Wellness Center Resort Microgrid

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Why a Microgrid for This Site?

- Existing grid is not sufficient
- Three phase power is too far away to bring it to site.
- The goals of the project include being as environmentally friendly as possible.

Design Philosophy for the Project

- Energy
  - 100% Renewable Energy
  - Fossil Fuel Free
  - Reducing Energy Demand
- Water
  - Using Non-potable Water for Irrigation and Flushing
  - Closed Loop Water System with Well and Septic
- Wellness
  - Adaptive Thermal Comfort
  - Circadian Lighting in Guest Rooms
  - Well Standard for Air and Water Quality

Microgrid Design Requirements

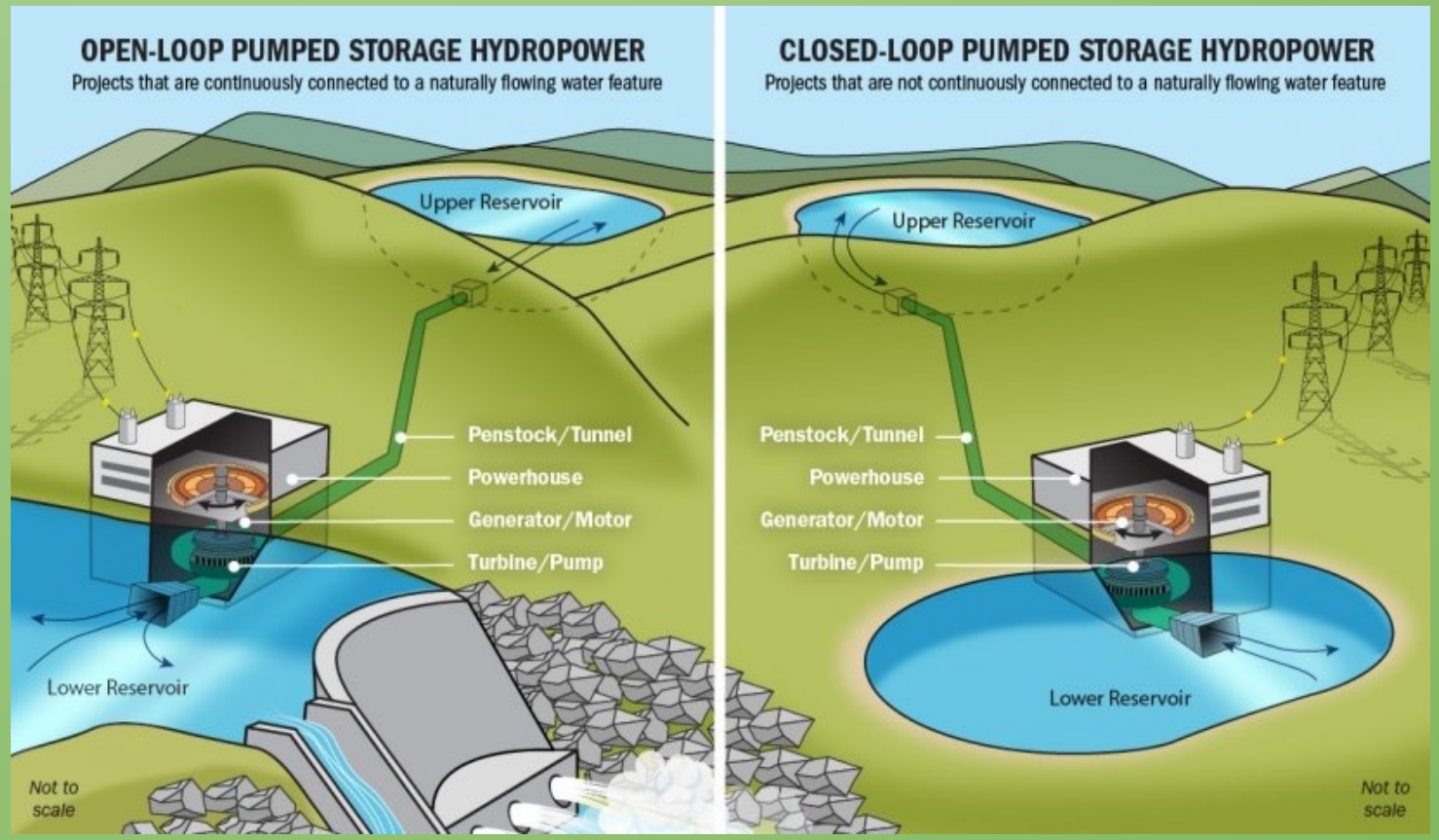
- Reliable Power
  - Continuous Power Required for the Site
    - Loss of Utility cannot cause a power outage
- Resilient Power
  - The Microgrid Shall Adapt to Changes in the
    - Load
    - Distribution Network
    - Weather
- Renewable Power
  - The Microgrid Shall use be Net Zero Energy or Better

