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Testimony to the House Subcommittee on Science, Space and Technology in Support of Geothermal and Water Technology R&D: "Water and Geothermal Power: Unearthing the Next Wave of Energy Innovation"

I. Introduction

Chairman Lamb, Ranking Member Weber, and distinguished members of the Subcommittee, I appreciate and thank you for the opportunity to appear before you today. My name is Sander Cohan, I lead innovation efforts for Enel Green Power North America, Inc. My team and I are part of a global organization within the Enel Group to lead the deployment and commercialization of new energy technologies. Within this group, I focus on developments in the United States and Canada, serving as the project lead for proof of concept projects domestically and a conduit to communicate local best practices to our worldwide organization.

I am pleased to provide testimony in support of continued U.S. programs to foster geothermal and water technology research and development. Enel Green Power North America, Inc., in conjunction with its affiliated entities, has a long history of building and supporting geothermal and water power. As a longtime advocate for this technology, we focus on the commercialization and deployment of innovative inventions that lower overall cost of the technology, to achieve Enel's long term corporate and environmental sustainability goals.

The programs described in the draft legislation create the necessary groundwork and first step to enable broad scaling and market development of challenging and fundamental energy technologies. Without cooperation and collaboration from government, national laboratories, and inspiring startup technologies, the economic and social benefits of geothermal and marine technology would remain theoretical.

II. About Enel and Enel Green Power North America, Inc.

The Enel Group is a multinational energy company and one of the world's leading integrated electricity and gas operators. The Group works in 34 countries across five continents, generates electricity with a managed capacity of more than 90 gigawatts (GW) and distributes electricity, across a network spanning over 2.2 million km to more than 73 million end-users.

Enel Green Power North America, Inc. is one of the largest and fastest growing renewable energy companies in the United States, based in Andover (Massachusetts) with offices in Washington DC, San Diego (California), Oklahoma City (Oklahoma) Reno (Nevada), and Lenexa (Kansas). From 2015 to 2019 the company more than doubled its managed capacity, expanding from 2 GW to over 5 GW.

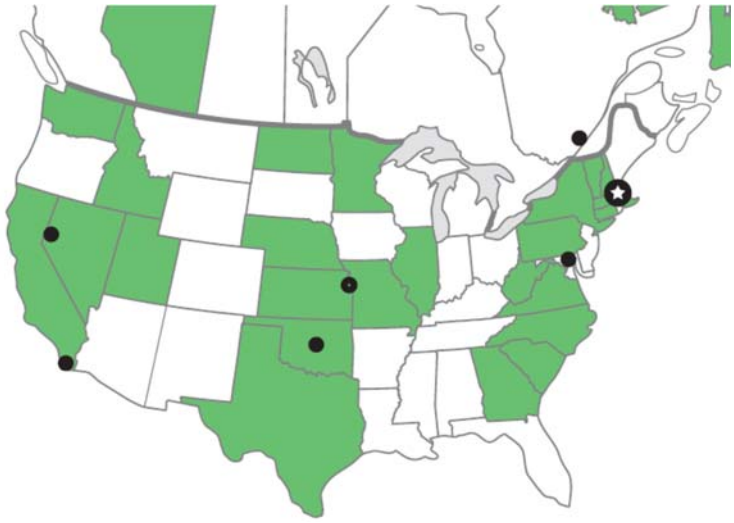


Figure 1: Enel Green Power North America, Inc. Footprint

To date, Enel Green Power manages over 100 renewable energy plants in 24 U.S. states with a diversified technology portfolio (wind, solar, geothermal and hydroelectric). The company is currently the largest wind farm operator in Kansas and second-largest in Oklahoma.

Enel Green Power is also a leader in the direct supply of renewable energy to corporate customers through long-term supply agreements. In total the company has 11 contracts, representing over 1 GW of Enel's capacity in the U.S., serving customers such as Anheuser-Busch, T-Mobile, Facebook, Adobe, General Motors, Bloomberg and Kohler.

III. Enel Green Power Innovation – Open Innovation Network Approach

Enel's approach to innovation is based on the creation of an Innovation ecosystem – a network of startups, national laboratories, industry consortia, and other formal and informal networks to push new clean energy technologies and business models into the marketplace.

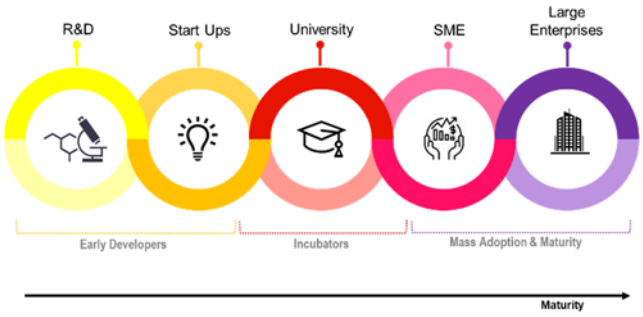


Figure 2: Innovation Network Ecosystem

With reference to geothermal energy, as detailed in a later section of this document, new ideas and potential partners come from a variety of sources. The majority of projects originate in academic and startup circles from researchers devoted to developing solution for the geothermal energy space. We also work with industrial partners from adjacent industries, such as oil and gas development, to take lessons learned and new ideas from their world into ours.

In the innovation ecosystem, Enel works as the strategic partner. We provide the capital, manpower, and industry expertise to take an invention from the late pilot stage to commercial deployment. This enables inventions to cross what is commonly referred to in emerging technology as the "commercialization valley of death". In this latter stage of research and development, the core technology has proven to have the potential to make a substantial impact in the market place but lacks the infrastructure and capital to scale from a single iteration. Crossing this valley is especially difficult for "hard" technology like geothermal and water power, which require the development of physical infrastructure and devices that have substantial technical risks and cost requirements. Our approach gives them the opportunity to scale up their solutions on our operations at global level so that we can use the innovation in place to make our traditional activities more efficient or to uncap new growth opportunities.

Enel typically does not make investments in startups. Instead, with its focus on providing equitable access to electricity it serves as the catalyst and the driver of energy innovation into the marketplace as an invention's first large industrial partner.

IV. Enel Green Power Geothermal Innovation

In our interest to support the global growth of renewable energy and the economic and social benefits this energy resource provides, we share the priority from the proposed legislation that increasing the use and reducing the cost of geothermal energy in the United States is essential.

Enel has a long history of geothermal innovation, starting with the development of the first commercial geothermal facility in Larderello, Italy outside of Pisa in the early 20th century. Today, Enel Green Power manages more than 880 MW of geothermal capacity globally, enough to power nearly 880,000 homes every year.

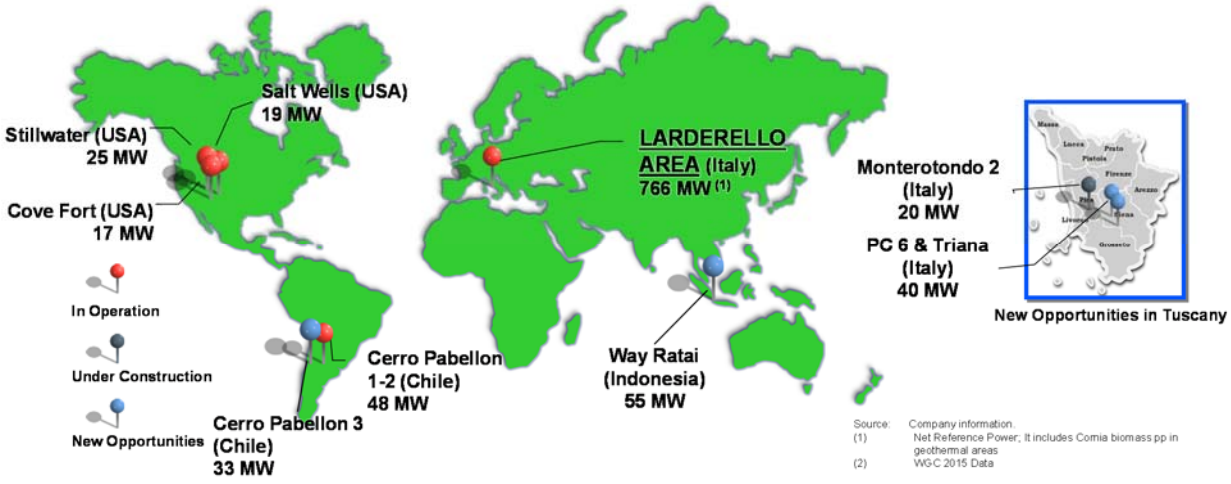


Figure 3: Enel Green Power geothermal footprint

Geothermal energy is an important cornerstone of Enel Green Power's technology agnostic approach. In order to reach its decarbonization goals, the company understands the importance of relying on portfolio approach to project development. To that end, we seek to continuously grow our geothermal generation as a component of our portfolio spanning the spectrum of renewable energy generation technologies.

