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August 10, 2018

VIA HAND DELIVERY

Diane Hanian, Secretary
Idaho Public Utilities Commission
472 West Washington Street
Boise, Idaho 83702

Re: Case No. IPC-E-17-13
New Schedules for Residential and Small General Service Customers with On-Site Generation – Idaho Power Company's Opening Brief on Reconsideration

Dear Ms. Hanian:

Enclosed for filing in the above matter please find an original and seven (7) copies of Idaho Power Company's Opening Brief on Reconsideration.

If you have any questions about the enclosed documents, please do not hesitate to contact me.

Very truly yours,

Lisa D. Nordstrom

Lisa D. Nordstrom

LDN:kkt
Enclosures

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Attorney for Idaho Power Company

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BEFORE THE IDAHO PUBLIC UTILITIES COMMISSION

IN THE MATTER OF IDAHO POWER COMPANY'S APPLICATION FOR AUTHORITY TO ESTABLISH NEW SCHEDULES FOR RESIDENTIAL AND SMALL GENERAL SERVICE CUSTOMERS WITH ON-SITE GENERATION	)))))))	CASE NO. IPC-E-17-13 IDAHO POWER COMPANY'S OPENING BRIEF ON RECONSIDERATION

Idaho Public Utilities Commission ("Commission") Order No. 34098 asked the parties in this matter for "briefing related to whether a customer's ability to export energy should determine if the customer should be included in new Schedules 6 and 8."[1] The ability to export has several significant flaws as a criterion for exclusion from Schedules 6 and 8.

First, all self-generators, regardless of what other technology may be coupled with the generation, are partial requirements customers. The load service requirements and pattern of use for these partial requirements customers are much different than those of

[1] Order No. 34098 at 2. The Commission approved the creation of Schedule 6, Residential Service On-Site Generation, and Schedule 8, Small General Service On-Site Generation ("Schedules 6 and 8"), in Order No. 34046 issued on May 9, 2018.

standard customers -- even if the partial requirements customer limits their ability to export energy. The load service requirements of those customers are consistent with those of other exporting self-generating customers in Schedules 6 and 8.

Carving out a subset of partial requirements customers, as Vote Solar suggests, would simply provide that subset with an opportunity to continue the cost shifting between customers with on-site generation and those without. In Order No. 34046, the Commission cited "evidence of cost shifting, or subsidization, and load and usage characteristics" as to what informed its decision and went on to describe that "the history of the Company's on-site generation program reveals an unfairness in how current and future on-site generation customers avoid fixed costs. The ability these customers have to 'net out' or net to zero their electricity use causes them to underpay their share of the Company's fixed costs . . . ."[2] A customer with on-site generation operating in parallel who limits exports has the same ability to offset consumption which, under a largely volumetric-based rate design, creates an opportunity for that customer to avoid paying the full fixed cost to serve them.

Second, the parallel connection of an on-site generation system is the appropriate criteria to determine inclusion in the new customer classes. Self-generation systems connected in parallel to the grid, even those with battery storage or export limiting devices, use grid services to operate. An export limiting device only limits energy *sent* to the utility; these devices do not limit the customer's ability to *receive* energy or other grid services. Consequently, self-generating customers who operate in parallel but limit the export of

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[2] Order No. 34046 at 16-17.

energy to the utility take the same services as other self-generators in Schedules 6 and 8 who do export.

Lastly, even if the Commission were to explore options for creating a subset of customers with on-site generation without energy export in the standard rate classes, there are several operational and safety considerations that would make enforceability of that impractical and unadvisable, particularly given the limitations of Idaho Power's net hourly consumption meters.

For these reasons, which are described in greater detail in the pages that follow, the Commission should reject Vote Solar's request to require the Company to revise new Schedules 6 and 8 to apply only to customers who export electricity.

I.

LOAD SERVICE REQUIREMENTS AND PATTERN OF USE BY PARTIAL REQUIREMENTS CUSTOMERS ARE DIFFERENT THAN STANDARD SERVICE CUSTOMERS, REGARDLESS OF WHAT OTHER TECHNOLOGIES ARE PRESENT

In its case-in-chief, Idaho Power provided evidence to demonstrate the difference between the load service requirements and the pattern of use[3] of customers with on-site generation as compared to residential customers who take standard service from Idaho Power. The evidence[4] included comparisons of load factor, load profile, system-coincident demand ("SCD"), and non-coincident demand ("NCD"); the bi-directional flow of energy was only one component of the usage characteristics of a customer with on-site generation. Likewise, customers with on-site generation who either prevent the

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[3] *Idaho State Homebuilders v. Washington Water Power*, 107 Idaho 415, 690 P.2d 350 (1984). Differences in rates charged to classes of customers are not per se unreasonable or unlawful under *Idaho Code* § 61-315. The Idaho Supreme Court interpreted this statute in the *Homebuilders* decision and explained that the setting of different rates may be justified by factors such as cost-of-service, quantity of electricity used, differences and conditions of service, or the time, nature, and pattern of use.

[4] Tr. at 598-618.

export of excess energy via an export limiting device, or who use battery storage to eliminate the export to the grid, continue to have different load service requirements than standard service customers.

To study the effects of preventing the export of excess energy, the Company produced a Limited Export Simulation to simulate a residential customer before and after the installation of on-site generation without the capability to export excess energy.[5] A simulation was necessary because the Company is not aware of any residential or small general service customers with parallel-connected on-site generation system that uses an export limiting device to prevent the export of excess energy to the grid. The methodology used by the Company to create the Limited Export Simulation is described in Attachment 1.

The Limited Export Simulation demonstrates how the load service requirements and usage characteristics differ for a customer before and after the installation of on-site generation without the capability to export excess energy. Importantly, even in the absence of energy exports, the customer with on-site generation still has the ability to offset their usage on an hourly basis; this reduction in energy consumption, coupled with a rate design that collects fixed costs through a volumetric rate, creates the opportunity for shifting costs from customers with on-site generation to standard service customers.

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[5] For the simulation, the Company used the hourly load data for 272 sample customers in the Boise metro area from the 2016 load research sample as the reference load profiles. An additional data set was created from this data set by offsetting the load with an annual production profile of a photovoltaic ("PV") system appropriately sized for each customer. All hourly energy exports were replaced with zero. The 2016 load research data used for the Limited Export Simulation was previously provided to all parties in response to Vote Solar's Data Request No. 27.

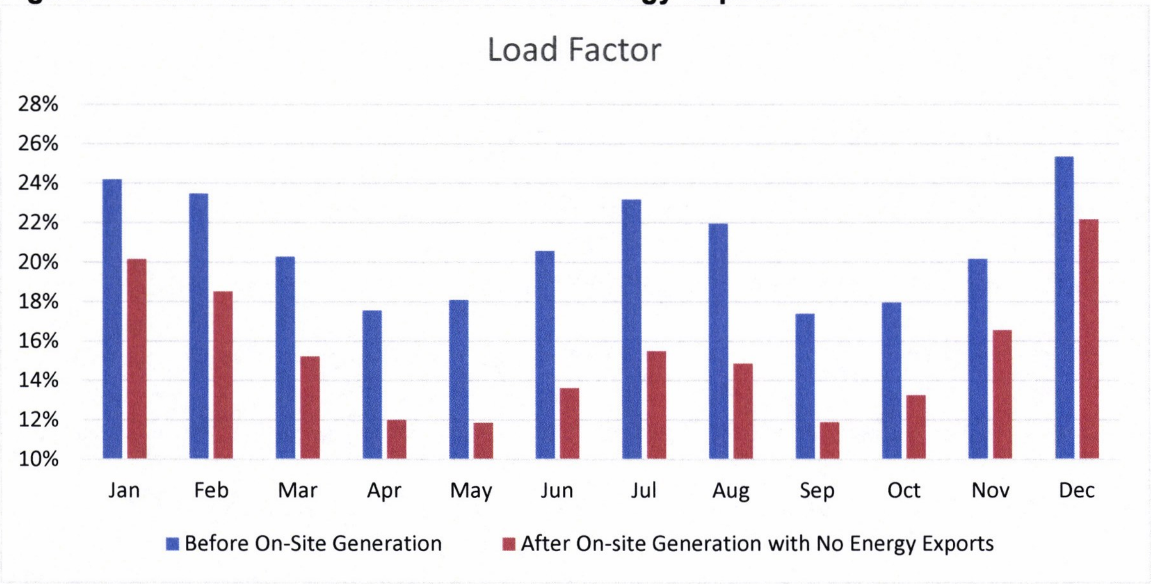
A. Load Service Requirements

Load factor analysis is an important measure to compare the load service requirements of one segment of customers to another. The load factor is the average load divided by the maximum load for a specified time period.[6] It is a computation that captures the degree of demand variation; a load factor approaching one hundred percent represents less variation in the demand pattern, and a load factor near zero portrays more demand variation. Over the period of measurement, a low load factor identifies a customer with infrequent maximum demand and the capacity required to serve that peak demand is idle for long periods. Under a rate design that collects most fixed costs for system capacity through volumetric kilowatt-hour charges, customers with a lower load factor are subsidized by customers with higher load factors.

Using the Limited Export Simulation, the Company calculated the load factor for each sample customer before and after the installation of on-site generation without the capability to export excess energy. The average of the monthly load factors of the sample customers before and after the installation of on-site generation without the capability to export excess energy are shown in Figure 1.

[6] Tr. at 601, ll. 1-15.

Figure 1. Load Factor -- Simulated for No Energy Exports



The Company's load factor analysis of each sample customer before and after the installation of on-site generation without the capability to export excess energy demonstrates that load factor is notably lower in all 12 months after the installation of on-site generation -- even without the capability to export excess energy. For the months of April through September, the load factor is reduced by roughly 33 percent after the installation of on-site generation without the capability to export excess energy.

B. Pattern of Use

1. Load Profile – Simulated for No Energy Exports

The load profile portrays the pattern of demand through a particular period of time. Using the Limited Export Simulation, the Company developed the load profile for each sample customer before and after the installation of on-site generation without the capability to export excess energy. The average load profile of the sample customers for a winter month, a spring month, and a summer month are shown in Figures 2, 3, and 4, respectively. For the three graphs, each hour data point is the average for that hour throughout the month.

Figure 2. January 2016 Simulated Load Profiles

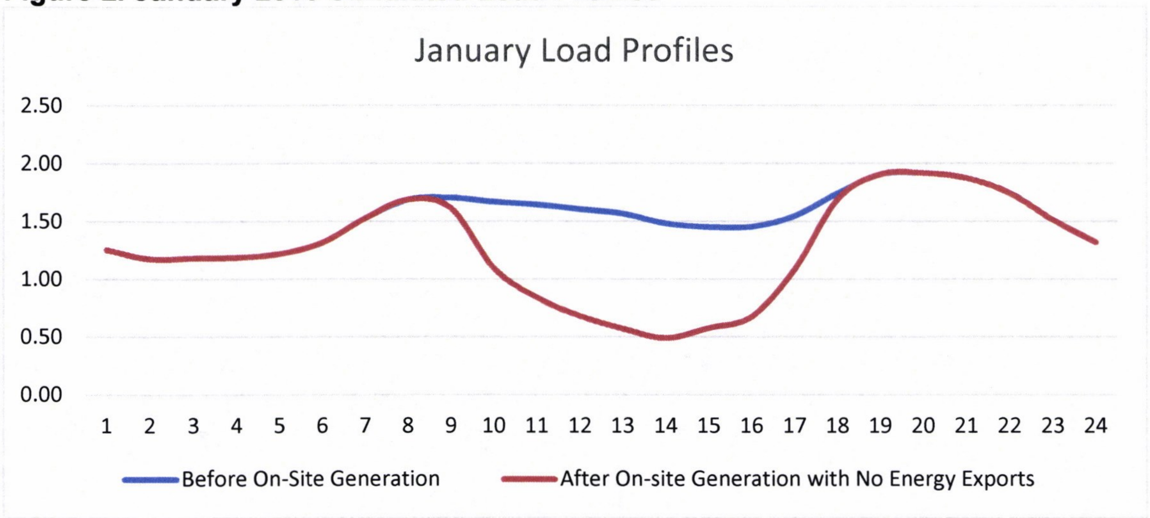


Figure 3. April 2016 Simulated Load Profiles

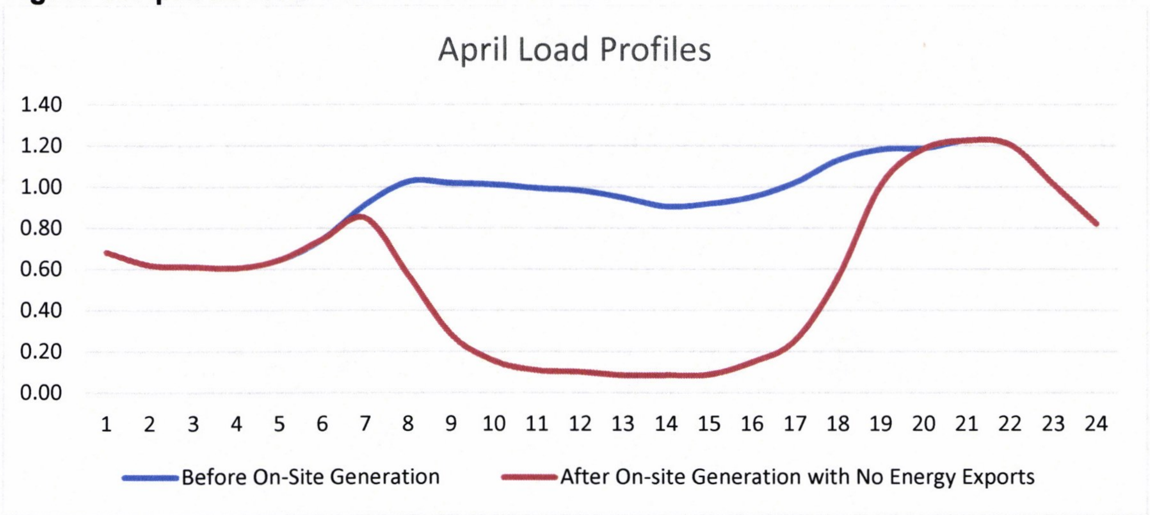
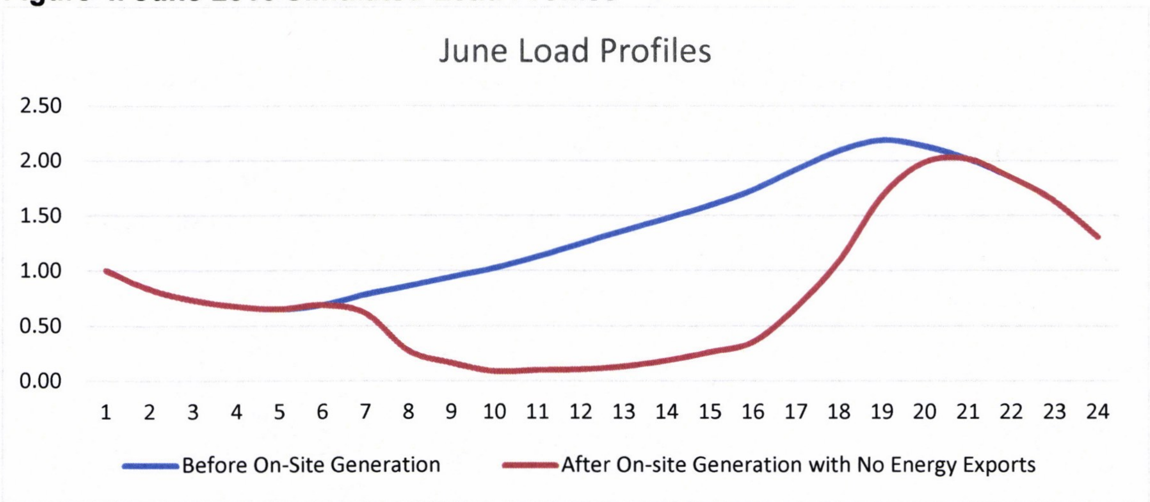


Figure 4. June 2016 Simulated Load Profiles



The Company's load profile analysis of each sample customer before and after the installation of on-site generation without the capability to export excess energy demonstrates that the load profile changes significantly after the installation of on-site generation -- even without the ability to export excess energy. The on-site generation causes a downward ramp after the sun rises and generation from the utility is replaced by the on-site generation for several hours. Then, as the sun sets and solar generation ends, a significant upward ramp occurs. This is vastly different than the load curve before the installation of on-site generation, where the transition from hour-to-hour is smoother with significantly lower rate of change in usage during the morning and evening hours.

