MICROGRIDS FOR PASSIVE HOUSE BUILDINGS

AN INTRODUCTION TO MICROGRID DESIGN AND THE SYNERGIES BETWEEN MICROGRIDS AND PASSIVE HOUSE BUILDINGS

Learning Objectives

1) Understand the purposes of Microgrids
2) Design considerations for Microgrids
3) Synergies with resiliency for Passive House microgrid projects
4) Evaluate real world examples

Outline

- Introduction
  - What is a microgrid?
- Purposes for Microgrids
  - Backup Power
  - Reliability
  - Energy/Power Management
- Synergies between Passive House and Microgrids
  - Reduced Energy Load
  - HVAC Operations
- Examples
  - Hitt
  - Care First
  - Stack 8

WHAT IS A MICROGRID?

"a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode." - DOE

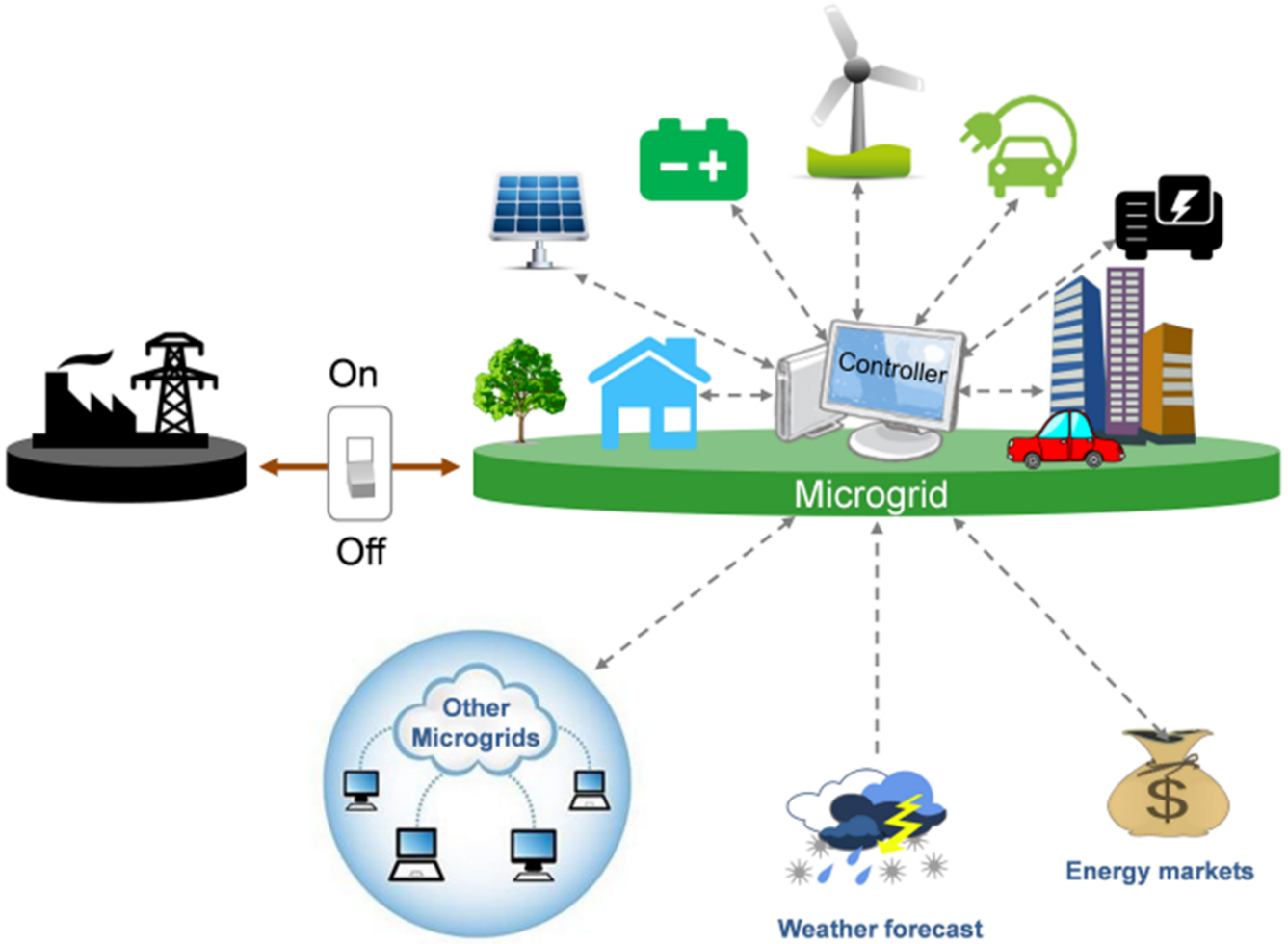
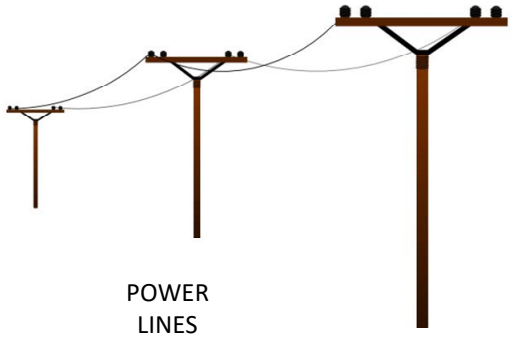


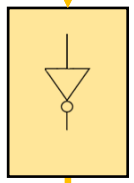
Image used courtesy of Berkeley Lab

SOLAR WITHOUT STORAGE



POWER
LINES

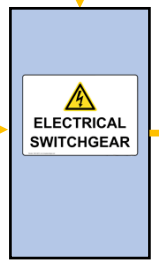
SOLAR
ARRAY



INVERTER

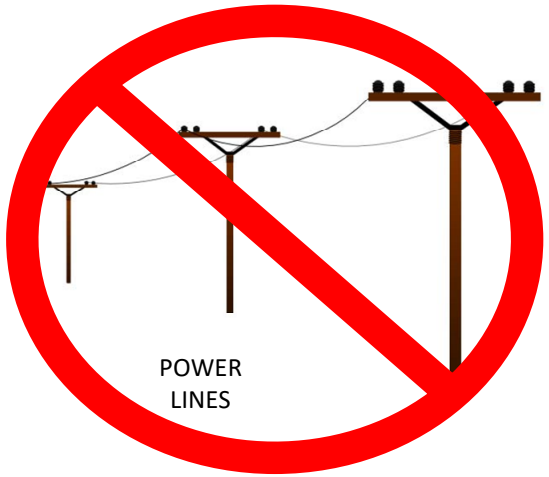
LOAD
CENTER

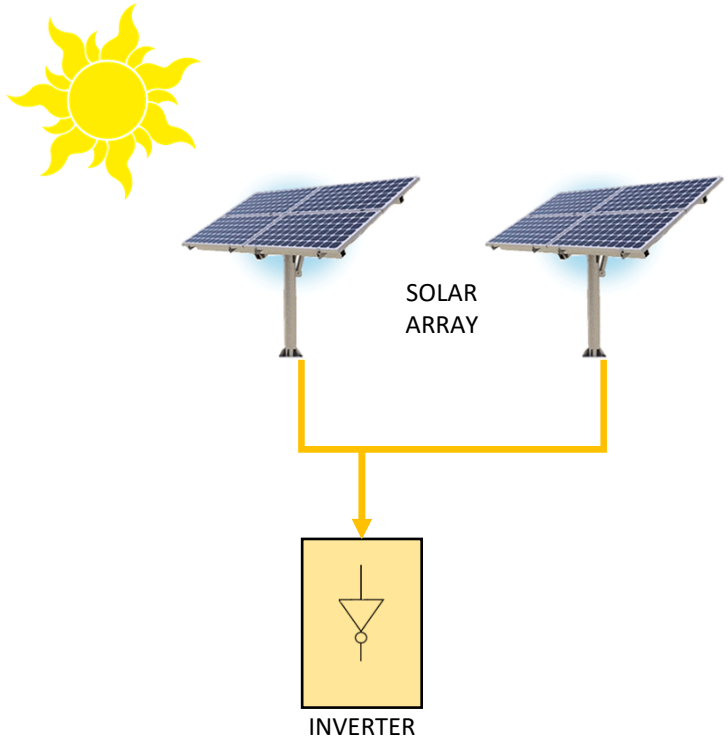
M



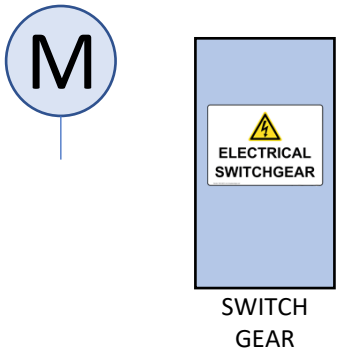
SWITCH
GEAR

SOLAR WITHOUT STORAGE
"ANTI-ISLANDING"

