# SPACE FOR INFRASTRUCTURE – ENERGY INFRASTRUCTURE USE CASES


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# 1. INTRODUCTION

This document lists the use cases to be used as part of the “Energy Infrastructure” thematic area within the umbrella of the “Space for Infrastructure” thematic call for proposals.

The use cases presented result from the cooperation between the European Space Agency (ESA) and key stakeholders of the energy infrastructure sector. It aims at developing sustainable services leveraging space assets to address the needs for modern day energy grids.

When writing the initial proposal (APQ/Outline proposal), the applicant will make clear what use case(s) their solution will address.

# 2. ANNEX A: ENERGY INFRASTRUCTURE USE CASES

## 2.1. ESA Energy Task Force

The following use cases in this section have been developed following the support of the ESA “Task Force for Innovation in Energy Through Space” (Energy Task Force) members EPRI and E-REDES.

Members of ESA’s Energy Task Force have identified the following 3 focus areas in which space can provide value in providing the next generation of solutions for Energy Infrastructure:

1. Monitoring of existing infrastructure
2. Provision of a digital twin of European energy networks
3. Operations and planning.

### *2.1.1. Monitoring of Existing Infrastructure*

With the threat of climate change and global warming along with other challenges such as the build-up of urban areas, monitoring of infrastructure is becoming ever more prevalent for the national Distribution System Operators (DSOs). As such, the monitoring of existing infrastructure is of increasing importance. The following areas of interest have been highlighted as topics for innovative, future service development:

#### 2.1.1.1. Use Case 1: Monitoring of the near-Environment for Overhead Cables

The impact of vegetation and other obstacles such as illegally erected man-made structures cause a problem for DSOs due to the issues of these obstacles possibly causing disruption to the network. I.e. Trees touching high-voltage overhead cables which can then lead to a fire. By using Earth Observation to check on the presence of nearby obstacles or vegetation to the overhead cable, corrective actions can be automatically activated such that the risk is removed. In addition to this, the integration of time-series data would be of interest to provide AI-generated predictions (over a period of 1-5 years) of future vegetation growth so that future network maintenance plans can be made. For example, for E-REDES, more than 80% of the grid is overhead and will require inspection for encroaching vegetation or obstacles in the near future. The end user(s) of this use case would be those organisations (such as DSOs) which operate and maintain overhead cable networks.

#### 2.1.1.2. Use Case 2: Real-time monitoring of Renewable Energy Infrastructure

To provide accurate measurements for the generation of renewable energy due to the increase in proportion of energy generated from renewable source (wind, solar, etc…), monitoring of energy generation is required to provide DSOs with figures such that they can properly load and manage the grid.

By integrating sensors and data from renewable energy assets such as energy production, thermal and vibration sensors, information can be provided to both the DSO and asset operator to ensure that the asset is performing optimally. In addition to the real-time monitoring, this data can be used in conjunction with technologies such as AI/ML for the prediction of maintenance, thus saving asset operators time and money in the maintenance of their assets. Another important point is the acknowledgement of visible resources connected to the network, which can have an impact on grid load management.

Typically, renewable energy assets are in remote locations where access to terrestrial, cellular networks are limited. Satellite communications can be used to mitigate this problem by using low-latency LEO-based satellite networks. Therefore, real-time diagnostic information can be supplied to a central data centre from which asset operators or DSOs can make strategic decisions based on the asset’s condition.

#### 2.1.1.3. Use Case 3: An Increase in Observability of the Grid

To increase the tactical awareness of DSOs and grid operators to changes in grid condition, an increase in observability of the grid is needed. This can be achieved through the roll-out of internet of things (IoT) devices so that measurements can be made on a granular level.
Since distribution grids are sparse, some areas of the grid may not be able to access terrestrial cellular networks. IoT devices when used in tandem with satellite communications, can be used to solve this technical challenge. Satellite communication networks can provide ubiquitous, low-latency connectivity to remote areas where cellular areas may not have access. In addition to using satellite communications, using GNSS signals allows the asset to be geo-located, and also allows for the time verification of data.

### *2.1.2. Digital Twin of the Energy Network*

To help enable a swift transition where the EU Green Deal and the Digital Decade EU Policy programme for 2030 go hand-in-hand. In 2022, ENTSO-E and EU DSO Entity have led to signing a declaration of intent in which it aims to develop jointly a digital twin of the EU energy grid. The following focus areas have been highlighted which are of interest to the end user community.

#### 2.1.2.1. Use Case 4: Load Management and Prediction

As electrification is ever increasing in Europe, load management and prediction are becoming more prevalent in DSO needs. Specifically, the following features are needed:

- Real-time monitoring of existing assets to predict future load/utilisation.
- Forecasting of the optimisation of power flows.

To achieve this, it is envisaged that through using a network of IoT devices will be needed. As the energy distribution system can be remote in places, communication to the IoT devices may prove difficult. By using satellite communications, low-latency connectivity can be achieved. Thus, allowing DSOs to communicate to those sensors which would be placed in remote locations. In addition to using satellite communications, using GNSS signals allows the asset to be geo-located, and also allows for the time verification of data.