The results of the load profile analysis illustrate the additional requirements of the Company to meet the ramping needs of these customers, when the Company must reliably forecast load and efficiently dispatch the generation fleet to maintain the balance between production and forecasted use.[7]

The Limited Export Simulation's load profile analysis also illustrates that, while customers with on-site generation who limit their export energy consume less volumetric energy from the utility, the maximum demand over the course of a day is not necessarily reduced. This load service characteristic is consistent with customers who export energy.[8] Consequently, it is appropriate to include customers with on-site generation who limit their exports in Schedules 6 and 8 which will provide the Company an opportunity to apply a rate design that will not shift the collection of costs through the standard service's current volumetric rate design.

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[7] Tr. at 568, ll. 14-25.

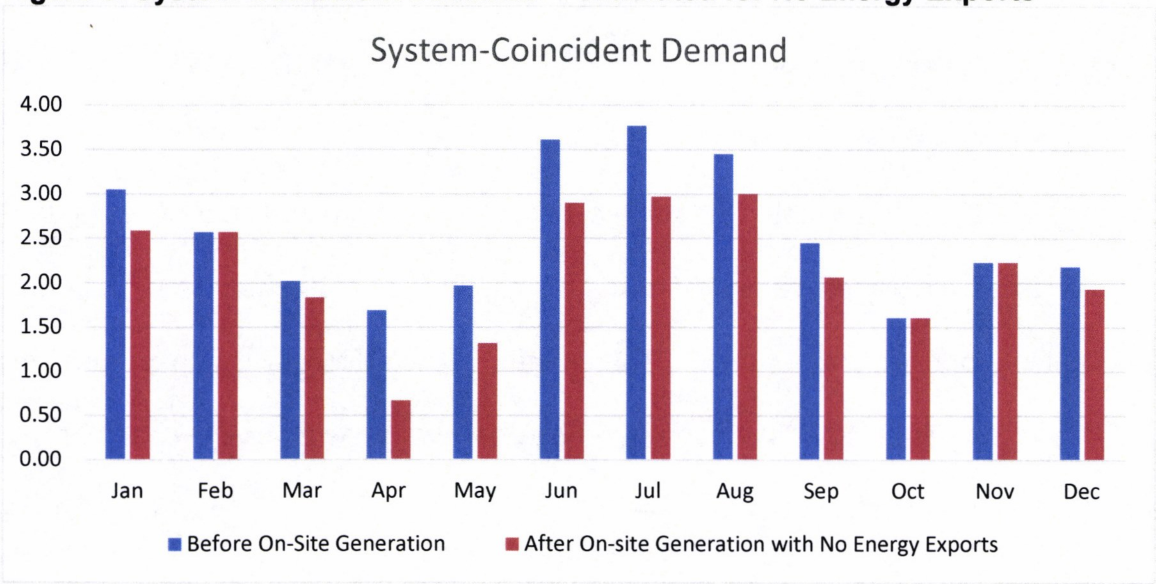
[8] Tr. at 614, ll. 5-7.

2. <u>System-Coincident Demand – Simulated for No Energy Exports</u>

The SCD is the average demand for a segment of customers at the time of Idaho Power's system peak.[9] The analysis of SCD is important for cost allocation purposes because: (1) production plant costs associated with serving base and intermediate load are allocated using an average of the 12 monthly SCDs, (2) production plant costs associated with serving peak load are allocated using an average of the three monthly SCDs occurring in June, July, and August, and (3) transmission costs are allocated using an average of the 12 monthly SCDs.

Using the Limited Export Simulation, the Company calculated the SCD for the group of sample customers before and after the installation of on-site generation without the capability to export excess energy. The monthly SCDs for the group of sample customers before and after the installation of on-site generation without the capability to export excess energy are shown in Figure 5.

Figure 5. System-Coincident Demands -- Simulated for No Energy Exports



[9] Tr. at 715, ll. 3-5.

The Company's SCD analysis of the group of sample customers before and after the installation of on-site generation without the capability to export excess energy demonstrates that the SCD is lower in nine out of 12 months after the installation of on-site generation -- even without the capability to export excess energy.

The results of this analysis suggest that the allocation of production plant costs associated with serving peak load would decrease after the installation of on-site generation without the capability to export excess energy because these costs are allocated using an average of the three monthly SCDs occurring in June, July, and August. Consequently, the resulting different allocation of costs supports the argument that it is appropriate for all customers who install on-site generation -- even without the capability to export excess energy -- to be included in Schedules 6 and 8.

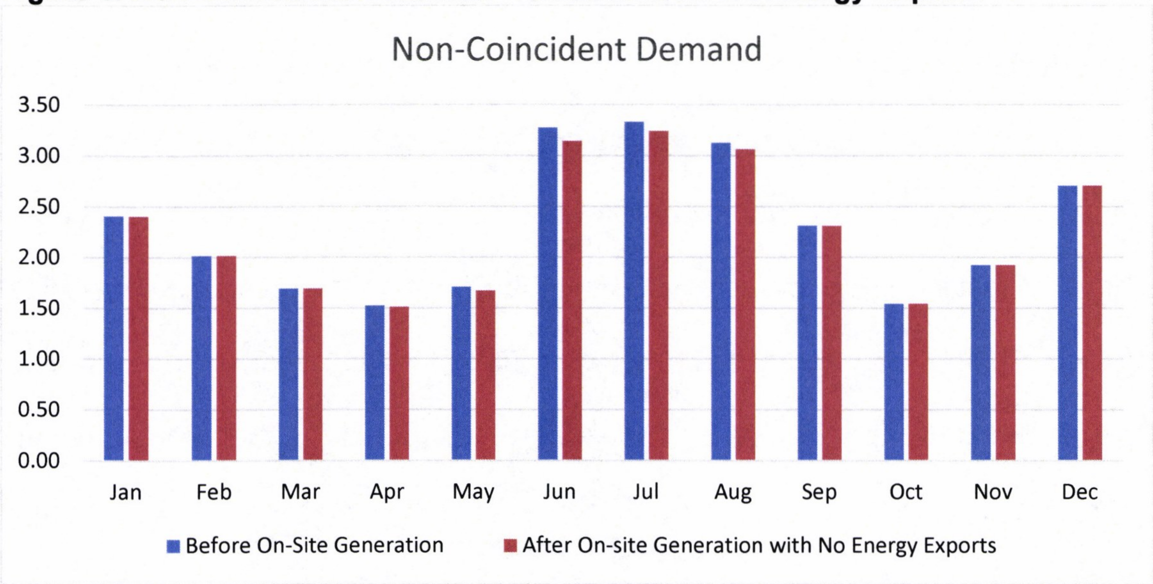
3. Non-Coincident Demand – Simulated for No Energy Exports

The NCD is the maximum average demand for a segment of customers in any given hour, regardless of when it happens.[10] Similar to SCD, the analysis of NCD is important for cost allocation purposes because NCDs are used to allocate Idaho Power's distribution system costs.

Using the Limited Export Simulation, the Company calculated the NCD for the group of sample customers before and after the installation of on-site generation without the capability to export excess energy. The monthly NCDs for the group of sample customers before and after the installation of on-site generation without the capability to export excess energy are shown in Figure 6.

[10] Tr. at 614, ll. 7-9.

Figure 6. Non-Coincident Demands -- Simulated for No Energy Exports



The Company's NCD analysis of the group of sample customers before and after the installation of on-site generation without the capability to export excess energy demonstrates that the installation of on-site generation has very little impact on the NCD; that is, a customer's monthly peak is not necessarily reduced by the installation of on-site generation -- even without the capability to export excess energy. The customers load over the course of the month will continue to place the same level of peak demand on the system.

This is an important observation because NCDs are used to allocate distribution costs. While customers who install on-site generation without the capability to export excess energy contribute to distribution costs in a similar manner, the collection of these costs through the volumetric charge for standard service customers will result in cost shifting if customers with on-site generation were to remain in the standard service schedules. To mitigate this impact, all customers with on-site generation -- even those who have no ability to export energy -- should be included in new Schedules 6 and 8 to appropriately assign and collect costs and address cost shifting.

C. Validation of the Limited Export Simulation Using Actual Customer Data

To verify and validate the results of the Company's Limited Export Simulation, the Company performed a supplementary analysis on the effects of preventing the export of excess energy. For the supplementary analysis, the Company obtained actual data from a segment of 18 residential solar customers in Idaho Power's Oregon service area who participate in a Solar Photovoltaic Pilot Program ("Pilot").[11] The metering requirements for the Pilot require the Company to record separately the amount of generation produced by the solar PV system, the amount of energy consumed from the utility, and the amount of excess energy exported to the grid. Because the amount of excess energy exported to the grid was recorded separately, the Company was able to set the energy exports to zero. The same analyses were performed on the load service requirements and pattern of use to determine if the results differ for a residential customer who installs on-site generation and then prevents the export of excess energy.

The results of the supplementary analyses were consistent with the results of the Limited Export Simulation, validating the results of the Company's Limited Export Simulation. The Company's resulting analysis, "Pilot Customer Load Shapes With No Energy Exports," can be found in Attachment 2.

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[11] On July 22, 2009, Oregon House Bill ("HB") 3039 was signed into law. This legislation required the Public Utility Commission of Oregon to establish a pilot program for each investor-owned electric company to demonstrate the use and effectiveness of volumetric incentive rate payments for electricity delivered from solar PV energy systems. The pilots were intended to apply to solar PV energy systems permanently installed in the state of Oregon by retail electricity consumers and first became operational on or after July 1, 2010. HB 2893, enacted in 2013, revised the cumulative nameplate capacity from 25 megawatts ("MW") to 27.5 MW. Each electric utility was assigned a share of the capacity goal based upon their individual retail sales; Idaho Power's share of the pilot program's capacity is 0.450 MW.

D. Cost Shifting and Subsidization

In its case-in-chief, the Company argued that the outdated volumetric rate structure intended for residential and small general service ("R&SGS") customers who take standard full-requirements service from Idaho Power, does not provide a reasonable opportunity for the utility to recover grid-related fixed costs of serving R&SGS customers with on-site generation.[12] Customers who install on-site generation do so with the intent to offset their own usage and reduce or eliminate the volume of energy they consume from Idaho Power. These customers, or "prosumers,"[13] both produce their own energy and consume energy from the utility. The Company's consumption-based rates were intended for customers who take fully-bundled service from the utility and are designed to collect generation, transmission, distribution and customer-related costs primarily through a volumetric rate. That is, the services used by these customers are not priced individually. Because the R&SGS customer classes both have a two-part rate design with most of the customer-related fixed costs and all the demand-related fixed costs being recovered through a volumetric charge, the current rate design has the potential to create a cost shift between self-generators and those that do not self-generate, as well as under collect fixed costs. Vote Solar's recommendation to exclude non-exporting customers would only perpetuate the cost shift by sustaining a financial carve out for self-generating customers.

From a policy standpoint, regardless of energy exports, the load service requirements and the usage characteristics of any R&SGS customer who installs on-site

[12] Aschenbrenner REB at 18, ll. 1-9.

[13] Tr. at 780 and 1068-1088.

generation justify a separate and unique rate structure. The usage characteristics of customers with on-site generation are not based on volumes of energy but rather on capacity. Customer classes are determined by grouping customers with similar usage patterns because customers with similar usage characteristics impose similar costs on the utility. When customers impose similar costs on the utility, rates can be designed for that segment of customer to recover the costs of providing utility service.

As demonstrated in the Company's case-in-chief,[14] R&SGS customers who install on-site generation are different than R&SGS standard service customers -- this is true regardless if the on-site generation system is coupled with battery storage or an export limiting device to prevent the export of excess energy. Nevertheless, the Commission ordered[15] the Company to provide additional information about the effects of battery storage and export limiting devices for its consideration in this matter.

1. Battery Storage

The addition of battery storage to a customer's parallel-connected on-site generation system will further reduce the volume of energy they consume from the utility and cause an even greater under collection of fixed costs. This under collection of fixed costs will perpetuate the cost shifting between customers with on-site generation and those without that the Commission seeks to avoid.[16]

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[14] Tr. at 598, l. 6 – Tr. at 618, l. 2.

[15] Order No. 34098 at 3.

[16] Order No. 34046 at 16-17. "The ability these customers have to 'net out' or net to zero their electricity use causes them to underpay their share of the Company's fixed costs to serve customers, and this inequity will only increase as more customers choose on-site generation."

To study the effects of battery storage as a means to eliminate the export of excess energy, the Brattle Group performed a simulation of the net load shapes of such customers.[17] A simulation was used because Idaho Power is not aware of any residential customers with an on-site generation system connected in parallel with the addition of a battery storage system to eliminate the export of excess energy. The Brattle Group's resulting analysis, "The Effect of Storage on Customer Load Shapes when Coupled with Distributed Generation," can be found in Attachment 3.

