US Senate Energy and Natural Resources Committee Field Hearing

Cordova, Alaska – June 10, 2017

Testimony of Dr. Abraham Ellis, Sandia National Laboratories

Good Morning. Chairman Murkowski, Ranking Member Cantwell, and Members of the Committee, thank you for the opportunity to share my perspectives on the important matter of microgrids and hybrid systems. I'd like to commend the committee for choosing Cordova, Alaska for today's discussion. Cordova clearly exemplifies the magnitude of the challenge to meet the energy needs of remote communities, but also what is possible when stakeholders work together to find a sustainable solution. As we learn more about this subject and hear about Cordova's success story, it is important to remember that access to energy is a daily struggle for many other communities in Alaska and elsewhere.

The key messages I'd like to convey today are:

(a) While microgrids are not a new technology, they represent a complex system-level challenge with significant unresolved questions that merit research and development.
(b) Remote microgrids have served as an incubator of new grid technologies in the past, and will continue to be a catalyst for innovation.
(c) Advancement of microgrid technologies supports a continuum of major needs, from remote power to energy resilience and national security.

Definitions

- A ***microgrid*** is a group of interconnected loads and distributed energy resources (such as renewable generation and storage) within clearly defined boundaries that acts as a single controllable entity. A microgrid can connect and disconnect from the interconnected grid to enable the microgrid to operate in both grid-connected or island mode. Many universities and large businesses operate microgrids that have this flexibility.
- A ***remote microgrid***, also known as a ***mini-grid***, is a microgrid that does not have the possibility to connect to a larger grid, and thus operates in island mode all the time. Legacy remote microgrids typically rely on diesel generators, but new installations and retrofits increasingly include storage and renewables. Examples of remote microgrids include island, remote community power systems, oil platforms, and forward operating bases.
- A ***hybrid power system*** is a microgrid that combines diesel generators with renewable energy generation such as wind, solar or hydro, as well as energy storage.
- An **interconnected grid** is a large and complex network of synchronized power providers and consumers that are connected by transmission and distribution lines and operated by one or more control centers. Most large interconnected grids started as a collection of independent microgrids.

I would like to share with you a bit of my personal and professional experience. I grew up in a small mountain community isolated from the grid, where electrification evolved in much the same way it did in Cordova. We started with small diesel generators in stores and coffee processing plants. Electricity was expensive and unreliable. Eventually, we added a hydroelectric generator and small distribution grid. The benefits were broad and immediate, but we quickly learned the difficulties of maintaining the system and planning for growth. In retrospect, my life work has been motivated by growing up in a time and place where electricity is a precious resource.

My first job, almost 25 years ago, promoted sustainable rural electrification in Latin America. Even though the cost was high, it made good sense to demonstrate the technical viability of solar- and wind-powered water pumping and refrigeration. In a few larger communities, we added renewables and storage to existing diesel systems, which resulted in some of the earliest remote hybrid systems in operation. These early efforts, led by Sandia and other national labs, demonstrated the feasibility of drastically reducing diesel fuel consumption and keeping the lights on for longer. Renewable energy is a good fit for remote communities that tend to be located in environmentally-sensitive areas. We also encountered and documented key challenges for future sustainability and replicability:

1. ***Initial cost*** – Few could afford the high initial cost, even if the benefits in the long run were greater than the cost.
2. ***Technology readiness*** – The operating conditions were more challenging—high humidity, temperature swings, salt spray, and even insects! Off-the-shelf electronic components and batteries failed or degraded sooner than expected.
3. ***Institutional factors*** – These included the lack of business models, lack of access to technical support and financing, complicated by difficult logistics.

Why Pursue Microgrids Developments in Alaska and Elsewhere?

That brings us to today and all the work that has been done in Alaska, home to many remote microgrids. I am sure that my colleagues will agree that we have made monumental progress over time, but many

Examples of Alaska Microgrid Projects with Sandia Participation

- **Cordova Energy Storage Project –** Sandia is collaborating with the Cordova Electric Cooperative (CEC) and the Alaska Center for Energy and Power (ACEP) to investigate the feasibility of using energy storage to reduce diesel fuel consumption and make optimal use of existing hydro generation. The basic concept is that the energy storage system will provide contingency reserve capacity, deliver more low-cost hydro energy to the load, and extend the period of time when the system can operate in “diesel-off” mode. This project will result in an energy storage system deployment planned for 2017.

