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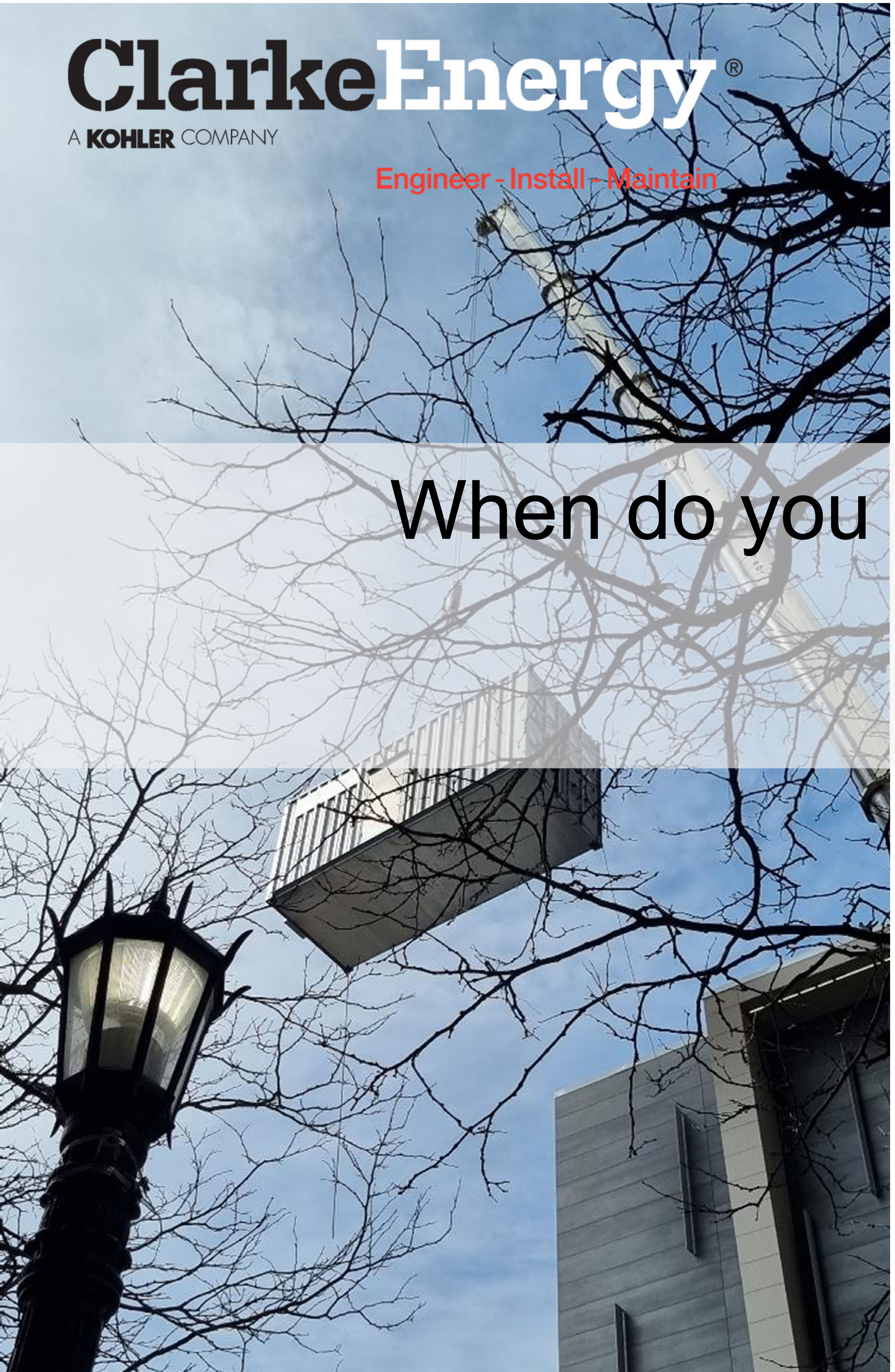
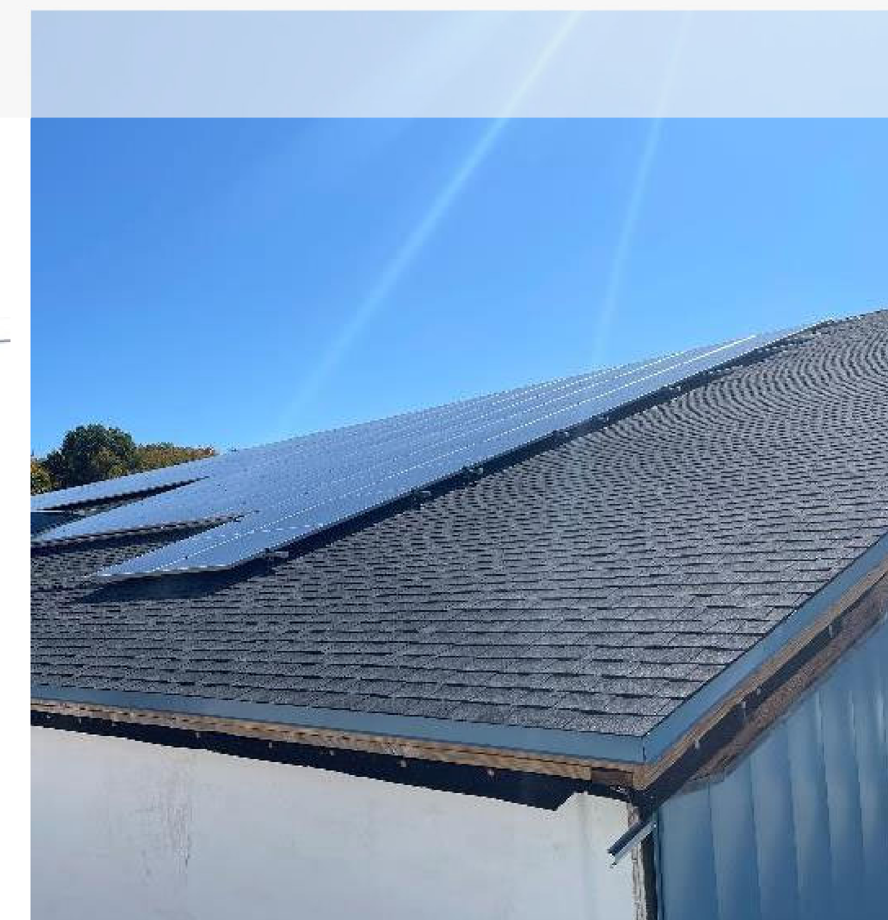




When do you need an advanced EMS for your microgrid?

Justin Lenoff
Group Application Manager Microgrids

Contents

- **What is a Microgrid and Why is it Valuable?**
- **What kind of control solution do you need for your microgrid?**
- **How does complexity and load/source variance influence your microgrid?**
- **Analyzing Energy Management System costs**

What is a microgrid and why is it valuable?

What is a Microgrid?