Microgrid Generators Explored

- Renewable Sources
  - Solar
  - Wind
  - Hydro
  - Biogas
- Fossil Fuels
  - Not explored due to the philosophy of the project
  - Potential to connected in an emergency

Microgrid Storage

- Battery System
  - Readily Available
  - Commonly Understood
- Pumped Hydro System
  - Long Time Energy Storage
  - Expensive
  - Requires Large Area
- Thermal Storage
  - Works well with the HVAC system

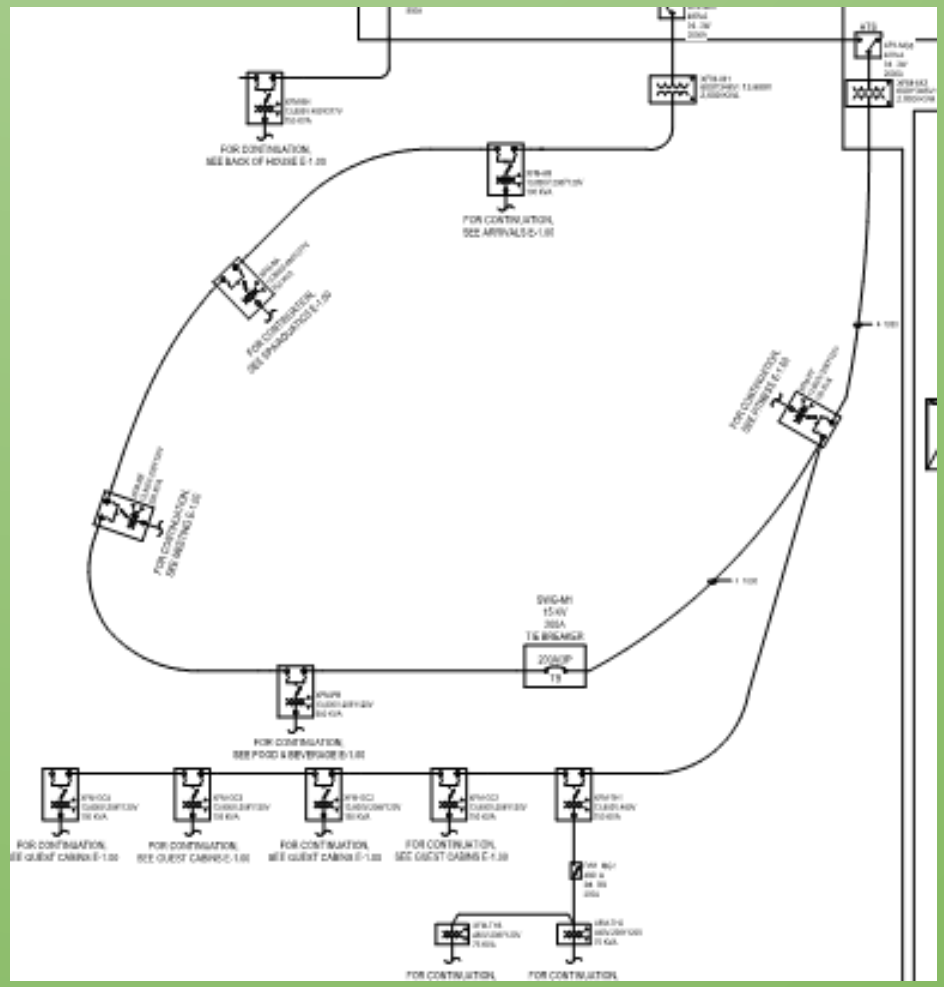


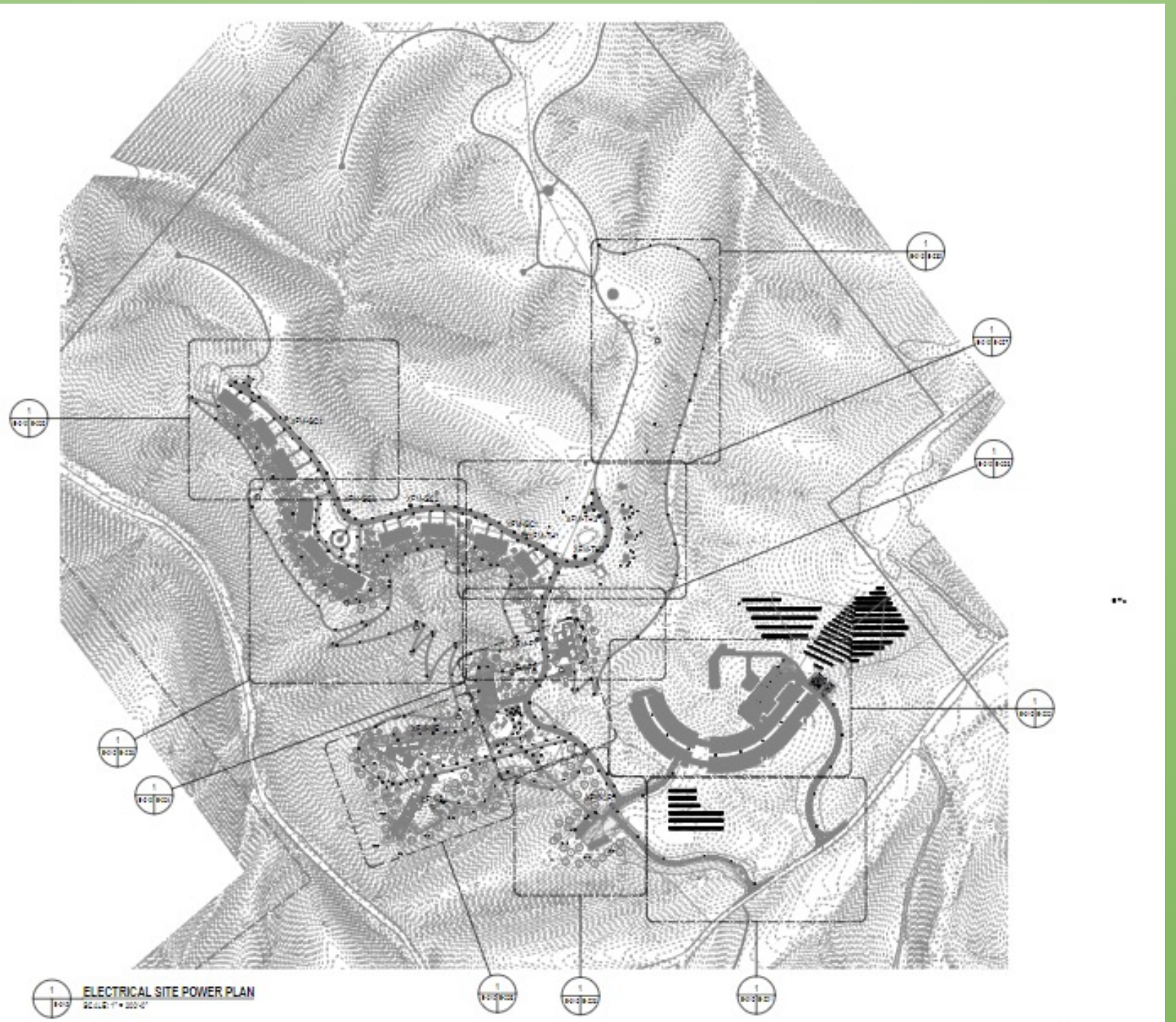
Microgrid Storage (cont.)

