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DISTRIBUTION ROOFTOP SOLAR STUDY

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EXECUTIVE SUMMARY

Rocky Mountain Power performed a study to estimate the potential for rooftop solar generation to offset the daily peak load and provide benefits for reduced infrastructure. The study specifically targeted the southwest quadrant of the Salt Lake valley in order to provide a comparison to a similar study completed in 2010 based in the northeast quadrant. Several circuits in the area were considered and Bingham #11 circuit in South Jordan, Utah was selected for the study. Quick facts for the study area can be found in Appendix A.

The study was performed using publicly available GIS and solar modeling tools to estimate the maximum amount of rooftop solar generation that would be produced and delivered to the distribution circuit. This was done by identifying rooftops in the area served by the Bingham #11 distribution circuit, determining the maximum panels that could be installed and calculating the annual solar radiation received. The solar generation profile was developed based on measured solar insolation levels in Salt Lake City in addition to information available on the National Renewable Energy Laboratory website.

The study estimated the maximum generation of the rooftop panels in the study area at 9.01 megawatts (AC) occurring at solar noon on May 13. The circuit peak demand occurred on July 14 at 5:30 pm mountain standard time. Comparing the solar production with the circuit profile shows that the rooftop solar reduces the circuit peak demand by less than 7%.

Considering the interaction between variable customer load and variations in solar production due to cloud cover and other interference, our distribution planning guidelines will continue to be based on peak load requirements and not consider solar generation reductions.

INTRODUCTION

Rocky Mountain Power "The Company" is experiencing growing levels of distributed energy resources being interconnected to its distribution system. Distributed energy resources generally include rooftop solar panels, energy storage devices, fuel cells, microturbines, small wind, and combined heat and power systems. These "behind-the-meter" power generation and storage resources are usually located on an end-use customer's premises and operated for the purpose of supplying all or a portion of the customer's electric load. At Rocky Mountain Power, interconnection requests for distributed energy resources are categorized based on size, type of technology, voltage of the distribution or transmission lines being connected to and the type of financial relationship the customer has with the utility, either net metering or Qualified Facility.

The growth of distributed energy resources has been primarily due to cost reductions in technology, performance improvements and the company's net-metering policy. In the past few years, Rocky Mountain Power has experienced an exponential growth in net-metering applications, especially in the state of Utah.

SOLAR INSOLATION IN UTAH

Tthe National Renewable Electricity Laboratory (NREL) estimated that the Salt Lake City area will average between 5 and 5.8 kilowatt-hours per square meter per day (kWh/m²/day.)

The model input values are taken from insolation measurements provided by a network of hundreds of meteorological stations. In Utah, Salt Lake County insolation potential is considered just above average. Solar insolation intensity increases with southward direction. Figure 1 shows NREL's annual solar potential map for Utah.

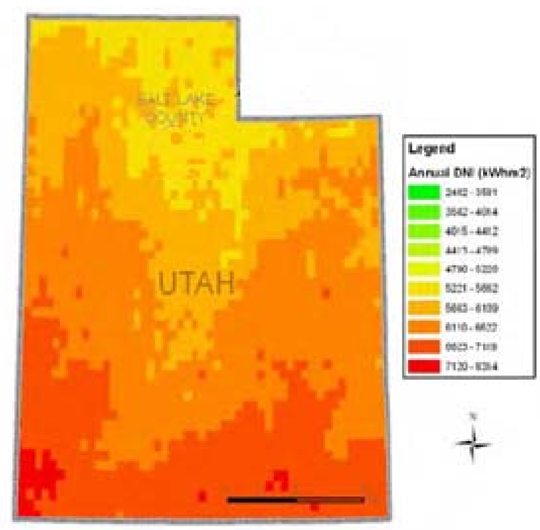

Figure 1: NREL Direct Normal Insolation 10-Degree GRID for Utah (kw/h/m2)

Factors such as slope, aspect, shading, changing solar positions, and weather conditions must be considered in order to generate useful estimates for individual roof surfaces. The Company developed monthly solar insolation models using the ArcGIS Area Solar Insolation tool and half meter resolution LiDAR data. This approach yields high-resolution results that identify roof faces that have the best characteristics for installation of photovoltaic (PV) panels based on roof slope, shading, area, and estimated solar insolation. Further, based on measured solar insolation data in addition to data extracted from the NREL PVWatts database, fifteen minute generation profile was developed to understand the potential contribution of solar generation towards circuit load.

MODELING OF ROOFTOP SOLAR PHOTOVOLTAIC SYSTEM

The typical method used to estimate the number of photovoltaic panels per rooftop is calculated by merely dividing the total rooftop area by the area of an individual solar panel. However, this approach has the potential to overestimate the number of panels per rooftop since it does not take into account roof shapes, objects, obstructions, shadows, etc. To avoid such an overestimation, the company developed a comprehensive solar model that consists of the following three parts:

1: The Solar Model

The solar model uses to estimate daily insolation averages per month and per year. This model calculates solar ESRI's Solar Insolation tools insolation values using 0.5 meter resolution elevation data derived from LiDAR, radiation parameters from NASA, and atmospheric factors based on local climate.

