Final Report
Fargo's Smart Energy Ramp Project
NDIC Agreement R-038-048

Prepared by
The Alliance Risk Group, LLC

The Alliance Risk Group

Disclaimer – The Alliance Risk Group, LLC

Acknowledgment

This report was based on a research project that was supported by a number of organizations including The City of Fargo, eSmart Systems US, Inc., Xcel Energy Inc., Border States Industries, Inc., Kilbourne Group, MBN Engineering, Inc., Microsoft Corporation, Innowatts, Inc., Green Ways 2Go and the North Dakota Industrial Commission. However, any opinions, findings, conclusions or recommendations expressed herein are those of the author(s) and do not necessary reflect the views of these supporters.

The Alliance Risk Group

renewable ENERGY PROGRAM
NORTH DAKOTA INDUSTRIAL COMMISSION

Table of Contents

Appendices – Under Separate Cover

- **A. Final Fargo Drawings**
- **B. Specifications**
- **C. Guide to a Smart-Energy, Carbon-Reducing Commercial Package**

List of Figures

1. Executive Summary

The original proposal stated that:

> *"Fargo's Smart Energy Ramp project objective is to demonstrate, and provide a guide to developers and cities, on how a Smart Clean Energy Package ("Package") including renewable energy (e.g., solar) and artificial intelligence (AI) can add value and cost-effectively attract tenants and enhance economic development while making efficient use of the utility grid in a public-private partnership.*
> *More specifically, the City of Fargo wants to use the Package in a demonstration at the Roberts Common (RoCo) mixed use facility (City Parking ramp with a private residential and commercial wrap) as a step toward lowering costs, making a more efficient use of land, enhancing the attractiveness of downtown, and reducing carbon footprint."*

These objectives were achieved. The Smart Clean Energy Package ("Package") was installed with the components of figure 1.1.

Smart Clean Energy Package Components

15 kW of solar photovoltaic
3 smart batteries @ 15 kw-hr
10 Level 2 Electric Vehicle chargers
Smart Motion Sensor controls on all garage lighting
Smart Meter with real-time communication
to an Intelligent Demand Monitor and Controller

Figure 1. 1 Components of Smart Clean Energy Package

The Packge was operated for 12 months to achieve the targeted energy and carbon benefits. As figure 1.2 shows, the biggest benefit was the economic development benefit. Indeed, in two

Fargo Annual Benefits Pro Forma

	Annual Benefit
City of Fargo Utility Bill	$ 4,747
Gasoline Savings (Private Citizens from EV Charging)	$ 4,157
Sub-Total Net Energy Cost Savings	**$ 8,904**
Economic Development	
Regional Impact	$ 12,066,600
# Jobs	133
# Businesses benefiting from new employees	56
Total Annual Economic Benefit	**$ 12,075,504**
Annual Carbon Reduction	
lbs of CO2/year	**81,000**
Equivalent to 100,000 miles of auto driving	

Figure 1. 2 Benefits Summry

adjacent new mixed use properties, 85% of the residents came from outside North Dakota and filled 133 new jobs supporting 56 Fargo businesses -- and these smart energy technologies were a significant influence. The salaries of these people plus a modest regional economic multiplier lead to an economic development benefit exceeding $12 million.

This project did reduce the carbon footprint – off-setting the equivalent of 100,000 miles of normal automobile driving. As the use of Electric Vehicles (EVs) increases, this number is expected to continue to grow. Indeed, as figure 1.2 shows, the number of EV Charging session grew over the project. Furthermore, the use of intelligent energy management allows the battery charging to be done during periods of lower power generation costs and lower carbon-intensive generation on the power grid operated by the Midcontinent Independent System Operator. Thus, this project helps support Gov Burgum's goal of Carbon Neutrality by 2030 while accomplishing economic growth. This also shows how Smart Clean Energy Packages reinforces North Dakota's "all of the above" approach to energy options.

This project is a 2-fer:
- ***Support economic growth.***
- ***Reduce carbon footprint.***

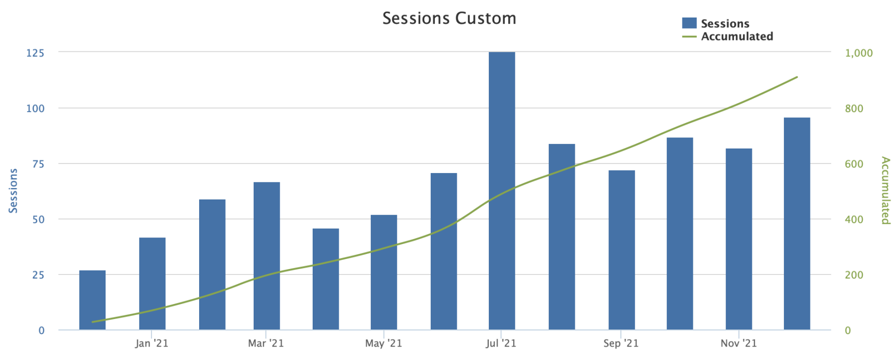


Figure 1. 3 The number of EV sessions grew each month.[1]

A discussion of the Project from the perspective of several project participants can be found at https://www.youtube.com/watch?v=JqseqGcmyTE. Furthermore, as discussed in the Section 5 "Economic Analysis", there are a number of commercial sites with new construction or major remodeling where a Package with some configuration of these components can be workable and provide similar types of economic benefits.

[1] This growth has continued into 2022. The number of charging sessions in May 2022 was 341.

2. Introduction and Background

Fargo's Smart Energy Ramp project objective was to demonstrate, and provide a guide to developers and cities on, a Smart Clean Energy Package ("Package"). The demonstration site was the Roberts Common (RoCo), a joint effort by the City of Fargo and Kilbourne Group. The RoCo project is mixed use and includes a 450+ stall parking garage, residential space with 74 apartments and townhomes, and 9,500 square feet of retail and restaurant space.

Figure 2. 1 Roberts Commons Mixed Use facility -- site for the Smart Clean Energy Package.

This Smart Clean Energy Package consists of roof-top solar, Electric Vehicle (EV) charging, battery storage, smart lighting and Intelligent Demand Control[2]. The project objective was determine if the Package could achieve both economic and carbon reduction goals. That is, could the Package cost-effectively attract tenants and enhance economic development while using clean energy to reduce carbon footprint and minimize the impact on the utility grid?

Renewable or clean energy is used to reduce carbon footprint in two ways:

a) directly, to meet building electricity needs (e.g., lighting) and
b) indirectly, through charging Electric Vehicles to reduce transportation costs and auto emissions.

Solar energy is an underutilized resource in North Dakota, since North Dakota is about the same latitude as Germany, the greatest user of solar energy in the world. With the cost of solar dropping nearly 70% and the cost of batteries dropping about 80% over the last decade, there is significant opportunity to re-examine solar energy.

[2] Intelligent control will be applied to the battery storage, EV charging, and major building loads (e.g., lighting, cooling).

Furthermore, there is a major national and North Dakota initiative to promote electric vehicles. This project sought to see how to support electric vehicle charging while managing the peak demand impacts to prevent inefficient and costly use of the electric grid.

Operational Strategy:

The operational strategy of the Package in this project is shaped by the interests and goals of the various participants.

There are three major sets of interests:

a) The City of Fargo and the developer, Kilbourne Group, are interested in enhancing the attractiveness/vibrancy of downtown while lowering costs.
b) The utility, Xcel Energy, is interested in managing the impact of renewables and EV charging on an efficient and reliable use of the grid,
c) The others (Alliance/eSmart, Innowatts, Green Ways 2Go, Microsoft, BSE, MBN) are interested in demonstrating a cost-effective intelligent, clean energy solution that meet the needs of the first two groups.

One common underlying thread across the interests and operational strategy is "precise timing in managing energy use".

- Electricity grids must be designed to insure supply and demand are in balance at all times. Therefore, the electricity utility includes a peak demand charge component (highest electricity use during any 15 minute period of the month) that often is about 20-25% of the total bill for a medium-size commercial account, such as RoCo.
- The times of solar output, EV use, and electric system need are typically not synchronized. To illustrate this, the figure 2.2 below shows that solar output typically peaks between noon and 2pm[3] whereas the MISO[4] summer electricity system demand typically peaks between 4 and 5 pm (16.00 – 17.00) and we do not know when EV Charging will peak – some results below show morning peak in business and evening peak for residences.

Since much of the tangible benefit to a developer or city come from a reduction in the electric utility bill, the ability to intelligently control or shape the timing of electricity use can drive a significant portion of the cost-effectiveness. That is, "synchronization" of electricity use and on-site supply can influence the timing of the net purchases and hence costs from the utility. Such "synchronization" can also influence the efficient and reliable use of the grid as well as maximizing the use of solar. In particular, the intelligent charging and discharging of battery storage plus control of EV charging peak demands can influence such synchronization and

[3] Germany has a comparable latitude to North Dakota and hence comparable solar output.

[4] MISO is the Midcontinent Independent System Operator, which controls the electric power grid for North Dakota and other states.

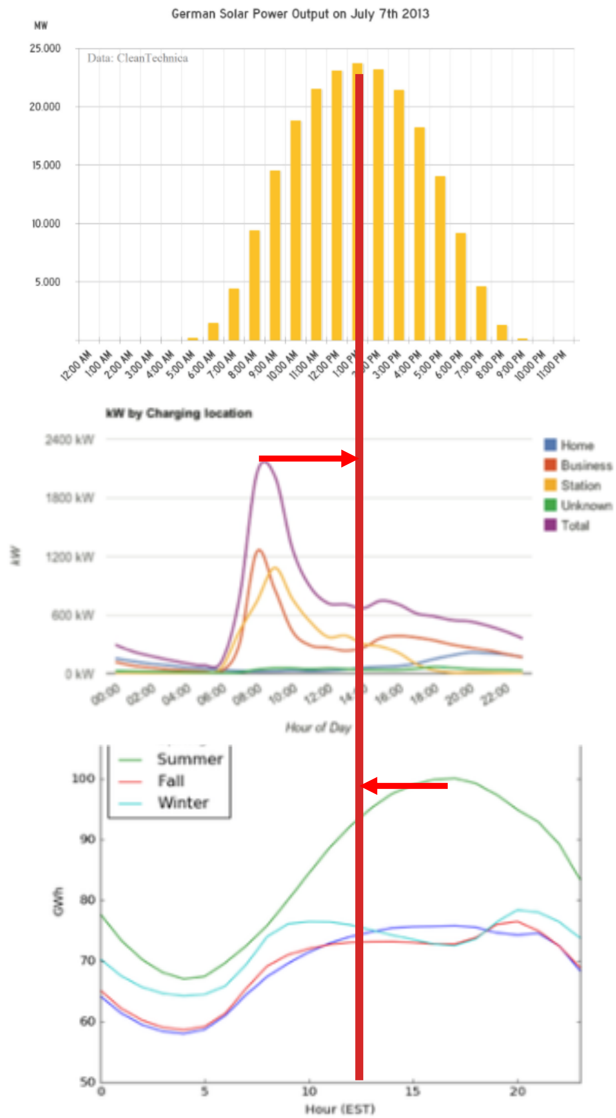


Figure 2. 2 Shifting the timing of electricity use can make better use of renewables and reduce peak demand on the electric grid.

timing of net purchases from the utility. This influences the utility bill, which in turn influences the cost-effectiveness of the Package. The AI-based systems will help provide such intelligent control and enhancing the cost effectiveness.

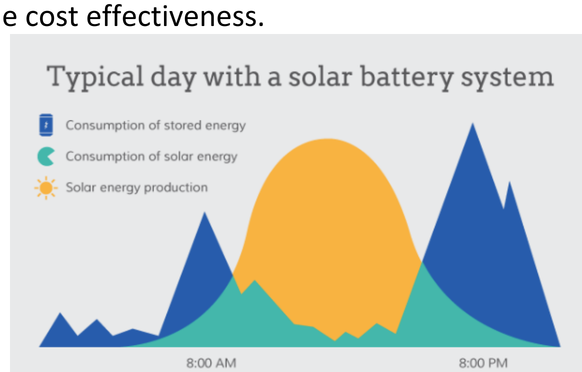


Figure 2. 3 Managing electric demand with a combination of solar energy and batteries.

As the figure 2.3 illustrates, there are times when the sun is shining when a facility will normally be using electricity (green). There may be times when the sun is shining and there is no net usage and the power would normally flow back into the grid (yellow). With battery storage we want to shift solar electricity production to other hours (blue). Typically, the cost-effectiveness of a project is enhanced by sizing the solar system and managing the facility energy production/usage so that the green area is the largest and the yellow area is the smallest of the three areas. Intelligent demand control helps achieve that.

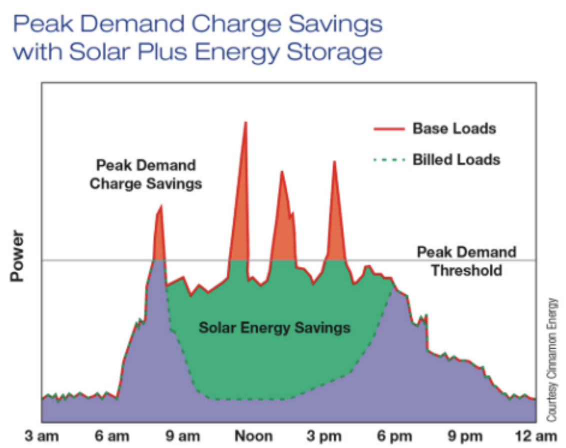


Figure 2. 4 Adding intelligent control helps control the peak demand spikes.

As noted above, another key driver of the net utility bill is the peak demand charge cost which is driven by spikes in normal demand (see "red" in figure 2.4). Such spikes could be caused by EV charging, high demand for facility heating or other usage. The intelligent control can help control the timing of the EV charging and the operation of battery storage and other loads so as to minimize those peak demand spikes.

Because the "timing" of electricity use and production is so critical, one key part of both the operation of the intelligent control and the "evaluation" of the project was the collection of electricity use data from the total facility as well as key loads (EV charging, battery operation, solar production, other loads).

3. Final Package Design

The Smart Clean Energy Package was generally configured as shown in Figure 3.1. The utility provided a meter that transmitted a Zigbee signal to a Smart Meter. That Smart Meter recorded electricity use every minute so that it could be accessed via the internet by the

Intelligent Control system.[5] Separately, the 15 kW solar photovoltaic (PV) system[6] fed power below the electric meters to reduce the net electricity use purchased from the utility. The electricity load at the facility (mainly lighting, EV Chargers and some electric heat in the parking stairwells) was wired behind three storage batteries -- each battery capable of storing 15 kWh

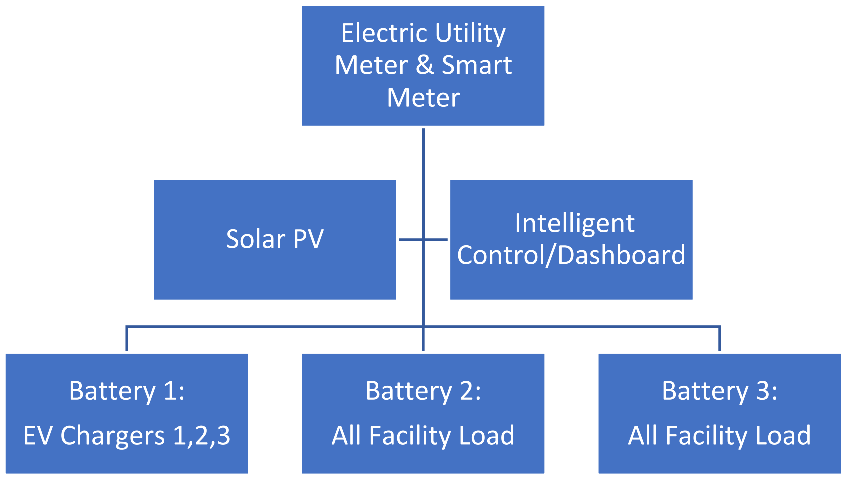


Figure 3. 1 Package Simplified Design

and able to charge or discharge electricity at the rate of 3- 7 kW (or kWh/hr). The three dual EV chargers[7] used in non-reserved parking spaces (and expected to be used most frequently) were put on their own battery in an attempt to reduce some of the electric demand spikes. The other two batteries were connected behind the main meter so that they could support load reduction across all loads. This wiring configuration also proved to be useful in providing some redundancy in battery storage capability when there were operating issues with a battery.

The downtown RoCo location is ideal for these battery chargers. With an average EV battery capacity of 40-50 kWh, it could take up to 6-7 hours to fully charge an EV battery when the EV Charger is set to a Level 2 EV charging rate of 7 kWh per hour. Downtown workers could leave their EVs at the RoCo parking garage to charge for 6-7 hours during the workday. Moreover, residents in the RoCo residential spaces (and in nearby housing) could leave their EVs there to charge for up to 6-7 hours overnight. Of course, EV users could park for a shorter time to partially charge the batteries as well.

---

[5] eSmart Systems Connected Prosumer module was initially used for Intelligent Energy Control. Effective April 1, 2021, the City of Fargo entered into an agreement with Innowatts, Inc to replace eSmart Systems. The Alliance Risk Group has an agreement with both eSmart Systems and Innowatts for a smooth transition in Intelligent Energy Control under this project. All other components of the Package are now owned by the City of Fargo.

[6] The solar PV panels were installed so as to not use any parking spaces and reduce parking revenues. However, one parking space near the Data Room (where the batteries were installed) was used to place the transformers necessary to convert from 208 3-phase to 120 volt 1-phase for the batteries.

[7] A dual charger could charge up to two EVs simultaneously. Each charger could do either a Level 1 charge (at about 3.6 kW) or Level 2 charge (at about 7.2kW).

The Intelligent Control system received electricity usage information not only from the smart meter, but also from the PV system and the battery storage units. This allowed the Artificial Intelligence capability in the smart system to better monitor and forecast electricity usage patterns and to execute an intelligent control strategy. The intelligent control capability in the EV Chargers and battery storage was also used.

As noted in the previous section, there are several types of intelligent control:

- Reduce RoCo Facility peak demand and energy use based on the current General Service demand-energy rate from Xcel Energy.
- Manage usage upstream on the power grid (Midcontinent Independent System Operator -- MISO):
    - Monitor forecasted hourly costs (and reliability) to optimize battery charging and discharging to minimize the wholesale costs in a type of synthetic real-time pricing. The costs to supply power some hours can be typically 25% - 50% higher – and sometime 3000+% higher during critical conditions.
    - Monitor forecasted hourly carbon intensities of grid power to optimize battery charging and discharging so as to reduce the carbon footprint of grid level power plants serving the RoCo facility. In the future with a greater diversity in MISO fuel mix, there could be over 25%- 100% variation in carbon intensity of various hours.[8]

Just as helpful as the intelligent control, is the Dashboard information. Figure 3.2 illustrates an indicative Dashboard – which shows the system status of key equipment, the carbon impact and energy use impacts from the Package. This allows humans to see if there is any major change in equipment performance as well as monitor the progress in carbon and energy savings.[9]

[8] The variations in hourly costs and carbon emissions are discussed further in Section 4 and 5.

[9] Fig 3.2 shows an average daily kWh usage from June 1-10, 2022 of 155 kWh per day. That is almost 6x the average EV charging consumption during the test period of 28 kWh per day.

System Status

Rainforest (Facility Meter)	**Good**
Solar Panels	**Good**
EV Chargers	**Good**
Batteries	**Good**

Carbon Footprint (June 2022)

Parking Garage*	4,227
Carbon offset from PV	- 1,300
Carbon offset from benefits of EV	- 2,329
Net Carbon Footprint	**598 lbs CO2**

EV Charging and Solar Generation has saved an estimated **3,629 lbs of CO2** between June 1 - June 10, an **86% reduction**.

*Excludes Consumption from batteries, EV and PV (Baseload)

Usage Insights

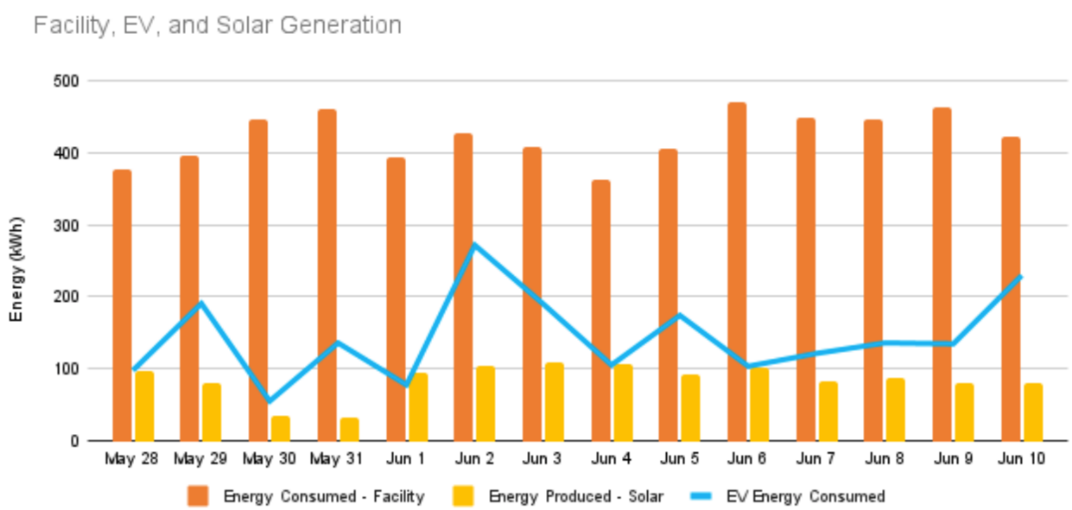


Figure 3. 2 Indicative Dashboard Shot displaying Carbon Impact and Electricity Use.

More details on the Package Design can be found in Appendix A, which shows the engineering drawings. Furthermore, the specifications for the equipment are provided in Appendix B.

3.a Equipment Design Lessons Learned

In designing this contract, we tried to balance using leading edge technology and using local ND suppliers and contractors. That worked well with the exception of some challenges with battery storage. These challenges, along with the supply chain and work force challenges of COVID-19 delayed the project. For example, we wanted battery storage technology with remote communications and intelligent control capability. That limited the number of options. Local supplier Border States Electric worked with us to source such a battery company. Because of the leading-edge nature of this project, we needed the best experts for applying storage technology – and such experts for the vendor were located mainly on both coasts. Because of this and then the COVID-19 situation, it took longer to do most battery storage related tasks: finalize best location in RoCo for the batteries (e.g., the batteries needed conditioned space to protect from extreme conditions), battery specifications, wiring diagrams, intelligent control strategies and the acquisition and installation of the batteries.