- Gravity Energy Storage
  - High Energy Density
  - Expensive if Hidden
  - Unsightly if not Hidden
- Flywheel Storage Systems
  - Fast Response
  - Short Duration

Microgrid Design Concept

- 2 MW Solar Array
  - Ground Mounted
  - 3.2 Acre total field
  - 0.65 GCR
- 7000 kWH Battery
  - 800kW Inverter
- 150 kVA Utility Connection
  - Single Phase
- 13.8 kV Distribution
  - Reduce Infrastructure Costs
  - Reduce Losses in the Wire
- Ring with Spoke Architecture




ELECTRICAL SITE POWER PLAN

Battery Technology Explored

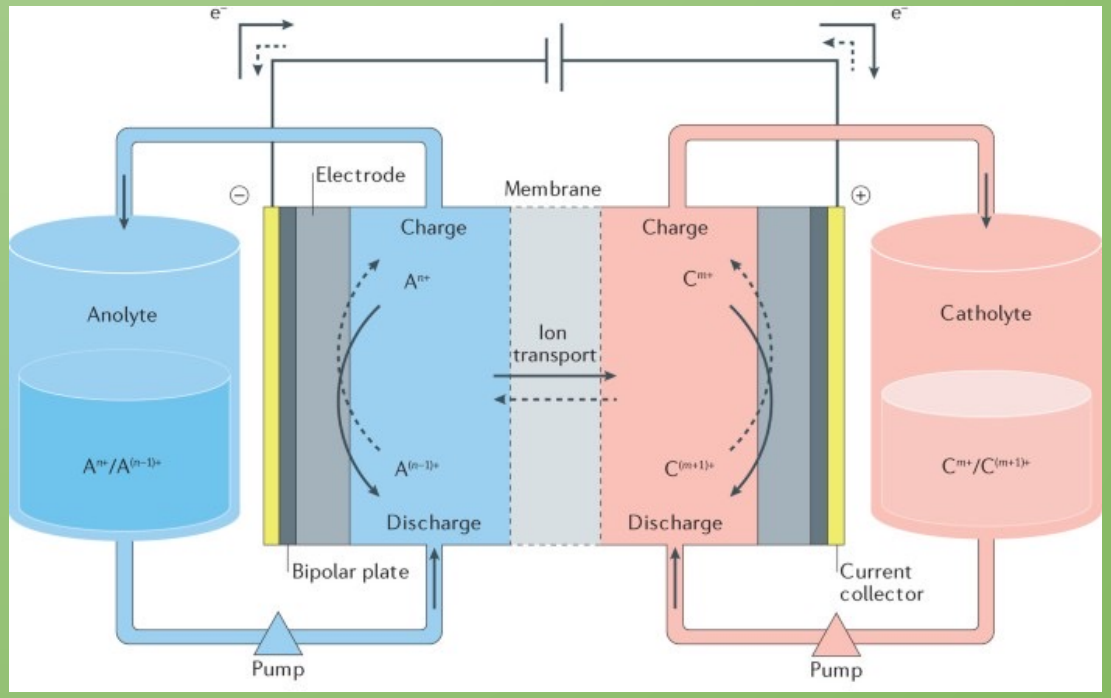
- Lead Acid Batteries
  - Benefits
    - Common
    - Inexpensive
    - Recyclable
  - Problems
    - Maintenance
    - Energy Density
    - Not in-line with the Design Philosophy of the Project.

Battery Technology Explored (Cont.)

- Lithium Iron Phosphate
  - Benefits
    - High Energy Density
    - Increasingly Common
    - Decreasing Cost
    - Lower Maintenance
  - Problems
    - Availability
    - Total Carbon Impact
    - Frequent Deep Discharge can Lead to Early Replacement
    - Potential for Thermal Runaway
    - Environmental Impact of Mining Lithium

Battery Technology Explored (Cont.)