The output from this part of the model is a half meter resolution grid where each cell represents the estimated average insolation for a half square meter.

2: The Rooftop Model

The model uses elevation data derived from half meter resolution LiDAR gathered from Utah Automated Geographic Reference Center (UAGRC). The model also uses an algorithm to extract rooftop outlines and calculate roof aspects and pitches. The model identifies objects such as chimneys, dormers, etc. that would hinder the installation of solar photovoltaic panels. Focal standard deviations and flow of fluids were calculated for this purpose using GIS software.

Figure 2 shows color coded roof aspects where red indicates roofs facing north, green facing south, blue facing west and yellow facing east.

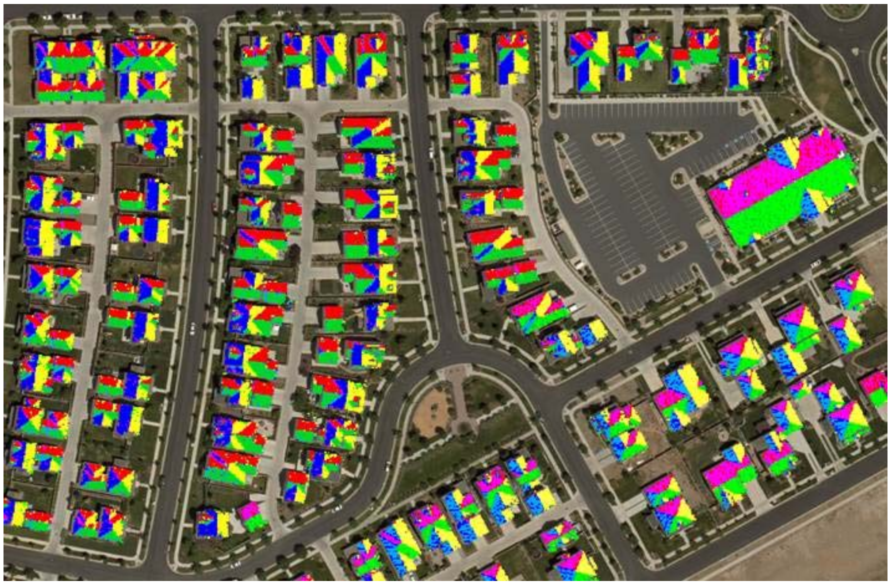

Figure 2: Calculated roof aspects

3: The Photovoltaic Panel Model

The next part of the model simulates solar panel installations by overlaying solar panels with a specific dimension over all rooftops while removing solar panels that can't be fitted due to an obstruction, change of pitch or aspect.

This study used dimensions for the Kyocera 250 watt photovoltaic panel. Figure 3 shows modeled solar panel installations on rooftops for a particular residential area served by the Bingham#11 distribution circuit.

Figure 3: Modeled solar panel installations

ESTIMATING NUMBER OF PANELS PER ROOFTOP

The study used Kyocera 250 watt solar panels with dimensions of 1 meter by 1.6 meters to estimate the total number of photovoltaic panels that could be installed on each rooftop. The calculation took into account roof aspect, changes in shape, and other objects that may interfere with installation. The model also eliminated irregular roof areas where standard solar panels cannot fit.

The rooftops identified in this study were found to be able to accommodate an estimated 42,439 panels with a total installed ac generation capacity of 9.01 megawatts at peak production. Figure 4 illustrates the total estimated number of panels for rooftops and the corresponding ac power generation capacity for respective orientations.

