Q. Please state your name, business address, and position with PacifiCorp dba Rocky Mountain Power ("the Company").

A. My name is Douglas L. Marx. My business address is 1407 West North Temple, Salt Lake City, UT 84095. I am director of Engineering Standards and Technical Services for Rocky Mountain Power ("RMP").

Q. Please briefly describe your educational and professional background.

A. I've worked for RMP for 33 years in various engineering, operations and management positions. I hold a bachelor's degree in electrical engineering from the University of Utah and a master's degree in business administration from Utah State University.

Q. Please describe your present duties.

A. I oversee all non-routine technical studies including distributed generation, power quality and smart grid reports. I am responsible for the development of all material and equipment specifications and standards used in the construction and maintenance of the transmission and distribution systems.

Q. What is the purpose of your rebuttal testimony?

A. The purpose of my rebuttal testimony is to show the operational effects of rooftop solar, primarily through engineering studies the Company has performed in the Salt Lake Valley. I will demonstrate that conventional rooftop solar does not significantly reduce the need for the Company to add capacity to its system and that customers with rooftop solar do in fact utilize the full benefit of the local electric distribution system.

Q. What experience does Rocky Mountain Power have with large penetrations of solar or other renewable resources?

A. Presently, there are not high levels of Net Energy Metered ("NEM") solar penetration on RMP's distribution system. To understand the potential impacts and prepare for the future, we work closely with industry associations as well as perform our own studies. Several studies have shown that, depending on the electrical characteristics of the distribution system, a high penetration of NEM will require infrastructure upgrades to maintain safe and reliable electrical service to our customers. RMP operates a complex electrical infrastructure in a safe, reliable and cost-effective manner, and it remains in the best interest of our customers for us to continue to do so. Though we encourage solar NEM on our system, we also realize that there are technical challenges, sometimes subtle and unintended, caused by the increasing interconnection of solar NEM systems.

Q. Has Rocky Mountain Power studied the impacts or potential benefits or impacts of large penetrations of conventional rooftop solar in its service area?

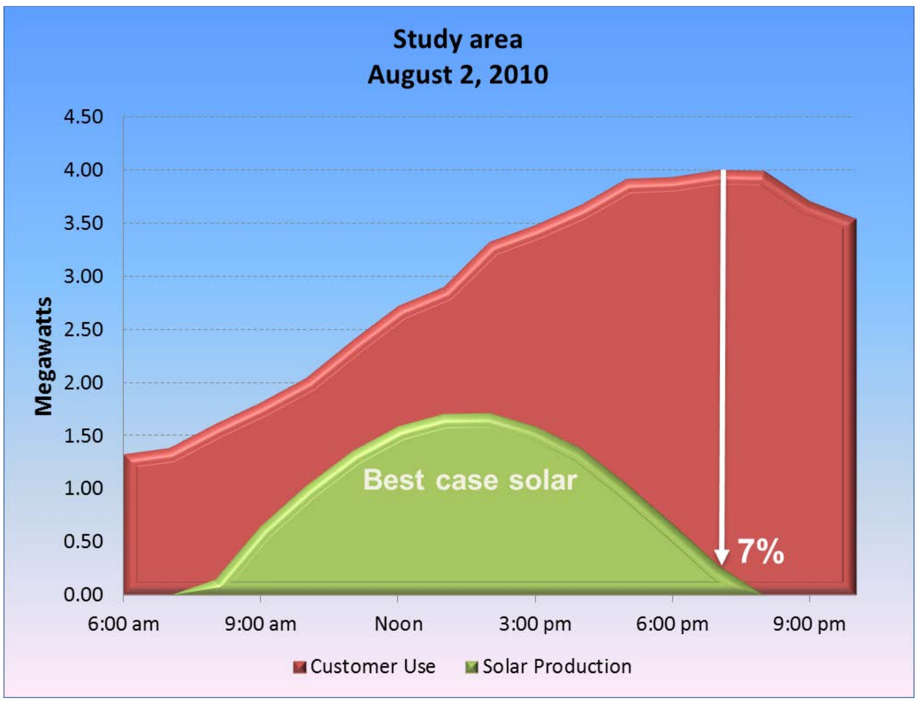
A. Yes. In 2011, the Company completed a study to evaluate the viability of rooftop solar and its ability to offset utility infrastructure upgrades, attached hereto as RMP Exhibit___(DLM-1R). We selected a single distribution circuit located near the University of Utah campus in Salt Lake City, Utah for the study. This area has a very modest annual load growth of two percent and was an ideal candidate as it has a diverse mixture of residential and commercial customers. The study is unique as it utilizes detailed data that takes into account the true viability of available roof space by accounting for the roof angle, shape and impeding items such as chimneys or dormers. The model also accounted for the impact on solar output caused by shading from nearby trees and other structures adjacent to the subject roof. Further, the model was developed for the various weather conditions throughout the year including clear sky conditions, partly cloudy skies and overcast days. The study evaluated each roof independently to determine the viability of that roof to accommodate solar photovoltaic ("PV") systems. The study placed high efficiency solar panels on every viable roof space and the total generation potential from all roofs was calculated.

