Clean Energy and Earth Observation

GDA M&E Topical Overview

April 2023

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Acknowledgements

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Contents

Key points

- Investments in clean energy are projected to grow exponentially over the next decades. While the Ukraine crisis and Covid-19 pandemic has been exacerbating the energy crisis, the present situation offers governments the opportunity to make sizeable investments in the clean energy sector.
- However, clean energy projects tend to be capital intensive and long term which means that International Financial Institutions (IFIs) will have a central role in facilitating clean energy investment in developing countries.
    - IFIs such as the World Bank (WB) and the Asian Development Bank (ADB) have committed a large number of financial resources for clean energy programmes and initiatives.
- Earth observation (EO) data are very important in enhancing the implementation of renewable energy technologies and improving energy efficiency and can support decision makers where knowledge and data gaps may otherwise occur.
- There are several existing EO use cases for clean energy, such as feasibility assessment and design of clean energy assets, construction and operation of clean energy assets, maintenance and resilience of clean energy assets, and environmental impact assessment.
- However, there are still some challenges in using EO products in developing countries, such as lack of data for some areas, lack of awareness and confidence and capacity barriers.
- EO technology can support governments in addressing some prerequisites affecting clean energy investments, such as the creation of an integrated energy strategy, monitoring legal compliance, and designing a complete & informed investment plan.

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Introduction

This report is a topical overview analysis carried out by the M&E and Impact Assessment (GDA M&E) (GDA M&E) activity, under the European Space Agency (ESA)'s Global Development Assistance (GDA) programme. Which is a global partnership to mainstream the use of Earth Observation (EO) into development operations, implemented in cooperation with major International Financial Institutions (IFIs).

To foster adoption and accelerate impact, GDA focuses on targeted Agile EO Information Development (GDA AID) applied to thematic priority sectors; one of these sectors is clean energy. This report outlines the main issues, the status of clean energy in the development sector and the resulting relevance and opportunities for the Space for IDA cooperation framework.

The document aims both to inform IFIs of the potential use of EO data to develop and implement clean energy interventions and strategies, and to make the GDA AID Clean Energy consortium aware of the initiatives and practices for clean energy already in place in IFIs. GDA Clean Energy has recently started and will continue to expand and delve deeper into the subject.

There are four sections of this report split as follows:

- A background into clean energy, its definition and an overview of the new trends.
- A detailed portfolio of the various clean energy programmes implemented by ESA's partner institutions, the WB and ADB.
- The value of EO for clean energy, including its main characteristics and potential uses for development operations.
- Key learnings that will help facilitate the mainstreaming of EO into the clean energy development assistance operations.

Background

According to the Sixth Assessment Report[1], recently published by the Intergovernmental Panel on Climate Change (IPCC), greenhouse gas (GHG) emissions continue to increase globally, causing the warming of the planet. It is estimated that in the next ten years alone, climate change will drive 32 to 132 million people into extreme poverty[2], because the threats to the ecosystem will become more and more persistent: faster and faster transmission rates of diseases, increasing scarcity of food and water, fast melting of glaciers and rising seas, leading to more and more environmental disasters, displacement, and wars.

One of the major causes of climate change is energy production, the largest source of GHG direct and indirect emissions (72%).[3] Most direct emissions come from the consumption of fossil fuels for energy, while most indirect emissions (40%)[4] are produced by electricity generation. According to Climate Watch, energy emissions have increased by 56% since 1990, although its growth has slowed down in the last 5 years (at a 3.5% rate per year).[5] In order to lower GHG emissions and not exceed the 1.5°C threshold compared to pre-industrial levels, it is necessary both to increase energy efficiency and to move the energy system away from fossil fuels, by investing in clean energy. Increasingly competitive clean technologies can offer structural benefits such as economic development and job creation, while also reducing emissions and fostering technological innovation.

Definition: In this report we will discuss both clean and renewable energy, being the former referred to any energy source that emits negligible pollution and greenhouse gases (including nuclear energy) and the latter including all forms of energy produced from renewable sources, such as bioenergy, geothermal energy, hydropower, ocean energy, solar energy, and wind energy (International Renewable Energy Agency definition). These sources of energy could supply four-fifths of the world's electricity by 2050, massively cutting carbon emissions and helping to mitigate climate change.

Clean energy trends

We are currently facing an energy crisis, exacerbated on the one hand by the pandemic complicating the procurement of materials and on the other by the more recent war in Ukraine. Costs are rising due to multiple supply chain pressures, tight markets for specialised labour and services, and the effect of higher energy prices on essential construction materials like steel and

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[1] IPCC, AR6 Synthesis Report: Climate Change 2022, 2022, https://www.ipcc.ch/report/sixth-assessment-report-cycle

[2] Levin K., Boehm S., Rebecca C, *6 Big Findings from the IPCC 2022 Report on Climate Impacts, Adaptation and Vulnerability*, World Resource Institute, 2022, https://www.wri.org/insights/ipcc-report-2022-climate-impacts-adaptation-vulnerability

[3] Friedrich J., Ge M., Pickens A.,*This Interactive Chart Shows Changes in the World's Top 10 Emitters*, World Resource Institute, 2020, https://www.wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters

[4] IEA, Drivers of CO2 emissions, https://www.iea.org/reports/greenhouse-gas-emissions-from-energy-overview/drivers-of-co2-emissions

[5] Friedrich J., Ge M., Pickens A.,*This Interactive Chart Shows Changes in the World's Top 10 Emitters*, World Resource Institute, 2020, https://www.wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters

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cement. These cost pressures are most visible in fossil fuel supply but are affecting clean energy technologies as well: after years of declines, the costs of solar panels and wind turbines are up by between 10% and 20% since 2020.[6]

A worsening global economic outlook reduces governments' ability to fund energy projects, especially in developing countries where there are many state-owned utilities accounting for around half of energy investment. In these economies, public investments are typically scarce, and therefore clean energy spending remains stuck at 2015 levels. It is therefore necessary to attract private investment to develop an efficient renewables system and to do so, developing countries must deploy a pipeline of large-scale renewable infrastructure projects that ensure a return on investment, while also keeping costs affordable for consumers, even for the poorest. IFIs technical and financial support is also very important to implement a sustainable transition to clean energy in developing countries.