Since this demo project began, the battery market has matured more and there is greater expertise in the Upper Midwest to support battery installations.

3.b Equipment Promotion

There were four main threads in promoting the Package.

First, a special event on December 9, 2020 was held with five EV users coming to highlight the opening of the EV Charging at RoCo. General information was provided to local civic and environmental groups. Also, to entice EV users, there was no incremental charge for use of the EV Chargers – just the normal parking fees.

Second, information about these EV charging stations was posted on many EV websites such as https://chargehub.com/en/countries/united-states/north-dakota/fargo.html and https://evstationslocal.com/states/north-dakota/fargo/ . Furthermore, the EV Charger supplier with a national network, ChargePoint, provided a nice article on the project -- https://www.chargepoint.com/blog/norway-north-dakota-fargo-puts-ev-charging-map-upper-midwest .

Third, a couple videos were created and posted on the City's YouTube channel to promote the entire project: https://www.youtube.com/watch?v=Zme8VQ9Azt8 and https://www.youtube.com/watch?v=JqseqGcmyTE .

Fourth, local residential property managers begin discussing the Fargo Smart Energy Ramp to prospective renters. The "remote work" around the COVID-19 situation allowed many people to consider re-locating to Fargo. And the property managers found that highlighting the Smart, Clean Energy Package, especially the EV Chargers, helped in convincing people to relocate to Fargo from outside North Dakota. Section 5.b provides further insight on this.

3.c Equipment Performance

This equipment generally performed as expected. A discussion of each component of the system is included below:

Photovoltaic Solar (PV)
This system performed as expected. Indeed, the annual kWh output for the PV system was within 2-3% of what PVWatts, the PV design model predicted it should be. See the United States Department of Energy, National Renewable Energy Laboratory website link https://pvwatts.nrel.gov/. There was one minor issue -- repairs were needed on the communication link for one of the 48 microinverters.

Electric Vehicle (EV) Charging
The EV Charging system worked as expected. The only problem experienced was a broken charger hook – seemingly caused by a user backing their car into the EV charger. That EV charger has been restored to working order.

Smart Lighting Controls
The Smart Lighting controls have performed fine after some fine-tuning on the motion sensor settings.

Smart Metering
The smart meter provided by the utility to provide near-real time data via Zigbee signal has worked since installation. The smart gateway, which received the Zigbee transmission and forwarded it over the internet to our Intelligent Demand Control, performed perfectly with the exception of one brief downtime. Service was quickly restored and all data was recovered.

Intelligent Demand Control
This performed well for the portions of the test for optimal control under MISO real-time pricing and MISO hourly carbon intensity scenarios. (See sections 4.d and 4.e.) When we shifted to alternate demand control strategies (e.g, control of peak billing demand), we had a couple issues. The root cause of the problem was the fact that the control algorithm had been designed for a 60-minute billing demand, which is common in Northern Europe. A 15-minute billing demand is typically used in the US. We compensated for this by using intelligence in the EV Charging and battery systems plus human intelligence in the monitoring the results on the dashboard. The combined system was working well as the test period was ending.

One other complicating factor was that there was a change in Intelligent Demand Control providers partway through the field testing. Fortunately, there was a continuity in project managers to minimize the impact of the change-over.

Dashboard
The new Intelligent Demand Control partner provided a dashboard which the City found useful in monitoring over-all equipment performance as well as the project-related activities.

Battery Storage
We had three batteries. They performed well In the first part of our operations and with the Intelligent Demand Control under the MISO hourly scenarios. When we tried some other demand control strategies (e.g., controlling the 15-minute billing demand), as noted above, we needed to make some modifications in the communications and operations of the batteries – and there were some subsequent challenges. Most of those issues were related to communications or control setpoints, which seemed to affect mainly one battery. The battery system was functioning at the hand-off of operations to the City.

4. Evaluation of Electricity and Carbon Impacts

Projects are evaluated based on the objectives for the project. The primary objective of this project is to demonstrate how a Smart, Clean Energy Package can reduce carbon footprint and cost-effectively attractive tenants and enhance economic development while making efficient use of the utility grid. This section focuses on the electricity use impacts which drives both the carbon impact and efficient grid use. Section 5 evaluates the economic benefits.

This section focuses on evaluating the electricity use and carbon impacts by quantifying the:
- Energy supply contributions of on-site clean energy equipment (on-site solar power, electric vehicles, smart efficient lighting and
- Change in wholesale grid renewables such as large-scale wind and solar).
- Reduction in carbon footprint, which also attracts tenants and businesses.

This section is structured to show impacts under normal control strategies based on:
- kWh energy usage at RoCo -- in total and by type of clean energy equipment,
    - and associated carbon impacts
- kW peak impacts at RoCo – in total and by type of clean energy equipment, and
- MISO grid real-time pricing
- MISO grid hourly carbon intensity.

4.a kWh Energy Usage

There are three basic means to impact RoCo on-site total kWh use and also reduce carbon:

a) on-site renewables (e.g., solar PV)
b) efficiency (e.g., smart lighting)
c) electrification (e.g., EV replace gasoline cars).

The first two *reduces* kWh usage at the RoCo site and the third one *increases* kWh usage at RoCo. These three means are reflected in Figure 4.1 which shows the monthly kWh impacts for the major measures.[10]

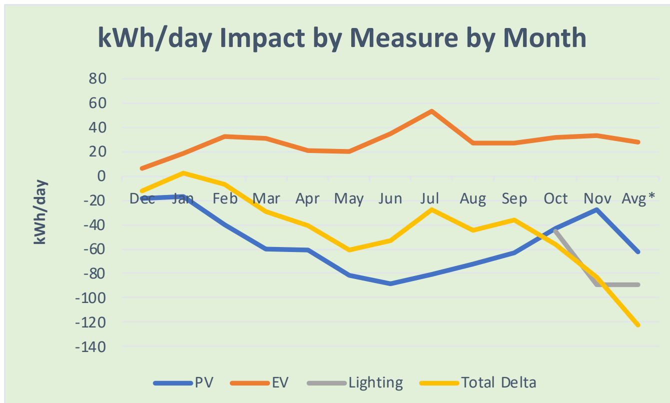


Figure 4. 1 Energy Impacts by Clean Energy Measure

The Solar Photovoltaic (PV)[11] and Electric Vehicle (EV) Charging impacts in Figure 4.2 were based on metered data. The Smart Lighting impact was calculated based on changes in total site kWh usage after controlling for weather and EV usage. Note also that the Smart Lighting was not fully implemented until November 2021 due to a variety of reasons.[12]

Billing Month	PV	EV	Lighting	Total Delta
Dec	-19	6		-12
Jan	-17	19		2
Feb	-40	33		-7
Mar	-60	31		-29
Apr	-61	21		-40
May	-81	20		-61
Jun	-88	35		-53
Jul	-81	53		-27
Aug	-72	27		-45
Sep	-63	27		-36
Oct	-43	32	-45	-56
Nov	-27	33	-89	-83
Avg*	-62	28	-89	-123

Figure 4. 2 kWh/day Impacts by Month and Clean Energy Measure

[10] The other major measures in this project – battery storage and intelligent control – are used to impact the peak kW demand or hourly usage of the measures and accordingly are discussed below.

[11] As an aside, we note that the annual kWh output for the PV were within just a couple 2-3% of what PVWatts, the PV design model predicted it should be for a 15 kW system. See the United States Department of Energy, National Renewable Energy Laboratory website link https://pvwatts.nrel.gov/.

[12] Smart Lighting was technically more easily separated from the project and so it was originally separated due to the timing of co-funding. COVID and a change in project ownership lead to further delays so that the lighting was not fully operational until November, 2021. Thus, this leaves a data gap on lighting use. However, lighting efficiency impacts can typically be more reliably estimated than other measures.

Because the PV decreased the RoCo site usage and the EV increased site usage, during the late fall and winter months the PV and EV largely off-set each other. During the summer months the PV provided a net reduction in kWh usage. And the full implementation of Smart Lighting lead to a greater net reduction in kWh usage. Of course the net kWh usage balance will change as there is increased usage of the EVs.

Figure 4.3 below shows what the expected total site usage (or baseline) of the RoCo facility would have been if these measures had not been in place . These numbers were very consistent with utility billing information. We calculated the 2021 Gross or baseline (see grey line in Figure 4.3) by taking the Net Total Site Usage based on the Utility bills (see orange line in Figure 4.3) and adding in the Measure impacts (see Figure 4.2). The calculated 2021 Gross is consistent with the 2019 utility billing data before any of these Clean Energy measures were implemented.[13]

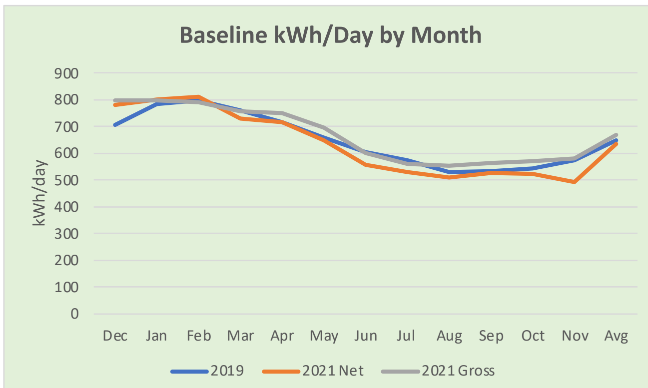


Figure 4. 3 Projected Baseline Usage "fits" the Utility Bill Data

4.b Carbon Savings from modifying kWh Energy Usage

The kWh usage analysis above allows us to calculate the carbon savings from the three basic Clean Energy measures – PV, EV, Smart Lighting. Figure 4 below illustrates those calculations. To calculate a Baseline CO2 usage from the electricity use at RoCo, we used the annual average kWh/day of 668 from Figure 4.3. We multiplied that by the annual average Carbon Intensity of the electricity production in the MISO North grid which serves Fargo – 1.25 lbs of CO2 per kWh of electricity generated[14]. Multiplying these two quantities yields a baseline amount for RoCo electricity use of 835 lbs of CO2 per day. Note that this MISO North mix includes almost 30% of output from coal and 13% from renewables – mostly wind.

The daily average output of the PV system was 62 kWh. Since this off-sets grid electricity, the PV system averages a CO2 savings of 78 lbs/day. Similarly, the 89 kWh daily savings of Smart Lighting yields a daily savings of 111 lbs.

[13] The 2020 utility billing information had a bigger difference from the 2019 billing data than the 2021 Gross. The 2020 data seemed to be affected by temperature, COVID and other things.

[14] https://www.epa.gov/sites/default/files/2020-01/documents/egrid2018_summary_tables.pdf We used the MROW number. Innowatts also captures hourly carbon intensity numbers.

The EV calculation is slightly more complex. The EV charging actually increases electricity use by 28.2 kWh per day and grid CO2 footprint by 35.3 lbs/day. However, the use of EVs off-sets the need to operate gasoline powered vehicles. At 3 kWh/ mile[15] the EVs are off-setting 85 miles per day. Since a normal gasoline-powered car produces 0.81 lbs of CO2 per mile, [16]it would have produced 68.5 lbs of CO2 for those 85 miles. Combining the CO2 from increased grid electricity use from EV charging (35.3 lbs/day) with the corresponding decreased CO2 from reduced gasoline car usee (68.5 lbs/day) yields a net savings from EV charging of 33.3 lbs/day.

RoCo Carbon Calcs	**kWh/ day**	**Intensity lbs CO2/kWh**	**EV mi/kWh**	**# mi**	**Gasoline Car CO2/mi**	**Carbon lbs/day**	**Carbon Savings %**
RoCo Daily Avg Baseline	668	1.25				835	
Measures:							
Solar Photovoltaic Output	-62	1.25				-78	-9%
EV Charging @**1.75%** capacity							
-- increased electric use	28.2	1.25	3	85		35.3	
-- decreased car emissions				-85	0.81	-68.5	
Combined						-33.3	-4%
Smart Lighting Controls	-89	1.25				-111.25	-13%
Site Net Total	545 *						
Current Carbon Footprint						613	
Impact/Savings -- lbs CO2/Day						222	**27%**
Impact/Savings -- lbs CO2/Year						81039	
Annual Car Miles Equivalent Savings						100,049	

* Reflects the impact of Smart Lighting Controls for a full Year.

Figure 4. 4 Carbon Savings in test period from RoCo on-site Clean Energy Measures

Combining all three (PV, EV, Smart Lighting) yields a total savings of 222 lbs of CO2 per day, which is about 27% of the RoCo baseline carbon use. If we determine the total annual impact, the savings are about 81,000 lbs of CO2. This is the equivalent of off-setting about 100,000 miles of driving in a gasoline car. Thus, even though fossil fuel is a significant part of the MISO North generation fleet, shifting to EV's still reduces the carbon footprint.

We expect the EV chargers to become more fully utilized over the next several years. Indeed, the EV charging jumped from an average of 28 kWh/day during the test period (Dec 2020 – Nov 2021) to 155 kWh/day on June 1-10, 2022 (as shown in figure 3.2). That over 5.5-fold increase

[15]https://pushevs.com/electric-car-range-efficiency-epa/#:~:text=Electric%20car%20range%20and%20efficiency%20%28EPA%29%20%20,19%2C6%20kWh%2F100%20km . Also see https://ecocostsavings.com/average-electric-car-kwh-per-mile/ .

[16] This number is in the range of numbers such as https://css.umich.edu/publications/factsheets/sustainability-indicators/carbon-footprint-factsheet and https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle#driving

translates into an annual average EV Charging Utilization[17] of almost 10%. On that basis, we could easily see the EV Charging Utilization increase to 17.5%. Figure 4.5 below shows how this 17.5% utilization leads to a 62% reduction[18] in the RoCo's electricity use carbon footprint or off-sets 235,000 miles of normal gasoline car driving.

RoCo Carbon Calcs	**kWh/ day**	**Intensity lbs CO2/kWh**	**EV mi/kWh**	**# mi**	**Gasoline Car CO2/mi**	**Carbon lbs/day**	**Carbon Savings %**
RoCo Daily Avg Baseline	668	1.25				835	
Measures:							
Solar Photovoltaic Output	-62	1.25				-78	-9%
EV Charging @**17.5%** capacity							
-- increased electric use	282	1.25	3	846		352.5	
-- decreased car emissions				-846	0.81	-685.3	
Combined						-332.8	-40%
Smart Lighting Controls	-89	1.25				-111.25	-13%
Site Net Total	799 *						
Current Carbon Footprint						314	
Impact/Savings -- lbs CO2/Day						522	**62%**
Impact/Savings -- lbs CO2/Year						190351	
Annual Car Miles Equivalent Savings						235,001	

* Reflects the impact of Smart Lighting Controls for a full Year.

Figure 4. 5 Carbon Savings with increased EV Charging

4.c kW Peak Impacts and Hourly kWh Impacts

The above discussion focused on total kWh or energy usage impacts. However, electric utilities must build capacity (generation, transmission and distribution capacity) to meet the peak demands. As a result, most commercial customers in Fargo face a "demand charge" based on the highest kWh usage during any fifteen minutes of the billing month[19]. This usage is called "demand" and is typically expressed as "kW", which utilities typically compute as multiplying

[17] EV Charge Utilization is defined as the kWh of electricity used during a time period (e.g.,. a year) divided by what thee kWh usage would have been if the EV Charger were operating at Level 2 charging the whole time. By this definition achieving 100% utilization is practically impossible for several reasons -- e.g., EV cars are connected to the charger when not charging, there typically is a time delay between when one car has finished and left and before the next car arrives.

[18] The dashboard in figure 3.2 is a gross reduction in carbon reduction vs a net reduction in this analysis. The difference is this analysis considers the increase in carbon emissions from the electricity used for charging the EVs.

[19] Because different meters are read om different days of the month (e.g., one electricity meter is read on the 5th and another meter is read om the 25th, the concept of "billing month" is used to reflect time time from one meter reading to the next – which is the time period on which the utility "monthly" invoice is based.

the fifteen-minute peak kWh usage by 4. If the highest fifteen-minute kWh usage were 10 kWh, then the peak demand would be 40 kW (= (10 kWh per fifteen-minute period) x (4 fifteen-minute periods /hour).

Standard meters for small-medium commercial customers in North Dakota do not show track which fifteen-minute period during the billing month the highest demand occurred. Therefore, for us to evaluate the impact on peak demand, we first needed to review the smart meter data which showed kWh usage for all fifteen-minute periods during the billing month. Then we determined on which day and in which fifteen-minute period during the day had the electricity usage during the billing month. In addition, we determined what the electricity use during those fifteen-minute periods would have been without the presence of the relevant Clean Energy measures (PV, EV, Battery Storage).

In billing month May 2021[20] the highest demand without the Clean Energy measures ("Gross Demand") would have been 45.7 kW at 8:30 am on May 11, as Figure 4.6 shows. The actual net demand was 35.5 kW for a 22% reduction.

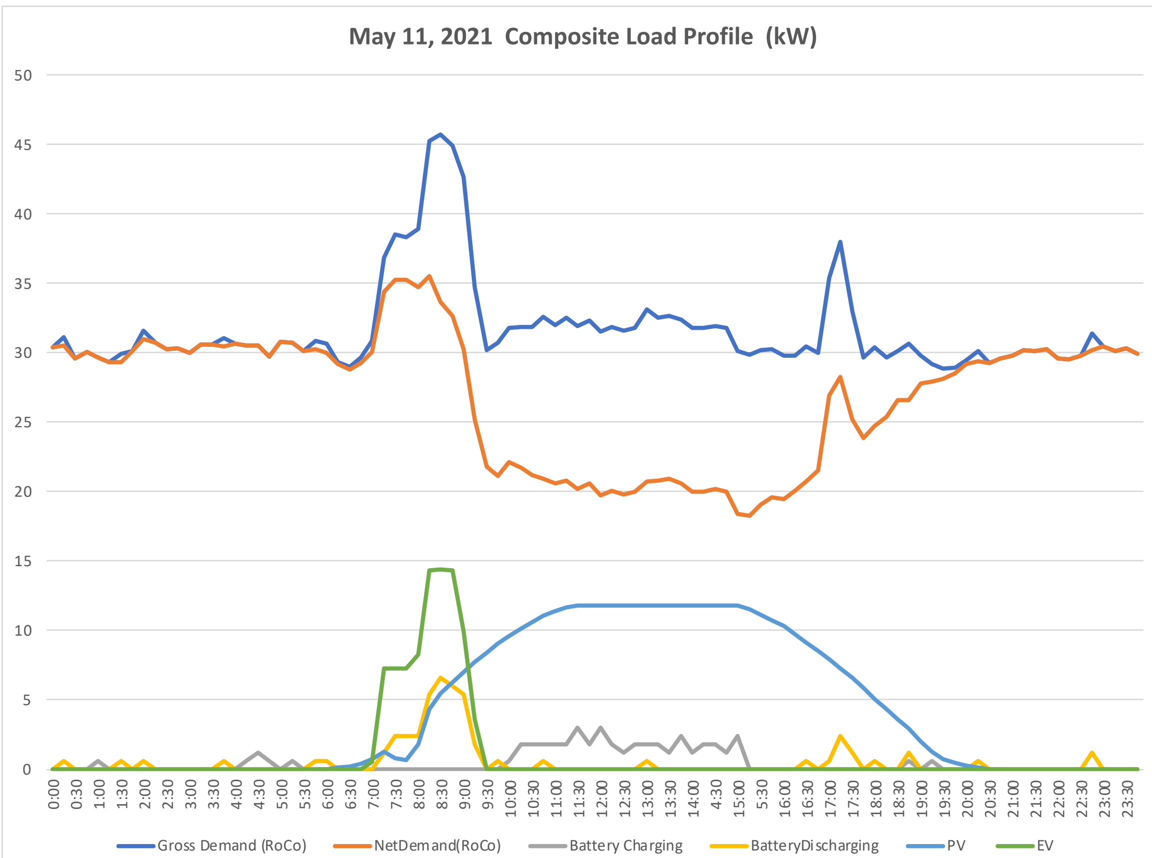


Figure 4. 6 Composite Demand (Load) Profile for the Peak Day in May, 2021

[20] The May 2021 billing month was chosen because it is a simple example that most straightforwardly illustrated the points in this paragraph. Also, to be clear the "billing month" is the time between days on which the utility (Xcel Energy) read its billing meter (April 28 and May 27). These days (April 28 – May 27) did not correspond to the calendar month.

They are several observations about Figure 4.6 worth noting. First, the EV charging is what created the peak demand at that time. The demand (or load) for EV charging (14.4 kW) was the highest for the day at 8:30 am. The load the rest of the day, with one exception[21], was relatively flat around 30 kW. Second, note that two Clean Energy measures[22] (PV and Battery Storage) created the demand reduction at this time. In particular, the PV supplied 5.5 kW to the demand reduction at the utility meter and the discharge of the battery storage supplied 6.6 kW for a total demand reduction of 12.2 kW. (See This 12.2 kW nearly off-set the 14.4 kW from the EV charging.

A third observation about Figure 4.6 is the timing of the battery charging. It was mostly done from 10 am to 3 pm when the PV had its highest output. This kept the battery charging from setting a new peak demand.

Figure 4.7 shows that the EV charging load profile for the first 6 months of the pilot (Dec 2020 – May 2021) is generally consistent the EV charging load profile in Figure 4.6. The peak usage is between 8:30 – 10:00, although there is some usage throughout the day.

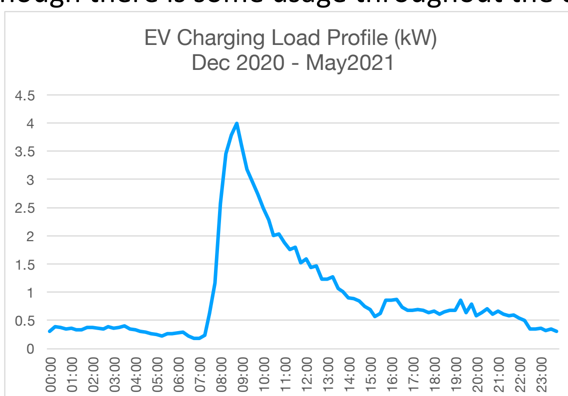


Figure 4. 7 Average EV Charging Load Profile for the first six month.

