2020- 2022 GEO Work Programme Implementation Plan for GEO Vision for Energy (GEO-VENER) Initiative

Submitted to:

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Submitted by:

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26 March 2019

2020-2022 GEO Work Programme
Implementation Plan for GEO Vision for Energy (GEO-VENER) Initiative

Executive Summary

Full title of the Initiative*:* GEO Vision for Energy
Short title or acronym: GEO-VENER
Existing or proposed category: Existing GEO Initiative
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Overview

The GEO-VENER initiative was launched in September 2016, to ensure a more efficient link between the renewable energy community and the GEO Community and to stress the benefits of Earth Observation (EO) data for decision-making in the development of renewable energies (RE). GEO-VENER built on the community portal Webservice-energy.org, to serve the development of RE by providing an easy interoperable and GEOSS compliant access to documented, precise, trustable (or bankable) data, observation, information, knowledge and services related to RE. Five key objectives were defined in the 2017-2019 implementation plan, including: 1) Define structures of governance, 2) Define renewable energies essential variables (RE-EV), 3) Conduct gap analysis, 4) Develop in-situ meta-networks for RE, and 5) further develop the webservice-energy.org platform. Some progresses have been achieved, but there is a need to revisit and to adapt them to the new vision of a results-oriented GEOSS and expanding opportunities and challenges in the energy sector (e.g., infrastructure resilience). There is also a need to continue to grow the community of this initiative. This is the aim of the new 2020-2022 GEO-VENER implementation plan and will be discussed further below.

As analyzed by the International Renewable Energy Agency (IRENA) (see Figure 1), renewable energy is central for human development, sustainable growth and environmental sustainability and contribute to all SDGs of the 2030 Agenda for Sustainable Development. As the 2018 report from IRENA shows, RE and energy efficiency can, in combination, provide over 90% of the necessary energy-related CO_2 emission reductions. Keeping the global temperature rise below 2 degrees Celsius (°C) is technically feasible and GEO-VENER will contribute to the 2015 Paris Agreement on Climate Change objectives. However, the global energy system must undergo a profound transformation, replacing the present system that is largely based on fossil-fuels. The total share of RE must rise from around 18% of total final energy consumption (in 2015) to around two-thirds by 2050. Over the same period, the share of renewables in the power sector would increase from around one-quarter to 85%, mostly through growth in solar and wind power generation.

GEO-VENER will also propose activities to build capacity in increasing awareness and utilization of EO for resilience planning for utility infrastructure and operations to prepare for future extreme events and other impacts of climate change, minimize damage to infrastructure, and maintain reliable access to energy services, thereby minimizing impact to other sectors. This focus on resilience planning for energy

services will also help to contribute to the Sendai Framework for Disasters Risks Reduction. GEO-VENER contributions to the GEO Priorities engagement are described in the related section.

Planned Activities

Objective 1: Solidify means of stakeholder engagement, governance, and funding for GEO-VENER. This includes redefining priorities based on stakeholder input and participant interest, as well as defining governance structures based on consensus. GEO-VENER should not be approached as a project or information system to be completed, but as a set of processes on ownership, governance, information management, communication and funding to establish. As the previous activities were based on community activities, they were more built on opportunities. The first objective of GEO-VENER is to define and then share its objectives and planned activities and outputs with the broader energy services and EO community and to define the pathways to success. Means of engaging with the broader community will also be identified but will begin with a robust and sustainable Community of Practice (CoP).

Objective 2: RE-EVs are the key elements to provide data, observation, information, knowledge and services related to RE. The H2020 ConnectinGEO Project is an attempt to define RE-EV. They have been defined as: **RE-EVs are variables that meet important requirements from RE stakeholders and that are technically and economically feasible for systematic observation and global implementation**. For solar, wind and marine renewable energies a set of RE-EV has been proposed. Within the GEO-VENER, the definition of RE-EV for all renewable energies will be pursued by interacting with the whole community and by engaging exchanges with the public and private sectors.

Objective 3: Gap analysis is key within the RE domain. No specific EO system or program dedicated to RE exists, but the RE Domain is using EO systems and programs dedicated to others domains to extract relevant RE information. Based on the RE-EV and on the practices of the RE stakeholders, the gap analysis will be conducted through different approaches:

- Identification of a collection of observation requirements
- Research programs dedicated to specific RE energies
- Consultation process and prioritization of identified gaps
- GEOSS Discovery and Access Broker analysis
- Industry-driven challenges

Objective 4: Development of in-situ meta-networks for RE will be also one of the objectives of GEO-VENER. In-situ observations in RE are not aggregate in a specific community network. An in-situ measurements platform has been developed within the H2020 ConnectinGEO project in order to extend the GEO Energy community portal to allow access and sharing of in-situ data between companies and organizations. The platform developed can aggregate data as a so-called “in-situ meta-network”. Within GEO-VENER, the definition and development of the renewable energy “Meta-network” will continue in order to attract institutional users but also subject matter experts (SMEs) in the solar domain. Interactions will the end-users will help engaging the solar community. Based on this experience and on its results, a promotion oriented to other RE community will be considered. This first work will be

pursued and adapted in close cooperation with the newly hired in-situ data management specialist of the GEO Secretariat. Given that the industry is investing to increase data relevant to solar production, there may be a need to consistent standards and a global approach to this could be useful. There are currently existing portals that could be assessed for these purposes, including AREMI of Australia.

