

sonnen ecoLinx Installation Case Study

Completed at cyberManor, Inc.
Summer 2018



Table of Contents

Objectives.....	3
Overview of the Project.....	4
Customer Requirements.....	5
Design Considerations.....	6
Installation Considerations.....	7
Performance Review.....	8
sonnen Power Graph.....	8
Future sonnen/Control4 Performance Enhancements.....	9
sonnen Energy Flow Dashboard.....	11
System Layout.....	11
Equipment List.....	13
Material.....	13
Labor.....	13
Photographs.....	14

Written by: Gordon van Zuiden, cyberManor

With sincere appreciation to all those that assisted our cyberManor team on this sonnen ecoLinX intelligent energy management system performance case study, including Blake Richetta, Jessica Weiss, Michelle Mapel, Mathew Foley, and Dhaval Patel from sonnen, along with AJ Brunson from Cinegration.

This document is for informational purposes only.

SONNEN MAKES NO WARRANTIES, EXPRESSED OR IMPLIED, IN THIS SUMMARY.

© 2018 cyberManor, Inc. All rights reserved.

sonnen are either registered trademarks or trademarks of sonnen Corporation in the United States or Germany. The names of actual companies and products mentioned herein may be the trademarks of their respective owners.

Objectives

The objectives for installing the sonnen ecoLinx to support our existing PV solar array in the new cyberManor town house showroom are to:

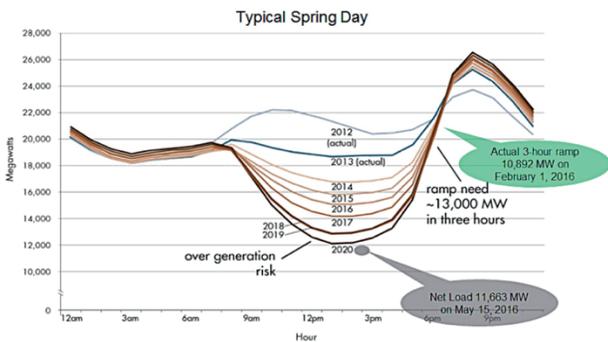
- Leverage the Control4 home automation platform to provide energy automation to our clients
- Reduce overall energy costs and maximize the use of solar energy
- Help flatten the electrical load curve for our local utility, Pacific Gas and Electric
- Serve as a backup battery for our showroom's critical electrical loads (including networking equipment) in the event of a power outage.

The sonnen ecoLinx lowers the overall electrical costs by enabling us

1. To store excess solar energy generated during the day for use when the sun is not shining (like at on a cloudy day or at night).
2. To store energy purchased from the grid during inexpensive off-peak hours and use it to power the showroom during more expensive on-peak hours.

And while the sonnen ecoLinx uses stored energy to power the showroom, it is programmed to never fully discharge – with the battery-state-of-charge no lower than 10% at any given time. As a result, there is always an energy reserve (backup power) available to power essential loads should a power outage occur - like networking equipment, the garage door, and smart irrigation system.

One of the great values we deliver to our clients is the ability to connect all their home technologies into one, unified home control platform, giving them single app or simple voice command control of their entertainment, comfort, and security systems. By adding the intelligent sonnen ecoLinx storage solution, we extend our expertise beyond the typical home automation offering to now include total home energy management enhancing the Control4 platforms we previously installed in most of our clients' homes.



The sonnen ecoLinx energy management system also helps flatten the utility load curve by using stored energy to power the showroom during peak hours (late afternoon/early evening) rather than relying on the grid, ultimately reducing grid strain. The intelligent ecoLinx software is pre-programmed to ensure the batteries reach 100% state-of-charge prior to the start of high-peak periods by charging from solar and grid energy previously purchased during off-peak times. Ultimately, this charging strategy eases the utility's burden of having to build more power plants to meet the growing need for peak energy demand as illustrated in the

California Independent System Operator (CAISO) Duck Curve graph above. While solar modules alone greatly reduce the demand for grid power during the middle of the day, there is a huge increase in demand for power during peak evening times - when the sun sets and people return home and start nighttime routines. Energy storage helps solve this supply and demand problem by allowing consumers to re-deploy stored excess solar energy generated earlier in the day to power nighttime loads, reducing the overall customer demand and the need for utilities to use dirty peaker plants to generate energy, even enabling homeowners to be entirely "invisible to the grid".