#### 2.1.2.2. Use Case 5: Digital Twin partial Model Verification

With the digital twin model being currently developed, the verification of the model in terms of confirming the location and number physical assets will be important. To solve this challenge, it is expected that Earth Observation (EO) will play a role in developing a new solution in which EO imagery will be used to cross-reference the model to the physical assets on the ground.

### *2.1.3. Operations and Planning*

#### 2.1.3.1. Use Case 6: Energy Security & the Detection of Anomalies

With the creation of accurate digital models (i.e. a digital twin) of the energy infrastructure, the detection of anomalies within the network using AI/ML should be achievable. By integrating external IoT sensors such as movement, temperature, electrical load etc… Anomalies within the system should be detected quickly and then actioned to the maintenance team.

For this to be achieved, using satellite communications to communicate with maintenance teams in a secure way is needed along with the ubiquitous connectivity when cellular networks are not available. In addition, GNSS technology can be used to geo-locate an asset but can also be used to provide geo-fencing and applications in the areas of data validation. This in-turn enables the use of technologies such as Edge computing can be used to provide information where communication links are either of a low band bandwidth or a large data set is being generated.

An example application of this would be a maintenance system in which a fault is discovered in the energy grid through a IoT sensor network. This then actions a drone to fly over the faulty area to survey the grid for any problems (i.e. a overhead cable failure) so that maintenance teams can quickly respond to faulty situations.

#### 2.1.3.2. Use Case 7: Response in Emergency Situations

In the case of emergency situations (e.g. natural disasters, security breaches, wildfires, etc…) clear communications and continuous connectivity to the distribution assets must be available to ensure a close-to-continuous distribution service as possible.

This issue can be solved using satellite communications as they are not affected by the ground conditions and can provide secure, reliable and ubiquitous connectivity where cellular networks either fail or do not provide coverage. One example of this is the recent fires in Portugal in which the DSO did not know the state of their assets  in remote areas.

This use case also applies to supporting the response personnel on the ground handling the situation. As mentioned above, satellite communications provides the secure connectivity needed for these emergency situations. In addition, by integrating GNSS receivers, personnel can be geo-located and geo-fencing can be applied to ensure the responding personnel are in the correct areas. The end users of such a solution would not just be the DSO personnel on the ground but also DSO central control and the emergency services handling the situation.

## 2.2. E.ON Innovation

E.ON is a leading European energy company with a strong focus on delivering reliable and sustainable energy through its robust grid infrastructure. We are responsible for developing and distributing solutions that address the biggest challenges of our time, such as climate change and energy efficiency.

E.ON is one of Europe's largest distribution system operators with around 1.6 million kilometres of electricity and gas grids in nine European countries, including Germany as the largest distribution system operator. In Germany alone, our nine regional companies operate over 800,000 kilometres of electricity and gas grids. Through our distribution grid, we bring the energy transition directly to the people's doorsteps. For example, we are connecting more and more new renewable energy plants as well as industry, commerce and private households to our distribution grid.

For E.ONs network business we want to present the following two use cases to ESA’s “Space for Infrastructure Call - Energy” to find innovative satellite or space based solutions.

### *2.2.1. Use Case 8: Detection of acute damage to overhead lines*

**Problem:** We already use the automated evaluation of satellite images to identify and remove risk vegetation on our overhead lines in advance. Nevertheless, damage caused by vegetation after extreme weather events such as storms cannot be ruled out. This damage is usually caused by trees falling into the overhead lines and leads to power outages. Due to technical restrictions, the location of the damage can only be determined very roughly (up to 50km line length). In order to determine the exact location, the lines must then be walked or driven along. This is very time-consuming and requires a high level of staff commitment. In addition, the situation after storms can sometimes become very dangerous for the employee due to wood falling. Sometimes forest areas are also closed for several days, so that damage detection is further delayed. Technical aids such as drones can usually not be used due to legal restrictions and weather conditions.

**Challenge:** We are looking for a digital solution that automatically detects and displays acute damage caused by vegetation in a defined area. For this purpose, satellite data is to be evaluated by AI. Ideally, detection should take place within 24 hours of the damage occurring, but within 48 hours at the most. The solution should be easy to use and mobile for on-site staff. The accuracy should be in the range of 100m (or visibility of the employees).

### *2.2.2. Use Case 9: Third party interventions*

**Problem:** Besides vegetation, third party interference is the main cause of damage to overhead lines. This mainly includes unreported construction sites and unauthorized construction under or along the overhead line or gas line. In addition to possible damage, this also violates legal provisions on hazard prevention. As a network operator, we are responsible for checking and complying with the legal requirements. Currently, these violations can only be detected by walk-throughs or helicopter flights. For reasons of cost and resources, these inspections can only be carried out at long intervals (1 to 5 years). Therefore, violations are only detected late or not at all. In addition, the control is cost and resource intensive.