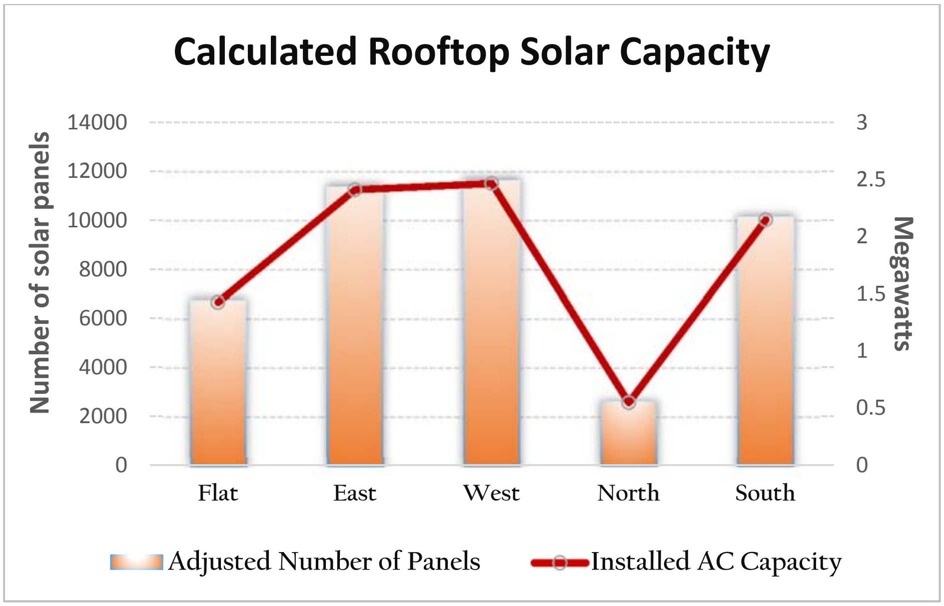

Figure 4: Total number of photovoltaic panels installed and corresponding installed capacity (AC)

SOLAR GENERATION CALCULATIONS

A hybrid approach was used to generate solar generation curves for the rooftop installations. Measured data from a flat roof solar installation in Salt Lake City was used for flat roofs and information from NREL PV Watts® database was used for all other rooftop solar panels identified in this study. Figure 5 shows a solar generation profile for a peak solar day and includes generation from all solar panels identified in this study.

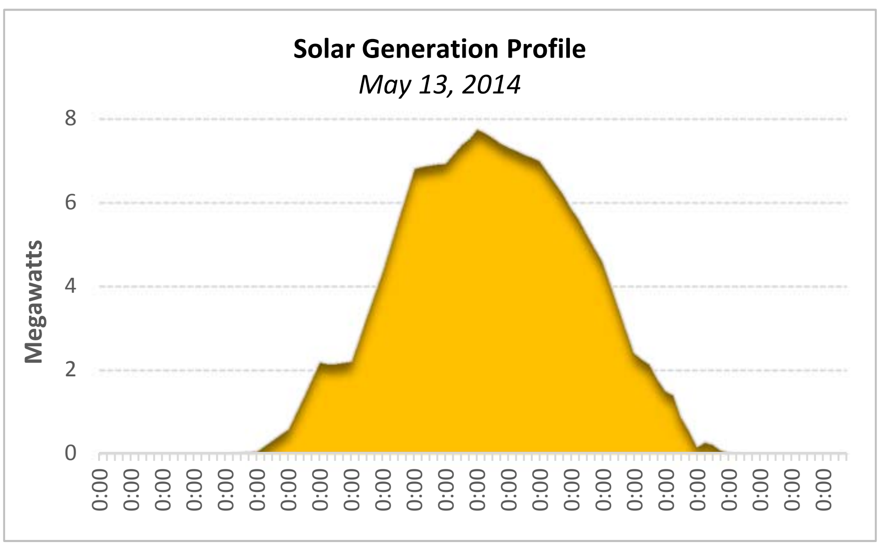

Figure 5: Calculated solar generation curve

DISTRIBUTION CIRCUIT LOADING

The circuit loading data for the Bingham #11 distribution circuit is shown in Figure 6. The circuit serves 2,244 customers with a peak demand of 9.95 megawatts that occurred on July 14, 2014 at 5:30 pm Mountain Standard Time.