Overview of the Project

At cyberManor, we recently built a new Control4 Certified 1,000 square foot town house to showcase the latest, most cutting-edge home automation and energy management solutions (see elevation plans shown below). The home features 210 square feet of Southeast-facing Suniva solar panels optimized by the TiGo Energy Maximizer Management Unit. These solar panels charge the sonnen ecoLinX 10 kWh smart energy management solution, which is programmed to perform as follows:

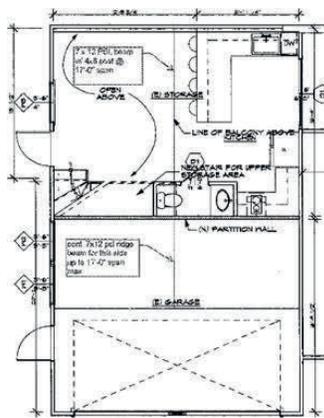
1. Solar energy generated during the day powers the immediate electrical needs of the town home, and any excess energy is stored in the sonnen ecoLinX for later use.
2. The sonnen ecoLinX is programmed to use off-peak energy to top off the batteries and reach 100% state of charge, prior to peak time of day.
3. During the peak time the sonnen discharges the clean and low-cost energy to meet the electrical needs of the town home and minimize the use of energy from the grid.
4. Once discharged to the 10% battery reserve, the battery then recharges from the grid during inexpensive, off-peak hours (like early morning) to supplement energy needs the following day. The timing of when grid power is used to charge the battery is based upon cyberManor's time-of-day pricing structure. Maximum peak rates are:
 - a. \$0.56/kWh during summer month weekdays from noon to 6PM
 - b. \$0.19/kWh during the late evening and early morning hours from 9PM – 8:30AM.

Note: The sonnen ecoLinX never discharges below 10%, ensuring that there is an energy reserve at all times for the networking infrastructure, garage door, refrigerator, and smart irrigation system in the event of a power outage.

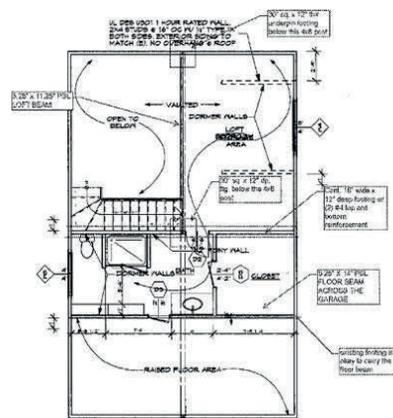
To reduce summer daily energy consumption, the Control4 system is programmed to create a “summer natural cooling scene” to minimize how long the air conditioner runs. This is accomplished by controlling intelligent sub-systems to provide convective cooling:

- Turns on the Haiku intelligent fan provides convection cooling
- Electronically opens the Velux intelligent skylights to vent the hot ceiling air

cyberManor Elevation Plans



First Floor



Second Floor

Note: cyberManor has a small business time-of-use schedule with the Pacific Gas and Electric (PG&E) utility company. PG&E has summer daytime peak hours that correspond with business peak energy demands. For residential clients, the peak hours occur from 3 PM to 9 PM, further bolstering the benefit of using a sonnen ecoLinx intelligent energy storage solution to offset high-peak energy costs in the evening when residential energy consumption is often at its highest.

Customer Requirements

Can you give a brief overview of your business?



cyberManor (www.cybermanor.com) is a professional home technology integrator located in Los Gatos, California that has been serving clients seeking custom home technology solutions for new and remodeled homes for almost 20 years. Within the past year, cyberManor built a new 1,000 square foot showroom to showcase the most cutting-edge, latest home automation and energy management solutions. In 2018, this esteemed showroom was designated by Control4 as an official certified showroom – one of only two in the San Francisco Bay Area.