Definition

"Microgrids may be defined as a *localized group of interconnected and managed electricity sources, storage and loads* that can *connect with other local microgrids* and/or the *traditional electrical utility grid* (macro grid) but *can seamlessly and selectively disconnect from them and function independently* as conditions, policies or economics dictate."

Simplified: Electrical system that connects multiple sources and loads that is controllable by the user to allow independent operational choices.

Looking Towards a Sustainable Future

The world is facing a difficult “trilemma”.

Our need for power grows, but at the same time we need to cut carbon emissions to combat climate change and set the course towards a sustainable future. Hybrid power solutions can solve this trilemma, letting you reduce emissions and manage costs without putting reliability and safety on the line.

The technology to do it is mature and available on the market today.

Microgrid Controls – What do you need?

There are many control system available, some cater to building management, some cater to microgrids, some cater to both.

What do you need?

PLC (Programmable Logic Controllers)

Microgrid Controllers

Energy Management Systems

Control systems can be confusing

Q - Is a PLC a microgrid controller?

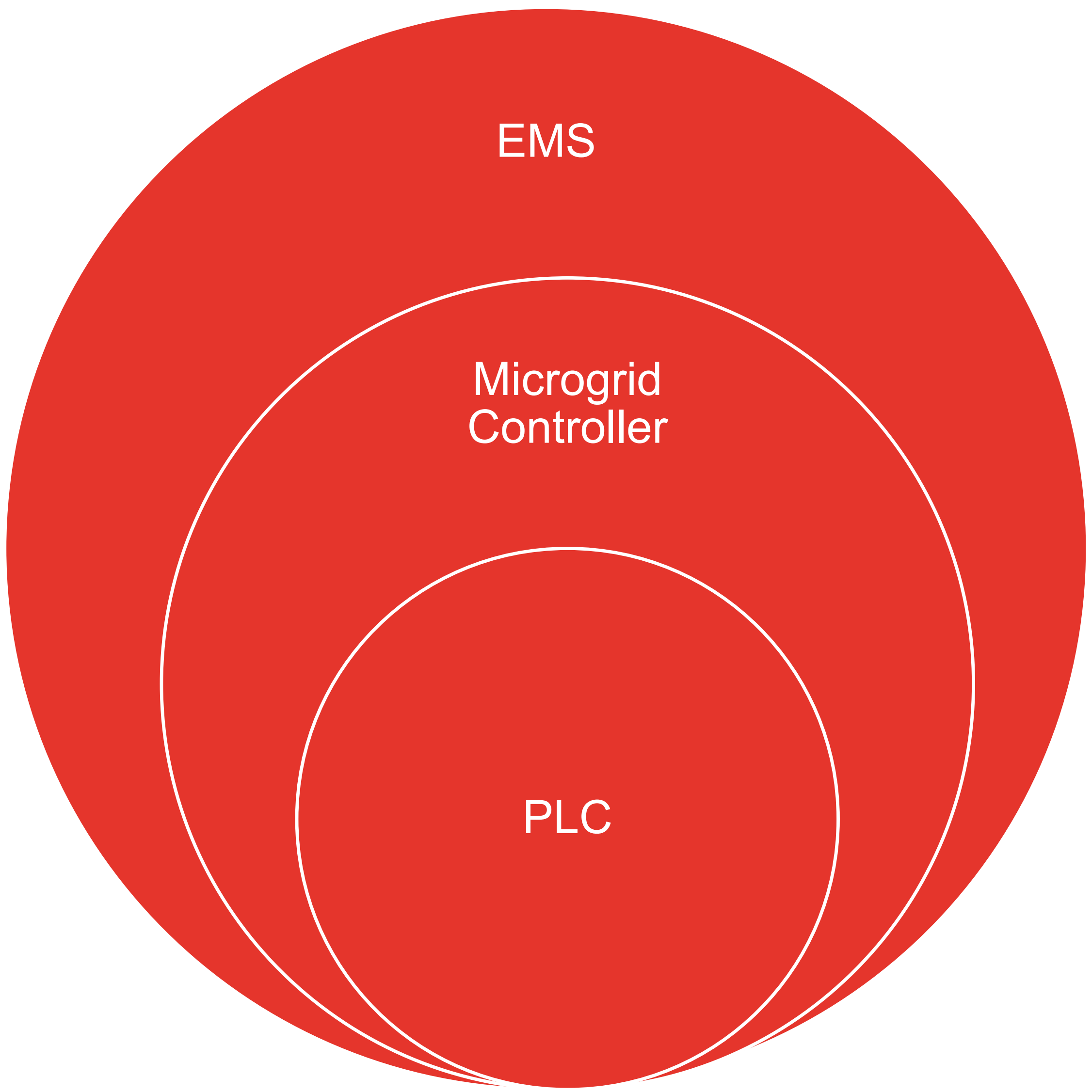
Q - Is a microgrid controller an Energy Management System (EMS)?

Q - If I already have a trusted PLC system in my facility, can I bolt on an EMS and preserve my existing infrastructure?

Not all control system are created equal

Any control system with modbus can coordinate dispatch, even a Raspberry Pie or Arduino! – The question is, how well do they do this?

What are the differences between EMS, Microgrid Controllers and PLC?



Energy Management Systems (EMS)
- Performs load/source and dispatch forecasting
- Integrates with revenue generation programs (Demand Response and other)
- Optimizes dispatch schedules for maximum efficiency

Microgrid Controller
- Designed specifically for integration with modern inverters, batteries and other DER assets
- Commissioning is more intuitive and less labor intensive
- Typically does not have load forecasting

PLC
- Basic dispatch via schedules and Boolean logic
- Commissioning is challenging and labor intensive