Clean energy in IFIs

Clean energy projects tend to be capital intensive and long term. For this reason, the IFIs, including the WB and the ADB - facilitate clean energy investment in developing countries. They operate at national level, in cooperation with their Client States (CS). Their lending operations are commonly accompanied by technical assistance activities and, often, programmatic approaches are applied to transfer knowledge across national and regional efforts.

Biggest challenges in clean energy

Although it is desirable for more and more energy to come from renewable sources, there are still several challenges that those implementing such projects must face.

Foremost, economic viability, as mentioned above. Indeed, for clean energy projects, the final decisions are economically driven more than technologically driven. In this sense, when we talk about innovation, this is mainly in the most effective approaches used to implement clean energy projects: to get to the goal more efficiently, using fewer resources. "*People are interested in innovation, because it can potentially enable them to do something better or cheaper, but then the appetite for actual consumption is more of an economic case than an innovation case: that's what you have to come back to, at the end of the day, is someone who is adding value in a cost-effective way*".[7]

Besides the economic barrier, another major challenge is the storage capacity of the energy produced. One of the criticisms levelled at renewable energies is their variability. For example, there are times when a cloud gets in front of the sun or when the wind drops, so the ability to store energy for these downtimes is essential for an uninterrupted flow of energy. At the moment, the coupling of energy storage with renewable energy production is in its infancy: it happens, but of the

[6] IEA, *World Energy Investment 2022*, https://iea.blob.core.windows.net/assets/db74ebb7-272f-4613-bdbd-a2e0922449e7/WorldEnergyInvestment2022.pdf

[7] Andrew Groom, Business Development Director at the Institute for Environmental Analytics, interview with Caribou Space

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total amount of solar and wind energy generated, a very small percentage is stored, and the cost of energy storage is one of the biggest obstacles.

Another, more specific challenge is represented by the practice of methane gas flaring, resulting from *market and economic constraints and a lack of appropriate regulation and political will.*[8] The 2022 Global Gas Flaring Tracker reported that efforts to reduce global gas flaring volumes have stalled over the last decade. All the above-mentioned complications are being addressed by the IFIs in several ways.

The World Bank

The WB is today the world's largest financier of climate action in developing countries – over US$26 billion in 2021 alone.[9] For the world's poorest countries, the WB support drives investments in clean energy at scale: it has more than doubled its annual financing for energy access, from over US$400 million in FY13-15 to over US$1 billion in FY19-22. In its support to developing countries, the WB prioritises efforts to boost renewable energy generation: in the last five years, 90 percent of its total lending for power generation went to renewable energy. In FY18-22, around 7.6 GW of renewable energy generation capacity was constructed or rehabilitated through WB operations. Over the same period, the WB helped 28 million people get access to cleaner, more efficient cooking, and heating.

Energy Sector Management Assistance Program (ESMAP)

The Energy Sector Management Assistance Program (ESMAP) is one of the biggest initiatives implemented by the WB, a partnership between the WB and 22 partners to help low- and middle-income countries reduce poverty and boost growth through sustainable energy solutions. ESMAP is scaling up renewable power technologies in developing countries, using a three-pronged approach, to:

- Help countries improve their enabling environments for renewable energy to unlock large-scale investment in mature technologies and aid the integration of variable renewables in power systems.
- Broaden the range of renewable energy technologies deployed in developing countries to include new innovations such as battery storage, rooftop and floating solar, and offshore wind.
- Build a pipeline of sustainable hydropower projects in recognition of their role in power grids for system balancing, flood control, and irrigation.

In 2013, ESMAP launched an initiative on Renewable Energy Resource Mapping to help countries to map their renewable energy resource potential using the latest methodologies, and then incorporate this data into national planning. All country projects funded under ESMAP procure

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[8] World Bank, *A Decade of Stalled Progress on Reducing Global Gas Flaring*, 2022, https://www.worldbank.org/en/news/press-release/2022/05/04/a-decade-of-stalled-progress-on-reducing-global-gas-flaring

[9] World Bank, Climate Change Overview, https://www.worldbank.org/en/topic/climatechange/overview#2

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consultancy services to support with resource mapping. Vendors were selected for a roster to provide solar and wind resource assessment and mapping services over a multi-year period. The suppliers on that roster were Solargis for solar mapping, VORTEX for wind mapping and Technical University of Denmark (DTU) for the Global Wind Atlas. Moreover, during COP24, ESMAP developed the Sustainable Renewables Risk Mitigation Initiative (SRMI), in partnership with Agence Française de Développement (AFD), International Renewable Energy Agency (IRENA) and International Solar Alliance (ISA). SRMI has three components to mitigate the risk of solar and wind deployment: (i) Upstream and Downstream Technical Assistance (via ESMAP), (ii) Public Sector Investments (WB financing blended with climate finance), and (iii) Risk Mitigation Instruments (WB's guarantees and political risk insurance, and climate finance instruments).

Energy Storage Partnership (ESP)

As countries seek to transition from fossil fuels, energy experts and government officials need to find ways to secure constant renewable energy supply to power systems. Hosted at ESMAP, the Energy Storage Partnership (ESP) aims to foster international technological cooperation and training to develop and adapt to new energy storage solutions tailored to the needs and conditions of developing countries. The ESP supports the expansion of the global market for energy storage, leading to improved technologies and accelerating cost reductions over time. Specifically, the ESP aims to foster international cooperation on:

- Technology Research Development & Demonstration, Applications.
- System Integration and Planning Tools.
- Policies, Regulations and Procurement.
- Enabling Systems for Management and Sustainability.

Global Gas Flaring Reduction Partnership (GGFR)

Through the Global Gas Flaring Reduction Partnership (GGFR), the WB works with governments and companies to end routine gas flaring and venting, which releases methane at oil production sites.[10] GGFR helps identify solutions to the array of technical and regulatory barriers to flaring reduction. To achieve this, the partnership develops country-specific flaring reduction programmes, conducts research, shares best practices, raises awareness, secures global commitments to end routine flaring, and advance flare measurements and reporting. Currently, GGFR is developing the Global Gas Flaring Explorer, an online platform in collaboration with the Oil and Gas Climate Initiative (OGCI) and the Payne Institute (Colorado School of Mines). Through the development of a transparent web platform, this project will deliver real-time and improved monitoring of gas flaring globally; it will feature, mapping, visibility, and transparency of gas flaring data at oil production

[10] During oil production, the associated natural gas is often flared (burned) when economic, regulatory or technical barriers to the development of gas markets and gas infrastructure prevent it from being used, or when re-injecting the associated gas back into the reservoir is not possible.