What type of energy management system did you previously use?

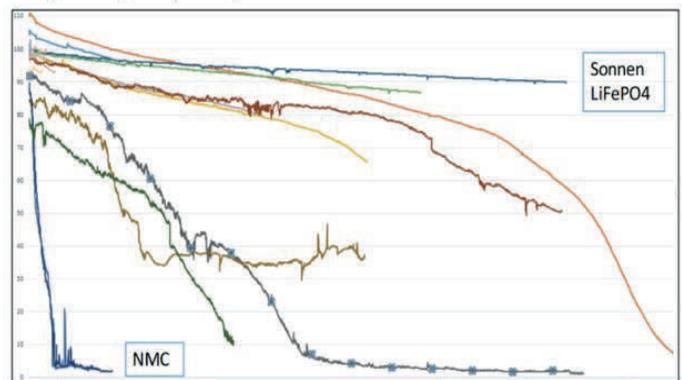
In 2014, cyberManor installed (12) Suniva PV solar panels to provide a renewable energy source. Using a software/hardware solution from Smappee, we monitored our daily solar energy supply and office load consumption. While this solution worked fairly well, we could not use our excess solar power in the early evening weekday hours or on the weekends. Adding the sonnen ecoLinx smart energy storage solution alleviated both of these issues by allowing us to store all excess solar energy for use any day of the week and even when the sun was not shining – like on a cloudy day or at night.

What were the top three or four must-have requirements?

To us, it was very important to have an energy storage system that met the following criteria:

- An energy capacity that was large enough to meet the majority of our electrical needs in the new townhouse throughout the day.
- A long-lasting product with a storage retention rate of at least 85% (reality is about 70%) after 10 years of daily cycling up to 3 times per day (we did not want to replace this battery in 3-4 years - see graph to the right).
- A product that is safe – lithium iron phosphate batteries are incapable of thermal runaway even when punctured
- A software that is flexible and compatible with Control4 to provide additional energy management functionality, both today and in the future.

Battery Chemistry Life Cycle Comparison



Source: [sonnen](http://sonnen.com) Battery Chemistry Laboratory

What home control sub-systems does cyberManor use?

Our showroom already has a Control4 total home control system that showcases a touch screen, keypad, mobile phone, and voice control to integrate the following systems:

- Control4 centralized lighting
- Whole- house audio
- Media room TV
- Control4 front door camera and intercom
- Ecobee HVAC thermostat
- Velux motorized skylights and shades
- Lutron motorized shades
- Haiku ceiling fan
- NuHeat bathroom floor heating
- Infratech outdoor infrared heating
- Rachio irrigation system
- LiftMaster garage door

We needed a smart energy storage system that was compatible with Control4 to optimize off-peak/on-peak rate performance and one that also graphically showcased performance on all of the Control4 touch screens around the home.

Design Considerations

How many rooms are in the home (showroom)?

There is a living room, kitchen, loft bedroom, master bathroom, and laundry room in the showroom town home. (See floor plans in the Overview section of this document.)

How many heating and cooling zones are in the showroom?

There is one heating and cooling zone for the entire town home. The bottom zone can be shut off with a manual damper.

What were the unique software considerations related to the sonnen ecoLinx battery?

To us, it was important that the energy management solution's software driver had the following Control4 home control features:

- A real-time, graphical representation of overall system performance on all Control4 touch screens throughout the home (including the solar panel production, battery status/state of charge, and energy to/from the grid).
- The ability to use weather forecasting to determine how much backup power the battery should hold in order to prepare for a potential power outage.

What were the top 2-3 design challenges with this installation?

1. Understanding the showroom's daily energy consumption, solar PV energy generation, battery storage capabilities, and the utility's time-of-day rate structure to optimally program the Control4 and sonnen ecoLinx systems and minimize the purchase of on-peak energy.
2. Developing a strategy that enabled the regular use of devices throughout the showroom at the lowest possible electrical costs and without sacrificing comfort.
3. Developing a whole-home electrical backup strategy that optimized the use of critical loads in an outage situation.