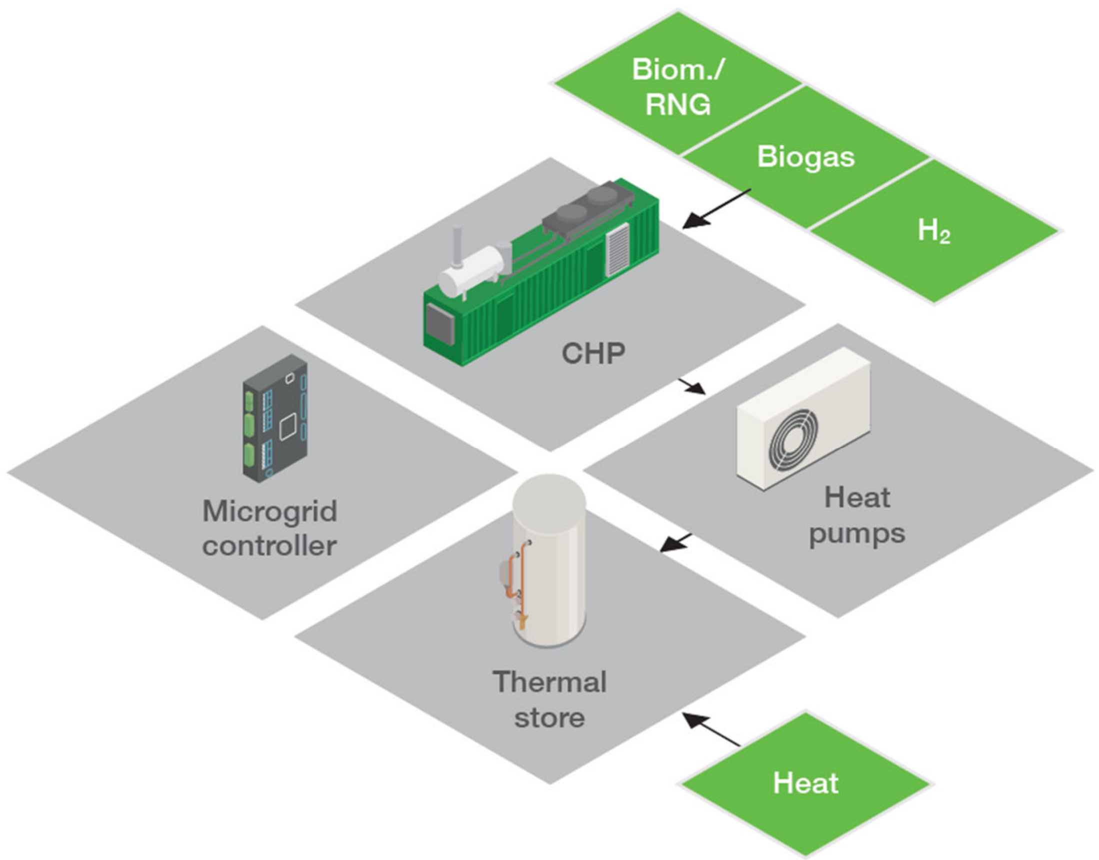
Microgrids come in all shapes and sizes

	Type	Definition
1	Basic	CHP (island mode or other)
2	Simple	CHP plus synchronized solar, island mode, plus basic microgrid controller
3	Advanced	CHP plus solar, battery
4	Complicated	Higher multiples of CHP, solar, battery,

There are many types of microgrids. There are control solutions. How do you choose?

You can always use what is familiar, but what if that isn't the best solution?

Type 1 – Basic Microgrids

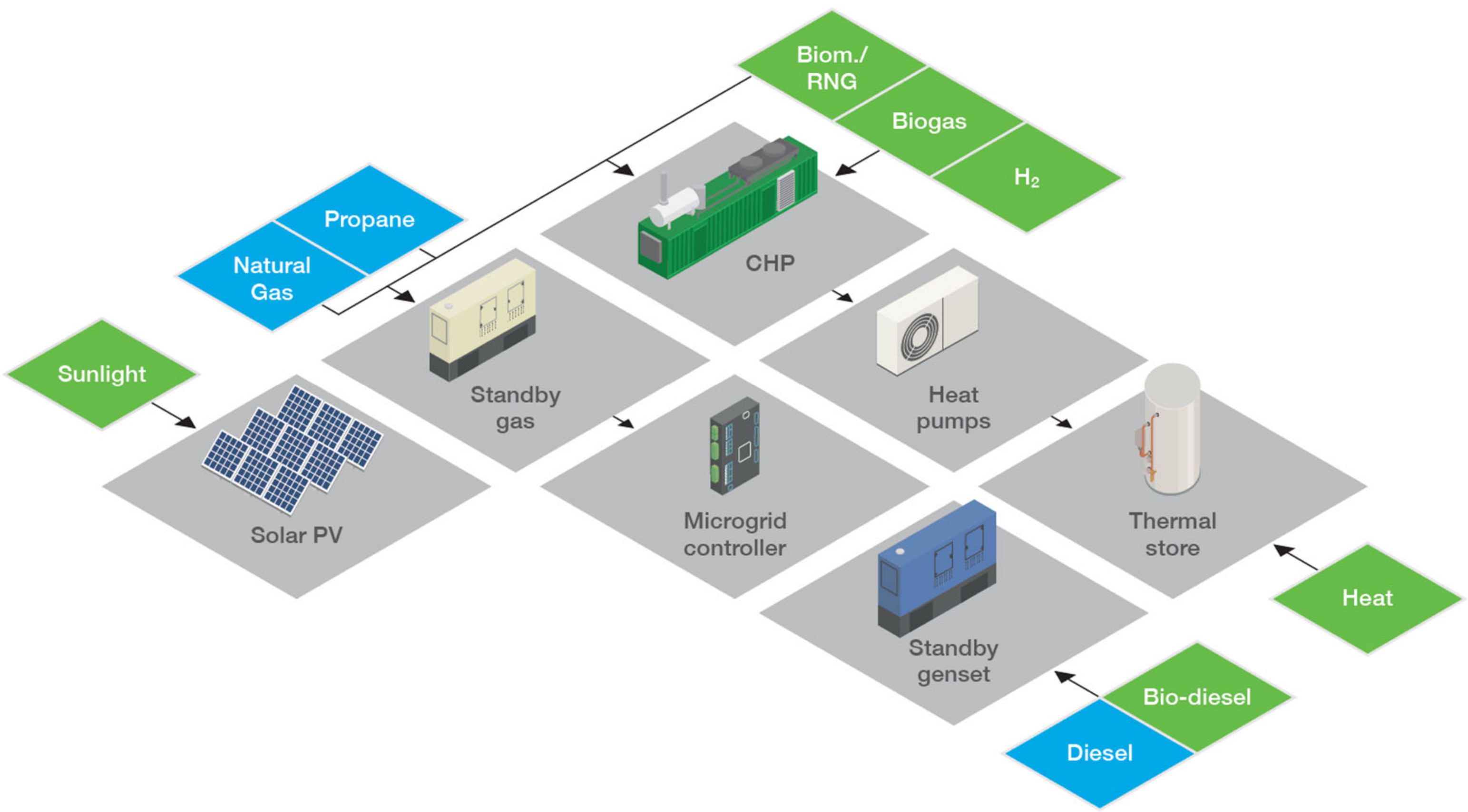


DER Elements
- CHP (island mode or other)

Recommendation
- Utilize a PLC or Master Control Unit that integrates with your site well

Rationale
- No DER asset coordination is required, scheduled dispatch is sufficient