The analysis performed by the Brattle Group finds that coupling battery storage with on-site generation to eliminate the export of excess energy results in similar reliance on the utility infrastructure to that of a customer with on-site generation that does export excess energy to the grid.[18] The key takeaways[19] from the Brattle Group's analysis of customers that combine distributed generation and battery storage are:

- the installation of battery storage moderately flattens the average daily load shape;
- the customer's maximum demand remains high relative to the customers' total usage;
- the median load factor is still 50 percent lower than that of the standard service residential customer class; and

[17] The Brattle Group used the same net metering customer data that was previously provided to all parties in response to Vote Solar's Data Request No. 90 to simulate the net load shape of a customer that combines distributed generation and battery storage.

[18] Brattle Group, *The Effect of Storage on Customer Load Shapes when Coupled with Distributed Generation* at 1 (August 8, 2018).

[19] *Id.* at 9.

- customers who combine distributed generation and battery storage and continue to take service under the current rate structure for standard service customers will pay less than their share of the cost of using the grid.
- Without an alternative rate design, customers who combine distributed generation and battery storage would not have a financial incentive to operate their battery in a way that would significantly reduce their reliance on the power grid.

Regardless of whether a customer with on-site generation stores their excess energy in a battery, because they generate some or all of their own energy, they continue to be a partial requirements customer who offsets the volume of energy they consume from the utility. It is appropriate to include all customers with parallel-connected on-site generation in the newly established Schedules 6 and 8 customer classes, for which a rate structure can be developed that will provide customers flexibility in meeting some of their own energy needs while allowing the utility a reasonable opportunity to appropriately assign and collect costs without cost shifting to standard service customers.

2. Export Limiting Devices

Available technology, in the form of an export limiting device, can be used to prevent the intentional export of energy to the grid.[20] Such devices include dynamically controlled inverters and reverse power relays. A dynamically controlled inverter continually monitors the customer load and adjusts the on-site generation production

[20] While Idaho Power is not aware of any existing residential or small general service customers with an export limiting device to prevent exporting energy to the grid, other utilities serve such customers. For instance, Hawaiian Electric's Customer Self-Supply (CSS) program enables customers to only install private rooftop solar systems that do not export power to the utility grid. All power produced by the customer either must be used as it is produced or stored in energy storage devices for later use. Credits are not available for CSS systems and minimum billing requirements apply.

down if the load drops below a specific threshold. A reverse power relay is installed at the meter location and will disconnect the generation system if power flows toward the utility.

Even if customers with on-site generation prevent the export of excess energy with an export limiting device, they continue to be partial requirements customers who offset the volume of energy they consume from the utility by generating some or all of their own energy. In order to develop a rate structure that will provide customers flexibility in meeting their own energy needs, yet allow the utility a reasonable opportunity to appropriately assign and collect costs without cost shifting to standard service customers, all customers with parallel-connected on-site generation should be included in the newly established Schedules 6 and 8 customer classes.

II.

PARALLEL CONNECTION IS THE APPROPRIATE CRITERIA FOR INCLUSION IN SCHEDULES 6 AND 8

Establishing the parallel connection as the criteria for a different service offering is not a new concept. Since 1983, when the Company began offering net metering service under Schedule 86, Cogeneration and Small Power Production Non-Firm Energy,[21] the Company has required customers with parallel-connected on-site generation systems to take service under a different tariff schedule in addition to the standard service tariff schedule. Prior to the establishment of Schedules 6 and 8 on June 1, 2018, all customers with an on-site generation system connected in parallel with Idaho Power's system were

[21] *In the Matter of the Application of Idaho Power Company for Approval of Revised Rates to Be Paid for Power and Energy Sold to Idaho Power Pursuant to Section 210 of the Public Utility Regulatory Policies Act of 1978*, Case No. U-1006-200, Order No. 18358.

required to take service under Schedule 84, Customer Energy Production Net Metering Service.[22]

A. Parallel Connection

"Parallel connection" means the customer's on-site generation system is connected to, and operating in conjunction with, the utility's electric grid. A generation system that is connected in parallel to the utility's electric grid is commonly referred to as a "grid-tied" system or an "on-grid" system. A customer with an on-grid system uses electricity from their on-site generation system, as well as from the utility's electric grid. The customer can draw energy from the grid at times when their system is not generating enough to meet their energy demand or when their system is not generating energy at all due to maintenance or a lack of resource.

A parallel-connected on-site generation system is connected to the utility's electric grid through a grid-tie inverter. In the case of a PV generation system, the grid-tie inverter converts the direct current electricity generated by the PV solar panels into alternating current electricity required by customer electrical appliances.

In order for the on-site generation system to operate in parallel with the electric grid, the on-site generation system must synchronize with the grid. To synchronize the two systems, the alternating current waveforms of the on-site generator and grid must match in time, voltage magnitude, and frequency. Connecting an on-site generator

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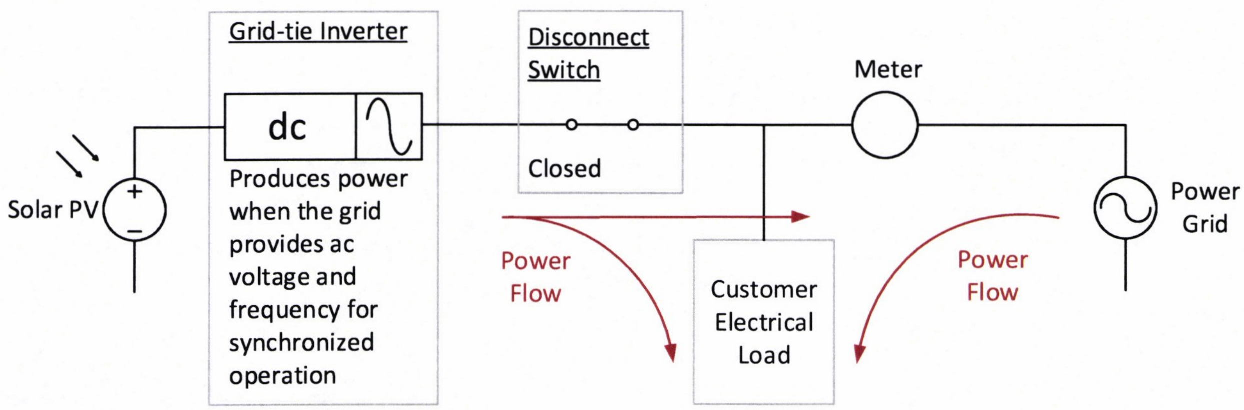
[22] *In the Matter of the Application of Idaho Power Company for Approval of a New Schedule 84 -- Net Metering*, Case No. IPC-E-01-39, Order No. 28951.

without matching these parameters may result in significant on-site generator mechanical damage as the power grid suddenly enforces alignment.[23]

The grid-tie inverter relies on the grid voltage and frequency to produce power that is synchronized with the grid. As a result, the parallel-connected system cannot operate without the grid, and therefore, when the utility experiences an outage, the parallel-connected system will also experience an outage.

Per Idaho Power's Schedule 72, Interconnections to Non-Utility Generation ("Schedule 72"), a generation disconnect switch is required to provide isolation of the on-site generation from the customer's load service.[24] Figure 7 illustrates an on-site solar PV connected in parallel to the utility's electric grid.

Figure 7. On-Grid Installation Connected in Parallel: The inverter delivers energy when synchronized and the solar panels are producing direct current power

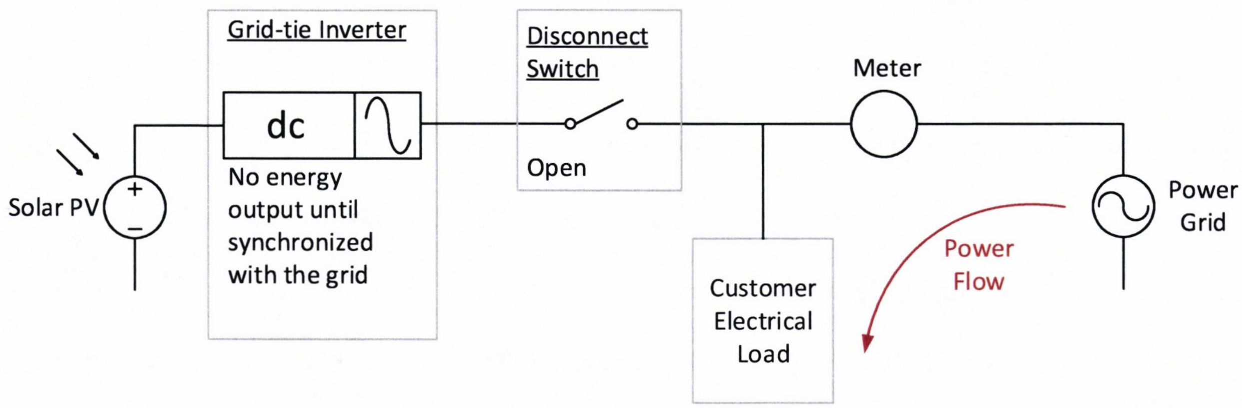


[23] The 2007 Idaho National Lab's Aurora Generator Test demonstrated how a cyberattack could destroy physical components of the electric system. When a computer program opened and closed a generator's circuit breakers out of phase from the rest of the grid, the torque from the forced system synchronization caused the generator to explode apart. www.cnn.com/2007/US/09/26/power.at.risk or https://en.wikipedia.org/wiki/Aurora_Generator_Test

[24] "Disconnection Equipment is required for all Seller Generation Facilities. The Disconnection Equipment shall be installed at an electrical location to allow complete isolation of Seller's Generation and Interconnection Facilities from the Company's system. Disconnection Equipment for Net Metering Systems or Small On-Site Generation Systems will be installed at an electrical location on the Seller's side of the Company's retail metering point to allow complete isolation of the Seller's Generation and Interconnection Facilities from the Seller's other electrical load and service." Schedule 72, Sheet No. 72-5.

The grid-tie inverter is not able to supply power independent from the power grid, thus, the disconnect switch location isolating the solar PV system from the grid and customer load allows the customer to service the PV solar system without adversely impacting the customer load service, as shown in Figure 8.

Figure 8. On-Grid Installation: No energy is produced until the inverter is synchronized with the power grid



1. Essential Grid Services

The grid provides many benefits to the customers who choose to connect their on-site generation in parallel to the utility's electric grid. These services include reliability, voltage reference and voltage control, frequency reference and frequency control, motor starting current, and reactive power support.[25]

All customers currently taking services under Schedules 6 and 8 are connected in parallel to Idaho Power's electric grid. It is that parallel connection that allows these customers to enjoy the essential services offered by the grid. While benefiting from the essential grid services listed above, these customers can both consume energy generated from their own on-site generation system and consume energy from the utility when their system is not generating sufficient energy to meet their energy demands.

[25] Tr. at 566, l. 6 – Tr. at 574, l. 8; Tr. at 60, ll. 3-11.

2. Backup and Standby Service

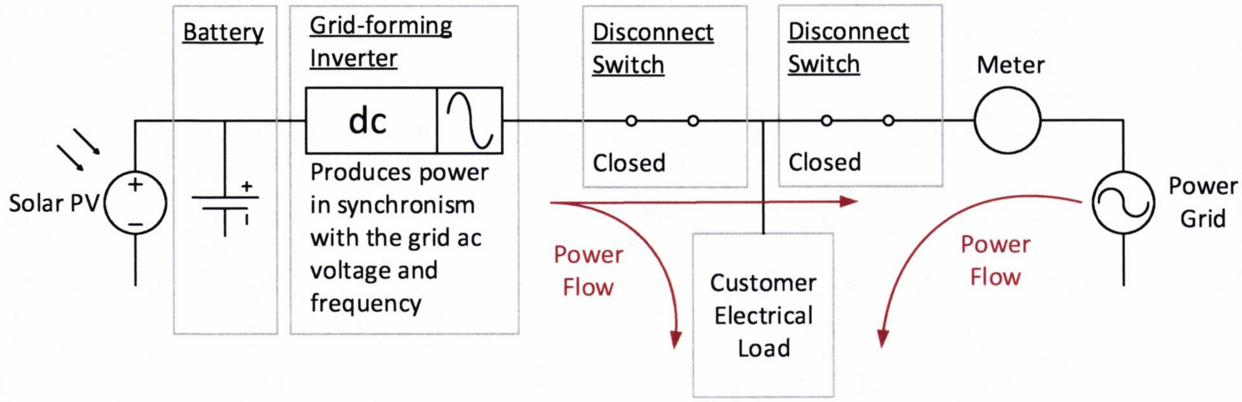
The grid also acts as backup generation for customer systems in the event their system fails. The grid also stands ready to provide standby service when the customer's system is not large enough to meet the customer's demand or when, in the case of a PV system, the sun is not shining. The electric power grid is in many ways like a battery to customers with on-site generation, but at a much lower cost to the customer than installing and maintaining their own battery.

B. Parallel Connection with Backup Capability

As discussed in Mr. David Angell's testimony, there are "off-grid" inverters which produce alternating current voltage and frequency for operation independent of the grid.[26] Additionally, "grid-forming" inverters exist that may operate in parallel with the grid and yet have the ability to regulate alternating current voltage and frequency and supply power independent of the grid. Grid-forming inverters are often used in conjunction with batteries and on-site generation. When operating in parallel with the grid, these grid-forming inverters synchronize to the grid alternating current voltage and frequency as shown in Figure 9.

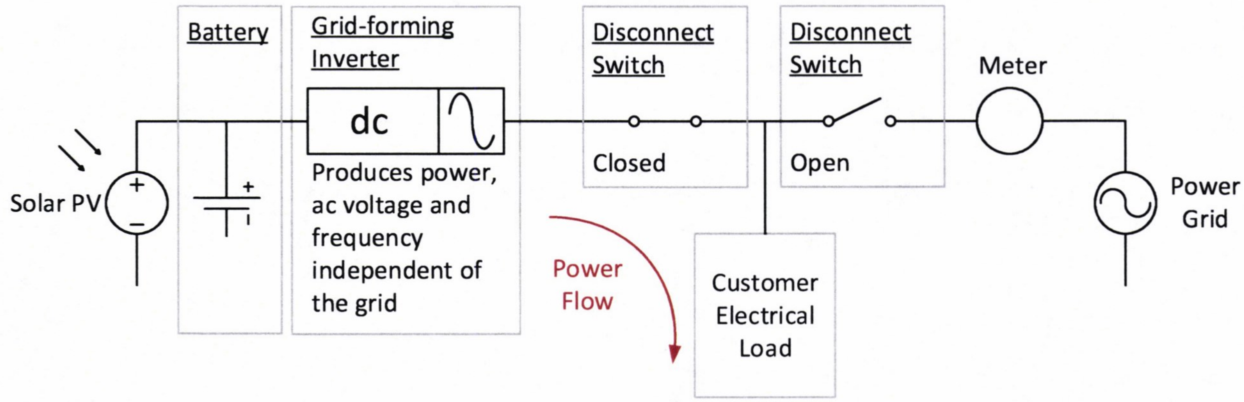
[26] Tr. at 572, ll. 3-10.

