Co-optimizing Energy and Process in the Microgrid

Microgrids are about energy supply and demand management at any scale

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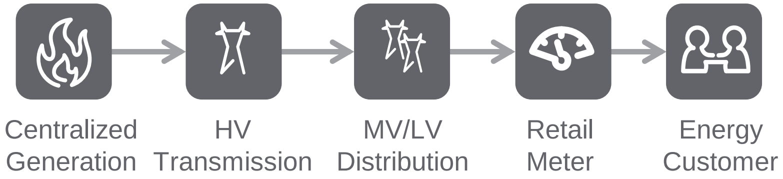
Energy Megatrends – 3D+E is setting the stage

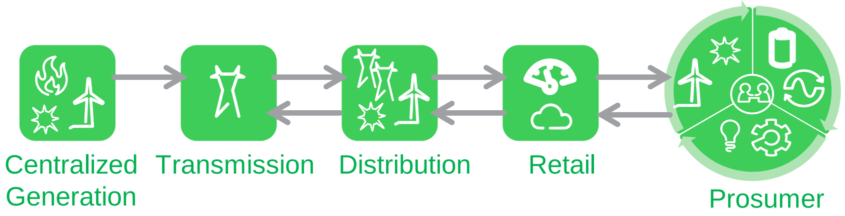
Decarbonization | **Digitization** | **Decentralization** | **+ More Energy**

Historical Energy Value Chain



- Consumers responsible for their own MV/LV Traditional Power Distribution Assets and Operations “behind the meter”, Many implement EE Measures
- Consumers have some partial base-load and traditional backup power generation of many varied capabilities, but few significant islanding systems.
- Beyond EE, Increasing Local, Efficient Self-Generation + Microgrid Islanding is the road ahead.

The New Energy Landscape



- Utilities house significant Grid-Connected 3rd party owned Solar PV plants with complementing BESSs. In some cases the developer is the utility, but in others it is a 3rd party or a new “Prosumer”.
- Larger Prosumers and Municipalities use PPA and ESCO/IPP PPA/Lease models to leverage existing and build new DERs
- Reduction in costs for DER technologies, increase in reliable delivery + new business models for Energy Services result in the new Energy Landscape

What new energy "Prosumers" are looking for

Efficiency

kWh

- Reduce energy consumption
- Improve and monetize flexibility
- Energy / Fuel source arbitrage

Supply Flexibility

$

- Innovative Product and Hedge Structures
- Global Program
- Real-time-price forecasting
- Portfolio Risk Management

Sustainability

- Reduce Greenhouse Gasses
- Minimize carbon footprint
- Improve LEED
- Corporate Perception/Image

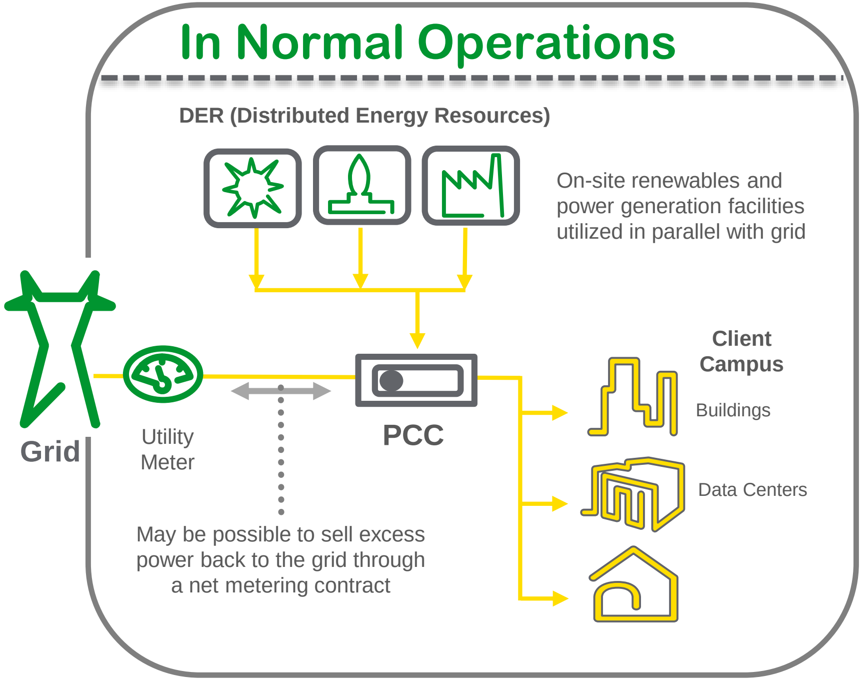
Resiliency

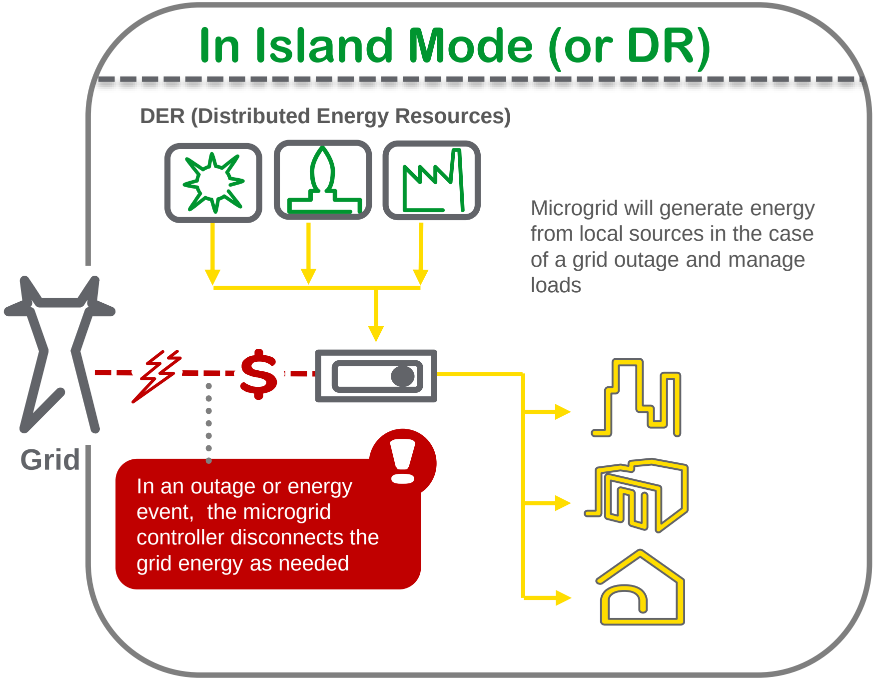
- Service site loads during times of grid instability
- Protect assets against harmful effects of poor power quality
- May have 0 Risk Tolerance

+ solution able to **scale** to the entire enterprise *and* be **delivered simply.**

What is a Microgrid?

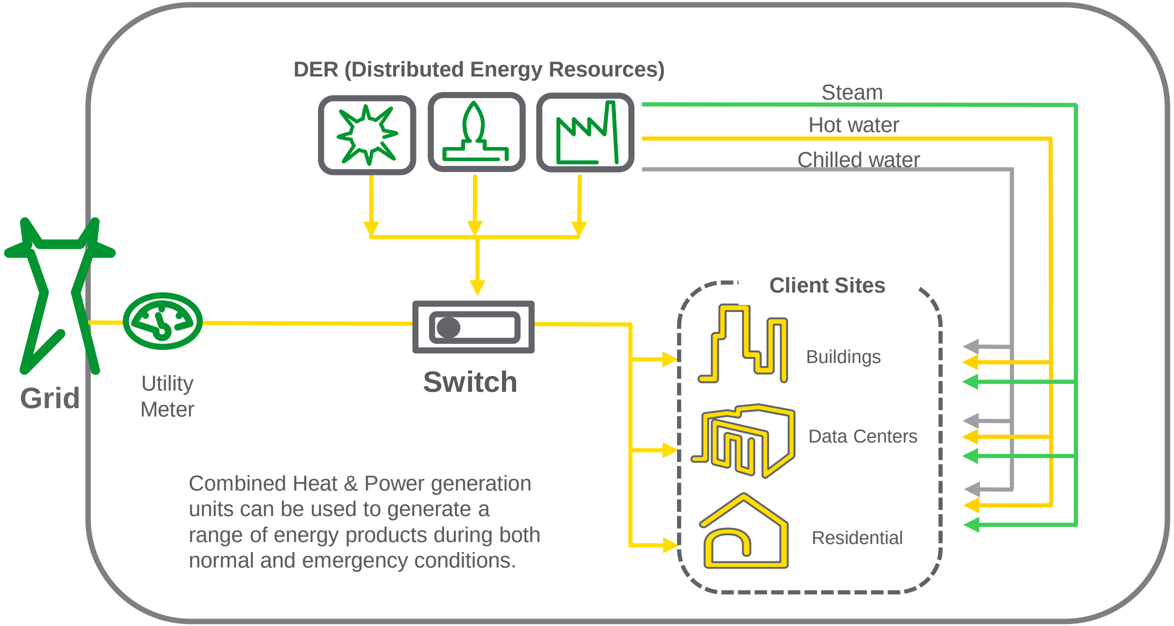
"An integrated energy system consisting of interconnected loads and distributed energy resources which, as a single entity, can be controlled and operated in parallel with the grid or in an intentional *islanded* mode."