Type 2 – Simple Microgrids

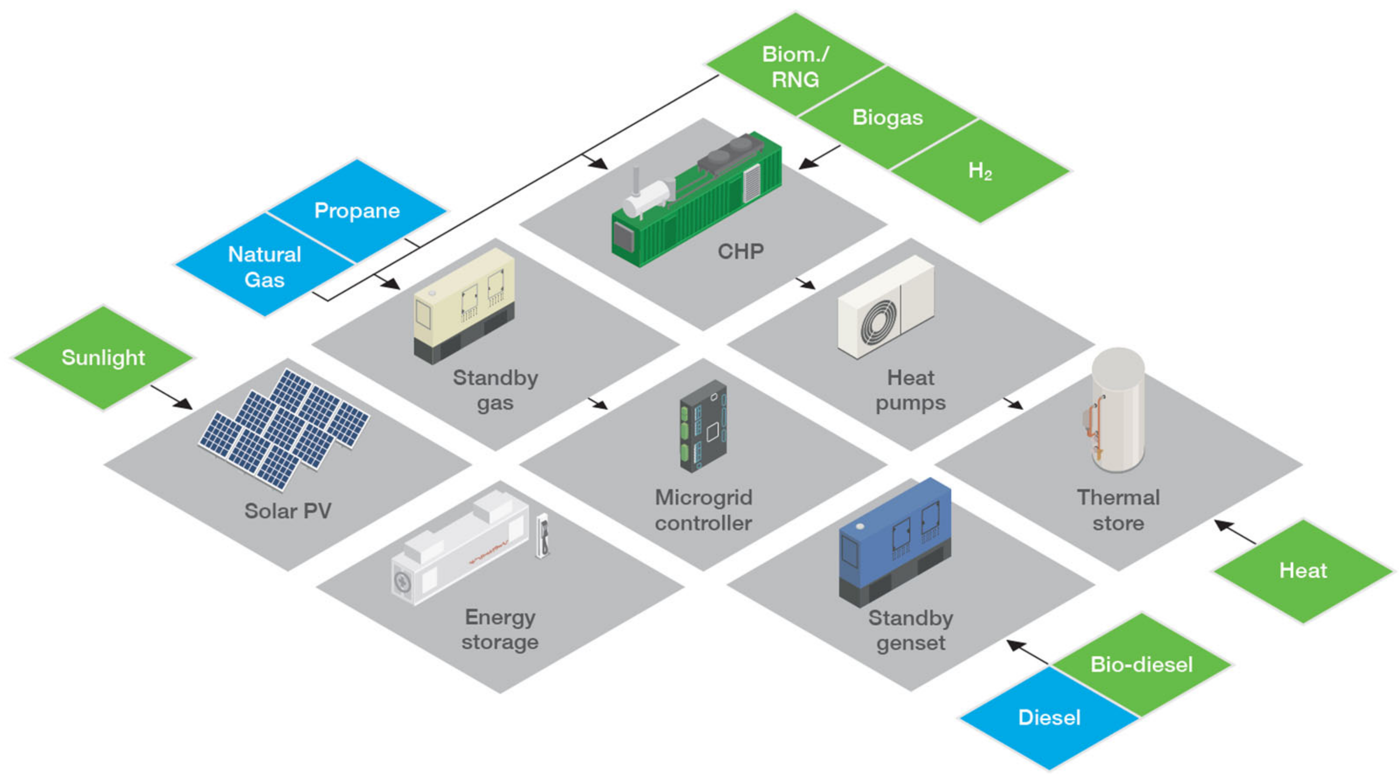


DER Elements
- CHP (island mode or other)
- Standby Assets
- Synchronized solar

Recommendation
- Either a microgrid controller or PLC will work, go with what fits your site the best from an integration and commissioning perspective

Rationale
- Solar should be fully utilized by the load during the day, no opportunities for peak shifting and the like

Type 3 – Advanced Microgrids



DER Elements

- CHP (island mode or other)
- Synchronized solar
- Standby assets
- Storage

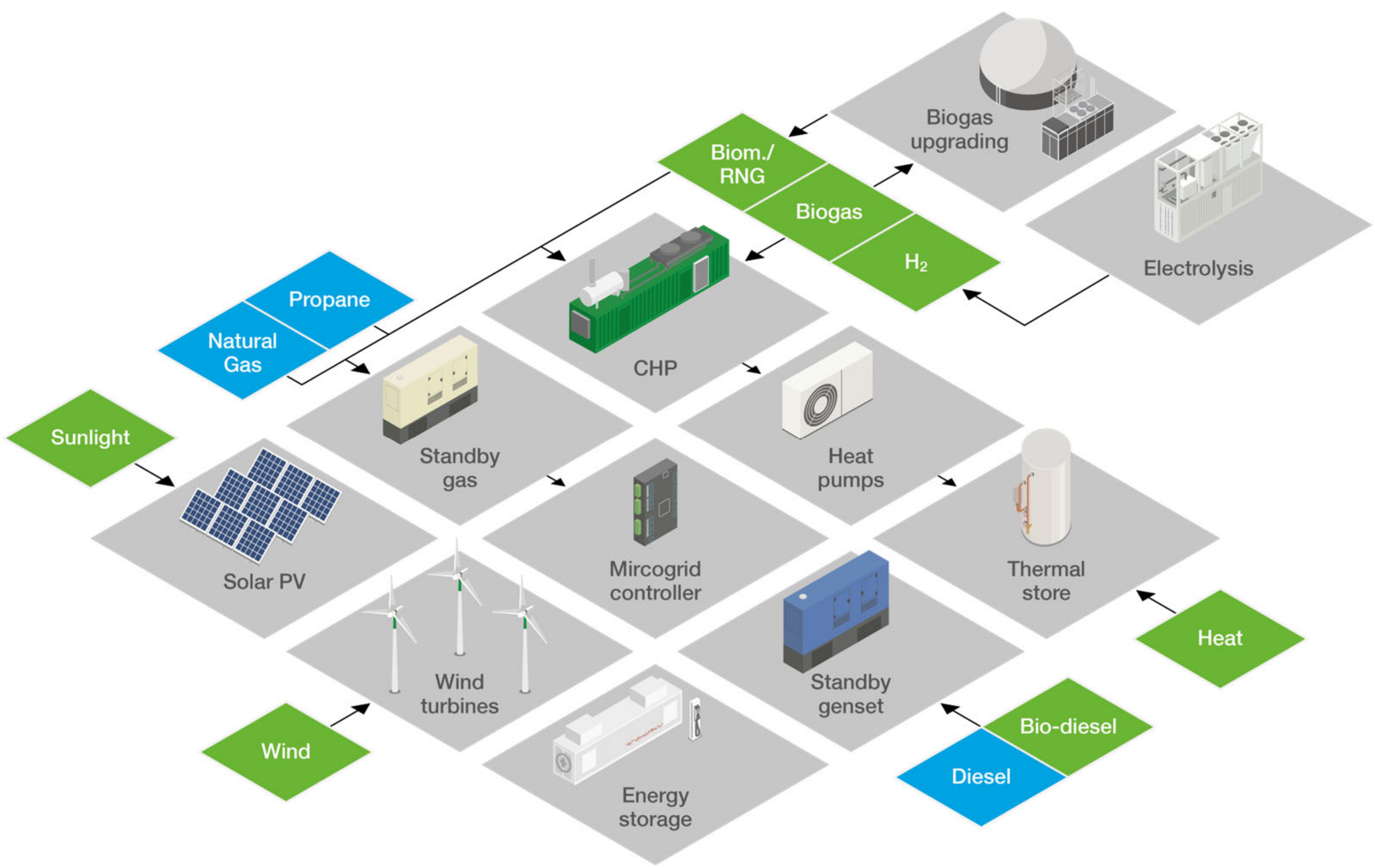
Recommendation

- Use a microgrid controller and EMS

Rationale

- If you want to fully monetize your solar/storage, an EMS will be necessary

Type 4 – Complicated Microgrids



DER Elements

- CHP (island mode or other)
- Synchronized solar
- Standby assets
- Storage
- Higher multiples of the above