- Flow Batteries
  - Benefits
    - Safe
      - No thermal runaway
      - Environmentally friendly* components and fluids
    - Easy to Maintain
    - Potential to Reach Cost Parody with Li Batteries in Near Future
    - Excellent Deep Cycle Capabilities
    - Long Lifetimes
      - Rated for 25 year, potential for much longer)
  - Problems
    - Most Cost Effective
      - When energy arbitration is available
      - For larger systems
    - Large Footprint
    - Requires Deep Cycling to Maintain Chemistry

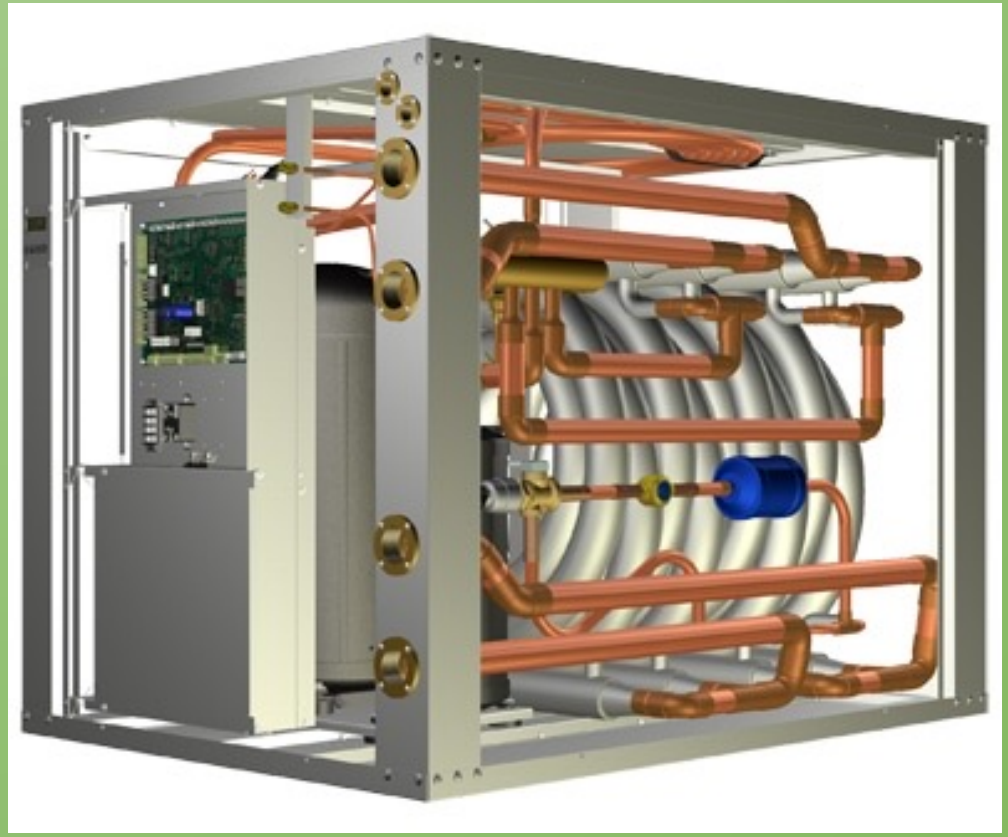


Battery Technology Explored (Cont.)

- Combination of Flow and Lithium Batteries
  - Benefits
    - Good Peaking and Depth of Discharge
      - Lithium handles high instantaneous current well
      - Flow Batteries handle deep discharge well
    - Reduces the replacement Costs for the Lithium Batteries
      - By minimizing the frequency of deep discharge
      - By reducing the size of the Lithium battery required
  - Problems
    - High Initial Cost
    - Complicated Control System Required

