San Diego Gas & Electric:

A Utility-Owned Microgrid

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ASSOCIATION FOR
demand response
+ smart grid

ADS chose SDG&E for this case study for the following reasons:

1. **The utility had a desire to explore options outside of its normal business model;**
2. **There is currently a large amount of interest in microgrids, especially those that are utility-owned;**
3. **Stakeholder buy-in from parties across the state and country provides an example of successful collaboration;**
4. **The willingness of the utility to shift course during the planning in order to become more successful and meet stated goals;**
5. **The lessons are applicable to other jurisdictions for utilities of any size or governance structure.**

National Action Plan on Demand Response Case Study #6

The National Action Plan on Demand Response (NAPDR), published by the Federal Energy Regulatory Commission in June 2010, called for the development of case studies that would illustrate "lessons learned."

Case Study Audience

The NAPDR called for the development and dissemination of case studies as an action to support demand response practitioners and policymakers. In developing its own plan, the Association for Demand Response & Smart Grid (ADS) deliberated over what kind of case study would be most useful to its target audiences of DR practitioners, smart grid technology and service providers, policymakers, and other stakeholders involved in demand response and smart grid activities.

The approach ADS has chosen includes interviewing relevant stakeholders and leveraging other published sources to collect varied perspectives (representative customers, consumer and/or environmental advocates, utility staff, regulators, and relevant technology or service providers and analysts) and present them in a way that would help others apply the practices to their own situations.

Case Study Structure and Uses

ADS hopes these case studies will become the subjects of a series of articles, will be presented at industry conferences, and will be used in workshops emulating the business school case study process. Written versions (printable on demand) are posted online with links to relevant studies, data, and web, video, and collateral at: www.demandresponsesmartgrid.org.

To complement the detailed reports and data analyses common in the industry, ADS chose a narrative style that allows the individuals involved in the program or project to "tell their story" and state the challenges that presented themselves. ADS focuses on the questions:

- How did the key players view the challenges?
- What happened? What processes were used to meet the challenges?
- What were the reactions and perspectives of different stakeholders?
- What worked, what didn't work, what problems had to be overcome, and what is next?

SDG&E: A Utility-Owned Microgrid

San Diego Gas & Electric (SDG&E) is a regulated public utility that provides energy service to 3.4 million people through 1.4 million electric meters and 870,000 natural gas meters in San Diego and southern Orange counties. SDG&E's service area spans 4,100 square miles.

The intent of this case study is not to cover ground that other reports have already answered about program performance, but to get a better picture of the internal workings of an organization by telling the practitioners' story.

The idea for this study originated in a Breakout Panel Session during the National Town Meeting on Demand Response and Smart Grid that featured Neal Bartek of San Diego Gas & Electric presenting on the Borrego Springs Microgrid Project. The presentation was well received by Town Meeting attendees, and there was interest in knowing more.

The chief value of the interviews that follow is to supply other practitioners and interested parties with a sense of the challenges and barriers addressed by SDG&E and other stakeholders during the planning and implementation of a microgrid, and to explain changes and updates that occurred in the project over the years.

Top lessons learned by SDG&E:

1. Be sure to include a technical evaluation on all plug and play technology to ensure everything works in your specific environment.
2. Make sure the community is involved and has buy-in to the project.
3. Include a lot of simulations and modeling before putting everything together.
4. Be aware of all regulations (siting, emissions, etc.) before launching the project.

This case study was prepared by Jenny Senff of the Association for Demand Response & Smart Grid (ADS) on behalf of the National Action Plan on DR to provide a basis for conversations among stakeholder groups. Funding was provided by the Association for Demand Response & Smart Grid and the U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability.

Introduction

Many observers of the energy world these days are predicting that the future of the U.S electricity system will be a distributed one. Policy proceedings are underway in numerous states to develop new distribution planning processes and to move toward a more dynamic operation of the distribution system. Moreover, the primary focus of these proceedings and processes is on Distributed Energy Resources (DER).

Discussion Questions:

Is higher penetration of DER in your area a threat or a potential benefit?