Enel's current innovation pipeline for geothermal through 2021 contains budget for roughly 15 new projects. This pipeline includes a broad range of technologies, from ways to streamline and improve plant operations, to data analytics and methods to evaluate and process seismic data, to hardware intensive activities such as new drilling methods and investment in and support of Enhanced Geothermal Systems (EGS).

In the United States, Enel continues to leverage its presence as a geothermal operator to drive the state of innovation in the industry forward. Three projects highlight our ongoing and future commitment to advancing the state of this technology.

Stillwater Triple-Hybrid Plant and CRADA with National Renewable Energy Lab and Idaho National Laboratory Teams: By adding a photovoltaic solar plant to an existing geothermal binary power plant and by subsequently enhancing that hybrid system with the further addition of solar thermal (concentrating solar power), Stillwater, located in Churchill County, Nevada, is the first plant in the world to incorporate all three renewable energy technologies at the same site on an industrial scale.

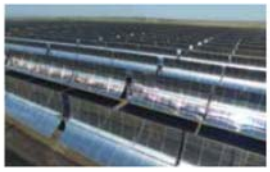
Stillwater's first-of-its-kind hybrid technology inspired a Cooperative Research and Development Agreement (CRADA) between Enel Green Power North America, Inc. (EGP), the National Renewable Energy Laboratory and the Idaho National Laboratory under the oversight of the U.S. Department of Energy Geothermal Technologies Office, to study the integration of these three technologies at the same site. This resulted in an award winning power plant and revolutionary research that confirms this hybrid theoretical model, paving the way for the possible deployment of hybrid solutions at other sites around the globe. In 2017, EGP began construction of a fourth project at the Stillwater site, the Stillwater PV II Solar Plant. The project, located adjacent to the existing site, supplies the project's corporate off taker, Wynn Las Vegas, with enough energy to meet up to 75% of the resort's current peak-power requirements.

Stillwater Geothermal Plant

- Start of Operations: 1H 2009
- Capacity: 33.1 MW
- Annual Generation: 150,000 MWh
- State-of-the-art medium enthalpy geothermal binary power plant. One of the only sites in the world to operate large-scale electrical submersible pumps for the extraction of geothermal fluid.

Stillwater Solar Photovoltaic Plant

- Start of Operations: 1H 2012
- Capacity: 26.4 MW
- Annual Generation: 44,000 MWh
- Over 89,000 polycrystalline silicon PV panels built on 110 acres.
  The PV plant compliments the geothermal plant's efficiency and production creating a better whole.



Stillwater Solar Thermal Plant

- Start of Operations: 1H 2015
- Capacity: 2 MW
- Annual Generation: 3,000 MWh
- 22-row parabolic trough system that concentrates the sun's energy by 75 times and adds energy to increase the temperature of geothermal fluid entering the plant, and allowing for a substantial increase in the amount of energy the plant can produce.

Wynn Solar at Stillwater

- Start of Operations: 1H 2018
- Capacity: 27 MW
- Annual Generation: 44,000 MWh
- The energy produced by the 160-acre solar PV facility will be sold to Wynn Las Vegas, marking an industry first partnership for a gaming operator in Nevada.

Cove Fort Downhole Generator Project – Adding Hydroelectric to Geothermal and Collaboration with Oilfield Operator Baker Hughes: Continuing the pattern of hybridizing our geothermal facilities is the ongoing effort to add hydroelectric power to binary geothermal energy. Enel's Cove Fort facility, located

in Beaver County in Southwest Utah, was commissioned in 2013 and has an installed capacity of approximately 25 MW, enough to power more than 13,000 U.S. households.

The unique geologic conditions at the Cove Fort site created a situation where it was possible to integrate hydroelectric technology on the downstream side of the facility as geothermal brine was reinjected into the aquifer. The innovative generator technology captures the energy of the water flowing back into the earth to generate additional electricity while also better controlling the flow of brine back into the ground. This has the additional effect of mitigating conditions that that had potential to cause damage to the wellhead. The result is a new technology that can reduce operational and maintenance expenses, while also having the potential to generate additional revenues.

A partnership with oilfield services company Baker Hughes catalyzed the innovation. Baker Hughes manufactured the type of electric submersible pumps that the Cove Fort plant uses to pump geothermal brine out of the ground on the upstream side of the facility, and they collaborated with Enel to modify this technology to use it as a generator.

The first version of this technology was used throughout 2016 and produced noticeable results and improvements in efficiency. Findings from the initial testing phase held between July and September 2016 reveal that the addition of the hydro generator to the geothermal injection well resulted in an overall increase in output of 1,008 MWh over this time, improving the plant's operational efficiency. Enel continues to collaborate with Baker Hughes on this project to iterate and improve the generator design.