Q. Why was this study initiated?

A. In 2010 the Company was in the process of seeking permits for a substation expansion project to address load growth in the area. The Company had shifted all loads that it could to adjacent substations with capacity, and in order to address the continual load growth the substation expansion was needed. During the permitting process for the Northeast Substation expansion the Salt Lake City council and local residents raised the issue of the potential to eliminate a substation expansion by use of distributed solar generation.

Q. Did this study align with the common belief that roof top solar concentrated in a given area could defer or eliminate distribution system capacity upgrades?

A. No. The study considered various critical factors such as roof aspects, shading characteristics, interference caused by rooftop objects such as chimneys, and accurately estimated the total number of solar PV panels that could be practically installed on each rooftop. The study found that on the day when the highest annual demand on the circuit under consideration was recorded, the best case solar generation only offset seven percent at the hour when the demand on the circuit was the highest. Thus, the utility had to provide 93 percent of the customer's demand. But more importantly, the peak demand continues for an hour even as the solar production continues to drop requiring more power from the utility. This is shown in the study area figure below.



The seven percent contribution of solar generation would be reduced if served by similar generation remote to the study area due to additional power delivery losses.

Q. Do you have other data that supports the detailed study given above?

A. Yes. In an effort to validate the model, we installed interval meters on several NEM customers to measure their total solar production, energy delivered to RMP and energy received by the customer from RMP. The data was collected for a calendar year that included the summer of 2012. This coincidental data validated the model in as much as the customer's generation peaked between 1:00 and 2:00 p.m. and the peak energy received from RMP occurred at 4:00 p.m. or later.

Additionally, Mr. Nathanael Miksis, on behalf of The Alliance for Solar Choice, cites a study completed by Crossborder Energy. Figure 1 of his testimony shows the typical energy production and consumption of a customer with solar PV production as derived by Crossborder Energy. The data from that study correlates nicely with the results of our study. The customers' peak energy requirements are between the hours of 5:00 p.m. and 7:00 p.m. extending well past the end of the solar generation. We need to design the distribution system for this peak time of energy consumption to ensure reliable electric service for these customers.

Q. Do NEM customers rely on RMP's electric grid?

A. Absolutely. NEM customers use the electric grid to store power at times when their generation units produce more energy than they need and then return that energy from the grid when their systems are not producing. From a customer's viewpoint, the electric grid is the cheapest form of energy storage available. Due to the high cost of energy storage devices such as batteries with corresponding charge controllers and special inverters, nearly all NEM customers refrain from installing energy storage systems. Even the grid-connected customers who do install energy storage systems tend to not use them regularly, preferring instead to use the grid for storage because it is less costly and will extend the life of their batteries. For instance, NEM customers rely on RMP's electric system during night times when the sun is not shining. Further, during daytime when there are rapid cloud transients, NEM customers rely on RMP's grid to help support their voltage and thus maintain a high level of reliability and power quality at their location.

The examples illustrated above clearly show that NEM customers heavily rely on the grid to meet their total energy needs in a reliable way.

Q. How could the solar generation peak be shifted to better align with the system load peak shown in the above figure?

A. In the absence of time-of-use rates, customers design their rooftop solar installations to maximize annual energy production. For optimal energy production from rooftop solar installations, the solar panels are installed on the south-facing roof. Ignoring this basic design criterion, there are three ways to align these peaks, each with tradeoffs. First, the modules on the rooftops could be turned or tilted to a more optimal angle to align with the system load peak in the late afternoon. To get the highest level of solar production coinciding with RMP's system peak, panels would need to be mounted on the south-facing roof and have an approximate 60-80 degree orientation towards the west. For rooftop solar installations, this would be a structurally impractical and cost prohibitive endeavor. Irrespective of the higher rooftop installation cost, if all the panels were oriented for output at 5:00 p.m., the total annual energy production would decrease about 40-50 percent compared with south-facing panels. Furthermore, the maximum output level would drop nearly 70 percent due to the lower number of panels caused by shading and the reduced angle of incidence from the sun.