**Challenge:** We are looking for a digital solution that automatically detects construction sites and buildings on our overhead lines by evaluating satellite data using AI. If risks are detected, a warning should be issued automatically. The evaluation should take place in a fixed defined cycle (first suggestion: every 14 days). A pilot project has already been carried out, but there were too many false alarms (e.g. due to parked cars). Therefore, the project was not continued.

## 2.3. Leading Energy Utility

The use cases presented in this section have been developed with a leading energy utility.

### *2.3.1. Use Case 10: Working Monitoring on Photovoltaic construction sites*

**Context**

To monitor the progress of the activities on photovoltaic (PV) plant construction site, personnel and external contractors need to check the progress of the installation daily. The collection of this data is necessary to produce a weekly report that represents the official statement of the Site Manager towards Project Manager and the Management of the company.

**How does the process work today?**

Up to now, the monitoring of construction progress in PV power plants has been carried out via manual and visual checks, involving personnel and suppliers.

The process implemented today needs to involve many people to collect, verify, elaborate and share information and it requires all parties to spend many hours to execute it.

Furthermore, many PV plants are large scale power plants, that occupy a large area (> 100 hectares), and this forces personnel to reduce the percentage of spot site surveys to countercheck information provided by suppliers or to increase the work hours spent to do it. Sometimes to make a survey of all power plant is almost impossible with standard means because it requests all day or more time.

**How can the process be improved?**

We wish to reduce the time required for periodical reporting as well as the precision of the reports. The aim is to reduce the workhours spent for monitoring, ensure the possibility to cover all the PV plant surface (100 MW can cover approximately 200 hectares), increase the construction quality and the level of supervision over suppliers. If remote inspections were possible, fewer plant visits would be required, reducing travel costs and interference with construction site operations.

**What is the target process?**

The target process is a construction advancement reporting adopting satellite data and Machine Learning solutions based on computer vision.

The algorithms should analyse available data and provides the status of the plant's construction and installation of each plant element (e.g. element installed / not installed) for selected subset areas chosen by the user.

The main assets to monitor are:

1. Mechanical Works:
   1.1. Metal piles: number, percentage.
   1.2. Trackers structure: number, percentage.
   1.3. PV modules: number and percentage.
2. Electrical Works:
   2.1. Trenching: Length, Percentage
   2.2. Trenching Backfill: Length, Percentage
   2.3. Conversion Unit (Cabin which host the inverters in charge of the DC to AC conversion): done/not done, percentage
   2.4. Transformer CU: done/not done, percentage (if transformer is installed outside the CU)
3. Site Works:
   3.1. Conversion Units (Standard foundation):
      3.1.1. Excavation of Foundation, Lean concrete & Grounding System: percentage, done/not done
      3.1.2. Lean Concrete: done/not done
      3.1.3. Reinforcing bars: done/not done
      3.1.4. Pouring: done/not done
      3.1.5. Backfilling & Grounding Finishing: done/not done
   3.2. Drainage system and retention/sediment basins: percentage
   3.3. Roads: length of roads (polyline)
   3.4. Road Clearing: Length
   3.5. Road Excavation and Fill: Length
   3.6. Road Execution: Length
   3.7. Road Drainages: Length
   3.8. Surface preparation: Hectares/percentage
   3.9. Site Fence: Length of installed fence and gates
4. Site Logistic:
   4.1. PV modules Pallet positioning: number/sub area
   4.2. Coil medium voltage cable: number per sub area
5. Project Phases and construction method

5.1. Identification of which phases are carried out at each satellite pass (e.g. substation, civil works, module installation
5.2. Identification of machinery present on site and working methodology according to a pre-defined list (e.g. centralized assembly, automation, etc.)

**Requirements**

The progress analysis will have to evaluate the progress of all the areas worked with respect to the overall work area and will have to be automatically processed in a maximum time of about 24 hours.

Cost reduction drivers are key in order to make the service accessible for utilities (low cost starting data, free access data, low data transfer to ground, etc…).

### *2.3.2. Use Case 11: Evaluation of hydrometric level in canals and rivers*

**Context Information**

The estimation of water levels in basins, natural rivers and artificial canals takes on particular importance in the management of hydroelectric plants, in particular for their safety.

**How does the process work today?**

Currently, water levels are measured manually or automatically through the use of manual or automatic instruments. The cost of the instrumentation and the necessary manual skills make the measurements punctual or extended over limited areas.

**How can the process be improved?**

The process could be improved through the use of satellite images that allow the estimation of hydrometric heights continuously and over large extensions of basins, channels or rivers.

**What is the target process?**

The objective of the project is the use of satellite images for real-time knowledge of hydrometric levels in linear hydraulic works characterized by considerable extension such as natural rivers and artificial canals and in hydraulic basins upstream of dams. The satellite image allows the evaluation of water levels even in areas that are not normally accessible.