Combined Heat and Power Microgrid & District Energy

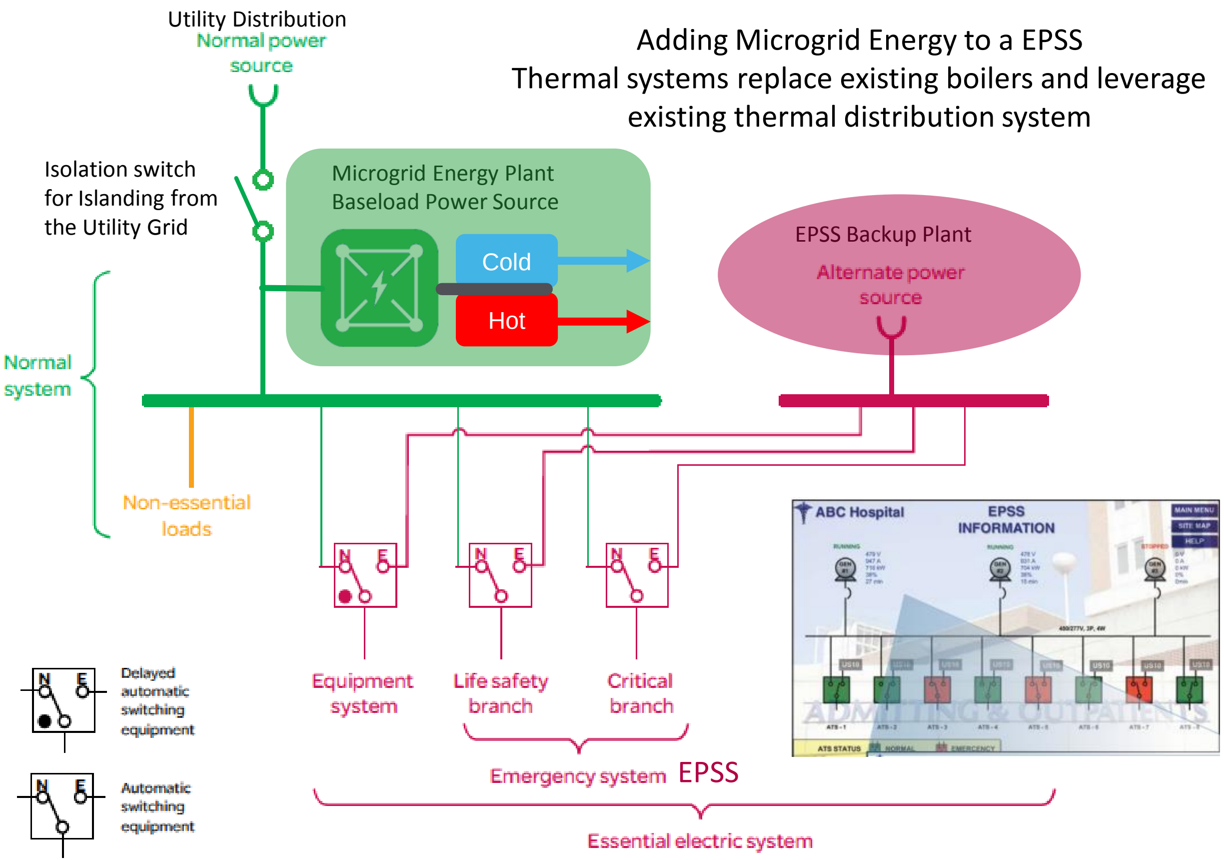
CHP provides superior reliability, meeting a site's thermal needs in addition to its electrical needs, round-the-clock, even in the event of a grid outage.



- Steam, hot water and chilled water is produced at District Energy Centers
- Environmentally Sound
- Individual buildings do not need their own chillers/ boilers
- Easy to operate and maintain
- Comfortable and Convenient
- Provides Architectural Flexibility

Microgrid: Complements what your facility has today

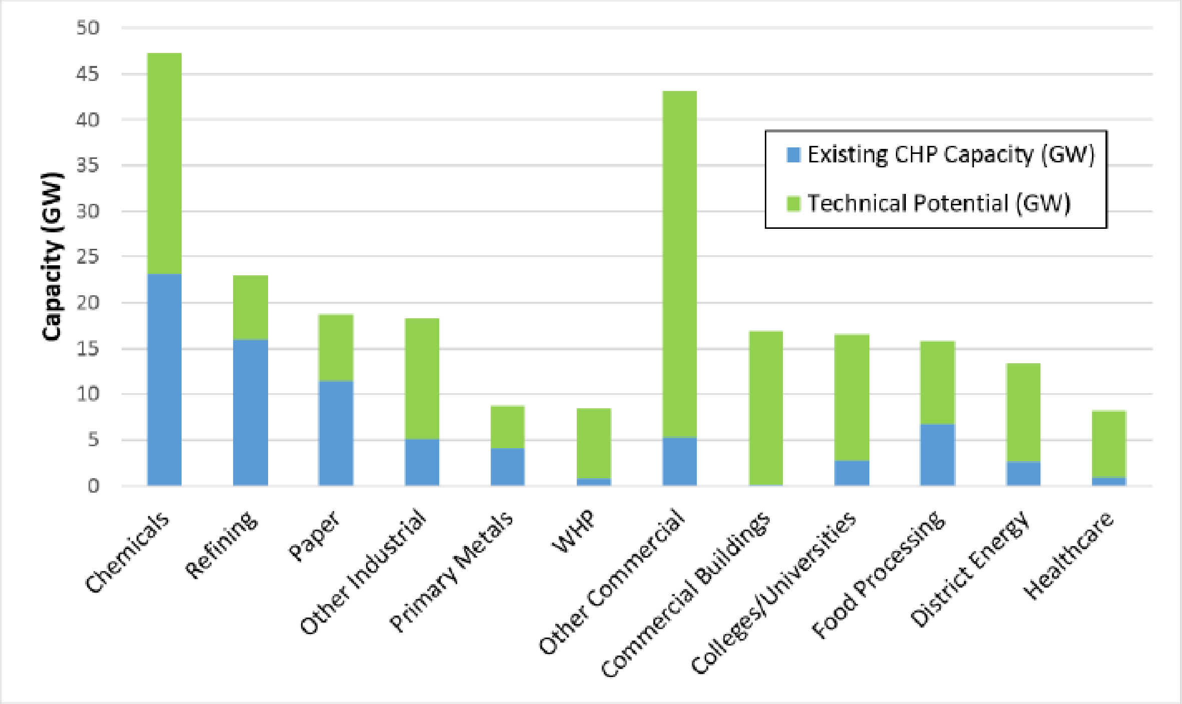
- A Microgrid Energy Plant may be composed of CHP, Storage, Solar or other Distributed Energy Resource
- Complements and extends the capabilities of existing Emergency Power Supply Systems (EPSS)
- A baseload Microgrid provides most if not all baseload generation and all thermal energy required. Remainder of electric power supplied by solar, storage, or combination with utility.
- In Emergency, Microgrid islands from Utility and powers more loads than EPSS alone, if not all loads.



Combined Heat & Power (CHP) Potential in the U.S.

Today the vast majority of installed CHP is not islandable

Figure 1: Existing CHP Compared to On-Site Technical Potential by Sector[2]



U.S. DOE CHP Deployment Program, 2016.

