MEMORANDUM

To:	**Dean Charter, Town Manager, Town of Acton**
From:	**Charlie McClelland, Dave Beavers, and Ryan Fahey, Cadmus**
Subject:	**Recommendations re: the DOER Community Clean Energy Resiliency Initiative**
Date:	**October 3, 2014**

Overview

The Town of Acton (the "Community") applied for technical assistance as part of the Department of Energy Resources (DOER) "Community Clean Energy Resiliency Initiative" (CCERI). The Community requested a preliminary analysis of how clean energy technologies can bolster the energy resilience at two facilities:

- Public Safety Facility (DPW)
- Department of Public Works Facility (PSF)

Project plans, which detail resiliency project options and modeling results, have been completed and submitted to the Community. This memo identifies the most promising alternatives and recommends next steps. Per CCERI funding guidelines, the Community can apply for up to $297,306[1] in grant funding. Considering a 10 percent matching contribution, maximum potential project funding is $330,340.[1]

Recommendations

We recommend three project scenarios for further consideration, summarized in Table 1 and described in more detail in the following sections. This recommendation is based on information provided by the Community and modeling[2] results. Detailed modeling results are discussed in the project plans for the Facilities. Emergency load information was not available for the Facilities. For purposes of modeling, we assumed that the emergency load of facilities matches the load under normal operations. This is believed to be a conservative scenario; during a real grid interruption event, the emergency power resources could be extended through load management (e.g., turning off lights in unoccupied space and shutting down non-critical equipment).

[1] The Acton-Boxborough Regional School District (ABSRD) also received technical assistance under CCERI. If ABSRD seeks project implementation funding under CCERI, ABSRD's funding will be based on the potential project funding from the towns of Acton and Boxborough.

[2] Modeling was carried out by Cadmus using custom-developed tools. Assumptions are documented in the appendices.

Table 1. Project Scenarios

Facility	Description	Benefits	Costs
Public Safety Facility	45 kW solar PV PPA[3] with 413 kWh battery storage and existing 250 kW diesel generator	• 100% of building load covered in grid outage for three days when used in conjunction with existing 250 kW diesel generator • Annual energy savings of $2,269 from solar PV electricity sales partially offsets increase in operational costs for battery maintenance • Reduced diesel consumption of 530 liters over a three-day emergency power period (at 100% of load) • Energy storage system capable of providing about 4 hours of autonomy (battery only) during average winter load	• Storage Capital Cost: $330,400 • Storage Annual Operating Cost: $4,130
Department of Public Works Facility	78.75 kW solar PV system with 419 kWh battery storage and existing 60 kW natural gas generator	• 100% of building load covered in grid outage for three days when used in conjunction with existing 60 kW natural gas generator • Reduced natural gas consumption of 589 therms over a three-day emergency power period • Energy storage system capable of providing at least 12 hours of resilience during average load	• Storage Capital Cost: $335,200 • Storage Annual Operating Cost: $4,190
	78.75 kW solar PV system with 156 kWh battery storage and existing 60 kW natural gas generator	• 100% of building load covered in grid outage for three days when used in conjunction with existing 60 kW natural gas generator • Reduced natural gas consumption of 431 therms over a three-day emergency power period • Energy storage system capable of providing about 6 hours of resilience during average load	• Storage Capital Cost: $124,800 • Storage Annual Operating Cost: $1,560

[3]Further analysis is needed to determine the Community's ability to monetize additional net metering credits, based on the Community's municipal electric usage.

Public Safety and Department of Public Works Facilities

Available grant funding could be used to cover the estimated capital cost of the energy storage system modeled, or buy down the cost of a lease. If the Community is interested in pursuing resiliency projects at a single facility, the Community could seek to maximize the battery storage capacity based on the available grant funds at either the DPW facility (about 413 kWh) or at the PSF (about 419 kWh). In a worst-case winter storm scenario, we estimate that battery storage in combination with the generators and solar PV would be sufficient to power 100 percent of the each facility's load for at least three days. However, with building load reduction to reduce energy use during emergency operations, this period could be extended substantially.

The Community could also consider lesser amounts of storage at each facility. For instance, 156 kWh of storage at the DPW facility would provide approximately six hours of autonomy in an emergency; this duration could be extended substantially with careful load management and isolation of critical circuits.

For the purposes of modeling the scenario, we assumed lead-acid batteries for the storage technology; however, we recommend the Community consider a range of storage technology options when seeking requests for bids for the project. Further information on battery storage technologies is located in the appendices.