Objective 5: Webservice-energy.org is a community portal dedicated to RE offering access to RE observation, data, information and services for the benefits of Energy users. The webservice-energy.org platform is recognized as a GEOSS Community Portal. It has been previously registered in the GEOSS Registry and it is now part of the Discovery and Access Broker (DAB) resources list. Consequently all resources deployed under these platforms are available in the GEO Portal. The webservice-energy.org platform hosts a collection of Web Services offering data and applications in Renewable Energy and Environment. The exploitation of RE sources such as solar and wind energy requires accurate knowledge of the resources and their availability -in space and time- as well as accurate forecasts in the different phases of an energy system life cycle. Web services are an efficient means to access to up-to-date knowledge by achieving connections, and facilitating exchange of data, applications, and information between actors. The Web services are made available by various providers on a for-free access or restricted access basis. Within GEO-VENER, the webservice-energy.org community portal will be used as a focal point and will evolve to ensure the link with the Energy CoP; to cover all RE (solar, wind marine, biomass, geothermal, hydro) and to offer the one-stop portal for the community of RE.

Objective 6: Draw connections and synergies between GEO-VENER and other GEO work groups and thematic areas including regional GEO initiatives such as AmeriGEOSS, EuroGEOSS, AO-GEOSS and AfriGEOSS, and thematic areas such as resilience, disasters, and risk. Energy has reach into all sustainable SDGs and all regions therefore strengthening the connections between GEO-VENER and other initiatives will make it a more sustainable and engaging work program.

Other more general activities relate to information sharing and technical exchange, such as:

- Promote the 2 Energy Pilots to be developed in the frame of the H2020 NextGEOSS project
- Promote the RE showcase (with 3 pilots) within the E-SHAPE H2020 project contributing to the Regional GEO EuroGEOSS.
- Leverage the ongoing work of the IEA (International Energy Agency) Task 16 “Solar resource for high penetration and large scale applications” that aims at establishing methods to provide products and solar datasets along with their uncertainty from different sources of EO (ground measurements, satellite, numerical weather models) and combinations of them and more precisely the action related to “Data dissemination and exchange using interoperable standards”.
- Develop Climate services for Energy through Copernicus Climate Change Service (C3S) energy and ERA4CS CLIM2POWER projects.
- Promote existing EO products and tools for energy applications and resilience planning, including NASA products (e.g., the Disasters Mapping Portal, Fire Information for Resource Management System (FIRMS)), as well as NOAA products available through the Climate Resilience Toolkit.

Also see attached for separate files containing related Annexes and Tables as required by GEO.

Purpose

Rationale

As the 2018 report from IRENA shows, renewable energy and energy efficiency can, in combination, provide over 90% of the necessary energy-related CO_2 emission reductions. Keeping the global temperature rise below 2 degrees Celsius (°C) is technically feasible. However, the global energy system must undergo a profound transformation, replacing the present system that is largely based on fossil-fuels. The total share of RE must rise from around 18% of total final energy consumption (in 2015) to around two-thirds by 2050. Over the same period, the share of renewables in the power sector would increase from around one-quarter to 85%, mostly through growth in solar and wind power generation. As analyzed by IRENA (see Figure 1), RE is central for human development, sustainable growth and environmental sustainability.

Energy systems are critical infrastructure, with electricity serving society to meet basic human needs such as cooking and lighting, as well as to support other critical social functions and infrastructure needs such as communications, transportation, healthcare, and emergency response. With the simultaneous challenges of increasing global populations and pressure for sustainable economic development, the demand for reliable energy services is also increasing. Additionally, impacts from climate variability and change, such as extreme weather or sea level rise, threaten energy reliability and community resilience. Currently, the provision of energy services, primarily with fossil fuels, accounts for anthropogenic greenhouse gas (GHG) emissions that contribute to global climate change. Renewable energy can play a vital role in reducing GHG emissions while satisfying society's increasing demand for energy, contributing to more sustainable development. However, vulnerabilities and needs in the energy sector vary widely by component, region, and geography. Therefore, a successful strategy for addressing resilience planning in the energy sector and uptake of RE can benefit from strengthened connections between the Earth science community and electric utility providers end users who can incorporate the use of EOs products, tools and data packages into routine planning and maintenance activities.