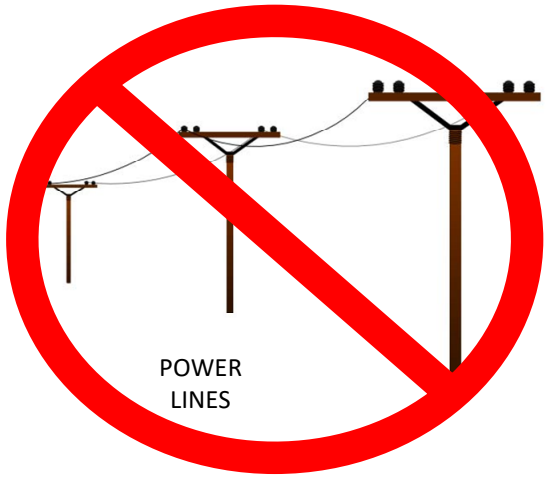


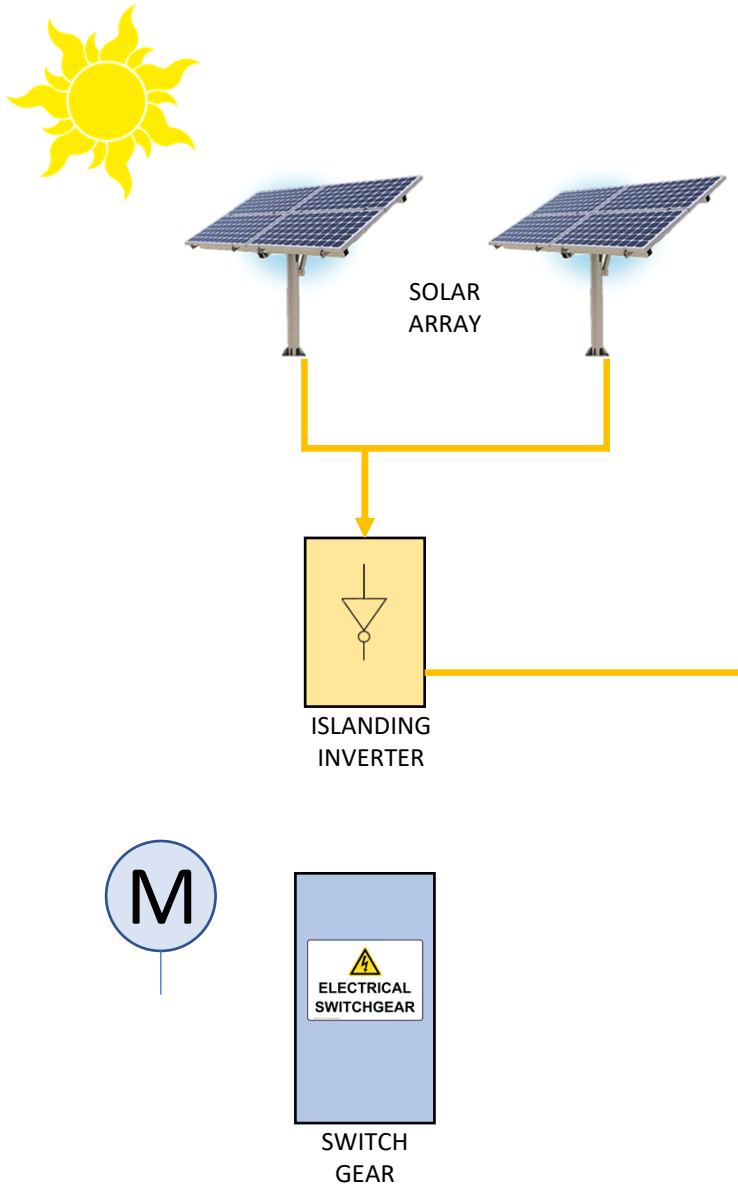



LOAD
CENTER

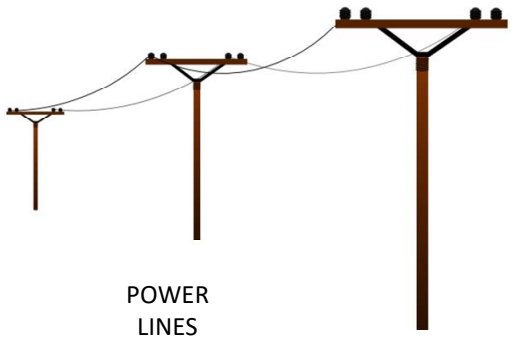


SOLAR WITHOUT STORAGE
ISLANDING INVERTER

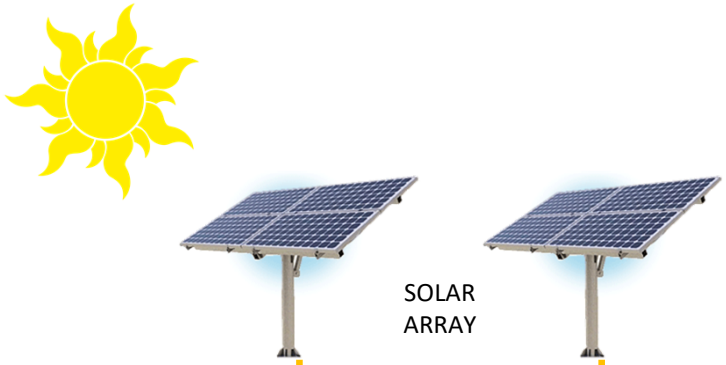




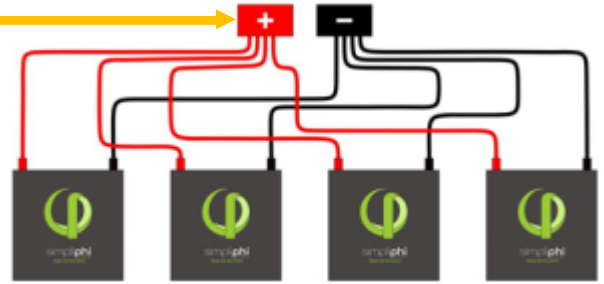
SOLAR WITH STORAGE



POWER
LINES



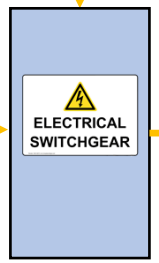
SOLAR
ARRAY



BATTERY ARRAY

ISLANDING
INVERTER

M

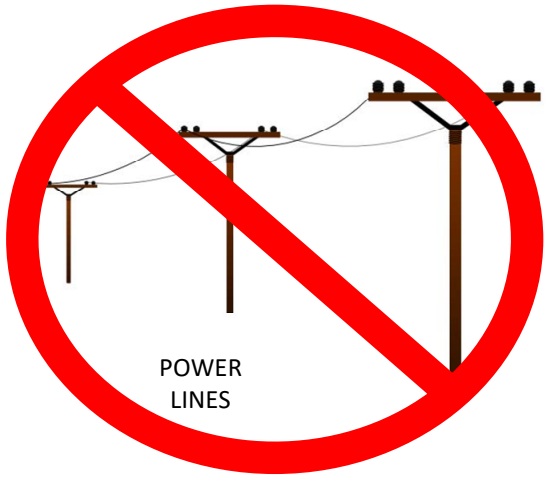


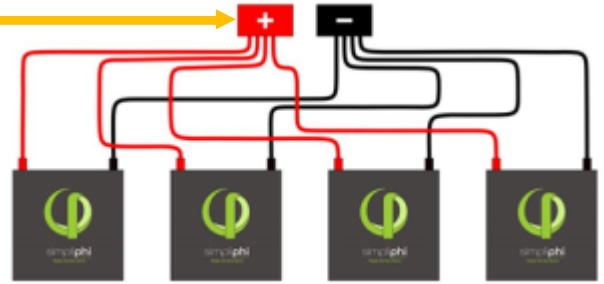
SWITCH
GEAR

BACK-UP
LOADS

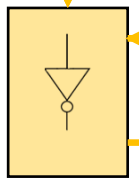
LOAD
CENTER

SOLAR WITH STORAGE

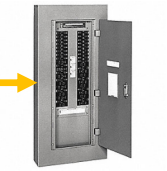




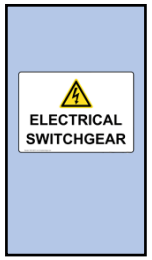
BATTERY ARRAY



ISLANDING
INVERTER



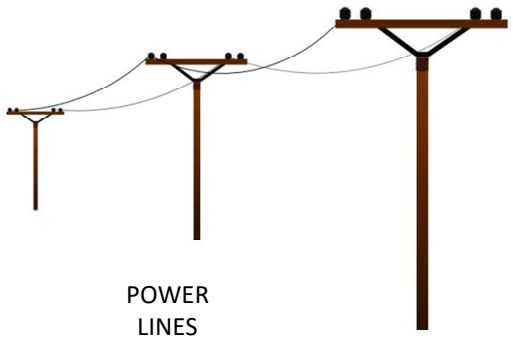
BACK-UP
LOADS



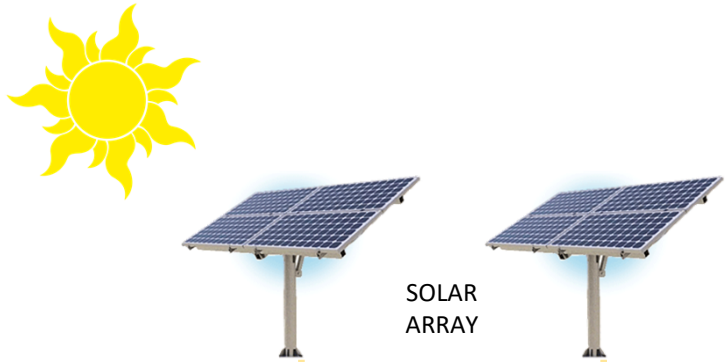
SWITCH
GEAR

LOAD
CENTER

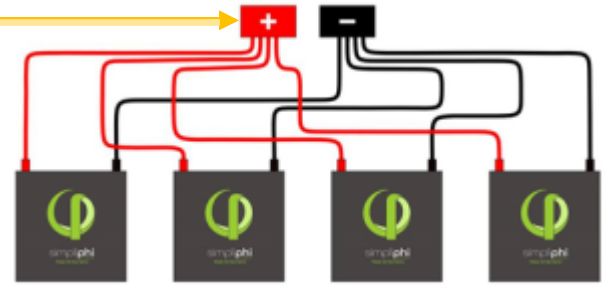
DC MICROGRID



POWER
LINES



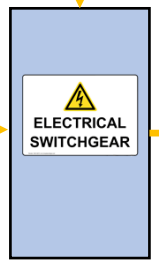
SOLAR
ARRAY



BATTERY ARRAY

INVERTER /
CHARGE
CONTROLLER

M



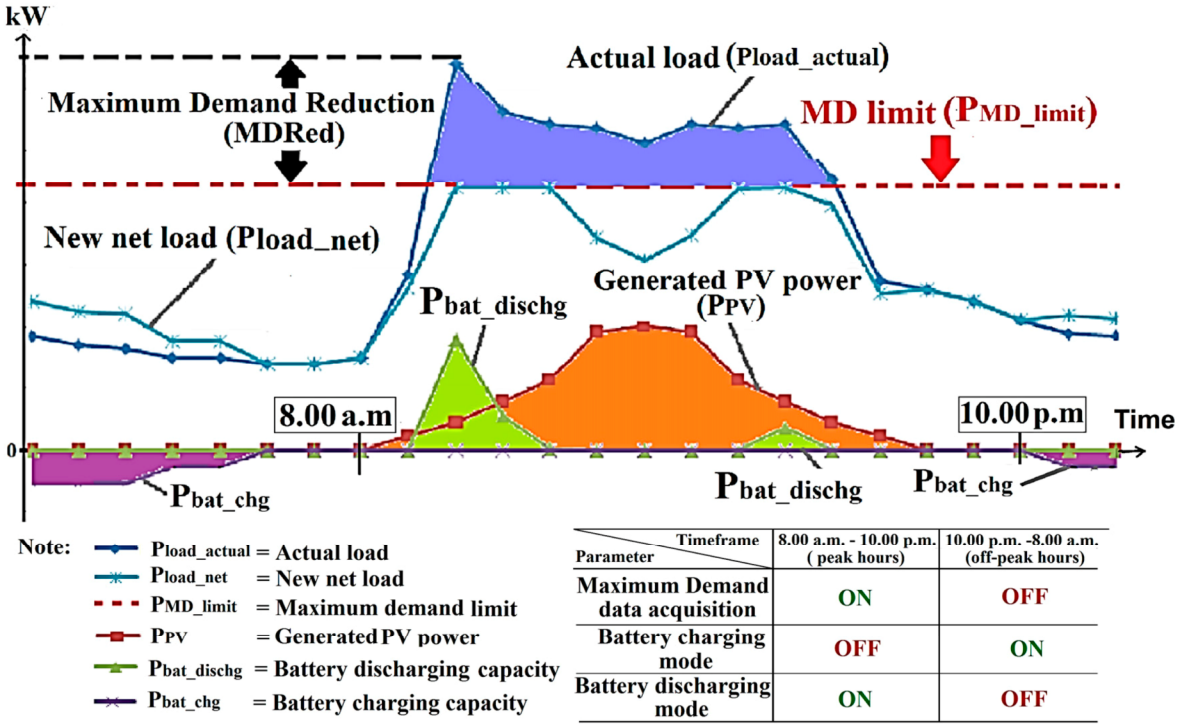
SWITCH
GEAR

DC LOAD
CENTER

LOAD
CENTER

WHY WOULD YOU WANT A MICRO-GRID?

- Purpose of microgrid
  - Reliability
    - Backup Power
    - Building Resiliency
  - Economics
    - Demand Control
    - Time of Use
    - Return on Investment
  - Grid Shaping
    - Poor Power Quality
    - Frequent Blackouts/Brownouts
  - Off Grid



Parameter \ Timeframe	8.00 a.m. - 10.00 p.m. (peak hours)	10.00 p.m. -8.00 a.m. (off-peak hours)
Maximum Demand data acquisition	ON	OFF
Battery charging mode	OFF	ON