sites around the world. The tracking of flare volumes over time will improve the ability to monitor and demonstrate progress towards the WB's Zero Routine Flaring by 2030 initiative.[11]

Climate Investment Funds (CIF)

The Climate Investment Funds (CIF) is one of the world's largest multilateral funds helping low- and middle-income countries adapt to and mitigate climate change. The WB is the Trustee of the CIF, which works in partnership with governments, the private sector, civil society, local communities, and six major multilateral development banks (MDBs). CIF empowers transformation through its several programmes[12]:

- **Accelerating Coal Transition Program** - Offers a comprehensive toolkit to support countries in transitioning away from coal. It builds local support to reconsider the development of new coal plants and accelerate the retirement of existing coal assets.
- **Clean Technology Fund** - Supports fossil fuel-dependent countries with the deployment of low-carbon technologies with significant potential for reducing long-term greenhouse gas emissions. It provides concessional financing to large-scale renewable energy, energy efficiency, and sustainable transport projects. South America's first geothermal power plant is one of its many projects.
- **Global Energy Storage Program** - A funding window under the Clean Technology Fund, this programme supports clean energy storage technologies to expand integration of renewable energy into developing countries. Funding from this programme is expected to mobilize a further US$2 billion in private and public investments.
- **Forest Investment Program** - Tackles deforestation and forest degradation by empowering indigenous groups and developing countries to sustainably manage their natural resources and preserve the forest as a carbon sink. In Burkina Faso, which has lost 22 percent of its forest cover since 1990, one of the three interventions under this programme is expected to prevent ~7 million total carbon dioxide content (TCO_2) of emissions.
- **Industry Decarbonization Program** - Supports middle-income countries, where industries constitute a growing share of their overall emissions, by aiming to decarbonise industrial practices and change behaviours in the sector.
- **Nature, People & Climate Program** - Aims to harness the land management experience and capacities of indigenous groups for climate action and accelerate sustainable practices. At the same time, it seeks to work alongside key national, regional, and local stakeholders to adapt to climate change across a diversity of land uses and ecosystems and mitigate its effects.

[11] World Bank, Zero Routine Flaring by 2030 (ZRF) Initiative, https://www.worldbank.org/en/programs/zero-routine-flaring-by-2030
[12] Climate Investment Funds, Climate Investment Funds' Programs, https://www.cif.org/cif-programs

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- **Pilot Program for Climate Resilience** - Supports the world's most vulnerable countries in integrating climate resilience into strategic development planning and then implementing the plans through innovative climate solutions. For example, in Jamaica and five other Caribbean nations, this programme is enhancing their disaster risk management abilities.

- **Renewable Energy Integration Program** - Supports fossil fuel-dependent economies by enabling them to integrate renewable energy into their economies. This can include funding projects, such as enhancing the existing infrastructure to be renewable energy-ready or addressing potential regulatory barriers to a smooth transition.

- **Scaling Up Renewable Energy Program in Low Income Countries** - Supports the deployment of renewable energy solutions, such as solar, geothermal, and wind, to increase energy access for the many global communities with no access to power. The programme is one of the biggest global funders of mini-grids, with projects in 14 countries.

- **Smart Cities Program** - Helps countries undergoing challenges from rapid urbanisation to support their newly emerging cities, while they are still in development, by ensuring that their growth is managed in climate-smart, green, inclusive, and sustainable ways.

The Asian Development Bank

The energy operations of the ADB made substantial contributions to the energy sector's growth and became a significant share of ADB's overall operations, averaging about 21% of total approved lending to developing member countries from 2009 to 2020. Over that period, ADB's lending and grants in the sector totaled US$42.5 billion, making energy the second-largest sector in terms of volume of ADB support, after transport. The ADB invested US$8.5 billion in clean energy from 2016-2020 and now it aims to have 75% of its committed investments allocated to climate finance, investing US$100 billion cumulatively from 2019 to 2030. Under ADB's Energy Policy 2021[13], ADB will not support coal mining, processing, storage, and transportation, nor any new coal-fired power generation. ADB will also not support any natural gas exploration or drilling. The ADB will be selective in its support for midstream and downstream natural gas initiatives.

Clean Energy Program

ADB's energy portfolio has been increasingly focusing on renewable energy generation and energy efficiency through its Clean Energy Program since 2008. The programme was developed to help developing member countries meet their energy security needs, provide reliable and affordable access, and aid the transition to low-carbon growth.

Among the activities that ADB will implement under the programme are:

- Expansion of clean energy investments in developing member countries.

[13] Asian Development Bank, *Energy Policy: Supporting Low-Carbon Transition in Asia and the Pacific*, https://www.adb.org/documents/energy-policy-supporting-low-carbon-transition-asia-and-pacific

- Implementation of demand-side clean energy components in ADB-funded projects in water, transport, urban, and agriculture sectors.
- Monitoring of the pipeline of clean energy projects and achievements against the outcome indicators of the 2009 Energy Policy.

The approaches and phases of work identified include, among others, mainstreaming and replicating proven technologies to achieve greater scale and lower costs.

Clean Energy Financing Partnership Facility

The facility was established in 2007 to help improve energy security in developing member countries and decrease the rate of climate change, through increased use of clean energy. These are the eligible activities: biomass, biofuel, biogas; rural electrification and energy access; distributed energy production; waste-to-energy projects; demand-side management projects; energy-efficient district heating, transport, street lighting, buildings and end-use facilities; clean energy power generation, transmission, and distribution; manufacturing facilities of clean energy system components, high efficiency appliances and industrial equipment; energy service companies development; carbon capture and storage; integrated gasification combined cycle or IGCC, supercritical and ultra-supercritical steam technologies. Governments of Australia, Canada, Norway, Spain, Sweden, the United Kingdom, and Japan, and the Global Carbon Capture and Storage Institute support the grant.