At minimum, the systems proposed in the table above would provide the following benefits:

- In a worst-case winter storm scenario, we estimate that the storage in combination with the existing generators and solar PV would be sufficient to power 100 percent of each facility's load for about three days.
- Battery systems alone would be adequate for provide autonomous power through outages lasting six hours or more, considering average annual load.
- In conjunction with the back-up generators and the solar PV array, the battery systems would provide enough energy to power the facility for over three days during a worst-case winter storm scenario:
  - The energy storage will enable the generators to run at full load for shorter periods of time, improving generating efficiency.
- During a summer loss of grid power, the solar PV systems combined with battery storage would further reduce fossil fuel usage beyond the worst-case winter storm scenario.
- Refer to the appendices for additional information on battery storage.

Other Scenarios Considered

No other resiliency scenarios were considered.

Next Steps

If the Community is interested in pursuing any of the clean energy scenarios described above, we recommend applying for CCERI Project Implementation Funding by October 29th, 2014. More

information related to our analysis is provided in the project plan appendices. More information about CCERI and links to the solicitation are available at: http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/resiliency-initiative.html.

MASSACHUSETTS DOER COMMUNITY CLEAN ENERGY RESILIENCY INITIATIVE
DETAILED PROJECT PLAN
TOWN OF ACTON PUBLIC SAFETY FACILITY

Initiative Overview

As part of the Massachusetts Administration's Climate Change Preparedness Initiatives, the Governor of Massachusetts directed the Massachusetts Department of Energy Resources (DOER) to administer a $40 million grant program to ensure energy resiliency at critical facilities in municipalities using clean energy technology. Energy resiliency is intended to reduce electric service interruptions and support critical infrastructure during power outages due to both gradual and acute pressures. The Community Clean Energy Resiliency Initiative (CCERI) recognizes that climate change-induced events impact the entire Commonwealth and that communities are at the forefront of responding to such events.

The first phase of CCERI included technical assistance to provide communities and DOER with an understanding of how clean energy technologies can bolster the energy resilience of critical facilities. DOER contracted with Cadmus to provide this technical assistance, in conjunction with Cadmus' subcontractors, HOMER Energy and MCFA.

Proposed Project and Purpose

Proposed Project

The Town of Acton (the "Community") is interested in understanding how clean energy technologies might be utilized to increase the energy resiliency of the Public Safety Facility (the "Facility"), while reducing the Community's use of fossil fuels. Currently, the Facility utilizes 250 kW Diesel generator for back-up power during a power outage.

Purpose

The Facility houses the Acton Police Department, which acts as the dispatch office for all of the Community's police, fire, and emergency management system (EMS) calls. Historically, two days has been the maximum length of outages in the Community. The Community would like to strengthen their critical facilities to allow them to remain self-sufficient during an outage through the installation of on-site solar PV generation and battery back-up, or a battery bank capable of powering critical loads for two days. Currently, the Facility has an uninterruptable power supply and uses approximately 30,000 kWh per month in the winter and 50,000 kWh per month in the peak air-conditioning season. Separated critical wiring for the building's essential functions are connected to an outside panel that can be fed by a mobile generator, the site for which could be used for the battery bank funded by the CCERI grant. By enabling the Community's critical facilities to operate, regardless of the state of both the electric grid and the diesel fuel supply, would create self-sufficiency and improve security for all 22,599 members of the Community during a grid outage.

Technical Assistance Project Overview

Cadmus reviewed materials provided in the Community's application and conducted a desktop evaluation of the Facility. We then evaluated the potential for solar PV and battery storage to provide energy resilience benefits, including continuous power at the Facility during a three-day (72-hour) power outage. Model results and assumptions are contained in the appendices.

We analyzed the following resiliency scenarios, as depicted in Table 1:

- **Baseline**: Utility power with portable 250 kW diesel generator
- **Scenario 1**: 45 kW solar PV PPA with 413 kWh battery storage

Through the use of a portable diesel generator, the Facility can remain operational so long as there is an adequate supply of diesel fuel and the generator remains functional. Adding solar PV and battery backup, however, could allow the Community to repurpose the portable generator to service other loads in the event of an outage.

Approach

Upon review of the Community's technical assistance application, the Cadmus team noted the current onsite back-up generation capacity, one 250 kW portable diesel generator, which is considered the baseline resiliency scenario for the Facility. Based on discussions with the Community and feedback from DOER, the Cadmus team evaluated adding battery storage to the baseline configuration.

Scenario 1

Model results indicate that adding a 45 kW PV system with 413 kWh of battery back-up would substantially improve the energy resiliency of the Facility and would be sufficient to maintain operations for approximately 12 hours under average load, or to power the Facility at 20 to 40 percent average load, so long as there was sufficient solar irradiance. In particular, this system could provide autonomous power for up to four hours at average load, or longer-term autonomy with load management to operate the facility at 20 to 40 percent of average load. While this would require curtailing non-critical loads, it should be sufficient to provide back-up power for many of the Facility's critical systems and/or to reduce reliance on the diesel generator.

