Goals, Challenges, and Pitfalls

STONE EDGE FARM
ESTATE VINEYARDS & WINERY

CRAIG WOOSTER


We demonstrate what is possible

Stone Edge Farm Proprietors:

Mac & Leslie McQuown

After earning a mechanical engineering degree at Northwestern University, a Harvard M.B.A., and serving as an officer in the navy, Mac embarked on a career in banking and finance in New York. He joined Wells Fargo in San Francisco in 1964, where he and colleagues created the first stock index fund. He subsequently founded and built several entrepreneurial businesses.

Mac began collecting wine in 1965. With his friend Dick Graff, the legendary winemaker, he co-founded the Chalone Wine Group in 1970, serving on its board for twenty-five years. In 1980 he co-founded Carmenet Winery and began an enduring friendship with Jeff Baker, now Stone Edge Farm's winemaker.

Mac credits his wife, Leslie, with providing Stone Edge Farm's overarching aesthetic vision. Her eye for design informs the property's architecture and landscaping, with its outdoor rooms, inviting courtyards, and art pieces.

Microgrid Project: Prime Directive

The primary directive of the Microgrid project is to reduce the carbon footprint of the Stone Edge Farm property as well as establish a degree of energy independence.

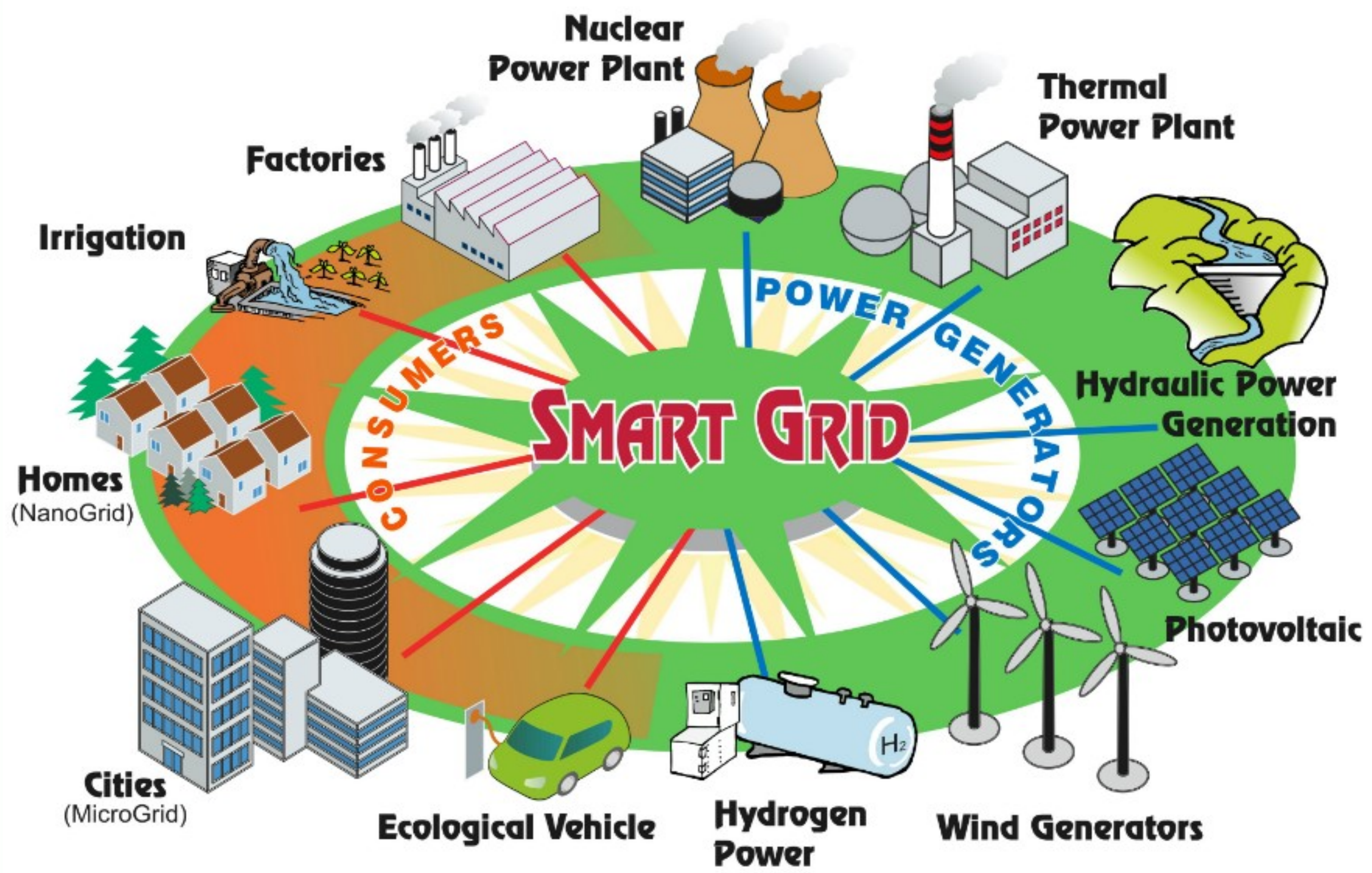
This goal is to be the fundamental design consideration at all times.