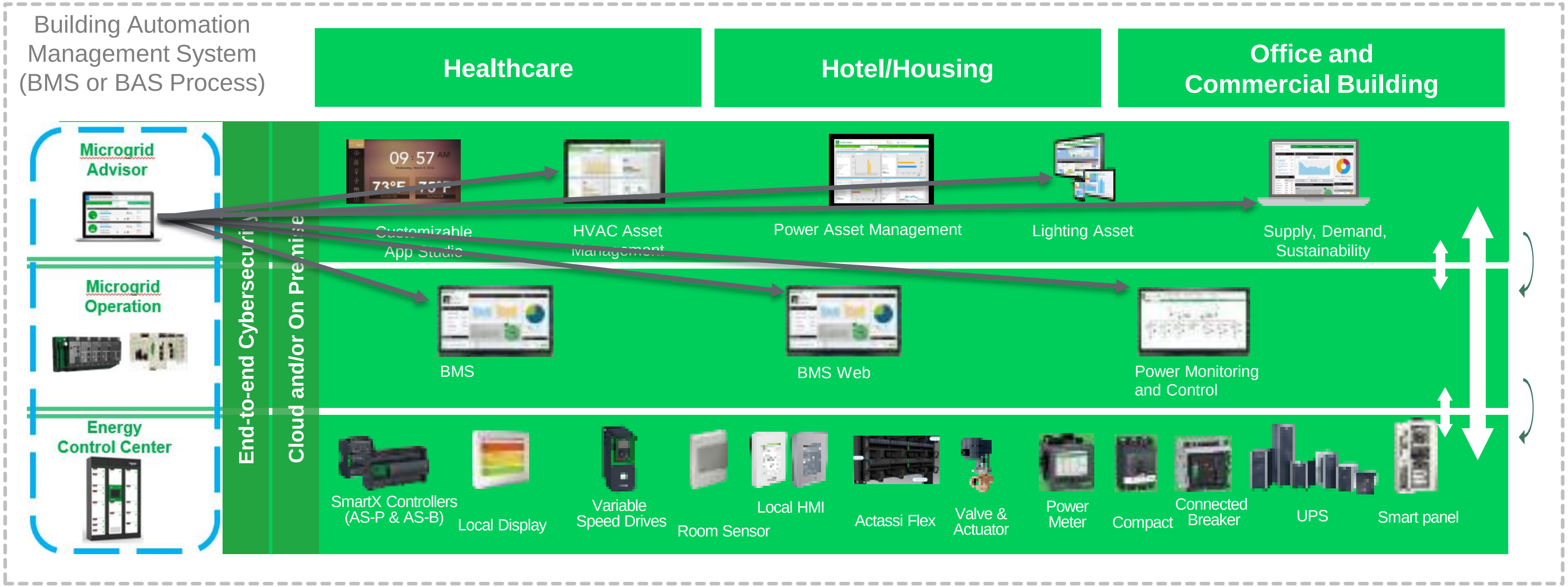
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Hospitals Discover Advantages to Using CHP Systems

Combined heat and power systems—also known as cogeneration systems—use a heat engine or power station to simultaneously generate both electricity and heat. They convert waste heat from electrical generation into energy that can be used for heating and cooling. More than 200 hospitals nationwide operate CHP systems.[1]

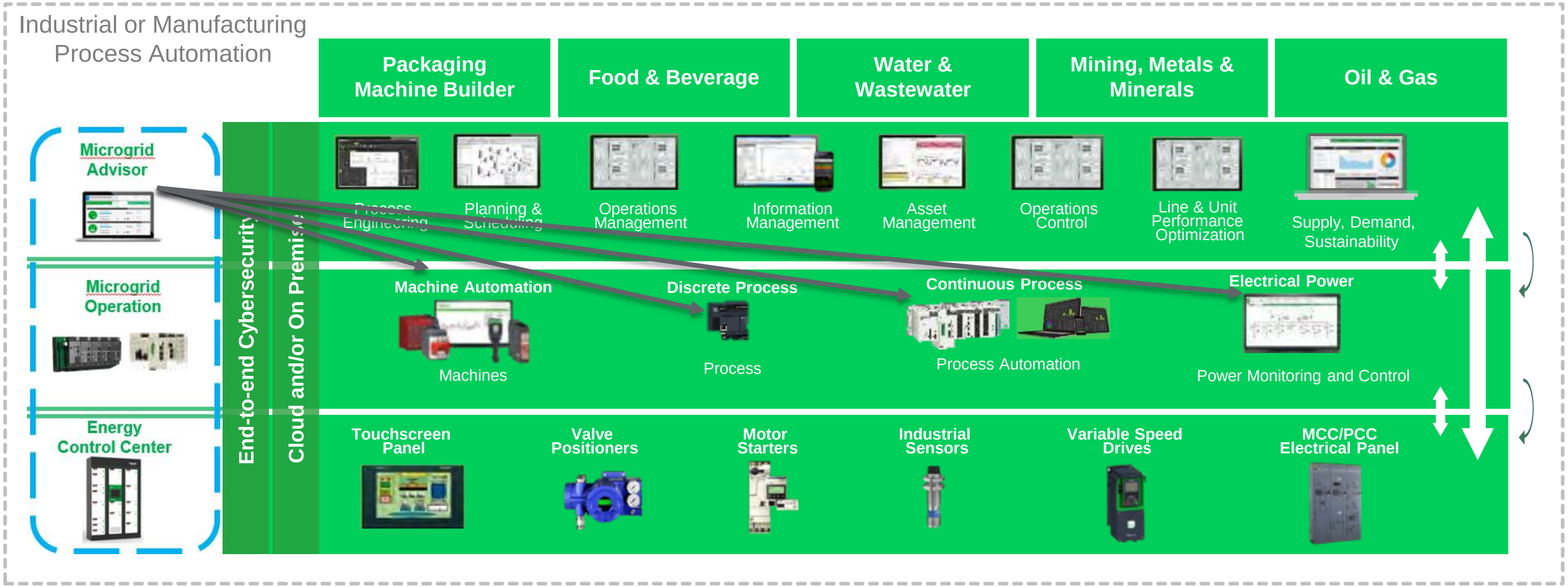
Building Automation Systems

Represent Smart Load Management Options to reduce loads, a good alternative to load dispatch



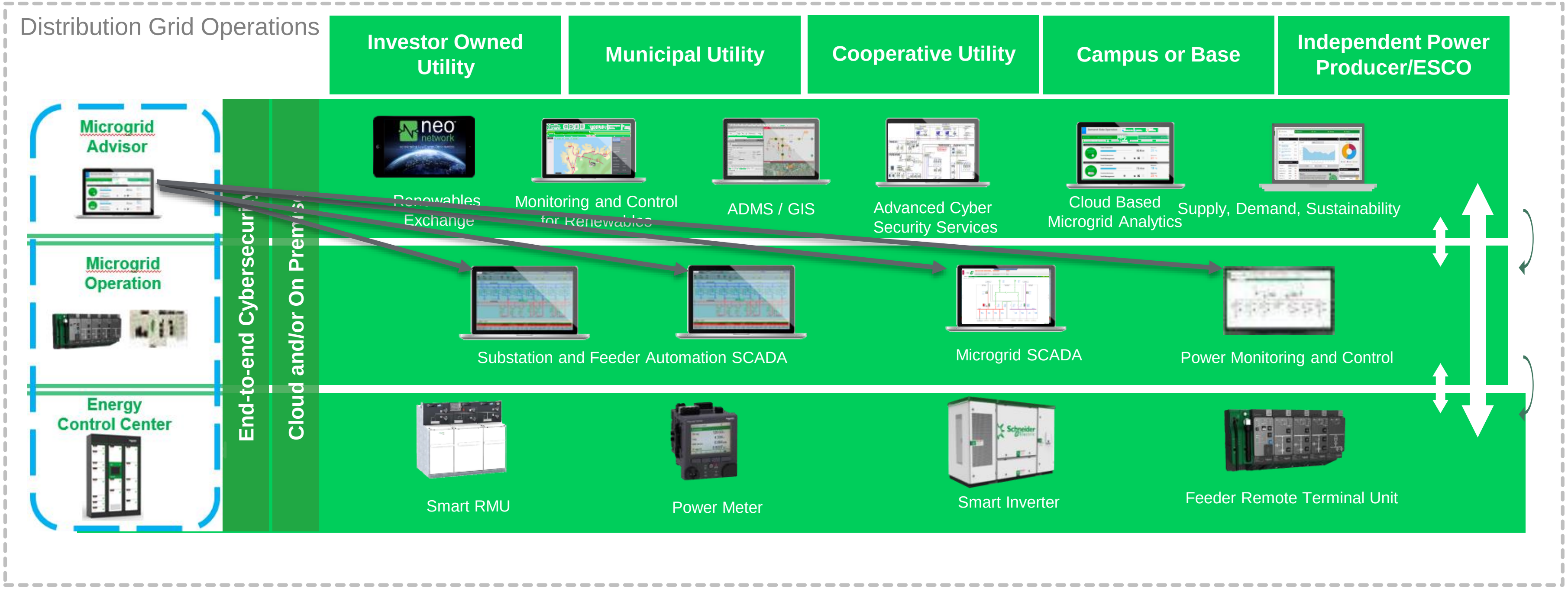
Industrial and Energy Plant Automation Systems

A dynamic process of load prioritization, system operation and economic efficiency