Figure 9. Grid-Forming Installation Connected in Parallel: The inverter delivers energy from the solar PV and battery when synchronized to the grid



When grid supply ceases, the grid-forming inverter senses the loss of supply and automatically disconnects from the grid at which time the grid-forming inverter develops, regulates, and supplies voltage and power to the customer load as shown in Figure 10.

Figure 10. Grid-Forming Installation Off-Grid Operation: The inverter delivers energy from the solar PV and battery when the grid is disconnected



During this off-grid operating mode, the customer will not experience the parallel operation grid benefits of energy balancing, voltage and frequency regulation, and motor starting capacity. The on-site generation system must supply energy to the largest combination of customer loads, which may be reduced through a well-planned load management system. Additionally, the customer will need to size the system for motor starting currents or replace larger motors with electronically commutated motors to reduce the starting currents. In summary, configuring and managing a system to operate in the off-grid mode can be difficult and costly.

C. Non-Parallel Connection

Unlike the prior on-site generation configurations, a generation system that is not connected in parallel to the utility's electric grid is completely independent of the utility grid. A generation system that is not connected in parallel to the electric grid is commonly referred to as an "off-grid," or a "standalone" system. An off-grid system may be required to provide backup supply for critical customer systems in the event the grid service is interrupted. Because there is no connection between the off-grid system and the utility's grid, an off-grid system is *incapable* of providing excess energy to the grid and it is also incapable of receiving energy from the utility. Because an off-grid system is not connected to Idaho Power's electric grid, the customer load is not served by Idaho Power, and is therefore not required to take service under new Schedules 6 and 8.

Figures 11 and 12 illustrate the installation of an off-grid system that is not connected to the utility's electric grid. Note that the switch is designed to automatically transfer the load from the grid, during the loss of grid supply to the on-site generator to supply the customer load independent of the power grid.

Figure 11. Backup "Off-Grid" Installation: Normal Operation -- the grid supplies the customer load

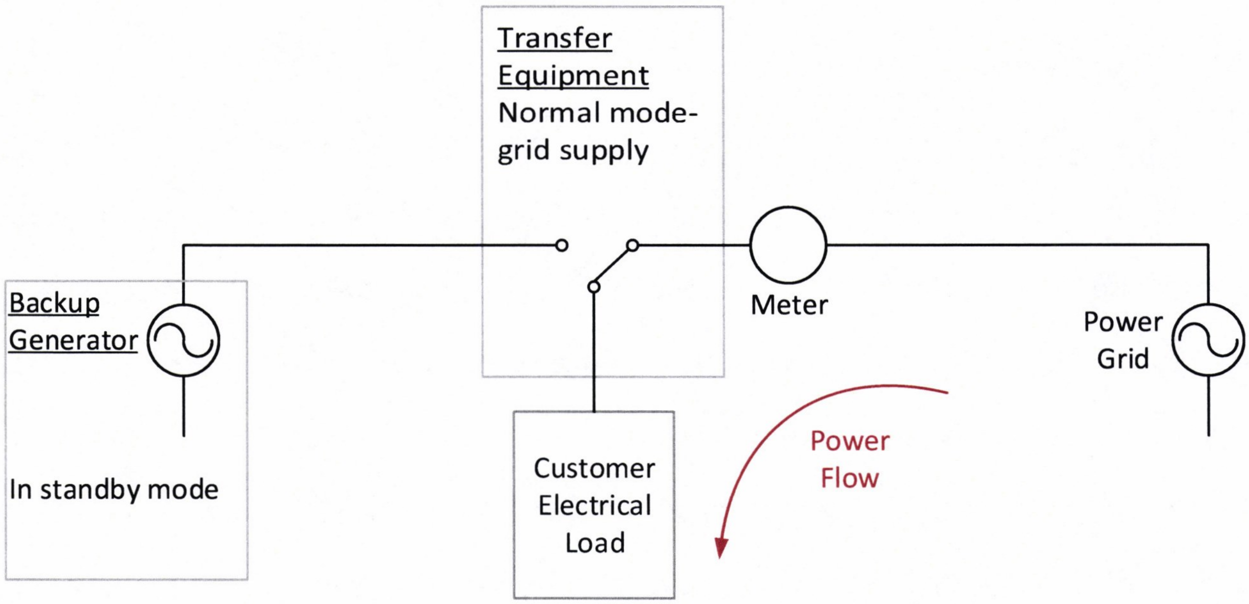
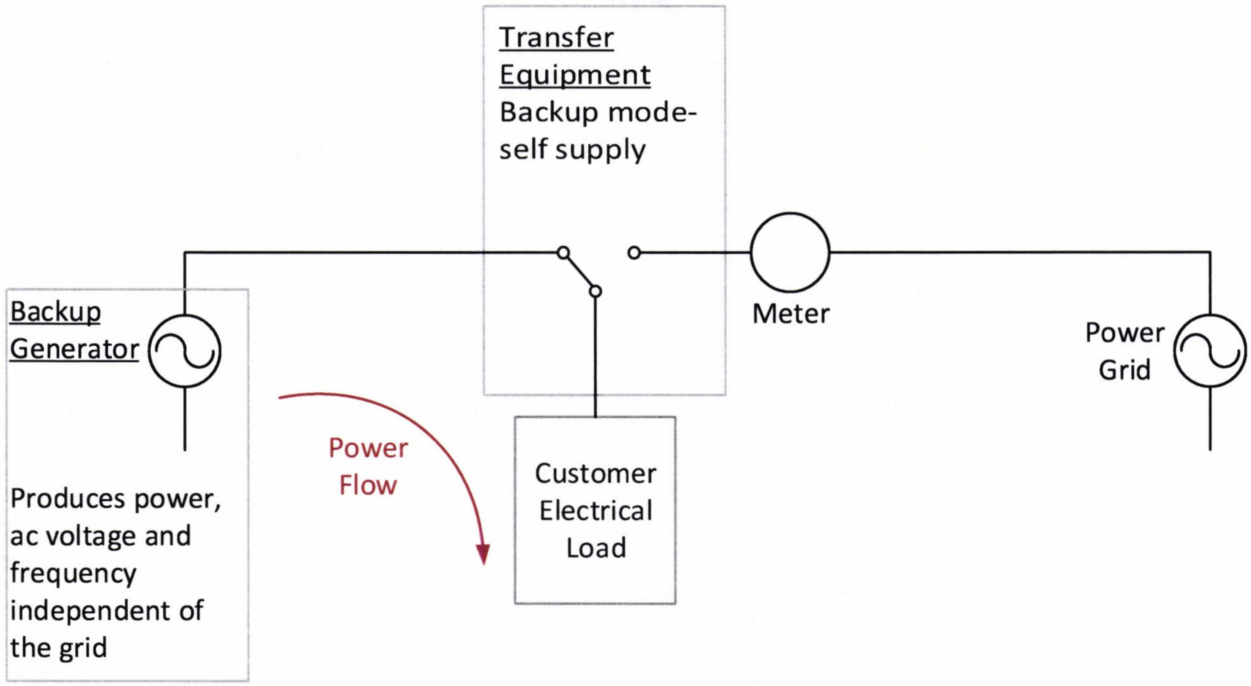


Figure 12. Backup "Off-Grid" Installation: Backup Operation -- the on-site generator supplies the customer load



An example of a standalone, off-grid system would be a hospital with a backup generation system that is not intended to offset consumption. The hospital's automatic transfer switch is configured to isolate the hospital's load from the electric distribution system when it senses very low or no voltage.

III.

EXCLUDING ANY ON-SITE GENERATORS FROM SCHEDULES 6 AND 8 CREATES OPERATIONAL AND SAFETY CONCERNS

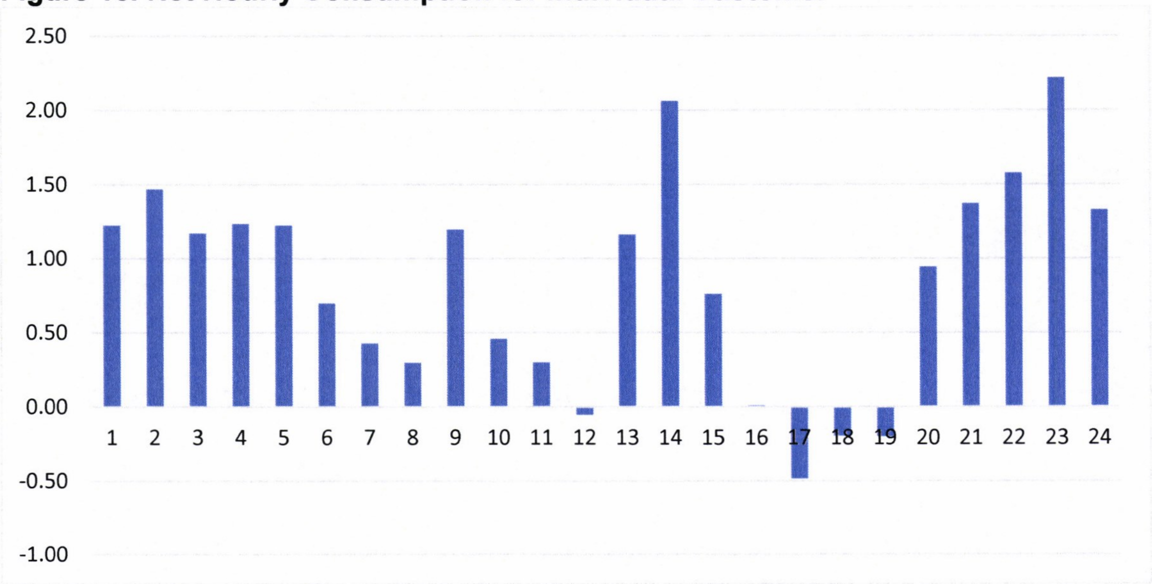
A. Intra-Hour Usage Not Detectable in Net Hourly Consumption

Finally, Idaho Power explained in its Answer to Vote Solar's Petition for Reconsideration that: "Even if the Commission granted Vote Solar's request, using the export of electricity as the criterion to determine the applicability of Schedules 6 and 8 is not enforceable because intra-hour usage is not detectable."[27] Because Idaho Power measures the hourly net consumption with one meter, the Company cannot measure the total of energy exported to the grid separately from how much energy the customer consumes from the Company. To determine net consumption, the amount of energy exported to the grid is deducted from the amount of energy from the utility consumed by the same customer. If the sum at the end of the hour is greater than zero, the customer consumed more energy from the utility than they exported to the grid. If the sum at the end of the hour is less than zero, the customer exported more energy to the grid than they consumed from the utility. As a result, there is no way to know if any energy has been exported to the grid within the hour if the customer always consumes more energy from the utility on an hourly basis.

[27] Idaho Power Company's Answer to Vote Solar's Petition for Reconsideration at 4.

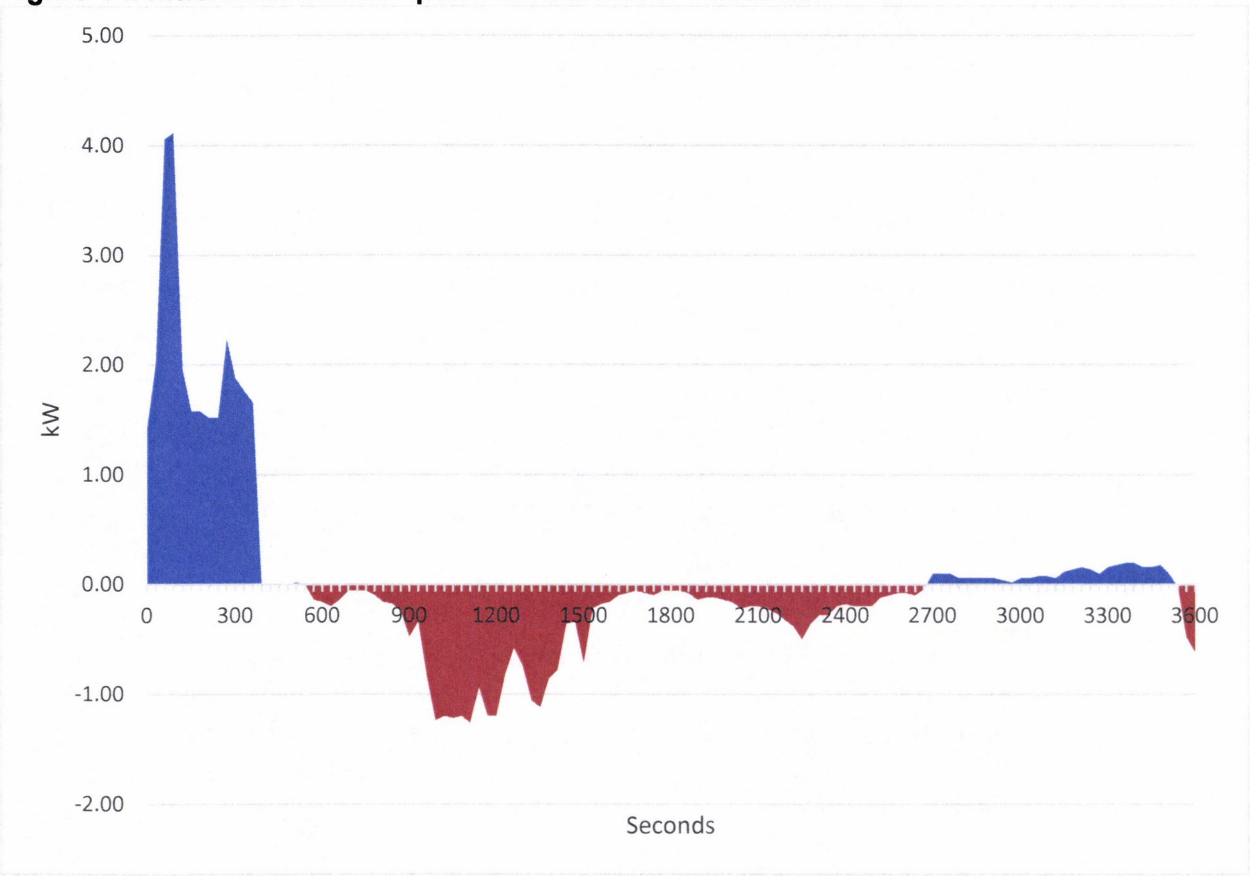
To illustrate this, Idaho Power obtained the data for a single customer from March 2016 where a power quality meter was temporarily installed at the customer's request to record data on a 30-second basis. Figure 13 illustrates the net hourly consumption over a 24-hour period at the customer's premise.