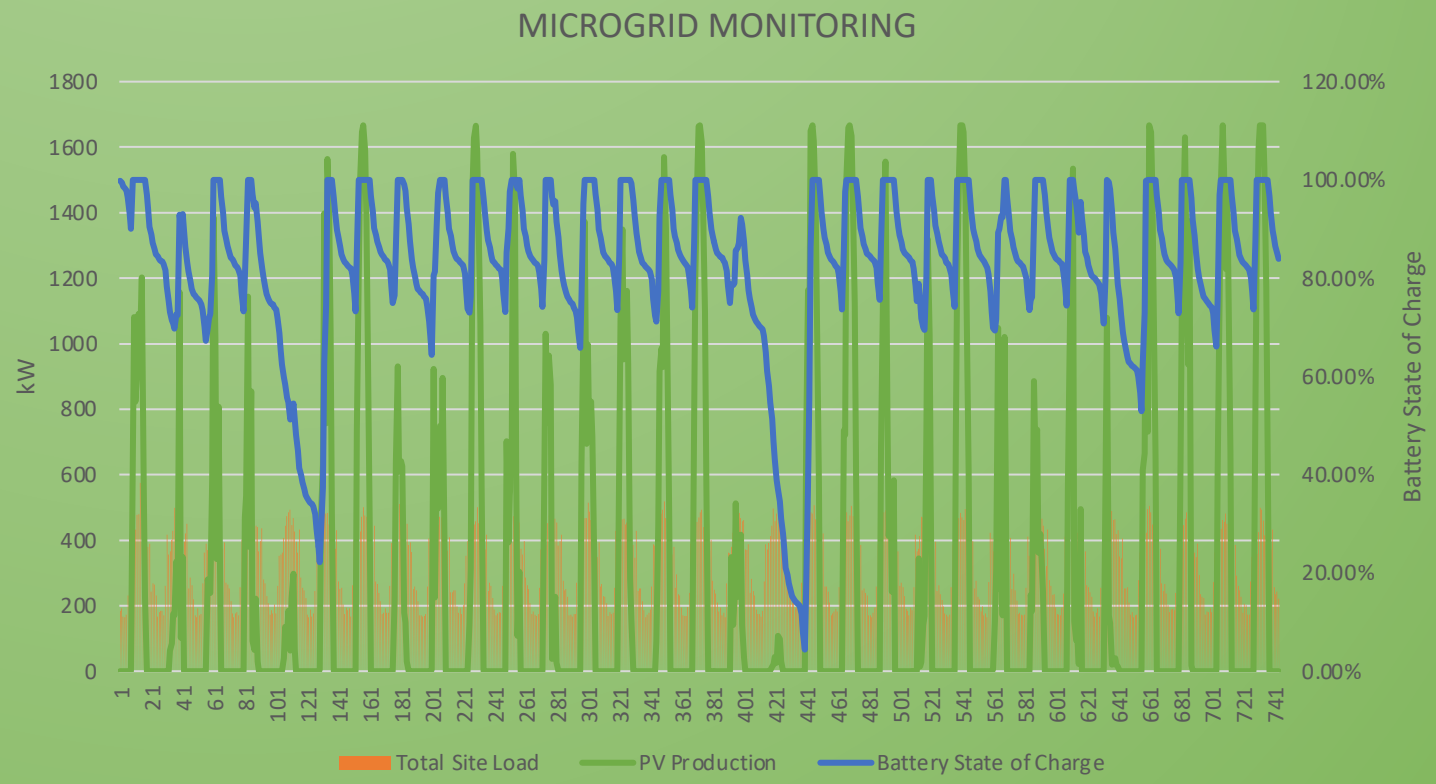
Thermal Storage

- Geothermal System
  - Used for the HVAC System and Water Heating
    - Stores energy in the ground for later use
    - Reduces the electricity required to heat and cool
  - Not Used for Electricity Production