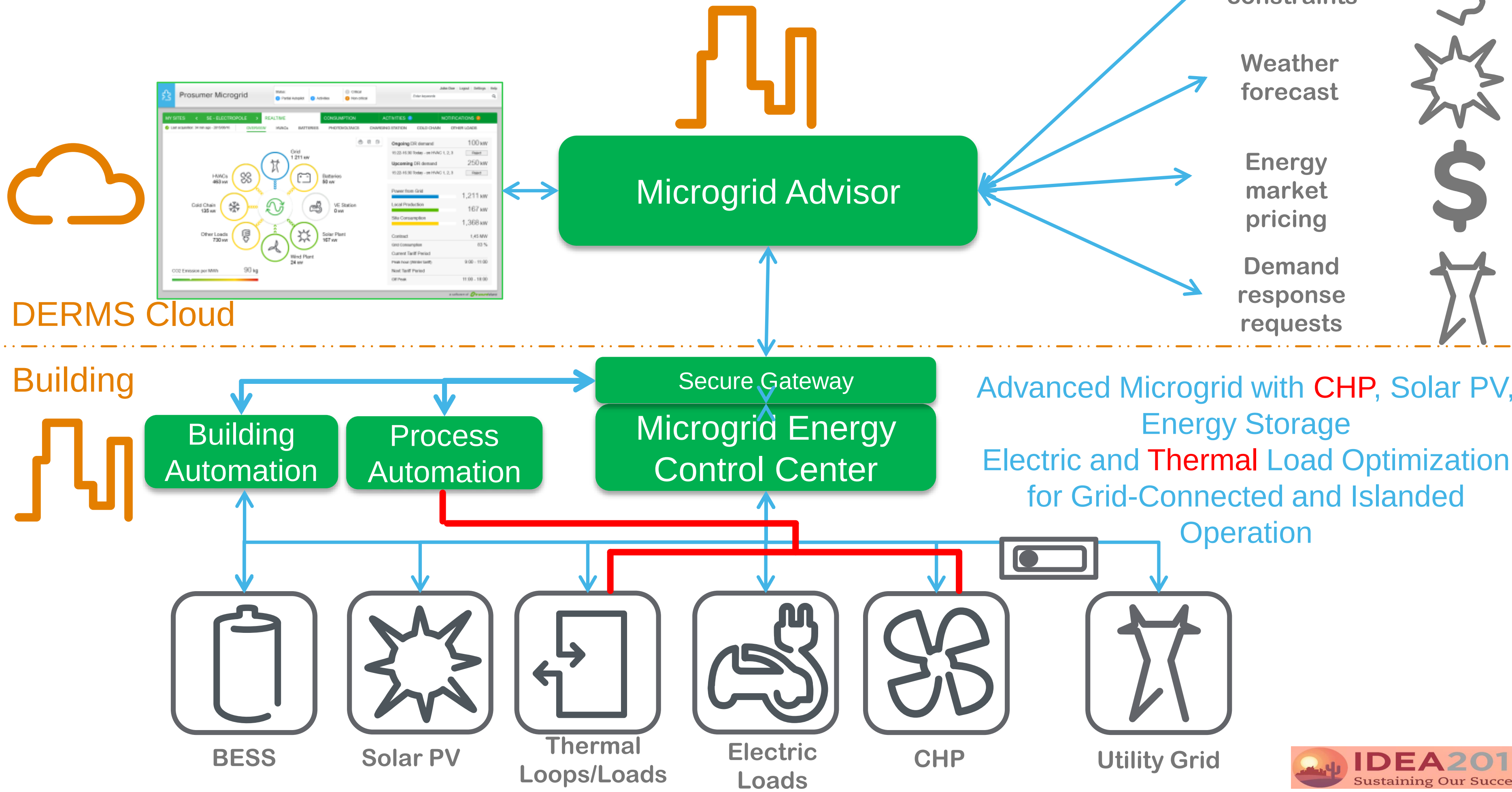


Grid Automation Systems

Utility Scale, Medium Voltage Distribution systems may form Microgrid islands across a campus, city or other district. Substation Area, Feeder or Multi-Feeder level

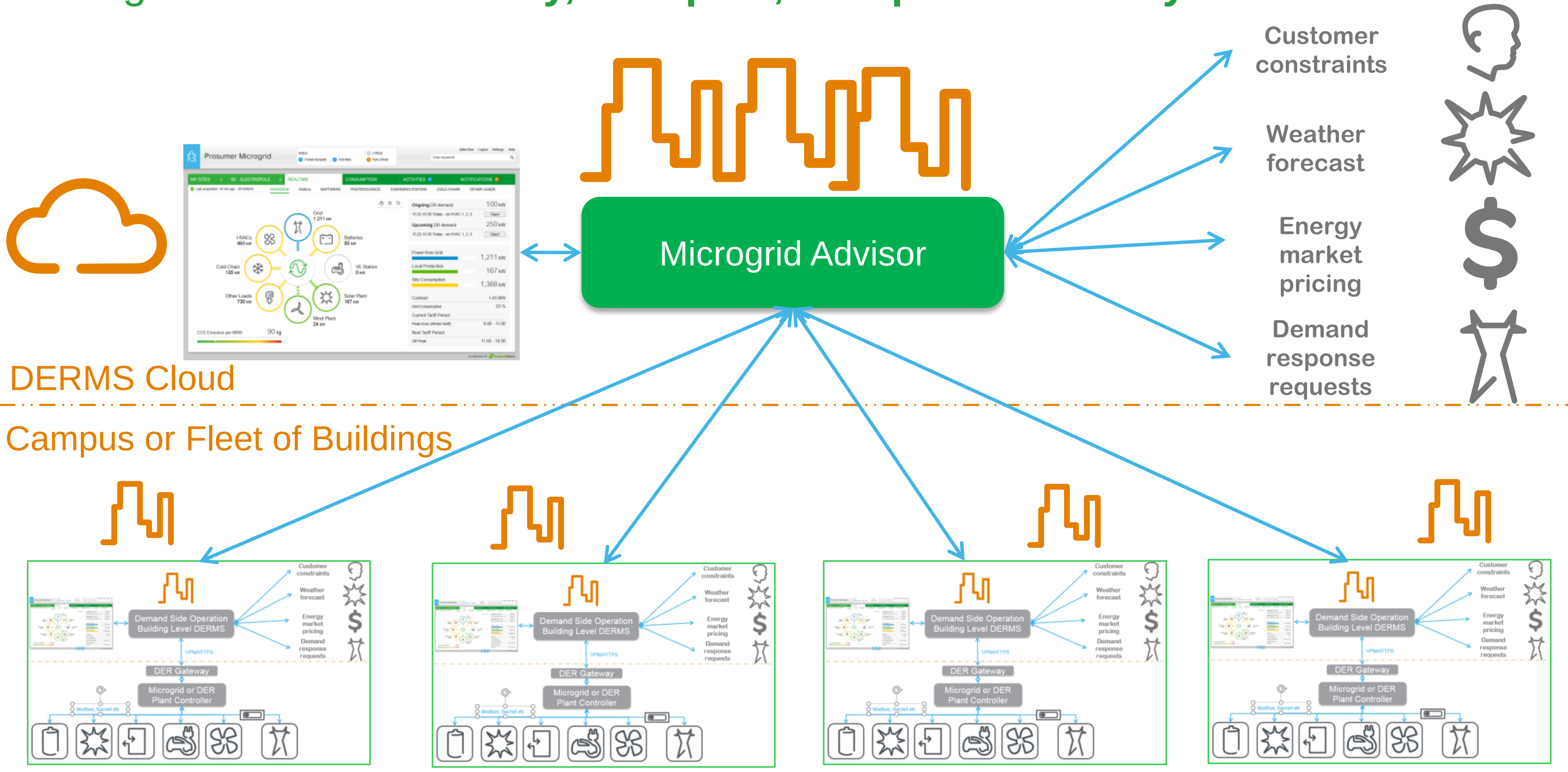


Microgrid Architecture – **Building or Facility**



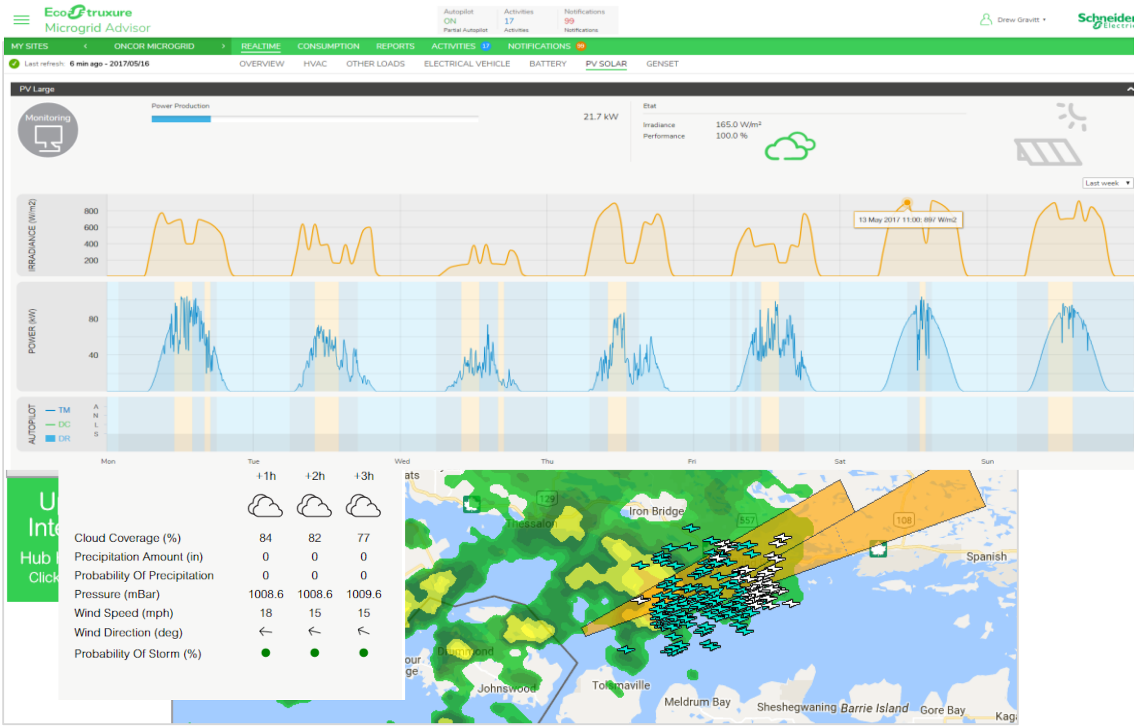
Advanced Microgrid with CHP, Solar PV, Energy Storage
Electric and Thermal Load Optimization for Grid-Connected and Islanded Operation