**Requirements**

The measurement must be available in real time with a delay of a few hours compared to the actual time and continuously with a maximum time step of once a day The procedure must be calibrated using historical series of hydrometric measurements and satellite images in order to evaluate the degree of precision of the measurement via satellite compared to traditional manual or automatic measurement.

A cost reduction drive is key in order to make the service accessible (low resolution starting data, free access data, low data transfer to ground, etc…).

### 2.3.3. Use Case 12: Damage assessment after an extreme weather event

**Context Information**

Damage caused by natural events on hydropower facilities differs in extent and nature, but the possibility of having information about what happened in a timely manner is important for a first action plan.

Similarly, strong hailstorms and extreme events can hit photovoltaic and wind production plants causing extensive damage.

Mapping, characterizing and assessing damage in rural or urban environments following natural extreme events by combining various types of satellite data would provide an excellent tool to support intervention strategies.

strategies.

**How does the process work today?**

The assessment process is carried out through ground-based inspections of the personnel, with issues related to ease of access to sites affected by natural events. It may be the case that access roads to sites are interrupted or difficult to navigate, delaying an initial assessment of what has happened.

**How can the process be improved?**

The possibility of using multiple satellite sensors together would solve specific problems of individual sensors, such as the presence of clouds or low resolution on the ground.

**What is the target process?**

The objective of the project is to evaluate a strategy for using different satellite sensors, to provide timely data regardless of the presence of surrounding situations which are generally problematic for remote sensing techniques (revisit time, geometric resolution, sky coverage, etc…).

Examples of what to be detected is: landslides occurring close to a water basin/roads, number of location of damaged PV modules, significantly damaged wind turbine blades.

**Requirements**

- Maximum temporal acquisition frequency: daily
- Image in visible, near infrared and radar bands
- Infographic presentation on GIS systems
- Links to official national and international databases for meteorological data acquisition

Cost reduction drivers are key in order to make the service accessible for utilities (low cost starting data, free access data, low data transfer to ground, etc…).

### *2.3.4. Use Case 13: Water Leak Detection*

**Context Information**

Open canals in hydroelectric plants may have under-surface cracks which cause water leaks very difficult to detect before significant damages are done to the surrounding areas. Early detection of these leaks can be possible by advanced satellite image analysis and would allow maintenance efforts to be focused.

**How does the process work today?**

In practice, canals can be tens or even hundreds of kilometres in length. Manually inspecting canals can take weeks and is unlikely to provide a complete assessment of leaking. The fact that most cracks develop underwater is another difficulty; inspectors could not observe underwater conditions without draining the canals.

**How can the process be improved?**

Using satellite imagery and other types of remotely sensed data, such as ground surface temperature, vegetation water stress and soil moisture information, it is possible to develop deep learning algorithms to identify areas along canals that are abnormal compared to normal.

**What is the target process?**

The objectives are to verify the availability of satellite data on ground conditions near canals, to check the frequency with which such an analysis can be repeated, to train the algorithms by analysis of already known cases and to test the methodology on a few representative canals.

**Requirements:**

- Maximum temporal acquisition frequency: weekly
- Image in visible, near infrared and radar bands
- Infographic presentation on GIS systems

Cost reduction drivers are key in order to make the service accessible for utilities (low cost starting data, free access data, low data transfer to ground, etc…).

### *2.3.5. Use Case 14: Archaeological Underground Large Structure*

**Context Information**

Every energy system is developed, from design to final product, with accurate estimated times and costs by way of a detailed plan for every single phase of development. In each energy construction site everything is designed, managed, and analysed with high precision and accuracy. Archaeological evidence and finds, not properly detected, and identified during the preliminary phase of energy construction projects, could lead to serious consequences during the excavation activities, such as delays to project timelines, costly redesign works or, even, bringing the entire construction site activities to a halt. Remote-sensing techniques and Artificial Intelligence can be useful for improving the archaeological preliminary research with innovative technical solutions based on satellite images.

**How does the process work today?**

Archaeological survey, traditionally carried out by expert personnel, represents a considerable effort in terms of time, and they can be not compatible with project timelines, in particular when they are carried out over large areas of hundreds or thousands of hectares.

**How can the process be improved?**

Using satellite imagery and AI solution to detect archaeological Underground Large Structures at renewable power plant construction sites, before starting construction (pre-survey). In this way we can reduce risks of delays construction site, avoid extra costs and at least the deal break.

**What is the target process?**

The solution should be able to automatically apply of the artificial intelligence technologies to find the archaeological underground large structures based on satellite images.

**Requirements**

High and low resolution, multispectral satellite images with seasonal acquisition frequency

Cost reduction drivers are key in order to make the service accessible for utilities (low cost starting data, free access data, low data transfer to ground, etc…).

### *2.3.6. Use Case 15: Estimation of river sediment transport and basin sedimentation*

**Context Information**

One of the main problems in the management of reservoirs, whether they are used for energy or irrigation, is sedimentation. Sedimentation is the progressive accumulation of sediment that reduces the capacity of the reservoir and can limit or even prevent its operation. Therefore, in order to avoid the loss of resources of great economic and environmental interest, it is necessary to monitor sedimentation in reservoirs and rivers.