Actual outputs of the Initiative	***Users of the outputs***	***Expected types of decisions***
Copernicus Atmosphere Monitoring Service on solar Energy	*Solar farms developers* *Bankers*	*Development of solar systems* *Dimensioning of solar farms* *Performance of solar systems* *Investment decisions*
ENVI PV	*Decision makers for choice of energy systems taking into account environmental impacts*	*Plans for development of solar energy*
ECEM and C3S Energy services	*Electricity grid and distribution operators*	*Reinforcement or development of new electricity transport and distribution schemes based on Climate data*

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182 # Background and Previous Achievements

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184 **GEO-VENER Relevant Activities for the 2017-2019 period**

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Status	*Project description*
Completed	The H2020 ConnectinGEO project (2015-2017) has an activity related to identification of essential variables for renewable energies, gap analysis and industrial challenges on in-situ measurements (http://www.connectingeo.net). It contributes to all objectives of GEO-VENER. Publication in revision.
Completed	The European Network of Earth Observation Networks (ENEON), part of the ConnectinGEO project will try to establish its activities on the long-run. Renewable energies are linked with the involvement of the private energy sector. Activities of the GEO Energy activities will contribute to ENEON. It contributes to objective 3 of GEO-VENER
In Progress	The-operational COPERNICUS Atmosphere Monitoring Service for Solar Radiation (http://macc.copernicus-atmosphere.eu/catalogue/#list?st=Solar%20radiation) will serve the solar community. It contributes to the delivering of RE-EV to the community (objectives 1 and 4 of GEO-VENER). End of first period in Dec. 2018 - New programme for 2019-2021). (see http://www.soda-pro.com/web-services/radiation/cams-radiation-service/info for a description of the service)
Completed	A Sensor Observation Service capacity for the in-situ measurement for the Energy societal benefit area (SBA) has been established. In 2017, this activity will continue thanks to the support of ConnectinGEO H2020 project. This component (http://insitu.webservice-energy.org) has been added to the webservice-energy.org community portal. This Spatial Data infrastructure is operated by MINES ParisTech and will support GI-10. It contributes to objectives 3 and 4 of GEO-VENER.
In Progress	The launch of the call for project within H2020 ERA PLANET project is expected for 2016 with beginning of activities end of 2016, beginning of 2017. This project is a major contribution from Europe to GEOSS, with specific inputs for Energy within the Strand 2 – Resource efficiency and environmental management. This project will possibly contribute to all objectives of GEO-VENER. See GEO CRADLE initiative.
Completed	Activities of the Federation of Earth Science Information Partners (ESIP) Energy & Climate Working Group to enhance communication between data providers at US Federal agencies and RE decision makers. It contributed to the involvement of the private sectors within GEO.
In Progress	Continuation of the compilation of resources in the catalogue of the energy community portal http://www.webservice-energy.org. The webservice-energy.org is weekly harvested by the GEO DAB. It contributes to the GEO Data CORE (Collection of Open Resources for Everyone) in link with GEO Data Sharing Principles and in respect with GEOSS Data Management Principles and to objectives 1 and 4 of GEO-VENER. The catalogue included within the webservice-energy.org portal is developed based on the recommendations from GEOSS (formally known as GCI).

In Progress	Improvement of the Global Atlas for renewable energies from International-Renewable Energies Agency – IRENA (http://irena.masdar.ac.ae). It contributes to the GEO Data CORE in link with GEO Data Sharing Principles and in respect with GEOSS Data Management Principles and to objectives 1 and 4 of GEO-VENER. The Global Atlas infrastructure is developed on the model of GEOSS.
In Progress	Contribution of Copernicus Climate Change Service to exploration of Climate Change impacts to Energy sector through the European Climatic Energy Mixes project (ECEM). It contributes to objective 3 of GEO-VENER but also to the exploration of the links between Climate and Energy. ECEM project achieved, follow-up project C3S Energy. Linked with the C3S community activity.
Completed	Exploration of collaboration between IEA and IRENA on Environmental impact assessment through the IEA Photovoltaic Power Systems Program (PVPS) task 12 through the development of impact assessment of PV systems service. It contributes to objective 3 of GEO-VENER but also to the exploration of the links between Climate and Energy. See: http://viewer.webservice-energy.org/project_iea/
Completed	Looking for interaction with the Terawatt Initiative. It contributes to the involvement of the private sector within GEOSS.
In Progress	Organisation of the series of Solar training in Sophia Antipolis, France (since 2013). This contributes to capacity building, involvement of the private sector, science and technology within GEOSS. Similar training dedicated to other RE energies will be targeted in the new implementation plan. 7th session held in January 2019 with 44 professionals of solar energy (see https://tinyurl.com/y4rpsrao)
Open	Explore collaboration with Framework for Climate Services (GFCS) for Energy. It contributes to objective 3 of GEO-VENER but also to the exploration of the links between Climate and Energy.
In Progress	H2020 ERA NET Plus project "New European Wind Atlas" (NEWA) http://euwindatlas.eu/ (2015-2020). It contributes to the delivering of RE-EV to the community. It contributes to the delivering of RE-EV to the community (objectives 1 and 4 of GEO-VENER)
Completed	In 2016, Battelle and NASA conducted a stakeholder ideation workshop where stakeholders from across the energy management sector discussed current uses of EO data for energy management applications, including RE monitoring, building and energy efficiency, energy access, and other areas. Impediments to greater EO uptake were discussed.