Microgrid Architecture – **City, Complex, Campus or Facility Fleet**



Weather and Load Forecasting drives system behavior

Impacts Heating/Cooling and other industrial or manufacturing process operations. Pre-warns of possible electrical supply disruption

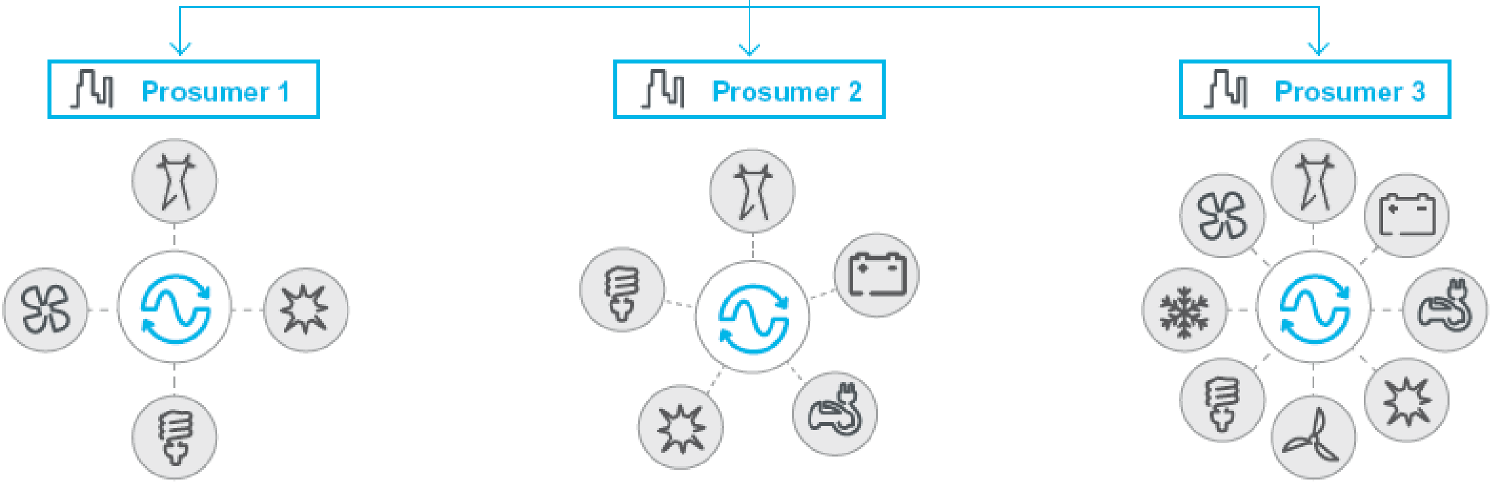


Microgrid Energy Management System integrates weather forecast information

- Pre-heat or cool HVAC Control
- Supply PV irradiance forecast
- Forecast Electrical and Thermal Loads
- Adjust Circuit Load Shed/Add schedule based on emergency operation or islanded mode

Prosumers have varying degrees of supply and demand flexibility

The more flexibility the better the optimization



Lights and Motors
Grid and Solar

Lights and EV Charging
Grid, Solar and Storage

Lights and EV Charging, HVAC and Cold Chain
Grid, CHP, Solar and Storage

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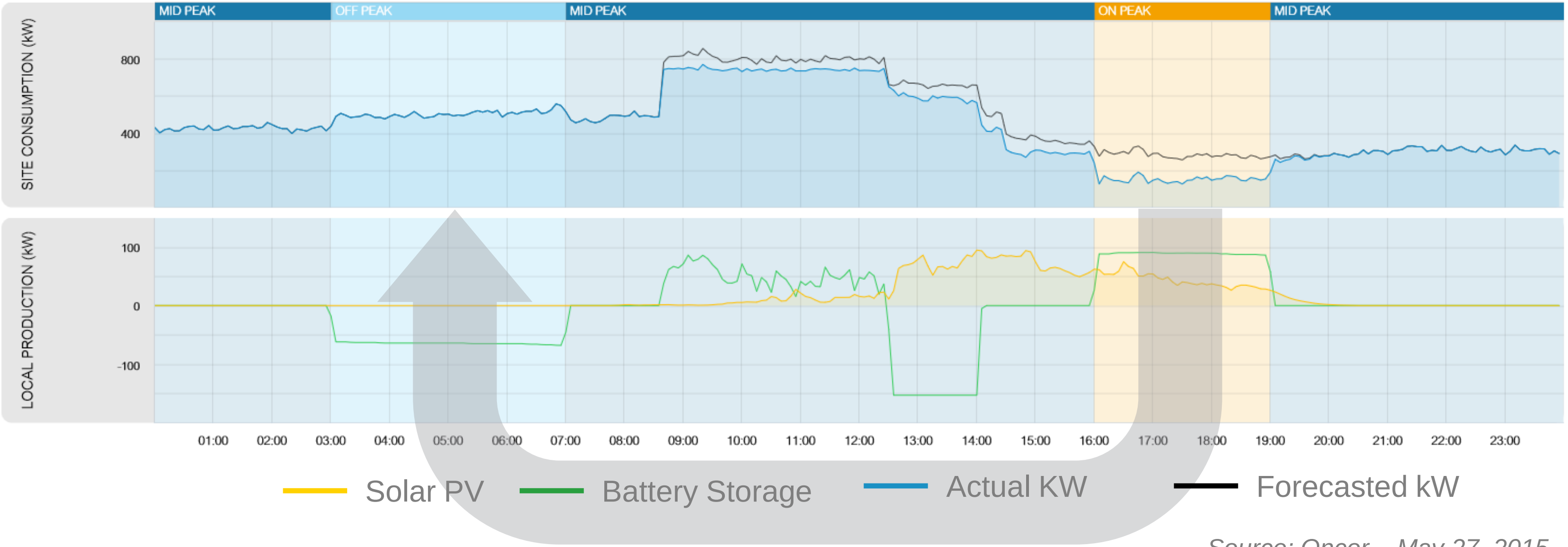
Peak Electric or Gas Pricing – Tariff Optimization

Shift consumption from times of high cost to times of low cost

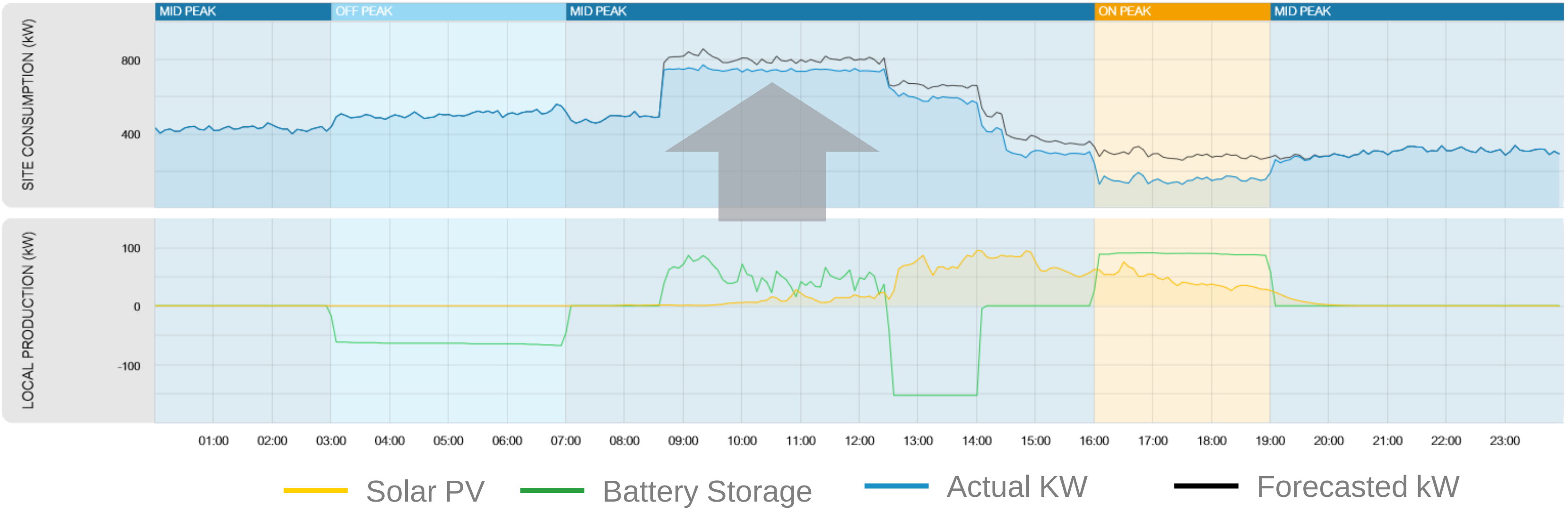


Source: Oncor – May 27, 2015

- *Mixed Use Case at the Prosumer Microgrid*
  - *Prosumer optimization of battery charge, discharge and peak shaving*
  - *However a utility demand response event may “interrupt” prosumer operation and execute based on what utility wants.*
  - *Algorithm Abandons Peak Shaving, and must recharge to prepare for DR event. We have left the Prosumer benefit and shifted to the Utility benefit.*