**How does the process work today?**

The reduction in reservoir capacity is related to the sedimentation of soil and rock particles. These particles originate from surface rock degradation processes in the reservoir upstream of the dam and are gradually transported by tributary waters. The most common method for quantifying suspended sediment runoff is to measure the flow in a given stream cross section and the corresponding suspended sediment concentration. The main problem with in-situ flow measurements is that they are labour intensive; consequently, flow data are limited in space and time, which is why many rivers have not yet been monitored.

**How can the process be improved?**

Sediment runoff in rivers is influenced by several natural and anthropogenic factors. Unfortunately, most rivers are monitored only at a limited number of stations or not at all. A useful alternative for monitoring the suspended sediment concentration and discharge of rivers could be the combination of remote sensing imagery and machine learning techniques.

River runoff is directly related to weather conditions (precipitation and evaporation) and watershed runoff; land use and land cover patterns also affect water runoff and its long-term variability. It is also necessary to know the characteristics of the sediment and its transport velocity to calculate or measure the runoff of suspended sediment from a river. Therefore, in-situ measurements of runoff and remotely sensed suspended sediment concentrations need to be combined.

**What is the target process?**

Understanding how sediment erosion occurs upstream of reservoirs, the phenomena that regulate its intensity, and the mechanisms of material transport can provide an indication of the strategies to be adopted to limit its accumulation in reservoirs. On the basis of specific studies, works can be designed to retain some of the sediment along the river or to slow its transport. Estimates of basin life can be updated and the removal of accumulated material can be planned. A policy of upland basin settlement can be adopted, aimed at controlling erosive phenomena through hydraulic forestry arrangements.

**Requirements**

- Maximum temporal acquisition frequency: weekly/monthly
- Image in visible, near infrared and radar bands
- Infographic presentation on GIS systems
- The hydraulic geometry of the river channel the hydro morphological properties of basins
- The vegetational cover and the soils maps
- The rivers' flow

Cost reduction drivers are key in order to make the service accessible for utilities (low cost starting data, free access data, low data transfer to ground, etc…).

### *2.3.7. Use Case 16: Biodiversity Preservation*

**Context Information**

During construction projects, the presence of protected tree species, not properly detected and identified during the preliminary project phase, could lead to delays to project timelines, costly redesign works or, even bring the entire construction site activities to a halt. These situations if properly managed in advance by adopting effective and efficient techniques and methods to detect protected tree or other vegetation species, that may be rare, in danger of extinction, or of particular importance for the biodiversity equilibrium of the considered area, or that are protected by regulation, can be leveraged to transform a potential issue into opportunities to add value to the project.

**How does the process work today?**

In compliance with local legislation, Energy utilities carries out manual investigations to evaluate and manage this task in order to detect protected tree species in an early stage of the construction project, and to identify areas where further detailed investigations are needed. Protected tree species search and survey, traditionally carried out by expert personnel, represent a considerable effort in terms of time, and they are often not compatible with project timelines, in particular when they are carried out over large areas of hundreds or thousands of hectares.

**How can the process be improved?**

Proposals should include artificial intelligence (AI) technologies that allow the detection of selected tree species using high or low resolution and, if necessary, multispectral satellite images. Large utilities have two types of commitments relating to the protection of vegetation species:

- NNL (No Net Loss): projects without net loss of biodiversity
- Performance Standards of the IFC (International Finance Corporation): requires the protection of Critically Endangered or Endangered species.

**What is the target process?**

The innovation solution should be based on algorithms able to:

- Be applicable at a Worldwide level
- Recognize vegetal rare species, species in danger of extinction, or of particular importance for the biodiversity preservation of the considered area
- Recognize the desired vegetation, the area where the vegetation species is present and/or the number of trees with a good level of confidence.

**Requirements**

High and low resolution, multispectral satellite images with seasonal acquisition frequency

Cost reduction drivers are key in order to make the service accessible for utilities (low cost starting data, free access data, low data transfer to ground, etc…)

### *2.3.8. Use Case 17: Photovoltaic O&M Support*

**Context Information**

Photovoltaic systems typically cover a very large area and are found in remote areas of countries. Consequently, control and O&M activities require a greater effort in terms of time and complexity.

**How does the process work today?**

Currently, the control activities of PV power plant can take place also using ML systems applied to satellite images coming from free sources such as Sentinel 2 and others.

However, the resolution and frequency of the images used do not allow frequent and precise monitoring.

**How can the process be improved?**

The solution should increase current performance by integrating different satellite data resources applied to AI and ML systems.

**What is the target process?**

The innovation solution should be based on algorithms able to:

- Recognize PV soiling and severity
- Recognize grass cutting need on the area surrounding the Power plant
- Recognize PV structural anomalies such as : Tracker Torque Tube Alignment, PV modules orientation, etc.

**Requirements**

Cost reduction drivers are key in order to make the service accessible for utilities (low cost starting data, free access data, low data transfer to ground, etc…).

### *2.3.9. Use Case 18 : Topographical survey for as-built situation*

**Context Information**

Realization of renewable power plants (e.g. solar photovoltaic, wind) or battery energy storage plants often require significant earth movements in order to facilitate installation. The as-built situation of topography as well as realized infrastructure is key for all operation and maintenance activities taking place in the years after construction.

**How does the process work today?**

Today the data are collected with traditional technologies (calorimetric survey, laser scanner survey, drone survey, etc...).

**How can the process be improved?**

Possibility to reduce the costs and time for topographic survey on field, obtaining more quickly data to prepare the As-Built documentation.

**What is the target process?**

Acquiring satellite information that allows to obtain useful data for the drafting of the as-built documentation that can be imported and managed with both BIM and GIS platforms with precision requested around 5 cm for equipment (e.g. Solar panel) and 10 cm for building (e.g. Cabinet).

**Requirements**

Cost reduction drivers are key in order to make the service accessible for utilities (low cost starting data, free access data, low data transfer to ground, etc…).

### *2.3.10. Use Case 19: Satellites for Energy Asset Monitoring*

**Context Information**

The observation of energy production plants for O&M and E&C purposes nowadays takes place in a mixed manner (drones, helicopters, ground stations, radars, satellites etc).

Currently there is a great fragmentation of the global offer, essentially divided between suppliers of data from drones, helicopters, satellites etc and suppliers of data post processing services based on machine learning.

However, the great expansion of Low Earth Orbit (LEO) systems and their large reduction in cost is making the possibility increasingly interesting due to a reduction in entry costs to the market, thus making LEO satellite constellations accessible to private organisations.

The great variety of use cases and geographical distribution of energy production plants suggest that a  deep dive in to the different business models related to satellites, in order to find out which business case to adopt today and in the future, is necessary to address the increasing needs faced by energy utilities in operating and managing energy assets.

**How does the process work today?**

Currently, satellite data acquisition and processing services in power generation facilities are very fragmented, country by country and use case by use case. To help promote efficiency within the sector, other methods of data collection/asset monitoring need to be investigated.

Furthermore, although some satellite services are technically ready to solve many use cases of interest for the company, they are still covered by alternative technologies without really knowing whether the business model adopted is optimal.

**Project Scope**

The scope of the project is to complete a feasibility study of micro satellites in LEO or potentially larger satellites in a higher earth orbit for the monitoring of energy assets with the aim to obtain a technical and economic digital simulation system that allows to understand how and whether to modify the current business model (based in the acquisition of satellite imaging, either processed via ML or not processed) to a proprietary (satellite owner) or hybrid model.
For this purpose, it is necessary to develop a parametric simulation system which allows to actively see the costs and complexities between the various business models, such as: satellite service, satellite owners, satellite fleet owners, etc…
Moreover, the system should be able to automatically calculate the optimal point between business models as the boundary conditions vary.
A flexible input table should be easily upgradeable with the following starting boundary conditions:

- Costs of different technologies (drones, helicopter, satellite, etc);
- The technical parameters such as acquisition times, download times, resolution, accuracy, etc…;
- The obtainable geographical coverage;
- Acquisition volume per location;
- Data format (Image in visible, near infrared and radar bands, etc );
- Targeted use cases for the analysis.

**Deliverables**

The project would provide the following key deliverables involving a technical and economical evaluation from a large energy utility perspective.
The key output of the project would be to assess the opportunity to switch from a pure downstream approach (acquisition of images) to a third-party supported management/ownership of satellite constellation. (E.g. the investment in a satellite constellation (supported by space economy players/large utility entity is not foreseen to manage directly satellite orbits, ground stations, etc…) will stand only if a minimum amount of data is acquired, with a minimum frequency on specific geographies etc...)
Other output of the project will include:

1. Basic mission design of the proposed solution
2. Satellite basic design and estimated costs

3. Satellite revisit time and downlink time/method
4. Coverage of relevant use cases
5. Relevant geographic coverage of interest areas
6. Optimal Economic / Technical point of the business model (considering the entire value chain)

## 2.4. Innovate UK/Strategic Innovation Fund

The use cases presented in this section have been developed in partnership with Innovate UK's strategic innovation fund (SIF). SIF's vision is as follows:

- To find and fund ambitious, innovative projects which can help shape the future of the energy networks and accelerate the transition to net zero, at lowest cost to consumers.
- To help transform the UK into the 'Silicon Valley' of energy, making it the best place to be a) an energy consumer and b) an energy entrepreneur.

Delivered in partnership with Innovate UK, the SIF programme taps into the best of UK and international innovation whilst aligning with other public innovation funding for the benefit of network users and consumers.

It was launched in 2021 and is expected to invest £450 million by 2026, with the option to increase and extend as necessary.

### *2.4.1. Use Case 20: Overhead conductor line sag measurement*

Scottish & Southern Electricity Networks Transmission (SSEN-T) is the owner of the high voltage electricity assets in the north of Scotland, including the 132kV, 275kV and 400kV electricity network. Whilst operating in the north of Scotland, SSEN-T faces some of the most extreme weather conditions in the UK. During winter periods temperatures can drop as low as -30°C with wind speeds up to 110 mph. Such weather conditions can result in thick, dense ice forming on the overhead lines, causing them to sag under the weight of the accrued ice.

Recently a 132kV overhead line has been fitted with ACCC conductors, which are high-temperature low-sag conductors, however subsequent design studies have indicated that the conductor will sag to an unacceptable level due to ice build-up. This may present a hazard to third parties and/or require additional manpower as a result of potential outages. These conductors and transmission towers can be in very hard to access locations which may require a person walking long distances over difficult and often mountainous terrain to address issues.

The ideal operating height of such lines typically around is 6 - 7m above ground level, however under iced conditions ground clearance can reduce to as little as a few meters with the potential for serious issues to occur.

Ice build-up on conductors of sufficient weight to cause problematic sagging is thought to be unlikely, but a lack of records makes it difficult to accurately define the risk level and subsequent mitigation strategies. To control the risk, SSEN-T has previously installed an indirect monitoring system aimed at detecting weather conditions leading to ice build-up and sending a notice when these conditions are present. This system has proved unreliable, producing a high number of false alarms, requiring interpretation of photos to discern if a potential risk is occurring and therefore costing significant staff time.

### 2.4.2. Use Case 21: Improved operational decision-making tools for offshore wind farm maintenance

SSER is a leading developer and operator of renewable energy across the UK and Ireland, with a portfolio of around 4GW of onshore wind, offshore wind and hydro. SSER has the largest offshore wind development pipeline in the UK and Ireland at over 6GW and has an onshore wind pipeline across both markets in excess of 1GW.

Efficient operation of offshore wind farms is essential, to ensure profit is maximised but also to maintain a high level of Quality, Health and Safety (QHSE) on site. For example, a single, unplanned, essential trip to an offshore wind turbine might cost a wind farm operator £1-3k in vessel hire fees, £2-5k in personnel costs as well as any associated overhead and fuel costs. The wind farm operator also takes weather risk, so any days where the vessel cannot go out due to high sea states, or Weather Days, are another cost to bear. A typical single 5MW turbine might also generate revenue of £1-3k per day so it is critical to maximise uptime.

Wind farm servicing and maintenance is either scheduled or unscheduled. Routine servicing and maintenance is required on a regular basis and is driven by component-specific requirements. Unscheduled maintenance is required due to failure or damage of a component.

Where possible, any works that can be forecast and scheduled into routine visits, vastly reduce the cost of Operations and Maintenance (O&M). Combining this with an understanding of weather and future energy yield can offer great insight to an operator trying to optimise energy production on site.

Planning of maintenance works remains a largely manual process in many cases, with staff using available data from multiple sources to make subjective decisions on optimal maintenance processes. Whilst experienced staff can be very accurate in this manual planning process, with a future pipeline of complex offshore wind sites, which must operate on tighter margins, there is a need to move towards holistic, accurate and consistent objective planning systems.

### *2.4.3. Use Case 22: Remote diagnostics and digital twins for offshore wind*

SSER is a leading developer and operator of renewable energy across the UK and Ireland, with a portfolio of around 4GW of onshore wind, offshore wind and hydro. SSER has the largest offshore wind development pipeline in the UK and Ireland at over 6GW and has an onshore wind pipeline across both markets in excess of 1GW.

Industries such as automotive and aerospace have paved the way for effective use of digital twins and AI-enabled modelling and in doing so have adapted their operating and maintenance model to allow more informed and progressive decision making. The offshore wind sector is yet to widely utilise digital twin technology, however doing so offers opportunities to increase safety, reliability and optimal efficiency of turbines by enabling pre-emptive monitoring and maintenance.

SSER has significant individual system analysis data and modelling for their assets and now require a solution for integrated data management and an innovative digital approach for whole-system structural analysis and modelling as well as WTG major component diagnostics.

### 2.4.4. Use Case 23: Offshore wind farm array cable monitoring

SSER is a leading developer and operator of renewable energy across the UK and Ireland, with a portfolio of around 4GW of onshore wind, offshore wind and hydro. SSER has the largest offshore wind development pipeline in the UK and Ireland at over 6GW and has an onshore wind pipeline across both markets in excess of 1GW.

In offshore wind farms, array (inter-turbine) cables are installed in jointed lengths from one turbine to its neighbour, forming a string (collection circuit), which feeds into the offshore substation. Array cable faults are not automatically detected and located; in the event of failure, a visit to the relevant substation is required to confirm failure status. A megger tester (or similar) is connected at the associated substation and used to identify a fault location. All wind turbines on the affected array are then offline until the fault is located, and a repair is implemented. Array cable faults are responsible for the majority (around 80%) of insurance claims in the offshore wind sector and are a significant cause of downtime and lost revenue.