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Relationship to GEO Engagement Priorities and other Work Programme Activities

Sustainable Development Goals Agenda 2030:

The 2030 Agenda for Sustainable Development, adopted by the United Nations Member States in 2015, provides a shared blueprint of action centered around the 17 Sustainable Development Goals (SDGs), and an urgent call for action by all countries - developed and developing - to act in a global partnership to promote peace and prosperity for all. The combination of EOs and geospatial data with demographic and other sector-specific data offers an opportunity to provide the derived information needed by stakeholders to analyze and model potential resource related supply and demand scenarios, evaluate impacts across sectors and geographical regions, create maps and other visualizations to relay information, and otherwise assist end-users in making informed decisions that will contribute toward achieving the SDGs.

As demonstrated in the figure above, ***SDG Goal 7: Ensuring access to affordable, reliable, sustainable and modern energy for all*** plays a central role in supporting all other SDGs through direct and indirect contributions to environmental sustainability, human development, and sustainable economic growth. The mitigation of environmental impacts of energy consumption at the local to global scale contribute to overall environmental sustainability. Access to affordable and reliable energy is also critical to ensuring basic services to improve human health and support income generating activities for human development. The provision of energy also is necessary to generate economic development through generation of new jobs and industries.

There are various planned GEO-VENER Initiative activities and outputs that are supportive of achieving the following targets under **SDG Goal 7:**

Goal/Target 7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

- "Capacity Building for the Utilization of Earth Observations among Utility Providers" will engage stakeholders to increase awareness and utilization of EOs for resilience planning for utility operations and management, as well as the uptake of RE sourcing.
- IRENA's Global Atlas allows users to find maps of RE resources across the world.
- Webservice-energy.org give access to different services related to RE (see http://www.webservice-energy.org/web-gis-client)

Goal/Target 7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

- "Capacity Building for the Utilization of Earth Observations among Utility Providers" will engage stakeholders to increase awareness and utilization of EOs for the uptake of RE sourcing.
- Several key projects/resources can be used to increase the use of solar resources, including Copernicus Atmosphere Monitoring Service (CAMS) for Solar Radiation, NASA POWER (Prediction of Worldwide Energy Resources), IRENA'S Global Atlas, and others.
- The SoDa Service is a broker to a list of services and web-services related to Solar Radiation proposed by several providers (htpp://www.soda-pro.com)
- The NASA-funded MAD-WRF research project will provide an improved solar irradiance forecast system (https://ral.ucar.edu/projects/mad-wrf).

Goal/Target 7.3 By 2030, double the global rate of improvement in energy efficiency

- The NASA POWER tool provides solar and meteorological datasets in support of RE and building efficiency needs.

Goal/Target 7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology

- "Capacity Building for the Utilization of Earth Observations among Utility Providers" will engage stakeholders to increase awareness and utilization of EOs for the uptake of RE sourcing.
- CoP will identify and engage stakeholders across the globe on a variety of activities related to RE.

The **Paris Agreement**, within the United Nations Framework Convention on Climate Change (UNFCCC), aims to limit the increase in global average temperature through mitigation efforts, increase the ability of countries to adapt to climate change impacts and foster climate change resilience, and promote climate resilient development through financing.

According to IRENA, there is a need to scale up RE at least six times faster in order to meet the decarbonisation and climate mitigation goals set out in the Paris Agreement. Additionally, recent findings from the United Nations Intergovernmental Panel on Climate Change (IPCC) note that global warming is likely to reach 1.5°C between 2030 and 2052 and climate models project increases in extreme events such as extreme heat, and heavy precipitation or drought, depending on the region, requiring communities to be more resilient to extreme events and other impacts of climate change. The GEO-VENER initiative is actively contributing to and/or has the potential to contribute to four of the five Pillars of Earth Observations support for the Paris Agreement (i.e., Adaptation, Loss and Damage, Capacity Development/Technology Transfer, National Reporting, and Mitigation) as described below:

Adaptation:

- Potential for considerable contribution through "Capacity Building for the Utilization of Earth Observations among Utility Providers" which will engage stakeholders and build capacity to increase awareness and utilization of EOs for resilience planning for utility infrastructure and operations to be prepared for future extreme events.

Loss and Damage:

- Potential for considerable contribution through "Capacity Building for the Utilization of Earth Observations among Utility Providers" which will engage stakeholders and build capacity to increase awareness and utilization of EOs for resilience planning for utility infrastructure and operations to be prepared for future extreme events and minimize damaged infrastructure and loss of energy services for other sectors.