Installation Considerations

What specifically helped with ease of install?

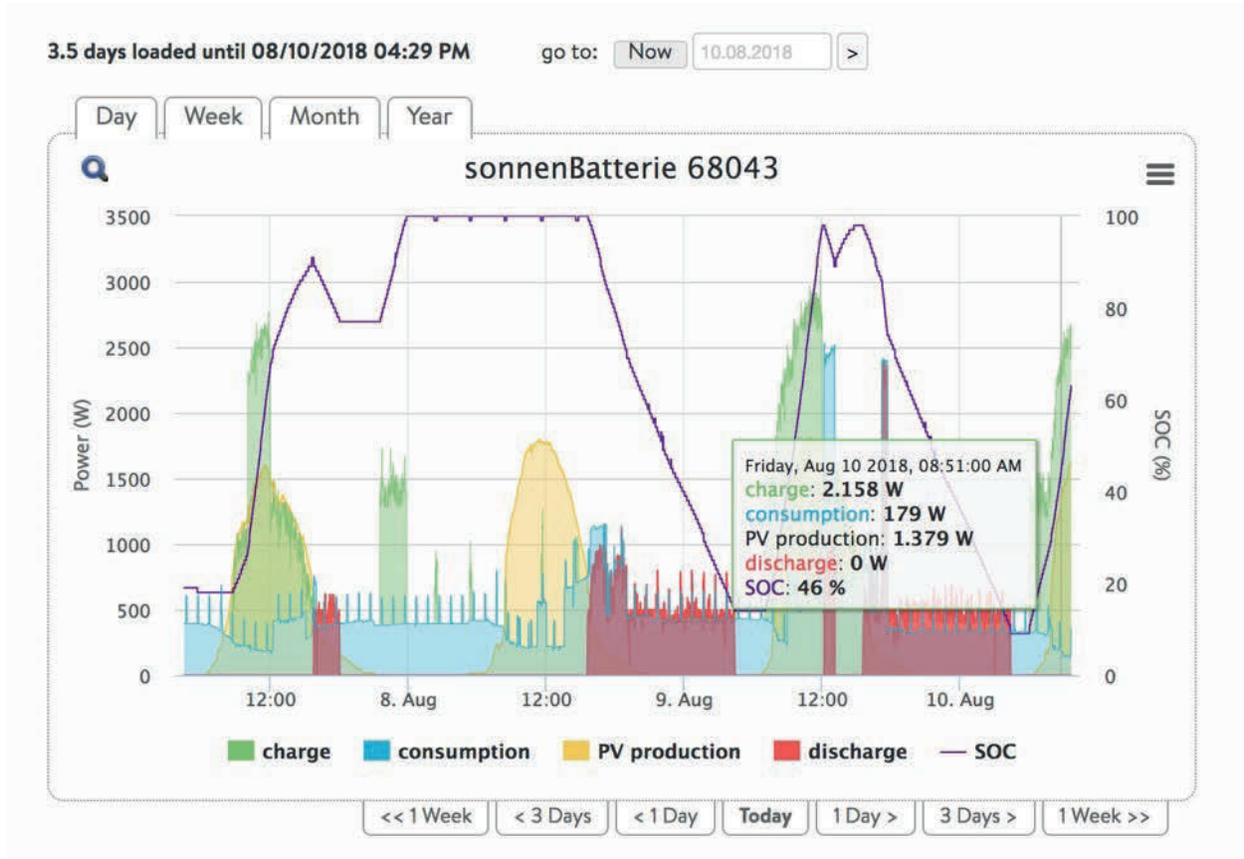
- Being trained by sonnen on how to properly design and install the system through their authorized contractor certification training program
- The individual battery units were shipped separately from the cabinet, reducing the overall weight of the assembly
- Well-planned conduit entries position the cable entry points with the corresponding terminals for main and protected loads connection
- A well-written installation manual with good photographs and diagrams to ensure proper component connection
- The product shipment included an appropriately-sized, electrically rated 10 mm wrench for the battery terminals. Without this tool, many installers would likely use an unsafe method for these connections.
- Upon being powered-up for the first time, the unit is set for DHCP, saving time trying to find a device that may be on a different subnet than the current LAN
- An easy-to-configure commissioning assistant enabled us to get the sonnen system up and running quickly

What were some of the challenges of installing the sonnen ecoLinx energy storage solution?