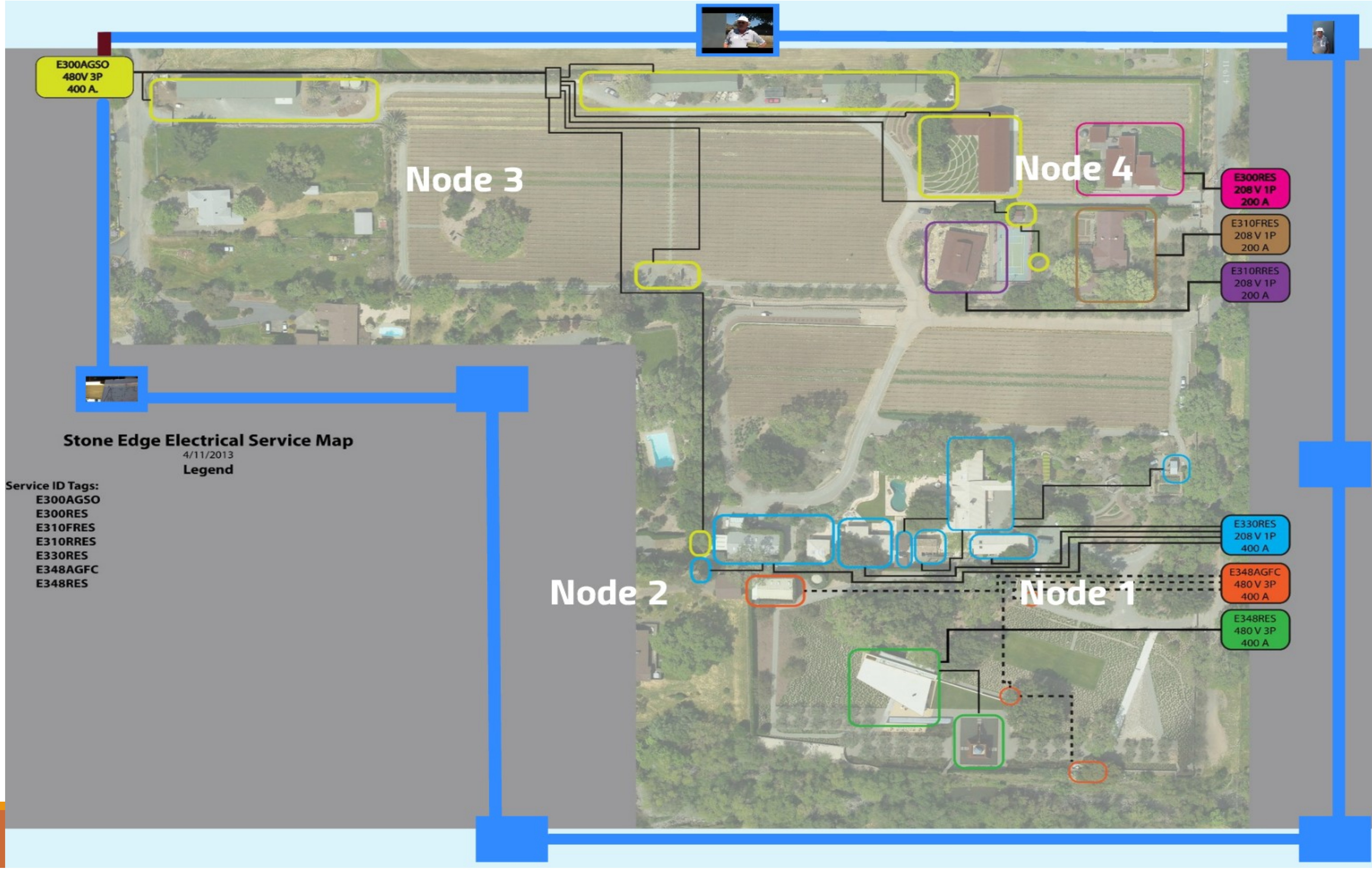
This goal shall be used for guidance when determining system changes, equipment choices, and implementation of work efforts.

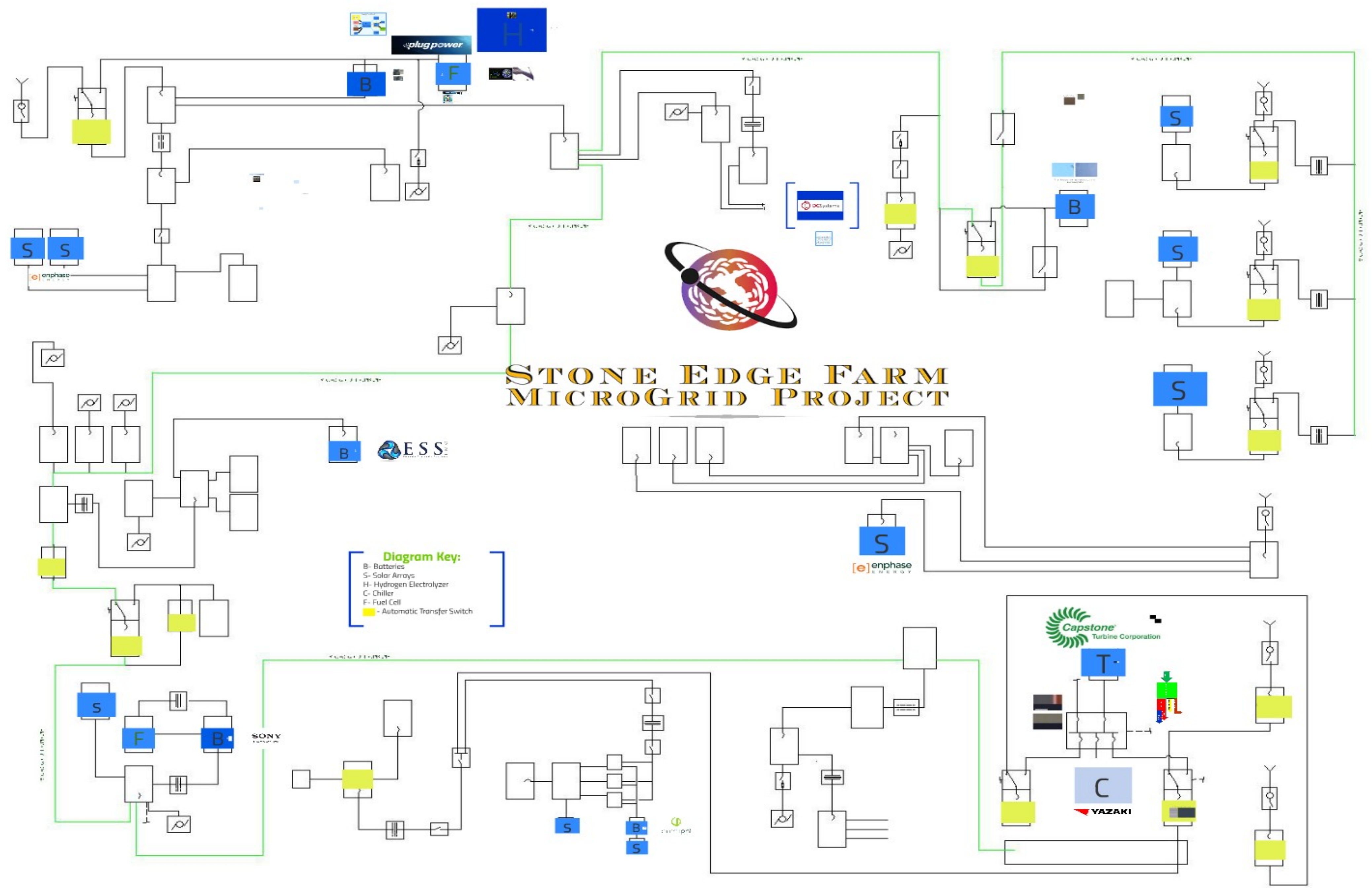
It is the intent of the parties involved to see how far below zero a 6.5 ha urban farm can reduce greenhouse gas emissions.