Energy Transition Mechanism

To accelerate the transition toward clean energy, the ADB is working with Indonesia, the Philippines, and Vietnam to study the feasibility of the Energy Transition Mechanism (ETM) programme. The pilot study aims to lead to the formation of an ETM facility in each country, to purchase coal-fired power plants to accelerate their retirement and help jumpstart reliable and affordable clean energy. The ETM will be made up of two separate funds; the first is a carbon reduction fund, and the second is a clean energy fund. The purpose of the carbon reduction fund is to provide a blended finance mechanism that brings together a variety of different actors to incentivise the early retirement of coal-fired power assets. On the other hand, the clean energy fund will invest in the growth and expansion of renewable power to replace the old power. The pilot will seek to retire or repurpose 5-7 coal-fired power plants in the pilot countries in the near-term. Repurposed plants will be converted to renewable energy generation or alternative uses. The ETM involves developing financing mechanisms that are tailored to political-economic conditions in specific countries. For instance, in the Philippines, where almost all electricity generation comes from private companies, the ETM will likely seek to deal directly with these private companies and appeal to their commercial interests. Instead, any clean energy transition in Indonesia requires the buy-in of the state-owned utility PLN, which plays the most significant role in Indonesia's electricity sector and does not operate according to the same commercial logic as a private company.

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Other IFIs initiatives

Renewables for Latin America and the Caribbean (RELAC)

RELAC is a regional initiative that aims to reach an installed capacity of 70% of renewable energy in the region by 2030. This initiative is led by the governments of Chile, Colombia, and Costa Rica and supported by the Inter-American Development Bank (IADB) (acting as the Technical Secretariat), the Organización Latinoamericana de Energía (OLADE), and IRENA.

Sustainable Energy Fund for Africa (SEFA)

The SEFA is a multi-donor Special Fund managed by the African Development Bank that provides catalytic finance to unlock private sector investments in renewable energy and energy efficiency. SEFA offers technical assistance and concessional finance instruments to remove market barriers, build a more robust pipeline of projects and improve the risk-return profile of individual investments.

The role of IRENA

The International Renewable Energy Agency (IRENA) is the leading global, intergovernmental agency for energy transformation that serves as the principal platform for international cooperation and supports countries in their energy transitions. IRENA can support IFIs by providing state of the art data and analyses on technology, innovation, policy, finance and investment, since it operates all over the world, through several regional initiatives. Two of the main products IRENA produces are the Renewables Readiness Assessments (RRA), and the Renewable Energy roadmaps (REmap). RRAs are designed to define a detailed list of criteria considered necessary for the on-going operation of existing renewable energy facilities and for further renewable energy development. Applying this framework to individual countries provides a comprehensive analysis of the presence or absence of enabling conditions for the development of renewables. IRENA's REmap programme[14] determines the potential for countries, regions and the world to scale up renewables. The roadmap focuses not just on renewable power technologies, but also technology options in heating, cooling and transport. Based on country driven results, REmap provides insights to policy and decision makers for areas in which action is needed. RRAs and REmaps, together with other project facilitation activities such as the Energy Transition Accelerator Financing Platform, the Climate Investment Platform and the Renewable Potential Assessment, can support the deployment of renewable energy projects by helping IFIs to secure financing more efficiently and supporting Client States to build stronger project portfolios.

[14] IRENA, Renewable energy roadmaps (Remap), https://www.irena.org/Energy-Transition/Outlook/Renewable-energy-roadmaps

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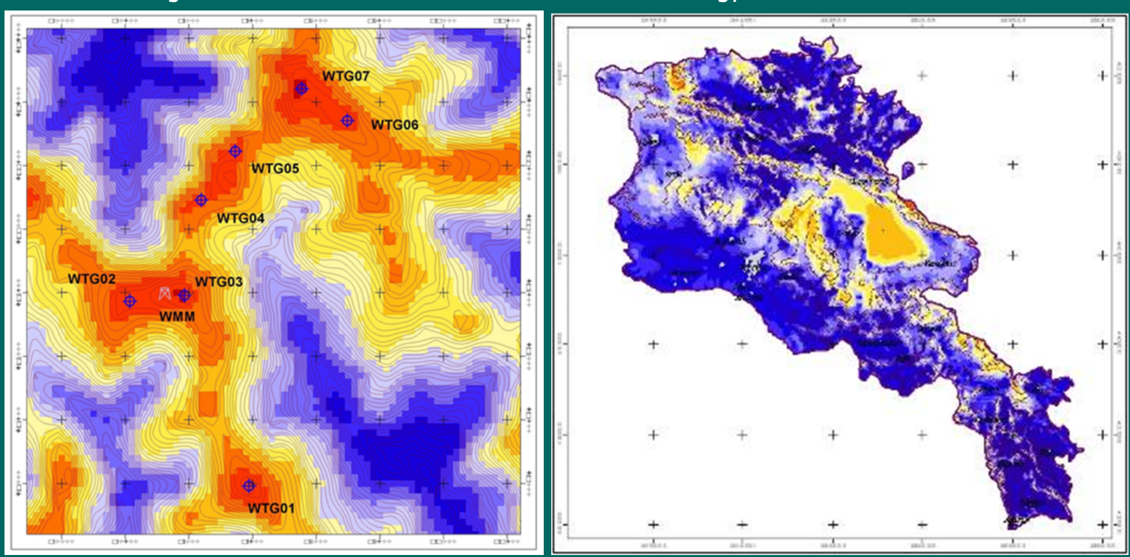
Value of EO for clean energy

EO satellites are critical in enhancing the implementation of renewable energy technologies and improving energy efficiency. Measurements of solar radiation at the Earth's surface, winds, and a range of atmospheric parameters are being used to assess the potential of renewable energy resources at a given location across a variety of scales ranging from the individual household to large solar thermal power generation, transmission, distribution, and maintenance projects.

Use case example: Figure 1 shows two wind fields with locations of wind energy plants in two distinct regions - the German low mountain range on the left and the Asian Caucasus region on the right - highlighting the diverse geographical locations where wind energy can be harnessed as a sustainable source of power.

Figure 1: Wind Fields with Locations of Wind Energy Plants. (© GEO-NET)



In clean energy projects, it is also necessary to understand the geospatial context in which planning takes place: several geospatial layers can be integrated, derived from information received from satellite data, such as land cover datasets, network infrastructure maps, socio-economic data, and environmental datasets. EO data provides a more cost-effective data source for renewable energy exploration and plant siting compared with ground-based exploration

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Table 1 lists some use cases for clean energy and some domain-specific examples.

