



**Minnesota Department of Natural Resources**  
**500 Lafayette Road, St Paul, MN 55155**

Project Title: *Development of Renewable Energy Strategies*

Contract Number: EP3-13 Milestone Number: 5 Report Date: 1.28.2011

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Congressional District (RDF Awardee): Fourth

Congressional District (PV Installations): TBD

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## **MILESTONE REPORT**

**Executive Summary:** The Department of Natural Resources (DNR) will be installing small-scale solar photovoltaic systems into several of their facilities and develop a renewable energy interpretive program. This is in preparation for large-scale implementation of renewable energy resources into new and existing DNR facilities. DNR is interested in doing renewable energy in a way that is not only in keeping with its mission and the Governor's Executive Order 05-16, but in a way that will inform and encourage other renewable energy applications. Installations included in this Project are rooftop solar photovoltaic systems connected to the grid and freestanding photovoltaic systems at locations where a building is well shaded but open sunlight is close; these systems will be installed at selected area offices, interpretive centers, visitor centers, and hatcheries. The Project will form the framework for establishing renewable energy design and specification standards for future photovoltaic installations at the DNR.

This project will provide DNR with a process and the tools for determining the feasibility of various renewable energy systems, the development of standard designs and specifications for photovoltaic systems, a number of grid-connected and customer-sited installations, a monitoring process, and a renewable energy interpretive program. The DNR has over 2,500 buildings ranging from vault toilets to visitor centers at 182 sites throughout the state. Within these facilities opportunities exist for solar photovoltaic systems. The DNR will use flat plate photovoltaic arrays mounted on sloped roofs at State Park sites, flat plate photovoltaic arrays mounted in series on flat roofs at larger buildings such as Regional offices, and flat plate photovoltaic arrays mounted on the ground at historic sites. All systems are anticipated to be fixed and will be connected to the grid.

The goals of this project are to develop a series of renewable solar energy strategies, prototypes, and specifications that will become part of all future new and renovated DNR facilities and to install at least 99kW of photovoltaic systems, both grid-connected and customer-sited. Specific objectives include:

- The development of assessment tools for building site selection, both to select sites for this project as well as for use by DNR to assess sites for future renewable energy installations
- Assessment and selection of sites serviced by Xcel electricity for inclusion in this project
- Design, construction documents, and construction administration for a minimum of 99kW of solar array collection systems for electricity generation at approximately 6 DNR state parks, regional and area offices
- The development of an interpretive program about the solar energy installations at the above referenced sites.

Technical Progress: This milestone required the installation of the second 33 KW of photovoltaic capacity. The actual installations were a 15KW ground mounted PV system at Afton State Park and a 16KW ground mounted PV system at Lac qui Parle Wildlife Management Area. These installations, along with 38 KW system at William O'Brien State Park, bring the total installed capacity to 69 KW. Afton State Park was selected based on the following criteria:

- Overall Site Criteria
  - Park Level: Good overall proxy for park attractiveness, amenities, prominence, etc.
    - Level 3 of 5 levels. Itasca State Park is the DNR's only Level 5 park.
  - Park Annual Visitors: More visitors means more opportunities for interpretation
    - Approximately 150,000 visitors each year
  - Park Overnight Stays: Overnight visitors are more likely to take time for interpretive activities
    - Approximately 7,000 overnight stays each year
  - Park Focal Point: A natural point of congregation like a Visitor Center, amphitheater, park store, etc. provides a good venue for interpretive activity
    - The array is located next to the Contact Station, where vehicles stop for information, permits, etc.
- Location-specific Criteria
  - Location Electricity Use: Provides opportunity to offset cost and carbon emissions
    - The entire Park uses approximately 60,000 KWh each year.
  - Location Demand Charges: Provides opportunity to offset large monthly costs of high usage rates
    - No demand charges
  - Location Solar Access: This was the result of a site assessment exercise, and included all related factors like roof slope/orientation/condition, shading, etc.
    - The arrays are mounted in an open, unshaded field next to the Contact Station
  - Location Interpretive Space: Space near the PV array that can be used for interpretive displays
    - The Contact Station will have signage and an interactive terminal for interpretation

Lac qui Parle WMA was selected based on the following criteria:

- Overall Site Criteria
  - Park Level: Good overall proxy for park attractiveness, amenities, prominence, etc.
    - Level 2 of 5 levels. Itasca State Park is the DNR's only Level 5 park.
  - Park Annual Visitors: More visitors means more opportunities for interpretation
    - Approximately 70,000 visitors each year
  - Park Overnight Stays: Overnight visitors are more likely to take time for interpretive activities
    - Approximately 6,500 overnight stays each year
  - Park Focal Point: A natural point of congregation like a Visitor Center, amphitheater, park store, etc. provides a good venue for interpretive activity
    - The array is located next to the Contact Station, where vehicles stop for information, permits, etc.
- Location-specific Criteria
  - Location Electricity Use: Provides opportunity to offset cost and carbon emissions
    - The Park and WMA use approximately 80,000 KWh each year.
  - Location Demand Charges: Provides opportunity to offset large monthly costs of high usage rates
    - No demand charges

- Location Solar Access: This was the result of a site assessment exercise, and included all related factors like roof slope/orientation/condition, shading, etc.
  - The arrays are mounted in an open, unshaded field next to the Contact Station
- Location Interpretive Space: Space near the PV array that can be used for interpretive displays
  - The Contact Station will have signage and an interactive terminal for interpretation

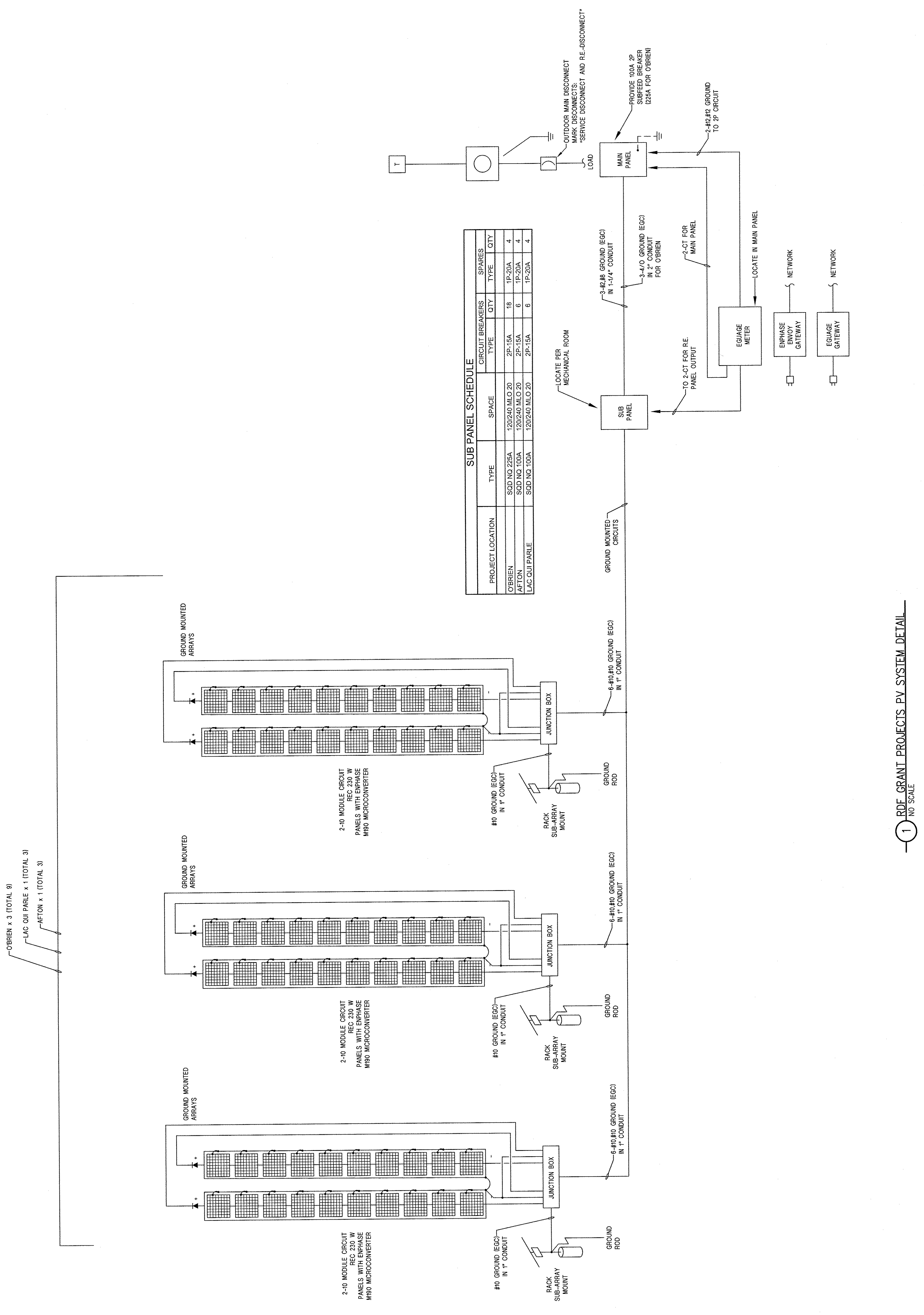
Evaluation criteria scoring metrics were defined and used to enable consistent evaluation across sites and evaluators. The criteria were weighted by a panel of experts representing DNR Parks, Regions and the Central Office. The completed selection tool spreadsheet provided a quantitative ranking for each potential location to help guide decision making. Afton scored 29 points and Lac qui Parle scored 25 points, compared to our highest site score of 35 points.