Battery discharging mode	ON	OFF

Moghimi, M.; Garmabdari, R.; Stegen, S.; Lu, J. Battery energy storage cost and capacity optimization for university research center. In Proceedings of the IEEE/IAS 54th Industrial and Commercial Power Systems Technical Conference (I&CPS), Niagara Falls, ON, Canada, 7–10 May 2018.

Design Considerations

- Define DESIGN duration for power outage
  - Short term
  - Long term
  - Indefinite
- Physical Size of Equipment
  - Where are you going to put it?
  - How far do you need to transmit the power?
- Electrical Capacity
  - Small load for a long time?
  - Large load for a short time?

Design Considerations

- Energy Converters
  - Generators
  - Solar Array
  - Wind Turbines
  - Hydroelectric
- Energy Storage
  - Batteries
  - Flywheels
  - Thermal batteries

FLYWHEEL STORAGE

Design Considerations

- Load Management
  - Production Capacity
  - Electrical Demand
  - Source Switching
  - Load Switching
- Outside Requirement
  - Building Codes
  - Utility Requirements
- Economics
- Available Technologies

Battery	Cost	Lifespan	Depth of Discharge
Lead Acid	$	⧗	▮
Lithium	$ $ $	⧗ ⧗ ⧗	▮ ▮
Saltwater	$ $	⧗ ⧗	▮ ▮ ▮

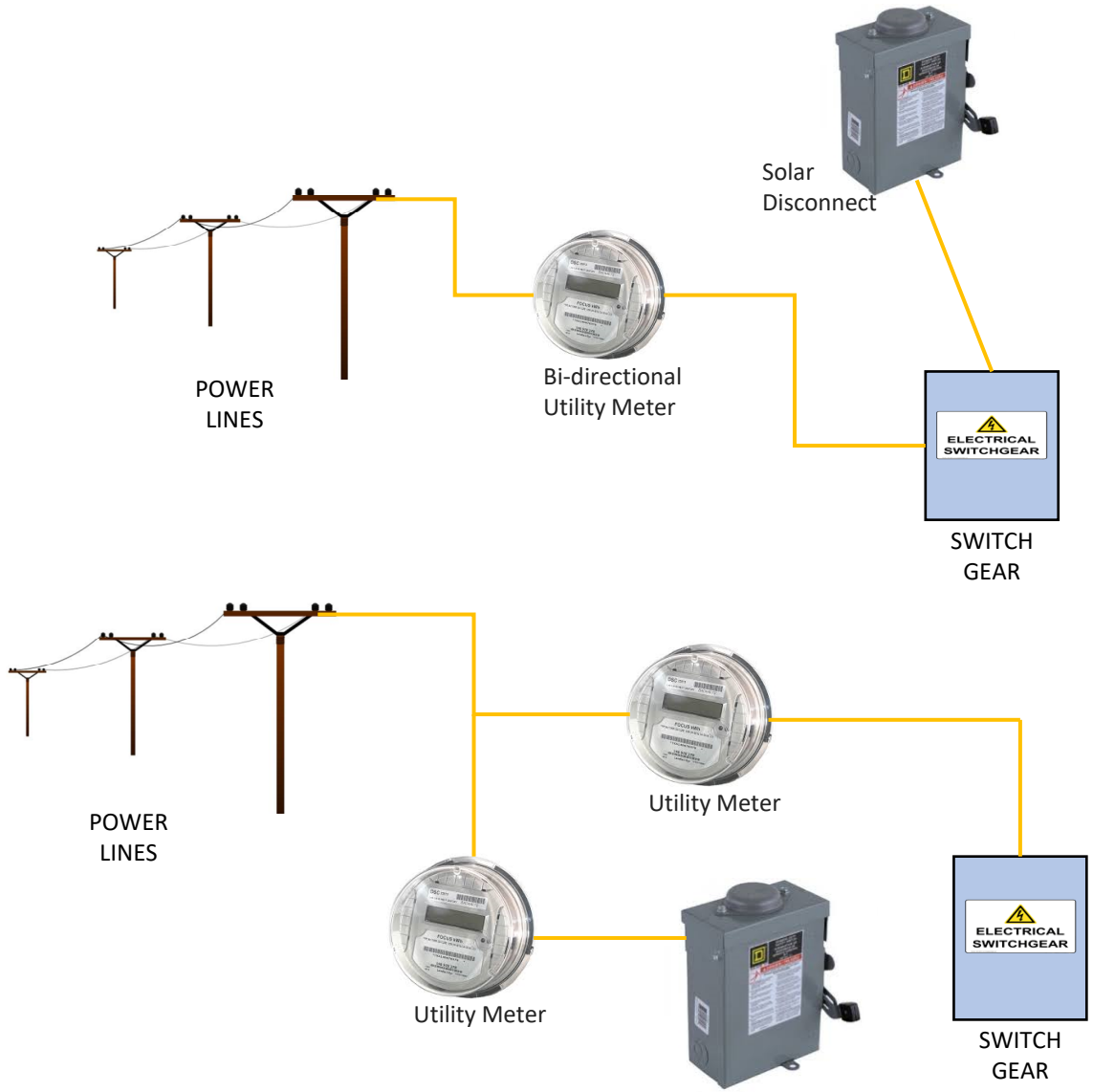
AW1

Inverter Issues

- Kinds of Inverters
  - Inverter Architecture
    - Voltage Source
    - Current Source
  - Solar Inverters
    - String Inverters
    - Microinverters
- Paralleling
  - Voltage Sources
    - Only one is ideal
    - Paralleling equipment
  - Generators
    - Voltage Regulation
    - Frequency Regulation