Microgrid Project: Smart Grid Defined

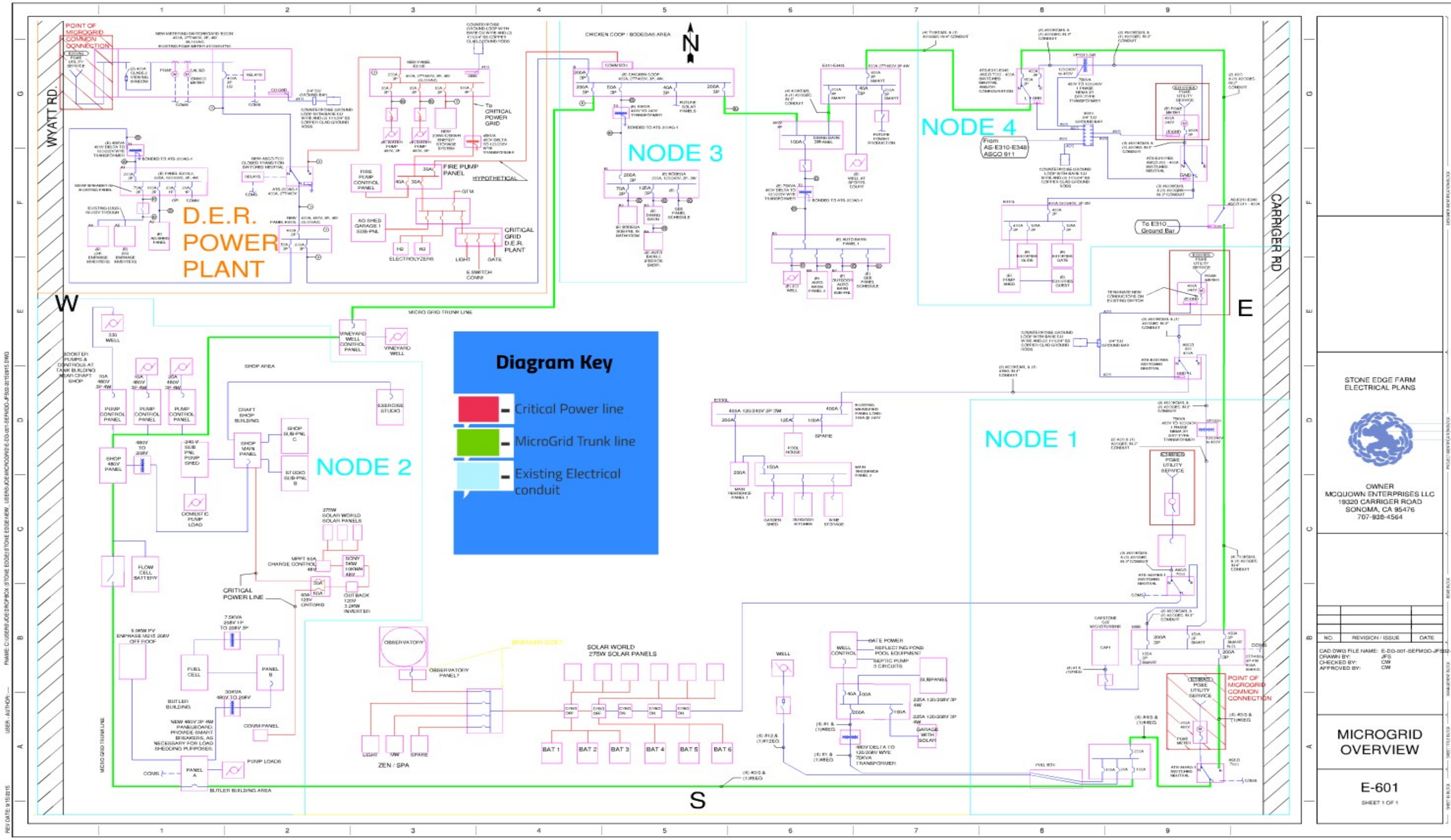
A smart grid is a modernized electrical grid that uses analog or digital information and communications technology to gather and act on information - such as information about the behaviors of suppliers and consumers - to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.




E300AGSO
480V 3P
400 A.
Node 3
Node 4
E300RES
208 V 1P
200 A
E310FRES
208 V 1P
200 A
E310RRES
208 V 1P
200 A
Stone Edge Electrical Service Map
4/11/2013
Legend
Service ID Tags:
E300AGSO
E300RES
E310FRES
E310RRES
E330RES
E348AGFC
E348RES
E330RES
208 V 1P
400 A
E348AGFC
480 V 3P
400 A
Node 2
Node 1
E348RES
480 V 3P
400 A



plugpower
Stone Edge Farm
MicroGrid Project
enphase
Diagram Key:
B- Batteries
S- Solar Arrays
H- Hydrogen Electrolyzer
C- Chiller
F- Fuel Cell
- Automatic Transfer Switch
Capstone Turbine Corporation
YAZAKI
SONY



WYATT RD
CARRIGER RD
D.E.R. POWER PLANT
NODE 3
NODE 4
NODE 2
NODE 1
W
E
S
N
POINT OF MICROGRID COMMON CONNECTION
FIRE PUMP PANEL
HYPOTHETICAL
CRITICAL GRID D.E.R. PLANT
CHICKEN COOP / BODEGAS AREA
MICRO GRID TRUNK LINE
SHOP AREA
CRITICAL POWER LINE
SOLAR WORLD 275W SOLAR PANELS
BAT 1
BAT 2
BAT 3
BAT 4
BAT 5
BAT 6
ZEN / SPA
OBSERVATORY
BUTLER BUILDING AREA
Diagram Key
Critical Power line
MicroGrid Trunk line
Existing Electrical conduit
STONE EDGE FARM ELECTRICAL PLANS
OWNER
MCQUOWN ENTERPRISES LLC
19320 CARRIGER ROAD
SONOMA, CA 95476
707-938-4564
MICROGRID OVERVIEW
E-601
SHEET 1 OF 1