Figure 13. Net Hourly Consumption for Individual Customer



Note that the net consumption in hour 16:00 is just barely positive -- the net consumption is 22 watt-hours. However, what is not obvious by looking at the total net energy consumption for the hour is that the customer did export excess energy to the grid during that hour. To understand what happens on a moment-by-moment basis, the Company plotted hour 16:00 using 30-second intervals. The intra-hour usage for hour 16:00 is shown in Figure 14. The usage for each 30-second interval is plotted over the course of the hour.

Figure 14. Intra-Hour Consumption for Individual Customer



The blue area of the graph indicates intervals where the customer consumed energy from the utility -- totaling 251 watt-hours. The red area indicates intervals where the customer generated more energy than they could consume and the excess energy was exported to the grid -- totaling 229 watt-hours. As indicated previously, the total net energy consumption for the hour was 22 watt-hours – this is the value Idaho Power would receive from the net meter for hour 16:00. Idaho Power would have no way to detect that this customer had in fact exported energy to the grid within the hour.

Given that intra-hour exports cannot be detected using current metering configurations, Vote Solar's request to use energy exports as the criteria for inclusion in new Schedules 6 and 8 is not enforceable.

B. Safety

Since 2002, Schedule 72 has required that all customers with on-site generation notify Idaho Power when a net metering system and small on-site generation system is interconnected (in parallel) to the Company's system. Net metering systems and small on-site generation systems interconnected to the Company's system without Company approval are considered unauthorized installations that jeopardize the reliability of Idaho Power's system and the safety of its employees.[28] This includes, but is not limited to, newly installed systems and unapproved expansions of approved systems.

The utility must be aware of any system connected in parallel to its electric grid to ensure that all systems have passed the proper electrical inspections and include the proper safety equipment to disconnect the system from the grid. Once Idaho Power is notified of a newly installed system or of an expansion of an approved system, the Company then has the opportunity to perform a feasibility review[29] to determine the capability of the Company's electrical system to incorporate the on-site generation system and determine if upgrades are necessary.

Upon installation of its on-site generation system, the customer must provide documentation to the Company verifying that all federal, state, and local requirements have been met.[30] The customer must also provide the Company with a System Verification Form detailing the specifications of all installed components of the system. The Company will then perform an on-site inspection to verify all requirements have been

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[28] Schedule 72, Sheet No. 72-10.

[29] *Id.* at Sheet No. 72-7.

[30] *Id.* at Sheet No. 72-8.

met.[31] Upon successful completion of the on-site inspection, the Company will move the customer to either the net metering service or small on-site generation service rate schedule.[32]

If the Commission were to grant Vote Solar's request to allow customers who do not export to continue to take service under their standard service schedule, the Company would not have an opportunity to verify those systems are interconnected in a manner that would not jeopardize reliability of Idaho Power's system or the safety of its employees. The Commission should require all on-site generation systems operating in parallel with the grid to continue to be subject to the interconnection requirements contained in Schedule 72 as set forth by Schedules 6 and 8.

IV.

CONCLUSION

It is imperative that the Commission establish the appropriate application of Schedules 6 and 8 now so that as technology evolves, one definitive criteria exists that makes sense for all forms of distributed energy resources. The Company believes the Commission's Order in this matter, and the tariff schedules approved in this case, appropriately establish the scope of the customers to be included in Schedules 6 and 8 as all customers whose on-site generation systems are connected in parallel to Idaho Power's system.

Eligibility for Schedules 6 and 8 should be based upon the existence of on-site generation that is connected in parallel with Idaho Power's system. This classification

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[31] *Id.*

[32] *Id.* at Sheet Nos. 72-7 and 72-8.

approach will establish two unique groups of self-generating customers with load service requirements that are distinctly different than customers without on-site generation. The ability to export, or lack thereof, does not significantly impact the load service requirements of these "prosumers." Separate classification for R&SGS customers with on-site generation connected in parallel with Idaho Power's system will best position the Commission to establish fair, just, and reasonable rates and compensation structures for these groups of customers into the future.

Idaho Power recommends the Commission reject Vote Solar's request to require the Company to revise new Schedules 6 and 8 to apply only to customers who export electricity. While there are several cost-of-service, operational, and safety benefits to including self-generating customers without exports in Schedules 6 and 8, there is no downside -- except perhaps for those self-generators who could benefit from continued access to the cross-subsidy that exists in volumetric standard service rates.

Respectfully submitted this 10th day of August 2018.

Lisa D. Nordstrom

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Attorney for Idaho Power Company

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that on the 10th day of August 2018 I served a true and correct copy of IDAHO POWER COMPANY'S OPENING BRIEF ON RECONSIDERATION upon the following named parties by the method indicated below, and addressed to the following:

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Kimberly Towell

Kimberly Towell, Executive Assistant

BEFORE THE

IDAHO PUBLIC UTILITIES COMMISSION

CASE NO. IPC-E-17-13

IDAHO POWER COMPANY

ATTACHMENT 1

ATTACHMENT 1

Methodology for Limited Export Simulation

Idaho Power Company ("Idaho Power" or "Company") developed a methodology, described herein, to simulate a residential customer net load profile that assumes the implementation of an export limiting device on a parallel-connected on-site generation system. A simulation was necessary because the Company is not aware of any application of an export limiting device on residential or small general service customer's parallel-connected on-site generation system within its service area that could be analyzed.

The simulation methodology encompassed selecting a sampling of residential customers, creating a photovoltaic ("PV") generation profile, scaling the PV generation profile per customer, producing the annual net hourly load profile for each sample customer by subtracting the PV generation from the customer load, and calculating monthly load factor, load shapes, system-coincident demand and non-coincident demand for the segment of customers analyzed.

1. Selecting a Sample of Residential Customers

The 2016 hourly load data from Idaho Power's residential load research sample was used as the reference load profiles for the simulation.[1] The Idaho residential sample is a stratified random sample that was designed using Oracle Utilities' LodeStar sampling package. A multidimensional stratified sample was utilized, using the Delanius/Hodges methodology to identify stratum breakpoints, and the Neyman allocation methodology was used to determine sample size. The sample design target statistics were based on

[1] The 2016 load research sample data was previously provided to all parties in response to Vote Solar's Data Request No. 27.

10 percent reliability with 90 percent confidence. The sample consists of four usage strata combined with six demographic strata resulting in 24 total strata (four usage by six demographic). The usage stratifying variable was the average 30-day normalized billed kilowatt-hour ("kWh"). The following usage stratum breakpoints were identified: 0-700 kWh, 701-1,250 kWh, 1,251-2,150 kWh, and 2,150+ kWh. The demographic stratifying variable was based on the six weather stations across Idaho Power's service area. They include the following weather stations: Boise, Ketchum, McCall, Ontario, Pocatello, and Twin Falls. The simulation was limited to the 272 sample customers from the Boise weather station.

An additional data set was created from this data set by offsetting the load with an annual production profile of a PV system appropriately sized for each customer. All hourly energy exports were replaced with zero.

2. Establishing a Normalized PV Generation Profile

A normalized PV generation profile was created for a PV system in Boise, Idaho. Idaho Power chose the National Solar Radiation Data Base, Typical Meteorological Year 3, Boise Air Terminal data set for the PV irradiance data. These data were applied to the most common system configuration of 5.6kWdc/5kWac, with a due south azimuth and a 25 degree tilt. Each simulation production hour was divided by the maximum annual production value to obtain a normalized annual PV generation profile.

3. Determining an Export Limited PV System Size

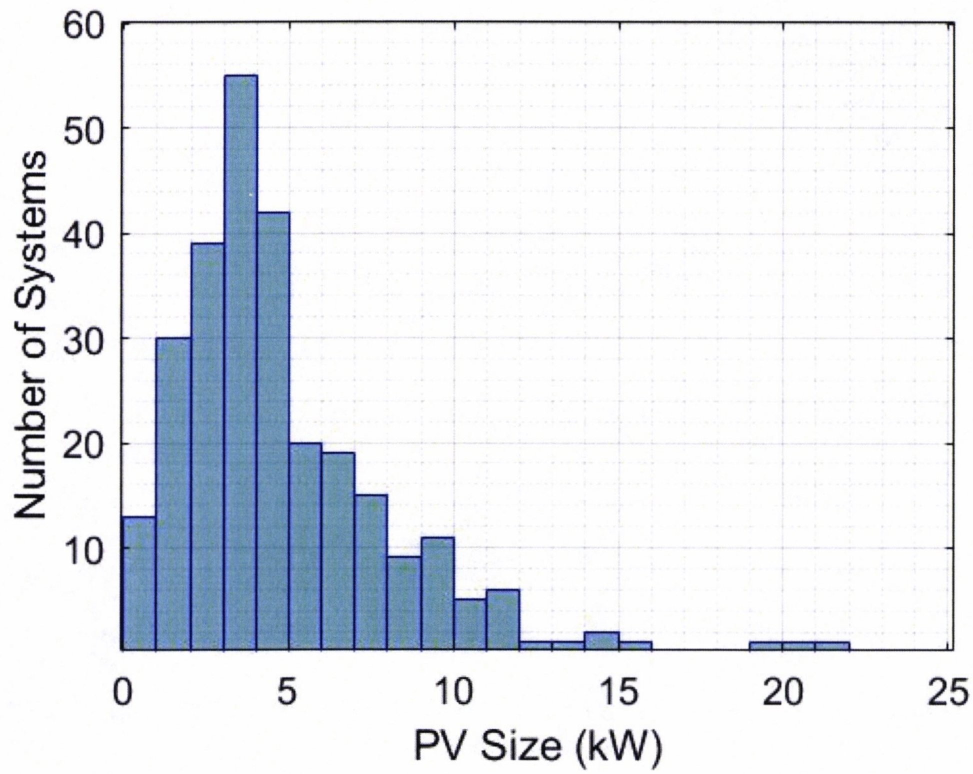
While the Company has found that a 6kW[2] system is the most commonly installed residential on-site generation size on Idaho Power's system, a customer that limits energy

[2] Idaho Power Company's 2016 Annual Net Metering Status Report at 9.

exports will likely install a smaller PV system than those who export excess energy. This is because a customer who can net their *annual* energy needs to zero through monthly net metering is incented to size their system to generate enough energy credits in the higher radiation months to cover the customer's energy requirements that exceed the self-generation through the remainder of the year. On the other hand, a customer with an export limiting device will size their PV system to limit most generation in excess of the customer's *hourly* energy needs.

To determine the size of the simulated PV systems, the Company first scaled the normalized annual PV generation profile by each sample customer's annual consumption. Then the PV generation system size was optimized for reduction of grid energy consumption while minimizing excess energy generation. A distribution of the resulting PV system sizes is provided in Figure 1.

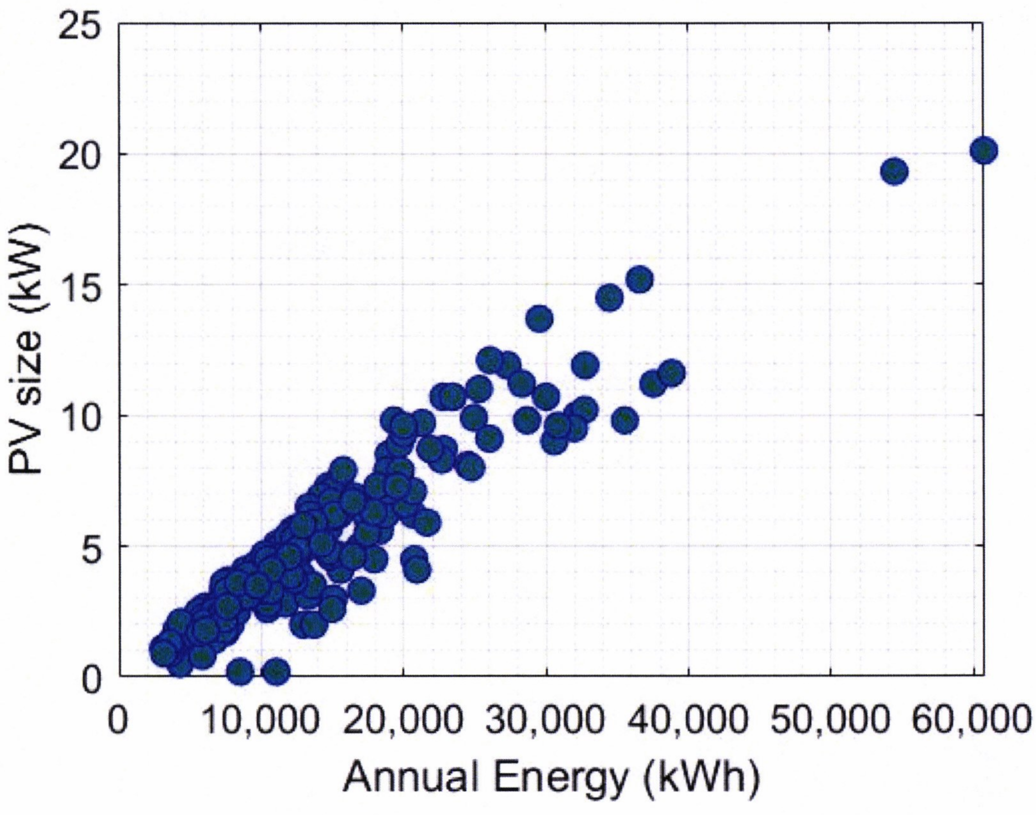
Figure 1. Distribution of Simulated PV Generation System Sizes



The distribution of PV system sizes illustrates that a majority of simulated PV systems were between 3 kW and 4 kW.

A scatterplot was used to illustrate the association between the PV system size and the annual energy consumption for each sample customer. The relationship between the PV system size and the annual energy consumption for each sample customer is shown in Figure 2.

Figure 2. Relationship Between Simulated PV System Size and Annual Energy Use



The scatterplot shows a strong, positive, linear association between the PV system size and the annual energy use.

4. <u>Creating Zero-Export Load Shape for Each Sample Customer</u>

The normalized PV production profile was scaled per sample customer by multiplying the normalized PV load shape by the size of each sample customer's PV system. The net hourly load shape was then created by subtracting the sample customer's PV production from their load. Finally, the zero-export load shape was created for each sample customer by taking the net hourly load shape and setting all negative net usage hours to zero.

5. **Calculating Load Factor and Load Shapes**

The monthly load factors and monthly load shapes were calculated for both the group of reference sample customers and for the simulated group of customers.