Figure 4.8 shows that there has been growth in the use of the EV charging. Indeed, the charging Sessions have grown from 22 in Dec 2020 to 127 in Dec 2021. The regression equation shows that there was an average increase of 7 (6.945) Sessions per month.[23]

---

[21] Most of the load at RoCo during May was lighting. During winter, early spring and later fall, electric space heating of the stairwells could also contribute to the load profile. Periodically fans and other auxiliary equipment would operate – this appears to be the case around 5:15 pm (17:15).

[22] The Smart Lighting was not in effect at this time. That made the kW and load profile analysis crisper as the other Measures (PV, EV, and Battery) had internal sub-meters for tracking their 15 minute usage. There was no direct sub-metering of the lighting, as noted above.

[23] Update: In May, 2022 there were 341 sessions. This equation would have predicted 152, so there has been exponential growth in the use of the EV chargers since the conclusion of the test period.

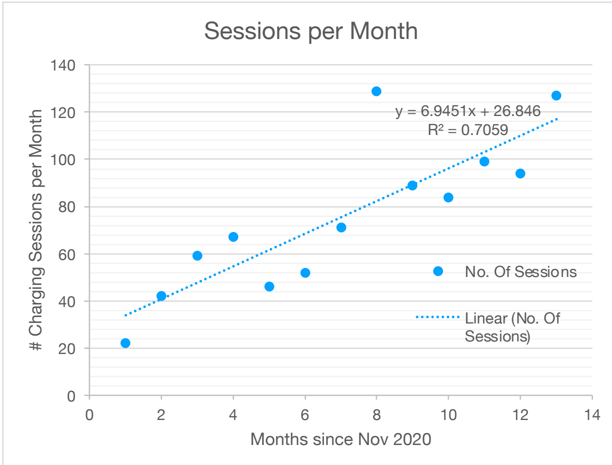


Figure 4. 8 Growth in EV Charging Sessions over time.

Not surprisingly this growth in sessions lead to a growth in energy use (from 22 kWh/day in the first six months to 35 kWh/day in the second six months). Correspondingly, the charging was used more in the afternoon and early evening. For example, the average usage at 18:30 in the first six months was 0.6 kW, but was 2.3 kW in the second six months – almost a 4x increase. But the peak demand, as Figure 4.9 shows, still stayed at around 4 kW around 9 am. This is good news in terms of getting greater use from the chargers throughout the day without putting extra stress on the power grid. But it also means peak demand control becomes more challenging as a double peak emerges. Indeed, in the last 6 months the highest demand days typically occurred when there was proportionately more car charging – which typically occurred in the early evening.

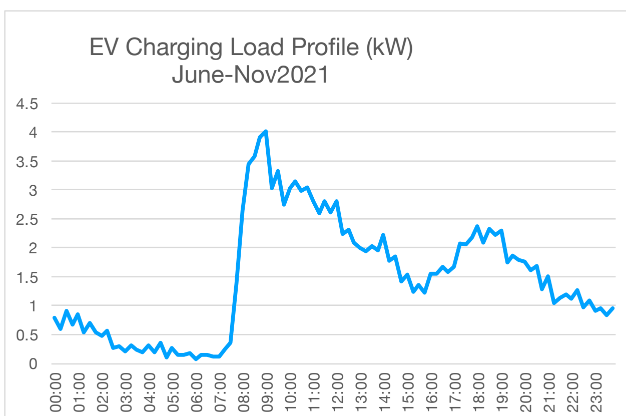


Figure 4. 9 Average EV Charging Load Profile the last six month

Figure 4.10 illustrates the increased demand from EV Charging in the early evening for June 28 -- see green curve. At 19:00 the EV Charging would have set the peak kW for the billing month if not for intelligent discharging of the battery.

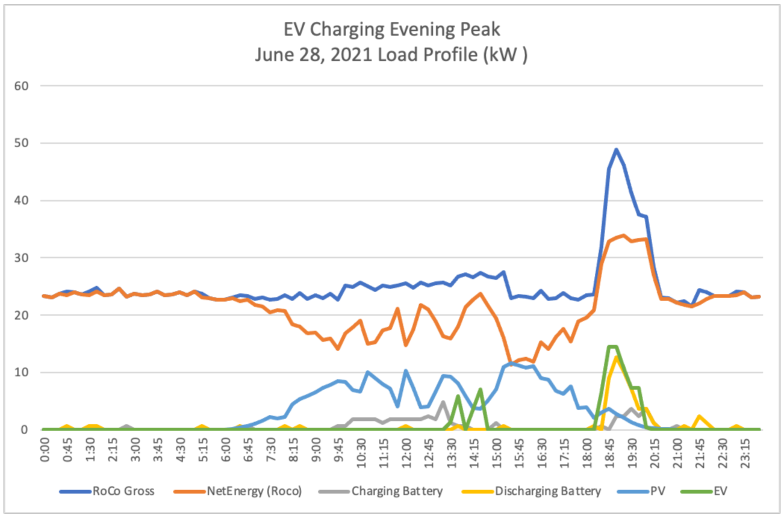


Figure 4. 10 EV Charging Load Profile – Evening Peak

4.d MISO Grid Real-Time Pricing Control

One project requirement was to use the Intelligent Demand Control to minimize wholesale or MISO hourly costs under a type of real-time pricing. This capability could provide extra generation cost savings to the utilities and its customers.

Electricity supply and demand must balance each second to maintain reliability. To help balance supply and demand, large grid operators (like the Mid-continent Independent System Operator (MISO) which serves eastern North Dakota) conducts a wholesale market for each hour of the next day (Day Ahead market.) They also conduct a real-time imbalance market for each upcoming 5 minutes.

In this project, we used the MISO hourly prices from the Day Ahead market for the week of January 27, 2019. During that week the MISO had emergency conditions and extra high prices (e.g., January 30, 2019) as well as normal winter days (e.g., January 29, 2019). Thus, the hourly prices of January 29 and 30 in 2019 were applied to February 16 and 17, 2021, respectively.

Figure 4.11 provides several interesting observations. First, the wholesale MISO price (orange) had two high price times – 6:00 -7:30 am with prices around $34/mWh (or $.034 /kWh) and 16:30 – 20:00 with prices around $44/mWh. This is typical as power plants must ramp up to meet the early morning and evening peak demands. A second observation is that the intelligent control algorithm discharges (see blue lines) up to 26 kW from the batteries during these high priced hours. A third observation is that we can see the major drops in Net Demand (gray line) at 6:00 am and 17:00 when the battery discharges.

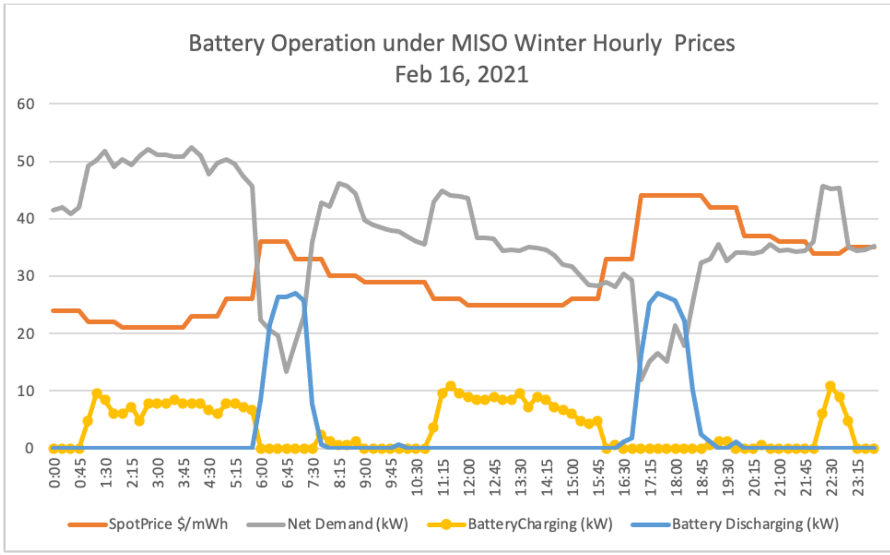


Figure 4. 11 Battery Charging and Discharging under indicative MISO Winter Hourly Prices

A fourth observation is that the intelligent control algorithm charges the batteries (see yellow lines) during the low cost times – 1:00 – 5:00 am with prices around $23/mWh and 11 am – 3pm with the prices around $25/mWh. This causes the net demand to be around 8 kW higher than it otherwise would have been during those low price times. This provides a benefit of flattening the MISO system load and reducing the ramping requirements on thermal plants like coal and natural gas – and allowing them to operate more efficiently and to reduce their "wear and tear". This is like car engines operating more efficiently and having less "wear and tear" when operating on flat ground versus up-and-down mountainous roads.

A fifth observation is the hours of MISO system peak and high costs do not necessarily match the hours of peak demand at the RoCo garage. For example, the MISO morning high cost period is 6:00 – 7:30 am but the RoCo peak demand is typically from 8:00 to 10:00, as figure 4.6 shows. The evening peak is typically closer – typically the MISO high cost starts around 17:00 while the RoCo charging peak is closer to 18:00.

The last observation is that improved utility costs savings is possible from more precise control of intelligent battery charging and discharging that is better synchronized to MISO system costs. These savings are about $11/mWh (=34-23) in the morning and $19/mWh (=44-25) in the evening on this day. About 10% of the RoCo daily load was shifted.

The emergency days provide a higher value benefit. The "2019 State of the Market Report" by the MISO Market Monitor observed, as reflected in Figure 4.12, that on January 30, 2019:
"MISO issued a Maximum Generation Event in the North and Central regions [including North Dakota] because extremely cold weather resulted in a sharp decline in wind output, issues with transmission elements (circuit breakers, and uncertainty regarding forced outages that may result from the cold temperatures."[24]

[24] https://www.potomaceconomics.com/wp-content/uploads/2020/06/2019-MISO-SOM_Report_Final_6-16-20r1.pdf

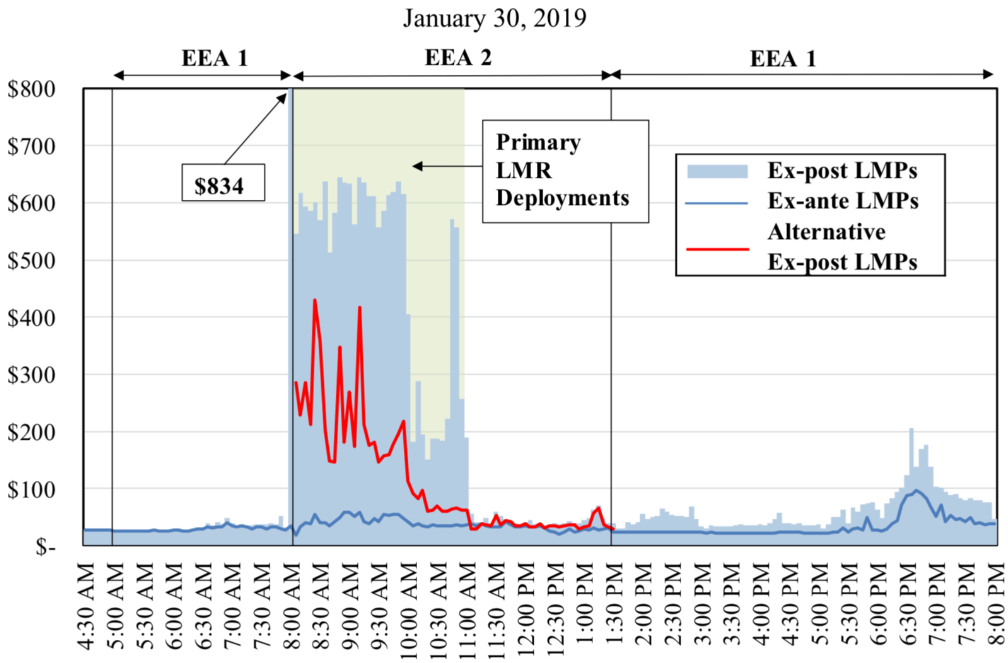


Figure 4. 12 MISO prices on the Emergency Winter Day, January 30, 2019

As Figure 4.12 indicates, an Emergency Energy Alert (EEA) was issued by MISO at 5 am to take effect at 8 am. This also included an increase in the Locational Marginal Prices (LMPs) from near $70/mWh to as high as $834 but averaging near $600/mWh (60¢/kWh) from 8:00-10:00.

Figure 4. 13 shows the charging and discharging of the battery on February 17, 2021 to operate under emergency prices of January 30, 2019. This included telling the Intelligent Demand algorithm at 5 am that the hourly prices from the day before had been changed. The net result – no material change in battery charging and discharging from normal operations. The normal spread of prices between low and high price hours was enough to shape the actions of the Intelligent Demand algorithm.

But there are observations about EV Charging and PV operations worth noting in Figure 4.14. First, note that there was significant EV charging from 7:45 to 10:00 – up to 14 kW.
This could be curtailed in future emergency situations – helping both the grid and potentially lowering City costs under the right utility pricing options. Second, even though it is winter, there is still 30 kWhs of electricity supplied by the PV which can have emergency value to the City. This could be used to back-up the on-site emergency generators, which serves many City IT resources. It could also be used in the future for charging critical City-owned EVs if there were prolonged outages such as in Texas in February 2021.

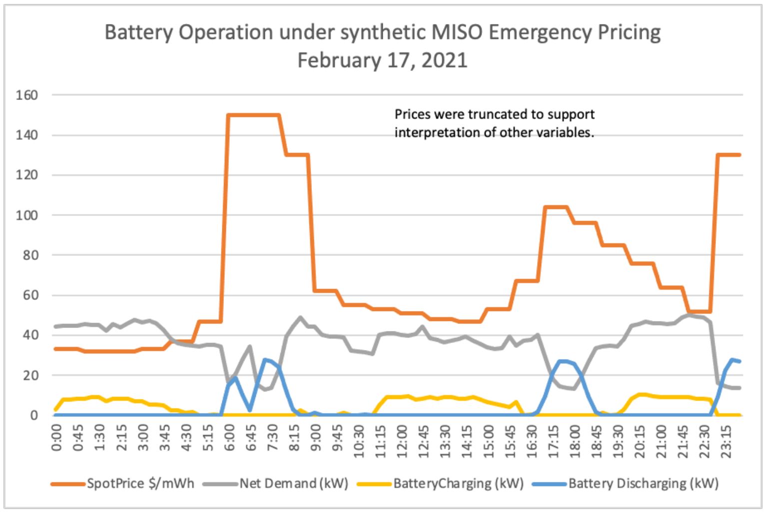


Figure 4. 13 Battery Operations under Emergency Winter Prices

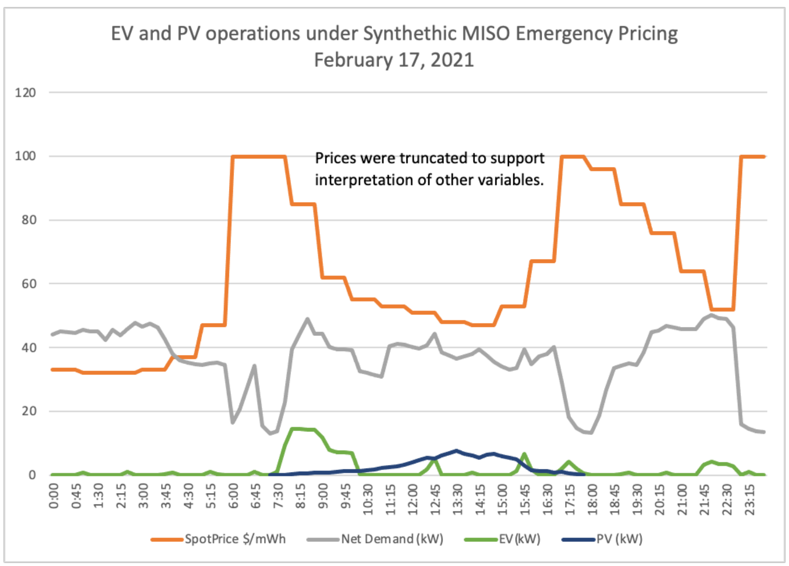


Figure 4. 14 EV and PV Operations on a MISO Winter Emergency Pricing Day

4.e MISO Grid Hourly Carbon Intensity

Another reason for using intelligent demand control is to shift electricity use to hours of higher wind and solar on the MISO grid and thereby reduce the average carbon footprint of power supply. In February 2020 MISO foresaw the possibility of up to 40% grid level and distributed renewables by 2033.[25] (see Figure 4.15.)

---

[25] https://www.lec.mn.gov/2020/MISO%20for%20MN%20LEC%20Feb%202020%20vf.pdf

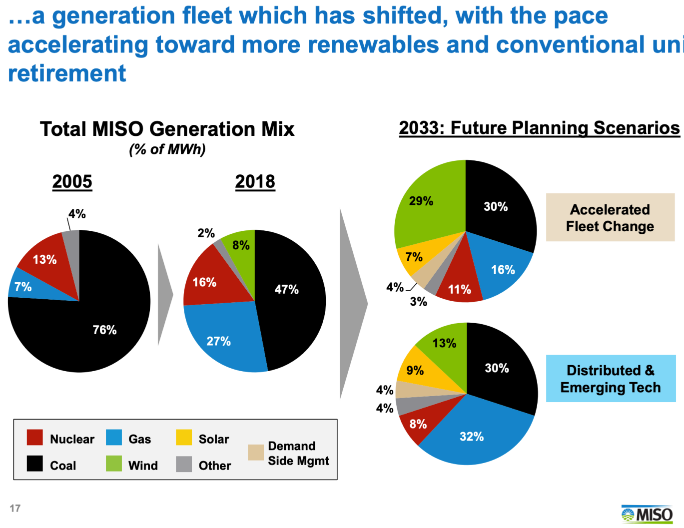


Figure 4. 15 MISO foresaw up to 40% renewables

One of the challenges of increased renewables is increased variability of supply and greater challenges for MISO to retain grid stability. Figure 4.16 highlights MISO's desire to have increased flexibility, such as intelligent demand control can provide.

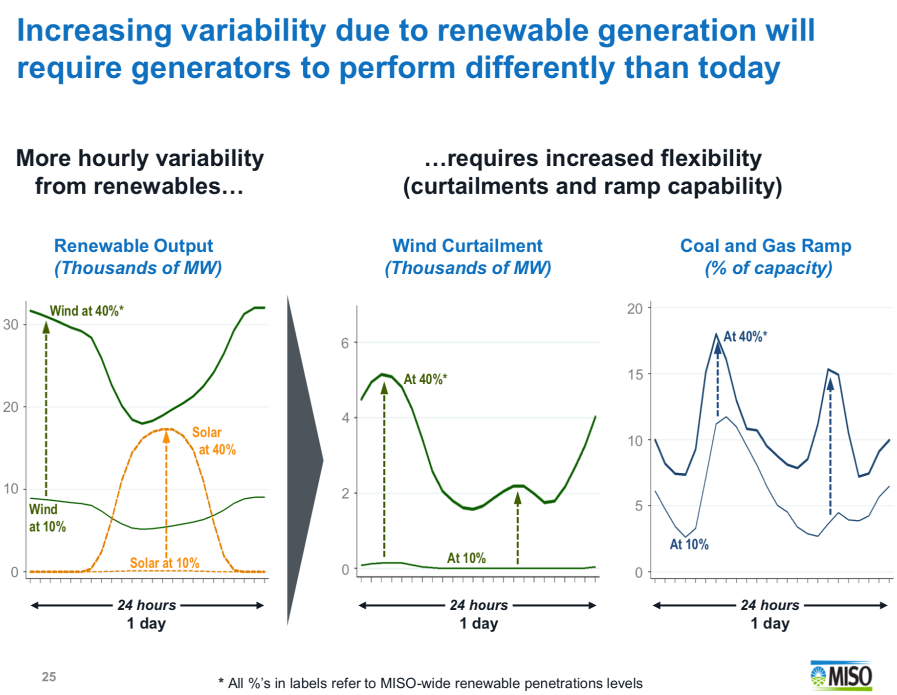


Figure 4. 16 MISO says Increased Renewables requires Increased Flexibility

Furthermore, as Figure 4.17 highlights, MISO saw North Dakota as one of the places particularly vulnerable to power system stability issues without action. A conventional solution is increased transmission lines. An alternate or complementary solution is Demand Flexibility, such as provided by storage and Intelligent Demand Control.

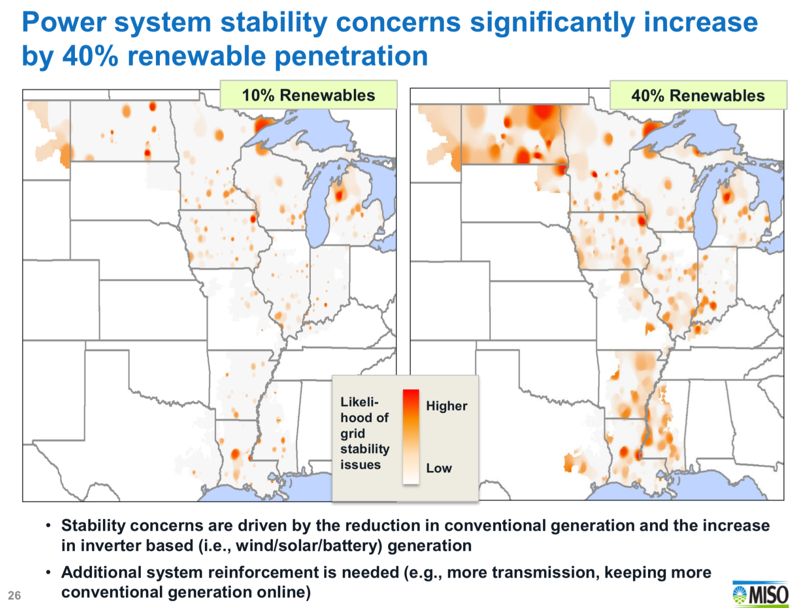


Figure 4. 17 North Dakota is particularly vulnerable without action.

In the set of summertime scenarios, we refined our pilot to using Intelligent Demand Control to focus on shifting load to hours of high renewable production so as to reduce carbon footprint and also enhance grid stability and local resiliency.