Demand Limit Management – Peak Shaving

Minimize / avoid fees by shaving peak demand



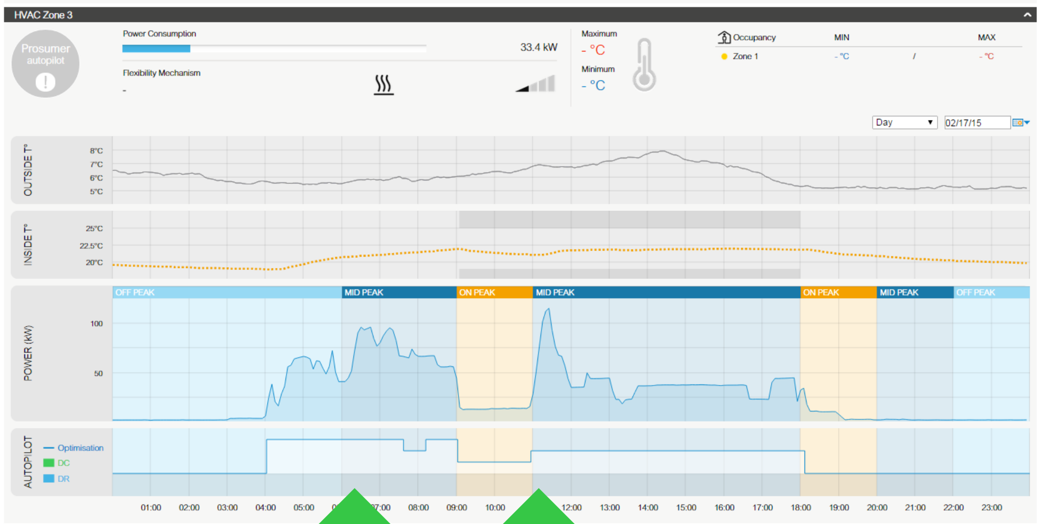
- *Example 1:* dispatch energy storage to supply some load to avoid a peak
- *Example 2:* shed loads (HVAC, EV Chargers, etc.) to avoid setting a peak
- *Example 3:* Sequence the start of large loads to avoid coincident peak demand

Source: Oncor – May 27, 2015

HVAC
Pre-Heat/Cool Building Zone

Microgrid Advisor
Energy savings and energy bill optimization

- *HVAC:* Starting and stopping an HVAC system at the right time during the day for ensuring the set point of the building zones and optimizing electricity or fuel tariffs
- Inside and Outside T forecasted
- *Process:* Process Automation integration. Industrial Heating and Cooling processes, variable speed motors and thermal loop temperature requirements may be optimized for tariff and demand charges



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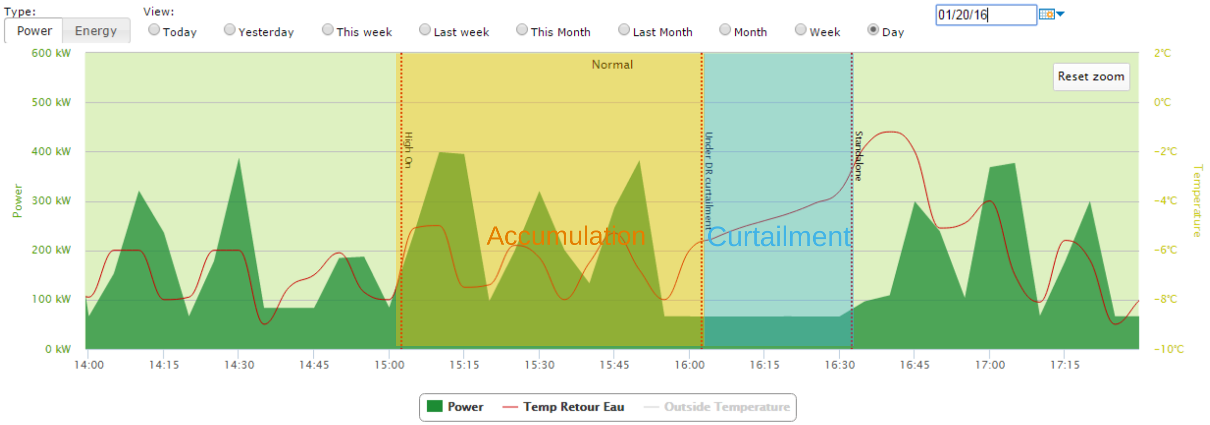
Cold Chain System Energy Optimization

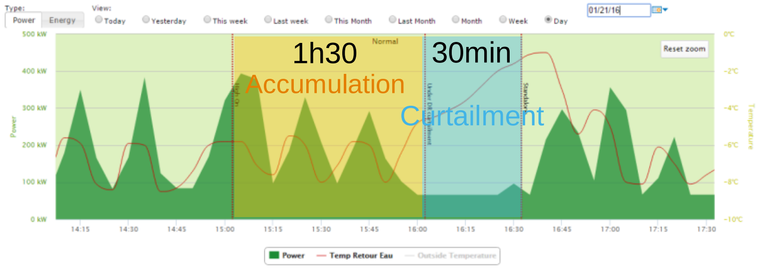
- Scenarios Analyzed in January 2016 with the following use cases
  - Remote monitoring/Historical Analysis of Cold Chain load and Energy performance
  - Adjustment of the parameters of energy and cold chain performance
  - Optimizing electrical energy consumption based on thermal inertia potential
  - Adding an additional period of lower energy consumption
  - -2c to -8c range

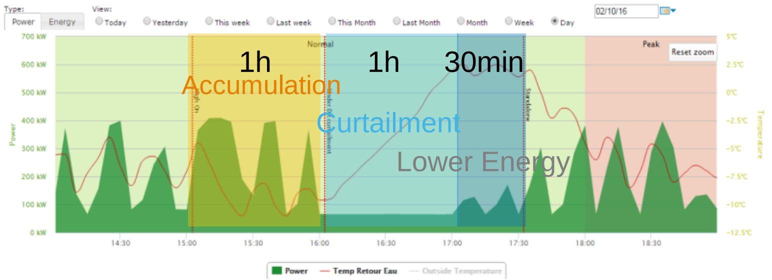


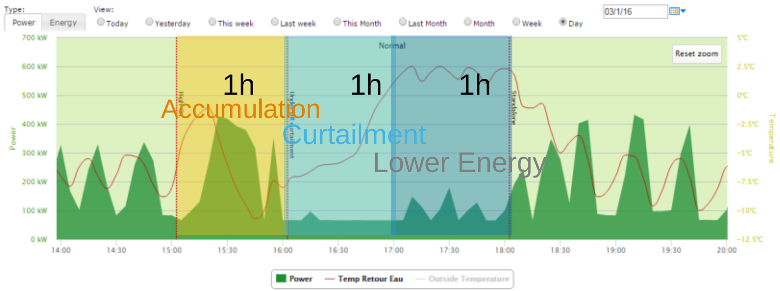
January 20th – Typical day
60 minutes accumulation + 30 minutes curtailment

Scenario Analysis

Regulation by the BMS at 2C







- Cold Chain
  - Without accumulation: about 100kW of flexibility during a curtailment
  - With accumulation: about 200kW of flexibility during a curtailment
  - 1h of accumulation allows to curtail the load for 1 h
  - After 1h of curtailment, the BMS is regulating the temperature at 2C. This results in a smaller energy consumption than the usual regulation at -8C)

With curtailment	No curtailment
- Water temperature regulated at -8°C - Accumulation at -10C during 30 minutes - Curtailment during 1h30 with a temperature regulation set point at +2Ck - Temperature goes back to -8C after 1h30	Water temperature is regulated at -8C during 3h30

Islanding and Islanded Operations: Load Preserve/Shed

Intelligent Fast Load Shed (iFLS) or Fast Transfer Trip are required

Islanding Operation may be required at any time, any day or night, at any point in your building, manufacturing or industrial process operations

iFLS must rapidly eliminate the right circuits/loads to keep CHP engines and other local energy resources from tripping offline. This varies by process and by time.