Review of Main Components:

1 - Alternative Energy:
Solar photovoltaic and solar thermal roof top systems
325 kW Solar panels and Enphase micro-inverters
85 kW New S-280 Smart Inverters
Plug Power's ReliOn Fuel Cell Hive (12) 2.4 kW Hydrogen
FuelCells with GTM & ground storage 1500 kWh

2- Millennium Reign Energy, LLC Model 330
Triple Twin Alkaline Electrolyzer 12 kg/d,
Millennium Reign Energy, LLC AutoARK Building
with 24 kg 40 MPa storage and filling station
1 KGTM 22 MPa Gas Transport Module 204 kg storage
in 6.1 m shipping container.

3- Utility interconnected SCADA command and control
MicroGrid Management by DC-SYSTEMS.
ASCO-Emerson Critical Power Management Systems
Grid Sights Energy Information System

4- six different battery storage systems:
* 250 kW, 475 kWh Tesla lithium-ion-cobalt battery,
  Dynapower 250 kW inverter
* 28 kW, 380 kWh Aquion M100-LS82p 48 V batteries series (725 V),
  Ideal 30 kW Inverter
* 12 kW, 24 kWh SimpliPhi lithium-iron –phosphate batteries
* 10 kW, 65 kWh All Iron Fuel Cell Battery,
  Outback 208 V 3-phase inverter
* 8 kW, 22 kWh Sony Lithium-iron –phosphate 48 V batteries.
  Schneider 240 Vinverters
* 28 kW, 1000 kWh PlugPower -Reli-On fuel cell hive

5-Tri-Generation – combined heat, power, & cooling:
Capstone natural gas fired 65 kW microturbine
with heat recovery

AIR CONNECTION

DCSystems
RT | Real-Time Smart Energy Suite.

Dersch Design & Engineering

EATON
Powering Business Worldwide

EMERSON.
Network Power

ESS INC
Energy Storage Systems

[e] enphase ENERGY

GRID SIGHTS

IES Independent Electric Supply

Millennium Reign Energy LLC

persistent efficiency

PG&E Together, Building a Better California

plug power ReliOn

SMARTGEOTECH

Sonoma Clean Power
Local. Renewable. Ours.

SONY
make.believe

Wooster Energy Engineering

Stone Edge Farm MicroGrid Project

Sonoma, California

Experiences with **Distributed Control** at the

Stone Edge Farm Microgrid

Stone Edge Farm (SEF) Microgrid Project


Background

Developed by **Wooster Engineering Specialties**, "the SEF Microgrid, provides solar self-consumption, peak shaving and load shifting services to Stone Edge Farm for energy self-sufficiency and to reduce its carbon footprint. The grid-tied microgrid is capable of islanding and operating autonomously, and is also generating sufficient energy that Stone Edge Farm is able to sell a substantial amount of the energy produced back to local utility PG&E."

Elements

- 320 solar panels with Enphase inverters
- 3 Hydrogen fuel cells
- 1 Millennium Reign hydrogen generator
- 1 Capstone 65 Kw gas turbine
- 6 All-Iron Flow Cell batteries with Outback inverters
- 14 Aquion batteries with Ideal Power Converter inverters
- 1 Tesla PowerPack battery with Dynapower inverters

HEILA™

was born after an internship at the **Stone Edge Farm Microgrid**

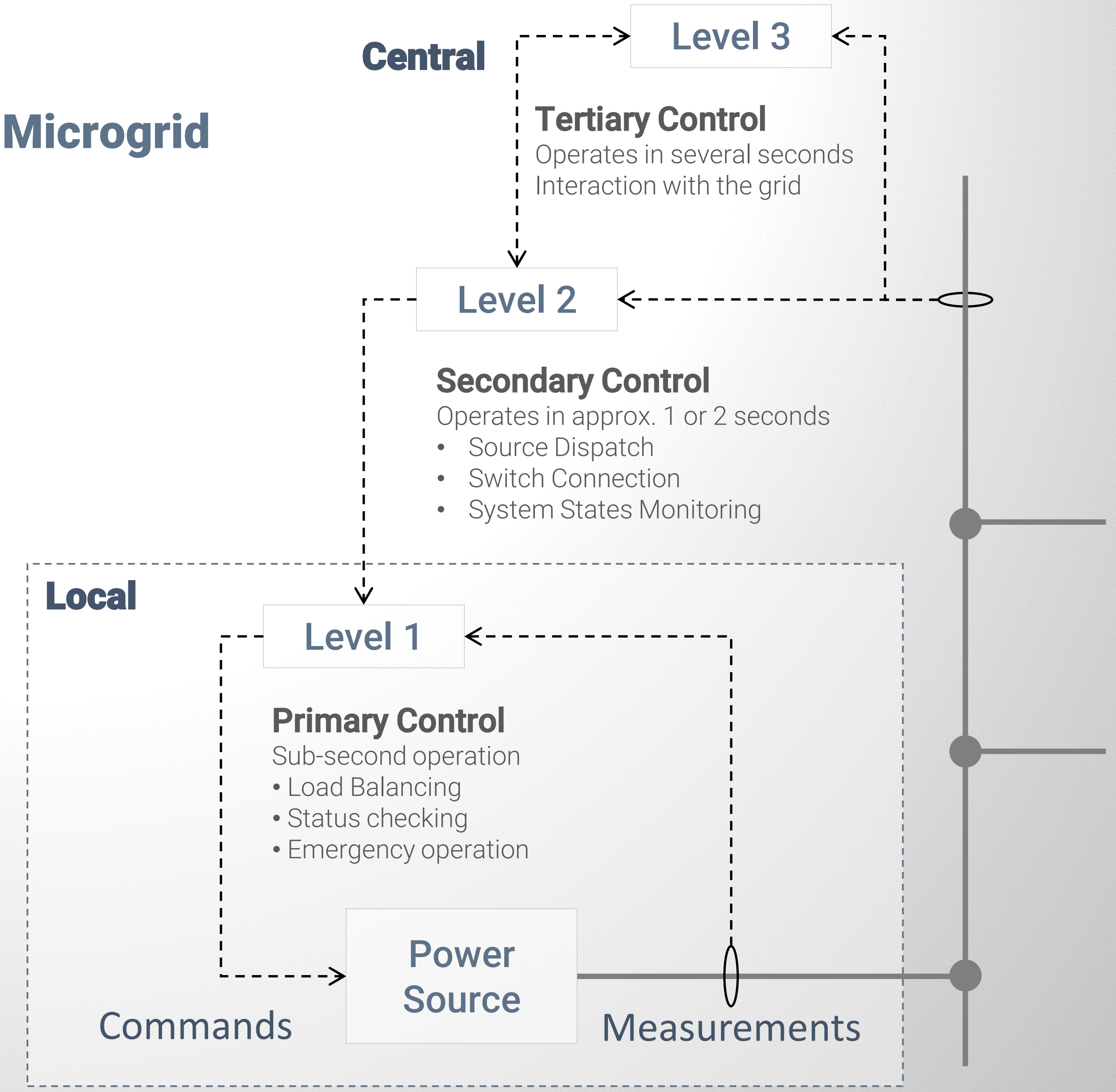
Dr. Elizondo joined the Stone Edge Farm project in the summer 2015 during his PhD studies