Table 1: A List of Use Cases for Clean Energy[15]

Use Case	Domain-Specific Examples
Feasibility assessment and design of clean energy assets	• Energy demand characterisation by mapping indicators of high electricity consumption economic activity. • Renewable energy resource mapping, by providing detailed and long-term statistics on solar irradiance, wind speed and direction, runoff due to snow cover, geothermal anomalies, biomass crops, etc. • Assessing water quantity and availability for hydroelectric projects. • Determining ideal dam locations and reservoir size. • Creating inventories of existing energy infrastructure. • Production of site-specific, seasonal variability forecasts for improved financial analyses. • Production and transmission infrastructure site selection, by combining resource information with information on the local or regional environment, existing land and infrastructure characteristics, natural hazards, etc. • Assessing energy infrastructure vulnerability by estimating climate and disaster risks and by monitoring external threats.
Operation of clean energy assets	• Optimisation of operations to minimise costs and emissions. • Managing energy production operations, by providing information such as available biomass crops and solid fuel in the form of waste. • Providing short- and medium-range forecast of renewable resources, to estimate energy yield and protect the infrastructure in case of extremes. • Evaluate impacts across sectors and geographical regions.
Maintenance and resilience of clean energy assets	• Provision of weather-related risk insights to operate transmission and distribution networks. • Monitoring clean energy infrastructure to enable maintenance.
Environmental impact assessment (EIA)	• Monitoring external threats such as human and natural. • Addressing the effects of plant construction. • Monitor decommissioning of sites to minimise environmental damage. • Environmental impact from re-routing or damming water for hydroelectric projects. • Monitoring methane gas flaring.

[15] Wording coming from both GDA AID Clean Energy Statement of Work and Caribou Space

EO can support future trends in energy policies

Much of the advancement in energy transition has been achieved thanks to effective policies and planning. As renewables have transitioned from niche to mainstream, policies that drive the transition must cover not only the deployment of renewables, but also their integration into the broader energy system and economy wide policies affecting the sustainability and pace of the transition. Data produced by EO satellites is very valuable to support these future trends in energy policies: Table 2 below shows some examples in which EO can facilitate three different categories of renewable energy policies classified by IRENA, IEA, and the Renewable Energy Policy Network for the 21st Century (REN21).

Table 2: EO support for Clean Energy Policies

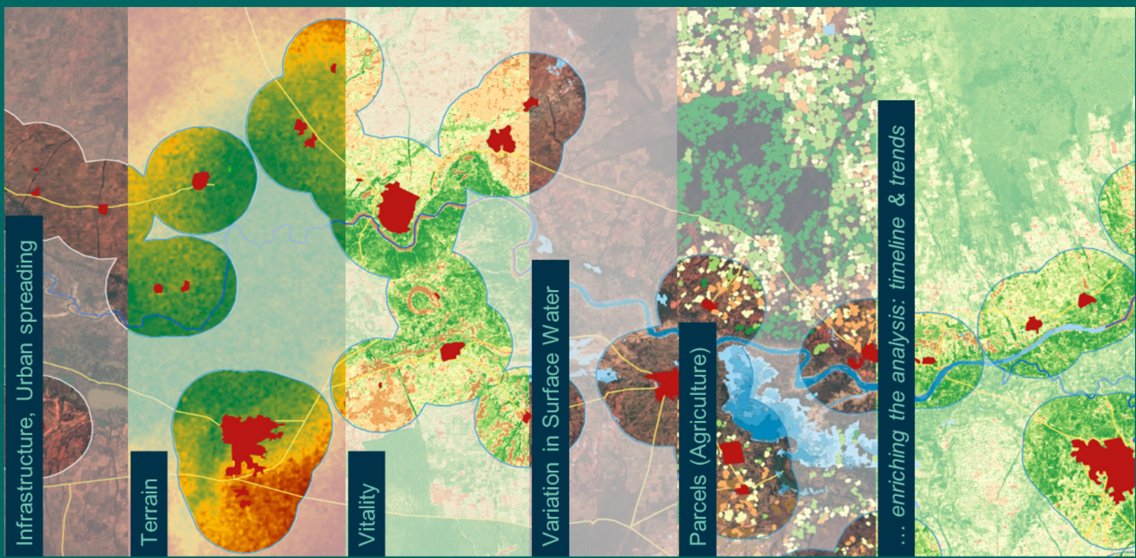
Policy Category	Description	EO Support
Direct policies and instruments	They support the development of renewable energy technology and products, both in the general sense and in the context of expanding access to electricity and other forms of clean energy.	EO can monitor and evaluate the progress towards targets for use of renewable energy, e.g., by assessing the number of clean energy facilities operating over time.
Integrating policies	They incorporate the use of renewables and energy efficiency in the heating and cooling, transport, and power sub-sectors into the larger energy and economic system and into consumers' daily lives.	EO can support, for example, policies that ensure the presence of needed infrastructure, by mapping the affected areas, and policies that facilitate the integration of off-grid systems with the main-grid, by optimising operations to minimise costs and emissions (see Table 3)
Enabling policies	They contribute to a wider environment for renewable energy development.	EO can uphold, for example, environmental and climate policies - through Environmental Impact Assessment (see Table 3) - and land-use policies, thanks to the reliable, remote monitoring of sites.

EO can facilitate decision-making and consensus building

EO information can support decision makers with investment decisions where knowledge and data gaps may otherwise occur, for example, it can help assess the actual energy demand in a certain area, analyse the feasibility of clean energy assets and prevent any environmental related risks. More informed decisions can facilitate consensus building between developers and community members. Participation mechanisms throughout the life of a project should be implemented, from the early proposal stage to post project.

Use case example: Figure 2 provides a detailed view of an area in Nigeria, showcasing the potential of EO based layers to support site characterisation and demand estimation in areas close to urban agglomerations. The map highlights the range of EO-based layers that can be utilised to evaluate the physical and environmental characteristics of a region, which can be a critical factor in determining the feasibility of clean energy assets.

Figure 2: Range of EO-based Layers Potentially Supporting Site Characterisation and Demand Estimation Close to Urban Agglomerations (© IABG)



However, research suggests that it is difficult to impose commitment on the public without informing them about the project development prior to its implementation: the public needs to familiarise with unfamiliar technologies e.g., renewable installations and understand the impact of their implementation across every sector. Using EO data in maps or visualisations can offer the public clear, unbiased information on environmental parameters such as land use, land change, and available resources.

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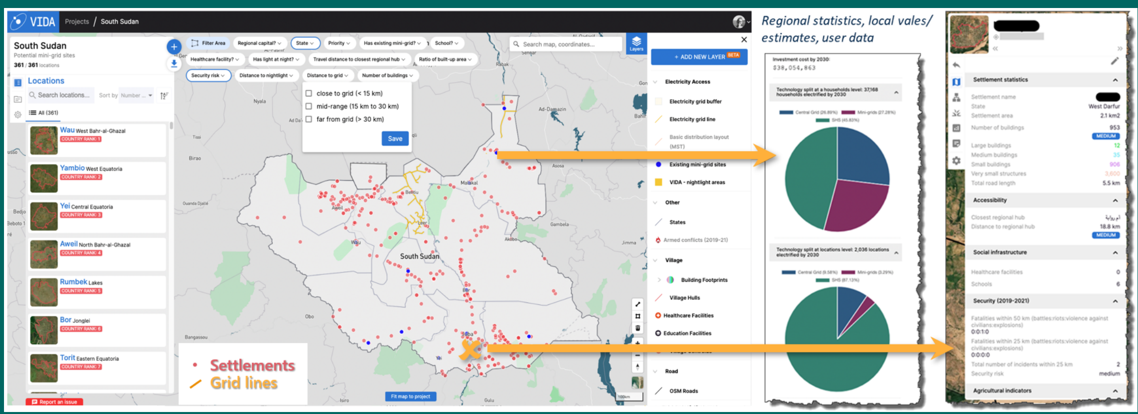
Use case example: Figure 3 provides an insightful look into the process of identifying settlements and analysing settlement attributes, using EO data in visualisations. The left side of the image displays a user interface featuring a map and a list of identified settlements, indicated by red markers. The yellow grid lines serve as a visual reference, providing a better understanding of the spatial distribution of settlements in the region. On the right side, the image shows a dashboard containing a range of data and information such as regional statistics and specific settlement attributes, presented in an easily understandable format. The example used in the dashboard is that of Sudan, which highlights the power of the user interface and dashboard in providing accurate and valuable insights for urban development and resource management.

Figure 3: (left:) User Interface with List and Map of Identified Settlements and Grid Lines; (right:) Related Dashboard Elements (Example: South Sudan) © VIDA



EO can enable the drivers for clean energy investment

Mobilising capital to support clean energy transitions depends on addressing some factors that affect the risks and returns faced by companies and financiers as they make investment decisions. EO can support the creation of an enabling environment for clean energy investments in several ways, as shown in Table 3.

Table 3: Drivers for Clean Energy and Potential Uses for EO

Drivers for Clean Energy	Potential Uses for EO
Clear energy goals, targets and strategies give an indication of the government's long-term commitment to clean energy transitions and serve as critical signals to attract investment.	EO can support the creation of an integrated energy strategy that includes supply- and demand-side assessment, renewable energy sites mapping and environmental impact assessment to inform action planning.

Investments in the sector are largely driven by regulatory policies such as quotas and obligations, supported by fiscal and financial incentives. The effectiveness of quotas depends on the presence of a solid framework to monitor and penalise non-compliance.	EO can support the governments in monitoring compliance to policy and regulations, by identifying areas undergoing change in near-real time and allowing users to collect evidence in the field that can be used to support legal claims.
Processes for obtaining licences, permits, rights and other approvals to build, own or operate an energy asset are critical variables in investment planning. When not well-designed or implemented, these can add economic burdens to project development, contributing to cost overruns and delays.	EO can help governments design a complete and informed investment plan by assessing environmental impacts and land acquisition. EO can also guarantee a continuous monitoring and evaluation during the implementation of the project.
Resource assessments for wind, hydro, and biomass need to be available on a site-specific basis and for an extended period (at least one year of reliable and auditable data, for example).	EO is the best way to assess renewable energy resources in a specific area having global coverage and providing repeatable, fast, and objective data. Moreover, EO sensors allow for different thematic-focused analysis such as wind power and biomass estimation.
In countries or cities where population density is high, land availability is a challenge. Presence of local populations or endangered species, can also affect investment decisions.	EO facilitates resource assessment and mapping, which is crucial for identifying suitable sites to build renewable energy assets. Once a suitable area is identified, EO can analyse the feasibility of the project.
Stakeholders of existing photovoltaic solar energy systems are typically interested in system performance for operation and maintenance planning, and performance guarantees for making investment decisions.	An EO-based information service for solar resource monitoring helps solar energy managers to automatically assess performances of PV plants (i.e., by comparing over a month the actual solar energy yield with the average one expected from satellite data) and rapidly detect faults, and thereby reduce costs.
Demand response programs are being used by some electric system planners and operators as resource options for balancing supply and demand. Such programmes can lower the cost of electricity in wholesale markets.	One major benefit of wide EO observations is that improved monitoring can improve forecasting of load and demand, and thereby optimise grid management.
For all renewable-energy systems, it is proper maintenance practice to inspect the integrity of mechanical and electrical connections at least once each year. Corroded or loose connections can result in decreased performance, and in extreme cases, they can create safety hazards.	EO can support the maintenance operations of renewable energy facilities by: • Monitoring the structural integrity of assets such as towers, poles, wind plants and solar plants.

	• Monitoring land subsidence around energy infrastructure such as pipeline and plants. • Assessment of vegetation encroachments. • Asset condition management: damages, degradation, corrosion, etc. • Asset monitoring and event detection for natural hazards. • Risk management dashboards providing insights and decision support.

Current use of EO for clean energy in IFIs

The World Bank

The WB has developed several systems and initiatives that use satellite imagery to provide data for energy transition operations in developing countries that can also be accessed directly by CSs.

A satellite-based carbon emissions database to enable easy tracking

To better track carbon pledges and support mitigation finance, WB researchers have developed a new database and web facility that uses satellite data from NASA's OCO (Orbiting Carbon Observatory)-2 satellite. The satellite provides reliable information about global CO_2 emissions at high levels of spatial resolution, following a sun-synchronous, near-polar orbit and having an observation repeat time of 16 days. The WB Development Data Hub has established an open web facility that pre-filters the OCO-2 data and publishes spatially-referenced monthly mean CO_2 concentration anomalies for the entire terrestrial world.[16] The data can be aggregated to provide new data-driven insights into CO_2 emissions for areas of interest (urban areas, other administrative areas such as districts/provinces/countries, landscapes/basins/watersheds or coastal zones). This can help promote a new generation of free/low-cost Monitoring, Reporting & Verification (MRV) systems that can facilitate mitigation investment instruments (e.g., performance-based payments in targeted areas of interest). With gridded information at 25 km resolution, the system can support analyses for states, provinces, urban areas and project areas. It can incorporate user-defined area boundaries, as well as standard boundaries for administrative areas. The system can be useful for WB studies such as Country Climate and Development Reports (CCDRs), as well as research by global stakeholders on CO_2 emissions sources and changes over time.

[16] Global XCO2, Global XCO2 Anomalies and Means, https://datacatalog.worldbank.org/search/dataset/0062760

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Land Use Repurposing Application

To help post-coal communities navigate a path to jobs and investment while also mitigating climate change, a WB team built LURA—the Land Use Repurposing Application.[17] LURA is a free, web-based, open-source tool that assesses coal lands' suitability for a mix of sustainable and productive post-coal projects. It relies on collaborative input from different stakeholders, such as mine operators and technical specialists. Once stakeholders' input has been added, LURA produces a map of the area, depicting zones where specific repurposing options would be most likely to succeed, given the conditions and the community's needs. The app then assigns a post-mining repurposing scenario that may include forests, agriculture, natural habitats or energy crops, as well as renewable energy generation and storage, hydrogen-infrastructure, and business parks for low-carbon industries.

Global Gas Flaring Estimates

GGFR, in partnership with the U.S. National Oceanic and Atmospheric Administration (NOAA) and the Colorado School of Mines, has developed global gas flaring estimates based upon observations from satellites launched in 2012 and 2017. These satellites' advanced sensors detect the heat emitted by gas flares as infrared emissions at global upstream oil and gas facilities. The Colorado School of Mines and GGFR quantify these infrared emissions and calibrate them using country-level data collected by a third-party data supplier, Cedigaz, to produce robust estimates of global gas flaring volumes.[18] The satellite data for estimating flare gas volumes is collected by NOAA's satellite-mounted Visual and Infrared Radiometer Suite of detectors (VIIRS). VIIRS has a multispectral set of infrared detectors which:

- at nighttime respond only to heat emissions and hence are not affected by sunlight, moonlight or other light sources.
- respond to wavelengths where emissions from flares are at a maximum.
- overfly every flare several times per night.
- have excellent spatial resolution.

The ability of VIIRS to detect and discriminate hot sources, such as gas flares, enables flares to be detected automatically with minimal manual intervention. Emissions from non-flare hot sources (e.g., biomass burning) can be removed from the data by selecting only emissions with temperatures above 1100C; other hot sources burn at lower temperatures. Indeed, flares burn hotter than any other terrestrial hot sources, including volcanos. Since the first year of operation in 2012, VIIRS has automatically detected ~10,000 flares annually around the globe.[19]

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[17] World Bank, About LURA, https://lurademo.geosysta.com/about
[18] World Bank, Global Gas Flaring Data, https://www.worldbank.org/en/programs/gasflaringreduction/global-flaring-data
[19] World Bank, *2023 Global Gas Flaring Tracker Report*, https://thedocs.worldbank.org/en/doc/5d5c5c8b0f451b472e858ceb97624a18-0400072023/original/2023-Global-Gas-Flaring-Tracker-Report.pdf

Renewable Energy Resource Mapping

This initiative under the ESMAP supported the scale-up of power generation from renewable energy sources through resource assessment and mapping activities globally and at the country level from 2013 to 2020. It included development and launch of the Global Solar Atlas[20] and Global Wind Atlas[21] in 2017, plus several further iterations. Furthermore, it included technical and financial support from the global team to country-level activities, including detailed resource assessment and mapping studies, ground-based measurement campaigns, geospatial planning, and related work to support renewable energy development. The ESMAP global team provided in-country teams with expert advice, standardised terms of reference, facilitated procurement, access to global data hosting solutions, and coordination with external stakeholders and donors. The development of the Global Solar Atlas and the Global Wind Atlas has been a major success, helping to provide critical information on solar and wind resource potential to clients, task teams, and development partners. In June 2020, monthly usage of the Global Solar Atlas and Global Wind Atlas stood at 23,000 and 15,000 unique users, respectively. The future development and maintenance of the Atlas have been transferred to a broader ESMAP-supported initiative, the Energy Data Hub, under the ESMAP Business Plan for FY21-24. The knowledge generated under this program will also directly feed into additional ESMAP programmes going forward, and the country activities that they in turn support: Energizing Renewables, Innovative Solar and Offshore Wind Development Program.

Renewable Energy Zoning (REZoning)

Furthermore, ESMAP developed the Renewable Energy Zoning (REZoning) tool[22], an interactive, web-based platform designed to identify, visualise, and rank zones that are most suitable for the development of solar, wind, or offshore wind projects. It is powered by global geospatial datasets and uses baseline industry assumptions as default values for economic calculations. Custom spatial filters and economic parameters can be applied to meet users' needs or to represent a specific country context. The spatial analysis consists of three steps:

- **Technical Potential**: This step estimates the technical potential or the capacity of a technology available for development by filtering on topographic limitations, land-use constraints, and system performance.

- **Economic Potential**: The users can also choose to use the default values for the input parameters to estimate the levelised cost of electricity generation of the resulting zones from step 1.

[20] The Global Solar Atlas supports the scale-up of solar power in WB client countries, by providing quick and easy access to solar resource and photovoltaic power potential data globally. It is funded by the Energy Sector Management Assistance Program (ESMAP) and provided by Solargis.
[21] The Global Wind Atlas is a free, web-based application developed to help policymakers, planners, and investors identify high-wind areas for wind power generation virtually anywhere in the world, and then perform preliminary calculations. The current version of the Global Wind Atlas (GWA 3.1) is the product of a partnership between the Department of Wind Energy at the Technical University of Denmark and the WB.
[22] About REZoning, https://rezoning.energydata.info/about

- **Multi-criteria analysis and prioritisation**: This step allows the user to include various criteria and factors to select and prioritise suitable renewable energy sites for development.

At the end of the three steps, the user can use the middle pane to visualise and explore the result using the satellite base map but also add additional contextual layers, such as roads, grid, location of airports, etc., to create a meaningful visual output. The final map can be printed in PDF or PNG format.

The Asian Development Bank

Unlike the WB, the ADB does not boast of any specific energy transition initiatives using satellite imagery. However, there are a couple of examples where the bank has used such technology in some projects:

- **Solar Energy Development** (project number TA 8008-UZB) – a satellite-based solar irradiance dataset and other space-based weather datasets were utilised for the project's models. GIS analysis has resulted in the identification of suitable solar power sites in Uzbekistan. In the end there were six proposed suitable sites where meteorological stations could be installed. It was concluded that GIS analysis with ranking values on resource and infrastructure is a helpful tool for site selection.
- **Quantum Leap in Wind Power Development** (project number TA 7990-REG) – Wind resource maps showing the estimated wind power and equivalent wind speed were used to understand wind resources in the target countries (Mongolia, Philippines, Sri Lanka). These maps used inputs obtained from satellites, including gridded terrain data and meteorological data. The meteorological data sources include surface (land and open ocean) and upper-air data sets. This data was screened to select representative stations and data periods for use in the mapping system.

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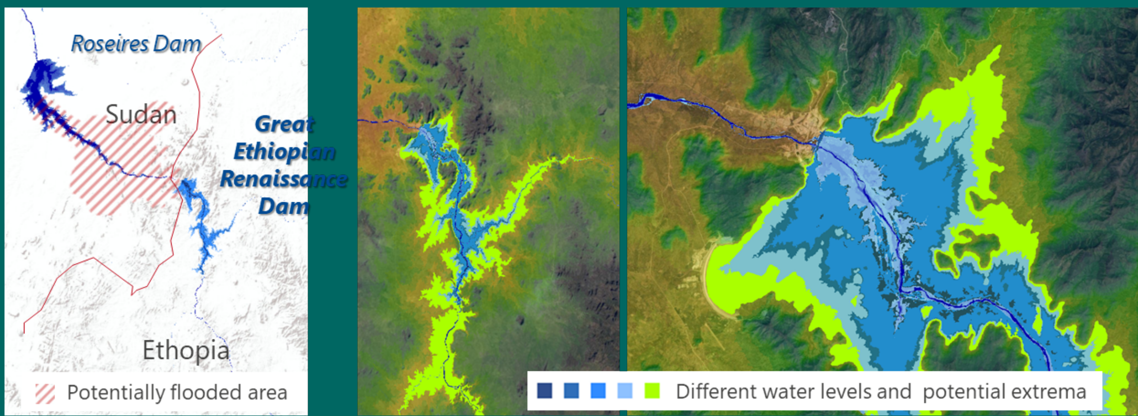
- **Hydropower Development –** ESA supported the construction of a hydropower plant in Vietnam, contributing with baseline and change maps to be used as reference after plant operation start, allowing measuring environmental changes due to encroachment of human activity around the dam and the reservoir. Additionally, precise ground and dam displacements in the order of a few mm/year during and after dam construction were delivered, to characterise the stress that the filled reservoir exerts on the dam and the ground in its vicinity. Information on illegal logging and other undesired and desired effects near the reservoir, the relocation sites and the nearby SNTR was also provided.

Use case example: Figure 4 showcases the extent and volume change of reservoirs, featuring a specific example of the Great Renaissance Dam in Ethiopia, as a case study. The map highlights the capabilities of advanced extraction methods that provide valuable insights into the changes in water resources and environmental impact resulting from reservoirs, such as dams (© IABG).

Figure 4: Extraction of Extent and Related Volume Change for Reservoirs (© IABG)



Challenges for using EO data for clean energy in developing countries

Despite the many EO satellite use cases for clean energy – as we saw in the previous section – there are still some limitations that hinder the exploitation of this technology in developing countries. The main barriers are not technological – although the difficulty of satellite sensors to distinguish the use of diesel generators to produce electricity from other sources remains, especially when villages are located inside forests.

The main barriers relate primarily to the difficulty of finding available data for the most remote regions of the globe, data that help renewable energy developers to do high level zoning, ranking clean energy options, shortlist potentially interesting development locations or inform an environmental impact assessment. Making data more available, in areas that have not been particularly well mapped, for people to access would be very valuable. Moreover, analysts or other electricity provider staff may lack general awareness of relevant EO resources for clean energy operations, and do not know how to appropriately apply such resources to their planning and decision-making efforts. Finally, there are confidence and capacity barriers, that mean governments of developing countries lack confidence to use EO-based tools for such complex and capital-intensive projects.

Implications & avenues for better integration

Increase end-users' awareness

Although the above use cases show promising signs for the use of EO in clean energy operations, they still lack a wide-spread recognition and implementation. Decision-makers are generally unfamiliar with the utility of EO to inform their decision, and this can lead to uncertainty or hesitation in using EO data. This confidence barrier to use EO can be lowered by adopting a tailored approach of providing data derived from EO in easily usable formats, relevant to end-users (IFIs project leaders). Data providers can seek to make their datasets available in intuitive, easily accessible formats, providing ample documentation, and guidance on possible applications. One good example is the RETScreen® Clean Energy Management Software[23], a platform that harnesses advanced algorithms to simplify decision-making around energy projects, including renewable energy, energy efficiency, and cogeneration. Combined with several databases, including global climate data from NASA satellites, the RETScreen software helps determine if a proposed energy project makes financial sense.

Enhance capacity building and staff training

Capacity building efforts, through technical trainings, demonstrations or provision of case studies, that help understand where and how to obtain EO resources for clean energy operations – and how to appropriately apply them – shall be implemented by the IFIs at both corporate and government level, with the support of the GDA AID Clean Energy consortium.

For the IFIs project leaders it is especially important to understand data and/or model uncertainty or other technical limitations, and training should accompany initial application of related datasets. Training on topics could be as preliminary as data management using statistical or geospatial software to advanced statistical or AI techniques.

For CSs, IFIs should ensure that trainings or capacity building is available and adapted for different audiences. Trainings should take place over extended periods of time so that time-constrained staff are able to accommodate the additional workload. Focusing on several staff increases the likelihood of technical capabilities remaining despite turnover. Documentation of procedures including analyses, modelling, or other activities should be detailed and maintained over time.[24]

[23] M. Argentiero, P.M. Falcone, *The Role of Earth Observation Satellites in Maximizing Renewable Energy Production: Case Studies Analysis for Renewable Power Plants*, 2020
[24] A. Leibrand et al., *Using Earth Observations to Help Developing Countries Improve Access to Reliable, Sustainable, and Modern Energy*, 2019

Bringing clean energy to health clinics after Covid-19

The pandemic caused IFIs such as WB and ADB to invest a lot of money in projects aimed at mitigating Covid-19 effects in the most affected countries. Many of these projects consist in harnessing renewable energy to bring electricity to the health clinics. One example is the Haiti: Renewable Energy for All Project, through which the WB aims to scale up renewable energy need feasibility and environmental impact assessment studies that GDA AID Clean Energy could support through EO products.

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