Second, tracking systems could be added to the systems. This would allow the panels to follow the sun throughout the day, but is a more expensive installation requiring more space and usually requiring ground-mounted pedestals to hold the arrays. Third, energy storage systems could be added; this adds significant cost, and regular use would reduce the life of batteries, but also add resiliency to each home generation system in case of a power outage.

Q. What other experience does Rocky Mountain Power have with large penetrations of solar or other renewable resources?

A. In addition to the study referenced above, RMP monitors closely the activities in Pacific Power. Pacific Power operates in Oregon, California and Washington and is owned by the same parent company as RMP. Pacific Power has incurred the cost of replacing distribution system transformers to accommodate the increasing levels of NEM customers in its service territory. The primary reason for the need to replace transformers was the absence of a primary neutral connection on the existing transformers. A line to neutral transformer connection is needed on the transformer bank's primary and secondary sides to meet the "effectively grounded" requirement as stated in the IEEE standards for customer generation.

Pacific Power also found that two solar customer generation units in Oregon with installed capacities of 500 kilowatts ("kW") and 363 kW each were having issues with line protection devices. This led to rapid voltage fluctuation of 5.3 percent every 15 seconds. These two projects are interconnected to Pacific Power's 12.5 kilovolt distribution circuit serving a total of 1760 customers. The voltage fluctuations triggered by these solar projects propagated into Pacific Power's distribution system, causing operational issues to not only the distribution circuit they were connected to, but also the adjacent circuit. A total of 2515 customers were affected by this event, several of whom complained about voltage fluctuation and light flicker. On investigation, we determined that the customer generation reclosing device was operating incorrectly and was the root cause of the problem.

Further, a significant amount of time, effort and money was spent by the Company to identify and mitigate the problem. The existing rules do not allow RMP to recover costs associated with such procedures from the owner of the customer generation unit. Such instances are not widespread; however, when they do occur, the costs associated with investigating and mitigating the problem is borne by our customers.

As I have previously mentioned, RMP operates a complex electrical infrastructure in a safe, reliable and cost-effective manner, and it remains in the best interest of our customers for us to continue to do so.

Q. Do voltage fluctuations caused by these solar systems affect other customers? Why do industry voltage limits exist?

A. Customers’ electrical equipment can typically only operate reliably if the voltage is steady and within five percent of its normal level. These normal levels and their tolerances have been standardized for the United States in ANSI C84.1. RMP, along with nearly every other utility in America, implements this standard very rigorously. Voltage variations outside these limits may present operational problems or damage to customer and utility equipment. Also, for rapid voltage changes caused by the customer’s load/generation, RMP requires customers to maintain strict levels that are listed in the Company’s voltage fluctuation and light flicker standards.

Q. How does Rocky Mountain Power currently manage voltage regulation without NEM customers to meet ANSI voltage standards?

A. Usually RMP meets the ANSI C84.1 voltage standards by deploying voltage regulating equipment at substation transformers or distributed along the distribution system to keep voltage within the specified tolerances. This equipment works well for normal changes in load, such as when homes and businesses turn on appliances and equipment over the course of the day. Fast changes in large load or generation, such as sudden changes in customer generation, must be handled with other equipment if the voltage is to stay within range.

Q. Do you have any observations regarding the testimony filed by Mr. Dustin Mulvaney representing the Sierra Club?

A. Yes. Mr. Mulvaney summarizes his review of several studies discussing the beneficial attributes of distributed generation. It is important to note that distributed generation includes, but is not limited to, synchronous generators, reciprocating engines, micro turbines, combustion gas turbines, fuel cells and wind turbines as well as solar PV. Each of these technologies presents different characteristics to the local distribution system. Precisely defining the form of distributed generation being cited is necessary to avoid confusion when stating system benefits.

Our studies are based on rooftop solar PV, by far the most popular form of customer generation, and are based on data from actual customer load profiles and local atmospheric conditions and solar insolation levels. They are not based on simplified hypothetical examples. Mr. Mulvaney presents data from models developed by his team but does not offer any actual or measured data for solar installations in Utah, and he does not acknowledge that the peak demand occurs when the solar production is very low and declining fast. He states that “PV capacity value is directly tied [to] its capacity for peak shaving”. As our studies demonstrate, PV systems do not significantly shave the peak. He further states that "the Commission should assume that there is a benefit to the system from NEM installations". This is an erroneous assumption. I have demonstrated with a detailed case study as well as actual measured data that this is not the case.

Q. What are your thoughts regarding the impact of NEM on maintaining reliable and safe voltage levels on the distribution system?