While no official definition exists for DER, there is consensus on what the term is referring to and the types of options it encompasses. In terms of options, the list includes, but is not limited to, roof-top solar, community solar, storage, electric vehicles (EVs), demand response, and microgrids.

With technology developments in those areas increasing rapidly, and with prices falling for the electricity they produce, the penetration of customer-owned DER is leading to what appears to be an entirely different type of electricity system. That system will be one that will not be as reliant on large central power plants owned by the utility or a generating company, but instead smaller, distributed resources owned by many customers as well as other parties.

Lawrence Berkeley National Laboratory released *Assessing Changes in the Reliability of the U.S. Electric Power System* in August 2015, which examines the relationship between severe weather events and system reliability.

Are extreme weather events impacting your systems' reliability more frequently than in the past?

However, the future will be more complex than that. Some of this DER includes generation by the customer to be used by the customer, meaning less load to be served by the utility. That situation has utilities and policymakers rushing to examine regulatory models and utility business models to determine what changes are necessary in order to plan and operate under these new circumstances and ensure a robust distribution system to support it.

One more overarching force coming to bear on the electricity system that must be noted is the need to increase the resiliency of the system, and maintain, if not enhance, its reliability. An increase in extreme weather events has continued to adversely impact and otherwise threaten the electricity system [see sidebar on LBNL report]. This has resulted in DER being viewed as an option for making the grid more reliable and resilient by virtue of it being distributed and "spread around." From the customer standpoint, the result has been to consider owning DER as a way to ensure more control over reliability at an individual's home or facility.

For purposes of this case study, a **microgrid** is defined as a localized grouping of electricity sources and loads that can operate connected to and synchronous with the traditional centralized grid, but can disconnect and function autonomously as physical and/or economic conditions dictate.

Far ahead of the developments and debate on DER occurring today, a California utility stepped out to pursue the deployment of one particular type of DER – a microgrid. And it did so in a way that shows not only a microgrid's value for reliability, but also may point to a new option for changing a utility business model. That utility is San Diego Gas & Electric (SDG&E), and this case study is focused on its development of a microgrid on its system in Borrego Springs, California. Most notably, it is a utility-owned microgrid.

Location and Background

Discussion Questions:

Do you have any communities in your service territory that could benefit from a microgrid?

Borrego Springs is an isolated town located in Southern California in San Diego County, which is served by a single, radial sub-transmission line. With a tenuous connection to the utility, and the numerous reliability concerns stemming from that, as well as significant weather impacts, there was a great opportunity to use this community as a microgrid test case. In addition to providing backup reliability options, this project has helped to explore an alternative service delivery model in the area as well as to better integrate the large amounts of solar power in the community.

The existing transmission line to Borrego Springs serves nearly 2800 customers, and close to 14 MW of peak load. The line traverses 30 miles with over 5000 feet of elevation change, and is at the end of a transmission hub. "It's the electrical equivalent of an extension cord running through East County forests up over the mountains and then down into the Desert Valley and into Borrego. It's not a good thing," said Steve Pullins of Green Energy Corp (formerly Horizon Energy Group), the lead external support on the project. "They've had some reliability issues with the line." The community consistently dealt with more frequent and sustained outages than elsewhere in the service territory. "Borrego Springs was definitely a community in need, so we were able to do some really good things out there," said Pullins.

A **Dark Sky Community** is a town, city, municipality or other legally organized community that has shown exceptional dedication to the preservation of the night sky through the implementation and enforcement of a quality outdoor lighting ordinance, dark sky education, and citizen support of dark skies. Dark Sky Communities excel in their efforts to promote responsible lighting and dark sky stewardship, and set good examples for surrounding communities.

Borrego Springs' Chamber of Commerce was excited to work with SDG&E. The town was one of the first Dark Sky Communities. Its citizens have been pioneers in other energy-related endeavors, and they were open to this new venture.

Prior to the commencement of the project, Borrego Springs already had smart meters and some rooftop solar installed, and SDG&E wanted to build on those resources by integrating demand response, storage, EVs, and smart appliances into the mix. Tom Bialek, Chief Engineer at SDG&E emphasized "the focus was not just on bringing in new generation, but rather looking at other resources to facilitate the microgrid implementation."