Capacity Development/Technology Transfer:

- Potential for considerable contribution through "Capacity Building for the Utilization of Earth Observations among Utility Providers" which will engage stakeholders and build capacity to increase awareness and utilization of EOs and NASA tools and products for improved planning and operational management among electric utilities.
- Potential for considerable contribution through an active and engaged CoP which will engage stakeholders in information sharing, technology transfer, and capacity development through trainings, webinars, case studies, potential side events, or other shared activities.

Mitigation:

- Potential for considerable contribution through "Capacity Building for the Utilization of Earth Observations among Utility Providers" which will engage stakeholders and build capacity of electric utilities to identify, access and utilize Earth observations and NASA tools and products to increase potential uptake of RE sources, thereby minimizing reliance on fossil fuels and ultimately leading to a reduction in emissions of greenhouse gases.
- Potential for contribution through NASA products and tools such as POWER, MAD-WRF, and others in assessing mitigation potential by increasing uptake of renewable resources.
- Potential for contribution through COPERNICUS Atmosphere Monitoring Service for Solar Radiation in assessing mitigation potential by increasing uptake of renewable resources.
- Potential for contribution through the set of services and resources available on webservice-energy.org.

The **Sendai Framework for Disaster Risk Reduction** includes the following key elements that are of particular connection to the GEO-VENER initiative:

C. Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030 and ***D. Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030.*** The "Capacity Building for the Utilization of Earth Observations among Utility Providers" project has the potential for considerable contribution through engaging stakeholders and building capacity to increase awareness and utilization of EOs and NASA tools for resilience planning for utility infrastructure and

operations to be prepared for future extreme events and other impacts of climate change, minimize damaged infrastructure, and maintain reliable access to energy services, thereby minimizing impact to other sectors.

There are important connections to regional GEO activities as well. For example, AmeriGEOSS has a focus area on disasters which is relevant for energy management as well. Extreme weather and climate impacts affect energy transmission systems and infrastructure and AmeriGEOSS stakeholders are increasingly interested in how these impacts are related. For example, NASA has worked in Puerto Rico with satellite images of the Black Marble to assess the impact of Irma on urban settlements, level of isolation, and impact of lifelines. Black Marble allows evaluating the effect of the disaster on electrical networks, as well as the level of recovery. Similarly, the EO community in Australia is interested in how climate impacts such as drought or flooding impact energy transmission services.

List of Flagships (F), Initiatives (I), Foundational Tasks (FT), and Community Activities (CA) in the 2017-2019 GEO Work Programme that are relevant to this Initiative

Title of activity	*Type*	*Relationship /plans for future engagement/collaborations*
AfriGEOSS	I	In the previous decade, some collaborations were established between the Energy activities and AfriGEOSS (on the bioenergy atlas for Africa initiative as an example). Links with this regional GEO needs to be re-explored and relaunched
EO4SDG	I	Participation of GEO-VENER to the EO4SDG workshops and contribution on the SDG 7 targets
EuroGEOSS	I	Participation to the EuroGEOSS Action Group on Energy. Contribution through 3 pilots in the framework of the E-SHAPE project (official launch 1st of May 2019).
GEO-CRADLE	I	Collaboration on the development of a common energy pilot in the framework of the E-SHAPE project
GEO-EVOLVE	I	Collaboration since the beginning of the initiative on architecture and implementation activities.
Blue Planet	I	Potential collaboration on renewable Marine energies
GEOSS In-Situ Earth Observation Resources	FT	Contribution to this FT through the ENEON / ConnectinGEO H2020 support with the release of an energy *in-situ* platform.
CAMS	CA	Contribution from the GEO-VENER members to the solar radiation services. Annual solar training for professionals.
C3S	CA	Contribution from the GEO-VENER members to the C3S for energy thematic area. Potential collaboration of the CLIM2POWER project to establish with the C3S Community activity
EO and Citizen Science	CA	Potential collaboration on the link between citizen science activity on energy

		and the GEO-VENER initiative
EO for managing Mineral resources	CA	Minerals are key for the development of RE systems. A common meeting has been held in the GEO Plenary in Kyoto. As minerals are part of the SBA related to energy close links should be defined
EO for Water- Energy-Food nexus	CA	Exploration to be done between both activities
GFCS - GEO collaboration	CA	GEO-VENER members worked with World Meteorological Organization (WMO) in the definition of the Global GFCS for energy. Further collaborations have to be explored in a near future.
TIGGE evolution in GFIS	CA	TIGGE is working on forecasting. Its activity is essential for the intermittency in the renewable energies. As TIGGE is also part of the EuroGEOSS Action Group on Energy, the collaboration will be explored through this instrument

Stakeholder Engagement and Capacity Building

There are several key organizations and stakeholders, including at the international level, relevant to the operation and continued success and activity of this initiative. These include:

- U.S. Governmental agencies (NASA, Department of Energy (DOE), National Oceanic and Atmospheric Administration (NOAA))
- U.S. Department of Energy's Partnership for Energy Sector Climate Resilience for representatives from U.S. electric utilities
- U.S. National Renewable Energy Laboratory (NREL)
- Non-U.S. government agencies, such as science or research agencies both within and outside the U.S. (e.g., Battelle, University Corporation for Atmospheric Research (UCAR), etc.)
- International Renewable Energy Agency (IRENA)
- World Bank and other potential international donor organizations
- Researchers from the academic community
- Associations
- Members of other GEO regional and topic initiatives
- Commercial sector

Engaging stakeholders in the co-development and co-production of the initiative is critical to a successful and sustainable initiative. This includes determining user needs and building individual, organizational, and institutional capacity to use the outputs associated with the GEO-VENER initiative. Various mechanisms for engaging these stakeholders will be employed toward this end. First, a GEO-VENER CoP will be revitalized to serve as a venue for improved information sharing and stakeholder engagement to meet the objectives of the initiative and will meet on a quarterly basis. The CoP will draw upon existing membership of the GEO-VENER initiative (see accompanying Table A). One of the first activities for the CoP will be to update the strategic plan and develop an understanding of the other GEO

initiatives with whom GEO-VENER participants currently engage, as well as what ongoing activities could lend opportunities to develop new collaborations, both within and outside of GEO. Secondary organizations or groups, such as NOAA Climate Services staff, U.S. Department of Energy's Partnership for Energy Sector Climate Resilience, and others can also serve as venues for stakeholder engagement and may help in recruiting and engaging additional members of the CoP. Finally, the Advisory Group (governmental, private and non-profit sector scientific and policy experts) of the current NASA/Battelle capacity building project can serve as an additional source of stakeholders and potential participants. This group is included in gray in accompanying Table A, and will serve as the first tier of stakeholders to recruit to build membership and engagement in GEO-VENER CoP and related activities during this phase of the Work Programme. Additional members can be also be recruited at workshops, conferences, or through additional related networks.

The strategy for engaging stakeholders in the co-development and co-production of the initiative emphasizes consistent meetings (quarterly) with action items and shared responsibility of participants and members. Activities may include:

- Conducting a shared needs assessment across the initiative, using the CoP as a mechanism for engagement, and publish articles or blog posts on findings and thoughts
- Assigning individuals as liaisons with other initiatives to increase collaboration and coordination between groups, striving to identify common activities, such as a shared side meeting at an event, or a co-sponsored session at a conference.
- Updating the CoP shared page with information on participants, projects, activities, case studies, and other information.

Stakeholder engagement and information sharing efforts will also coordinate with with and otherwise leverage the NASA GEO capacity building project and related networks:

- Through provision of trainings, workshops and/webinars from the capacity building for electric utilities for improved understanding of various EO tools available and how to access and utilize such tools for improved resilience planning and operational management
- Through provision of trainings, workshops and/webinars from the capacity building for electric utilities for improved understanding of various EO tools available and how to access and utilize such tools for additional uptake of RE sources
- Through provision of case studies of how model utilities have successfully utilized EOs in specific duties
- Engaging electric utility representatives from the U.S. Department of Energy's Partnership for Energy Sector Climate Resilience

Other current activities for stakeholder engagement, information sharing, and capacity building include side events and trainings associated with GEO-VENER. A side event was held at GEO Week 2018 in Kyoto, Japan, where engagement was discussed among side event participants. In addition, Solar Training for Professionals training sessions were initiated in January 2013, with an ever growing numbers of persons expressing interest participating in the training session, the most recent of which

was held in January 2019. At this most recent session, 44 persons from European Union, USA, Brazil, Uruguay, Morocco and Qatar attended the session.

Governance

As learned through the previous program period, the governance of the initiative could be improved, and relied mainly on teleconferences with the volunteers acting in the group. In this new period, we will learn from the past and organize and implement the governance of the initiative in a more formal way, in hopes of improving overall engagement, activity and output. Several governance structures will be put into place to ensure that the GEO-VENER initiative is well-managed and effective. This will include designating co-leads for the initiative, and identifying a steering committee for supporting various activities.

Expectations for various parties include the following:

- Co-Leads: convene the larger group, facilitate discussions, provide overall direction as needed to ensure activities are effective
- Steering Committee Members and co-leads: lead or participate in activities as applicable in support of initiative goals
- Subcommittee Members and leads: facilitate specific projects
- Participants: be active in participating and engaging

Monitoring and Evaluation activities will include collecting information pre- and post- activities to gauge interest or learning and measurement of capacity building effectiveness with questionnaires or interviews. Several new communication channels will also be utilized to engage with stakeholders, share information, and highlight successes. These include:

- Hosting regularly scheduled webinars or other virtual meetings for engaging the CoP and interested stakeholders
- Providing an email list-serve to assist ongoing communications in-between quarterly meetings
- Exploring interest in an initiative newsletter, social media presence and posts (e.g. LinkedIn, Twitter, What'sApp) to share updates on initiative activities, related progress on projects and activities, new tools and resources, and training and capacity building opportunities
- Updating the GEO-VENER and www.webservice-energy.org/ pages and maintaining timely and relevant content
- Planning and facilitating networking events, side meetings, sessions, etc. at in-person meetings and scientific/industry conferences

Several potential risks will be monitored. Lack of participant engagement is always a risk due to a lack of participant time. In an effort to encourage sustained engagement and commitment, GEO-VENER

initiative leadership will write a Terms of Reference document to make expectations and goals clear. Staffing changes among initiative leadership or steering committee leadership may also impact success, so the initiative will maintain several levels of active leadership and work to establish transition plans whenever possible. Finally, the lack of a GEO lead in climate/energy is a potential risk. GEO-VENER initiative leadership will work with GEO to identify new leads to ensure that the initiative receives the attention necessary from GEO.

Resources

Details regarding specific contributions to the GEO-VENER initiative are presented in accompanying Table B.

Contributors for this initiative at this time include the following:

- NASA is funding two projects related to GEO-VENER, with periods of performance from 2018-2021, to two research institutions, Battelle and UCAR. NASA may be open to providing additional funding to support ongoing engagement of the CoP and related GEO-VENER activities, but that is still under consideration.
- France is providing in-kind contribution through MINES ParisTech to the development, the operation, the maintenance of the Spatial Data Infrastructure webservice-energy.org.
- Contributions may also be made, both of financial and in-kind format, from the different participating organizations and the various projects supporting the initiative's objectives overall.

Additional in-kind contributions include the following:

- Space to facilitate the participation of participants at Battelle, MINES ParisTech, NASA, and other organizations.

Additional sources of funding should be identified. Activities should be leveraged across GEO groups and initiatives to maximize impact regardless of financial backing. This may include additional research grant funding through U.S. sources such as NASA or NOAA, through the H2020 programme and its follow-up Horizon Europe or international sources such as the World Bank. The link with the commercial sector is within the DNA of the GEO-VENER initiative as energy is most often a commercial activity. It will be maintained and enhanced in the different set of activities of this Implementation Plan.

Technical Synopsis

GEO-VENER is focusing on filling gaps, building capacity, making data, observation, information knowledge and services more discoverable and accessible for the Energy community. A data flow diagram has been provided to the GEO Secretariat to support the creation of information package for

each GEO flagship and initiative and to support the Programme Board in developing the next Work Programme (2020-2022).

The data flow diagram below indicates how the GEO-VENER initiative moves from core **(1) EO data** coming from key international support programs, uses state-of-the-art **(2) tools, knowledge, methods and software** to produce added value informations that are packaged into **(3) products and services** available into dedicated **(4) applications** supporting sound decision making for energy stakeholders.

The current trend to move GEO toward an infrastructure for a results-oriented GEOSS is of interest for the GEO-VENER initiative. This will imply to bind together currently existing spreaded resources including data (in-situ, satellite, model, IoT, citizen, etc.) information technology resources, software, code, application programming interfaces, algorithms, research paper, and others into a value added "element" providing a global enhanced knowledge for GEO stakeholders. While the general idea is appealing the implementation is still to be developed. GEO-VENER has all the above mentioned resources available to exemplify this GEO Knowledge concept. GEO-VENER will thoroughly follow the GEO infrastructure development for a results-oriented GEOSS and will be keen to participate to any pilot's implementation in that respect.

GEO-VENER Data Flow Diagram

1-Inputs EO Data	2-Tools, Methods and Knowledge	3-Output Products and Services
• **SoDa** - MINES ParisTech/Armines • **CAMS** - Copernicus Atmosphere Monitoring Service • **C3S** - Copernicus Climate Services • **IRENA** – Global Atlas	HelioSat Method: http://www.soda-pro.com/help/helioclim/heliosat-2 Solar Geometry: http://www.oie.mines-paristech.fr/Valorisation/Outils/Solar-Geometry/ Software libraries in C for manipulating of Meteosat pixel coordinates into latitude: http://www.oie.mines-paristech.fr/Valorisation/Outils/Meteosat-Library/	The-operational COPERNICUS Atmosphere Monitoring Service for Solar Radiation: http://www.soda-pro.com/web-services/radiation/cams-radiation-service/info will serve the solar community Contribution of Copernicus Climate Change Service to exploration of Climate Change impacts to Energy sector through the European Climatic Energy Mixes project (ECEM). Access to the demonstrator: http://ecem.wemcouncil.org/