Collaboration with University of Utah Energy and Geosciences Institute (EGI): In early 2019, Enel expanded its commitment to geothermal innovation in the United States by joining the Energy and Geosciences Institute at University of Utah. The goal of this partnership will be to leverage the strengths of institutions on both sides of the Atlantic to address persistent challenges facing the development of geothermal energy. The collaboration will be focused on both conventional geothermal technologies as well as enhanced geothermal systems.

V. Support for U.S. RD&D to Advance Geothermal Technology

Enel voices its support for continued federal funding and support of geothermal research, development and deployment efforts. As Enel and other developers work to expand the footprint of geothermal energy, fundamental investment in scientific capital is essential to overcome the substantial challenges geothermal energy faces. In order to remain competitive with other renewable technologies and serve as a viable resource, the programs being discussed at today's hearings are essential.

As a developer of technology, Enel's focus would be to expand and deploy the inventions fostered under the investment made through this policy. As described above, our innovation program focuses on ameliorating the challenges that emerging technologies and business models face in the commercialization and deployment phases, dealing with the ability of an idea to scale from basic proof of concept pilot to fully realized, market ready product.

Enel's effort to help bridge the second, commercialization valley of death are only effective if there is investment and focus from U.S. institutions to bridge the first fundamental challenge of new ideas, the technology valley of death, concerned with growing ideas from core academic theory to initial proof-of-concept and minimum viable product stages.

The program areas described in the draft bill are, in general, congruent with Enel's geothermal innovation priorities. As technology development in these areas progress, the company would find itself a logical first customer, helping to scale and develop the technology and allow it to achieve a scale that would benefit U.S. jobs, economic growth and environmental goals.

Within the draft bill text, several specific goals align with Enel's innovation priorities

- **Support for Enhanced Geothermal Systems (EGS):** This is an area of active exploration. While in the past we have worked predominantly with European partners in this topic looking at the fundamental technologies required to make Enhanced Geothermal Systems possible, the foundation and creation of the Frontier Observatory for Research in Geothermal Energy (FORGE) project is a positive development. Enel looks forward to exploring opportunities to work in the U.S. to develop EGS technologies.

- **Geothermal energy as a grid management resource or seasonal energy storage:** As a way of improving the overall performance of geothermal electricity production, Enel is actively exploring ways to integrate new hardware and software technology to better manage the geothermal heat resource and overall plant output, both to deliver more baseload power and to increase the flexibility and reactivity of the geothermal resource to grid conditions.

- **Geothermal minerals recovery:** This remains an area of interest for Enel and could be an area for which our sites in the United States can serve as potential test sites as technologies leave the research area or are successful in a proposed prize competition.

The topics above, notably EGS and geothermal minerals recovery, have substantial overlap with priorities seen in the oil and gas industry. Oil and gas expertise in drilling, subsurface monitoring are also applicable to the geothermal world, and Enel looks to opportunities to gain from expertise in that sector. Other areas of Enel innovation focus that have connections to oil and gas include:

- **Artificial Lift Technologies:** Enel works with oil and gas industry partners to develop high temperature, high horsepower artificial lift systems (Electrical Submersible Pumps) and we have actively contributed to this cause through our involvement in the Society of Petroleum Engineers. Enel has even provided no cost training in Midland Texas to oil field ESP operators on ESP equipment reliability and operations, as the improvement of ESP technologies industry wide is well aligned to our mission in Geothermal power and district heating technologies.

- **Breakthrough drilling technologies:** Drilling costs are one of the major components of the entire geothermal project. Technologies that can reduce this cost have a formidable impact on savings for future projects.

- **Geothermal exploration and monitoring technologies:** Reducing drilling risk through better surface exploration techniques, applying modern models to seismic, gravity and magnetotelluric data.

- **New approaches to reservoir stimulation:** Utilization of alternative chemicals for well stimulation, utilization of hydraulic/thermal stimulation, including radial jetting.

- **Corrosion Scaling Monitoring and Control:** Corrosion is a major issue for steam systems, while scaling is more critical for water systems. Both the phenomena can create severe damage in wells, piping and turbine inlet.

In addition to these areas above, R&D priorities for Enel Innovation include, but are not limited to:

- **Zero (or near zero) emission geothermal**: We are currently studying closed loop plant designs, with total reinjection of all non-condensable gases to be ready for new European regulation limiting the CO_2 dispersion in the atmosphere by geothermal plants

- **CO_2 reuse, either from biological or chemical transformation, from geothermal emissions:** Testing different techniques for removing CO_2 from the emission stream, using chemical and biological components.