When not operating in emergency mode, the modeled solar PV system would provide approximately 57,000 kWh annually. Note that further analysis is needed to determine the Community's ability to monetize additional net metering credits from the proposed 45 kW solar PV system.

Additional batteries could be installed to provide greater autonomy, though with added capital and operations and maintenance (O&M) costs, and space requirements. Autonomous power from battery storage for this Facility would cost in excess $2 million for a three-day outage.

Notes on the Analyses

The following caveats apply to the Cadmus team's model results:

- Energy usage profiles were not available for the Facility; rather, we assumed a typical office load profile and scaled this to match actual energy consumption at the Facility.
- No specifications were provided on the uninterruptable power supply (UPS), so any additional operating time or loads supplied by the existing UPS have not been considered in this analysis.

Model assumptions and results are documented in the appendices.

Energy Usage during Normal Operations

The clean energy technologies proposed would operate during "business as usual," reducing the Community's dependence on energy from the utilities. Table 1 details costs and emissions figures associated with the baseline and proposed scenarios.

Table 1. Baseline and Clean Energy Generation Scenario Costs and Emissions

Scenario	Clean Energy Resiliency Technology Versus Baseline	Initial Capital Cost[2]	Annual Operating Cost for Community[3]	Emissions[4] (CO_2e kg/yr)
Baseline	Portable 250 kW diesel generator	$0	$66,661/yr	188,143
1	Baseline, 45 kW solar PV PAA[1] with 413 kWh battery storage	$330,400	$68,522/yr	164,318

[1]Assumes a PPA rate of $0.10 per kWh produced by the solar PV.
[2]Initial capital costs include the batteries and battery management system (50 percent); and, islanding inverter and switchgear, installation, and other balance of plant equipment (50 percent).
[3]Operating costs include all electricity purchases during normal operation, system O&M costs, and amortized replacement cost of the equipment.
[4]Net emissions under normal operations, considering all electricity usage.

Energy Usage during Emergency Operations

Table 2 compares resiliency attributes of the baseline and clean energy generation scenarios.

Table 2. Load Coverages and Fuel Requirements for Baseline and Proposed Scenarios

Scenario	Energy Resiliency Technology	% of Full Load That Can be Met for 3 Days	Diesel for 3-day Outage[1] (L)
Baseline	Portable 250 kW diesel generator	100%	3,196
1	Baseline, 45 kW solar PV PAA with 413 kWh battery storage	100% (with generator) 16% (without generator)	2,666L at 100% load 0L at 16% load

[1]At corresponding percent of full load.

Appendices

Appendix A: Modeling Assumptions

Appendix B: Supporting Documentation

MASSACHUSETTS DOER COMMUNITY CLEAN ENERGY RESILIENCY INITIATIVE
DETAILED PROJECT PLAN
TOWN OF ACTON DEPARTMENT OF PUBLIC WORKS FACILITY

Initiative Overview

As part of the Massachusetts Administration's Climate Change Preparedness Initiatives, the Governor of Massachusetts directed the Massachusetts Department of Energy Resources (DOER) to administer a $40 million grant program to ensure energy resiliency at critical facilities in municipalities using clean energy technology. Energy resiliency is intended to reduce electric service interruptions and support critical infrastructure during power outages due to both gradual and acute pressures. The Community Clean Energy Resiliency Initiative (CCERI) recognizes that climate change-induced events impact the entire Commonwealth and that communities are at the forefront of responding to such events.

The first phase of CCERI included technical assistance to provide communities and DOER with an understanding of how clean energy technologies can bolster the energy resilience of critical facilities. DOER contracted with Cadmus to provide this technical assistance, in conjunction with Cadmus' subcontractors, HOMER Energy and MCFA.

Proposed Project and Purpose

Proposed Project

The Town of Acton (the "Community") is interested in understanding how clean energy technologies might be utilized to increase the energy resiliency of the Department of Public Works Facility (the "Facility"), while reducing the Community's use of fossil fuels. Currently, the Facility utilizes 1.6 MW solar PV array located on a landfill, 78.75 kW solar PV array on the roof, and a 60 kW natural gas generator for back-up power during a power outage.

Purpose

The Facility houses the Engineering and Highway Departments, which acts as the staging location for snow plows, tree trucks, crew dispatch, vehicle repair, fueling, and emergency coordination, among other services. Historically, two days has been the maximum length of outages in the Community. The Community would like to strengthen their critical facilities to allow them to remain self-sufficient during an outage through the installation of on-site solar PV generation and battery back-up, or a battery bank capable of powering critical loads for two days. By enabling the Community's critical facilities to operate regardless of the state of both the electric grid and the diesel fuel supply, the project would create self-sufficiency and improve security for all 22,599 members of the Community during a grid outage.