- As an electrical appliance, it requires working clearances that may be hard to achieve without proper planning
- The overall weight of the cabinet assembly – this is not a one-person installation.

Performance Review

sonnen ecoLinX Power Usage Graph



Our sonnen ecoLinX 10 kWh smart energy management system’s backup buffer was set to 10%, meaning that 10% of the system’s capacity, or 1 kWh, is always on reserve in case there is a power interruption. At 10% buffer the sonnen ecoLinX is capable of powering the critical loads we defined, including the networking equipment, garage door, and irrigation system.

We programmed the sonnen ecoLinX to discharge during peak hours from 12PM to 6PM (when energy rates are high) as well as from 6PM to 6AM (which, while technically partial peak and off-peak, allows us to power the showroom with stored energy instead of relying on the grid).

As you can see in the power graph above, the battery charges in the morning (beginning at 6AM) from a combination of solar energy (shown in yellow) and grid power. Currently, the grid can augment the solar production during these off-peak times at a net rate of about 1 kWh per battery module in our sonnen ecoLinX system (after DC to AC conversion loss of about 250Wh). (We have a total of five 2kWh battery modules charging at a fixed rate of 250Wh.)

As you can see, at 8:51 AM our PV production was 1,379 W and our load consumption was only 179 W - therefore 1,200 W of solar energy was stored in the sonnen ecoLinX system. Coupled with the approximate 1,000 W of

energy received from the grid, the net rate of charge at that time was 2,158W. By that time, the sonnen ecoLinX was almost half charged (State of Charge - SOC - is at 46%), with only about five kWh remaining to reach 100% state of charge. At that current charging rate of 2 kWh per hour, the battery was fully charged by about 10:30AM. Ultimately, the goal each day is to use both solar and grid energy to fully charge the 10kWh battery by noon (when peak energy rates take effect), as shown in the power graph above.

Then, beginning at noon, the battery begins to discharge to meet the showroom's energy needs (consumption loads are shown in blue, battery discharge is shown in red). Here, the graph demonstrates the battery discharging in the early afternoon (when it typically charges off of excess solar), representing a period of time when energy consumption exceeded solar production. Then, once solar production was able to meet the energy consumption needs and provide excess energy, the battery began to charge off the solar again. As the afternoon and evening progressed the battery slowly discharged until the early morning hours when it reached a 10% state-of-charge (at which point, it did not discharge any further, as it is programmed to always maintain a 10% backup power reserve). After reaching a charge of 10%, solar and/or grid energy was used to recharge the showroom until there was enough excess solar energy to once again charge the sonnen ecoLinX using clean energy.

Note: The above power graph is available via a web browser or on sonnen's iOS application.

Future sonnen/Control4 Performance Enhancements

Users of the sonnen ecoLinX energy management system will have the ability to change the system's on-grid charging rate. As a result, this could accelerate the charge rate of the battery modules during off-peak hours to accommodate for cloudy and/or high energy consumption days or to attain a desired state of charge in preparation for using stored energy during peak times-of-day.

sonnen is currently working with software developers to develop a backup buffer and grid charging rate scheduler that will examine the upcoming day's weather forecast and home's energy consumption patterns to optimize the backup buffer level.

