the feasibility of developing a bespoke satellites system for communication to distribution assets in the UK as a possible solution meeting this specification. We believe that the low energy requirements needed to make battery back-up feasible over periods of two weeks or more probably point to these being based on micro-satellites in LEO, but we would be happy to consider other space born solutions that can meet the exacting specifications given.

2.2.3. Project scope

The scope of the project is to complete a feasibility study of micro satellites in LEO or potentially larger satellites in higher earth orbit for energy assets control to facilitate the transition towards Net Zero. The focus is on those requirements relating to critical infrastructure (resilience, availability, coverage, and power outage recovery requirements).

We are particularly interested in understanding:

- Physical links of the satellite communication (how many bits/seconds for the uplink/downlink bandwidth), signal margins and likely latency.
- Details of the radio transmitting system, frequency and bandwidth requirements together with whether such spectrum already exists or will need to be acquired.
- The number of satellites required for good coverage over an area such as the UK or Europe.
- In which way the system can support the scenario of a power outage, for example with a battery back-up system.
- What would the ground station antenna size be, bearing in mind the need for mounting.
- What type of battery system would be required to ensure resilience and details of the technology needed.
- In which orbit would the satellites be placed and what would be the end-of-life plan.
- How easy it would be to meet the radio jamming and cybersecurity requirements.
- What are the financial costs of the solution, with details of both set-up and ongoing costs.
- What are barriers to the achievability of the proposed solution and what innovation would be required to take this solution forward.

2.2.4. Deliverables

The project would produce the following key deliverables:

- A report containing the technical details of the proposed solution.
- A report containing financial costs of the proposed solution.
- A report containing risks and barriers to achievability of the proposed solution.
- An executive summary detailing the methodology employed and the key conclusion.
- Presentation of findings to BEIS and other key stakeholders.

The aim would be to have an initial estimate of whether these requirements could be met using space technology and whether it is worth taking this concept further.

2.2.5. References

[1] https://es.catapult.org.uk/case-study/energy-data-taskforce/

[2] https://www.contractsfinder.service.gov.uk/Notice/d1f18984-c211-4ac6-94ae-7805c2909d9b

2.3. Use Cases from DCMS/BEIS

2.3.1. ESA/Solar ideas

Using space/5g tech to enable:

i. Deployment (mapping, planning, forecasting, risk management)
   - Mapping out of suitable roof and land for solar- using Lidar or other related technologies, that can link to existing energy industry / infrastructure datasets e.g., electricity meter/supply points, grid connection points, accredited solar installer databases. This can help to better estimate/understand the fuller range of likely costs of and storage potential from (large scale, commercial and small-scale rooftop) solar deployment for developers and consumers. This can also help to improve (household and business) consumers' grid connectivity, reduce consumers' bills, provide (and in time, strengthen) electrical vehicle charging infrastructure, support improved (electricity) infrastructure planning and maintain grid stability e.g., via more accurate forecasting, use optimisation, risk planning. This can also help to better match renewable energy generators with (corporate and household) consumers, which can create demand for independent solar development financing that may lead to more funding options becoming available.

ii. Operations (tracking, monitoring, maintenance/replacement)
   - Tracking of sites- using tracking technology to monitor and predict operations and management of solar sites (factors like panel degradation, cleaning, necessary replacements) This can also help with redeployment: by identifying areas where the

existing solar panels may need to be replaced (as needed) as solar panels become more efficient / other solar surface electricity-generating technologies are developed

- Using drone technology to survey and maintain solar sites.
- Tracking and monitoring of (often currently unquantified) benefits of solar farms – increased biodiversity, monitoring of soil quality under solar sites, carbon sequestration and savings

iii. Innovation (circular economy)

- Promoting the circular economy in solar – looking at whole project lifetimes, recycling and reusing of panel glass and minerals found in panels. This can also encourage innovation in methods and/or materials that may be used to improve the efficiency / performance of solar panels/surfaces' and to support growth in UK content in solar products and supply chains.
- Monitoring of the solar supply chain. Giving detail to a complex international supply chain. Allowing ability to identify and track sources of panel elements such as polysilicon etc.
- Innovations to deploy solar more widely – deploying solar on all suitable buildings and building surfaces (glass, walls, rooves etc.) in the UK. (*Timeline- likely to happen increasingly in next couple of years*)
- Innovations to deploy more widely solar on non-building surfaces in the UK (such as bus stops, streetlights etc.,) (*Timeline- likely to take longer, perhaps 10years+*)

2.3.2. ESA/Onshore Wind ideas

Using space/5g tech to enable:

- Tracking of sites – using tracking technology to monitor and predict operations and management of onshore wind sites (necessary replacements, system/gear maintenance)
- Using drone technology to survey and maintain onshore wind sites. This could be used particularly in decisions around lifetime extension of sites
- Promoting the circular economy in wind – looking at whole project lifetimes, recycling, repurposing of blades, and reusing of minerals used in turbines
- Tracking of migratory bird patterns and/or endangered birds – to help avoid these areas when building turbines

- Identifying solutions to co-existence between onshore radar and surveillance systems and wind turbines
- Using satellite imagery to be able to visualise how sites would look *before* construction starts

2.3.3. BEIS Renewable Electricity: Sustainable Future competition

i. Broad thematic areas

- Identifying and monitoring existing renewable capacity
- Mitigating the intermittency of renewables generation by developing and improving grid balancing services
- Identifying the most suitable areas for renewables deployment in the UK on land, rooftops, and water bodies (oceans, lakes etc.)
- Speeding up the rate of renewable deployment by identifying and removing barriers
- Monitoring and tracking community acceptance and resistance to renewable technologies
- Lessening the impacts of increased deployment (such as biodiversity net gain)

ii. Technology improvement

- Improving the efficiency and performance of renewable technologies
- Developing smart metering and home systems incl. price monitoring/smart tariffs
- Identifying solutions to co-existence between radar and surveillance systems and wind turbines

iii. Removing barriers

- Identifying solutions to make onshore renewables more acceptable to local communities (such as use of VR headsets or visualisation techniques during public consultation)
- Identifying ways of matching renewable energy generators with corporate offtakers to develop the subsidy free market
- Identifying methods to support better planning for renewable electricity infrastructure at a local and national level (such as using mapping/GIS data)

iv. Supply chains

- Identifying ways to boost UK content of renewable technologies

- Identifying routes to increase employment in the UK renewables sector
- Identifying ways of improving supply chain traceability

UK government priorities on renewable energy include:

- Enabling renewable generation capacity deployment in line with the need to meet the decarbonisation commitment, including CB6;
- Ensure that renewable generation capacity is deployed cost-effectively and benefits household and businesses consumers alike;
- Consolidating and building on the UK's leading position of technological innovation in renewable technologies;
- Increasing UK content in supply chains for renewable technologies to secure more jobs and investment;
- Working with communities on the acceptance of renewable electricity infrastructure.

2.4. 5GTT / BEIS smart systems Use Cases

i. Facilitating flexibility from consumers

- Use of standardised communication protocols and technologies to enable interoperability for electricity system integration and consumer protection
- Use of high bandwidth communication technologies for two-way communication with millions of distributed devices, 5G enabled domestic appliances (including electric vehicles, heat pumps and electric batteries) can be controlled by flexibility providers and optimisation platforms to provide flexibility
- Use of low latency communication technologies for real-time network and asset monitoring, to enable operational control and use of flexibility for system balancing
- Use of AI and ML to improve electricity supply and demand forecasting and to optimise operational planning to lower costs and carbon (at both household and network levels)
- Developing cyber secure systems for consumer protection and electricity system protection, tackling solutions for encryption whilst maintaining low latency

ii. <u>Electricity Storage, Grids, Interconnection, and Markets</u>

- Use of 5G data services to control dispatch of distributed storage on the electricity grid of different capacities and storage durations
- Monitoring of major energy flows on the electricity grid in real time
- Aiding 'black start' capability on the electricity network- e.g. to remotely control breakers on the network
- Monitoring quality factors such as phase balance, power factors and voltage levels remotely on the network
- Monitoring gas quality and pressures in the gas grid, especially for aiding the potential transition between the existing natural gas and a hydrogen-based gas grid
- Monitoring of major energy flows on the electricity grid in real time
- Use of 5G data services to control dispatch of distributed energy resources
- Use of low latency communication technologies for real-time network and asset monitoring, to enable operational control and use of flexibility for system balancing across distribution and transmission control rooms

iii. <u>Energy Digitalisation Strategy</u>

- AI and ML for energy digital twin development
- Edge computing for decentralised energy management
- Monitoring and sensors on grid assets to aid real-time management and self-healing grids
- Digital detection solutions to identify 'legacy' assets already in play
- Interoperability solutions at all levels, from national down to device-level
- Security protocols to combat any new data infrastructure risks

<u>UK government priorities on Smart Energy</u>

- Deploy smart and flexible technologies to enable a net zero electricity system and save up to £10 billion per year by 2050 by reducing the amount of generation and network needed to decarbonise
- Use smart and flexible technologies to support the cost-effective electrification of heat and transport in order to deliver net zero carbon commitments

- Use innovation to develop smart and flexible technologies and drive consumer uptake
- Use smart 5G technologies to improve the reliability of the electricity and gas grids
- Develop cyber secure digital technologies to protect consumers and the electricity system