The average monthly load factor was generated by calculating the weighted average of the monthly load factor for each month for both groups.[3]

The average monthly load shape was generated by calculating the weighted average of the hourly energy consumption for each hour for both groups.[4]

6. **Calculating System-Coincident and Non-Coincident Demand**

The monthly system-coincident demand and non-coincident demand were calculated for both the group of reference sample customers and for the group of simulated customers.

The monthly system-coincident demand was determined by finding the monthly weighted average of hourly energy consumption at the time of the system peak for both groups.[5]

The monthly non-coincident demand was determined by finding the monthly maximum weighted average of hourly energy consumption for both groups.[6]

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[3] Idaho Power Company's Opening Brief on Reconsideration, Figure 1.

[4] *Id.*, Figures 2, 3, and 4.

[5] *Id.*, Figure 5.

[6] *Id.*, Figure 6.

BEFORE THE

IDAHO PUBLIC UTILITIES COMMISSION

CASE NO. IPC-E-17-13

IDAHO POWER COMPANY

ATTACHMENT 2

ATTACHMENT 2

Pilot Customer Load Shapes With No Energy Exports

To study the effects of preventing the export of excess energy and to verify the results of Idaho Power Company's ("Idaho Power" or "Company") Limited Export Simulation of a residential customer who installs on-site generation and then prevents the export of excess energy, the Company performed the same load factor, load profile, system-coincident demand ("SCD") and non-coincident demand ("NCD") analyses on a segment of 18 residential solar customers who participate in a Solar Photovoltaic ("PV") Pilot Program ("Pilot") in Idaho Power's Oregon service area.

The metering requirements for the Pilot are such that the customer must have a second, Company-owned, meter that measures only the net solar PV generation. The meter must be placed at a location designated by the Company on the customer load side of the retail meter and on the alternating current side of the inverter. Due to the required meter configuration, the Company records separately the amount of excess energy exported to the grid. This enabled the Company to set the energy exports to zero for these analyses in order to determine if the results differ for a residential customer who installs on-site generation and then prevents the export of excess energy, and without the installation of the on-site generation.

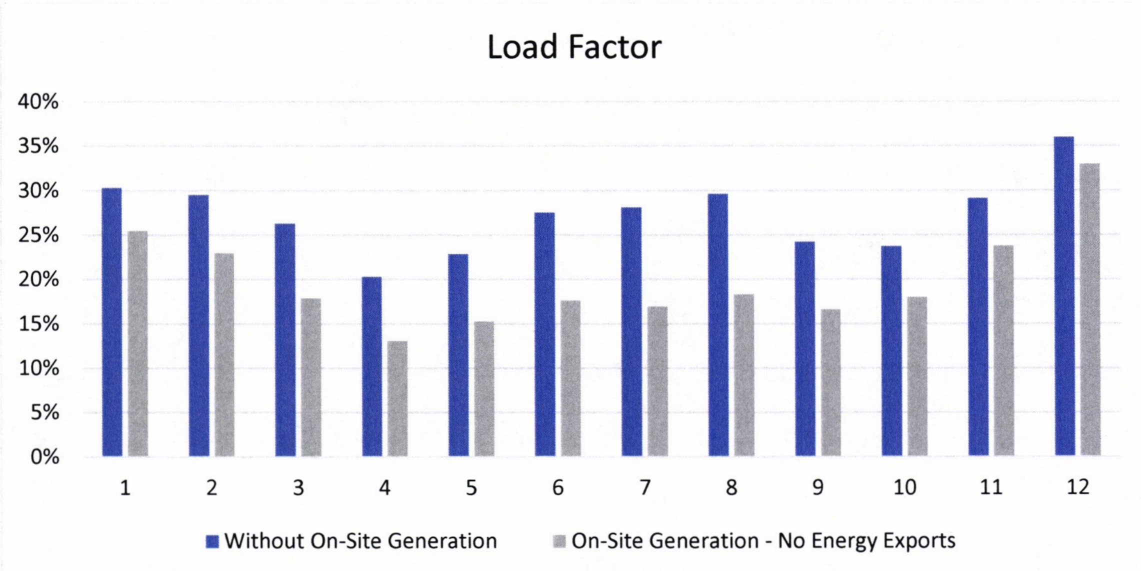
The Company analyzed the data for these 18 residential customers for all 12 months of 2016. The following results of the Company's supplementary analysis confirms that the load service requirements and usage characteristics differ for a customer when they do not have on-site generation as compared to when they do have on-site generation and prevent the export of excess energy.

Load Service Requirements

Load Factor – Residential Pilot Participants with No Energy Exports

Using the data from residential Pilot participants, the Company calculated the load factor for each Pilot participant before and after the installation of on-site generation without the capability to export excess energy. The average monthly load factors of the Pilot participants before and after the installation of on-site generation without the capability to export excess energy are shown in Figure 1.

Figure 1. Load Factor -- No Energy Exports for Residential Pilot Participants



The Company's load factor analysis of the Pilot participants demonstrates that load factor is notably lower after the installation of on-site generation -- even without the capability to export excess energy. This result is consistent with the Limited Export Simulation performed by the Company.

Pattern of Use

Load Profile – Residential Pilot Participants with No Energy Exports

Using data from residential Pilot participants, the Company developed the load profile for each Pilot participant before and after the installation of on-site generation without the capability to export excess energy. The average load profile of the Pilot participant for a winter month, a spring month, and a summer month are shown in Figures 2, 3, and 4, respectively. For the three graphs, each hour data point is the average for that hour throughout the month.

Figure 2. January Load Shape -- No Energy Exports for Residential Pilot Participants

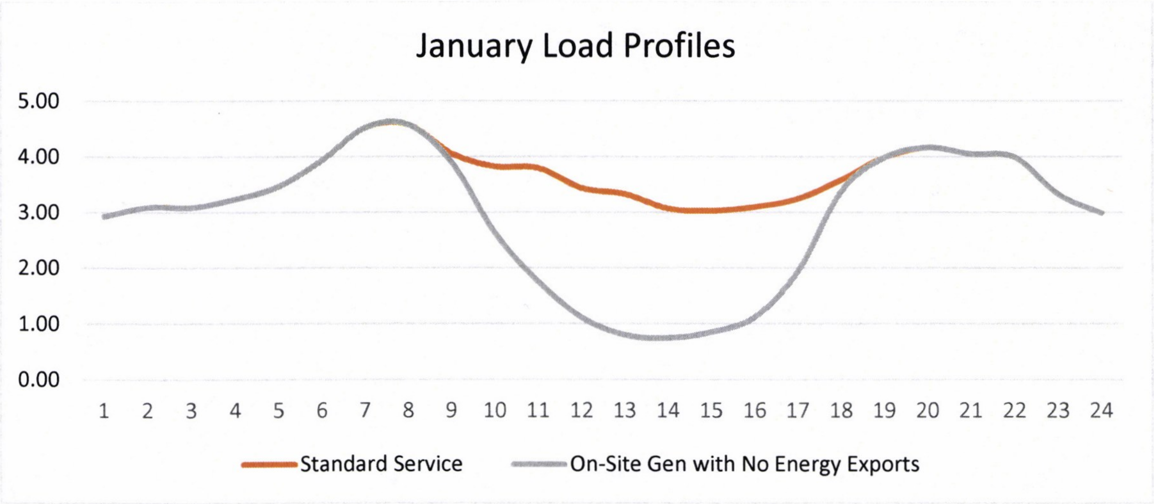


Figure 3. April Load Shape -- No Energy Exports for Residential Pilot Participants

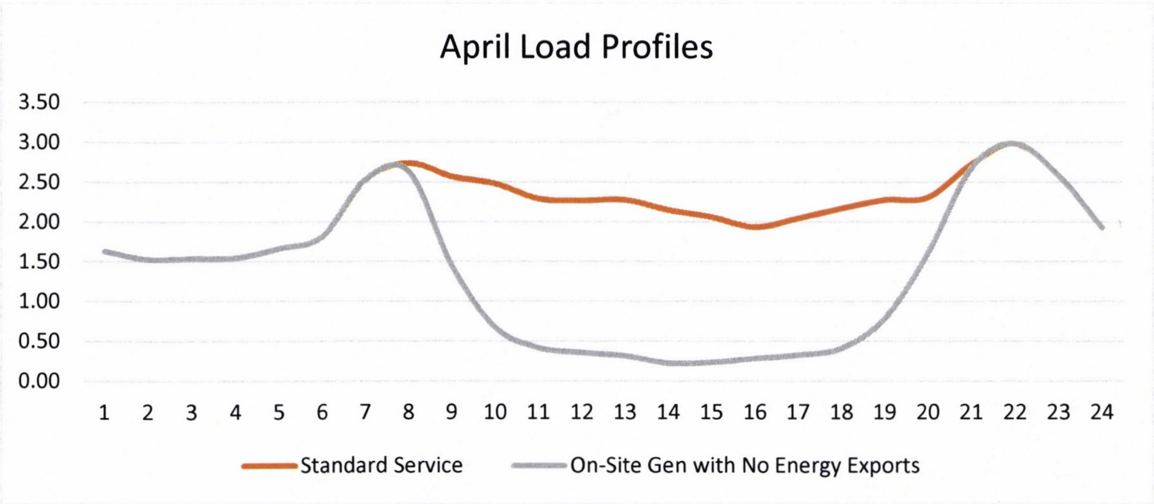
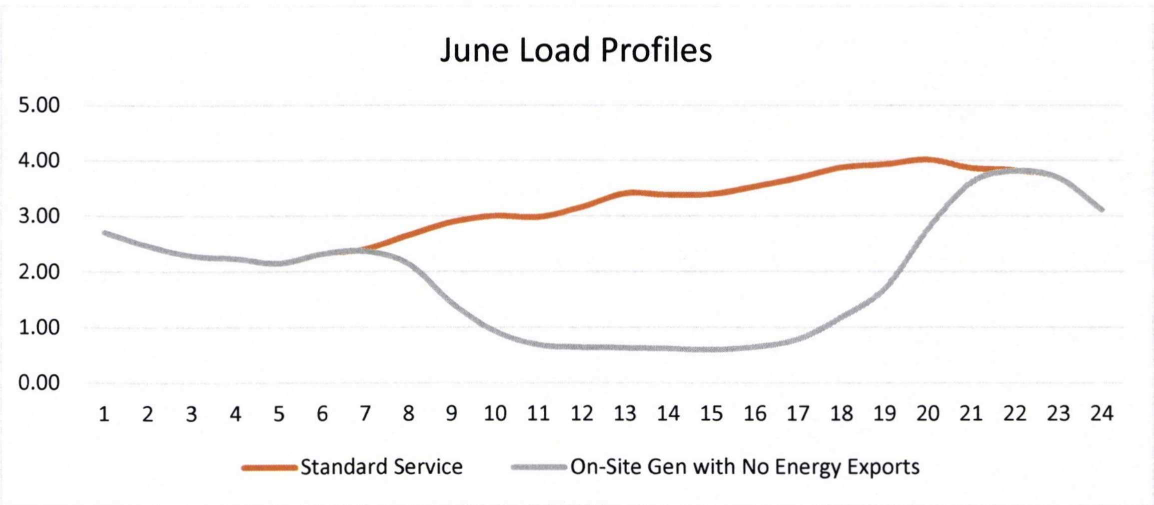


Figure 4. June Load Shape -- No Energy Exports for Residential Pilot Participants



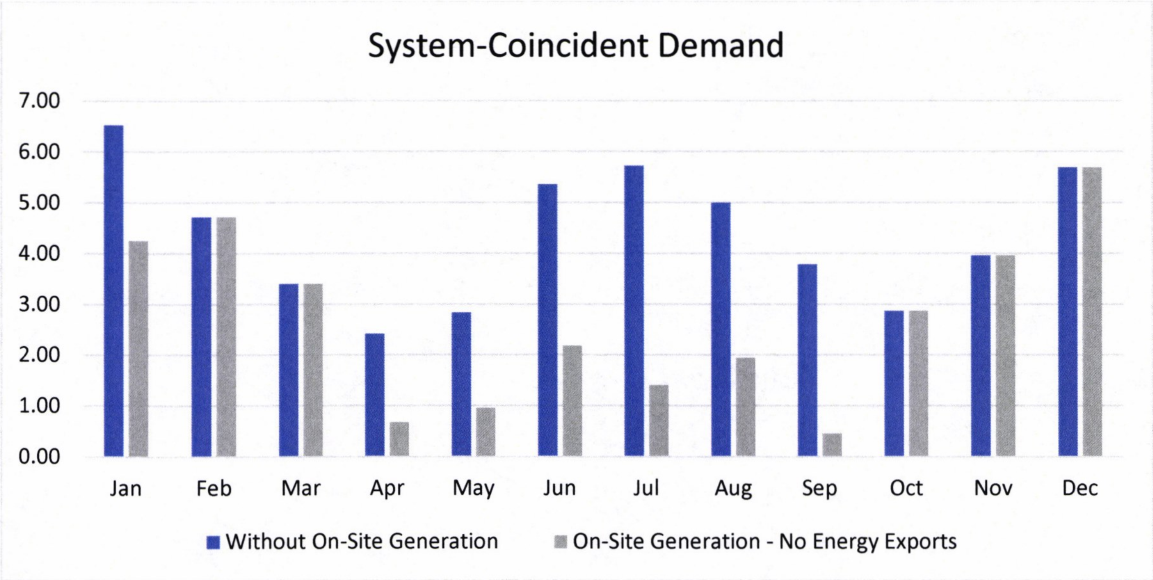
The Company's load profile analysis of the Pilot participants demonstrates that the load profile changes significantly after the installation of on-site generation -- even without the ability to export excess energy. The on-site generation causes a downward ramp after the sun rises and generation from the utility is replaced by the on-site generation for several hours. Then, as the sun sets and solar generation ends, a significant upward ramp occurs. This is vastly different than the load curve of a standard service customer, where the transition from hour-to-hour is smoother with significantly lower rate of change in usage during the morning and evening hours. This result is consistent with the Limited Export Simulation performed by the Company.

System-Coincident Demand – Residential Pilot Participants with No Energy Exports

The SCD is the average demand for a segment of customers at the time of Idaho Power's system peak. The analysis of SCD is important for cost allocation purposes because: (1) production plant costs associated with serving base and intermediate load are allocated using an average of the 12 monthly SCDs, (2) production plant costs associated with serving peak load are allocated using an average of the three monthly SCDs occurring in June, July, and August, and (3) transmission costs are allocated using an average of the 12 monthly SCDs.

Using data from residential Pilot participants, the Company calculated the SCD for the group of Pilot participants before and after the installation of on-site generation without the capability to export excess energy. The monthly SCDs for the group of Pilot participants before and after the installation of on-site generation without the capability to export excess energy are shown in Figure 5.