Technical Assistance Project Overview

Cadmus reviewed materials provided in the Community's application and conducted a desktop evaluation of the Facility. We then evaluated the potential for battery storage to provide energy resilience benefits, including continuous power at the Facility during a three-day (72-hour) power outage. Model results and assumptions are contained in the appendices.

We analyzed the following resiliency scenarios, as depicted in Table 1:

- **Baseline**: Utility power with 78.75kW existing PV array and 60kW natural gas generator
- **Scenario 1:** Add 419kWh battery bank
- **Scenario 2:** Add 156kWh battery bank

Approach

Upon review of the Community's technical assistance application, the Cadmus team noted the current onsite back-up generation capacity, one 60 kW natural gas generator and one 78.75kW solar PV array connected behind-the-meter, which is considered the baseline resiliency scenario for the Facility. Based on discussions with the Community and feedback from DOER, the Cadmus team evaluated adding battery storage to the baseline configuration.

Scenario 1

Adding a 419kWh battery bank will be sufficient to meet 50 to 70 percent of the Facility's three-day load during an outage. Alternatively, with load management and sufficient available solar resource, the Facility can operate for longer periods if loads are curtailed to keep within the limits of the battery bank. On a typical winter day, the PV array will supply approximately 180 kWh, while the Facility's average load is approximately 254 kWh/day. Under typical irradiance conditions and operating the existing generator for battery charging and peak loads, the Facility could operate through long-term outages under this scenario.

Additional batteries could be installed to provide greater autonomy, though with added capital and operations and maintenance (O&M) costs, and space requirements. Autonomous power from battery storage for this Facility would cost in excess $1 million for a three-day outage. If constrained by available space or other funding priorities, a smaller battery bank could still provide islanding capability that would make the output of the PV system at least partly available during an outage (considered in Scenario 2, below).

Scenario 2

Space and funding may be at a premium so we also considered adding a smaller battery bank at the Facility. A smaller battery bank would still allow the Facility to operate in islanding mode, which would keep the existing 78.75 kW PV system operational. With a 156 kWh battery bank, the system could power approximately 40 to 50 percent of Facility loads over a three-day outage period. However, if supplemented by the existing generator for battery charging and peak loads, this scenario could allow the Facility to operate for longer periods of time, given a sufficient supply of generator fuel and/or solar irradiance, at a much lower cost than in Scenario 1.

Notes on the Analyses

The following caveats apply to the Cadmus team's model results:

- Hourly energy usage profiles were not available for the Facility; rather, we assumed a typical office load profile and scaled this to match actual monthly energy consumption at the Facility.
- This analysis did not include assessment of thermal loads at the Facility.

Model assumptions and results are documented in the appendices.

Energy Usage during Normal Operations

The clean energy technologies proposed would operate during "business as usual," reducing the Community's dependence on energy from the utilities. Table 1 details costs and emissions figures associated with the baseline and proposed scenarios.

Table 1. Baseline and Clean Energy Generation Scenario Costs and Emissions

Scenario	Clean Energy Resiliency Technology Versus Baseline	Initial Capital Cost[1]	Annual Operating Cost for Community[2]	Emissions[3] (CO_2e kg/yr)
Baseline	78.75 kW solar PV system with 60 kW natural gas generator	$0	$12,102	5,526
1	Baseline, 419 kWh battery storage	$335,200	$16,289	5,526
2	Baseline, 156 kWh battery storage	$124,800	$13,660	5,526

[1]Initial capital costs include the batteries and battery management system (50 percent); and, islanding inverter and switchgear, installation, and other balance of plant equipment (50 percent).
[2]Operating costs include all electricity purchases during normal operation, system O&M costs, and amortized replacement cost of the equipment.
[3]Net emissions under normal operations, considering all electricity usage.

Energy Usage during Emergency Operations

Table 2 compares resiliency attributes of the baseline and clean energy generation scenarios.

Table 2. Load Coverages and Fuel Requirements for Baseline and Proposed Scenarios

Scenario	Energy Resiliency Technology	% of Full Load That Can be Met for 3 Days	Natural Gas for 3-day Outage[1] (therm)
Baseline	78.75 kW solar PV system with 60 kW natural gas generator	100%	844
1	Baseline, 419 kWh battery storage	100%	255
2	Baseline, 156 kWh battery storage	100%	413

[1]At corresponding percent of full load.

Appendices

- Appendix A: Modeling Assumptions
- Appendix B: Supporting Documentation