Intertie Considerations

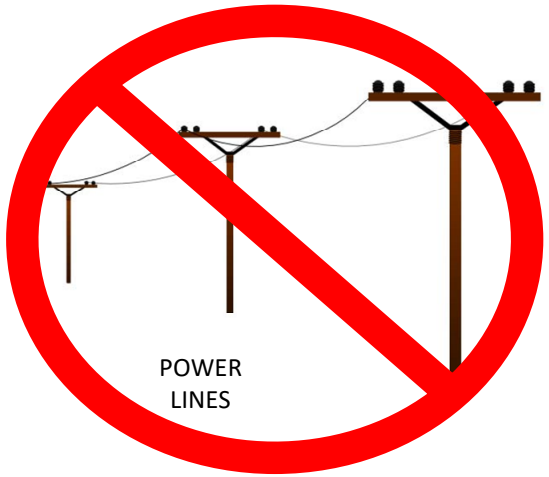
- Where to Connect
  - Load Side Connection
    - Capacity is limited by electrical equipment
    - Net metering
  - Line Side Connection
    - Unlimited capacity - maybe
    - Requires a separate meter
    - Aggregated metering

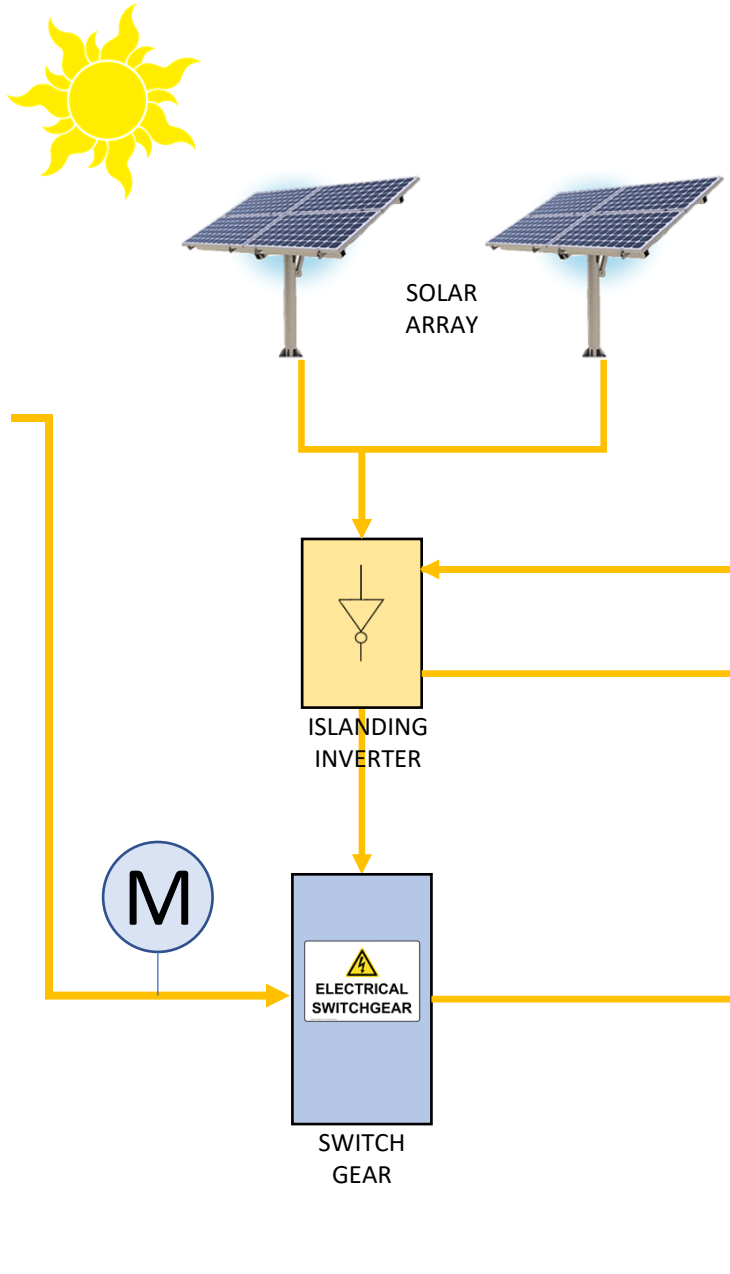


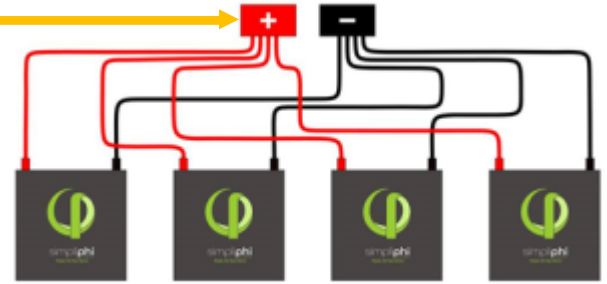
Load Types

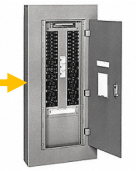
- Emergency
  - Requires inverters to be listed for this purpose
  - Integral batteries charged by microgrid
- Legally Req’d. Standby
  - Requires inverters to be listed for this purpose
  - Beware of motors on batteries
- Optional Standby
  - What ever else you want

PARALLEL DISTRIBUTION





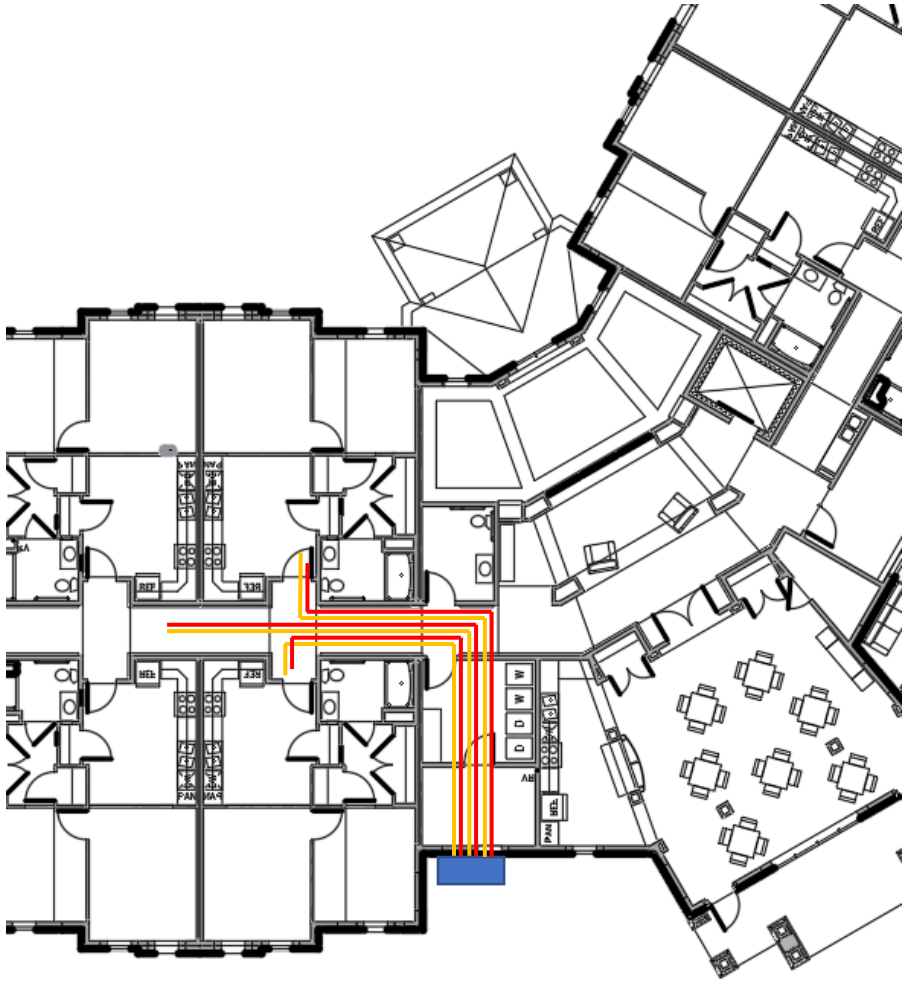




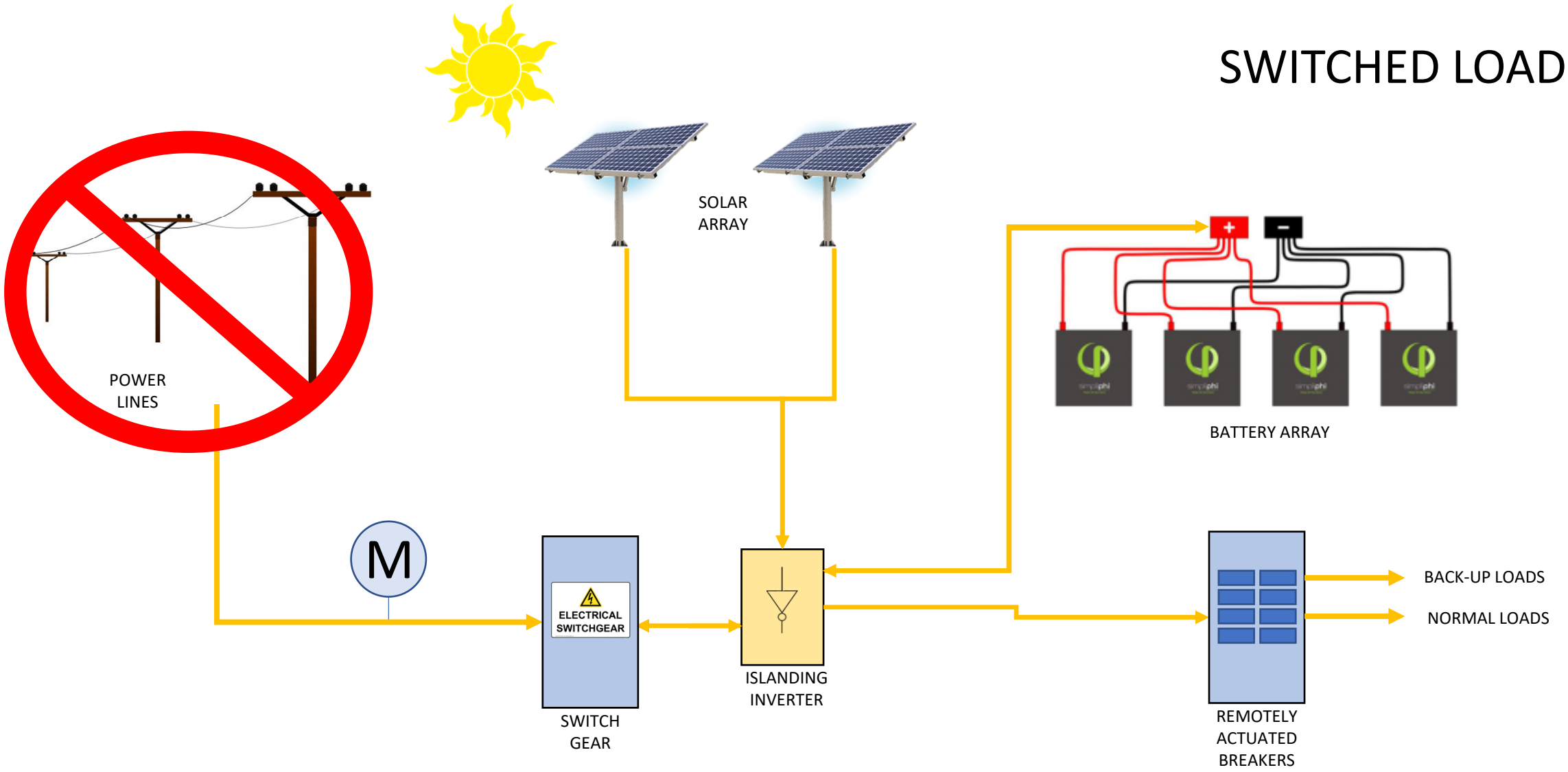
DISTRIBUTION ISSUES

Separate back-up power circuiting

- Separate back-up power distribution required to each apartment
- Redundant distribution is costly



SWITCHED LOADS

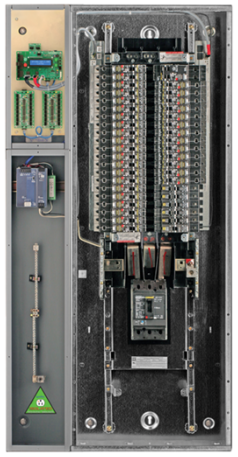


DISTRIBUTION ISSUES

Switched breakers allow real-time load shedding

- Redundant wiring infrastructure not required!
- Allow for real-time load management. Can take advantage of generation energy when available.
- Currently costly, but emerging products will likely bring costs down quickly.

Eaton remote controlled circuit breaker

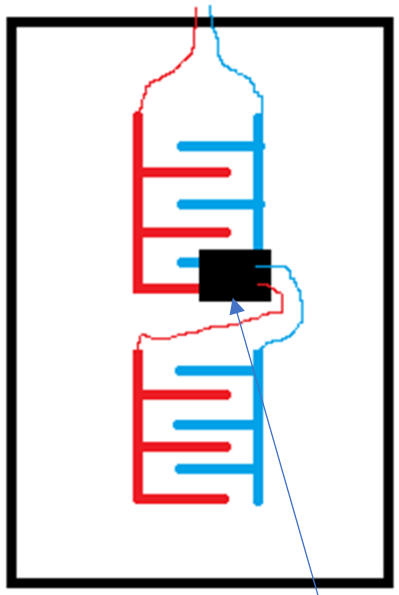


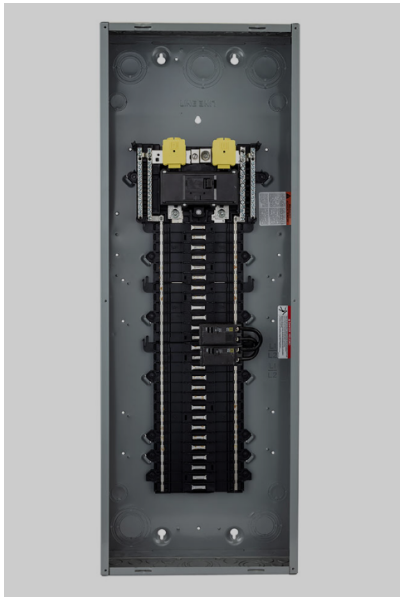
Lyntec controllable breaker panel with monitoring capability

DISTRIBUTION ISSUES

Split-bus panel

- Only one actuated breaker required.
- Control back-up vs. regular loads.
- Less flexibility than actuated breakers on all circuits.
- Much cheaper!!



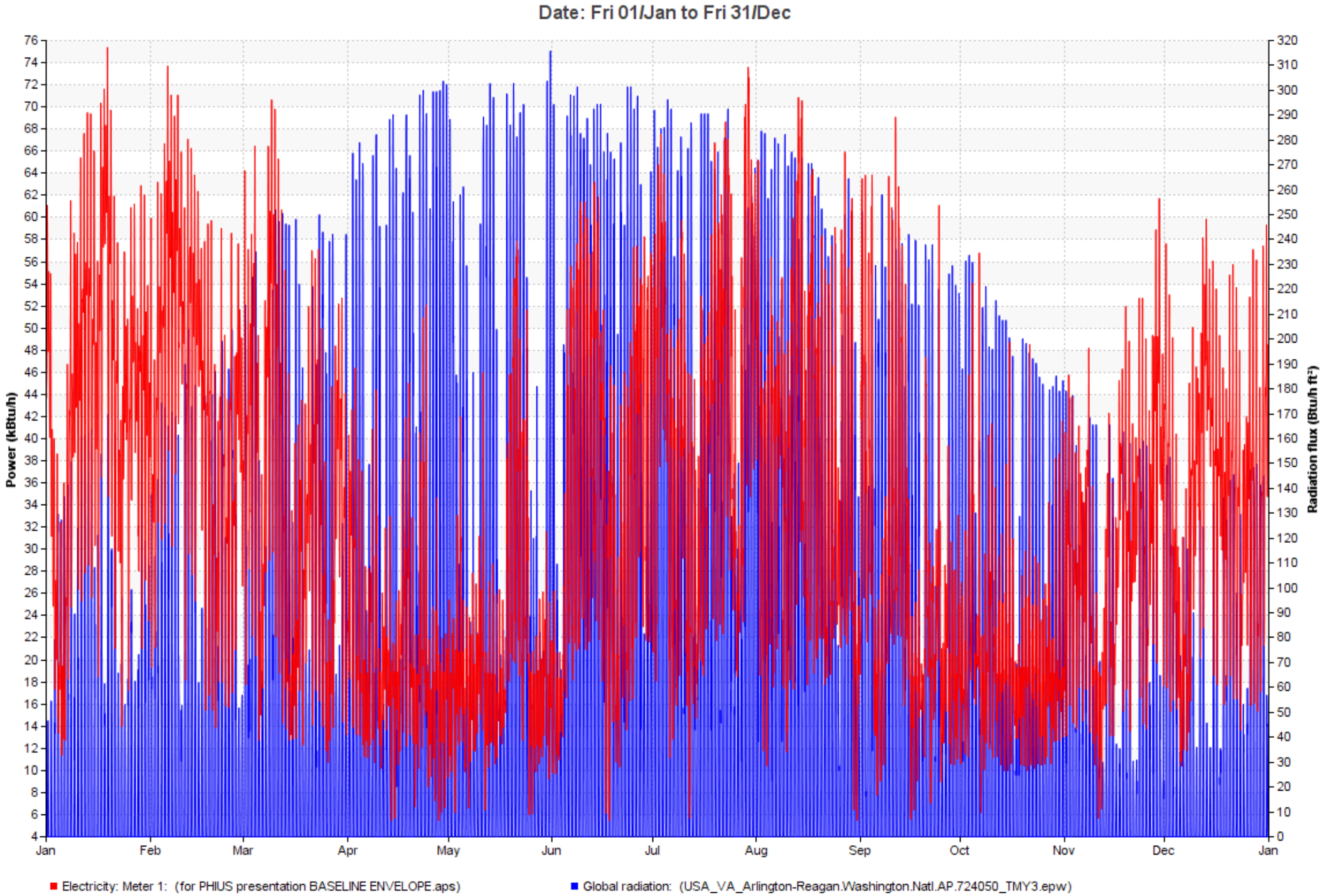


ACTUATED BREAKER

Passive House and Micro-Grids

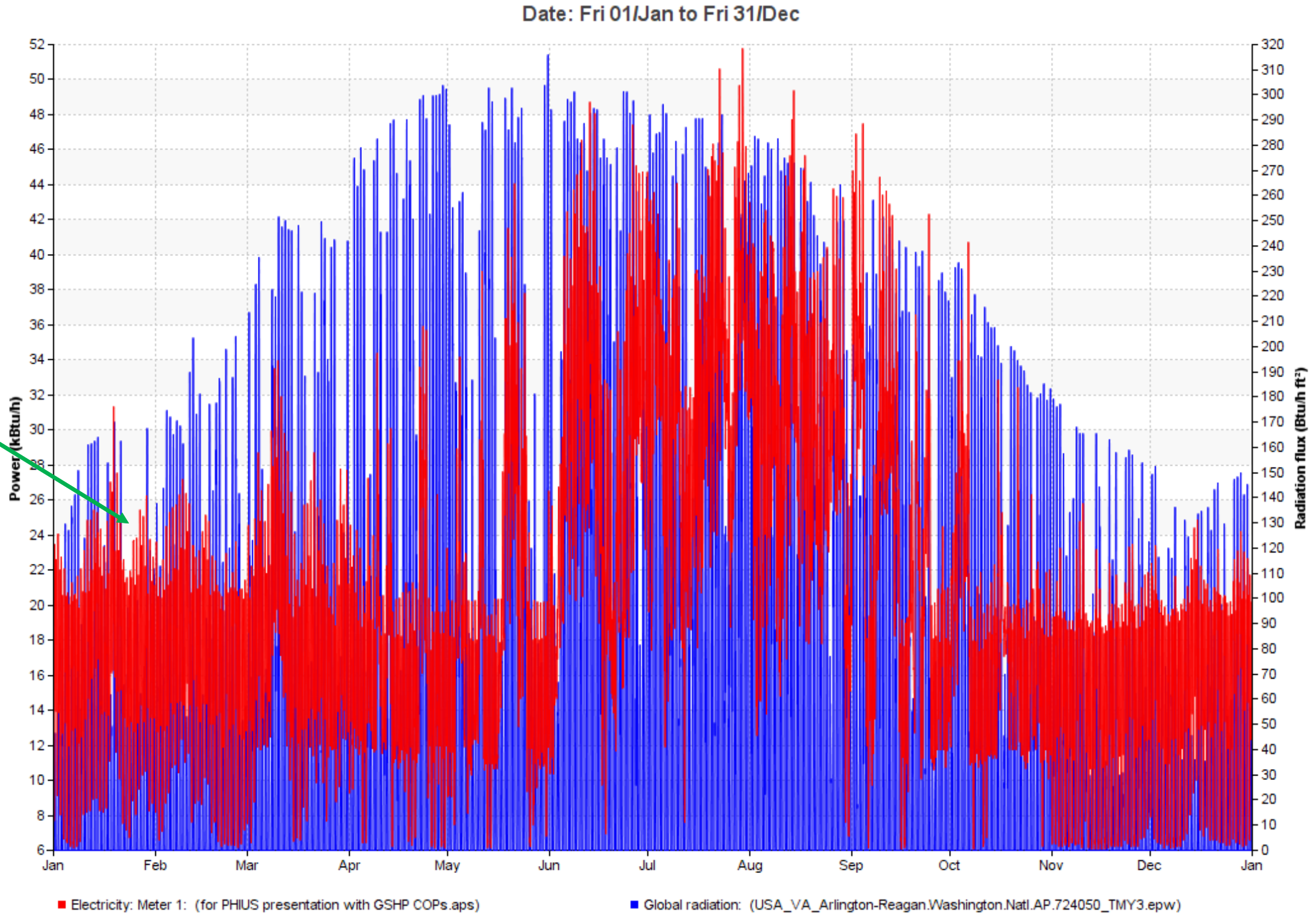
- Code Building Envelope Simulation
  - Heating load is much higher than the winter production can accommodate
  - Higher summer production approximate the high cooling demand
- Passive House Envelope Simulation
  - Winter heating load is lower and PV production can match.
  - Lower summer cooling load means it is easier to achieve net zero energy.

Energy Code Minimum Envelope (IECC 2012)



Design Case

Winter consumption is reduced, making consumption align better with production



HVAC Advantages

PH Envelope Gives Advantages

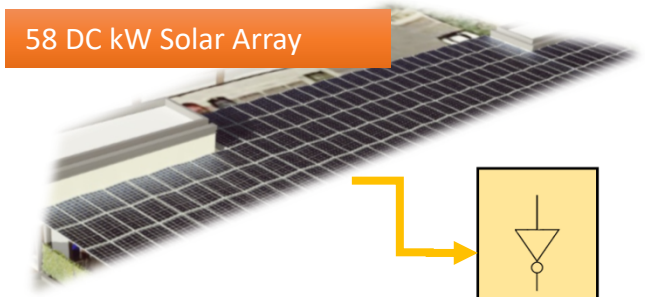
- Turn off the HVAC at night
  - Smaller battery required to run other loads
  - More economical
- Turn it on during the day
  - PV arrays are generally much larger than needed to handle the backup loads
  - Switched loads allows this control

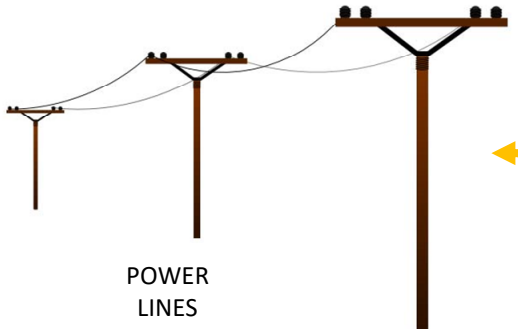
HITT CoLab

LEED Platinum Certified
Living Building Challenge
(Pending)

Owner / Developer: Hitt Contracting
Architect: William McDonough+Partners

HITT CoLab





M

ISLANDING
BREAKER

SOLAR
INVERTERS

ELECTRICAL
SWITCHGEAR

COMBINER
PANEL

BACK-UP LOADS
- CONFERENCE ROOM
  - LIGHTS
  - RECEPTACLES
  - A/V

EMERGENCY POWER LOADS HANDLED SEPERATELY WITH INTEGRAL BATTERY PACKS – INVERTERS NOT LISTED FOR EMERGENCY POWER

P1

ISLANDING
INVERTER

P2

ISLANDING
INVERTER

P3

ISLANDING
INVERTER

Battery array sized to meet LBC criteria: Microgrid to power 10% of lighting for one week.

8.8 kWh

8.8 kWh

8.8 kWh

8.8 kWh

8.8 kWh

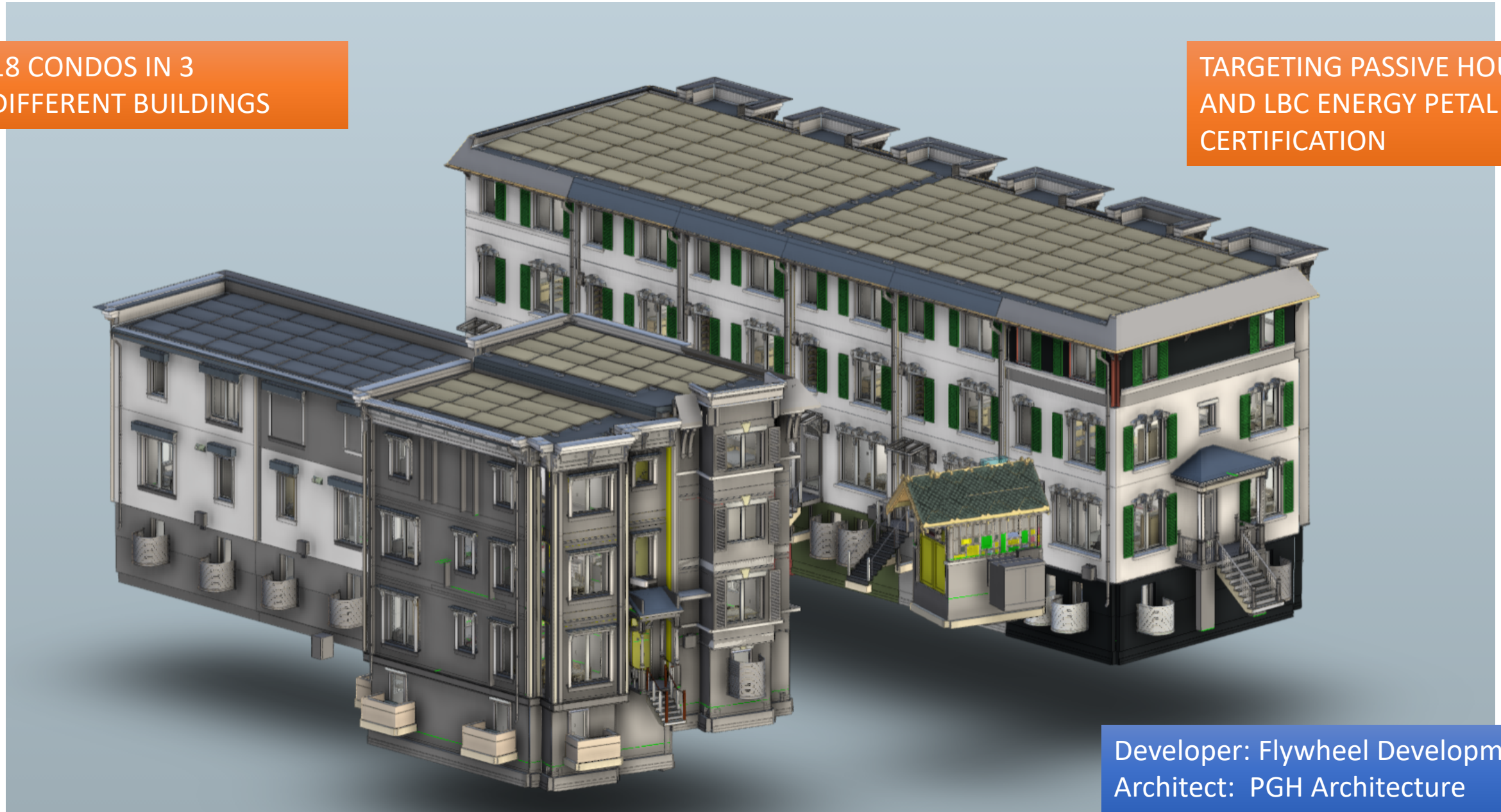
8.8 kWh

HITT CoLab

STACK 8 – A NET-ZERO ENERGY COMMUNITY

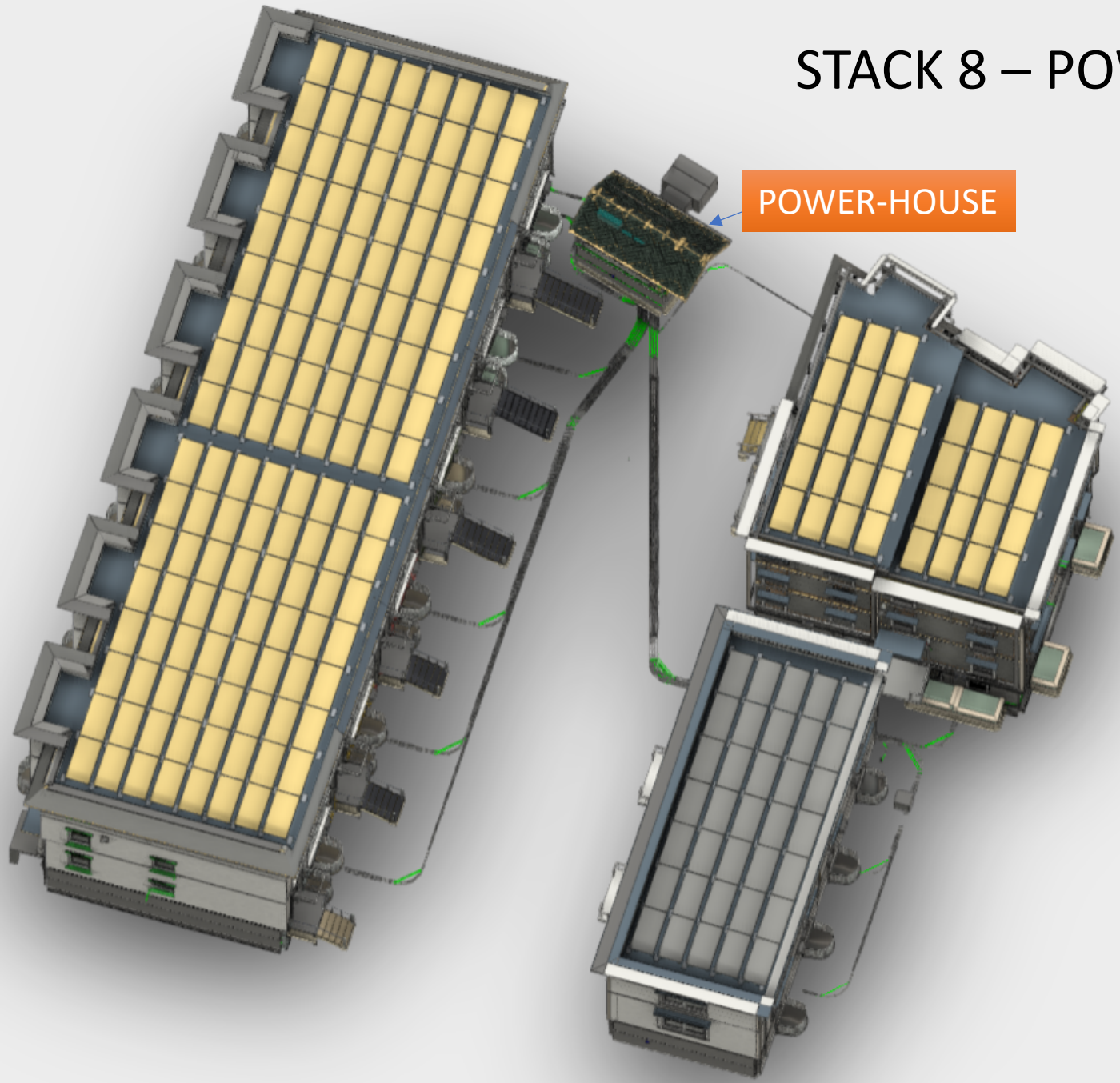
18 CONDOS IN 3 DIFFERENT BUILDINGS

TARGETING PASSIVE HOUSE AND LBC ENERGY PETAL CERTIFICATION



Developer: Flywheel Development
Architect: PGH Architecture

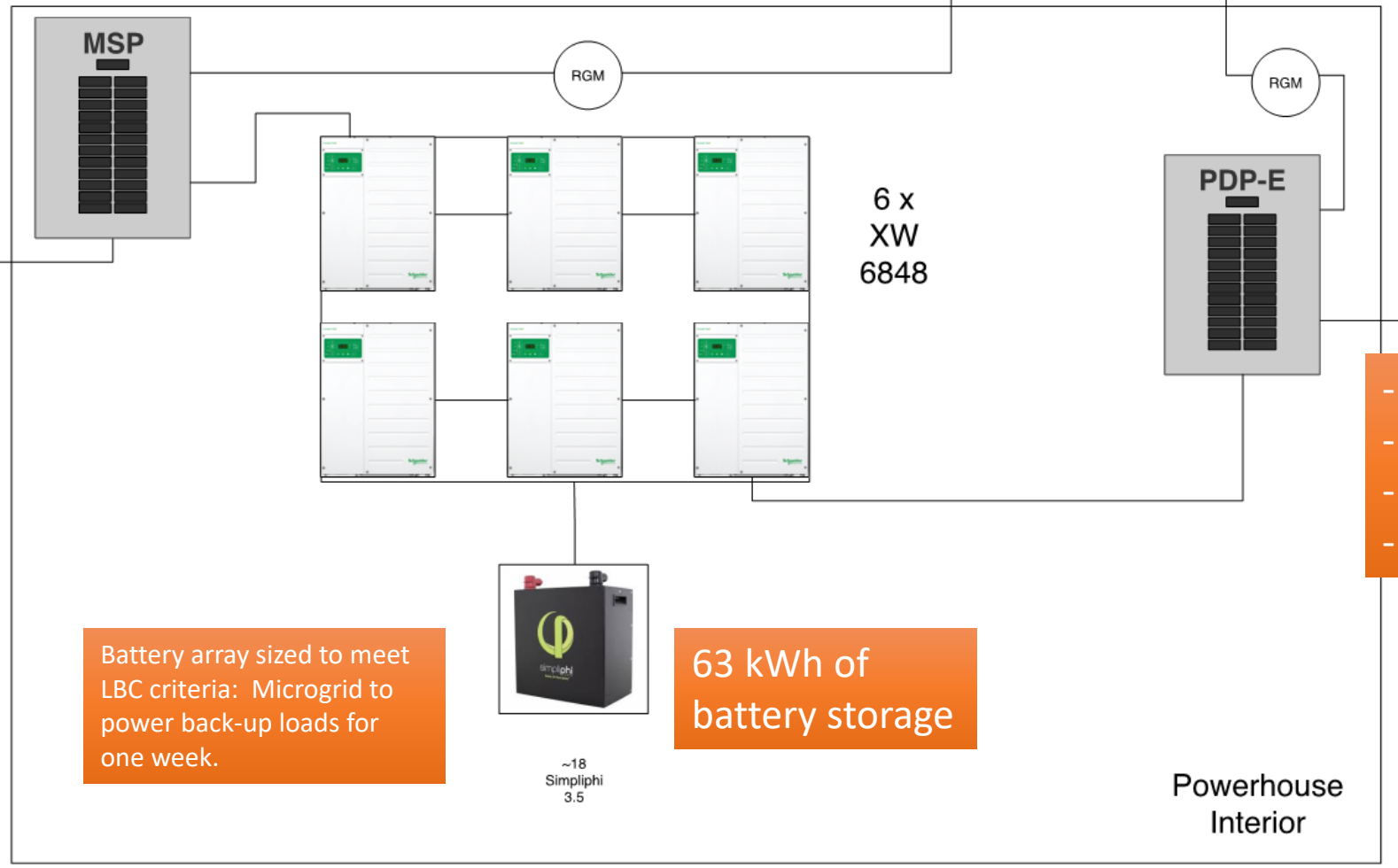
STACK 8 – POWER DISTRIBUTION



STACK 8 – A NET-ZERO ENERGY COMMUNITY

Half of the array for net-metering only

Half of the array serves micro-grid



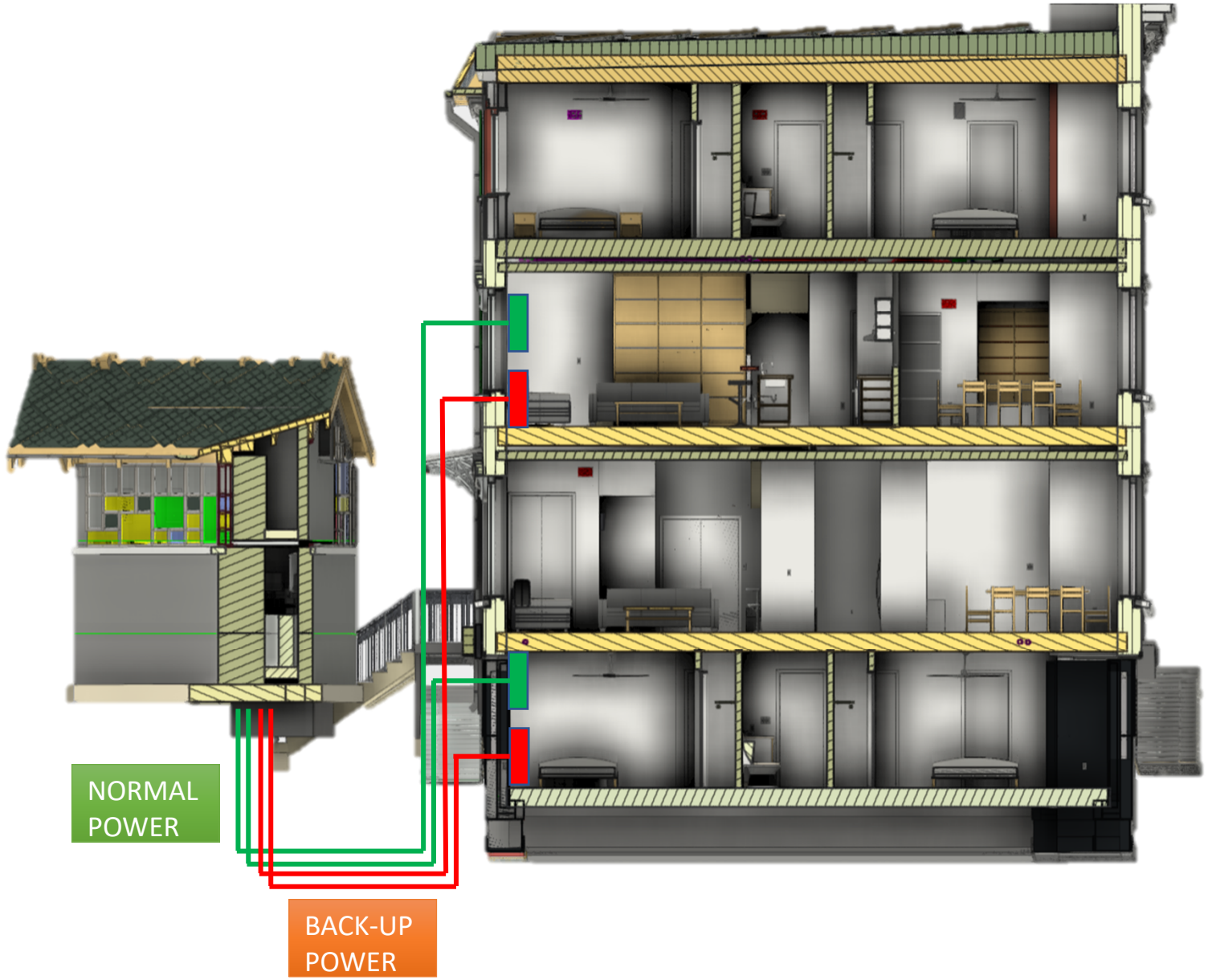
- 10% of Lighting
- Refrigeration
- ERV
- One Plug

Battery array sized to meet LBC criteria: Microgrid to power back-up loads for one week.

63 kWh of battery storage

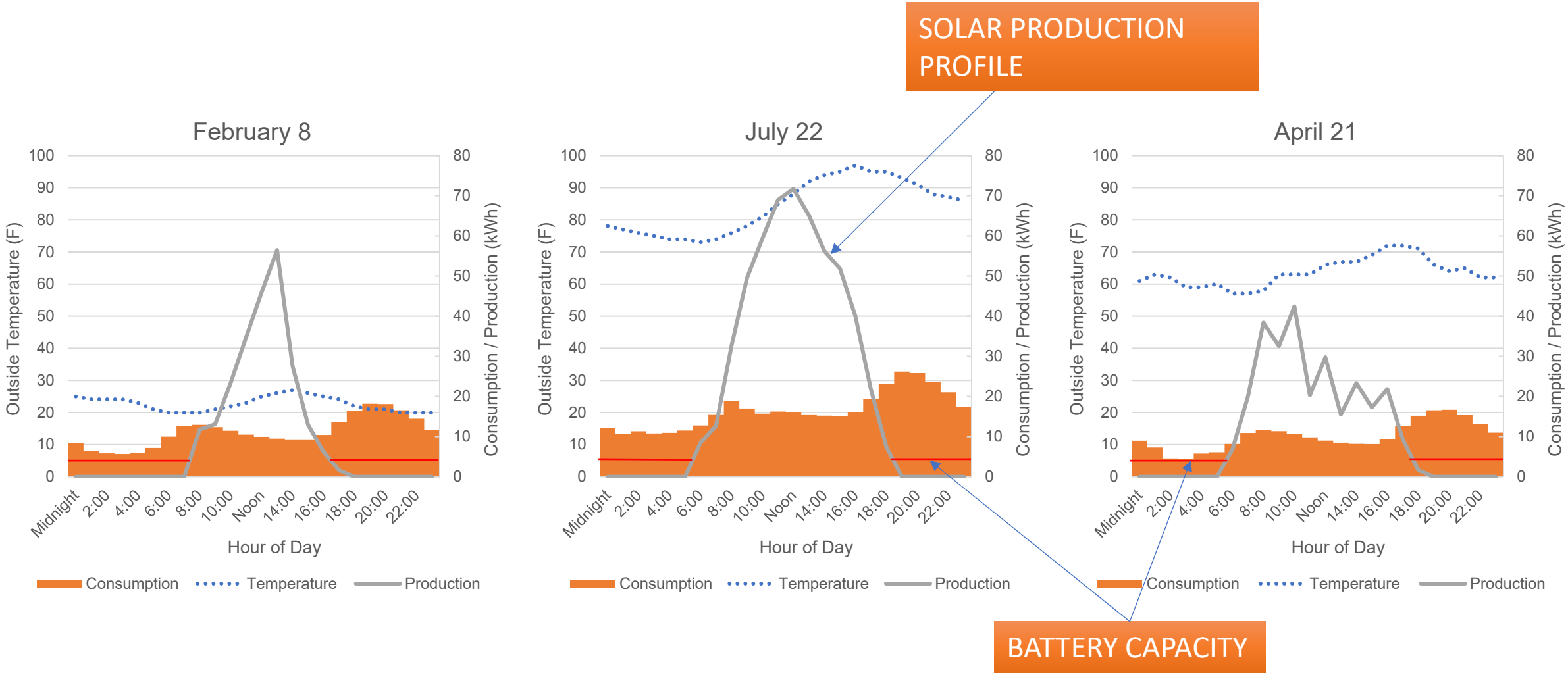
Solar System: Civic Solar

STACK 8 – POWER DISTRIBUTION



REDUNDANT POWER DISTRIBUTION FOR BACK-UP LOADS

STACK 8 – ELECTRICITY USE PROFILE

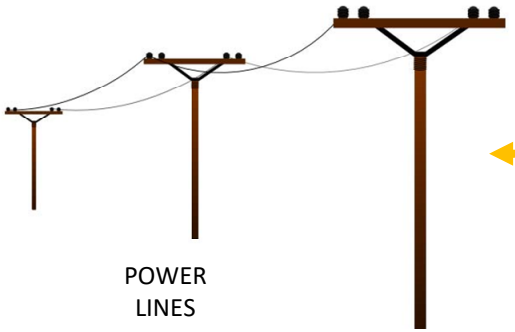


CAREFIRST OBERLIN – MIXED USE ANIMAL HOSPITAL

TARGETING PHIUS+ 2015 CERTIFICATION

Owner / Developer: Carefirst
Architect: Quantum Architects

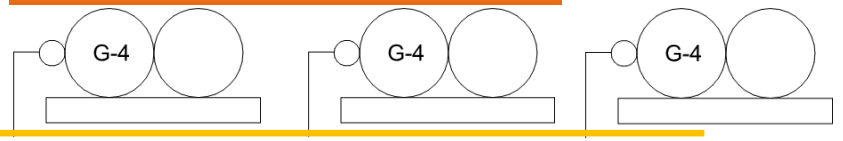
CAREFIRST OBERLIN



POWER LINES

M

THREE 125 KW NG FIRED GENERATORS



ELECTRICAL SWITCHGEAR

PARALLELING SWITH GEAR

125 DC kW Solar Array

SOLAR INVERTERS

ATS

ELECTRICAL SWITCHGEAR

SWITCH GEAR

1500 kWh Battery Array

ALL HOSPITAL LOADS CARRIED BY MICROGRID IN POWER OUTAGE

Fire pump is served by reliable power.

Emergency lighting equipped with battery packs but fed from power system.