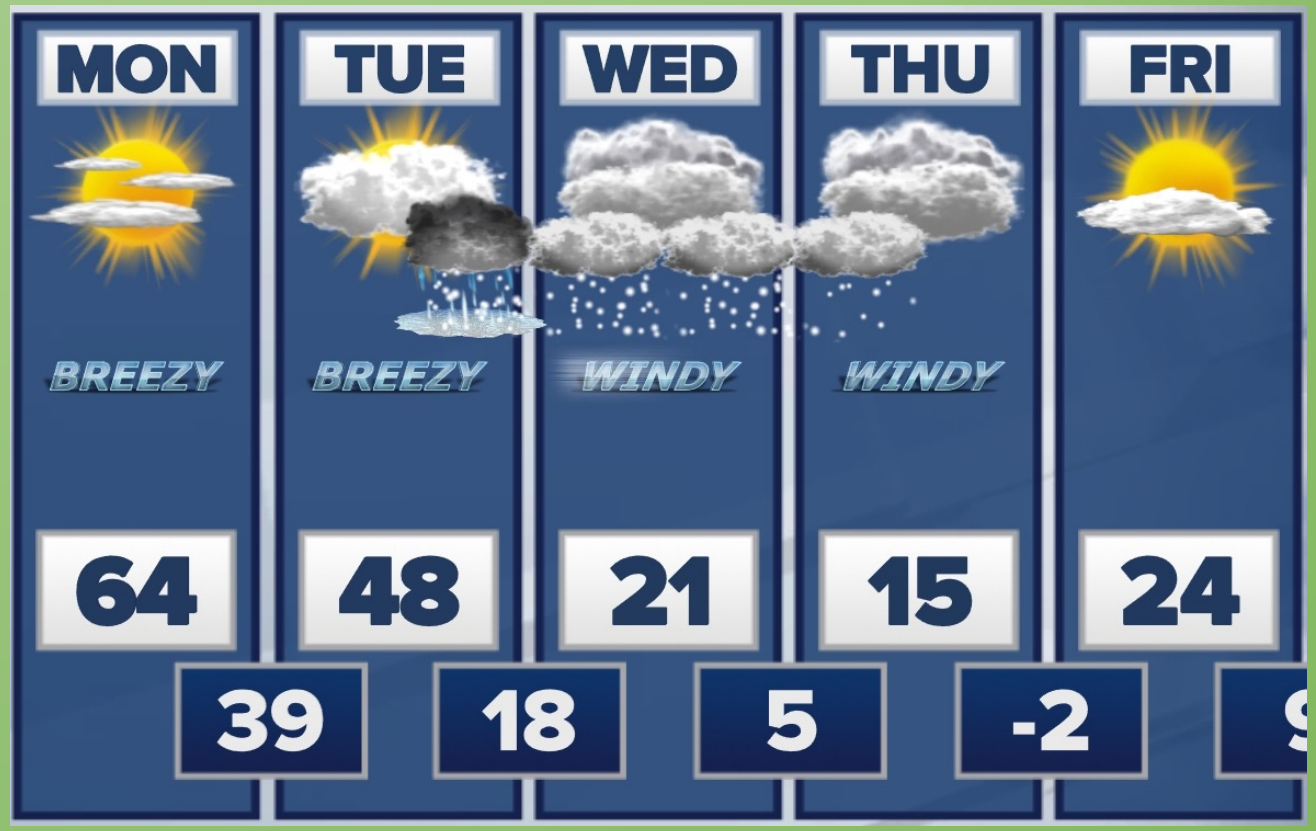
Microgrid Features

- Instantaneous Monitoring
  - Battery Health Monitoring
    - State of Charge
    - Cell Health
  - Distribution Losses
  - Solar Production



Microgrid Features (Cont.)

- Predictive Analyses
  - Weather Prediction
    - Weather Monitoring
      - Intensity and duration of storms
      - Weather leading up to the storm
      - Weather after the storm
    - Solar Production Predictions
      - Pre-storm predictions
      - During the storm
      - Post-storm predictions
  - Load Prediction
    - Historical Metering Data



Microgrid Features (Cont.)

- Load Shedding
  - Automatic Load Shed/Add
  - Building by Building
- States of Operation
  - Normal Conditions
  - Loss of Utility Connection
  - Inclement Weather
  - Summer Production

Complications of the Design

- Covid and Supply Chain
  - Long Lead Items
    - Batteries
    - Electrical Components
  - High Demand
    - Batteries are in high demand as their benefits are realized by the industry
    - Workforce reductions during Covid

Complications of the Design (Cont.)

- Cutting Edge Technology
  - New Energy Storage Technology
    - Flow batteries are new tech
      - Maintenance track record
      - End of life
      - Scaling down
  - Startup Companies
    - The latest tech is often provided by a startup company
    - Will the startup be there to support the installation?

Complications of the Design (Cont.)

- Phase Changing
  - One phase to three phase and back
    - DC coupled phase conversion.
  - Limitations of single phase inverters
    - 10 – 15 kW typical size
    - Interconnecting with available large battery systems
  - Utility requires current limitation
    - Achieved by single phase inverters
- Cost of Infrastructure.

Conclusions

- Benefits of the microgrid
  - Project can still move forward without major utility infrastructure requirements.
  - The design philosophies of harmonizing with nature and having a clean energy power source are realized.
  - The project provides resilient, reliable renewable power for the wellness center.