- **GMLC Alaska Regional Partnership –** DOE funded a team of national labs led by NREL and including Sandia, partnered with several Alaska-based partners including ACEP, to help remote Alaskan community microgrids reduce imported fuel by 50%, taking into account electricity, heat and transportation. The involves assessing of energy needs, improving energy information, and outreach to promote private and public engagement. The project also includes designing model remote microgrid pilot projects in Chefornak and Shungnak.

significant challenges remain. The efforts being undertaken here are breaking new ground and are making a difference for many Alaska remote communities, many of them Alaskan Native. Because the cost of energy is very high, it makes sense to consider new technologies that are not yet economically viable elsewhere. A similar equation is driving adoption of advanced microgrids and renewable energy integration technologies in Hawaii and at DOD installations and forward operating bases.

I want to stress that remote microgrid research, development and targeted demonstrations are also paving the way for new grid technologies that will modernize our national grid. Fundamentally, the same technologies used in remote and island microgrids are being deployed within the larger national grid, delivering cost savings as well as improved energy resilience for security, transportation, communications, health and other critical services. That is why the Department of Energy national labs are involved. With DOE leadership and funding, Sandia and its fellow national laboratories have been proud to spearhead the R&D in underlying technologies that are making advanced microgrids more viable.

An Example of High Return on Investment

Solar, wind power, energy storage, and associated power electronics and control systems matured in great measure due to application experience in remote microgrid and hybrid systems.

We have a vision of microgrids that are reliable, affordable, sustainable and scalable. Microgrids can enable higher penetration of distributed and renewable resources, including smart buildings, energy storage and electric vehicles, and make the grid more secure, efficient and resilient. To achieve this vision, there is a need to further develop energy storage, controllers, protection and cybersecurity systems. Better planning and operations methods are needed to achieve the full potential of microgrids and distributed energy resources. There is a need to develop and validate new design tools and

Microgrids and National Security – Two Success Stories

- ***Military Applications*** – Sandia played a principal role in the Smart Power Infrastructure for Energy and Reliability and Security (SPIDERS) JCTD, a groundbreaking program to bolster the cyber security and energy efficiency of U.S. military installations and transfer the knowhow to non-military critical infrastructure. Sponsored by DOD, DOE and DHS, the SPIDERS JCTD focused on four elements for enhanced national-security power surety: (a) Protect task critical assets from cyber-attacks, (b) Sustain critical military operations during prolonged power outages, (c) Integrate renewable and other distributed energy generation, and (d) Manage electrical efficiency to reduce petroleum demand, carbon "boot print," and cost. The program included demonstrations at three different sites: Pearl Harbor-Hickam, Hawaii; Fort Carson, Colorado; and Camp Smith, Hawaii (DOD's first installation-wide microgrid).
- ***Critical Civilian Infrastructure Applications*** – Major tropical storms pose a high risk to critical infrastructure on the East Coast of the United States. In 2012, Superstorm Sandy caused extensive damage in New Jersey and New York, and the resulting electrical outage severely hampered recovery efforts and put lives at risk. At the request of DOE and in partnership with NJ stakeholders, Sandia applied methods and tools previously developed in the SPIDERS program to define and optimize energy resilience options for the City of Hoboken and for the NJ Transit system serving Northern NJ and NY City. Both projects resulted in the conceptual design of a microgrid that could provide energy for critical services (hospitals, shelters and rail/ferry/bus service) in the event of a power outage caused by a major storm, cybersecurity attacks, or other events. The City of Hoboken is presently exploring options to finance its microgrid. The NJ Transit microgrid is presently under construction.

performance metrics to guide investment decisions and to inform policy. Finally, more work is needed to guide the orderly evolution of technical standards to ensure that microgrid components can interact safely and securely with each other, with utility systems, and energy markets.

This work is complex and must consider technical and institutional factors. And it requires close coordination with industry, as well as with tribal, municipal state government, and other local stakeholders such as the Alaska Center for Energy and Power (ACEP).

Conclusion

Thank you again for the opportunity to share my testimony about this important topic. I believe that advancing remote microgrid technologies not only supports the immediate needs of remote and island communities, but also supports the goal of a more secure and resilient electricity supply for our national grid. Public sector investment plays a critical role to ensure that microgrids reach their full potential as an enabler of grid modernization. I know this committee is familiar with the major economic impact driven by the Sandia Polycrystalline Diamond Compact (PDC) drill technology. In my opinion, investment in microgrid research and development has the potential to make an impact at a similar or larger scale.

Thank you very much for your attention and I look forward to your questions.