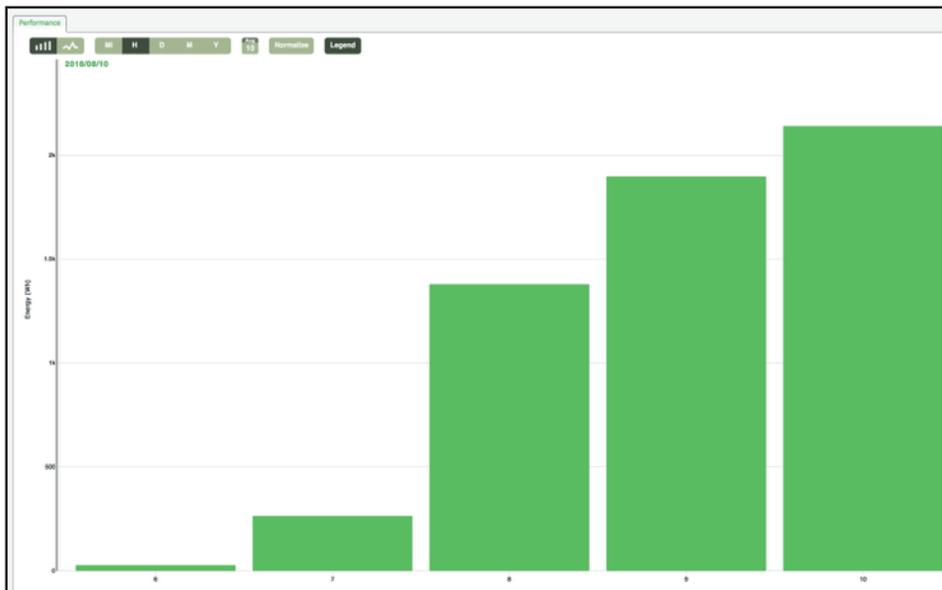
For example, based on typical low energy consumption and a predicted, sunny weather forecast, the backup buffer would remain at a low percentage to maximize daily cycling of the battery. On the other hand, if it is projected to be a cloudy day, and if there is a-typical, high energy consumption, the backup buffer would increase to ensure that the battery stays fully charged for use during peak-hours. Additionally, sonnen is able to accelerate the battery's charging rate in short order, enabling the backup buffer to stay low preferably during off-peak time window.

Solar kWh Generation from 12 PV Panels

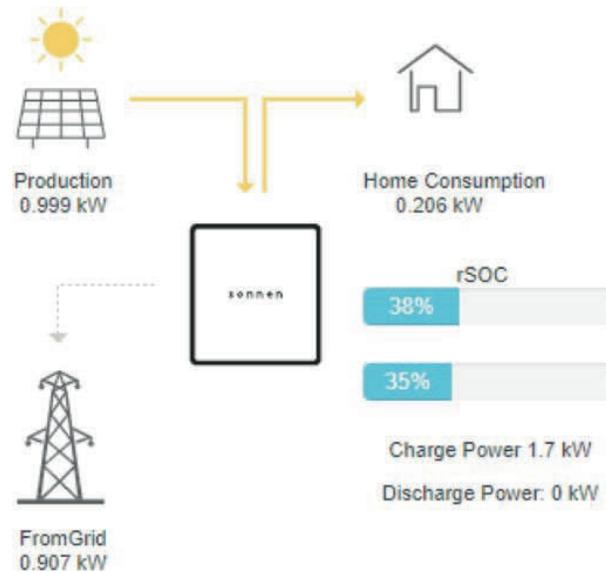
In this early morning screen shot of our Suniva solar panels, you can read the kWh production for each of the (12) solar panels. Note that (2) of the panels have lower production due to their position in a shady area at this hour of the morning.



The chart below shows the hourly kW production from the solar panels. Note that in the summer towards mid-day, these panels produce just over 2kW per hour.