Goals

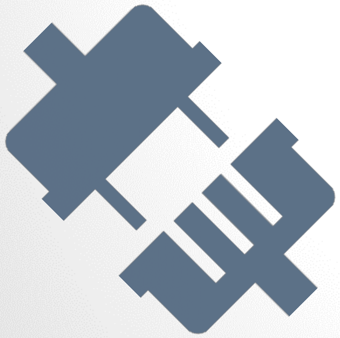
- Develop the control structure
- Bring academic concepts into the SEF system

Highlights

- Developed the first version of local controller using off-the-shelf components
- Identified the difficulties of building the right solution
- Noticed that off-the-shelf components did not allow for much intelligence to be added to the system

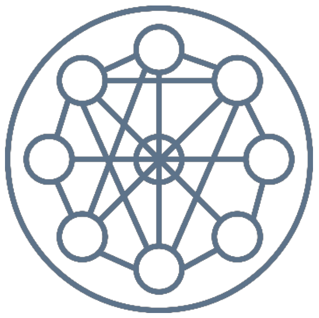


System integration and control are **primary pain points…**



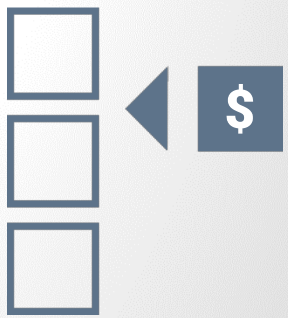
Non-Standardized Ecosystem

- Variety of protocols and physical layer standards
- Available equipment includes legacy and new models



Complex Systems

- Intermittent power generation and variable loads
- Single point of failure



Expensive to Modify

- Inflexible design
- Hard to modified once built

… increasing deployment **time** and **cost**

Introducing our vision for **distributed control**

1. **Technology Agnostic**
Controllers should be compatible with most industry standard protocols and interfaces.

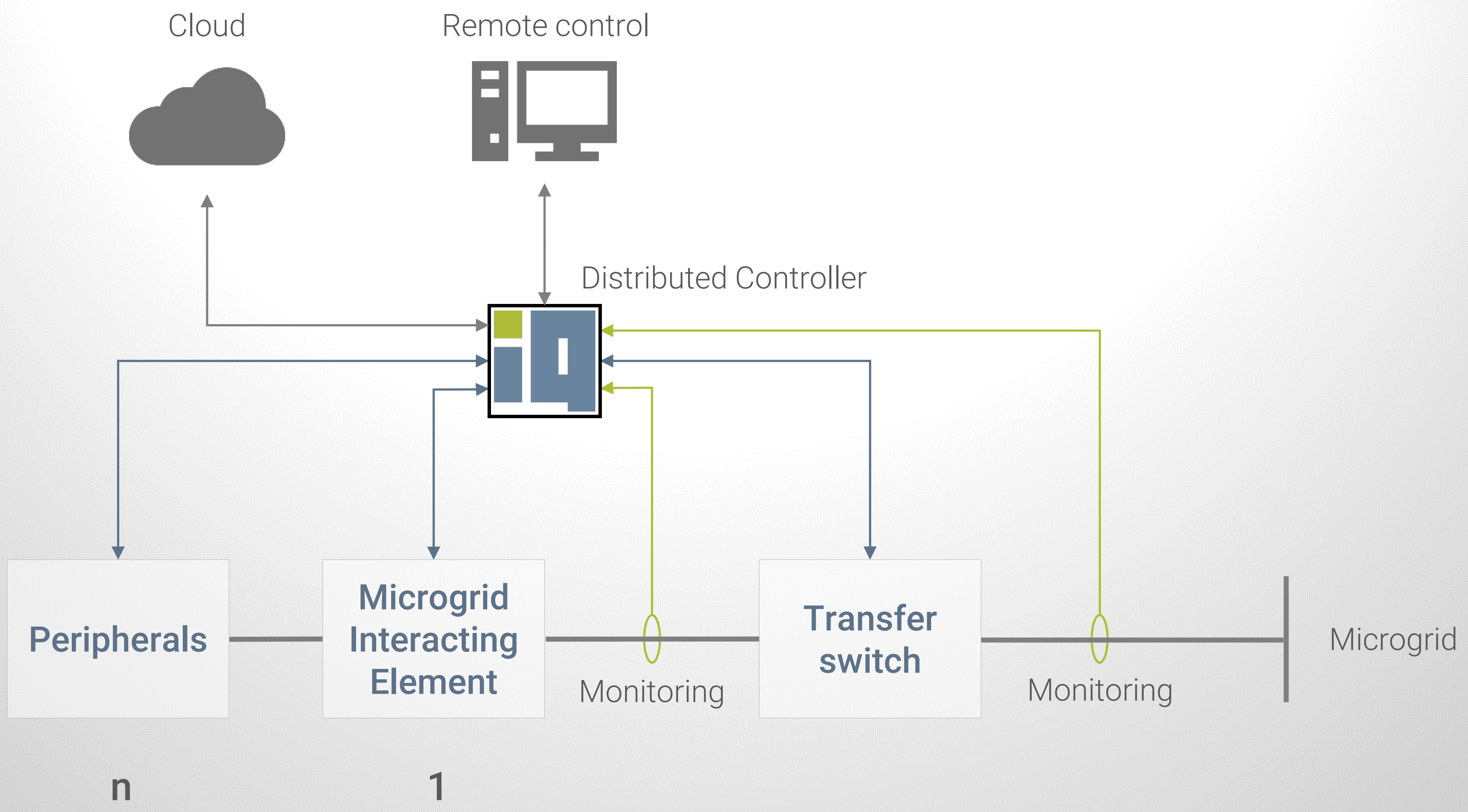
2. **Simple and Robust**
Controllers should encapsulate the microgrid complexity behind sophisticated and robust algorithms.

