Traditional New England City Builds a Modern Microgrid

This case study highlights a successful renewable energy project on a closed landfill site. It describes key challenges during the project, as well as the operation of the installation as part of a microgrid. The project is the type of installation that the U.S. Environmental Protection Agency's (EPA's) RE-Powering America's Land Initiative promotes—encouraging renewable energy development on current and formerly contaminated lands, landfills, and mine sites.

STAFFORD HILL SOLAR AT A GLANCE

- Rutland, VT (www.rutlandcity.org), population 16,495 (2010)
- Former 15-acre municipal solid waste landfill, which closed in the 1980s
- 2.3 MW solar PV installation on 9 acres
- 7,772 polysilicon panels
- Includes 4 MW of additional energy storage in the form of lead acid and lithium ion batteries
- System acts as a microgrid, providing power to the city's emergency center at the high school
- Provides economic benefits, including near-term annual benefits from the storage component of $350,000–$700,000 and annual land lease revenue of $30,600 to the city

Innovating on Contaminated Land

In 2015, the city of Rutland, VT, celebrated the repurposing of a defunct landfill into an innovative renewable energy site. After lying dormant for more than 30 years, Rutland's former municipal solid waste landfill site is now home to the Stafford Hill Solar Farm, a 2.3-megawatt (MW) solar photovoltaic (PV) installation. In addition to making use of a contaminated site, the installation provides unique benefits by including 4 MW of energy storage that allows the system to function as a microgrid.[1] Not only can the solar array operate as part of the main power grid, it can also be separated to operate autonomously in emergencies such as power outages. Vermont utility Green Mountain Power (GMP) developed the site through a partnership among federal, state, utility, industry, and non-governmental organizations (NGOs).

A Traditional New England Mining Town Going Green

The city of Rutland, VT, is located approximately 65 miles north of the Massachusetts state line and 20 miles east of New York. In the early 19th century, Rutland was the hub of Vermont's railroad system, which helped support the city's growth in the marble industry. By the time Rutland celebrated its 100-year anniversary, it was at the center of the world's largest marble business. Today, the city's lush New England landscape is better known as a tourist location than a mining town.

"Stafford Hill is a major milestone in creating more resilient and strong communities throughout Vermont. This innovative project is also a terrific example of how, working together, we can transform space that would otherwise be unusable into something that is critical to the community in times of need. This project will power the city's emergency shelter during storms, providing peace of mind to the people of Rutland."

— **Mary Powell,** Green Mountain Power President and Chief Executive Officer

The Property and Developer

Rutland's city landfill collected municipal solid waste for about 40 years before the city ceased use at the location in the late 1980s. The city-owned landfill was formally closed consistent with state requirements in 1991. Except for the operation of a recycling and transfer station and a metal storage facility on the non-landfilled area, the site has gone unused since its closure.

GMP's service territory covers approximately two-thirds of the state, primarily the southern portion. Based in Colchester, VT, the company owns more than 860 miles of transmission lines and 190 substations across the state, and has a generation portfolio that includes solar, wind, hydropower, and anaerobic digestion.

Like other utilities, GMP is subject to the state's renewable energy standard (RES). As of 2016, this standard requires all retail electricity suppliers in the state to obtain 55 percent of their annual retail electricity sales from eligible renewable sources by January 1, 2017. The requirement increases by 4 percent every three years until reaching 75 percent on January 1, 2032. GMP pursued the Stafford Hill Solar Farm in an effort to meet its desired generation portfolio objectives, help meet the state RES, and support its partnership with Rutland to "make [the city] the solar capital of New England."

1 The U.S. Department of Energy's Microgrid Exchange Group defines a microgrid as: "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode."

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As part of that effort, GMP started seeking sites in Rutland for a solar installation. Rutland's former landfill site had the space and infrastructure to support GMP's desired project size, and no upgrades to GMP's substation were required to accommodate an installation at the site. GMP recognized that the landfill had been capped decades earlier and was a natural fit for a solar location in the city, particularly given that there were limited other reuse opportunities for the land. GMP hired design firm Sanborn, Head & Associates, Inc., to prepare a full layout of the system and to develop the specific parameters for installing a solar array on the Rutland capped landfill.

Stafford Hill Solar Farm and battery system. Photo courtesy Green Mountain Power.

In 2013, GMP applied for a permit to reuse the defunct Rutland landfill for its proposed solar PV project. In June 2014, the Vermont Public Service Board issued the required Certificate of Public Good (CPG) for the project. Under Vermont law, certain net metered and communications projects must obtain a CPG in order to operate. Projects must meet certain criteria to qualify for a CPG including having a net economic benefit to the community, not adversely affecting the electric system, and not diminishing the surrounding air or water quality.

Why a Microgrid?