Microgrid and HVAC BMS integrated controls lower lighting or alter temperature set points

Microgrid and Process Automation System integrated to define circuits and dynamic iFLS schedule for islanding

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iFLS : efficient Load Preservation

Contingency-Based Fast Load Shedding is a key component of a Microgrid

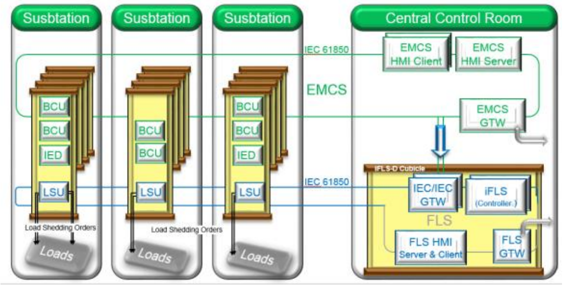
Load Preservation primary goal is to shed as less load as possible to maintain the stability of the system

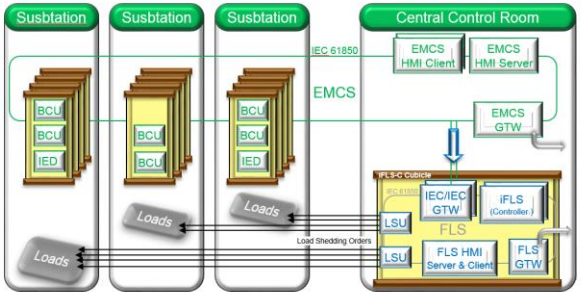
iFLS Controller

- iFLS Controller performs all the calculation functions required to achieve the Fast-Load-Shedding function.
- Monitors in real-time the electrical system topology changes and calculates the tripping sequence for every preselected “what-if scenarios” thanks to a load-flow algorithm
- iFLS Controller computes the forecasted tripping sequence based on priority dynamically set by the Load Shedding Operator and plant real time situation.
- Sequences are communicated to the microgrid controller

- Sudden triggering signals and alarms are continuously monitored to identify the tripping condition. Upon occurrence of one triggering signal, iFLS Controller automatically and immediately applies the optimal tripping sequence determined for the customer’s business process.

iFLS – Intelligent Fast Load Shed Architecture





Proactive evaluation of the system

- Contingency Base reaction
- Complete System Model of the system
- Embedded Topology Engine
- Analyze existing operation condition
- Predict system response
- Determines how much loads to shed and where to shed

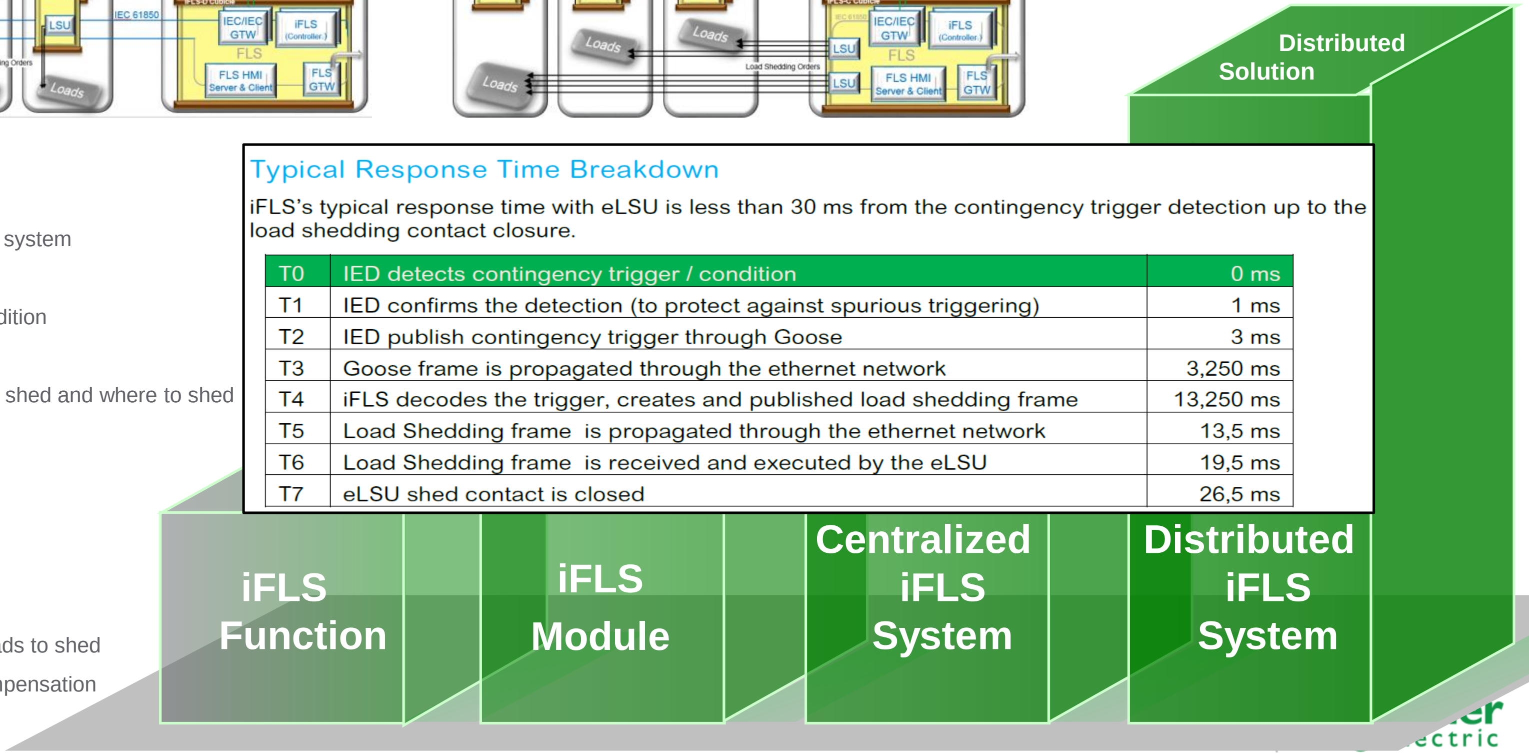
Optimal loads to shed selection

- High Selectivity
- Load Priorities
- Groups & Dynamic Groups
- Hardware Reaction Capability
- Selects best combination of loads to shed
- Breaker Failure Automatic Compensation
- High Response Performance