### 2.4.5. Use Case 24: Vehicle based internet access solutions for remote locations

SSE Renewables Hydro is the owner and operator of eight hydro schemes in the north of Scotland, with a portfolio totalling 1,459MW, including 300MW of pumped storage and 750MW of flexible hydro. SSE Renewables Hydro are also developing the 1,500MW Coire Glas pumped storage scheme, should the project receive consent it would double the current storage capacity in Great Britain.

SSE Renewables Hydro’s assets are geographically dispersed, large in terms of ground coverage and often in remote or rural areas, which makes the problem of internet connectivity for staff particularly challenging. Currently SSE Renewables Hydro’s operations struggle with access to the internet when operating within the wider Hydro catchment areas .

This lack of connectivity causes difficulty for the business to track staff & ensure safety, as there is not always reliable network coverage across the vast, remote areas in which their staff members work. Productivity is impacted as staff are not able to do their jobs as efficiently, due to having to travel to different locations to get a phone signal or internet connection to complete certain tasks. This extra travel in remote areas can also create additional risk for staff.

### *2.4.6. Use Case 25: Mechanised vegetation management near live power lines*

Scottish and Southern Electricity Networks (SSEN) Distribution is responsible for ensuring a safe and reliable supply of electricity to 3.8 million customers in communities across its network in central southern England and the north of Scotland. SSEN Distribution employs more than 3,500 people, including skilled engineers, customer service teams and future energy experts many of whom live as well as work in the communities they serve.

By enabling a smarter, more resilient electricity network, SSEN Distribution ensure that local communities from the Shetland Islands to the Isle of Wight, and Portsmouth to Aberdeen continue to receive the power they need, both now and in the future. With a commitment to ensuring customers have more involvement in vital infrastructure investment decisions, network reliability is a key priority for SSEN-D and the customers it serves.

As part of this commitment to resilience and increasing network reliability, SSEN have to undertake extensive vegetation management activities, including tree felling and pruning, to maintain safety clearances and avoid unplanned outages due to damage caused by falling trees or branches.

Typically, much of this work is done manually by specialist contractors or appropriately trained in-house staff. Tree cutting activities can vary depending upon the species being cut, availability of suitable access, landowner’s preferences, and the voltage level of the associated overhead line.

Currently a variety of cutting techniques are used:

- From ground level using insulated rods
- From appropriate access platforms – mobile elevating work platforms (MEWPS) etc
- Where necessary, trees are climbed by specially trained staff to allow access to use chainsaws etc.

These manual approaches present health and safety challenges, especially when working on diseased or dead trees, such as ash trees affected by Ash Dieback. In this specific case, the trees become very unstable, leading to significant risk when employing conventional manual

felling techniques. Ash Dieback is of primary concern at present; however, other diseases are starting to affect UK trees due to global warming and globalisation of trade and movements.
Vegetation management activities cover all voltage levels within SSEN-D from low voltage (415V) up to 132kV, across the entire license area. Where safe and practical, the works are performed with live power lines to prevent interruption to power supplies, but where necessary planned outages are organized to ensure that works can be carried out safely.

### 2.4.7. Use Case 26: Contracting priority service register customers without mobile phones during power cuts

UK Power Networks (UKPN) own and maintain electricity cables and lines across London, the South East and East of England and make sure power flows reliably, safely, and securely.
UKPN's priorities are to tackle the climate crisis by connecting renewable energy, electric car chargers and low carbon heating, meet their customers evolving needs by improving their services, support their customers in vulnerable circumstances and go above and beyond for the communities they serve. This challenge specifically focuses on supporting customers in vulnerable circumstances.
The Priority Services Register (PSR) is a free support service that makes sure extra help is available to people in vulnerable situations. This includes, but is not limited to, people of state pension age, people with disabilities or long-term medical conditions and those who require electrical life-essential equipment. During a power cut, PSR customers in UKPN's catchment area get a range of extra support, including text and voice message alerts, a 24-hour priority number to call, and tailored support such as home visits and meals, if required.
BT Open Reach is in the process of transferring telephone lines from the traditional public switched telephone network (PSTN) links to digital links – either fibre to the cabinet (SoGEA) or to the premises (FTTP). Current PTSN links carry an electrical current which can power some telephones, such as simpler corded models, which means these telephones can operate without mains power in the property.
This switch to digital means that these telephones will no longer receive power through the PSTN, so during a power cut customers will no longer be able to make calls if they do not own or have access to a charged mobile phone, or if they live in areas with poor mobile phone signal coverage. It will also not be possible to contact them via a landline during a power outage

– a particular concern for vulnerable PSR customers. Similarly, many traditionally used emergency contact systems will not function, including red button care alarm systems and existing emergency phone systems, such as those provided within substations, at train crossings and in lifts.

There are an estimated 157,000 PSR customers in UKPN's licence area who do not have a mobile phone registered on their account, with an estimated 11,000 of those customers registered with a medical dependent code.