Recommendation

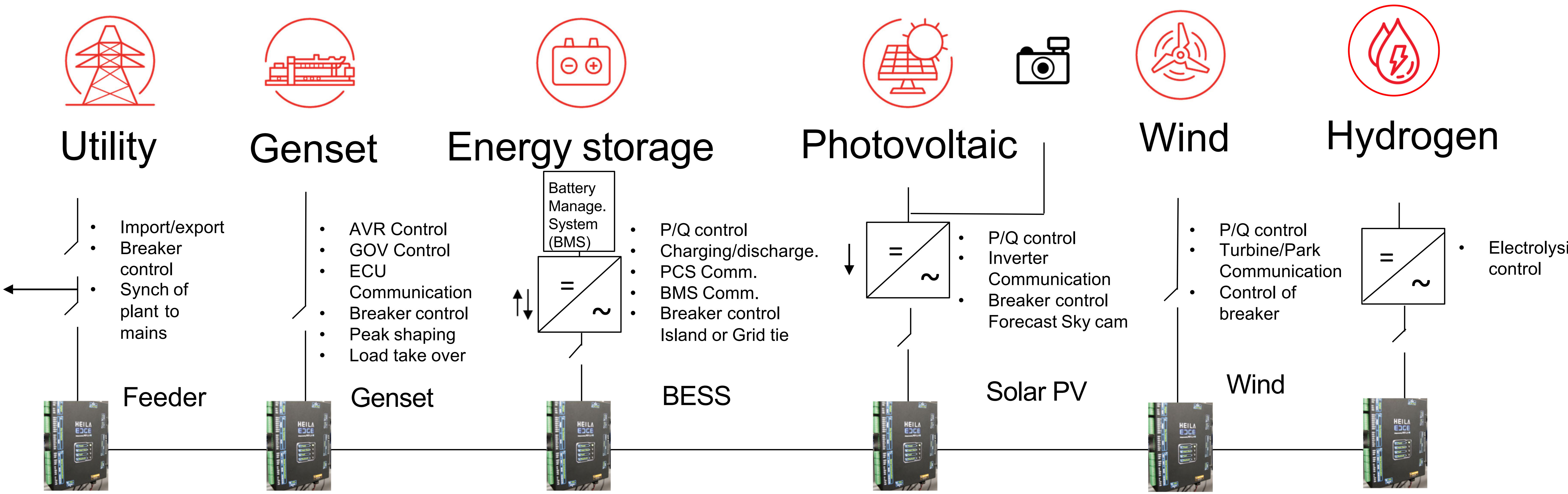
- Use a microgrid controller and EMS

Rationale

- If you want to fully monetize your microgrid and ensure you are achieving an economic objective, you will need a microgrid controller and EMS

Microgrid Onsite Controls

- Demand Response, On-Off Grid, Grid Services
- Connects to customer software – building management, etc



How do you get the most value out of your microgrid?

What do you want to do with your Microgrid?

OpEx Reduction				
Service	**Description**	**PLC**	**Microgrid Controller**	**EMS**
Demand Charge Reduction (dnuos and tnuos in the UK)	Uses stored energy to level peaks in load and reduce demand charges		X	X
TOU Bill Reduction	Shift the time of self generated electricity to take advantage of lower TOU usage rates		X	X
Resiliency and Backup Power	Sustain critical loads during outages	X	X	X
Avoid Renewable Curtailment	Avoid curtailing self generated renewable energy	X	X	X
Supply Capacity and Resource Adequacy	Meet peak-load growth and defer need for new generating capacity		X	X

What do you want to do with your Microgrid?

Revenue Production				
Service	**Description**	**PLC**	**Microgrid Controller**	**EMS**
Demand Response (requires IX Study)	Store used energy to support participation in utility programs that pay a customer to lower demand during system peaks		X	X
Frequency Regulation	Stabilizes frequency on a moment-to-moment basis		X	X
Reserve Markets (requires IX Study)	Supply spinning, non spinning reserve		X	X
Black Start	Helps restore the system after a blackout	X	X	X
Voltage Support	Inserts and absorbs reactive power to maintain voltage within required range	X	X	X
Energy Arbitrage	Stores energy during lower grid purchases and sells when price is rise		X	X

Why does complexity drive the need for an EMS and microgrid controller?

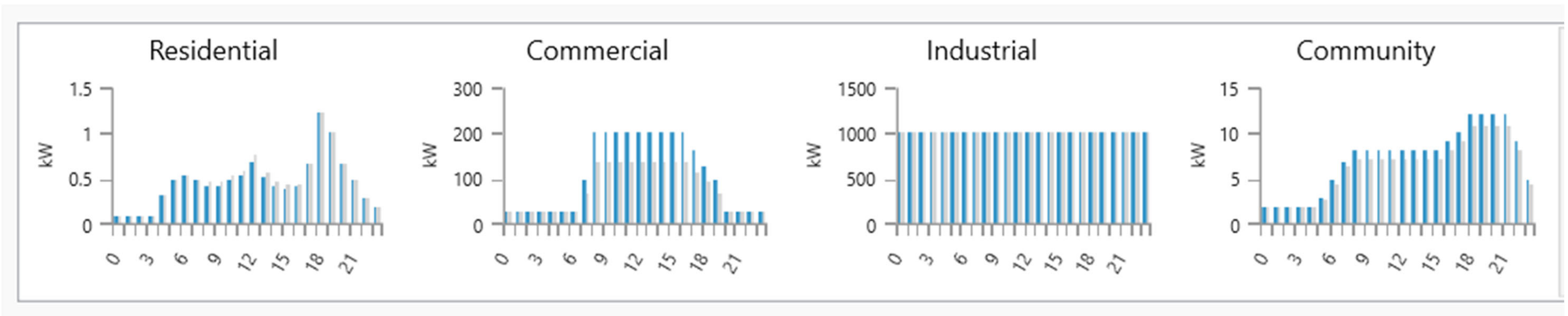
One word – Variance.

Sources of variance

- Changing sources (solar/wind)
- Changing load conditions
- Demand Response programs
- Market participation
    - Spinning reserve, freq response, etc
- Multiples of changing sources and loads

Most loads have variance

Know your load
(24 Hour Data)