sonnen Energy Flow Dashboard

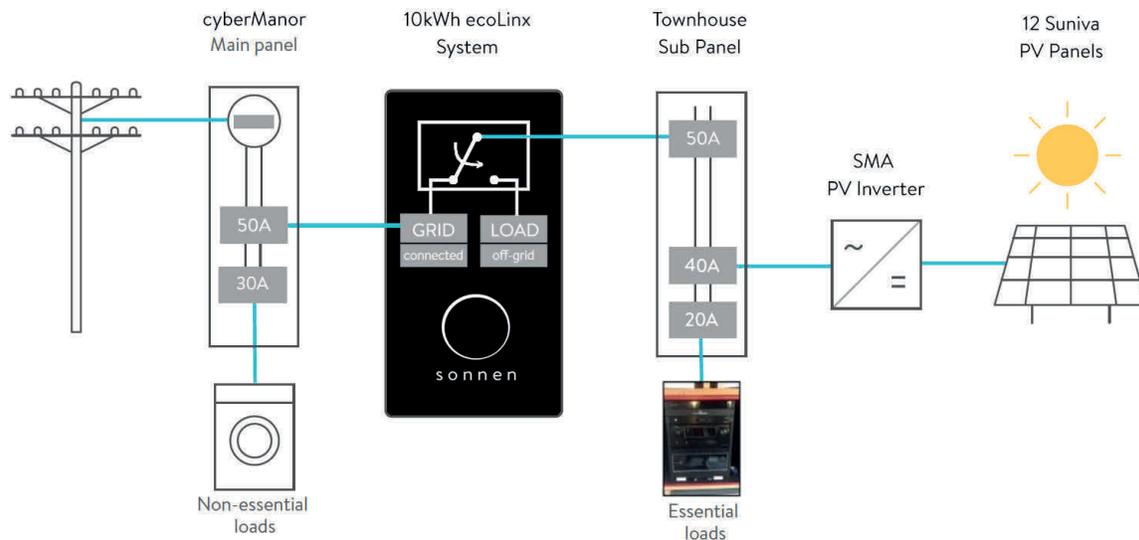


This early morning graphic (which can also be viewed on the Control4 touch screen) provides an overview of the showroom's overall energy performance. At 8:30 AM on a sunny weekday morning, the solar modules are producing about 1kWh of energy. Some of that energy is used to meet the current needs of the showroom, while the remainder is charging the battery with clean energy. The grid is also charging the sonnen ecoLinX with inexpensive, off-peak energy so that it is fully charged by noon when peak rates begin.

This dashboard power diagram on the Control4 screens is especially useful, as it allows the homeowner to monitor and control their energy consumption in real-time. For example, when the home's air conditioner turns on we add about a 2kWh load to the showroom's energy draw on the battery and then when all the Control4 centralized lights are turned on we add about half a kWh load, all of which appears in real-time showing homeowners the immediate impact of turning on and turning off loads.

By raising the thermostat a few degrees and reducing the air conditioning and turning off some lights, you can see an immediate decrease in the home consumption portion of the graphics – an effect we term the Prius effect. Just as in a Prius where the driver can see their improved gas mileage when they reduce their freeway speed, the homeowner can view their reduced load immediately and the resulting increase in the longevity of their stored energy capacity when they reduce their home's electrical consumption. Visualizing the impact of energy usage therefore helps homeowners understand the impact of adjusting their energy behavior.

System Layout



The diagram above displays how the sonnen ecoLinx integrates into cyberManor’s “clean energy power plant”. The grid feeds power to our main office building which then charges the sonnen ecoLinx as needed. The ecoLinx then supplies energy to power designated loads in the showroom sub-panel. Simultaneously, the battery charges from excess solar energy (not being used by the showroom) that is generated by the PV solar modules. In the event that excess solar energy is still being produced once the battery is fully charged, the energy flows back to the cyberManor main panel to provide electricity for the main office. At that point, if there is still excess solar energy left over after both the showroom and main office energy needs are met, it flows back to the grid and we receive a kWh hour credit from the utility to be used at a future time, otherwise known as net-metering, (which only typically occurs on sunny summer weekends when the office is usually closed).

“It’s a very empowering feeling watching our solar PV/sonnen battery storage system power all the electrical energy needs of our townhome showroom. To know that all the electronics that we typically install in our client’s homes - audio/video, lighting, comfort control, and security - can be powered all day and during power outages, using cleaner energy. The ecoLinx enables us to promote our total home technology solutions as zero carbon footprint installations.”