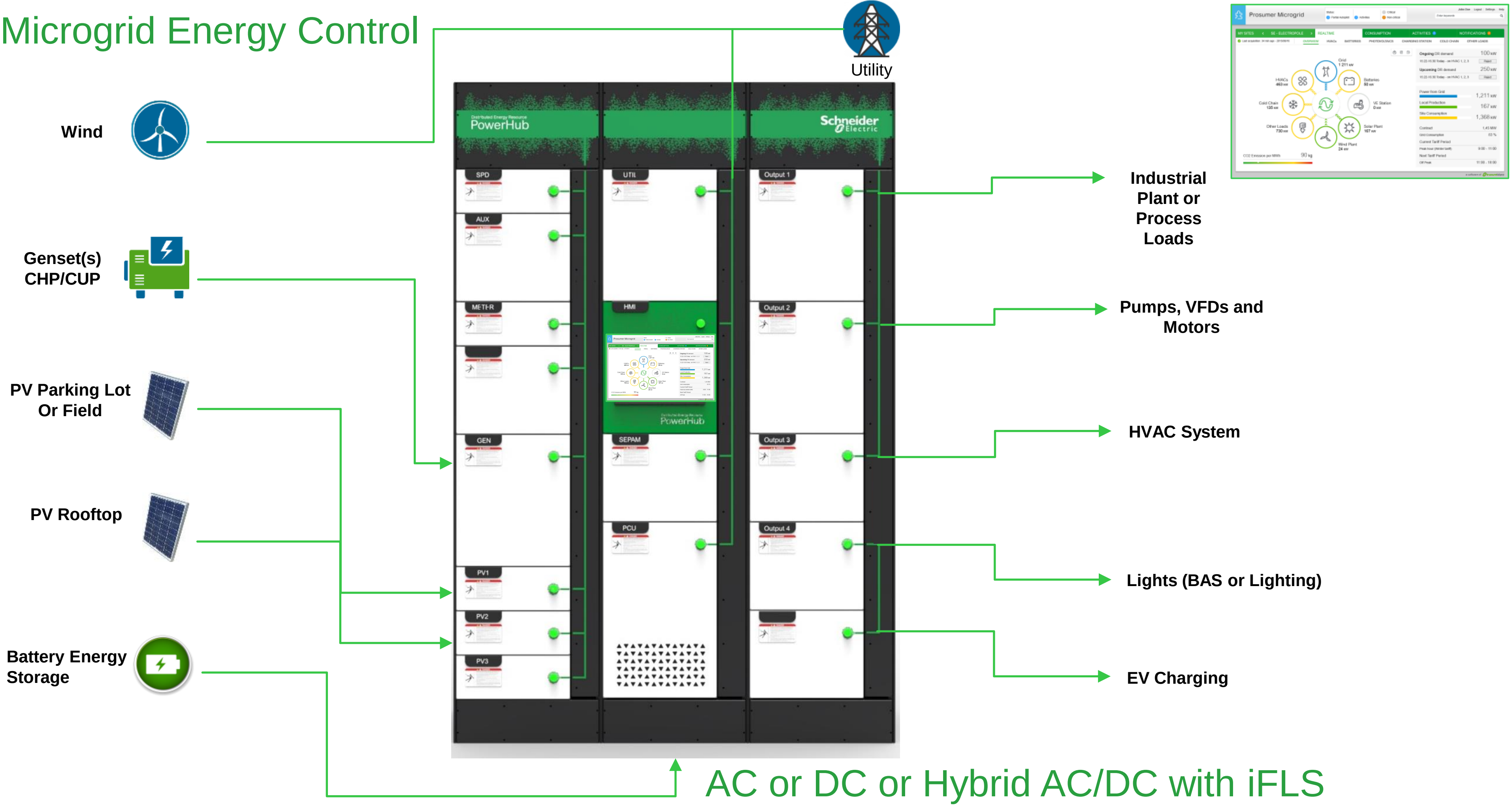
Typical Response Time Breakdown

iFLS's typical response time with eLSU is less than 30 ms from the contingency trigger detection up to the load shedding contact closure.

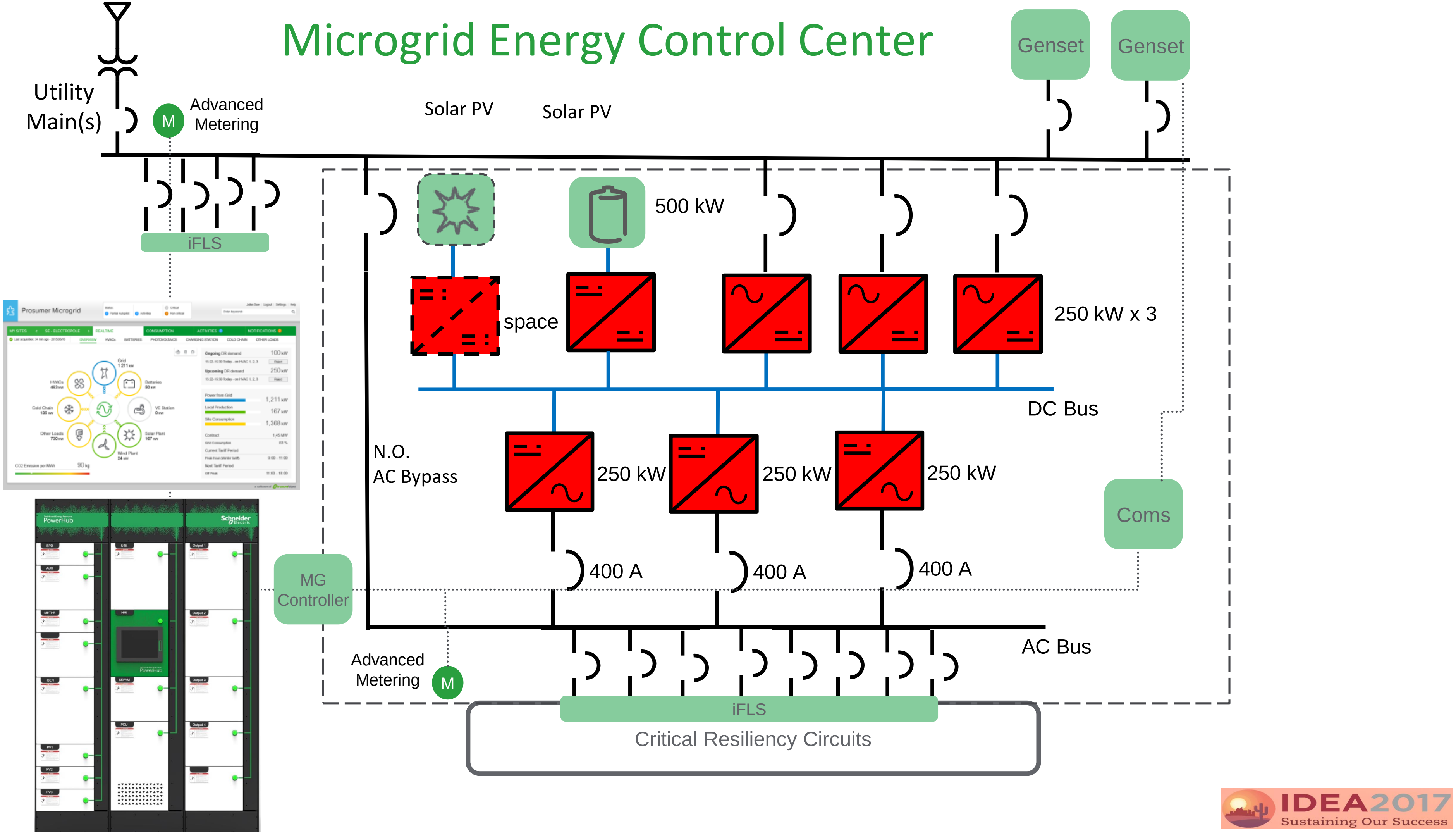
T0	IED detects contingency trigger / condition	0 ms
T1	IED confirms the detection (to protect against spurious triggering)	1 ms
T2	IED publish contingency trigger through Goose	3 ms
T3	Goose frame is propagated through the ethernet network	3,250 ms
T4	iFLS decodes the trigger, creates and published load shedding frame	13,250 ms
T5	Load Shedding frame is propagated through the ethernet network	13,5 ms
T6	Load Shedding frame is received and executed by the eLSU	19,5 ms
T7	eLSU shed contact is closed	26,5 ms



Microgrid Energy Control

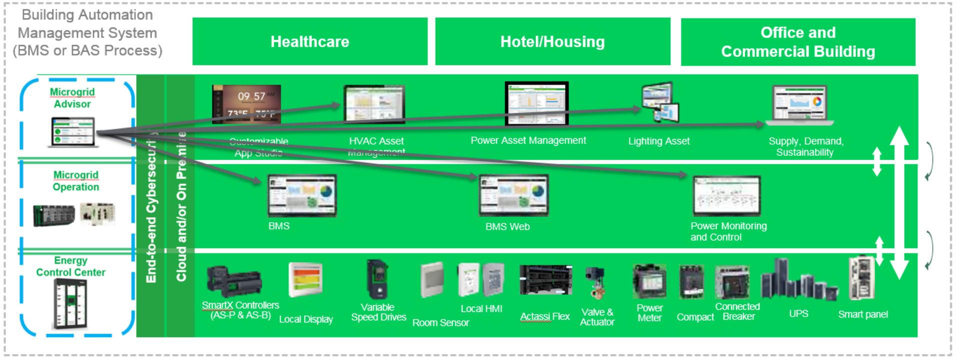


Microgrid Energy Control Center

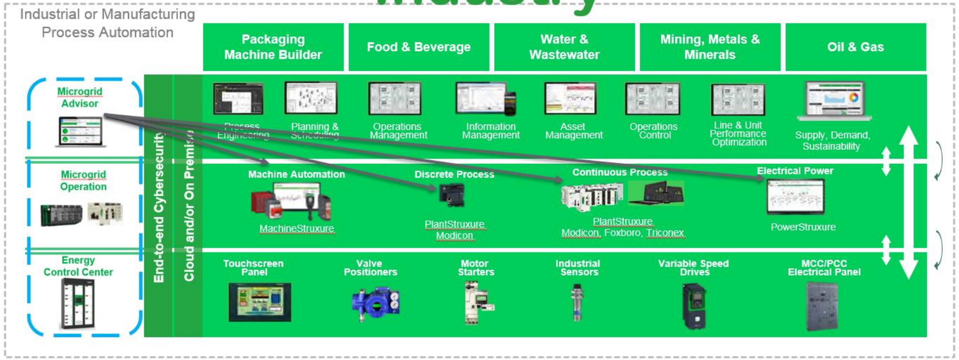


Closing Thoughts

Building



Industry



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Innovation At Every Level

Integration of Microgrid/Power Automation with Process/Energy Plant Automation for buildings and industrial processes can additional benefits that cannot be derived or managed separately

- Energy Economic optimization can treat the entire energy system (thermal and electrical) rather than treat as siloed processes

- Microgrid Control, PA Control along with iFLS enable islanding of CHP and other Distributed Energy Resources

- Economic optimization of microgrid islanding operation manages which loads can and should be shed to preserve key loads at the time balanced with local supply


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VWXYZ
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Thank You!
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