As an electricity generating project, GMP decided to design its solar system as a microgrid. A microgrid is a set of interconnected loads and distributed energy resources that can be used as a single controllable electricity entity. The primary reason for developing a microgrid is to provide reliable power to critical loads during loss of grid power. When the system is "islanded," or operating independent from the grid, the microgrid operator and control system manage available generation and the loads on the system to satisfy energy requirements. A grid-connected microgrid like the one at Stafford Hill Solar Farm can provide benefits including generation capability and load management, as well as ancillary services such as operating reserves, frequency regulation, and reactive power support for loads such as that resulting from air conditioners. Microgrids provide these functionalities by aggregating distributed energy resources such as solar, and through improved command and control capabilities, better communication systems, and energy storage.

Microgrids can also support a greater range of critical infrastructure, provide power to emergency service operations, and better manage available generation resources. They can help manage electricity loads on the overall system and provide more reliable electricity even during normal, non-emergency operation. Microgrids are often developed to mitigate the impacts of power loss to corporate facilities, campuses, municipal buildings, military bases, and emergency shelters. These systems provide energy security in the case of emergency events.

GMP wanted to include a battery system in its landfill solar installation to effectively create a microgrid system for a number of reasons. In GMP's view, the system reflected how they projected the electricity grid to perform in the future using energy storage and distributed generation, and to accrue other potential grid benefits, such as resiliency provided by the system's islanding capabilities. The company wanted to use the battery system to test the ability to smooth out fluctuations related to solar intermittency and reduce costs for customers by reducing peak demands. The city of Rutland also realizes benefits, since the storage system can power the city emergency shelter at the high school in the event of wide-scale power outages and weather events.

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Transforming a Trash Site into a Renewable Future

The Rutland Landfill stopped accepting waste in the late 1980s. The site was covered with a soil cap in 1990 and the state of Vermont's Agency of Natural Resources issued a closure certificate in 1991. An engineering assessment of the site completed before the PV was installed found that settlement of the landfill had occurred, which limited the overall acreage for the solar installation (in some areas, the landfill had settled approximately eight feet). To achieve a larger installation, GMP would have been required to level portions of the site, which they decided not to pursue. Nevertheless, GMP was able to use enough of the landfill site to achieve the desired project size, without disturbing the surrounding forest, storm water drainage, fences, and other features. Settlement considerations in the PV system design included the weight of the PV system and its ballast supports, the composition of the landfill waste and soil caps, and the proposed low-permeable fill. To address potential settlement issues in the future, the racking system for the PV includes adjustable supports that can adjust to changes in grade.

The $10 million Stafford Hill installation uses concrete ballasts to anchor the solar array – an approach common in landfill solar installations. These ballasts distribute the weight of the PV panels and guard against penetration or damage to the landfill cap. Any disturbance of the landfill footprint was pre-approved through design plans and backfilled with low-permeable soil. The project fencing also takes the cap into account, with the majority of fencing located outside the landfill footprint. The installation includes single row-to-row conduit cables that come together in a cable tray from the solar array field back to the inverters. System designers were also required to maintain setbacks due to existing nearby wetlands.

Storing the Sun's Energy

The energy storage system is perhaps the most unique feature at Stafford Hill Solar Farm. With 4 MW of battery storage in its inverter stations, the site is the first installation that includes a microgrid powered only by solar and batteries with no other fuel source. The regulation system maintains voltage when the system is connected to the grid and facilitates "islanding" in an emergency. In the event of an outage, the Stafford Hill circuit can be disconnected from the grid to provide electricity to the city's emergency shelter at the high school. GMP's on-call crews are able to get to the system and have it generating within about an hour. The emergency system was originally designed to connect through the grid distribution system, but GMP is building a separate distribution line. Having the system directly tied to the school will provide more flexibility if the distribution system goes down and will allow GMP to test the emergency system without having to cut grid power.

In most seasons, the solar installation and batteries are capable of providing full power for the emergency system around-the-clock even when the system is disconnected from the grid. This is assuming all solar and storage components are functional and the sun shines at least part of the day. This is especially true during summer vacation, since the electricity demand from the high school is reduced. In the winter, solar energy production and storage can be lower due to snow cover and shorter days, but is still generally expected to cover basic power needs and support the emergency system.

The Stafford Hill battery system includes lithium ion and lead acid batteries. According to GMP, the battery storage represents roughly half of the total $10 million system cost. The life of the batteries is a function of duty cycle (how often the system draws on the batteries), but GMP is expecting a minimum of 10 years before cell replacements are required. In addition to providing the city access to emergency power and helping GMP meet electricity demand when solar power is unavailable, the energy storage system benefits the grid. Such benefits include enhanced grid reliability, power load management, instantaneous voltage regulation, and opportunities for energy arbitrage (i.e., using stored power instead of more expensive peak power). The batteries also give GMP flexibility in responding to and optimizing energy demand. The utility has partnered with ISO-New England[2] to evaluate the effectiveness of the system in addressing rapid changes in electricity demand. Because the batteries are connected to and can be charged by the grid, they can be recharged quickly after use for grid testing or peak demand support. This means little disruption to the availability of power for emergency support. GMP intends to replace the battery cells as needed and expects advancements in battery technology to continually enhance cost effectiveness and resilience offered by these storage systems.