The community also has a large load variation between summer and winter with vacationers coming to the town in the winter and spring. Dan Ton, Program Manager of Smart Grid R&D at the U.S. Department of Energy (DOE), who followed the project with interest with respect to the DOE microgrid program, explained why this issue also made Borrego Springs a good option for this project. "I think the variation is kind of unique," said Ton. "And to me, it's similar to Europe. People in these areas where they have increases of 50-80 percent load during summer, but when these people leave, it's a really small town. So you don't want to build some capacity just waiting for them to come back." As Ton observed, a microgrid should be considered as an alternative to upgrading distribution lines, while realizing the benefits of integrating renewable energy, storage, and advanced controls for system reliability.

The need to increase reliability *and* the opportunity to leverage new technologies already installed, cast Borrego Springs as a community in need of some assistance and an ideal option for a microgrid.

Discussion Questions:

Do you practice envisioning exercises as part of your planning process?

The Utility Inception

In 2005, SDG&E was working on an envisioning exercise for the future. The utility was updating IT systems and working towards becoming a utility of the future, and the idea of a microgrid project fit into that plan.

Initially, SDG&E did not begin with Borrego Springs in mind as the location for this ambitious project. It instead began with a certain set of criteria. Bialek of SDG&E noted the utility was looking to integrate DR, energy efficiency, and other new options for resources, and wanted an appropriate and progressive community that would be on board with the effort. Technical requirements included an area with space adjacent to the substation for new infrastructure.

The project had originally been slated for a beach community in SDG&E's territory, but shifted because the utility had applied for DOE funding, and Borrego Springs "actually met even more of the objectives that DOE was seeking," said Pullins. "It was a community with a history of reliability issues, so there was an opportunity to really change the nature of the electric system in Borrego Springs to the benefit of the consumers as well as the utility."

In putting this project together, SDG&E was demonstrating some new and unique ideas. "Back in 2007-2008, the idea of microgrids in communities was just beginning to come to light," explained Mario Sciulli of the National Energy Technology Laboratory (NETL). "Most of the emphasis to that point had been on military installations and campus settings, but this project acted like a springboard to spark microgrids becoming more noticeable in general applications." While many microgrids had already been created as test cases to demonstrate new technologies, a microgrid in Borrego Springs was more of a necessity from the perspective of both the utility and the community.

The **National Energy Technology Laboratory (NETL)**, part of the U.S. Department of Energy (DOE) national laboratory system, is owned and operated by the DOE. NETL supports the DOE mission to advance the energy security of the United States. NETL has expertise in coal, natural gas, and oil technologies; contract and project management; analysis of energy systems; and international energy issues.

Regulatory, Government, and Funding

Are there any federal or state grants available for similar projects in your footprint?

Bialek explained that the Borrego Springs microgrid originally began as a research and development project self-funded by SDG&E. Some of the self-funding was rate-based and was included in their next filing.

Then in 2007, the U.S. DOE released a renewables and distributed systems integration (RDSI) funding opportunity announcement (FOA) soliciting proposals for projects to reduce feeder peak loads and incorporate demand response and other smart grid technology.

SDG&E was one of the grant awardees, although Pullins clarified that "we were notified of the DOE award in April 2008, but the cooperative agreement between SDG&E and DOE was not signed until June 2009. So by that point, the project had been in development for nearly four years. There was a lot of waiting around time for stuff to happen."

One of the biggest issues that caused a delay between the award and the contract signing was that DOE requested the Defense Contracting Audit Agency (DCAA) to conduct an audit of SDG&E's accounting system. "They requested

Discussion Question:

Are you aware of all of the rules and requirements for any grants for which you may apply?

The **American Recovery and Reinvestment Act of 2009 (ARRA)** (Pub.L. 111–5), commonly referred to as the Stimulus or The Recovery Act, was an economic stimulus package enacted by the 111th United States Congress in February 2009 and signed into law on February 17, 2009, by President Barack Obama.

The **California Energy Commission** is the state's primary energy policy and planning agency. It was established by the Legislature in 1974 and is located in Sacramento.

a DCAA audit even though this was not a defense contract," explained Pullins. "This proved difficult because the way regulated public utilities account for costs, which in SDG&E's case is determined by the California Public Utilities Commission, is very different from the defense contracting rules. So of that 15 month wait, probably 13 months was back and forth between the DCAA, DOE, and SDG&E." In the end, to address the DCAA audit findings, SDG&E proposed (and DOE accepted) modifications to its accounting system to more readily track project related expenses.

The project also received subsequent DOE funding under the 2009 American Recovery and Reinvestment Act (ARRA).

The California Energy Commission (CEC) became involved in 2009 as well. The Commission awarded SDG&E with a grant on May 18 of that year, and Jamie Patterson, working in Energy Technology Systems Integration at the CEC, was a part of the project from that point forward. Although the CEC had a public interest energy research program, "the microgrid aspect was a new concept," said Patterson. "It was quite interesting. We do not really look at microgrids as something in and of themselves, but rather as tools to help us reach our state's energy goals, enhance renewable use, and increase reliability. Borrego Springs presented a unique opportunity to partner with a utility on a new way to work with distributed energy resources on its distribution system."

Ultimately, the Borrego Springs microgrid was a $15.8 million project, including $7.5 million of federal funding through DOE, $4.1 million provided by SDG&E, $2.8 million added by the CEC for secondary DR features, and another $800,000 from other partners.

Although the timeline was extended due to some governmental grant processes, the administrative challenges did not prove as pressing as the technological ones.

Technology

At the beginning of the project, Borrego Springs already had smart meters installed and some rooftop solar, and in the plan to build out the microgrid, the proposed DER were all existing technology options. However, there was a key technological hurdle to be surmounted. "From a new technology perspective, the only thing that had to be invented, if you will, was a way to control it," said Pullins. "We were using all commercially available equipment. The only thing that was not available was a control system that could actually do it." And a microgrid without a controller would not help the reliability concerns.

Patterson explained, "In this microgrid, it was interesting because the majority of the customers it serves are residential. The citizens have smart appliances. They've got residential energy storage. They've got all kinds of things out there. But getting it to operate as a system, for a system response to grid events, is what it's all about. If you don't have a microgrid controller, you can't respond." So the creation of control technology was one of the most critical pieces of the puzzle.

Discussion Questions:

Are you aware of all of the regulations and restrictions in your area as they relate to DER?

One additional unexpected obstacle was the regulation of diesel generators, which were brought in, along with large-scale battery storage, to create a "microgrid yard" next to the existing substation, according to Bialek. But these generators had been permitted through the California Air Resources Board (CARB) for emergency use only. To be used for the microgrid, the generators had to be re-permitted through the local air quality district and required some upgraded emissions equipment. "SDG&E ended up putting an 'e-pod' on the back, which is basically an emissions reduction device to integrate new controls into those emergency diesels," said Pullins. "They had to upgrade those emergency generators so they would be viable for the project."

Another unforeseen snag with the diesels was the timing limitation. They were constrained to no more than eight hours a day, 20 hours a week, and 200 hours a year. "You can also only run them during the day time," said Pullins, "which is really strange because one of the things that we needed to do was some testing at midnight in the summer." Incidentally, this circuit incorporated a produce farm with irrigation and water pumps that caused a night peak. "During the summer, when they're on a summer irrigation rate, which is lower at night, the circuit peaks at 4.6 MW at midnight. During the day time when it's 122 degrees outside, it's running around 2.5 MW, so it's an inverted peak." This issue was not anticipated as it was very different than most other service territories.

Sciulli of NETL acknowledged how SDG&E dealt with some of the very stringent air quality restrictions and added that "going through that process provided information on how future projects could handle that type of situation."

What combination of DER would be most effective for a microgrid in your territory?

Upon completion of the demonstration project, with all of the technology in place, the Borrego springs microgrid consisted of two 1.8 MW diesel generators, a 1500 kWh (500 kW) battery at the substation, three smaller 50 kWh batteries, and 700 kW of solar, for a total capacity of nearly 4 MW.