3. **Open Source**
Controllers should allow users to safely build new functionalities on top of its existing code.

4. **Cybersecure**
Controllers should separate asset control from communication channels.

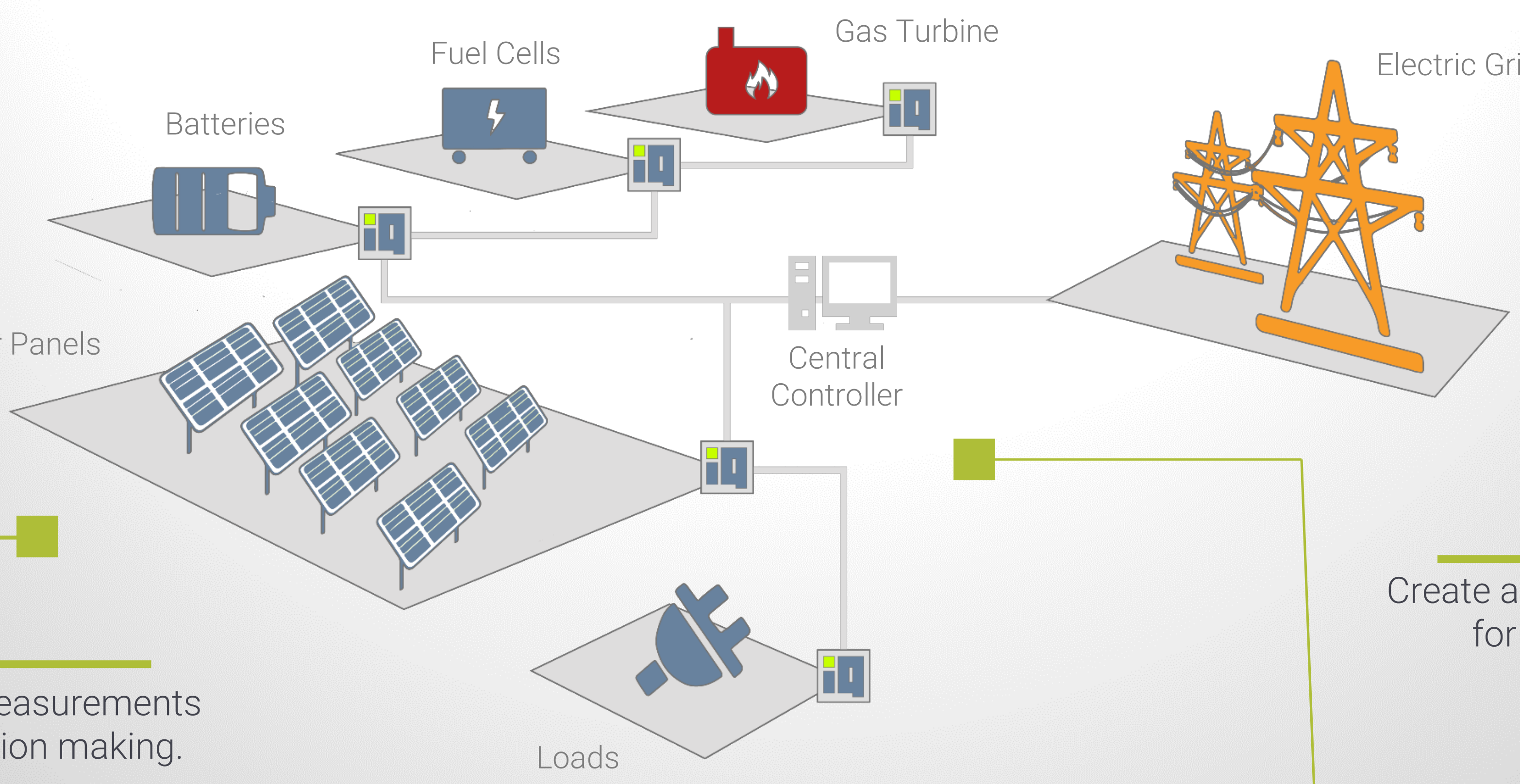
5. **Simple Optimization**
Controllers should enable internal bidding algorithms, increasing system efficiencies

A **typical subsystem** for the SEF distributed controller:



The **role of the distributed controllers** in the SEF microgrid

Encapsulate the complexity of the subsystems to simplify construction.



Create a homogeneous system for upper level controllers.

Perform real-time measurements for control and decision making.

Provide a primary control to each subsystem for power sharing capabilities.