A. Considering PV systems, and even wind systems, variability in customer generation output will cause voltage fluctuations that will trigger increased automated operations in line equipment (e.g., line voltage regulator) reducing life of the equipment, thus leading to larger maintenance costs to the Company. It has been found that voltage regulating devices can operate about 70 to 80 times on a cloudy day as compared to 12 to 19 operations during clear-sky days on systems with high levels of solar generation. It is a known fact that increased operations in any switching device leads to increased maintenance and will shorten its life expectancy.

Though I agree with Mr. Mulvaney that modern inverters can regulate voltage to ensure proper voltage is maintained on the system, the IEEE 1547 standard for interconnecting distributed resources with electric power systems, presently does not allow NEM installations to regulate voltage at the point of interconnection. Until the current standards are updated by IEEE and these devices become commercially available, RMP would not expect NEM customers to own inverters with advanced functionalities. Furthermore, Mr. Mulvaney states "End of line voltage will be increased resulting in lower energy consumption for end users' equipment as well." This is simply not true. It violates Ohms law and is contrary to the findings from studies of conservation voltage reduction.

In addition, Figure 1 in Mr. Miksis' testimony demonstrates a condition that can create a transient overvoltage condition. When the distributed generation exceeds the load on the circuit and events occur that require RMP's protective equipment to isolate that circuit, the delay in the inverters to disconnect from the system will create an overvoltage condition. This condition could have damaging effects on customer's equipment throughout the circuit if not properly mitigated, especially electronic-based devices. Due to these factors, RMP continues to maintain its concern regarding voltage fluctuation issues caused by a high penetration of NEM customers.

Q. What value do energy storage devices play in the role of NEM customers?

A. As Mr. Mulvaney describes in his testimony, proper planning can overcome some of the technical challenges triggered by high penetration of NEM on a utility's network. As I have previously mentioned, RMP remains concerned about voltage fluctuation issues on its distribution system. However, we also believe that energy storage could play a significant role in solving some of these issues.

Various techniques can be employed to reduce the impacts of sudden voltage fluctuations caused by clouds passing over the PV panels of the NEM customer. One technique is to install smart inverters that enable voltage control and help maintain a constant voltage irrespective of the rapid movement of cloud cover. Another technique is to install energy storage devices at the customer site (batteries or similar) to help bridge the gap in power flow caused by moving clouds. The current costs of energy storage devices are very high and have thus led most customers to not use this technology. This is the fastest moving area of research and development in the electric utility industry and RMP is following developments in energy storage very closely.

Q. What are the relative impacts of customer generation as compared to energy efficiency upgrades?

A. Energy requirements are predicated by the load characteristics at the customer's premise, and the end-use device will use the exact same energy regardless of the energy source. Solar generation does not reduce the customer’s energy requirements, it only shifts and divides the source of energy between the distribution system and the solar system. When the solar system is not available, the total energy requirements must be met by the distribution system. In contrast, energy efficiency reduces the actual energy requirements for the end-use device. For instance, a 100 watt incandescent lamp produces about 1400 lumens. A fluorescent lamp producing the same lumen output consumes only 22 watts. This reduction in energy requirement will be seen for the entire life of the lamp, Energy efficiency contributes to a reduction in the customer's peak demand whereas customer generation does not.

Q. Please summarize your testimony.

A. RMP believes that customers should have the ability to install their own generation mix and to be subject to the benefits and costs resulting from their choices. However, with its continuing mandate to serve its customers safely and reliably at the lowest reasonable cost, the Commission must consider the evidence offered by

RMP about some of the impacts of customer solar generation that are not often seen by the public and not discussed by solar advocates. These impacts are (1) little, if any, change in a customer's need for the RMP distribution system to supply energy; (2) customer solar generation does not reduce the distribution system's peak load; (3) continued capital investments in distribution infrastructure are required as load levels increase, even with significant penetration of customer generation; (4) increased labor to implement new standards and carefully study the distribution system to assure that customer generation can be accommodated; (5) increased capital cost for adjustments indicated by such study, where needed; (6) unintended additional operations and maintenance costs from an increased number of interconnections to RMP's system; and (7) increased wear and tear on equipment caused by the intermittent nature of customer generation.

These impacts are real and must be addressed, but they are not insurmountable. The application of proper engineering techniques for a known disruptive technology will enable RMP, working with regulators and customers, to maintain a safe and reliable electrical system while transitioning from a traditional grid to a grid integrated with more customer generation.

Q. Does this conclude your rebuttal testimony?

A. Yes.