- **District heating, process heat uses from geothermal electricity production:** We are providing several district heating systems with geothermal heat from our power plant systems. An optimization of this cascade utilization can improve energy efficiency factor and can have an important impact on the local community energy balance.

- **Technologies to reduce chemical consumption in geothermal emissions control systems**: Developing a downstream gas treatments (H_2S and CO_2 removal) aimed at limiting chemical consumption. Developing an upstream treatment (i.e. chlorine removal) aimed at limiting chemical consumption.

- **Utilization of supercritical fluids:** It will be the new frontier of geothermal development: using supercritical fluid at very high conversion efficiency can create a very powerful generation system and savings on overall cost and land occupation.

- **New technologies for geothermal plant management:** Better data handling for power plant management, integration of all different systems into a single data lake, for better plant management and advanced diagnostic.

- **New technologies for geothermal resource exploitation:** New unconventional ways to exploit geothermal energy for power generation can be evaluated

VI. Enel Green Power Marine Energy Innovation

In addition to our support for geothermal R&D, the points proposed under the proposed water power innovation R&D also resonate with Enel's innovation mission.

In the same way Enel manages an innovation competency in geothermal energy, we also maintain a similar competency in U.S. marine energy research and development on both wave and tidal streams, with stronger emphasis on wave power.

Marine energy is in an earlier stage than geothermal, and as such Enel Green Power is focused on supporting companies to develop and deploy the foundational technologies to allow project developers to capture the energy produced by ocean waves.

Currently the bulk of Enel's project activity in this sector is focused outside of the United States in Europe and Latin America, but it does not mean that the United States has not a good resource potential. That noted the substantial technology development taking place in domestic innovation clusters has created a scenario where while project development is not taking place domestically, there is substantial technology scouting taking place, with U.S. companies and organizations making meaningful contributions to Enel innovation programs.

VII. Enel Green Power Marine Energy Innovation Focus Areas

Enel Green Power Innovation has current operations supporting the development of marine technology.

Device Testing and Deployment: Enel Green Power Innovation has an active scouting activity looking for opportunities to test and deploy utility-scale wave energy conversion devices both in the United States and abroad. These are all in relatively pre-commercial stages. Recently, however, Enel Green Power signed a purchase agreement with New Jersey-based Ocean Power Technologies (OPT) to deploy their PowerBuoy devices at the Marine Energy Research and Innovation Center (MERIC) in Chile.

Marine Energy Research and Development Centers: In collaboration with the Chilean Government, French firm Naval Energies and University stakeholders, Enel is participating the development of a marine energy research and development center called the Marine Energy Research and Innovation Center (MERIC). Within this area, Enel Green Power has specifically taken leadership of establishing the Open Sea Lab, a facility devoted to providing a "test bench" for research to test technology solutions for marine energy in an open-ocean environment.

VIII. Support for U.S. RD&D to Advance Marine Energy Innovation

Enel Green Power supports the programs highlighted under the proposed legislation. It agrees that the establishment of open-ocean marine energy test centers are key to bridging the gap between university and military marine test areas and the commercial market. The company remains excited to support their development.

Other specific interests from Enel Green Power include, but are not limited to:

- **Grid Connection Cost Reduction:** One of the most significant components of marine energy project capital expense is represented by the grid connection. Enel would like to identify best practices for interconnection of marine energy production. This involves not only best an easiest solutions from a technical and economic point of view but also identifying potential partners to for collaboration.

- **Low environmental impact moorings and foundations:** A main issue for marine energy converters is the development of low impact moorings and foundations, ones that can secure advice in place in the ocean environment but minimizes the impact on wildlife and geography.

- **Power Take Off systems of Marine Energy Converters:** A best mechanism for power offtake for wave or tidal energy has yet to be found. Enel is looking for disruptive solutions to support. The solutions have to be robust, minimizing the mechanical parts in contact with water and full sustainable.

IX. Final Remarks

Thank you again for allowing me this opportunity. Energy innovation, especially ones that rely on the development of new infrastructure and hard assets to succeed, like geothermal and water technologies, are especially difficult to realize. They require intense cooperation through the entire value chain, originating in fundamental research development programs like the ones described in this legislation to initiate the process of technology transfer, and continuing through the process of technology deployment and commercialization. Contrary to how we think of it process is not a series of discrete steps, but rather an integrated ecosystem and a series of cooperative efforts. My team and the rest of Enel Green Power look to cooperate in this network with government programs, national laboratories, and industry in related fields, notably oil and gas, to lower the cost of deployment and realize geothermal and marine energy's full potential. The policy discussed in this hearing is an essential first step.