2 ISO-New England is an independent, non-profit Regional Transmission Organization serving Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. The ISO operates the region's electricity grid, administers the region's wholesale electricity markets, and provides reliability planning for the region's bulk electricity system.

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A Local Project with Local Benefits

Construction on the solar installation, which is named for the Stafford Technical Center and former U.S. Senator Robert Stafford, started in August 2014 and was completed in summer 2015. The project was designed and built using primarily local companies. White River Junction-based groSolar provided the solar panels, the inverters were custom designed by Burlington-based Dynapower, and Mosher Excavation from Killington was the work subcontractor. Other local companies included CDP Electric of Rutland and Middlebury Fence of New Haven (VT).

A number of Vermont organizations supported the project with both financial and technical assistance, including the Vermont Clean Energy Development Fund (CEDF), the Vermont Department of Public Service (VPS), the Stafford Technical Center, and the Vermont Energy Investment Corporation. The project benefitted from a unique federal-state-NGO partnership involving the State of Vermont; the U.S. Department of Energy; and the Energy Storage Technology Advancement Partnership (a project managed by Clean Energy States Alliance and Sandia National Laboratories). The PV system was constructed primarily by groSolar, and Dynapower provided the power electronics and energy storage.

Through competitive grants, the DOE's Office of Electricity Delivery and Energy Reliability awarded GMP and its partner Dynapower $235,000 for the energy storage portion of the project, and CEDF funded $50,000. The remainder of the project was funded by GMP. The utility will receive the 30% federal investment tax credit and is able to claim the depreciation on the system. These incentives lower total costs to customers and make the project more cost effective.

The Vermont Public Service Department estimates Stafford Hill is expected to provide economic benefits to the state and its residents, particularly if the system operates beyond the 25-year project life:

- GMP estimates the near-term annual benefits of the energy storage component to be $350,000–$700,000;
- The city will receive lease payments of $30,600 annually;
- The state of Vermont will receive tax payments on the site for at least 25 years (longer if GMP exercises the lease option at the end of the first 25 years); and
- The system provides Rutland with an alternate power supply for its emergency shelter.

The Stafford Hill Solar installation won a 2015 PV Project of Distinction Award from the Solar Electric Industries Association and the Solar Electric Power Association.

Stafford Hill Solar Farm. Photo courtesy Green Mountain Power.

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Key Takeaways from Project Participants

- **Identify strategic partners before you start.** The Stafford Hill Solar Farm relied on diverse and strong partnerships between GMP and its federal, state, local, and NGO partners.
- **Consider using an Engineering, Procurement, Construction (EPC) approach to this type of project.** Under such an approach, an EPC contractor will manage all activities—design, procurement, construction, and commissioning—and then hand the project over to the end user or owner. For Stafford Hill Solar Farm, GMP essentially served as its own general contractor. GMP staff designed the system, procured the solar, coordinated with Dynapower on the battery system design and purchase, garnered permits, etc. For its next solar project, the utility is instead planning to use an EPC package, under which they will develop specifications and then bid the project out. This will free GMP to concentrate on the grid-related aspects of the system and relieve some of the time and effort involved with actually executing the project.
- **Identify and decide on the grid controls early in the process.** Outlining and designing grid controls associated with the solar and its storage system was ultimately one of the more difficult tasks GMP noted in the planning and implementation of Stafford Hill. The utility notes that it is important to outline early in the process what grid controls will be needed, who is going to manage them, and what the different use cases are. Having a controls package completed near the start of the project will help ensure better design and a controls system that accommodates the necessary use cases.
- **Be prepared to adapt.** For landfill installations, get as much detail as possible about the landfill before the design is developed. This will make unanticipated changes to specifications easier to manage. The design of the Stafford Hill system placed the solar panels over the capped landfill and the batteries on a non-landfill portion of the site. The ballasts being used for the solar panels and GMP's pre-installation settlement evaluations helped ensure that the system would be designed to protect the cap and to accommodate any additional settling. The company had not planned on similar structural considerations for the batteries, since they were being placed on what was supposed to be a non-landfill portion of the site. When the utility started digging the battery site, however, they were surprised to discover themselves pulling up trash. This unexpected development required a rapid reworking of the foundation design and settlement evaluations for the battery site. GMP was able to adjust the design for the batteries by laying hundreds of thousands of pounds of stone over the location and pouring a footer for the battery system.