System Design: The systems consist of 65 PV modules (Afton) and 70 PV modules (Lac qui Parle) in a ground mounted array. The REC 230 watt photovoltaic module was selected for its proven production and moderate price. Each PV module is paired with an Enphase micro-inverter to convert the direct current produced by the module to the alternating current used on the electric grid. The Enphase micro-inverter was selected for the following reasons:

- Provides 10 – 15% more energy than traditional inverters. In an “apples to apples” comparison in the month of September, 2010 at our Gilbert OHV site 16 Enphase micro-inverter equipped PV modules produced 111% of the energy produced by 16 PV modules using a traditional inverter.
- No single point of system failure. Failure of a traditional inverter means loss of all energy production.
- Simpler design, installation and management.
- Safer because of low voltage DC and standard AC, instead of 600 volts DC with traditional inverters.
- Provides performance monitoring at the individual PV module level, not just at the entire array level.

The 15 KW array at Afton State Park should produce about 19,500 KWh each year, reducing the DNR’s yearly carbon emissions by over 16 metric tons. The PV array should offset about 33% of the park’s electricity usage. The 16 KW array at Lac qui Parle should produce about 22,500 KWh each year, reducing the DNR’s yearly carbon emissions by over 18 metric tons. The PV array should offset about 25% of the Park/WMA’s electricity usage.

System Construction: There were no significant issues in the construction of the Lac qui Parle PV array and the array was connected to the grid on December 1, 2010. At Afton State Park the transformer was initially determined by Xcel Energy to be undersized for the amount of power generated by the array. This resulted in a delay in interconnecting the completed system until it was determined that the existing transformer could handle the load. The PV array was interconnected to the power grid on December 28, 2010, about 2 months later than the original plan.



SUB PANEL SCHEDULE						
PROJECT LOCATION	TYPE	SPACE	CIRCUIT BREAKERS		SPARES	
			TYPE	QTY	TYPE	QTY
O'BRIEN	SQD NQ 225A	120/240 MLO 20	2P-15A	18	1P-20A	4
AFTON	SQD NQ 100A	120/240 MLO 20	2P-15A	6	1P-20A	4
LAC QUI PARLE	SQD NQ 100A	120/240 MLO 20	2P-15A	6	1P-20A	4

Afton State Park PV Array



Lac qui Parle PV Array



Data Monitoring: Data monitoring of the PV Array and building energy consumption is an important part of the DNR's strategy for reducing energy use and carbon emissions. Building energy monitoring allows the occupants to see the amount of energy they are using and change their behaviors to reduce consumption. Data monitoring of the PV Array allows for early problem detection and supports the DNR's interpretation efforts on solar energy. The energy monitoring portal for the Afton site can be found at: <http://aftoncs.d.egauge.net/>. The energy monitoring portal for the Lac qui Parle site can be found at: <http://lqpoffice.d.egauge.net/>.

**Milestones:**

- #1: Selection of an engineering firm; completed on June 11, 2009.
- #2: Process and tool to assess buildings for renewable energy; completed on October 6, 2009.
- #3: Site selection; completed on December 11, 2009.
- #4: Installation of first 33 KW of nameplate capacity; completed on December 28, 2010.
- #5: Installation of second 33 KW of nameplate capacity; completed on December 28, 2010.

**Project Status:** Project is ahead of schedule with implementation of 99 KW planned by the end of 2011 instead of by the end of 2012. This accelerated timeline will allow us to reduce our carbon emissions earlier and provide a more timely interpretive experience for park visitors. The modular design of the ground mounted arrays will also support a faster implementation.

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