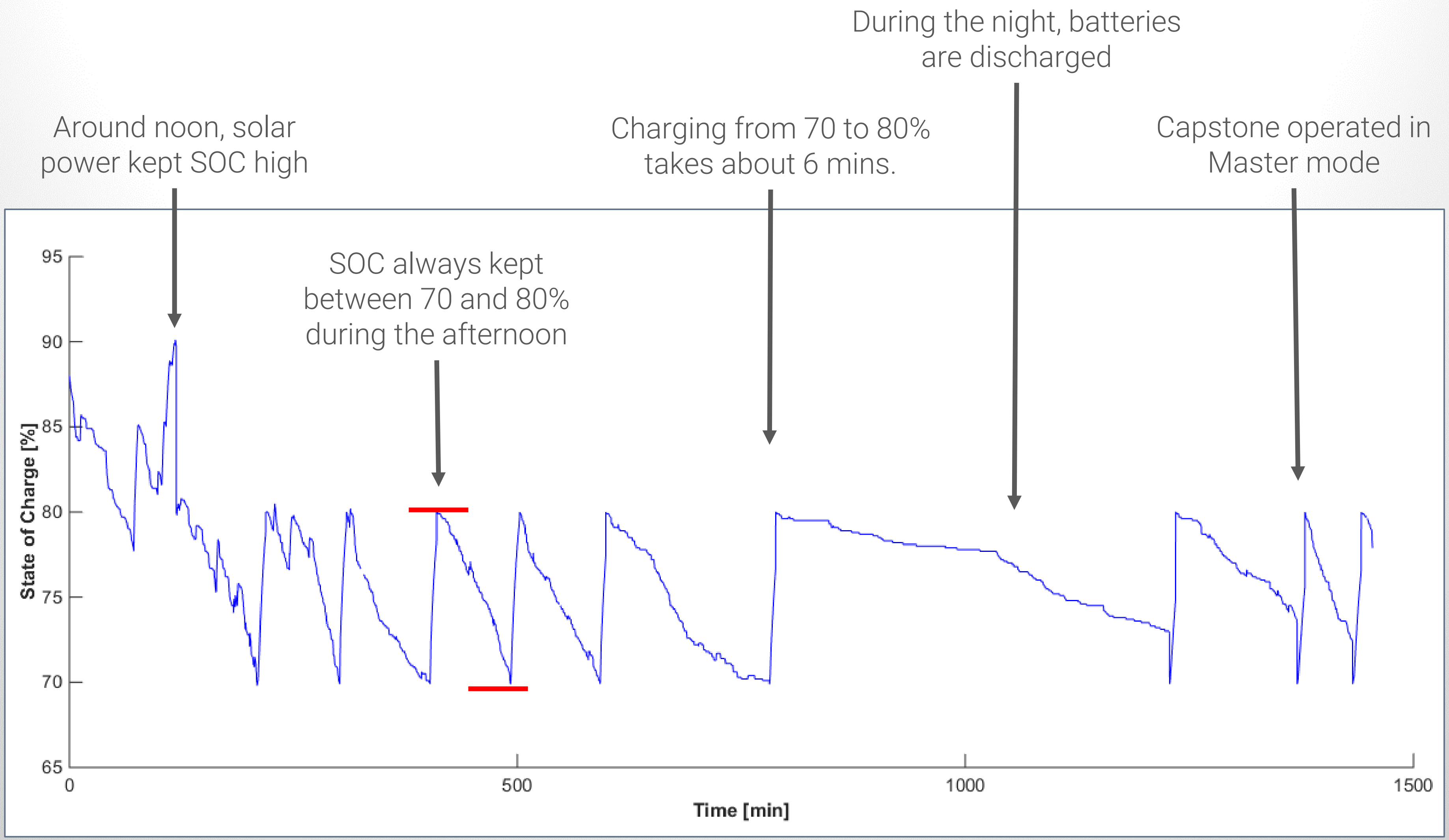
Some Results: Output of two assets, in tandem

Capstone operated in Master mode

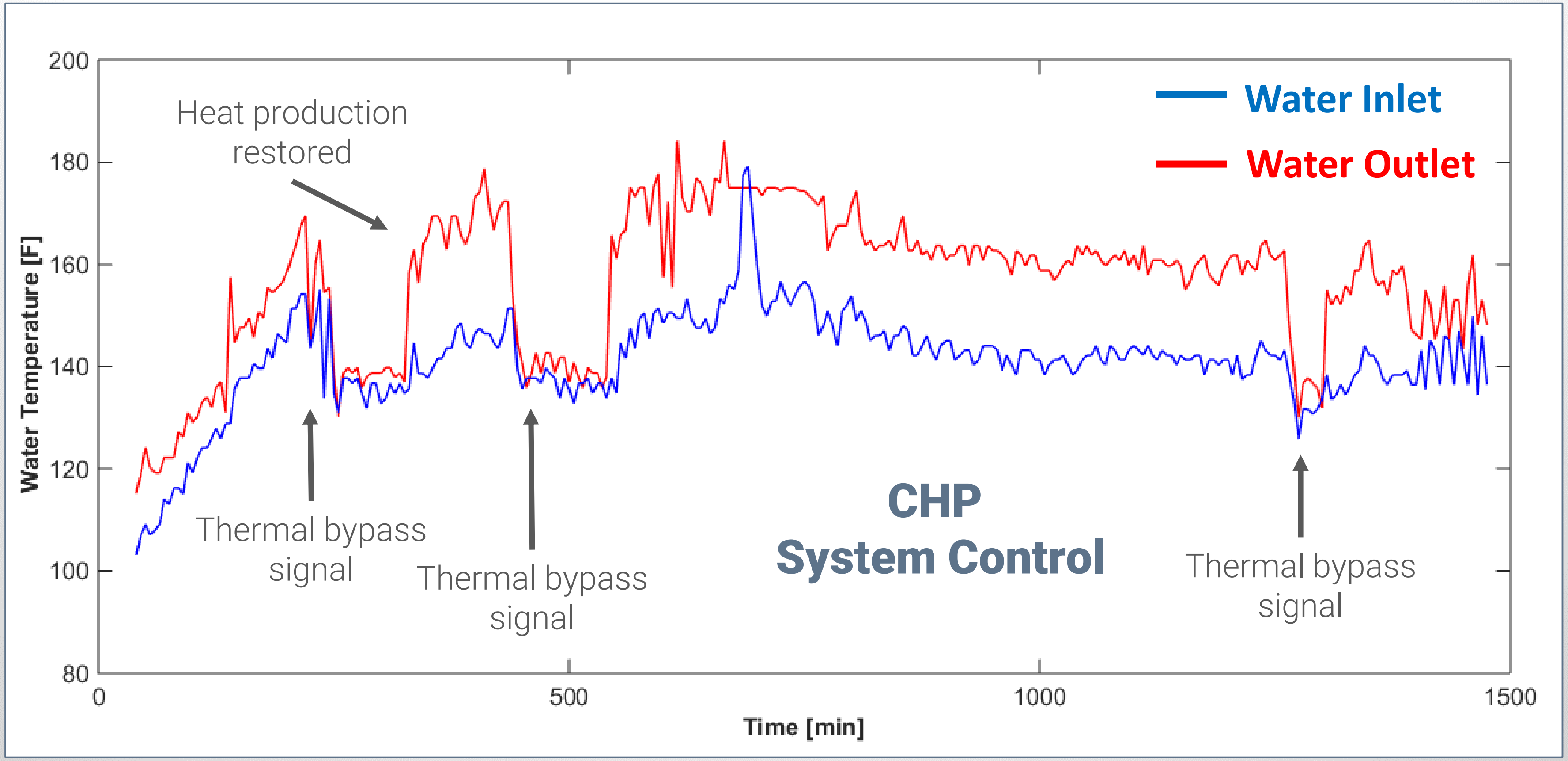
Aquion batteries support the Capstone at large loads