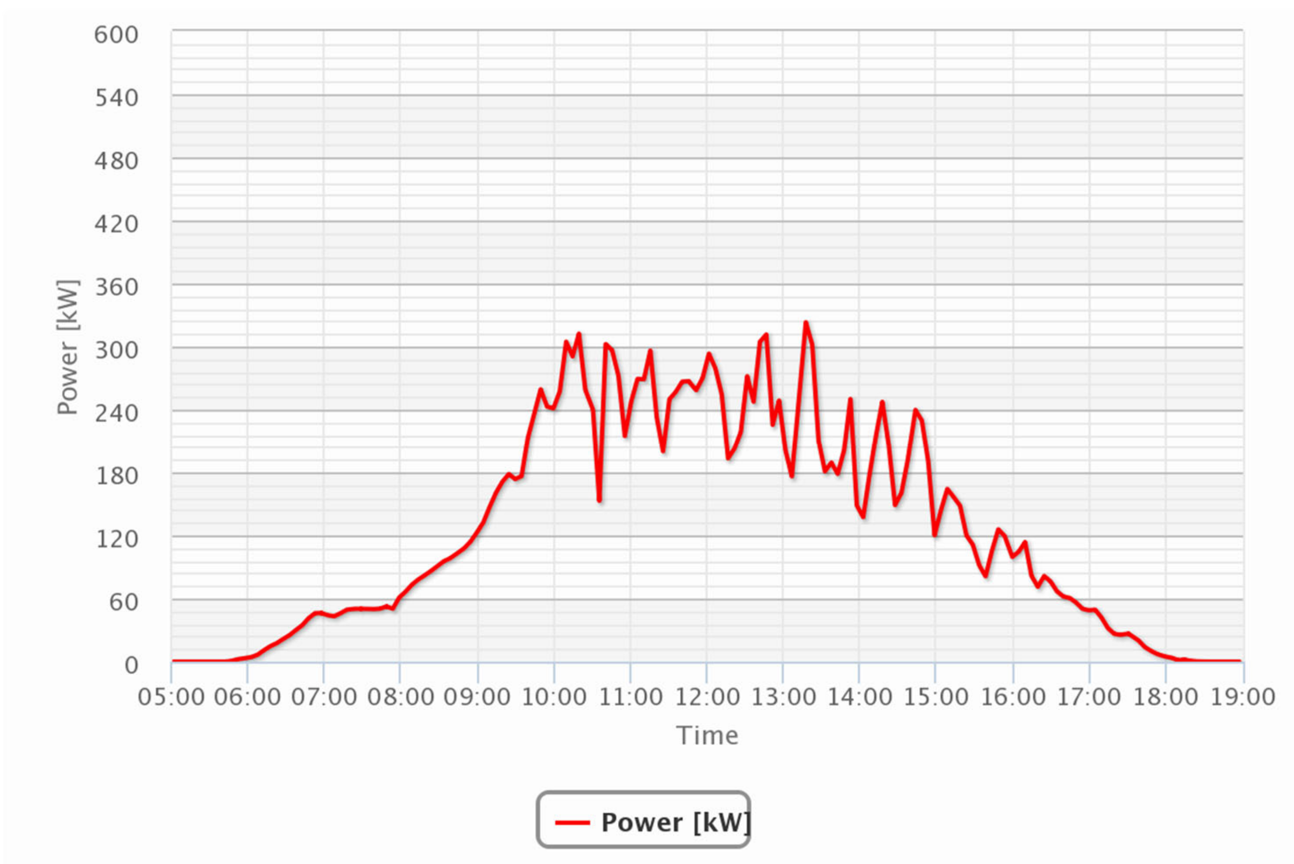
Industrial loads are most predictable → Best use case for PLCs

- If a load change on a daily basis, but not an annual basis → PLCs are still good
- <u>PLCs can respond to patterns, but NOT changing patterns</u>

Commercial, residential and community loads tend to vary the most→ Best for EMS

- If loads change on a weekly, monthly or annual basis → EMS is very helpful
- <u>Microgrid controllers and EMS can respond to changing patterns</u>

Renewable sources have variance

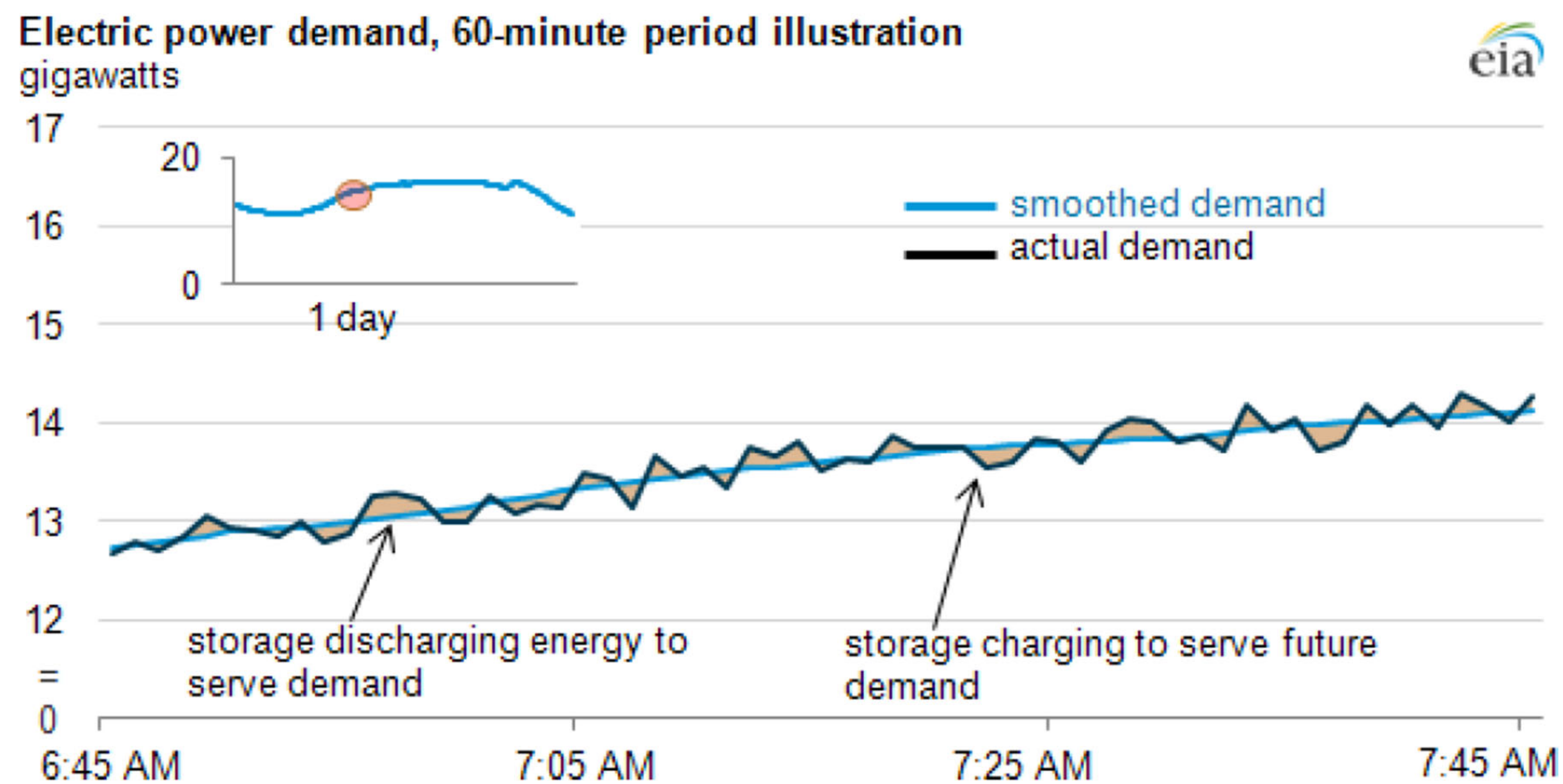


Sample solar data

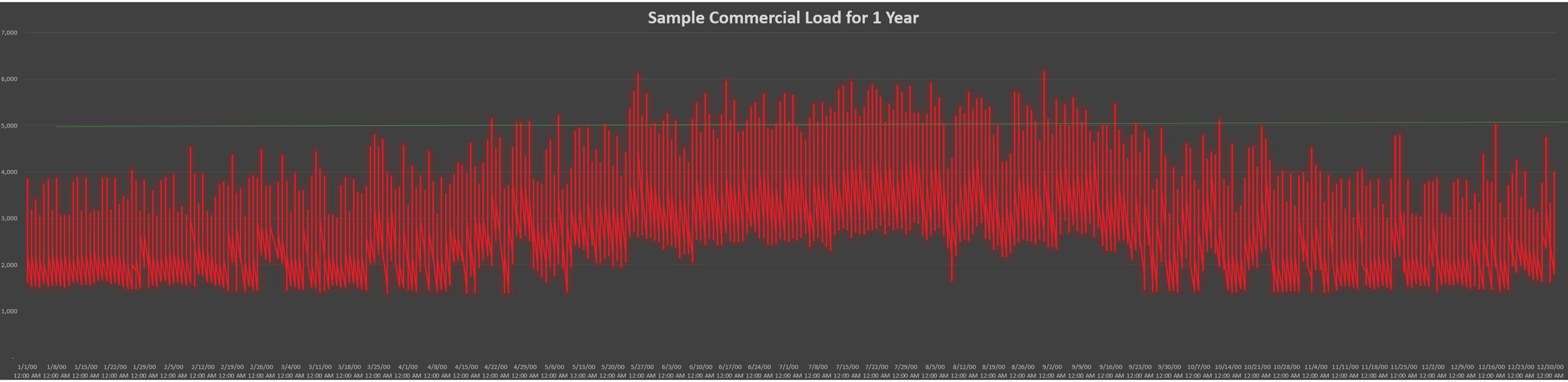
Microgrid controllers and EMS can handle sources with high degrees of variance

Renewable Energy Firming

One of the better understood applications of ESSs involves coupling with a solar PV installation to smooth out the intermittent fluctuations of solar production



Sample Commercial Scenario (Annual Load Data)



A good application for a microgrid controller and EMS

How do these control systems “think?”

PLCs vs Microgrid Controllers and EMS, how do they "think"?

- **PLCs**
  - Creates inflexible, time-based dispatch schedules
  - Used by SCADA, PLCs (Allen Bradely, etc), Master Control Units
  - At best, weighted averages can be used to but these are not very accurate when you have a complex microgrid
  - Cannot handle high degrees of variance

- **Microgrid Controllers and EMS**
  - Creates flexible schedules that adapt via data based mathematical analysis
  - Pulls in economic data (weather, prices) to inform optimal dispatch

A PLC thinks according to schedules and Boolean logic

- **PLCs coordinate energy dispatch according to pre defined time windows or moving averages.**
  - This means that a technician analyzes past data and **makes the assumption** that the load/source is always going to be the same in the future.
  - The technician then programs dispatch according to time-based dispatch strategies.

- **Batteries add significant complexity**
  - Because having a battery charged to a predetermined SOC (State of Charge) is critical to coordinating dispatch, responding to unexpected demand peaks with procedural dispatch can be impossible if your controller has not anticipated this need.
    - If the load changes significantly, the controller needs to be re-programmed

A microgrid controller and EMS think economically

- **Economic Dispatch**
  - Attempts to meet a defined economic objective. This can be minimizing reliance on the grid for non-islanded scenarios. This can also be minimizing fuel usage for islanded scenarios.
  - Economic dispatch will assess energy costs associated with various DERs and perform some kind of "market based bidding" in an attempt to minimize costs associated with dispatch.
    - More intelligent models will include cost of battery, (given lifetime), SOC and SOH, presence of absence of solar, wind and geographic location (for illuminance data).

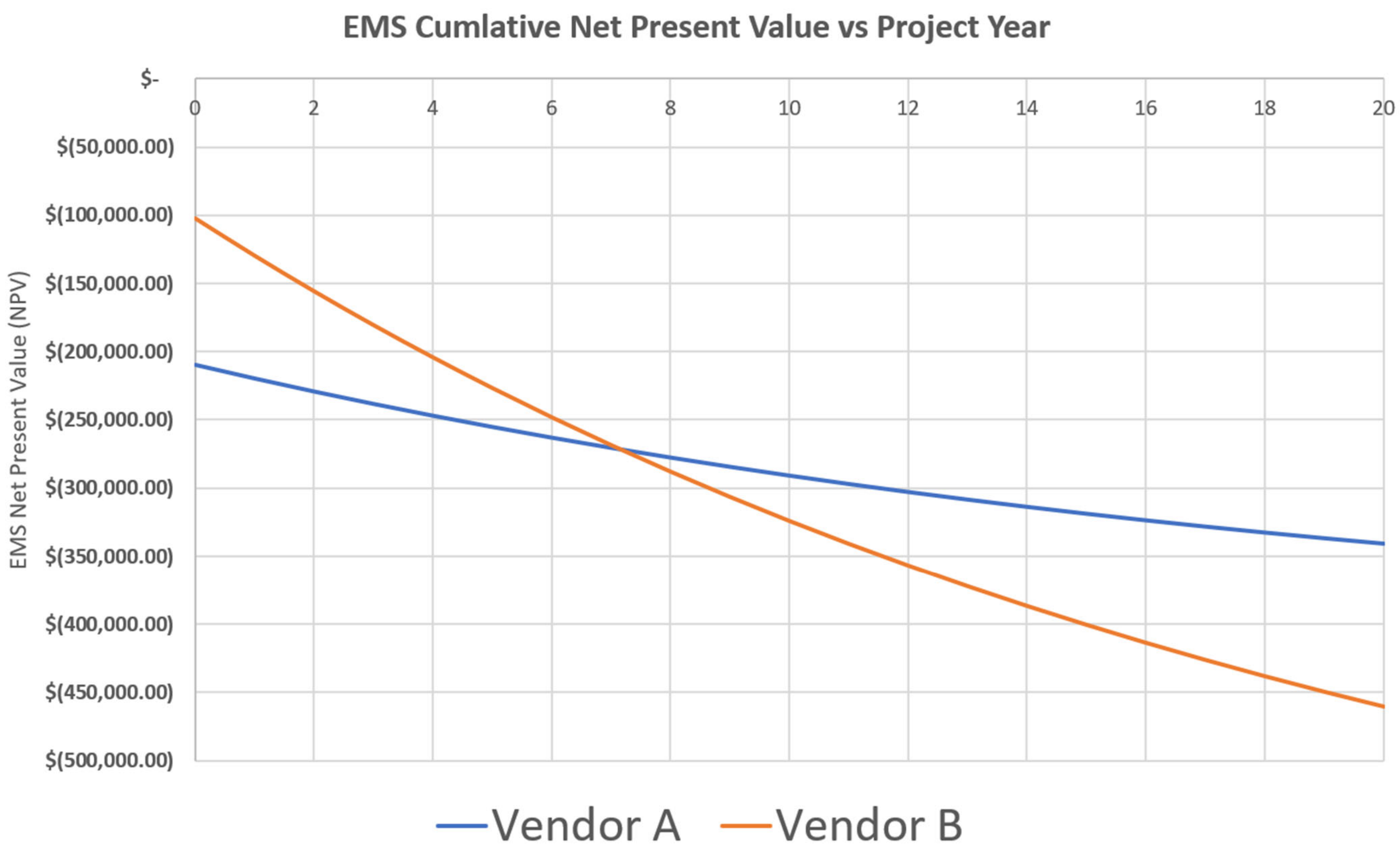
Control Systems For Every Application

Question - Is a PLC a microgrid controller?
It can be, if your microgrid is simple enough.

Question - Is a microgrid controller an Energy Management System?
Not necessarily. An EMS "formed" by the microgrid controller. The microgrid controller willy usually need to rely on a sophisticated cloud based data analytics platform to form an EMS.

Question - If I already have a nice PLC system in my facility, can I bolt on an EMS and preserve my existing infrastructure?
Yes, you can modernize a PLC system by adding on an EMS via a third-party peripheral.

How do you compare EMS costs? Look at your Net Present Value (NPV)



Vendor A – Higher CapEx, Lower OpEx

Vendor B – Lower CapEx, Higher OpEx

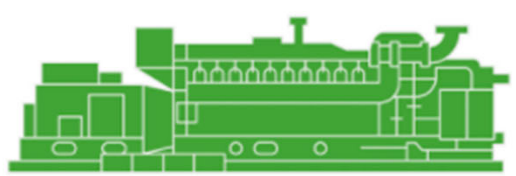
Both have similar features but work better with different DER assets.

It takes a global footprint to understand complexity

> 8.0GW	**>1.4GW**	**> 1.2GW**	**1,300**
Global installed base	Renewable electricity globally	Peaking and flexible globally	people employed

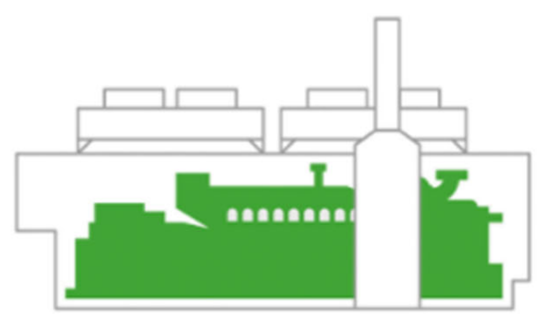
Flexible Delivery Model and Tailored Scope of Supply

Clarke Energy can supply a single engine through to full turn-key multi-engine plant



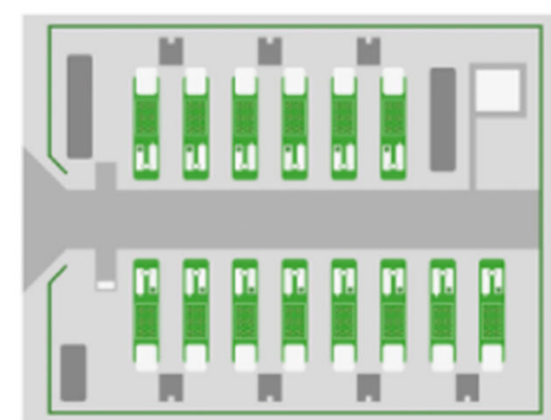
Gas Gensets

Jenbacher gensets configured to produce electrical power only offering savings over grid imported power.



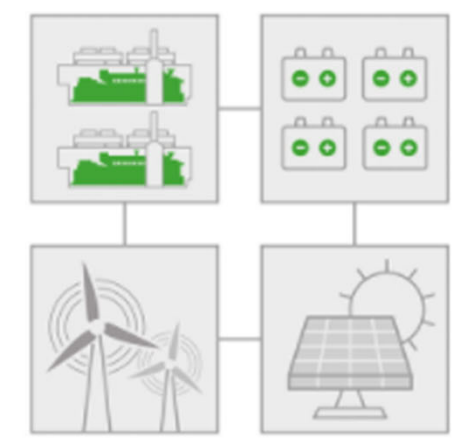
Combined Heat and Power Plants

Jenbacher gas engine module configured for both recovery of electricity and heat, offering greater savings.



Power Plants

Clarke Energy can take on the engineering, procurement, and construction (EPC) scope through turnkey installations.



Hybrid Energy Systems

Clarke Energy can take on a greater scope and incorporate different power generation technologies offering more resilient solutions.

Middletown Recreation Center, Connecticut, USA

- Repurposed site, previously Woodrow Wilson Middle School
- Recreation center office, gyms, pools, dedicated department building
- Heating and cooling center for homeless community during extreme weather events
- 35kWem 204.1BTU/hr hot water CHP, black start capability KOHLER KG100 back-up gas-fueled generator, 10kW battery energy storage system, 83.3kW solar PV array, COMAP Controller
- Funding X-Caliber Rural Capital

SENEX Energy - Queensland, Australia

Atlas East Stage 3 Power Station

Remote Power for a Gas Compression Facility

Clarke Energy Scope

- 1x *3MW/3MWH BESS*
- *7x J620 Engines*
- *Engine Enclosures*
- *HV/LV Switchroom*
- *BoP*

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Key Application of BESS/Microgrid

- Acts as Uninterrupted essential power supply during power trip
- Support short term essential onsite loads
- Significantly improve efficient Island operation of site
  - Without the BESS providing spinning reserve, an additional engine would be needed in operation to handle an engine trip.
    - This means that all the engines are running at a higher part load (79% vs. 60%) which is more fuel efficient
    - This reduces engine running hours per annum and maintenance costs on a $/kWh basis
  - the BESS can also provide support during short-term derate conditions (temperature >45°C).
- Operational Date: Q1 2025

Questions

Acronyms and Abbreviations

IX Study – Interconnection Study

DER = Distributed Energy Resource

CHP = Combined Heat and Power

EMS = Energy Management System

BMS = Battery Management System

MBMS = Master Battery Management System

SOC = State of Charge

SOH = State of Health

ToU = Time of Use

API = Application Programming Interface

AVR = Automatic Voltage Regulator

ECU = Electronic Control Unit

GOV = Governor

PCS = Power Conditioning System (Inverter typically)

ESS = Energy Storage System

HMI = Human Machine Interface

SCADA = Supervisory Control and Data Acquisition

PLC = Programmable Logic Controller

Communication Protocols Upstream (to ISO, utility)	**Modbus TCP Modbus RTU (RS485/232) IEC61850 DNP3 OpenADR IEEE 2030.5**	**Profinet RT Modbus TCP Modbus RTU (RS485/232) IEC 60870 and IEC 61850 DNP3 not possible**
Communication Protocols Downstream (to DER assets)	Modbus TCP Modbus RTU (RS485/232), Canbus Bacnet	OPC UA Modbus TCP Modbus RTU via converter box