The scenario was created by starting with the hourly outputs of solar and wind on the MISO grid from July 30 – August 5, 2021. These were scaled up so that solar provided 10% and wind provided 30% of the total kWh produced, consistent with the MISO scenario of figure 4.15. Then the percent of non-renewable output was created for each hour. [26]

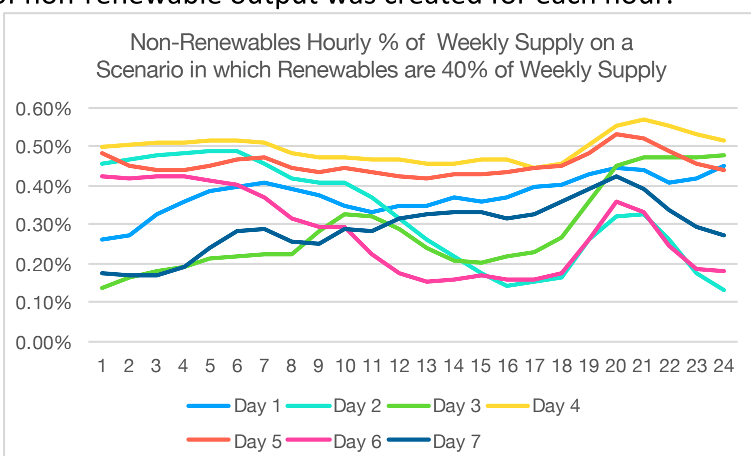


Figure 4. 18 Percent of non-renewable generation for each hour of the test week.

[26] It may be more intuitive to express the supply mix data as % of the mix coming from renewable power. However, the intelligent demand algorithm was set up to minimize costs. Thus, minimizing the % or fraction of the non-renewable energy used better fit with the minimization algorithm. In addition, the hourly costs in an ISO tend to reasonably follow % of non-renewable when the fraction of the supply mix coming from renewables becomes material.

Figure 4.18 shows the percent of non-renewable generation for each hour of each day. Note how different the days are. Days 1 and 7 have the lowest % of non-renewable (highest % of renewable generation) between midnight and dawn. Days 2 and 6 have the lowest % of non-renewable (highest % of renewable generation) during the afternoon hours. Days 4 and 5 are relatively flat throughout the day. Thus, greater carbon reduction (and system stability) is enabled by intelligent demand control being flexible from day to day so as to charge batteries during hours of low % of non-renewables and discharge batteries during hours of high % of non-renewables no matter when those hours occur that day.

Figure 4.19 shows the results for August 20-22, which corresponds to Days 1-3 in Figure 18. We can see several examples over these days in which batteries were charged during hours of low fraction of non-renewable energy (or a high proportion of renewable energy). These hours included late morning on August 20 (33-35% non-renewable vs 45% later in the day). The hours for charging on August 21 were mid-afternoon when the non-renewable percentage was only 13-17% vs 40% earlier in the day.

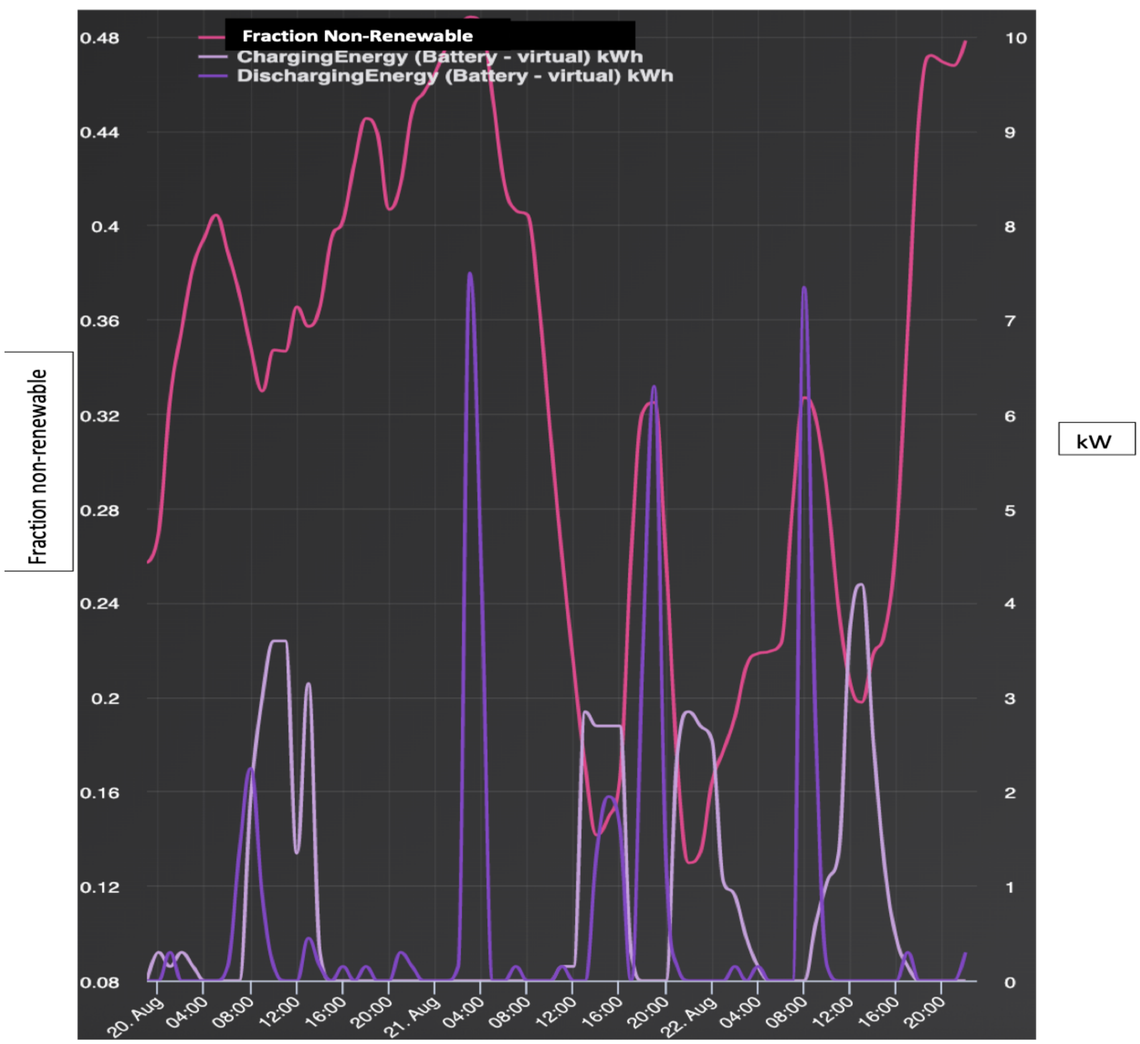


Figure 4. 19 Intelligent Demand Control Operates Batteries to Reduce Grid Carbon Footprint

Conversely, the batteries were discharged during the hours of high non-renewable generation. For example, the discharge on August 21 was both overnight (3-5 am) and evening (8-10 pm) when the non-renewable percentage was near 40%.

By shifting these kWhs from hours of low fraction of renewables to hours with a high fraction of renewables, we were able to reduce the net fraction of non-renewables for the kWh shifted by 23%. This is a material number and indicates there is potential future carbon reduction in the production of electricity if intelligent control of storage were expanded.[27] Using more electricity in the high renewable hours and discharging storage to lower the usage during low renewable hours has the additional benefit of reducing ramping of the non-renewable plants and both making them more efficient and reducing "wear and tear" to lower maintenance costs.

5. Economic Analysis

We want to look at the economic analysis from a pro forma perspective. Thus, we first define how the project can be most workable in the future. Then we analyze the cost-effectiveness from the perspective of that workable approach.

5.a Workability of the Approach

In this pilot project the Package was retrofitted to an existing facility as a stand-alone project. Thus, its costs were materially higher than if the project included as part of major remodel or new construction project. MBN Engineering assisted in the drawings for the procurement and installation of the components of this Smart Clean Energy Package ("Package"). They believe this project is workable if included in the preliminary design phase of either a remodel or new construction. Consistent with MBN's observation, this final report is scoped to have the cost-effectiveness based on a more desirable strategy of including it in the preliminary design phase of either a remodel or new construction.

5.b. Cost-Effectiveness

The cost-effectiveness analysis has two components – costs and effectiveness. The "effectiveness" analysis focuses on the project effectiveness in meeting the project objectives. As noted above the major objectives are using renewable energy to:

a) Reduce energy costs
b) Reduce carbon footprint
c) Enhance economic development.

[27] Of course this number is based on a limited number of days and the battery sized to be only about 8% of the total kWh use. So alternate battery sizes and a full-year analysis could influence these results.

Figure 5. 1 reflects the dollar benefits from effectively meeting these three-fold objectives. First, note that the combination of measures in the Package would have reduced the annual RoCo utility bill by about $8348. This included Solar PV, Smart Lighting, Intelligent Demand Control (IDC) and enhancing Equipment Performance. IDC reduces the peak demand at RoCo through intelligent charging and discharging of the battery storage as well as throttling back some of the EV Charging at peaks.[28] Enhancing Equipment Performance was the result of the availability of smart meter data and dashboard reporting to help identify malfunctioning equipment and to fine-tune and improve the performance of equipment.

Fargo Annual Benefits Pro Forma

	Electricity		Gasoline	Annual
	kWh/day	kW/mo	gallons	Benefit
Solar PV	62	2		$ 1,929
Smart Lighting	89	3		$ 2,789
EV Charging	-40	-17		$ (3,601)
IDC - Intelligent Demand Control		17		$ 2,550
Equipment Performance				$ 1,080
City of Fargo Utility Bill (excluding EVs)				**$ 8,348**
City of Fargo Utility Bill				**$ 4,747**
Gasoline Savings (Private Citizens)			1241	**$ 4,157**
Sub-Total Energy Net Benefits				**$ 8,904**
Economic Development				
Regional Impact				$ 12,066,600
# Jobs				133
# Businesses benefiting from new employees				56
Total Annual Economic Benefit				**$ 12,075,504**

Figure 5. 1 Annual Benefits of Smart, Clean Energy Package

The EV Charging partially off-set the electricity savings – by adding $3600 to the annual electricity bill. However, this yielded savings in gasoline costs to private citizens of $4157.[29] Of

[28] The benefits of these measures plus the EV Charging was based on pro forma operation going forward consistent with the analysis in section 4. Note that he IDC pro forma operation essentially off-sets the peak demand added from EV Charging at current levels of EV Charging.

[29] This cost savings was based on the current price of gasoline in Fargo of $3.35 per gallon, a typical fuel economy of 25 miles per gallon and a savings of 31,025 miles of driving. The City recoups some of these savings through an increase in parking fees from EV's parking at the garage. To recoup an additional portion of the private savings, the City could charge EV users for using the Chargers (the current ChargePoint system has that capability.) On the other hand, as discussed below, one could argue that the Economic Development benefit dwarfs the costs of the EV Charging.

course, the EV Charging is expected to increase over time so both the electricity use from EV Charging will increase and the gasoline savings will also increase. Combining the City's utility electricity bill savings and the private citizen's gasoline bill savings yields a total Energy Net Benefit of $8904 annually.

85% of residents (133) came from out of state. The Smart Clean Energy Package at RoCo was instrumental in attracting these new workers.

The Economic Development benefit dwarfs the other benefits. The Asset Manager of the Roberts Commons and nearby Dillard multi-family facilities says that 85% of the 156 new residents came from outside North Dakota with an average age of 31. The Asset Manager discussed including the EV stations in their marketing material and the positive impact green initiatives, like the Smart Clean Energy Package, can have in attracting these new residents. Moreover, many Fargo businesses (56) benefitted from this increased workforce.[30] With an average salary of $65,000 and a regional economic multiplier of 1.4[31], this increased workforce provided an economic development benefit of over $12 million. And this is only based on two multi-family complexes. The actual impact on downtown is probably larger. This dwarfs the cost of the Smart, Clean Energy Package discussed below.

Smart Clean Energy Package Installed Costs
If Reflected in Initial Design

	($OOO) +/- 30%
Smart Lighting	$ 40
Solar Photovoltaic	$ 50
Battery Storage	$ 40
IDC*+ Smart Meter	$ 15
EV Charging	$ 30
	$ 175

*IDC=Intelligent Demand Control;

Figure 5. 2 Pro Forma Installed Costs of a Smart Clean Energy Package

[30] Often the economic development benefit is assigned to new businesses in a region. But North Dakota has long held that its biggest constraint on growth was the lack of work force. Indeed, the North Dakota unemployment rate is about half the national average. Therefore, crediting the increased work force for regional economic growth is appropriate for North Dakota.

[31] The 1.4 regional economic multiplier is conservative compared to other national and some North Dakota calculations. https://aero.nd.gov/image/cache/ND_Individual_Airport_Report_Dickinson-Small.pdf ; https://www.ndsu.edu/fileadmin/legislators/Economic_Impact/NDSU_PPT_2010-11_Final_Notes.pdf https://www.bea.gov/news/blog/2020-08-03/bea-updates-regional-economic-tool

Figure 5.2 displays the likely or pro forma costs +/-30% for this Package if included in the Preliminary Design phase of a major remodel or new construction at a facility.[32] These costs are material -- $175,000 +/- 30%. They are covered by the energy costs over the expected life of the equipment. But the economic development benefit dwarfs these costs and would probably be the main driver of putting this Package in future projects. Additional information on the costs and other design considerations is provided in the companion report included as Appendix C, "Guide to a Smart-Energy, Carbon-Reducing Packagee for Developers and City Managers."

If a private party funds this project, much of the project can qualify for the Federal Investment Tax Credit, which is 26% in 2022 and 22% in 2023. Thus, the ITC can materially reduce the cost of the project.

5.c. User Co-Funding/Solar Credits

In the original proposal we proposed to sell solar credits as one source of co-funding for the project. To simplify we executed this co-funding strategy in two ways:

1) Business Contributions for recognition of sponsoring an innovative, clean energy project
2) Resident Contributions

Each of these is discussed below.

Business Contributions
We sent an e-mail letter to targeted businesses in the downtown area. We identified the opportunity for several types of recognition including a new video describing the project and partners, a page on the City of Fargo's website, and at a press conference announcing the completion of the project. In response to this e-mail letter, we received donations of about half of the total co-funding targeted amount.

Resident Contributions
As part 2, we offered residents the opportunity to also provide co-funding. We offered them the opportunity to make contributions that could off-set the carbon footprint of various activities in their lives. No customers chose to respond. The informal feedback received was that since these were higher quality, higher priced housing units they expected amenities like this Package to be included in the rental price.

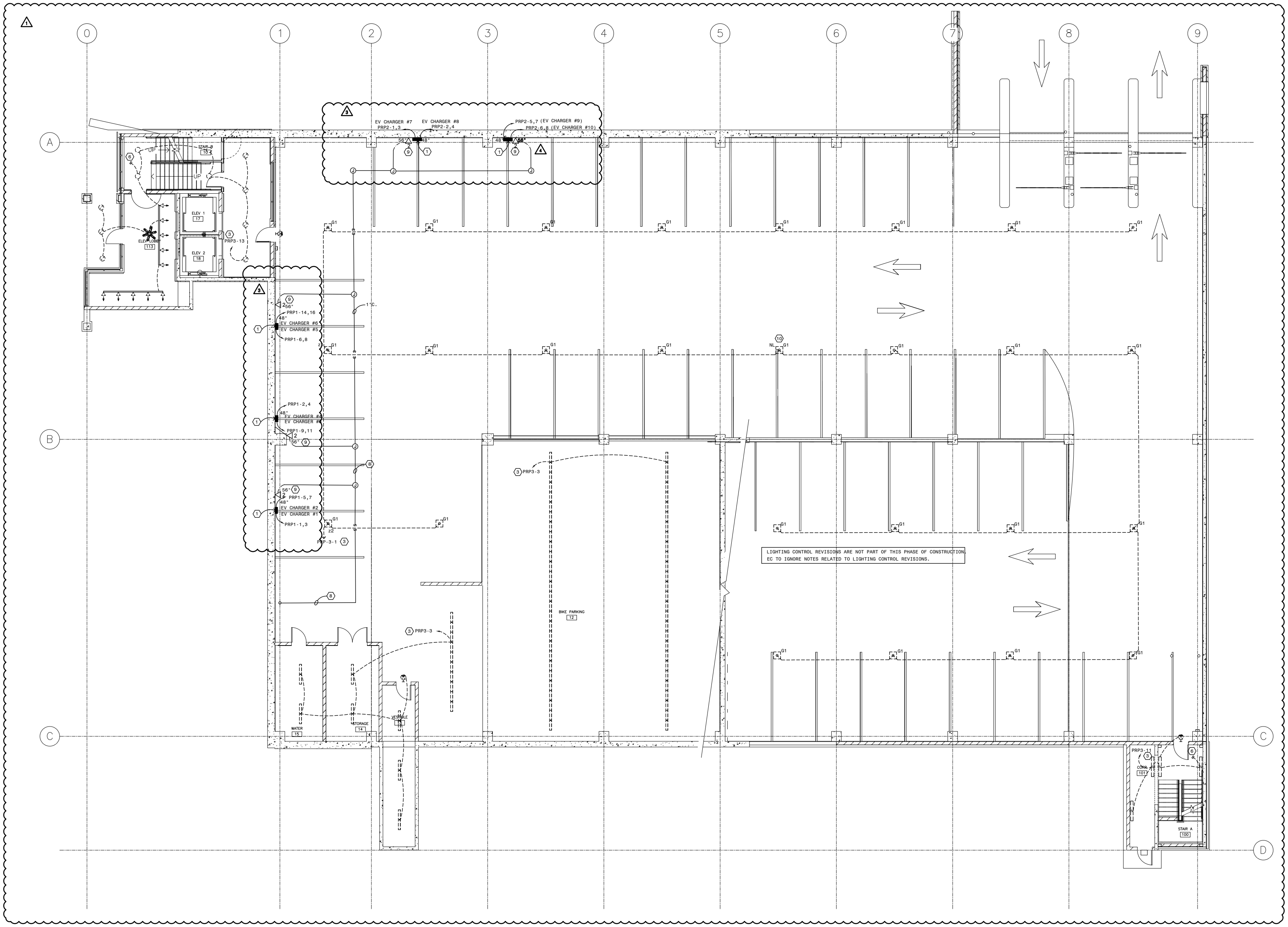
[32] Our project engineer, MBN, believes that the installation costs of this pilot as a retrofit were at least twice that of the installation costs if the Package were installed as part of a remodel or new construction.

Appendix A
Final Fargo RoCo Drawings

Fargo's Smart Energy Ramp Project
NDIC Agreement R-038-048

CONTROLLER AND SENSOR SCHEDULE

TYPE/SYMBOL	MANUFACTURER	MODEL #	DESCRIPTION
ⓂAz	LEGRAND	HB300B-L3	HIGH BAY PASSIVE INFRARED OCCUPANCY SENSOR WITH LENS AND BACK BOX
LRP-1	WATTSTOPPER	LP8S-8-G-115	PEANUT LIGHTING CONTROL PANEL WITH GROUP SWITCHING CARD



1 1ST LEVEL - LIGHTING PLAN
E100
0' 4' 8' 16'

MBN ENGINEERING
*MECHANICAL * ELECTRICAL * CIVIL*
503 7TH ST. N , SUITE 200
FARGO, ND 58102
PHONE: 701.478.6336
FAX: 701.478.6340

GENERAL NOTES:

1. EXPOSED CONDUIT TO BE RIGID GALVANIZED STEEL. EMT CONDUITS WITH COMPRESSION FITTINGS CAN BE USED IN THE CEILING AREA AND 72" ABOVE FINISHED FLOOR FOR EV CHARGER WIRING.
2. ALL WIRING TO BE IN CONDUIT.
3. LIGHTS TO BE KEPT ON/OFF ALL TIME TURNING TO 100% WHEN MOTION IS SENSED.
4. LIGHTS NOTED WITH "NL" TO BE ON ALL TIMES.
5. ALL DATA CABLES NEED TO BE CATEGORY 6A TYPE TO MATCH THE EXISTING CABLES.
6. EC RESPONSIBLE TO PROVIDE ADDITIONAL OCCUPANCY SENSORS PER MANUFACTURER'S RECOMMENDATION AS NEEDED.
3. RAMP CIRCUITS RUN VIA RELAY PANEL LRP1.
4. ALL DATA CABLES TO BE TERMINATED AT THE DATA RACK LOCATED IN IT ROOM 112. EC RESPONSIBLE TO COORDINATE AND VERIFY WITH CITY IT REPRESENTATIVE FOR EXACT REQUIREMENTS PRIOR TO ROUGH-IN OR ANY PURCHASE OF EQUIPMENT.

PLAN NOTES:

1. PROVIDE (2) TWO 240V, SINGLE PHASE CONNECTIONS TO DUAL POINT ELECTRIC VEHICLE (EV) CHARGER PROVIDED BY CHARGEPOINT+. PROVIDE (2) 1 INCH CONDUITS WITH (2)#6AWG PLUS #8 GROUND EACH. INSTALLATION OF EV CHARGER BY CHARGEPOINT+. SEE RISER DIAGRAM ON SHEET E200. EC TO PROVIDE CONDUIT AND WIRING. VERIFY LOCATION WITH OWNER PRIOR TO ROUGH-IN.
2. NOTE NOT USED.
3. DISCONNECT EXISTING CIRCUIT TO PANEL EMR AND RECONNECT TO NEW PANEL PRP-3. EXTEND CIRCUITS AS NEEDED. PROVIDE WIRING AND CONDUIT AS REQUIRED. SEE RISER DIAGRAM ON SHEET E200.
4. NOTE NOT USED.
5. NOTE NOT USED.
6. EXISTING CIRCUITS EXTENDED TO STAIRWELL ABOVE.
7. NOTE NOT USED.
8. PROVIDE (1) 1 1/4 INCH CONDUITS SURFACE MOUNTED, STUBBED UP TO IT ROOM #112 TO EXISTING DATA RACK IN A NEW PATCH PANEL. PROVIDE NEW PATCH PANEL. SEE SPECIFICATIONS 27-10-05.
9. DATA OUTLET FOR EV CHARGER. PROVIDE DATA CABLE TO EACH CHARGER FROM DATA RACK IN ROOM 112. ROUTE (1) 3/4" CONDUIT TO THE CHARGERS.
10. NOTE NOT USED.