Figure 5. System-Coincident Demand -- No Energy Exports for Residential Pilot Participants



The Company's SCD analysis demonstrates that the SCD of the group of Pilot participants is lower for several months after the installation of on-site generation -- even without the capability to export excess energy. This result is consistent with the Limited Export Simulation performed by the Company.

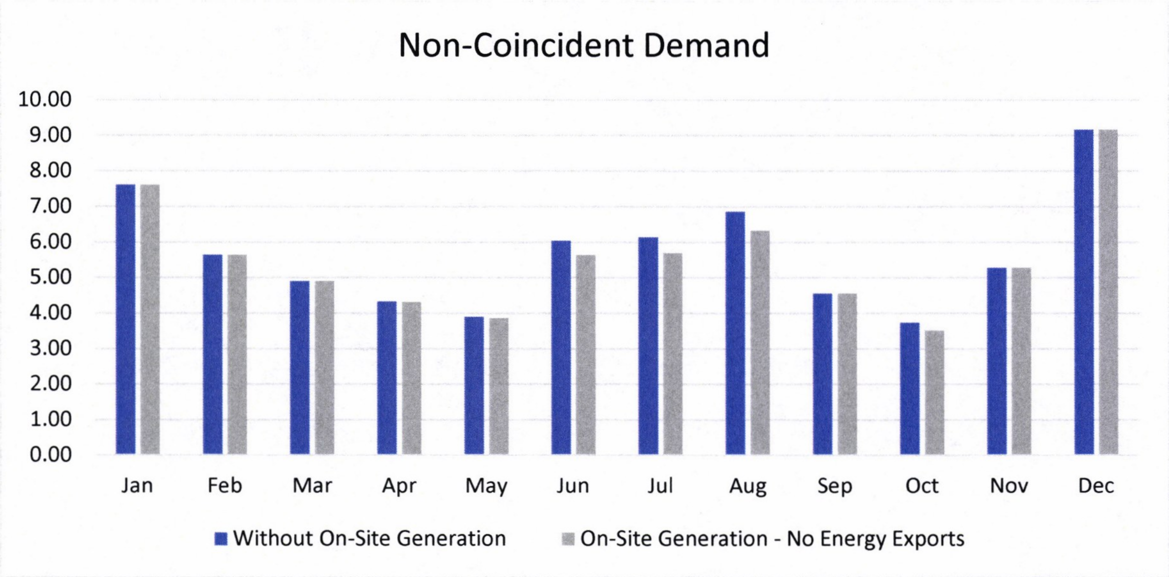
The results of this analysis suggest that production plant costs associated with serving peak load would decrease because these costs are allocated using an average of the three monthly SCDs occurring in June, July, and August, and transmission costs increased because they are allocated using an average of 12 monthly SCDs. Consequently, the resulting different allocation of costs supports the argument that it is appropriate for all customers who install on-site generation -- even without the capability to export excess energy -- be included in Schedules 6 and 8.

Non-Coincident Demand – Residential Pilot Participants with No Energy Exports

The NCD is the maximum average demand for a segment of customers in any given hour, regardless of when it happens. Similar to SCD, the analysis of NCD is important for cost allocation purposes because NCDs are used to allocate Idaho Power's distribution system costs.

Using data from residential Pilot participants, the Company calculated the NCD for the group of Pilot participants before and after the installation of on-site generation without the capability to export excess energy. The monthly NCDs for the group of Pilot participants before and after the installation of on-site generation without the capability to export excess energy are shown in Figure 6.

Figure 6. Non-Coincident Demand -- No Energy Exports for Residential Pilot Participants



The result of the Company's NCD analysis is consistent with the Limited Export Simulation performed by the Company and continues to demonstrate that the installation of on-site generation has very little impact on the NCD of the average residential customer who installs on-site generation -- even with no energy exports. The customers load over the course of the month will continue to place the same level of peak demand on the system.

This is an important observation because NCDs are used to allocate distribution costs. While customers who install on-site generation without the capability to export excess energy contribute to distribution costs in a similar manner, the collection of these costs through the volumetric charge for standard service customers will result in cost shifting. To minimize this, all customers with on-site generation -- even those who have no ability to export energy -- should be included in Schedules 6 and 8 to appropriately assign and collect costs and address cost shifting.

BEFORE THE

IDAHO PUBLIC UTILITIES COMMISSION

CASE NO. IPC-E-17-13

IDAHO POWER COMPANY

ATTACHMENT 3

The Effect of Storage on Customer Load Shapes when Coupled with Distributed Generation

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Introduction

The Idaho PUC is currently considering a request to create an exemption from Idaho Power Company's (IPC's) DG-specific rate class for those customers with DG who do not export energy to the grid.

These customers would self-consume the energy generated on-site and avoid paying the full retail rate for each kilowatt-hour of on-site energy that is generated.

In this context, the key issue is whether non-exporting DG customers are more similar to the class average non-DG customer, or to the DG customers for which a separate rate class has been created.

To address this issue, we quantified the impact that coupling DG with behind-the-meter battery storage ("DG+storage") would have on customer net load shapes.

We find that the addition of storage to eliminate exports will moderately flatten DG customers' net load profiles on average. However, a DG+storage customer's reliance on the utility infrastructure continues to be similar to that of a DG-only customer.

- We expect DG+storage customers to have a load factor that is very similar to the load factor of DG-only customers, on average.
- This is evidence that cost under-recovery would remain an issue for DG+storage customers if they were exempted from the DG-specific rate class.

Overview of methodology

Since there currently are no residential DG+storage customers in IPC's service territory, we have simulated the likely net load shapes of such customers.

The analysis is based on hourly load data for IPC's DG customers

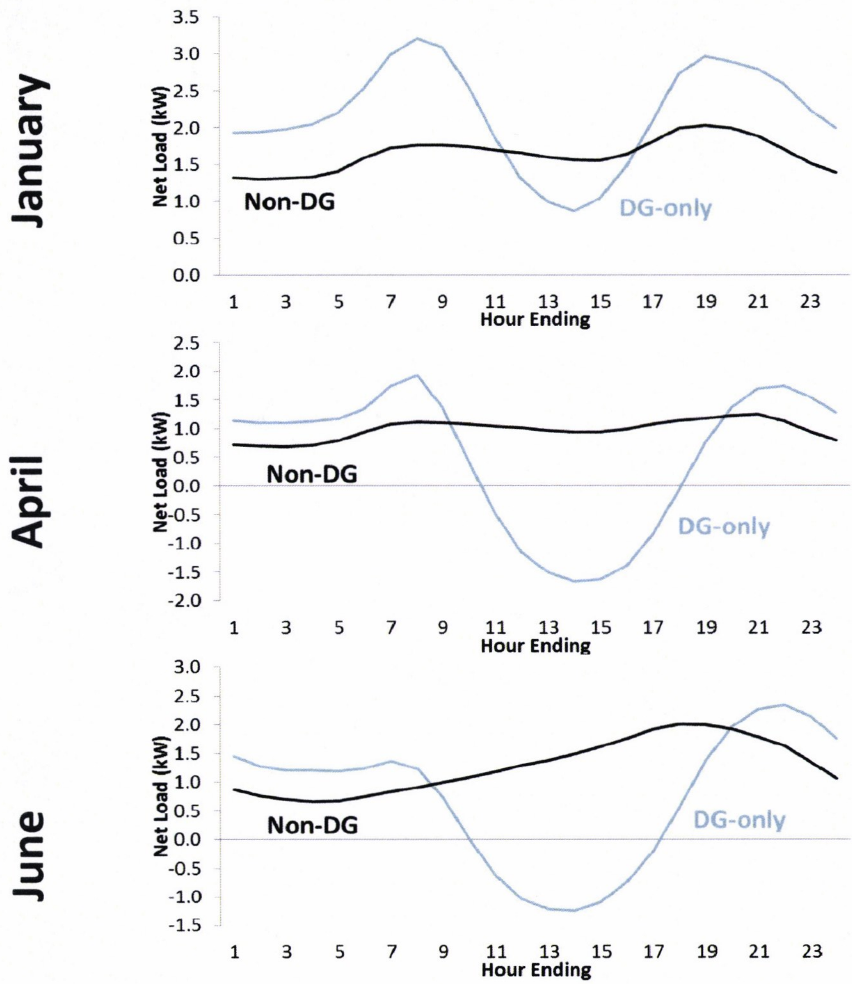
- We have analyzed 329 DG customers for which there is least one full year of interval load data and relevant load characteristics
  - See appendix for details of our approach to data screening

The analysis involves the following steps

1. Using the historical load data, summarize residential non-DG and DG customer load shapes before storage installation
2. Assume each DG customer installs a battery system sized equal to the customer's maximum daily net export (kWh) and max net export (kW) observed in their net load data. The result is a battery capable of storing all exported energy on any given day.
3. Assume the battery discharges any stored energy immediately to offset positive net load. Energy is discharged from the battery up to the customer's net load in any hour.
4. Calculate DG customer net load shapes after assumed storage installation
5. Compare net load shapes and related metrics for non-DG, DG-only, and DG+storage customers

Load shapes before storage installation

Average Load Shapes Before Storage Installation



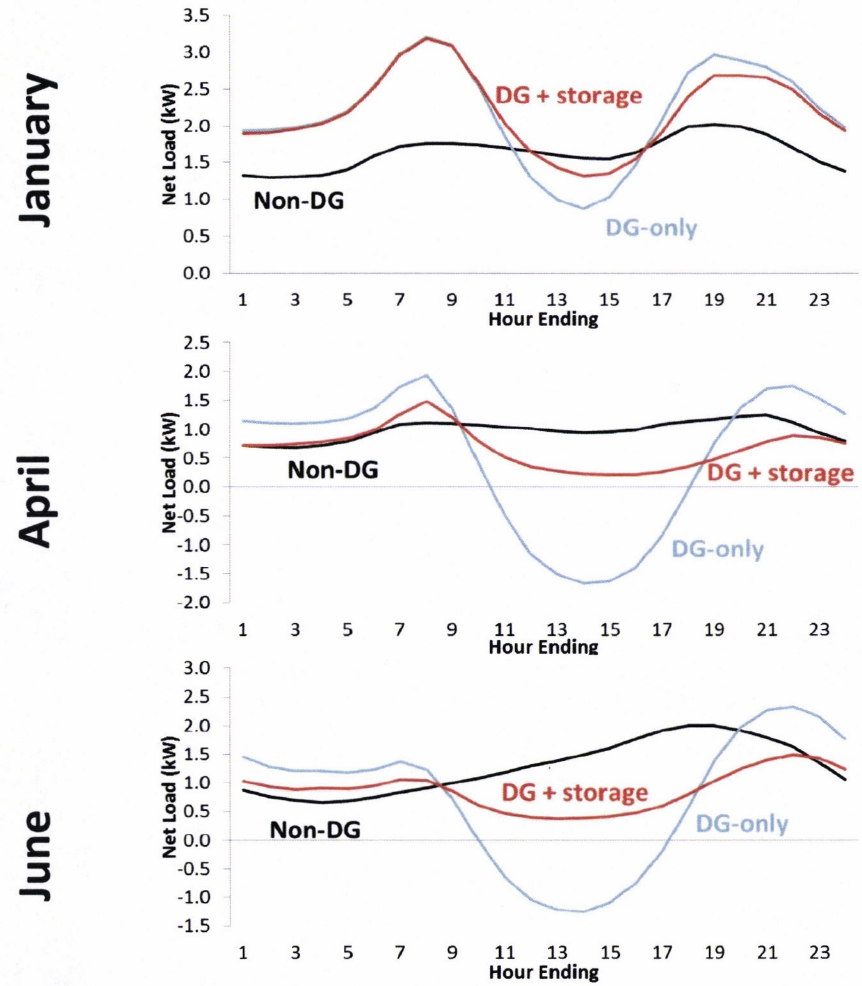
Observations

- Prior to the installation of storage, the average DG customer has **9% lower** average net monthly energy consumption but **20% higher** average monthly maximum demand compared to the average non-DG customer
- Thus, DG customers to have load factors which are, on average, significantly lower than those of other residential non-DG customers
  - Median non-DG load factor is **19%**
  - Median DG-only load factor is **9%**

Note: DG customer sample used in this analysis excludes customers that are net exporters on an annual basis. See appendix for details.

Load shapes after storage installation

Average Load Shapes After DG Installation



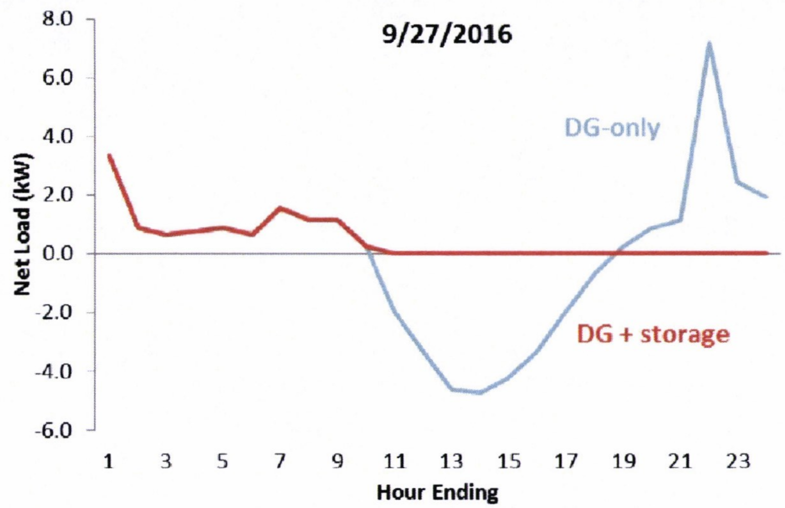
Observations

- The installation of storage marginally increases the average DG customer's net monthly energy consumption from 835 kWh to 897 kWh (**7% increase**) due to battery round-trip losses and occasional solar curtailment when battery is fully charged
- The DG customer's average peak monthly demand decreases from 7.2 kW to 6.7 kW (**7% reduction**)
- The addition of storage only slightly increases the load factor of DG customers
  - Median DG+storage load factor is **10%**

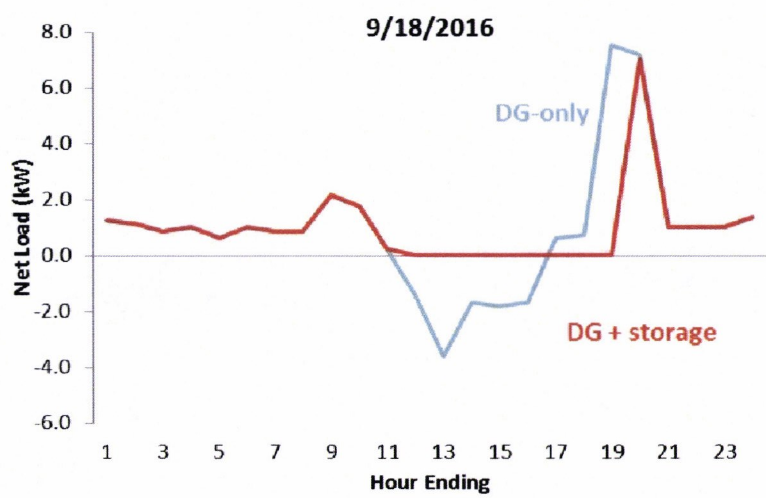
Day-to-day variation in load results in most DG+storage customers still having significant peaks