Marketing and Community Reaction

How regularly do you engage with the community in your service area?

Would your community be receptive to a utility-sponsored approach like this?

Is there outreach you can do before kicking off a similar project?

Early in the process, SDG&E realized it needed community buy-in from the citizens of Borrego Springs to ensure the project was accepted and embraced. The utility's public affairs team, from their customer communication people to their general corporate PR group, worked hard to reach out to the town in both small groups and at some of the local festivals. "They went in and co-sponsored some things and put up their table and answered questions," said Pullins. "They had a couple of community town hall-type meetings, and they also went to talk one-on-one with the neighbors nearest to where most of the work would be done. They did a really, really good job of that." The utility engaged in their normal process the same way they would do if they were to build a new substation, transmission, or distribution line, even though this project was different from the status quo.

Sciulli was pleasantly surprised by the reaction of the community. "Back then smart grid and smart meters had some negative connotations," he said. "One of the surprises was how receptive the community was to this project and some others SDG&E had going on. People were enthused and excited about the project in Borrego Springs. I attribute this to the outreach SDG&E put in before, during, and after the project." In this situation, the effort to engage, explain, and get early buy-in from the community led to a positive outcome for all involved.

During normal operation, central air conditioning turns "on and off" based on a thermostat setting. This is called **cycling**. Whenever there is a power emergency or critical demand, a demand response device can activate the A/C for a conservation period, and the run-time of the condenser (the cooling portion), will be cycled, or reduced to save energy.

Bialek shared an example of how enthusiastic the community was about helping out. Under the original plan, cycling of air conditioners during an event was suggested to allow temperatures up to 80 degrees within residences. However, customers asked for that level to be raised even higher to 90 degrees in order to provide even more energy savings for the microgrid.

Results to Date

Microgrids, and the components that comprise them, are not generally intended to operate on a daily basis, as they are primarily created for certain situations (e.g. planned outages and emergencies). In the case of Borrego Springs, some of those situations arose quite quickly following completion of the project.

In June 2012, a 26 MW solar array was being constructed in Borrego Springs and needed to be connected to the SDG&E system. Due to the configuration of the system, the utility had to shut down the entire Borrego Springs substation and transmission line going into the town in order to make the connection. During that five to six hour outage, the community was supplied successfully by the microgrid assets and components that were deployed as part of this project.

In September 2013, there was a very severe weather event with high winds, heavy rain, and lightning, which knocked out the town's only transmission line and damaged both transmission and distribution poles. SDG&E was able to use the components installed to power up portions of the damaged feeders as they were cleared or repaired. Bialek said "it was a big test of our system and took everything down for more than a day, but critical loads and cooling centers remained operational, thanks to the microgrid."

"Usually you don't expect to see that kind of demonstration so quickly," said Sciulli, "but in this case they had two situations where the systems worked just as planned."

In May 2015, the microgrid passed yet another test as a nine-hour planned maintenance project on the transmission line necessitated the town to be powered solely by the microgrid for that timeframe.

Changes, Updates, and Lessons Learned

Some challenges were addressed previously, including negotiating the DOE-required DCAA audit and creating a microgrid controller, as well as overcoming emission and timing regulations on the diesel generators. However, there were a few other unexpected issues that arose throughout the planning and implementation process and had to be addressed along the way.

In designing the microgrid, SDG&E planned to site the diesel generators and all of the energy storage in a separate yard just outside the substation. Unfortunately, that land is part of a 100 year flood plain. "This is out in the middle of the dessert, but it turns out that occasionally if there's a downpour in the mountains, all that water comes flowing down the valley in this particular area and flows right to the substation," explained Pullins. The remedy to this issue required putting the batteries and controls up on piers to avoid the water, and also installing break away fences, according to Bialek. "We had to build break away fences for the microgrid yard," he said, "such that if the water came through, the fences would not prevent all the trash carried from the water – like logs and things – flowing through." A viable solution was found despite adverse conditions.