Aquion batteries charged at low loads

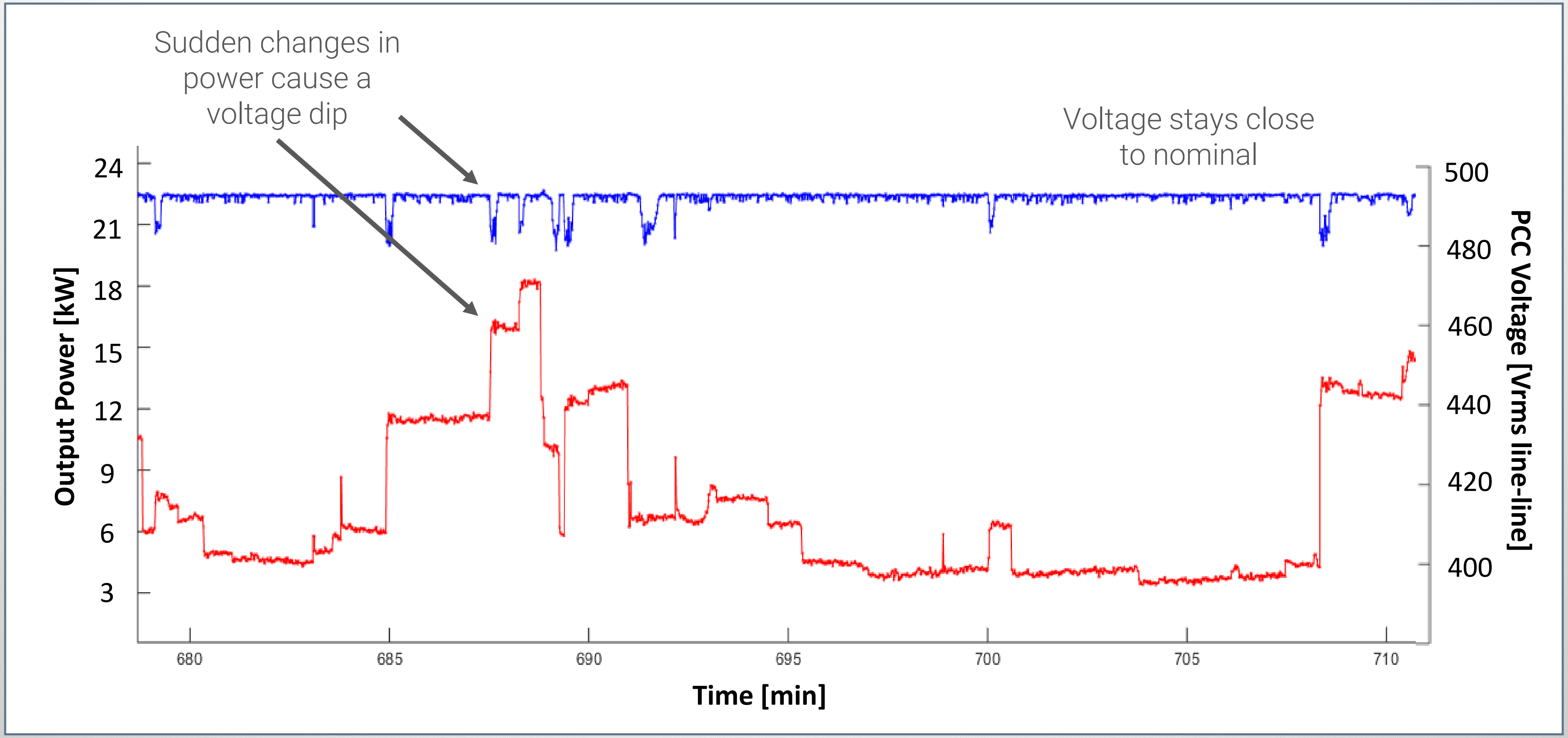
Some Results: Battery state of charge following typical rule



Some Results: Monitoring diverse assets



Some Results: Voltage vs output power of master source



Next Steps

- Demonstrate advanced functionality for distributed controls
- Expand ecosystem of equipment hardware
- Develop a standardized and ruggedized hardware for mass adoption

Contact us if you are

- A facilities manager interested in optimizing existing power equipment
- A project integrator interested in distributed controllers for new systems
- An equipment manufacturer interested in integrating with our controllers

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Team

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Operations

Awards

Back-Up Slides

ARK: A PLACE OF REFUGE IN TIMES OF NATURAL OR MAN-MADE DISASTER
EDEN: PLENTIFUL FOOD, WATER AND ENERGY IN GOOD TIMES

- 540 kW of rooftop solar
- 6 different battery storage systems:
  - 250 kW, 475 kWh Tesla lithium-ion-cobalt battery, Dynapower 250 kW inverter
  - 28 kW, 380 kWh Aquion M100-LS82p 48 V batteries in series (725 V), Ideal 30 kW Inverter
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  - 8 kW, 22 kWh Sony Lithium-iron –phosphate 48 V batteries. Schneider 240 Vinverters
  - 28 kW, 1000 kWh PlugPower -Reli-On fuel cell hive
- 65 kW Capstone CNG microturbine with combined heat and cooling
- Hydrogen Electrolyzer Millennium Reign Energy 330 triple Twin 12 kg per day production
- 24 kg Hydrogen fueling station for vehicles
- 150 kW , 160 kWh flywheel expandable to 800 kWh (will be added in March of 2017)

Water use:

36 revenue grade water meters installed in 2010

Stone Edge Farm can track water loss to 20 L of accuracy with cell phone interface

Sustainable Farming:

Chickens, bees, and seasonal vegetables and herbs