- Gordon van Zuiden, President, cyberManor

Equipment List

Material

Qty	Equipment Detail
1	sonnen ecoLinx 10 kWh, 15,000 cycle/15-year smart energy management system
12	Suniva Optimus Series Monocrystalline Solar Modules - OPT265-60-4-1BO
1	SMA America Invertor SB3000US-12 (240V)
1	TiGo Energy Maximizer Management Unit
1	Control4 E5 Processor
1	10" Control4 on-wall touchscreen
1	7" Control4 on-wall touchscreen
1	7" Control4 portable touchscreen
1	Cinegration sonnen/Control4 Driver

Labor

Qty	Description
2 hours	Build cement foundation for sonnen ecoLinx battery
8 hours	sonnen installation - connection to grid, circuit panel, and solar inverter
1.5 hours	sonnen - Control4 driver integration

Photographs



The 10 kWh sonnen ecoLinX smart energy management system installed in the cyberManor garage next to the circuit panel and PV Inverter.



Inside the 10 kWh sonnen ecoLinX smart energy management system – the five (5) x 2 kWh batteries are located in the bottom of this enclosure.



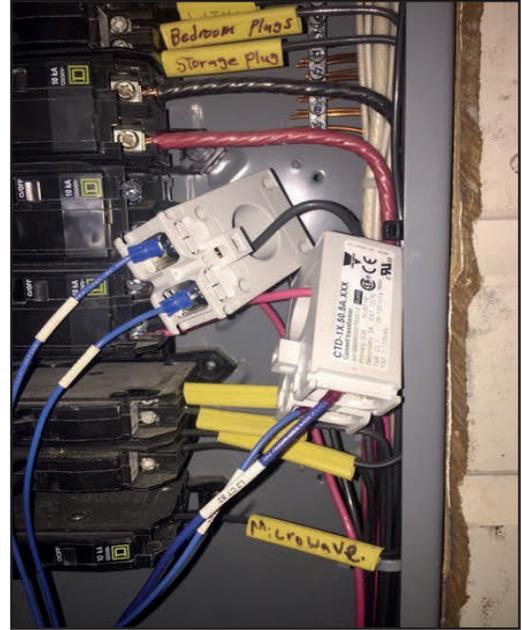
SMA America PV Power Inverter with the TiGo Solar Energy Monitoring.



Control4 centralized lighting panel for the showroom.



Main circuit breaker panel for all the town house loads.



Current transformer (CT) clamps in the electrical panel to measure solar PV power production.



Control4 10" to

Control4 10" touchscreen at the entry way showing a live dashboard of the home's electrical resources and consumption managed by the sonnen ecoLinX.



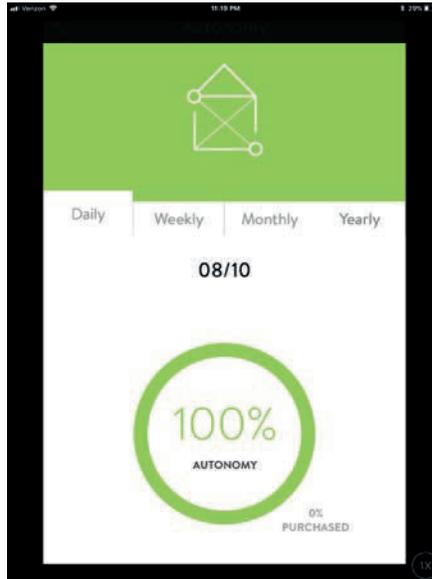
Living room in the showroom with Control4 touch screen monitor on the TV.



Front garden and entry way of the new showroom.



Roof top vegetable garden showcasing the PV solar panels - a smart Rachio irrigation controller, which is powered by the sonnen ecoLinx during power outages, keeps the plants irrigated at all times.



100% Autonomy

Fulfilling all the electrical needs of our cyberManor town home with solar energy and the sonnen ecoLinx intelligent energy management system.

The goal of each day!



610 University Avenue Los Gatos, California 95032

www.cybermanor.com

408-399-3331