Net Load Impact for One DG+storage Customer

September 27, 2016



September 18, 2016

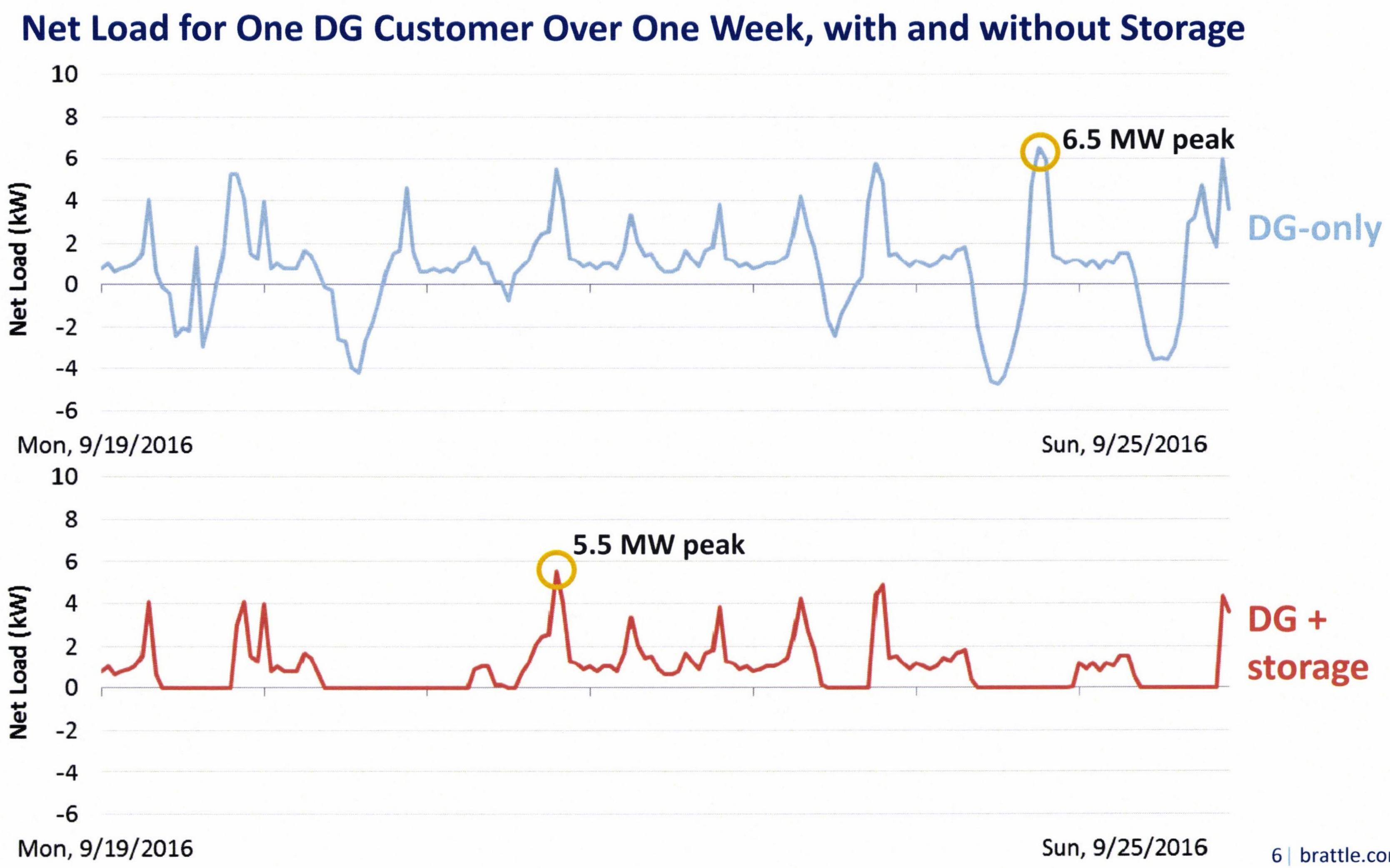


Observations

- The figure at left shows daily net load shapes for one customer on two days in September 2016. While net load is often flatter due to the addition of storage (as in the top figure), the monthly peak is only modestly reduced (as shown in bottom figure)
- Generally, DG+storage customers have flatter load profiles on average, but day-to-day variation in solar generation and gross load still lead to significant monthly peak demand on average
- DG customer average peak monthly demand decreases by only **7%** on average following the installation of storage

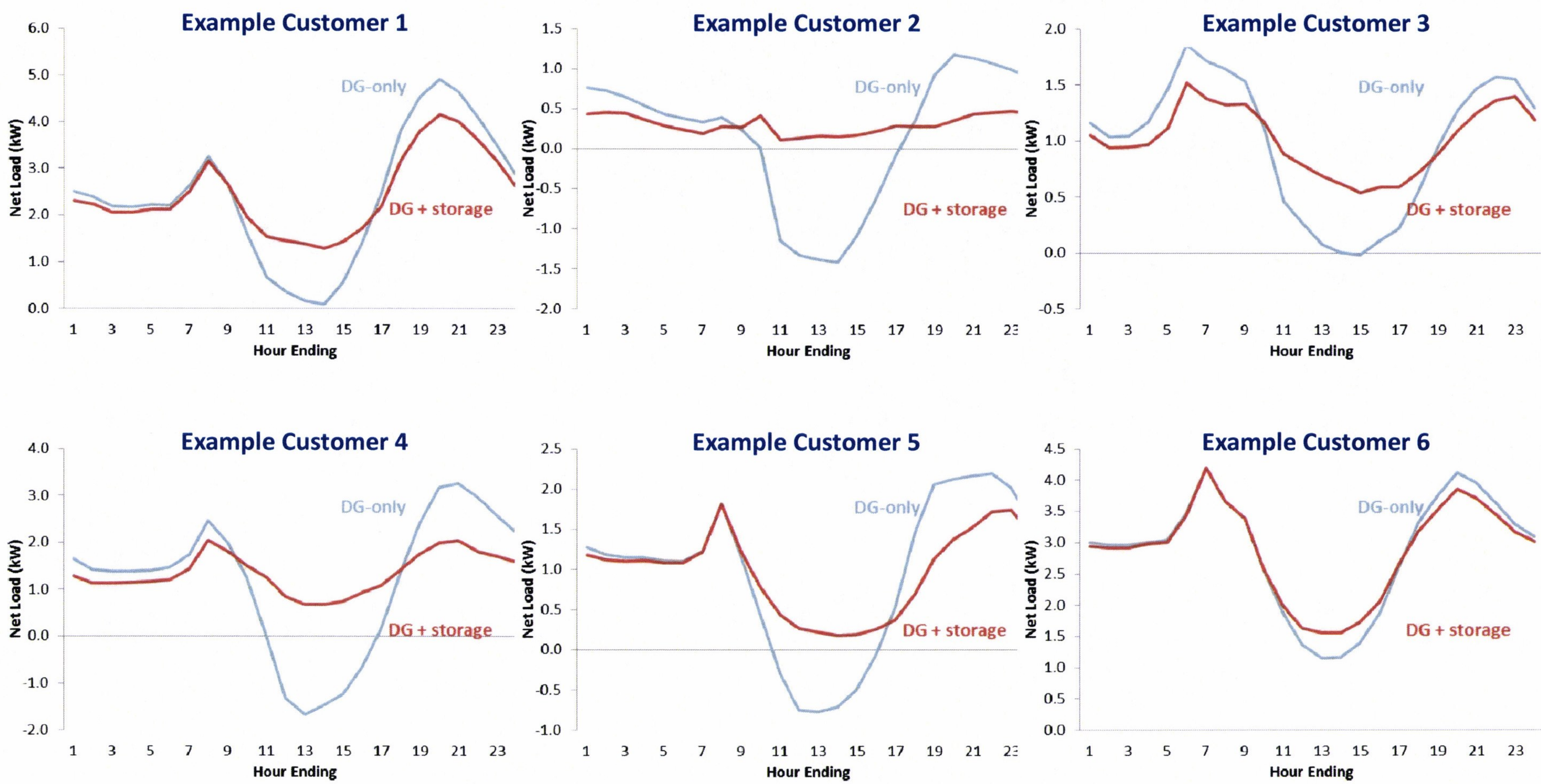
Storage eliminates exports to the grid, but only moderately decreases peak load

A snapshot of weekly net load further highlights the relationship shown on the previous slide



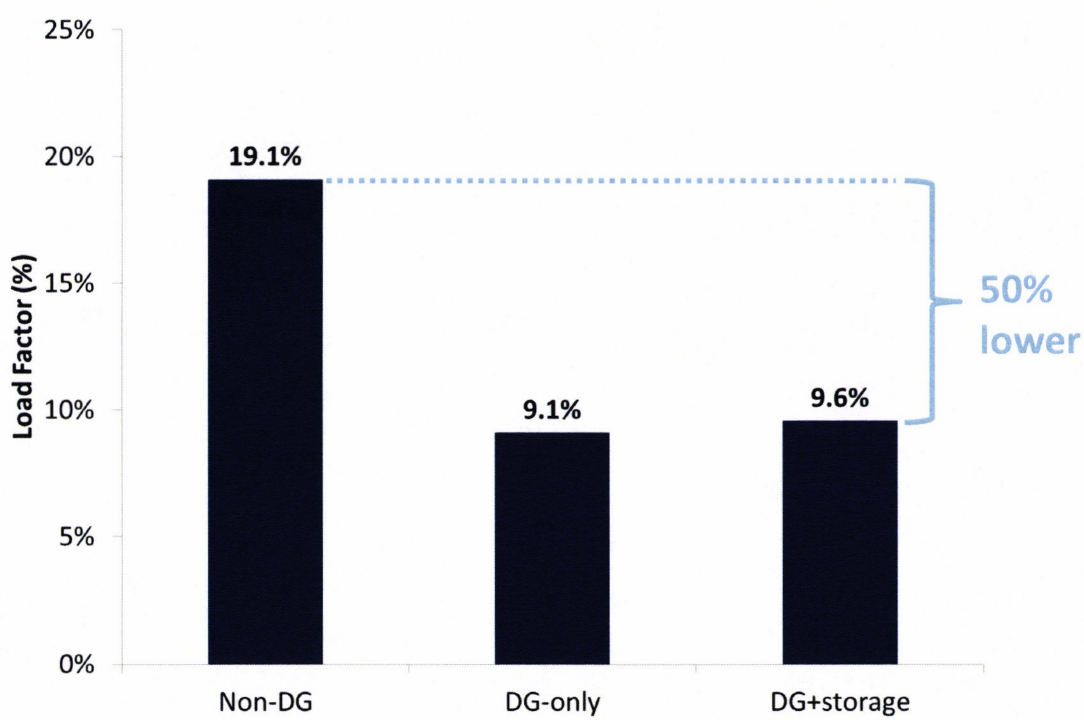
Individual DG+storage customer load shapes exhibit characteristics generally similar to the sample average

Annual Average Load Shapes for Individual Customers



Load factors across customers and scenarios

Median Monthly Load Factors



Observations

- The median load factor for DG+storage customers (**9.6%**) is similar to that of DG-only customers (**9.1%**)
- DG+storage customers have a load factor that is **50% lower** than that of the median residential non-DG customer, on average
- Their load factor is only slightly higher than that of DG-only customers, who have a load factor that is **52% lower** than the median non-DG customer

Key takeaways

The installation of storage by DG customers moderately flattens the average daily load shape

- After storage installation, customers increase their monthly energy consumption by 7% (due to battery energy loss) and reduce their peak demand by 7%. This results in a load factor that is 5% higher than the median DG-only customer
- Individual DG+storage customers typically exhibit the same general load patterns as observed for the average DG+storage customer

DG+storage customers' maximum demand remains high relative to total usage. Median load factor is still 50% lower than that of the residential non-DG class

- DG+storage customer load factors are much more similar to those of DG customers than to those of the average residential non-DG customer

This is evidence that DG+storage customers who remain on the standard non-DG-specific rate would pay less than their share of the cost of using the grid

Without an alternative rate design, DG+storage customers would not have a financial incentive to operate their battery in a way that would significantly reduce their reliance on the power grid

Appendix A:

Assumptions and Additional Methodological Details

Preparation of DG customer sample

Starting from a raw sample of DG customer hourly data, we keep customer-years (e.g., "John Smith in 2017") that:

1. Have more than 8,000 observations/year (out of 8,760 possible) with solar installed, in order to focus on years after each customers' installation of DG
2. Have fewer than 50 missing net load hours, as a complete dataset is necessary to accurately estimate the hourly storage dispatch
3. Have more than 100 negative net load hours, as customers with too few hours of exports would likely not find storage installation to be cost-effective

A further step, we remove:

1. Customers who export for more than 16 hours consecutively, as these customers may already have storage installed or otherwise have a different (non-solar) behind-the-meter generation, which is outside the scope of this analysis
2. Customers who have negative net load on average over the entire year, as these customers would likely not find it cost-effective to install storage for the purpose of completely eliminating exports to the grid (e.g., due to a large required battery size and a need to store surplus energy exports across seasons)

Methodological details and assumptions

Storage characteristics

- Battery with 90% roundtrip efficiency
- Each DG customer assumed to install a battery system sized equal to the customer's maximum daily net export (kWh) and max net export (kW) observed in their net load data. Further, we assume all battery durations are within a 2 to 4 hour range; we increase the battery kWh or kW if necessary to satisfy this constraint
  - This results in a battery capable of storing all excess generation in any given day. Some solar curtailment may be necessary if battery is not fully discharged between days. Average curtailment across customers is 10% of pre-storage exports.

Storage dispatch

- We assume the battery discharges any stored energy immediately to offset positive net load
- Energy is discharged from the battery up to the customer's net load in any hour
- Storage is not dispatched to minimize monthly peak demand, as customers remaining on flat rate structure (i.e., exempted from the DG rate) would have no incentive to target peak demand reductions

Storage dispatch

Our storage dispatch modeling assumptions generally concentrate discharge in late evening hours, when solar output has decreased and customer energy needs are still significant

Average Annual Storage Charge/Discharge Profile Across Customer Sample