• **NASA** - POWER Data Access Viewer	ESRA clear sky model providing estimates of the surface solar irradiance under clear sky: http://www.oie.mines-paristech.fr/Valorisation/Outils/Clear-Sky-Library/ Solar radiation general knowledge: http://www.soda-pro.com/help#general-knowledge	H2020 ERA NET Plus project "New European Wind Atlas" (NEWA) http://www.neweuropeanwindatlas.eu/ (2015-2020). It contributes to the delivering of RE-EV to the community. It contributes to the delivering of RE-EV to the community (objectives 1 and 4 of GEO-VENER) A Sensor Observation Service capacity for the in-situ measurement for the Energy SBA has been established this component (http://insitu.webservice-energy.org/jsClient-0.2.0/#map) has been added to the webservice-energy.org community portal Continuation of the compilation of resources related to energy within the catalogue of the community portal http://www.webservice-energy.org. The webservice-energy.org is harvested by the GEO DAB (GEOSS Platform) every week. The webservice-energy.org is a GEO community portal International Energy Agency (IEA) PVPS Task 12: the Environmental impact assessment of PV systems Web service: http://viewer.webservice-energy.org/project_iea/ Improvement of the Global Atlas for renewable energies from International-Renewable Energies Agency – IRENA
	4-Applications NASA Solar and meteorological data sets from NASA research for support of RE, building energy efficiency and agricultural needs: https://power.larc.nasa.gov/data-access-viewer/ Practical examples of Private sector users : https://nantes-metropole.insunwetrust.solar/ http://www.soda-pro.com/web-services/radiation/cams-radiation-service/info Public Users: Policy makers, energy planners, bankers http://irena.masdar.ac.ae	

		http://irena.masdar.ac.ae. The Global Atlas infrastructure is developed on the model of the GCI. Identification of essential variables for renewable energies, gap analysis and industrial challenges on in-situ measurements http://www.connectingeo.net NextGEOSS http://nextgeoss.eu supports energy pilots applications that address key GEOSS societal challenges, and directly engage researchers and developers, providing them with specific tools and scalable Cloud appliances, covering their requirements and contributing to increase the European capacity within and leveraging of GEOSS. Pilot 1: Constructing Gridded Data for Grid Operations Pilot 2: High Resolution Solar Mapping at Urban Scale NASA Solar and meteorological data sets from NASA research for support of RE, building energy efficiency and agricultural needs: https://power.larc.nasa.gov/data-access-viewer/

Data Policy

GEO-VENER is aligned with the GEO Data Sharing Principles promoting free, full, open and timely access to Earth observation datasets, products and services. Several key datasets for RE practitioners has been contribute as GEO Data CORE (Collection of Open Resources for Everyone) and are available in the GEO

Web Portal (https://goo.gl/zqKJa2) such as the Helioclim-1 database providing Surface Solar Irradiation (SSI) for the period 1985–2005 over Europe and Africa and the global horizontal irradiance NASA Surface meteorology and Solar Energy (SSE) dataset providing 22-year monthly & annual average (1983-2005) worldwide.

The Spatial data Infrastructure (SDI) and GEO community portal webservice-energy.org and more precisely its CSW (catalog service for web) enable the proper mechanism for flagging GEOSS Data CORE licence to each metadata records. The webservice-energy catalog is weekly harvested by the GEO DAB (Discovery and Access Broker) making GEO Data CORE resources displayed and ranked as top resources according to the GEO ranking algorithm that is fueling the GEO Web Portal search and display mechanism. Over 1600 energy related resources registered as ISO metadata are available on the webservice-energy CSW catalog. These resources come from over 25 different energy data providers enabling their resources to be registered through the webservice-energy CSW catalog and available for search & discovery on the GEO Platform.

Webservice-energy SDI offers also the possibility to associate a DOI (Digital Object Identifier) to any given ISO metadata record. DOI attached to a journal publication that is pointing to the data resource used to support the research findings is a data policy becoming a common practice from journal editors. The following example from the Earth System Science Data journal illustrates this practice. This publication about "Monthly-averaged maps of surface BRDF parameters in ten spectral bands for land and water masses" includes a DOI (doi:10.23646/85d2cd5f-ccaa-482e-a4c9-b6e0c59d966c) pointing to a landing page at webservice-energy SDI. This landing page allow to access a ISO 19139 metadata record hosted in the webservice-energy CSW catalog. This metadata record provides links to the NetCDF files deployed on a TDS (Thredds data Server) operated in the webservice-energy SDI that have been used to support the research findings of the article. The NetCDF data used to support the finding in this article have been provided as GEOSS Data CORE supporting the GEOSS Data Sharing Principle.

All the future developments within GEO-VENER initiative will be made in accordance with GEO Data Sharing Principles, GEOSS recommendation on interoperability and will promote and advocate open data and open licences approaches. The webservice-energy SDI contributed by MINES ParisTech is a strategic and long-term asset that will support the GEO Energy community. It has been deployed in 2008 and since then it is the cornerstone of the GEO-VENER initiative providing data, observation, information, knowledge and services for the benefit of RE practitioners.

GEO-VENER members are participating to various GEO activities including GEO-EVOLVE, GEO Expert Advisory Group (EAD) and GEO Program Board guaranteeing that the team is informed and participates in the requirements, definitions and follows-up the development and changes in the various GEO Platform components.

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