REVISIONS:

- 10.05.20 OWNER REQUESTED REVISIONS
- 04.27.20 OWNER REQUESTED REVISIONS
- 03.02.20 ADDENDUM 2
- 10.16.19 ADDENDUM 1

FARGO SMART ENERGY PARKING RAMP

FARGO, ND

MBN JOB #: 18-143 DATE: 08-12-19

1ST LEVEL PLAN-ELECTRICAL

E100

PANELBOARD LOAD SCHEDULE

PANEL: PRP-1 | MAIN: MCB 200A | ENCLOSURE: NEMA 3R | LOCATION: ROOM # 111
VOLTS: 240/120, 1 PH., 3W.
RATING: 225 AMP | AIC RATING: 10,000 | MOUNTING: SURFACE | FED FROM: T-1

CKT #	TRIP AMPS	POLE	LIGHTING	RECPT	MTRS&EQUIP	KITCHEN	HEAT/AC	LOAD DESCRIPTION	PH	LOAD DESCRIPTION	HEAT/AC	KITCHEN	MTRS&EQUIP	RECPT	LIGHTING	TRIP AMPS	POLE	CKT #
1	40				3600			EV CHARGER 1	A	EV CHARGER 4			3600			40		2
3		2			3600				B				3600				2	4
5	40				3600			EV CHARGER 2	A	EV CHARGER 5			3600			40		6
7		2			3600				B				3600				2	8
9	40				3600			EV CHARGER 3	A	SONNEN BATTERY-1			4000			50		10
11		2			3600				B				4000				2	12
13	20	1						SPARE	A	EV CHARGER 6			3600			40		14
15	20	1							B				3600				2	16
17	20	1			200			EF-1	A	SPARE						20	1	18
19	20	1						SPARE	B	SPARE						20	1	20
21	20	1						SPARE	A	SPARE						20	1	22
23	20	1						SPARE	B	SPARE						20	1	24

LOAD CALCULATIONS

LOAD TYPE	KVA / PHASE A	KVA / PHASE B	TOTAL KVA	DEMAND FACTOR	DIVERSIFIED LOAD
LIGHTING	0	0	0	1.00	0
RECEPTACLES	0	0	0	0.50	0
MOTORS & EQUIP	25,800	25,600	51400	0.90	46,260
KITCHEN EQUIP.	0	0	0	0.65	0
HEAT / AC	0	0	0	0.90	0
LARGEST MOTOR				0.25	0
TOTAL AMPS:	193		TOTAL VA:		46,260

NOTES:
1. BREAKERS NOTED WITH * TO BE GFCI
2. HINGED COVER
3. BOTTOM FEED

	LOAD IN VOLT-AMPERES LIGHTING	RECPT	MTRS&EQUIP	KITCHEN	HEAT/AC
A	0	0	25800	0	0
B	0	0	25600	0	0
C	0	0	0	0	0

PANELBOARD LOAD SCHEDULE

PANEL: PRP-2 | MAIN: MCB 200A | ENCLOSURE: NEMA 3R | LOCATION: ROOM # 111
VOLTS: 240/120, 1 PH., 3W.
RATING: 225 AMP | AIC RATING: 10,000 | MOUNTING: SURFACE | FED FROM: T-2

CKT #	TRIP AMPS	POLE	LIGHTING	RECPT	MTRS&EQUIP	KITCHEN	HEAT/AC	LOAD DESCRIPTION	PH	LOAD DESCRIPTION	HEAT/AC	KITCHEN	MTRS&EQUIP	RECPT	LIGHTING	TRIP AMPS	POLE	CKT #
1	40				3600			EV CHARGER 7	A	EV CHARGER 8			3600			40		2
3		2			3600				B				3600				2	4
5	40				3600			EV CHARGER 9	A	EV CHARGER 10			3600			40		6
7		2			3600				B				3600				2	8
9	40							SPARE	A	SONNEN BATTERY 2			4000			50		10
11		2							B				4000				2	12
13	20	1						SPARE	A	SPARE						40		14
15	20	1						SPARE	B								2	16
17	20	1						SPARE	A	SPARE						20	1	18
19	20	1						SPARE	B	SPARE						20	1	20
21	20	1						SPARE	A	SPARE						20	1	22
23	20	1						SPARE	B	SPARE						20	1	24

LOAD CALCULATIONS

LOAD TYPE	KVA / PHASE A	KVA / PHASE B	TOTAL KVA	DEMAND FACTOR	DIVERSIFIED LOAD
LIGHTING	0	0	0	1.00	0
RECEPTACLES	0	0	0	0.50	0
MOTORS & EQUIP	18,400	18,400	36800	0.90	33,120
KITCHEN EQUIP.	0	0	0	0.65	0
HEAT / AC	0	0	0	0.90	0
LARGEST MOTOR				0.25	0
TOTAL AMPS:	138		TOTAL VA:		33,120

NOTES:
1. BREAKERS NOTED WITH * TO BE GFCI
2. HINGED COVER
3. BOTTOM FEED

	LOAD IN VOLT-AMPERES LIGHTING	RECPT	MTRS&EQUIP	KITCHEN	HEAT/AC
A	0	0	18400	0	0
B	0	0	18400	0	0
C	0	0	0	0	0

PANELBOARD LOAD SCHEDULE

PANEL: PRP-3 | MAIN: MCB 100A | ENCLOSURE: NEMA 3R | LOCATION: ROOM # 111
VOLTS: 240/120, 1 PH., 3W.
RATING: 100 AMP | AIC RATING: 10,000 | MOUNTING: SURFACE | FED FROM: T-3

CKT #	TRIP AMPS	POLE	LIGHTING	RECPT	MTRS&EQUIP	KITCHEN	HEAT/AC	LOAD DESCRIPTION	PH	LOAD DESCRIPTION	HEAT/AC	KITCHEN	MTRS&EQUIP	RECPT	LIGHTING	TRIP AMPS	POLE	CKT #
1	20	1	1320					LEVEL 1 LIGHTS	A	LEVEL 4 LIGHTS					1705	20	1	2
3	20	1	1624					BIKE LIGHTS	B	LEVEL 5 LIGHTS					1705	20	1	4
5	20	1	1705					LEVEL 2 LIGHTS	A	SONNEN BATTERY3			4000			50		6
7	20	1	1705					LEVEL 3 LIGHTS	B				4000				2	8
9	20	1	280					ROOF TOP	A	SPARE						40		10
11	20	1	820					NORTH STAIRS	B								2	12
13	20	1	870					SOUTH STR 1-3	A	STOR/WATER					700	20	1	14
15	20	1	870					SOUTH STR 4-6	B	LIGHTCLOUD GT1			200			20	1	16
17	20	1	820					NORTH STAIRS	A	SPARE						20	1	18
19	20	1							B	LEVEL 6 RAMP					1705	20	1	20
21	20	1						SPARE	A	SPARE						20	1	22
23	20	1						SPARE	B	SPARE						20	1	24

LOAD CALCULATIONS

LOAD TYPE	KVA / PHASE A	KVA / PHASE B	TOTAL KVA	DEMAND FACTOR	DIVERSIFIED LOAD
LIGHTING	5,695	8,429	14124	1.00	14,124
RECEPTACLES	0	0	0	0.50	0
MOTORS & EQUIP	4,000	4,200	8200	0.90	7,380
KITCHEN EQUIP.	0	0	0	0.65	0
HEAT / AC	0	0	0	0.90	0
LARGEST MOTOR				0.25	0
TOTAL AMPS:	90		TOTAL VA:		21,504

NOTES:
1. BREAKERS NOTED WITH * TO BE GFCI
2. HINGED COVER
3. BOTTOM FEED

	LOAD IN VOLT-AMPERES LIGHTING	RECPT	MTRS&EQUIP	KITCHEN	HEAT/AC
A	5695	0	4000	0	0
B	8429	0	4200	0	0
C	0	0	0	0	0

PANELBOARD LOAD SCHEDULE

PANEL: R | MAIN: MLO | ENCLOSURE: NEMA 1 | LOCATION: MEP 111
VOLTS: 208Y/120, 3 PH., 4W.
RATING: 400 AMP | AIC RATING: 22,000 | MOUNTING: SURFACE | FED FROM: MTR CABINET

CKT #	TRIP AMPS	POLE	LIGHTING	RECPT	MTRS&EQUIP	KITCHEN	HEAT/AC	LOAD DESCRIPTION	PH	LOAD DESCRIPTION	HEAT/AC	KITCHEN	MTRS&EQUIP	RECPT	LIGHTING	TRIP AMPS	POLE	CKT #
1	20	1			800			PARKING GATE	A	SUH-1 RM 111	2000					30		2
3	20	1			800			PARKING GATE	B		2000						2	4
5	20	1			800			PARKING GATE	C	SUH-1 RM 112	1000					20		6
7	20	1			800			PARKING GATE	A		1000						2	8
9	20	1		800				BIKE PARK 012	B	NORTH PAY STAT			800			20	1	10
11	20	1		1200				NORTH STAIR	C	SOUTH PAY STAT			800			20	1	12
13	20	1		200	127			RM 111	A	EQUIP SERVER			800			20	1	14
15	20	1			1200			SUMP PUMP	B	EQUIP SERVER			800			20	1	16
17	20	1			1200			SUMP PUMP	C	CITY OF FARGO			800			20	1	18
19	20	1		400				IT ROOM	A	CITY OF FARGO			800			20	1	20
21	20	1			1176			EF-3	B	SPARE						40		22
23	20	1		400	100			RM 015	C								2	24
25	20						1500	SUH-3 015	A	PNLPRP-1 VIA T-1			25000			**250		26
27		2					1500		B				25000				2	28
29	30						1405	CRAC - OUTDOOR	C	SPARE						20	1	30
31		2					1405		A	PNLPRP-2 VIA T-2			25000			**250		32
33	15						160	CRAC - INDOOR	B				25000				2	34
35		2					160		C	SPARE						20	1	36
37	20	1						RAMP SIGN	A	PANEL PVM			5540			100		38
39	20	1						SPARE	B				5540					40
41	20	1						SPARE	C				3780				3	42
43	30						2250	UH-1	A	SPARE						20	1	44
45		2					2250		B	SPARE						20	1	46
47	20	1		500				RELAY PANEL	C	SPARE						20	1	48
49	20	1						SPARE	A	SPARE						50		50
51	20	1						SPARE	B	SPARE								52
53	20	1						SPARE	C	SPARE							3	54

LOAD CALCULATIONS

LOAD TYPE	VA / PHASE A	B	C	TOTAL VA	DEMAND FACTOR	DIVERSIFIED LOAD
LIGHTING	0	0	0	0	1.00	0
RECEPTACLES	600	800	2100	3500	0.50	1750
MOTORS & EQUIP	58867	60316	7480	126663	0.90	113997
KITCHEN EQUIP.	0	0	0	0	0.65	0
HEAT / AC	8155	5910	2565	16630	0.90	14967
LARGEST MOTOR					0.25	0
TOTAL AMPS:	363			TOTAL VA:		130,714

NOTES:
1. PROVIDE FEED THRU LUGS.
2. CONTRACTOR TO ADJUST CIRCUIT BREAKER LOCATIONS PER MANUFACTURER'S RECOMMENDATION TO BALANCE THE LOAD.
3. ** PROVIDE LOCKABLE ATTACHEMENT ON THIS BREAKER TO MEET NEC ARTICLE 450.14 DISCONNECTING MEANS FOR TRANSFORMER.

EXISTING PANELBOARD LOAD SCHEDULE

PANEL: EMR | MAIN: MLO | ENCLOSURE: NEMA 1 | LOCATION: MEP 111
VOLTS: 208Y/120, 3 PH., 4W.
RATING: 225 AMP | AIC RATING: 22,000 | MOUNTING: SURFACE | FED FROM: PANEL R

CKT #	TRIP AMPS	POLE	LIGHTING	RECPT	MTRS&EQUIP	KITCHEN	HEAT/AC	LOAD DESCRIPTION	PH	LOAD DESCRIPTION	HEAT/AC	KITCHEN	MTRS&EQUIP	RECPT	LIGHTING	TRIP AMPS	POLE	CKT #
1	20							SPARE	A	EF-1			11040			125		2
3		2							B				11040					4
5	20	1						SPARE	C				11040				3	6
7	**125							XFMR T-3 TO PRP-3	A	EF-2			11040			125		8
9		2							B				11040					10
11	20	1						SPARE	C				11040				3	12
13	20	1						SPARE	A	SPARE						20	1	14
15	20	1						SPARE	B	SPARE						20	1	16
17	20	1						SPARE	C	SPARE						20	1	18
19	20	1						SPARE	A	SPARE						20	1	20
21	20	1						SPARE	B	SPARE						20	1	22
23	20	1						SPARE	C	SPARE						20	1	24
25	20	1						SPARE	A	SPARE						20	1	26
27	20	1						SPARE	B	SPARE						20	1	28
29	20	1						SPARE	C	SPARE						20	1	30
31	20	1						SPARE	A	SPARE						20	1	32
33	20	1						SPARE	B	SPARE						20	1	34
35	20	1						SPARE	C	SPARE						20	1	36
37	20	1						SPARE	A	SPARE						20		38
39	20	1						SPARE	B									40
41	20	1						SPARE	C								3	42
43	20	1						SPARE	A	SPARE						20		44
45	20	1						SPARE	B									46
47	20	1						SPARE	C								3	48
49	20	1						SPARE	A	SPARE						50		50
51	20	1						SPARE	B									52
53	20	1						SPARE	C								3	54

LOAD CALCULATIONS

LOAD TYPE	VA / PHASE A	B	C	TOTAL VA	DEMAND FACTOR	DIVERSIFIED LOAD
LIGHTING	0	0	0	0	1.00	0
RECEPTACLES	0	0	0	0	0.50	0
MOTORS & EQUIP	22080	22080	22080	66240	0.90	59616
KITCHEN EQUIP.	0	0	0	0	0.65	0
HEAT / AC	0	0	0	0	0.90	0
LARGEST MOTOR					0.25	0
TOTAL AMPS:	165			TOTAL VA:		59,616

NOTES:
1. PROVIDE SPD
2. PROVIDE FEED THRU LUGS.
3. ** PROVIDE LOCKABLE ATTACHEMENT ON THIS BREAKER TO MEET NEC ARTICLE 450.14 DISCONNECTING MEANS FOR TRANSFORMER.

PANELBOARD LOAD SCHEDULE

PANEL: PANEL PVM | MAIN: MCB 100A | ENCLOSURE: NEMA 3R/12 | LOCATION: LEVEL 7
VOLTS: 208Y/120, 3 PH., 4W.
RATING: 100 AMP | AIC RATING: 10,000 | MOUNTING: SURFACE | FED FROM: PANEL R

CKT #	TRIP AMPS	POLE	LIGHTING	RECPT	MTRS&EQUIP	KITCHEN	HEAT/AC	LOAD DESCRIPTION	PH	LOAD DESCRIPTION	HEAT/AC	KITCHEN	MTRS&EQUIP	RECPT	LIGHTING	TRIP AMPS	POLE	CKT #
1	20				1260			PV ARR WT MCRINV	A	PV ARR WT MCRINV			1260			20		2
3		2			1260				B				1260				2	4
5	20	1						SPARE	C	SPARE						20	1	6
7	20				1260			PV ARR WT MCRINV	A	PV ARR WT MCRINV			1260			20		8
9		2			1260				B				1260				2	10
11	20	1						SPARE	C	SPARE						20	1	12
13	20				1260			PV ARR WT MCRINV	A	PV ARR WT MCRINV			1260			20		14
15		2			1260				B				1260				2	16
17	20	1						SPARE	C	SPARE						20	1	18
19	20				500			ENVOY	A	SPARE						20	1	20
21		2			500				B	SPARE						20		22
23	20	1						SPARE	C								2	24

LOAD CALCULATIONS

LOAD TYPE	VA / PHASE A	B	C	TOTAL VA	DEMAND FACTOR	DIVERSIFIED LOAD
LIGHTING	0	0	0	0	1.00	0
RECEPTACLES	0	0	0	0	0.50	0
MOTORS & EQUIP	8060	8060	0	16120	0.90	14508
KITCHEN EQUIP.	0	0	0	0	0.65	0
HEAT / AC	0	0	0	0	0.90	0
LARGEST MOTOR					0.25	0
TOTAL AMPS:	40			TOTAL VA:		14,508

NOTES:
1. PROVIDE FEED THRU LUGS.

MBN
ENGINEERING
MECHANICAL * ELECTRICAL * CIVIL
503 7TH ST. N , SUITE 200
FARGO, ND 58102
PHONE: 701.478.6336
FAX: 701.478.6340

REVISIONS:
- 4 — 10.05.20 OWNER REQUESTED REVISIONS
- 3 — 04.27.20 OWNER REQUESTED REVISIONS
- 2 — 03.02.20 ADDENDUM 2
- 1 — 03.02.20 ADDENDUM 1

FARGO SMART ENERGY PARKING RAMP

FARGO, ND

NOT FOR CONSTRUCTION

MBN JOB #: 18-143 DATE: 08-12-19

ELECTRICAL PANEL SCHEDULES

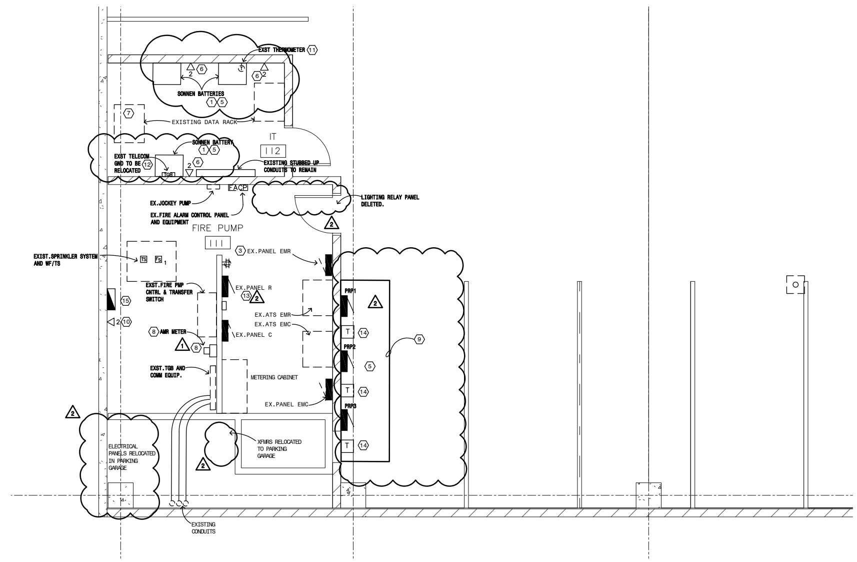
E103

GENERAL NOTES:

1. EXPOSED CONDUIT TO BE RIGID GALVANIZED STEEL.
2. ALL WIRING TO BE IN CONDUITS.
3. PROVIDE REQUIRED ANCHOR BOLTS FOR SURFACE MOUNTING EQUIPMENT TO CONCRETE WALL.
4. ALL DATA CABLES TO BE TERMINATED AT THE EXISTING DATA RACK IN IT ROOM #112.
5. ALL DATA CABLES TO TERMINATE AT EXISTING DATA RACK LOCATED ON SOUTH SIDE OF DATA ROOM. EC RESPONSIBLE FOR DATA CABLES TERMINATED AT THE JACKS TO BE PROPERLY LABELED TO IDENTIFY THE LOCATION.

PLAN NOTES:

1. PROVIDE 240V, SPLIT PHASE CONNECTION TO SONNEN BATTERY STORAGE TANK SUPPLIED BY BSE. COORDINATE AND VERIFY WITH SUPPLIER/MANUFACTURER. VERIFY METERING REQUIREMENTS WITH SUPPLIER. PROVIDE WIRING AND ACCESSORIES AS NEEDED.EC RESPONSIBLE TO GET TRAINING AND CERTIFICATION FOR INSTALLING SONNEN BATTERIES.
2. NOTE NOT USED. 2
3. EXISTING PANEL EMR. DISCONNECT EXISTING RAMP LIGHTING LOADS. REPLACE EXISTING 20A, SINGLE POLE CIRCUIT BREAKERS WITH NEW AS LISTED IN PANEL SCHEDULE ON SHEET E103. MARK UNUSED CIRCUIT BREAKERS AS SPARE.
4. NOTE NOT USED. 2
5. ELECTRICAL PANELS, TRANSFORMERS, AND SONNEN BATTERY STORAGE ARE SUPPLIED BY BSE. FIELD VERIFY EXACT SPACE AVAILABLE PRIOR TO ROUGH-IN OF NEW ELECTRICAL EQUIPMENT. ELECTRICAL CONTRACTOR RESPONSIBLE FOR INSTALLATION AND ELECTRICAL CONNECTIONS. SEE RISER DIAGRAM ON THIS SHEET. ANY DISCREPANCIES RELATED TO ELECTRICAL EQUIPMENT LOCATION OR CONNECTIONS TO BE BROUGHT TO ENGINEER'S ATTENTION PRIOR TO BIDDING.
6. DATA OUTLET FOR SONNEN BATTERY STORAGE. ROUTE TO IT ROOM #112 IN A 1 INCH CONDUIT WITH CAT 6 CABLE. SEE SPECIFICATIONS 27-10-05.
7. PROVIDE NEW PATCH PANEL BY PANDUIT CATALOG # CPPA48FMWBLY IN EXISTING RACK FOR TERMINATING NEW BUILDING DATA DEVICES. PROVIDE JACK MODULES BY PANDUIT # CJ6X88TG COMPATIBLE WITH EXISTING PATCH PANELS. SEE SPECIFICATIONS 27-10-05. EC RESPONSIBLE TO PROVIDE PATCH PANEL BY SAME MANUFACTURER AS EXISTING IN THE EXISTING DATA RACK. ANY DISCREPANCIES IN ABOVE MENTIONED PATCH PANEL CATALOG TO BE BROUGHT TO DESIGN ENGINEER'S ATTENTION PRIOR TO ROUGH-IN. EC TO COORDINATE WITH CITY IT REPRESENTATIVE PRIOR TO ANY ROUGH-IN AND TERMINATION AT THE DATA RACK. EC RESPONSIBLE TO LABEL ALL JACKS TERMINATED FOR THEIR IDENTIFICATION AND LOCATION AS REQUIRED BY CITY IT PROFESSIONAL. 1
8. AMR METERING BY OTHERS. ELECTRICAL CONTRACTOR RESPONSIBLE TO INSTALL AND CONNECT PER MANUFACTURER'S MANUAL AND UTILITY REQUIREMENTS. COORDINATE WITH UTILITY COMPANY FOR CONNECTIONS WITH EXISTING METERING PRIOR TO ROUGH-IN. PROVIDE WIRING AND PROVISIONS AS NEEDED.
9. PROVIDE SIX SECURITY PROTECTIVE BOLLARDS OR METAL CAGE SURROUNDING ELECTRICAL PANEL AND TRANSFORMER. VERIFY WITH OWNER PRIOR TO INSTALLATION.
10. DATA OUTLET FOR AMR METERING. ROUTE TO IT ROOM #112 IN A 1 INCH CONDUIT. VERIFY EXACT LOCATION WITH OWNER. SEE SPECIFICATIONS 27-10-05.
11. RELOCATE EXISTING THERMOSTAT IN THE NORTH-WEST CORNER AWAY FROM SONNEN BATTERY. COORDINATE AND VERIFY LOCATION WITH OWNER PRIOR TO RELOCATION.
12. RELOCATE EXISTING TELECOM GROUNDING BAR ALONG WITH CONDUCTORS ON THE EAST WALL AWAY FROM NEW SONNEN BATTERY LOCATION TOWARDS SOUTH-EAST CORNER. FIELD VERIFY EXACT LOCATION. COORDINATE AND VERIFY LOCATION WITH OWNER PRIOR TO RELOCATION.
13. EXISTING PANEL R TO BE REPLACED WITH A NEW SQUARE D I-LINE COMBO PANEL (FULLY RATED) OR APPROVED EQUAL PER ADDENDUM#2 (DIMENSION 32"W 91"H 9"D). EC RESPONSIBLE TO INSTALL ALL EXISTING CIRCUITS AND NEW CIRCUITS. INSTALLATION WOULD INCLUDE EXTENDING EXISTING CONDUITS AS REQUIRED TO ACCOMMODATE NEW PANEL AND ALL EXISTING AND NEW CIRCUITS. BALANCE LOADS PER MANUFACTURER'S RECOMMENDATION. REVISE (2) 125A/2P BREAKERS TO (2) 250A/2P BREAKERS. SEE RISER DIAGRAM ON THIS SHEET.
14. DONGAN TRANSFORMERS ARE FLOOR MOUNTED. EC TO COORDINATE AND VERIFY PAD REQUIREMENTS NEEDED FOR FLOOR MOUNTING TRANSFORMERS WITH SUPPLIER/MANUFACTURER AND ELECTRICAL INSPECTOR AT THE CITY OF FARGO PRIOR TO ROUGH-IN.
15. RAINFOREST EAGLE SYSTEM PROVIDED BY OWNER. VERIFY EXACT LOCATION AND REQUIREMENTS WITH OWNER. (2) CAT 6 CABLES SHALL SERVE RAINFOREST EAGLE SYSTEM AND AMR METERING. EC RESPONSIBLE FOR INTERCONNECTION OF ALL AMR METERING, RAINFOREST AND UTILITY METERING VIA ELECTRICAL PANEL CONNECTIONS PER MANUFACTUER'S RECOMMENDATION.



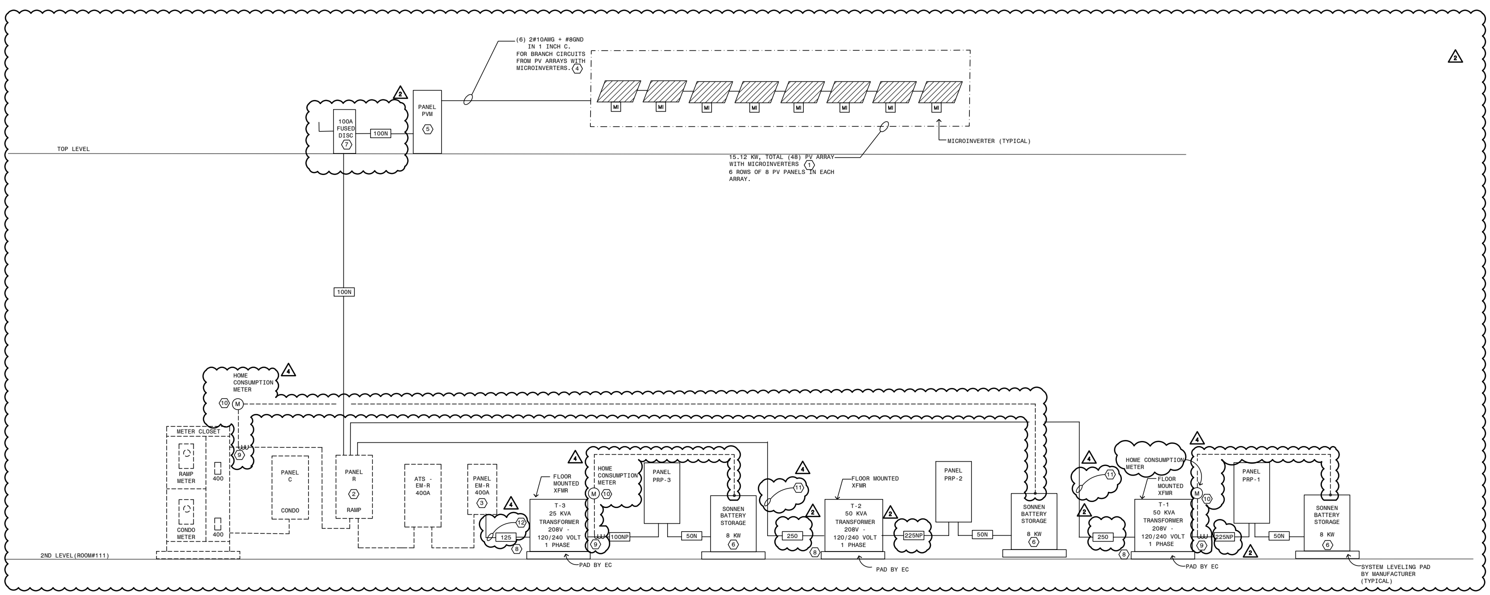
2 LARGE SCALE FIRE PUMP ROOM#111
E200
0' 2' 4' 8'

GENERAL NOTES:

1. EXPOSED CONDUIT TO BE RIGID GALVANIZED STEEL.
2. ALL WIRING TO BE IN CONDUITS.
3. PROVIDE REQUIRED ANCHOR BOLTS FOR SURFACE MOUNTING EQUIPMENT TO CONCRETE WALL.

DETAIL NOTES:

1. PHOTOVOLTAIC ARRAYS(Q.ANTUM DUO CATALOG#G5 305-320) AND ENPHASE MICROINVERTERS SUPPLIED BY BORDER STATES ELECTRIC.
2. EXISTING PANEL R. REPLACE EXISTING 20A, SINGLE POLE CIRCUIT BREAKERS WITH NEW CIRCUIT BREAKERS AS LISTED IN PANEL SCHEDULE ON SHEET E103.
3. EXISTING PANEL EMR. DISCONNECT EXISTING RAMP LIGHTING LOADS. REPLACE EXISTING 20A, SINGLE POLE CIRCUIT BREAKERS WITH NEW AS LISTED IN PANEL SCHEDULE ON SHEET E103.
4. (6) 2#10 AWG +#8 GND IN 1 INCH C. EACH BRANCH CIRCUIT WILL HAVE (8) MICRO-INVERTERS CONNECTED IN SERIES. TOTAL (6) BRANCH CIRCUITS FOR 48 PV ARRAYS.
5. NEW PANEL PVM WITH (6) TWO POLE 20A CIRCUIT BREAKERS FROM PV ARRAY-MICROINVERTERS.
6. PROVIDE ADDITIONAL LEVELING AND WALL BRACKETS AS NEEDED FOR INSTALLING SONNEN BATTERIES. 2
7. PROVIDE 100A DISCONNECT FUSED AT 100A WITH NEMA 4X ENCLOSER PER UTILITY COMPANY REQUIREMENTS. VERIFY WITH UTILITY COMPANY PRIOR TO INSTALLATION.
8. DONGAN TRANSFORMERS ARE FLOOR MOUNTED. EC TO COORDINATE AND VERIFY PAD REQUIREMENTS NEEDED FOR FLOOR MOUNTING TRANSFORMERS WITH SUPPLIER/MANUFACTURER AND ELECTRICAL INSPECTOR AT THE CITY OF FARGO PRIOR TO ROUGH-IN.
9. CT TO BE INSTALLED WITHIN THE EQUIPMENT (METERCLOSET OR SINGLE PHASE TRANSFORMER T1-T3) SHOWN. EC TO VERIFY EXACT CONTROL CABLING REQUIREMENT AND CONNECTIONS WITH SONNEN BATTERY HOME CONSUMPTION METER INSTALLATION MANUAL. 4
10. PROVIDE HOME CONSUMPTION METERING FOR EACH SONNEN BATTERY WITH CONTROL WIRING BELDEN 9533 OR EQUAL CONNECTING TO THE SONNEN BATTERY. VERIFY EXACT REQUIREMENTS, CONTROL WIRING TYPE AND CONNECTIONS WITH MANUFACTURER.
11. LOCKABLE MEANS TO BE PROVIDED ON THE PRIMARY SIDE OF TRANSFORMER OVERCURRENT PROTECTION (TRANSFORMER CIRCUIT BREAKER) WITH LOCKABLE ATTACHMENT AT PANEL R CIRCUITS (R-26,28 AND R-32,34) TO FULFILL THE NEC ARTICLE 450.14 (DISCONNECTING MEANS). EC RESPONSIBLE TO FIELD MARK ON THE TRANSFORMER T-1 AND T-2, LOCATION STATING REMOTE DISCONNECTING MEANS LOCATED AT PANEL R.
12. LOCKABLE MEANS TO BE PROVIDED ON THE PRIMARY SIDE OF TRANSFORMER OVERCURRENT PROTECTION (TRANSFORMER CIRCUIT BREAKER) WITH LOCKABLE ATTACHMENT AT PANEL EM-R CIRCUITS (EM-R-7,9) TO FULFILL THE NEC ARTICLE 450.14 (DISCONNECTING MEANS). EC RESPONSIBLE TO FIELD MARK ON THE TRANSFORMER T-3 LOCATION STATING REMOTE DISCONNECTING MEANS LOCATED AT PANEL EM-R.



1 ELECTRICAL INTERCONNECTION DIAGRAM
E200 NOT TO SCALE

MBN
ENGINEERING
MECHANICAL * ELECTRICAL * CIVIL
503 7TH ST. N , SUITE 200
FARGO, ND 58102
PHONE: 701.478.6336
FAX: 701.478.6340

REVISIONS:

4	10.05.20 OWNER REQUESTED REVISIONS
2	03.02.20 OWNER REQUESTED REVISION
1	10.16.19 ADDENDUM 1

FARGO SMART ENERGY PARKING RAMP

FARGO, ND

NOT FOR CONSTRUCTION

ELECTRICAL INTERCONNECTION DIAGRAM AND DETAILS

MBN JOB #: 18-143 DATE: 08-12-19

E201

ATTACHMENT B- SPECIFICATIONS

SUMMARY OF SMART ENERGY EQUIPMENT

ATTACHMENT B.1
PHOTOVOLTAIC
48 EA Q.PEAK DUO BLK G5.1 315 MONO HALF-CELL 48 EA IQ7-60-2-US ENPHASE IQ 7 MICROINVERTER
48 EA Q-12-10-240 Q-CABLE 240V PORTRAIT
1 EA 570-1174 Enphase converter
3 EA Q-TERM-10 TERMINATOR CAP FOR Q CABLE
1 EA PARKING CANOPY-CUSTOM

ATTACHMENT B.2
BATTERY STORAGE
3 EA ECO10SS-31 10KWH BATTERY STORAGE UNIT
6 EA ECOBATT 2.5KWH BATTERY MOD FOR GEN 3/3.1 3 EA EXTCAB31 EXT CAB FOR THE GEN3.1 ECO10
1 EA 25 KVA/208V TO 120V 3R TRANSFORMER
2 EA 50KVA /208V TO 120/240 ISOLATION TRANSFORMER

ATTACHMENT B.3
ELECTRIC VEHICLE CHARGING STATIONS -- CHARGEPOINT
5 EA CT-4023 Gateway (Dual Chargers)
5 year Enterprise Cloud Plan
5 year Assure (Warranty) Plan

ATTACHMENT B.4
SMART METER – Rainforest
1 Eagle 200

ATTACHMENT B.5
SMART LIGHTING– ECKO
181 Lights

Q.PEAK DUO BLK-G5 305-320

Q.ANTUM SOLAR MODULE

The new Q.PEAK DUO BLK-G5 solar module from Q CELLS impresses with its outstanding visual appearance and particularly high performance on a small surface thanks to the innovative Q.ANTUM DUO Technology. Q.ANTUM's world-record-holding cell concept has now been combined with state-of-the-art circuitry half cells and a six-busbar design, thus achieving outstanding performance under real conditions — both with low-intensity solar radiation as well as on hot, clear summer days.

Q.ANTUM TECHNOLOGY: LOW LEVELISED COST OF ELECTRICITY
Higher yield per surface area, lower BOS costs, higher power classes, and an efficiency rate of up to 19.3%.

INNOVATIVE ALL-WEATHER TECHNOLOGY
Optimal yields, whatever the weather with excellent low-light and temperature behaviour.

ENDURING HIGH PERFORMANCE
Long-term yield security with Anti LID Technology, Anti PID Technology[1], Hot-Spot Protect and Traceable Quality Tra.Q™.

EXTREME WEATHER RATING
High-tech aluminium alloy frame, certified for high snow (5400 Pa) and wind loads (4000 Pa).

A RELIABLE INVESTMENT
Inclusive 12-year product warranty and 25-year linear performance warranty[2].

STATE OF THE ART MODULE TECHNOLOGY
Q.ANTUM DUO combines cutting edge cell separation and innovative wiring with Q.ANTUM Technology.

EUPD RESEARCH TOP BRAND PV MODULES EUROPE 2017

VDE Quality Tested
www.VDEinfo.com
ID. 40032587

[1] APT test conditions according to IEC/TS 62804-1:2015, method B (−1500V, 168h)
[2] See data sheet on rear for further information.

THE IDEAL SOLUTION FOR:

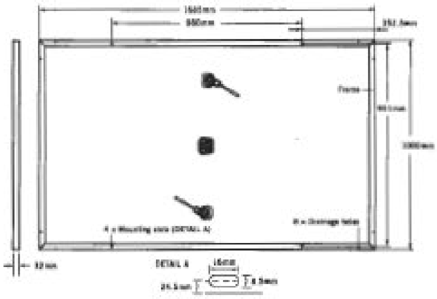
Rooftop arrays on residential buildings

Engineered in **Germany**

Q CELLS

MECHANICAL SPECIFICATION

Format	1685 mm × 1000 mm × 32 mm (including frame)
Weight	18.7 kg
Front Cover	3.2 mm thermally pre-stressed glass with anti-reflection technology
Back Cover	Composite film
Frame	Black anodised aluminium
Cell	6 × 20 monocrystalline Q.ANTUM solar half cells
Junction box	70-85 mm × 50-70 mm × 13-21 mm Protection class IP67, with bypass diodes
Cable	4 mm² Solar cable; (+) 1100 mm, (−) 1100 mm
Connector	Multi-Contact MC4, IP65 and IP68

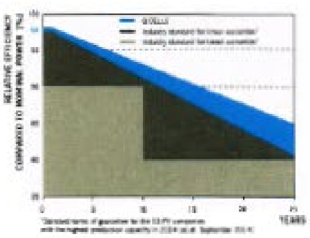


ELECTRICAL CHARACTERISTICS

POWER CLASS			305	310	315	320
MINIMUM PERFORMANCE AT STANDARD TEST CONDITIONS, STC[1] (POWER TOLERANCE +5 W / −0 W)						
Minimum — Power at MPP[2]	P_{MPP}	[W]	305	310	315	320
Short Circuit Current*	I_{SC}	[A]	9.78	9.83	9.89	9.94
Open Circuit Voltage*	V_{OC}	[V]	39.75	40.02	40.29	40.56
Current at MPP*	I_{MPP}	[A]	9.31	9.36	9.41	9.47
Voltage at MPP*	V_{MPP}	[V]	32.78	33.12	33.46	33.80
Efficiency[2]	η	[%]	≥18.1	≥18.4	≥18.7	≥19.0
MINIMUM PERFORMANCE AT NORMAL OPERATING CONDITIONS, NOC[3]						
Minimum — Power at MPP[2]	P_{MPP}	[W]	226.0	229.7	233.5	237.2
Short Circuit Current*	I_{SC}	[A]	7.88	7.93	7.97	8.02
Open Circuit Voltage*	V_{OC}	[V]	37.18	37.43	37.69	37.94
Current at MPP*	I_{MPP}	[A]	7.32	7.36	7.41	7.45
Voltage at MPP*	V_{MPP}	[V]	30.88	31.20	31.52	31.84

[1]1000 W/m², 25 °C, spectrum AM 1.5G [2]Measurement tolerances STC ±3 %; NOC ±5 % [3]800 W/m², NOCT, spectrum AM 1.5G * typical values, actual values may differ

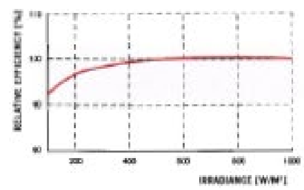
Q CELLS PERFORMANCE WARRANTY



At least 98 % of nominal power during first year. Thereafter max. 0.54 % degradation per year. At least 93.1 % of nominal power up to 10 years. At least 85 % of nominal power up to 25 years.

All data within measurement tolerances. Full warranties in accordance with the warranty terms of the Q CELLS sales organisation of your respective country.

PERFORMANCE AT LOW IRRADIANCE



Typical module performance under low irradiance conditions in comparison to STC conditions (25 °C, 1000 W/m²).

TEMPERATURE COEFFICIENTS

Temperature Coefficient of I_{SC}	α	[%/K]	+0.04	Temperature Coefficient of V_{OC}	β	[%/K]	−0.28
Temperature Coefficient of P_{MPP}	γ	[%/K]	−0.37	Normal Operating Cell Temperature	NOCT	[°C]	45

PROPERTIES FOR SYSTEM DESIGN

Maximum System Voltage	V_{SYS}	[V]	1000	Safety Class	II
Maximum Reverse Current	I_R	[A]	20	Fire Rating	C
Push/Pull Load (Test-load in accordance with IEC 61215)		[Pa]	5400/4000	Permitted Module Temperature On Continuous Duty	−40 °C up to +85 °C

QUALIFICATIONS AND CERTIFICATES

VDE Quality Tested, IEC 61215 (Ed. 2); IEC 61730 (Ed. 1), Application class A
This data sheet complies with DIN EN 50380.

PARTNER

NOTE: Installation instructions must be followed. See the installation and operating manual or contact our technical service department for further information on approved installation and use of this product.

Hanwha Q CELLS GmbH
Sonnenallee 17-21, 06766 Bitterfeld-Wolfen, Germany | TEL +49 (0)3494 66 99-23444 | FAX +49 (0)3494 66 99-23000 | EMAIL sales@q-cells.com | WEB www.q-cells.com

Engineered in **Germany**

Q CELLS

sonnen

Technical Data sonnenBatterie

	eco 8.0/2	eco 8.0/4	eco 8.0/6	eco 8.0/8	eco 8.0/10	eco 8.0/12	eco 8.0/14	eco 8.0/16
Grid Version (three phase)								
Rated inverter power (W) (charging/discharging)	1,500	2,500	3,000	3,300	3,300	3,300	3,300	3,300
Maximum inverter efficiency	96 %							
Variety[1] (2–10 kWh)								
Weight kg	55	96	121	146	171	–	–	–
Dimensions H/W/D cm	70/64/22	137/64/22	137/64/22	137/64/22	137/64/22	–	–	–
Variety[1] (2–16 kWh)								
Weight kg	55	107	132	157	182	207	232	257
Dimensions H/W/D cm	70/64/22	184/64/22	184/64/22	184/64/22	184/64/22	184/64/22	184/64/22	184/64/22

	eco 8.2/2	eco 8.2/4	eco 8.2/6	eco 8.2/8	eco 8.2/10	eco 8.2/12	eco 8.2/14	eco 8.2/16
Grid Version (single phase)								
Rated inverter power (W) (charging/discharging)	1,500	2,000	2,500	2,500	2,500	2,500	2,500	2,500
Maximum inverter efficiency	93 %							
Variety[1] (2–10 kWh)								
Weight kg	71	112	137	162	187	–	–	–
Dimensions H/W/D cm	70/64/22	137/64/22	137/64/22	137/64/22	137/64/22	–	–	–
Variety[1] (2–16 kWh)								
Weight kg	71	123	148	173	198	223	248	273
Dimensions H/W/D cm	70/64/22	184/64/22	184/64/22	184/64/22	184/64/22	184/64/22	184/64/22	184/64/22

sonnen

Technical Data sonnenBatterie

	eco 8/2	eco 8/4	eco 8/6	eco 8/8	eco 8/10	eco 8/12	eco 8/14	eco 8/16
Maximum battery efficiency	98 %							
Usable battery capacity (kWh)	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0
Cell chemistry	LFP (Lithium Iron Phosphate)							
Ambient temperature range	5° – 40 °C							
Dust & water protection	IP 21							
Tests and directives	VDE-AR-N_4105, Low Voltage Directive 2006/95/EG, UL1642, IEC62133							
Battery service life	designed for 20 years							
Warranty	10 years[2]							
Cycles	10,000[2]							
Charging time to 90 %, approx.	1.5 h	1.5 h	2 h	2.5 h	3 h	3.5 h	4 h	4.5 h
Recommended for use with annual household consumption up to [kWh] (based on experience)	2,500	3,300	4,400	5,500	6,600	7,700	8,800	9,900

Available options

Colour of cabinet[3]	black or silvergrey
Multi-Touch-Display	18 cm width

We reserve the right to make technical changes and updates without prior notice. Specific values, performance data and other information in this data sheet, brochures and other product information, as well as illustrations and drawings in these documents, are solely illustrative and are subject to ongoing revision and modification. We do not warrant the accuracy or completeness of any information in these documents unless otherwise explicitly stated. Only the information in order confirmation documents or purchase contracts is binding.

[1] Two base cabinet versions are available. Depending on your power requirements a smaller base cabinet can be acquired for capacity sizes up to 10 kWh.
[2] Warranty on all parts. To learn more about our current warranty terms and conditions, please visit www.sonnenbatterie.de/garantiebedingungen or call our customer hotline and request a copy.
[3] Standard Colour of cabinet: white

sonnenBatterie-Datasheet-eco-8-KD207-AU-161010

—chargepoin+

CT4000 Level 2 Commercial Charging Station

Specifications and Ordering Information

Ordering Information

Specify model number followed by the applicable code(s).
The order code sequence is: **Model-Options**. **Software**, **Services** and **Misc** are ordered as separate line items.

Hardware

Description		Order Code
Model	1830 mm (6 ft) Single Port Bollard Mount 1830 mm (6 ft) Dual Port Bollard Mount	CT4011-GW1 CT4021-GW1
	1830 mm (6 ft) Single Port Wall Mount 1830 mm (6 ft) Dual Port Wall Mount	CT4013-GW1 CT4023-GW1
	2440 mm (8 ft) Dual Port Bollard Mount 2440 mm (8 ft) Dual Port Wall Mount	CT4025-GW1 CT4027-GW1
Included	Integral Modem - North America	-GW1
Misc	Power Management Kit Bollard Concrete Mounting Kit	CT4000-PMGMT CT4001-CCM

Note: All CT4000 stations include Intergral Modem -GW1.

Software & Services

Description	Order Code
ChargePoint Commercial Service Plan	CPCLD-COMMERCIAL-*n**
ChargePoint Enterprise Plan	CPCLD-ENTERPRISE-*n**
ChargePoint Assure	CT4000-ASSURE*n**
Station Activation and Configuration	CPSUPPORT-ACTIVE
ChargePoint Station Installation and Validation	CT4000-INSTALLVALID

Note: All CT4000 stations require a network service plan per port.

*Substitute *n* for desired years (1, 2, 3, 4, or 5 years).

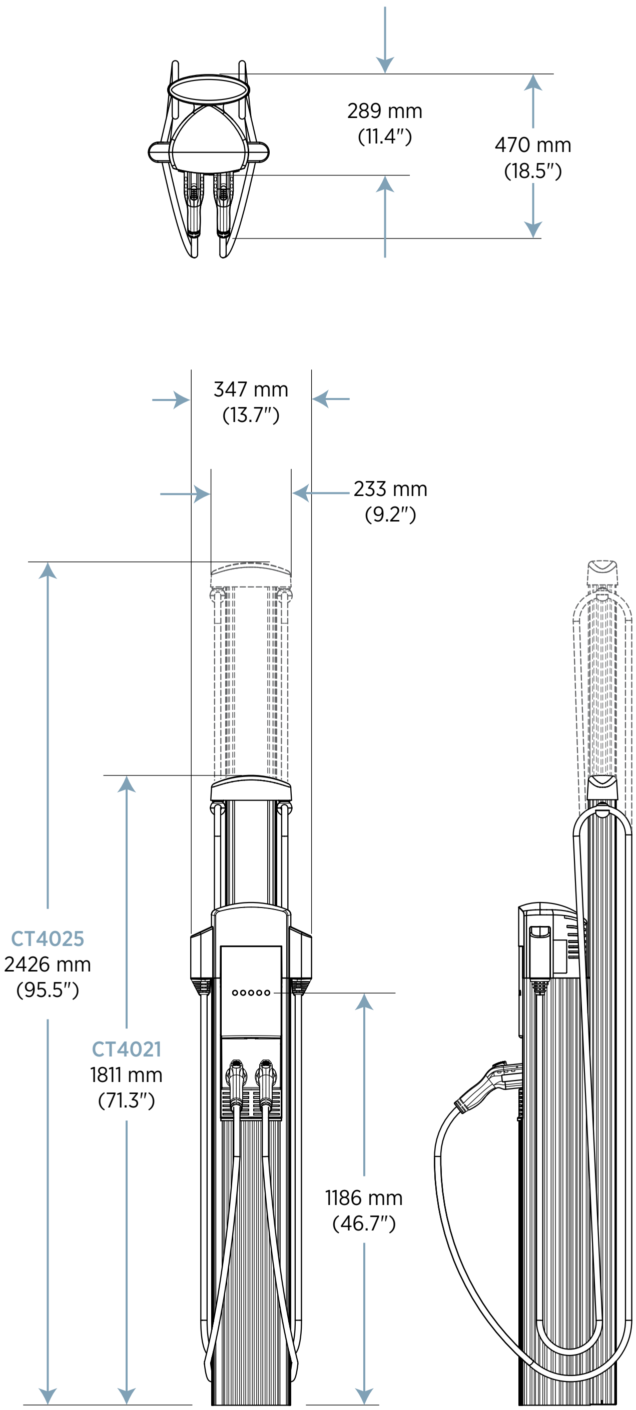
Order Code Examples

If ordering this	the order code is
1830 mm (6 ft) Dual Port Bollard Networked Station with Concrete Mounting Kit	CT4021-GW1 CT4001-CCM
ChargePoint Commercial Service Plan, 3 Year Subscription	CPCLD-COMMERCIAL-5
ChargePoint Station Installation and Validation	CT4000-INSTALLVALID
3 Years of Assure Coverage	CT4000-ASSURE5
1830 mm (6 ft) Single Port Wall Mount Networked Station	CT4013-GW1
ChargePoint Commercial Service Plan, 5 Year Subscription	CPCLD-COMMERCIAL-5
5 Years of Assure Coverage	CT4000-ASSURE5
Station Activation and Configuration	CPSUPPORT-ACTIVE

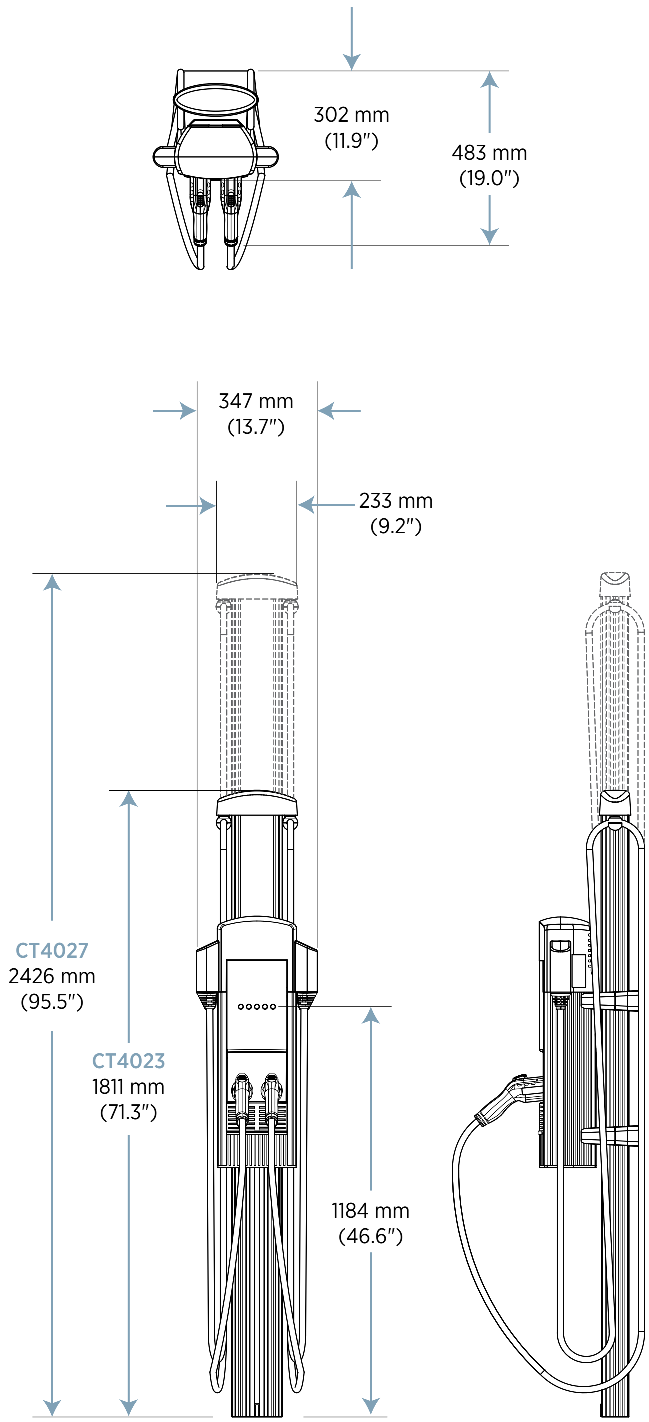
CT4021

The First **ENERGY STAR®** Certified EV Charger

CT4021 1830 mm (6′)
CT4025 2440 mm (8′)
Bollard



CT4023 1830 mm (6′)
CT4027 2440 mm (8′)
Wall Mount



CT4000 Family Specifications

Electrical Input	Single Port (AC Voltage 208/240V AC)			Dual Port (AC Voltage 208/240V AC)		
	Input Current	Input Power Connection	Required Service Panel Breaker	input Current	Input Power Connection	Required Service Panel Breaker
Standard	30A	One 40A branch circuit	40A dual pole (non-GFCI type)	30A x 2	Two independent 40A branch circuits	40A dual pole (non-GFCI type) x 2
Standard Power Share	n/a	n/a	n/a	32A	One 40A branch circuit	40A dual pole (non-GFCI type)
Power Select 24A	24A	One 30A branch circuit	30A dual pole (non-GFCI type)	24A x 2	Two independent 30A branch circuits	30A dual pole (non-GFCI type) x 2
Power Select 24A Power Share	n/a	n/a	n/a	24A	One 30A branch circuit	30A dual pole (non-GFCI type)
Power Select 16A	16A	One 20A branch circuit	20A dual pole (non-GFCI type)	16A x 2	Two independent 20A branch circuits	20A dual pole (non-GFCI type) x 2
Power Select 16A Power Share	n/a	n/a	n/a	16A	One 20A branch circuit	20A dual pole (non-GFCI type)
Service Panel GFCI	Do not provide external GFCI as it may conflict with internal GFCI (CCID)					
Wiring - Standard	3-wire (L1, L2, Earth)			5-wire (L1, L1, L2, L2, Earth)		
Wiring - Power Share	n/a			3-wire (L1, L2, Earth)		
Station Power	8 W typical (standby), 15 W maximum (operation)					

Electrical Output

Standard	7.2 kW (240V AC @ 30A)	7.2 kW (240V AC @ 30A) x 2
Standard Power Share	n/a	7.2 kW (240V AC @ 30A) x 1 **or** 3.8 kW (240V AC @ 16A) x 2
Power Select 24A	5.8 kW (240V AC @ 24A)	5.8 kW (240V AC @ 24A) x 2
Power Select 24A Power Share	n/a	5.8 kW (240V AC @ 24A) x 1 **or** 2.9 kW (240V AC @ 12A) x 2
Power Select 16A	3.8 kW (240V AC @ 16A)	3.8 kW (240V AC @ 16A) x 2
Power Select 24A Power Share	n/a	3.8 kW (240V AC @ 16A) x 1 **or** 1.9 kW (240V AC @ 8A) x 2

Functional Interfaces

Connector(s) Type	SAE J1772™	SAE J1772™ x 2
Cable Length - 1830 mm (6 ft) Cable Management	5.5 m (18 ft)	5.5 m (18 ft) x 2
Cable Length - 2440 mm (8 ft) Cable Management	n/a	7 m (23 ft)
Overhead Cable Management System	Yes	
LCD Display	145 mm (5.7 in) full color, 640 x 480, 30 fps full motion video, active matrix, UV protected	
Card Reader	ISO 15693, ISO 14443, NFC	
Locking Holster	Yes	Yes x 2

Safety and Connectivity Features

Ground Fault Detection	20 mA CCID with auto retry
Open Safety Ground Detection	Continuously monitors presence of safety (green wire) ground connection
Plug-Out Detection	Power terminated per SAE J1772™ specifications
Power Measurement Accuracy	+/- 2% from 2% to full scale (30A)
Power Report/Store Interval	15 minute, aligned to hour
Local Area Network	2.4 GHz WiFi (802.11 b/g/n)
Wide Area Network	LTE Category 4

Safety and Operational Ratings

Enclosure Rating	Type 3R per UL 50E
Safety Compliance	UL listed and cUL certified; complies with UL 2594, UL 2231-1, UL 2231-2, and NEC Article 625
Surge Protection	6 kV @ 3,000A. In geographic areas subject to frequent thunder storms, supplemental surge protection at the service panel is recommended.
EMC Compliance	FCC Part 15 Class A
Operating Temperature	-40°C to 50°C (-40°F to 122°F)
Storage Temperature	-40°C to 60°C (-40°F to 140°F)
Non-Operating Temperature	-40°C to 60°C (-40°F to 140°F)
Operating Humidity	Up to 85% @ 50°C (122°F) non-condensing
Non-Operating Humidity	Up to 95% @ 50°C (122°F) non-condensing
Terminal Block Temperature Rating	105°C (221°F)
Network	All stations include integral LTE modem and will be automatically configured to operate as gateway or non-gateway as needed

ChargePoint, Inc. reserves the right to alter product offerings and specifications at any time without notice, and is not responsible for typographical or graphical errors that may appear in this document.

Contact Us

Visit chargepoint.com

Call +1.408.705.1992

Email sales@chargepoint.com

chargepoint

ChargePoint, Inc.
240 East Hacienda Avenue
Campbell, CA 95008-6617 USA

+1.408.841.4500 or
+1.877.370.3802 US and Canada toll-free

chargepoint.com

Listed by Underwriters Laboratories Inc.

c UL us LISTED

ENERGY STAR

Energy Gateway and Smart Home Hub

EAGLE-200

SHOP NOW

Get back in control of your energy usage. With the EAGLE platform you can finally see where the power goes – as it happens! Turn on the A/C, plug in your EV, or turn on the dryer to instantly see how much electricity those things take. Have solar? There is nothing better than showing everyone that you're making money while you're not at home.

Rainforest Makes Energy Simple.

The EAGLE-200 connects wirelessly to your utility smart meter to get your electricity usage data even before the utility sees it. Your data is streamed in real-time to the Rainforest Cloud. It makes you and your home energy smart. You can see your energy, direct from your smart meter, on our apps and web portal. Connect smart home devices to build out a smart home experience

Be Empowered

Use the insights from your data to take control of your consumption – and your bill.

Easy Self-Install

No clamps, no electrician — just plug it in!

Monitor Your Home from Anywhere

On the web or with our app

Alexa & Google Home Compatible

Now with voice activation technology

Connect up to 10 Devices

ZigBee HA 1.2 and ZigBee Smart Energy 1.1 supported

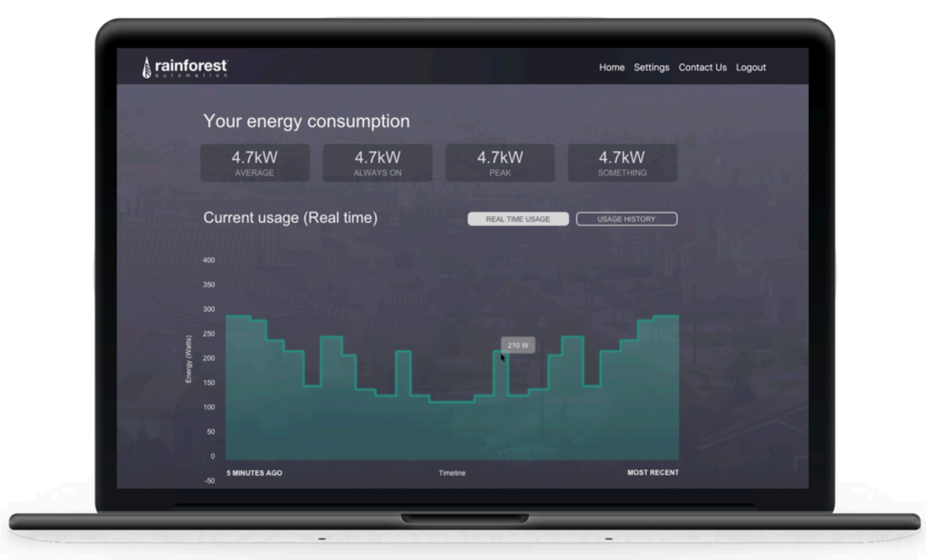
Simple. Secure. Flexible.

The EAGLE-200 can be self-installed in minutes and does not require an electrician or a utility visit. It's as simple as plug-and-play!

Stay Connected on the Cloud

The Rainforest Cloud can be accessed from your smartphone, tablet, or computer. All you need is a web browser to get up-to-the-minute consumption information anywhere you have internet access.

SHOP THE EAGLE-200



Specifications

Software Requirements	User Interaction: Web Browser, iOS app, or Android app;
Internet Connectivity	10/100 Ethernet, WiFi 802.11 b/g/n
Demand Response	HTTP REST API; OpenADR 2.0b compatible
Ethernet Control	Sunspec Modbus TCP (inverter, battery: control and monitoring)
Zigbee Wireless Link	IEEE 802.15.4 MAC, 2.4GHz ISM Band; Receiver sensitivity: -99dBm, Transmit Power: +20dBm
Zigbee Wireless Range	Up to 50m (150ft) (highly dependent on usage environment)
Zigbee Radio 1	Zigbee Smart Energy Profile 1.1 Endpoint
Zigbee Radio 2	Zigbee Smart Energy Profile 1.1 Coordinator, Zigbee Home Automation 1.2 Coordinator, ZigBee 3.0 Coordinator
Upgrade Path	Field upgradeable firmware over the internet
Expansion	USB 2.0 port for additional interfaces
API Support	HTTP REST interface for control and monitoring (local and cloud)
Power	External AC Adapter (included)
Operating Temperature	0°C to 50°C (indoor use only)
Storage Temperature	-10°C to 60°C
Dimensions	90mm x 95mm x 27mm
Weight	120g (not including AC Adaptor)
Warranty	One year

project name	type
catalog number	
comments	voltage
approved by	date

SCRG : SURFACE CANOPY, ROUND GARAGE

DESCRIPTION

A cost-effective, multipurpose fixture for garage and canopy lighting. It provides unmatched versatility with multiple mounting options, durable construction and an optional sensor for use in a wide range of indoor and outdoor applications.

FEATURES

- 130 lpw ultra-high efficiency delivers superior performance
- Optional integrated microwave motion sensor with photocell offers fully adjustable on/off and bi-level dimming capabilities
- Optional remote control commissioning device available for integrated sensors
- 0-10V dimming control

LISTINGS

- UL Listed for wet locations
- IP65 Rated
- DesignLights Consortium® Premium Qualified - meets the requirements for the highest DLC qualification for efficacy and lumen maintenance

PERFORMANCE

- Rated lifetime L90: >50,000 hours
- 4000K, 5000K CCT
- CRI: 80+

ELECTRICAL

- Input voltage: 120-277V
- Dimmable power supply (0-10V)
- Power Factor: >.9
- THD: <20%

THERMAL

- -40°F to 104°F (-40°C to 40°C) operating temperature

CONSTRUCTION

- Diecast aluminum heatsink
- Optional Integrated microwave motion and photocell sensor
- Impact-resistant polycarbonate lens
- 1/2" NPS entry point for conduit and accessories
- 3/4" NPS pendant mount
- Quick mount surface bracket included

WARRANTY

- 5 year limited warranty; see eiko.com for warranty details

APPLICATIONS

- Strip malls
- Entryways
- Educational facilities
- Plazas
- Canopies
- Eaves
- Public rest areas
- Cold storage
- Bridges, tunnels, and overpasses (with 3G bracket)
- Lowbay

IP65 OUTDOOR RATED | c UL us | RoHS Compliant | DLC QPL LISTED PREMIUM

ORDERING INFORMATION

EXAMPLE: SCRG-75/D0/840-DIM-U-W

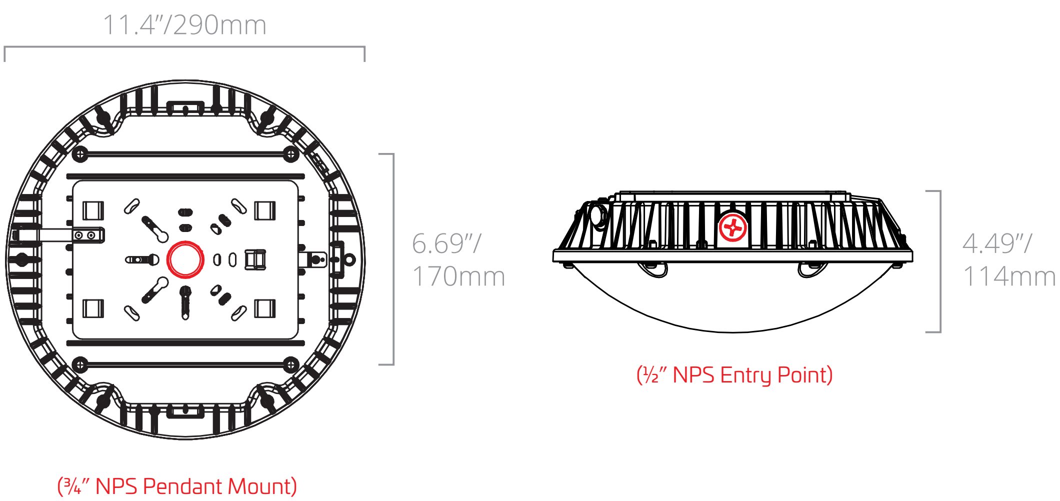
Model	Package	LPW	CCT/CRI	Dimming	Voltage	Sensor	Finish
SCRG : Surface Canopy Round, Garage	**50** - 40W; 5,000 lm **75** - 60W; 8,000 lm	**D0** - 130	**840** - 4000K; 80CRI **850** - 5000K; 80CRI	**DIM** - 0-10V Dimming	**U** - Universal	**S1B** - Sensor (Blank) - No sensor	**W** - White

PERFORMANCE SUMMARY

Order Code	Item #	Watts	Lumens	CCT	CRI	Dimming	Volts	DLC
09955	SCRG-50/D0/840-DIM-U-W	40W	5000	4000K	80+	0-10V	120-277V	✓
09956	SCRG-50/D0/850-DIM-U-W	40W	5000	5000K	80+	0-10V	120-277V	✓
09957	SCRG-75/D0/840-DIM-U-W	60W	8000	4000K	80+	0-10V	120-277V	✓
09958	SCRG-75/D0/850-DIM-U-W	60W	8000	5000K	80+	0-10V	120-277V	✓
09959	SCRG-50/D0/840-DIM-U-S1B-W	40W	5000	4000K	80+	0-10V	120-277V	✓
09960	SCRG-50/D0/850-DIM-U-S1B-W	40W	5000	5000K	80+	0-10V	120-277V	✓
09961	SCRG-75/D0/840-DIM-U-S1B-W	60W	8000	4000K	80+	0-10V	120-277V	✓
09962	SCRG-75/D0/850-DIM-U-S1B-W	60W	8000	5000K	80+	0-10V	120-277V	✓

✓DesignLights Consortium® Premium Qualified

DIMENSIONS



AVAILABLE ACCESSORIES

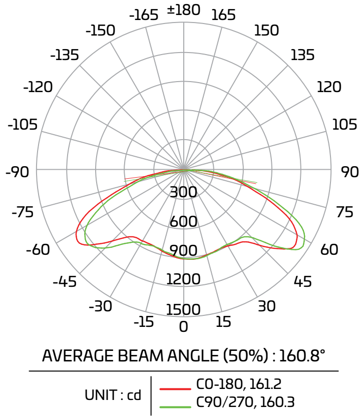
Order Code	Item #	Description
10113	SEN-S1-RC2	Remote Control for S1B Sensors
09963	SCRG-3G-BRK	Quick Mount Bracket for SCRG 3G applications
09908	SEN-S1A-KO	Sensor, OCC/PC/RC, IP65, 1/2″ Knock Out Mount, Remote Controllable

Rev. 10/7/20

PHOTOMETRICS

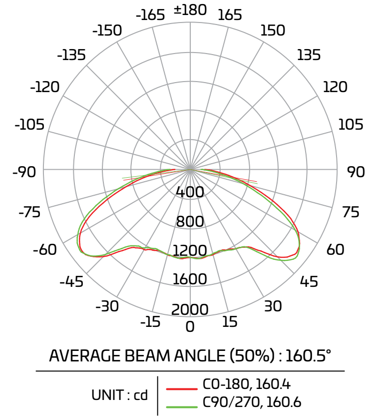
40W 5000K

ZONAL LUMEN SUMMARY		
Zone	Lumens	%Fixture
0-30	701.7	13.3%
0-40	1238.0	23.4%
0-60	3208.6	60.7%
60-90	2018.3	38.2%
70-100	975.6	18.5%
90-120	52.7	1%
0-90	5226.9	98.9%
90-180	55.5	1.1%
0-180	5282.3	100%



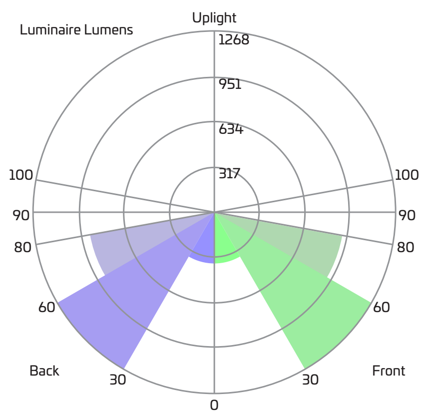
60W 5000K

ZONAL LUMEN SUMMARY		
Zone	Lumens	%Fixture
0-30	1001.1	13.5%
0-40	1780.8	24%
0-60	4580.1	61.6%
60-90	2770.1	37.3%
70-100	1370.2	18.4%
90-120	77.9	1%
0-90	7350.2	98.9%
90-180	82.1	1.1%
0-180	7432.3	100%

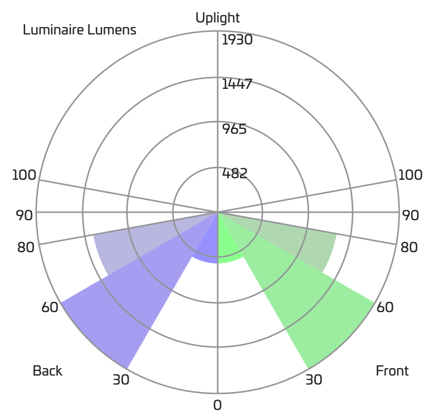


BUG RATINGS

Zone	Lumens	%Fixture
0-30	1001.1	13.5%
0-40	1780.8	24%
0-60	4580.1	61.6%



SCRG-50-D0



SCRG-75-D0

Rev. 10/7/20

Guide to a Smart-Energy, Carbon-Reducing Commercial Package for Developers and City Managers[1]

Appendix C
Fargo's Smart Energy Ramp Project
NDIC Agreement R-038-048[2]

[1] A special thank you to MBN Engineering who was the lead author for most of the material in this Guide.
[2] Effective April 1, 2021, this agreement was assigned from eSmart Systems US, Inc to The Alliance Risk Group, LLC.

Guide to a Smart-Energy, Carbon-Reducing Commercial Package

1. Introduction

This Guide is an outgrowth of the Fargo Smart Energy Ramp project co-sponsored by the North Dakota Industrial Commission (NDIC) to incorporate renewable energy and revitalize downtowns. The results of the Fargo project indicate that the Smart, Clean Energy package helped attract new workforce to North Dakota.[3] Using renewable energy and electric vehicles also reduces the carbon footprint, which supports the Governor's Goal of making North Dakota Carbon Neutral for 2030 goal. This Guide provides overview guidance to Developers, Property Owners/Managers and Cities on selecting appropriate Smart Energy features for their commercial, including multi-family, facilities.

2. Potential Smart Energy Building Components

There are a number of building components that can be implemented as part of a smart energy strategy for a facility. The following is a list of potential smart energy building components used in the Fargo Smart Energy Ramp project:

a. Solar Panels
b. Electric Vehicle (EV) Charging
c. Battery Storage
d. Smart Lighting Controls
e. Intelligent Demand Control

Each of these components require planning in order to properly deploy. These are emerging technologies that continue to evolve, so it is important to plan for the current configuration of the systems and to consider possible future changes to the technology. The building planning process should include consideration for smart technology, so even if not deployed initially, the systems could be deployed later. If planning and basic infrastructure is not installed during the initial building construction, adding these smart energy components in the future will be much more expensive.

3. Solar Panels Planning Considerations

Solar panels or photovoltaic panels are approximately 3 or 3-1/2 feet wide by 5 or 6 feet feet long and most are rated 300 to 400 watts. In order for a solar panel system to produce a significant amount of power as required by a commercial or mixed use building, the solar panel system will be fairly large in terms of wattage rating and in terms of physical size. In order to determine the physical size, first the wattage rating needs to be determined.

[3] This project found that the Smart Clean Energy Package was instrumental in attracting out-of-state workforce -- 85% of the residents in two new multi-family complexes adjacent to the Roberts Commons Parking Garage were from out-of-state, which added $12 million to the local economy.

Determining the kWh output goal

The wattage rating of the solar panel system is determined by the goals of the system. If there is a particular percentage of building power consumption for solar to meet, that can be the goal. If there is a particular system in the building that can be offset by the solar power system, like lighting or computer systems, then the solar system can be sized to match the rating of a particular system. There are also industry guidelines that can be used as a goal – e.g., the LEED (Leadership in Energy and Environmental Design) goal for renewable energy utilization in a building is between 1 and 13 percent, the Green Globes guidance for renewable energy is 5 to 10% or above 10%.

In order to meet a certain renewable energy goal in terms of consumption or particular system offset, first the building or system energy consumption needs to be determined. For a new facility, looking at similar facilities is often a prudent way to get the best estimate of energy consumption. The local power company can assist with this exercise. If you give them a description of the facility and size, they can locate a similar building and share the power consumption to use as a guide. Another option is to estimate the consumption based on type of building and square footage. Data can be found on typical kwh consumption on different building types. Perhaps your goal is to offset the energy consumption of a particular building system, like the lighting system. Again this can be estimated based on building type and square footage of a comparable building. Alternatively, if the actual lighting system load data is available, that can be used.

Determining the kW rating and physical size

Once the goal is determined in annual kilowatt hours produced by the solar system, the size of the system in terms of kilowatt rating and physical size can be calculated. The United States Department of Energy, National Renewable Energy Laboratory has a website called PVWatts, https://pvwatts.nrel.gov/. This website provides the estimated annual output of a solar panel system in kilowatt hours (kWh) based on the kilowatt rating of the system and the location of the system in the United States. The following inputs are required:

1. Location
2. DC Rating of the System in Watts
3. Type of Solar Module
4. Type of Array – Fixed or Tracking
5. Tilt of Panels
6. Direction Panels are Facing
7. Cost of Local Electricity in $/kwh

Based on these inputs, the website will generate a monthly kilowatt hour (AC) output of the system and the yearly total. This tool will determine watt kilowatt rating of the system needed to meet the kilowatt hour output goal.

The kilowatt rating (kW) rating can then be converted into the quantity of solar panels needed. If you need a 5,000 watt system and each panel is rated 250 watts, you will need 20 solar panels for your system.

Once the goals of the system in terms of energy production is determined, then the location for the array needs to be determined. Essentially there are two locations to be considered, on the roof or on the ground. There is also a third option to mount them on a carport structure, but this option is only used when space is not available otherwise.

Roof mount

Mounting solar panels on the roof is a good use of otherwise unused building square footage, however there are several considerations. The structure of the building needs to be designed to handle the weight of the solar panels and potential snow drifting caused by the panels. For a new building design, this consideration is easily handled and has minimal cost impact. For an existing building. it will require a structural analysis. Solar panel systems typically range from 3 to 4 pounds per square foot for a system attached to a sloped or flat roof and 4 to 7 pounds per square foot for a ballasted system where weights are used to hold the panels down to a flat roof. The other consideration is roof maintenance and access to roof mounted equipment. When the panels are placed on a roof, ongoing roof practices must be considered to prevent leaks or to ensure the roof warranty is not voided. The roofing manufacturer should be consulted on how to place and attach the solar panels to best interact with the roofing system. In addition, careful layout of the panels needs to be completed to maintain access for equipment maintenance. The amount of space available after leaving access for HVAC equipment and leafing pathways to traverse the roof will likely dictate the size of the solar array.

Ground mount

The other option for mounting solar panels in on the ground. In urban areas, this may not be an option, but in suburban or rural areas this is a good option. The primary advantage to this system is that it has no impact on building structural or roofing systems. As with a roof mounted system, layout of the components is important. Locating the array to avoid trees and other obstructions is critical. In addition, pathways need to be provided to allow for maintenance of the system. Moreover, the ground below and around the panels needs to be graveled or mowed to ensure weeds and grass do not obstruct the panels.

There are two additional options with ground mounting -- adding a solar tracking system or installing the panels on a car port. The tracking system is used to turn the panels to track the sun as it travels across the sky to improve the efficiency of the panels. The carport option is to place the panels on top of a carport so they can be installed above parking in a parking lot or the top level of a parking garage. Both options add cost to installation of the system, but may need to be implemented if space is not available otherwise.

Power interconnection

The last consideration for installation of the solar panel system is the power interconnection to the building power system. This seems like a simple issue, but this interconnection is dictated by the National Electrical Code (NEC), the power company and, in some places, local codes. The NEC has specific requirements for connecting a solar power system to the building power system. An engineer or licensed electrician should be consulted about what is needed locally. The local power company also has regulations on how the interconnection between the systems can be made. This requirement needs to be discussed with the power company so proper provisions are made so that costly revisions are not required later.

Metering interconnection

The power company will also dictate the type of metering that is allowed for the solar power system. Typically, the two options are net metering and load offset. Net metering allows the solar power system to send energy back to the utility company when the energy is not being consumed by the building and that energy is paid for by the power company. Load offset does allow power to be sold back to the utility company, but only to be used to offset building load. Both options can be beneficial depending on the power company rate structures, the load characteristics of the building, the size of the solar array, the ability to store the solar energy produced, etc. An analysis of the options should be completed with the assistance of the local power company.

Finally, the following is some guidance on the costs associated with a solar power system for a commercial building. Note that the costs are higher in areas or climates where installers are not as readily available.

<u>Budgetary Cost for Solar Power System</u>

Roof Mounted System

- $2.50 to $3.50 per watt depending on roof type.
- Additional 25% to 50% for northern climates or remote areas.

Ground Mounted System

- $2.25 to $3.25 per watt depending on structure type.
- Additional 25% to 50% for northern climates or remote areas.

4. Electric Vehicle Charging Planning Considerations

Electric Vehicle (EV) chargers come in several different varieties that are categorized based on charge time.[4]

[4] Other resources on this topic include: https://greenways2go.com/alternative-transportation-documents/

Level 1 Charger

Level 1 chargers are the type of chargers that are typically supplied with the purchase of the electrical vehicle. The typical use for this type of charger is within the purchaser's residence to recharge the vehicle overnight. This type of charger is usually powered from a standard 120 volt convenience receptacle and is rated from 1.4 to 1.9 kilowatts with a typical charge time of 20 hours.

Level 2 Charger

Level 2 chargers are sold separately from the electrical vehicle. This type of charger is used to charge a vehicle at the workplace, at a residence or in a parking garage. These chargers are rated 240 or 208 volts, from 7 to 20 kilowatts and 30 to 40 amperes. The typical charge time for this type of charger is 4 to 8 hours.

Level 2 chargers typically can be accommodated in most all commercial or residential buildings. If a larger number of chargers are deployed within a facility, the power requirements can become significant. A 200 ampere rated electrical panel would need to be dedicated for every 8-10 chargers, so planning for future chargers is important to allow for the needed electrical system capacity.

Level 3 Charger

A level 3 charger is a commercial DC charger that are used for fast charging applications. This type of charger would typically be located at fueling stations, along highways or in other similar locations to allow for a fast charge of the vehicle. The charger requires a 208 volt, 3 phase or 480 volt, 3 phase input power connection of up to 125 amperes. The typical charge time for this charger is 20 to 40 minutes.

Level 3 chargers are a commercial-only application as each charger requires a significant 3-phase power connection. If multiple chargers are to be accommodated, careful planning is needed to ensure the capacity is available within the building power distribution system.

Space Considerations

Level 1 and Level 2 chargers are typically wall or post mounted. The post mounting option is typically used for parking lot applications. Level 1 and Level 2 chargers work well in parking garages or parking lots as they do not require a large amount of space. Level 3 chargers are typically mounted to a concrete pad and thus only work well in parking lots where space is available to install this significant piece of equipment.

The chargers may be "standard" chargers with no remote communications capability. Or, the chargers may be "smart chargers" in which there is blue tooth or wi-fi communication capability so that the chargers can be remotely monitored and have the control settings remotely adjusted. This "smart" capability is important for Intelligent Demand Control, as discussed in section 7 below.

<u>Budgetary Costs</u>

Budgetary Cost for Chargers[5]

1. Equipment Cost for typical Level 1 and2 "standard" chargers
   a. Level 1 - $100 to $300
   b. Level 2 - $450 to $900
2. Equipment Cost for typical Level 1, 2 and 3 "smart" chargers
   a. Level 1 - $500 to $950
   b. Level 2 - $1250 to $9,000
   c. Level 3 – Up to $55,000

3. Installation costs
   a. Level 1 - $500 to $2000
   b. Level 2 - $5000 to $10,000
   c. Level 3 - $25,000 to $80,000

5. Battery Storage Planning Considerations

Battery storage is typically added to facilities for three purposes:

a) Make better use of on-site solar energy,
b) Reduce peak electrical demand,
c) Provide additional back-up electricity during power outages.

Solar

Battery storage is used to store excess energy produced by the solar panel system. Some facility owners may choose to have total solar output meet all or most of their electricity needs. In such cases there will be hours during the year that the electricity supplied by the solar systems exceeds the electricity used at the facility. Some utilities have "net metering" or "net billing" in which excess electricity produced in one hour can be "credited" to electricity used in another hour when facility demand exceeds solar output. Many North Dakota utilities have limits on how much "net metering" is allowed. In such situations, battery storage can be used to capture the excess solar generation rather than export power back to the utility company. This has value since most utilities pay "wholesale market prices" for such exported power which may be only 20-50% of retail market charges.

Peak Demand

Another potential use of battery storage is to reduce the peak demand for electricity. There are three types of electricity rates that businesses may see – and the way to reduce peak demand varies by type of rate.

Site Peak Demand. Medium to large commercial facilities often are charged both for total kilowatt-hours (kWhs) used and for the facilities peak demand in kilowatts (kWs). The peak demand typically is based on the highest kWh usage during any 15 minute period of the billing month. In this case the battery storage would be used in

[5] This information is based on input from Green Ways 2Go, who also wrote EV Readiness Decision Guide for Local Governments - Green Ways 2Go

conjunction with Intelligent Demand Control (IDC)[6] to discharge the battery during any 15 minutes of the month in which the IDC projected that the peak demand would exceed a threshold value (e.g., 40 kW) so as to keep the total facility load below that level. If the demand were projected to be below 40 kW the battery would not be discharged. Furthermore, the IDC would seek to charge the battery when a new peak would not be set.

Time of Day Peak Demand. Many utilities offer customers the opportunity to pay less for electricity per kWh and/or kW used at some times of the day (called "off-peak hours", e.g., 9 pm to 9 am) than at other times (called "peak hours", e.g., 9am to 9 pm on weekday). If the main cost driver is the Site Peak Demand (kW), then a control strategy similar to the one described above would be used, with more focus on the peak hours if the main cost driver was the difference between on-peak and off-peak price per kWh, then the batter would be used to discharge any time during the peak hours and charge any time during the off-peak hours.

Grid Peak Demand. Some utilities offer discounts if customers agree to reduce their electricity demand during certain critical supply hours of the year. Such critical hours may only occur 10-100 hours per year. In that case the IDC would be used to discharge the batteries when receiving a signal from the utility only during those critical hours. Typically during those critical hours the IDC would seek to control to a site-specific threshold (e.g., 40 kW similar to the Site Peak Demand above, but only during the critical hours). Alternatively, the utility may have a rate offering in which they want the maximum discharge possible, no matter what the site total demand is.

Facility Back-Up Power

A battery could also be used to provide back-up power to the facility when utility grid power is off. For those facility owners desiring to reduce the carbon footprint or air quality impacts of diesel back-up generators, the batteries could be used in conjunction with or before diesel generators are used. Other facility managers might use them to provide supplemental power to the diesel back-up generators.

Battery Storage System Considerations

a) Sizing the Battery. As implied from the three main uses of batteries described above, it is important to select the appropriate discharge rate (kw) and total storage capacity (kWh) of the battery. If reducing Site Peak Demand or Utility Peak Demand is more important, then typically a higher kW discharge rate desired. The greater the duration of control (e.g., Time of Day rates) the larger the kWh storage capacity of the battery is desired.

   One special case emerging is the increasing use of EV Charging. These chargers can significantly increase the Site Peak Demand – especially the Level 3 EV Chargers. Sometimes (especially if choosing the Grid Peak Demand strategy) it may make

[6] Also see "Intelligent Demand Control" in section 7 below.

sense to have the IDC throttle back the EV Charging in addition to operating the battery storage. Another sizing consideration is the potential for motors and compressors to increase peak demand during surge current starts. If surge currents are a major concern, then consider increasing the kW sizing to better control Site Peak Demand.

b) Modern battery storage systems consist of lithium-ion batteries rather than lead acid batteries which have a smaller foot print and require less maintenance.

c) Battery storage systems take a significant amount of space and require ventilation and heating/cooling to meet environmental requirements.

d) Battery storage systems are heavy; the facility must be structurally evaluated based on the battery system location.

It is recommended to work with a qualified engineer in considering these kW and kWh sizing and other considerations.

Budgetary Costs

- $700 to $2500 per kWh

As noted above the kWh and kW sizing and associated costs must be balanced against the other objectives.

6. **Smart Lighting Controls Planning Considerations**

Smart lighting controls are automated controls that adjust light fixture output based on daylighting in the space or based on occupancy. The controls can either dim the light fixtures or turn off lights.

Occupancy sensors, vacancy sensors and or photo sensors are incorporated into the space or at the light fixtures. The sensors are programmable to provide control of the lighting system. Occupancy sensors automatically turn lights on and off the when the space is occupied. In contrast, vacancy sensors require the occupant to manually turn on the lights and the sensor automatically turns off the lights after the occupant leaves.

Dimming controls and switches are incorporated into occupied spaces so users can override or adjust the automatic settings. “Occupied spaces” typically have users present, like an office or conference room. “Unoccupied spaces” are transient spaces like corridors, restrooms, storage rooms where the user isn’t concerned about being able to manually control the lighting system.

In order to implement a lighting system that is energy efficient, but also cost effective in terms of installation cost, the following system characteristics should be deployed:

- The system light fixtures should be high efficient LED type.
- Light fixtures in occupied spaces like offices, conference rooms, etc should have dimming capability.
- At a minimum, stand alone style lighting controls with occupancy sensors and vacancy should be implemented in most spaces.

- In areas with a large amount of windows, photo controls should be considered for the areas near the windows.

Keep in mind that the basic considerations outlined above are an energy code requirement in many states, so implementing a smart lighting control system is no longer a strategy outside the typical design standard.
Another rather new development is the availability of wireless lighting control systems. These systems have become widely used and are reliable. The only drawback is the need for batteries in some of the system devices. Wireless systems work very well and save significant labor for retrofit applications. Otherwise, wired systems are cost effective for new construction applications.

Budgetary Costs

- Typical costs are $0.65 per square foot to $1.00 per square foot.

7. Intelligent Demand Control Planning Considerations

An Intelligent Demand Control (IDC) system has three potential functions for a building manager:

1. *Equipment Operation.* The system can be used to monitor how the systems are operating and whether there are system component malfunctions that need to be repaired. The monitor can also be used to monitor how the building is consuming energy, how much energy the PV system is producing, how much savings the battery storage system is providing, etc. This can be displayed in a public space for building occupant to observe, included in a monthly newsletter, access on a website or by other communications techniques.

2. *Peak Demand.* The system can be used to control building power demand (kilowatts). Almost all commercial buildings pay a demand charge to the utility company. A demand charge is the charge for the highest peak kilowatt demand a building reached during a sliding 15 minute window throughout the month. The demand charge is an incentive for the customer to use power on a consistent basis and not use large amounts of energy for short periods of time. The IDC system can turn equipment on and off, turning off EV chargers, or use a battery storage system to reduce the building demand in order to save costs.

   In addition to reducing building demand, the IDC system can reduce the building carbon footprint by controlling how the PV energy is used. The system can maximize the battery charging energy and maximize EV charging when the PV's are producing peak energy (sun is shining) and use the battery energy to charge EV's when the PV's are producing low energy (sun is not shining).

   Not only does the IDC benefit the building carbon footprint it can also benefit the carbon footprint of the power grid by controlling when the battery storage systems and EV's are charged and discharged. The grid peak demand times during the fall, winter and spring typically are in the morning and early evening and typically when the power plants with the least fuel efficiency and higher carbon intensity are used. In the summer these peaks may occur in the afternoon or early evening. The control system can keep demand within the building to a minimum during those times by using battery power, not charging batteries during those times or controlling building loads during those time frames. This function assists the utility company in improving the reliability of the power grid during those higher system demand times. This helps prevent the need for bringing additional capacity onto the grid and allows utilities to achieve better utilization or capacity factors from existing facilities.

3. *Energy Use*. Lastly, the intelligent control system can be used to manage building energy use, to only use energy when you really need it. A good example are the smart lighting controls, which only turn the lights on when the room is occupied or when the sun isn't shining. This can also be extended to other systems like HVAC. Again, if a room is not occupied, the room does not need to be provided with fresh air or heating or cooled to an optimum temperature.

<u>Budgetary Cost for Intelligent Demand Control</u>

Up front: $5000
Monthly: $2000