The term "**100-year flood**" is used in an attempt to simplify the definition of a flood that statistically has a 1-percent chance of occurring in any given year. Likewise, the term "100-year storm" is used to define a rainfall event that statistically has this same 1-percent chance of occurring.

Discussion Questions:

What physical limitations might affect DER siting in your region?

In another twist, the original plan for the large scale energy storage at the substation included using a NAS battery (a sodium sulfur battery), "because it was really in vogue," said Pullins. However, due to the heat and drastic temperature changes in a desert environment, it was not a good fit technically for Borrego Springs. This resulted in a mid-project switch to lithium ion batteries instead. Bialek stressed that "you have to do a technical evaluation on every part of the project, including items that are seemingly just plug and play." All technology will not work in every situation and environment.

Do you have any unique environmental factors that could require one specific technology choice over another?

Ton of DOE observed that "projects combining technologies in new ways – such as microgrids – require constant reconsideration of system design as the components are integrated from the beginning of the process all the way to commissioning. The lessons learned in Borrego Springs confirm that microgrids have unique local requirements."

Pullins also clarified how the situation in Borrego Springs changed and made this project different from other microgrids. "If there's not natural gas available, then you really are shifting your microgrid to be primarily energy storage and solar. That changes the design towards renewables, and a much bigger renewables component leads to much more storage needed as well."

Despite the challenges, the overall process flowed fairly smoothly for the operation. Patterson of the CEC said that from his perspective he doesn't "really see a whole lot that should have been done differently. When you have successful projects, they're neat to see."

Moving Toward Additional Applications

DOE and the CEC, both funders of the Borrego Springs microgrid project, see this as an example of how other utilities and microgrid operators can learn and grow.

Patterson argues "the main thing about microgrids is that they develop local sources of renewable energy that will be used locally. Utilities who are experts at operating large networks of delivery systems just simply need to change a little bit of their outlook. I think that SDG&E is at the forefront of that and that this project basically helped them decide that maybe it's a good business model to adopt."

Patterson also notes "we look at microgrids as a way for Californians to get a better quality of life while maintaining and achieving the state's energy goals and greenhouse gas reduction goals. They also increase resilience. We believe that in the long term, microgrids may actually bring rates down because transmission lines are very expensive. Microgrids can decrease the reliance on ever-aging and fragile infrastructure and relieve congestion." He concludes, "Many things, all across the U.S. are old and need to be replaced. The cost to do so is high. So microgrids are certainly an option that can be used and adapted elsewhere."

As additional applications are considered and more lessons are learned at Borrego Springs and other locations, Ton notes that the DOE will be sharing these lessons with communities that have needs for improved reliability. Often these needs can be met by microgrids with renewable energy, storage, and other smart grid technologies. The hope is that this will lead to continuing progress.

Latest Developments

In February 2015, the California Energy Commission awarded SDG&E a $4.7 million grant to expand the Borrego Springs microgrid. This funding is being used to increase the size of the microgrid to encompass those in the community located outside the original boundary of the microgrid demonstration project, as well as to incorporate a nearby 26-MW solar facility.

The expansion and upgrades are expected to be completed in 2016, and SDG&E plans to use its success in Borrego Springs to develop microgrids in other locations of its grid.

Other pertinent case studies and resources

SmartGrid.gov - https://smartgrid.gov/project/san_diego_gas_electric_borrego_springs_microgrid

"Borrego Springs Microgrid Demonstration Project Final Report" (California Energy Commission) - http://www.energy.ca.gov/2014publications/CEC-500-2014-067/CEC-500-2014-067.pdf

Lawrence Berkeley National Laboratory - https://building-microgrid.lbl.gov/borrego-springs

"Four Important Lessons From the Borrego Springs Microgrid Pilot" (Smart Grid Library) - https://www.smartgridlibrary.com/2014/06/16/four-important-lessons-from-the-borrego-springs-microgrid-pilot/

More information on ADS, and additional Case Studies, can be found at www.demandresponsesmartgrid.org

The full NAP can be found at www.ferc.gov/legal/staff-reports/06-17-10-demand-response.pdf