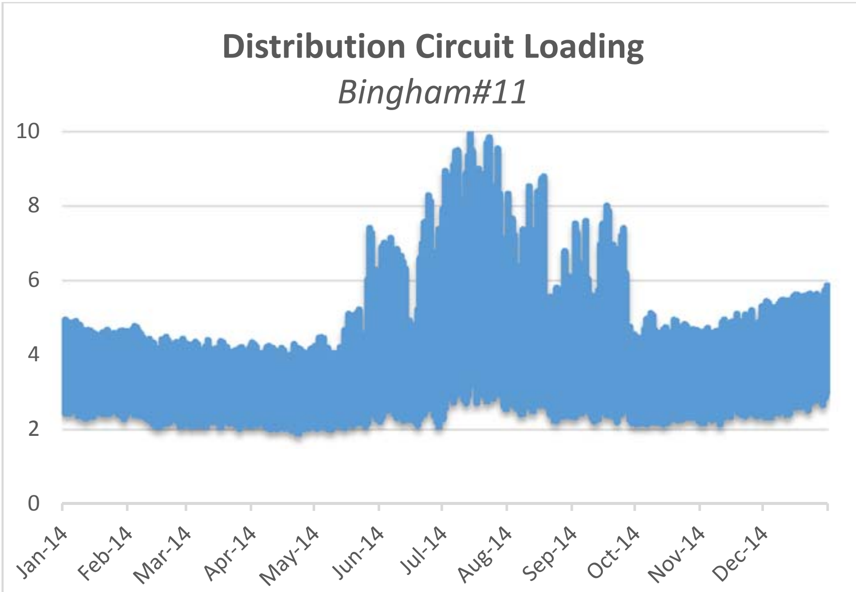

Figure 6: Distribution Circuit Loading for Bingham#11

IMPACT OF SOLAR GENERATION ON DISTRIBUTION CIRCUIT LOADING

The energy generated from solar photovoltaic systems is accounted for as a reduction in system demand as it reduces the amount of energy that the company must supply to the circuit from other generation resources. The more solar energy generated by solar photovoltaic panels, the more demand is driven down. The less solar power generated, the greater the demand on other energy resources to supply the required energy on the circuit. Further, due to various reasons, reduction of peak demand on a distribution circuit is of particular significance.

Figure 8 shows the circuit load profile on July 14, 2014 along with the estimated generation profile. The net difference between the load and the solar generation is the resultant circuit loading and shown with the black line. On the peak demand day, as shown in the chart, the solar generation reduces the overall circuit peak demand by only 6.8%. This is an insignificant reduction considering the large number of rooftop photovoltaic panels identified for installation in this study.

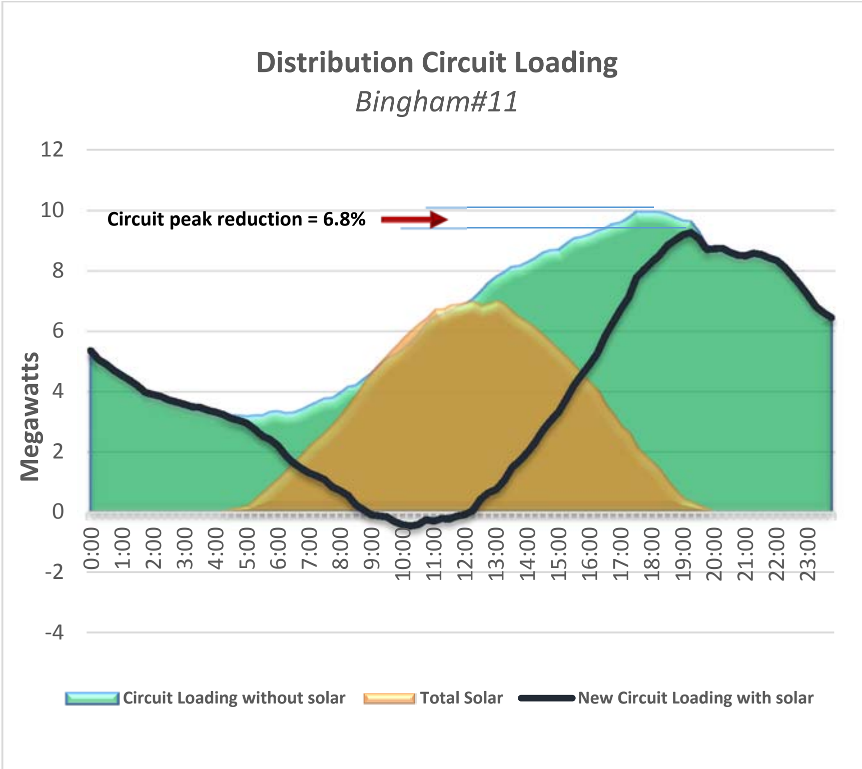

Figure 7: Solar contribution to distribution circuit loading

CONCLUSION

This study provides an overview of the complex techniques used to identify potential rooftops in a specific geographical location that can accommodate photovoltaic panels to generate electricity. Based on simulations, the approximate solar generation potential for customers connected to the Bingham#11 distribution circuit in South Jordan, Utah was found to be approximately 9.01 megawatts (ac). Further, this study clearly shows that for the identified study area, solar generation reduces the circuit peak demand by only 6.8%. It should be noted that solar contribution to circuit demand might vary significantly from minute to minute when the variability of customer load is combined with the solar generation volatility caused by cloud transients. Considering the insignificant reduction in peak demand and the potential volatility in solar generation levels, the distribution planner will continue to plan infrastructure improvements for circuit peak loading without consideration for the contribution from solar photovoltaic generation.

APPENDIX A – Quick Facts

Study Area – Bingham 11

Study Service Area (approximate boundaries):

EAST –	2865 West
WEST –	4500 West
NORTH –	10400 South
SOUTH –	11800 South

Maximum Solar Output – 7.77 MW (May 13, 1200 hrs)

Bingham 11 Feeder:

Capacity = 10.32 MW
2014 Peak = 9.95 MW (July 14, 1730 hrs)
2015 Projection = 10.15 MW

Bingham Substation (Xfmr #1):

Capacity = 25 MVA
2014 Peak = 17.82 MW
2015 Projection = 19.26 MW

Critical Loads: District Shopping Center

Map of Study Area: