Pittsburgh International Airport

Using hybrid microgrids to enable more reliable, resilient and renewable power solutions

Speakers: Michael Norelli & Joseph Martorano, P.E.

NORTHEAST – WESTERN™ ENERGY SYSTEMS

Steelers

EGSA

Today's Discussion

- **An opportunity for our industry:** Hybrid microgrids and the 3Rs
- **Case study:** Pittsburgh International Airport
- **The path forward:** Moving from interest to installs

OUR COMPANY

Over 50 years in business … Engine heritage

PENN POWER GROUP®

NORTHEAST – WESTERN™ ENERGY SYSTEMS

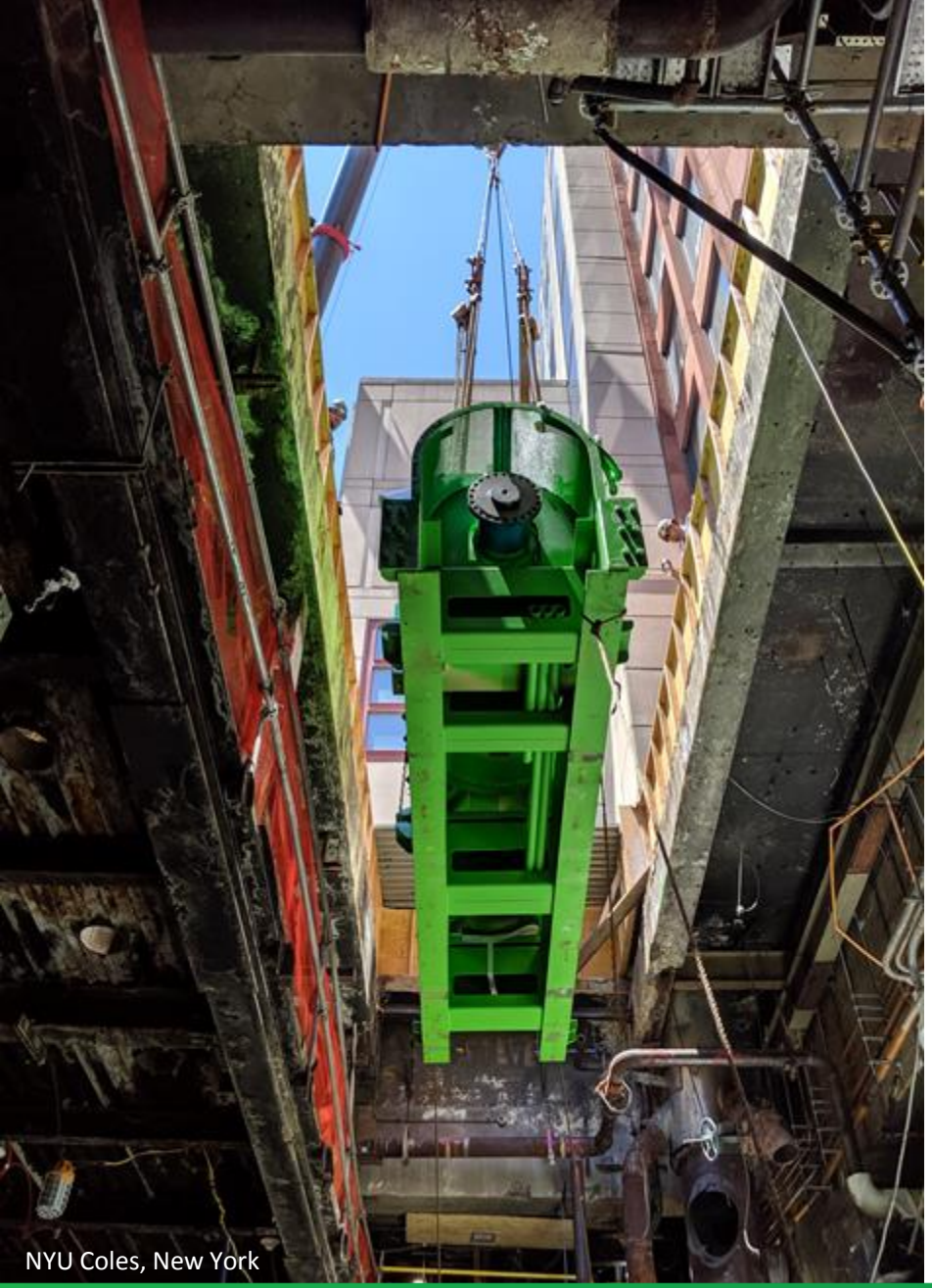
Distributed energy systems including hybrid microgrids

PENN POWER SYSTEMS®
Power and Industrial Solutions

Standby diesel and gas generator power systems

PENN POWER GROUP®
FLEET SERVICES

Truck Service Repair with 13 locations across PA, NJ and NY



NYU Coles, New York

DEVELOP, INTEGRATE AND MAINTAIN DISTRIBUTED ENERGY SYSTEMS

- 15+ years of integrating engines into power products
- 200+ gas engines in our fleet
- 50%+ of our engines sold to repeat customers
- Ability to do turnkey projects
- Jenbacher North America Channel Partner of the Year
- Integrated gensets with solar, storage & other technologies

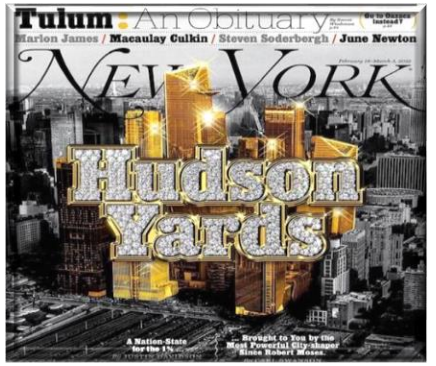
MICROGRID PROJECTS IN ACTION

EVERY PROJECT WAS A TEAM EFFORT.

SHERATON WAIKIKI

TWA HOTEL AT JFK

COLUSA RESORT



HUDSON YARDS

TOSOH

QUAKER COLOR

UMASS HOSPITAL

MULLICA HILL HOSPITAL

What we are hearing from customers

Without the solar scope, the deal would not have happened

I'm being told to add renewables but I need to keep my plant running

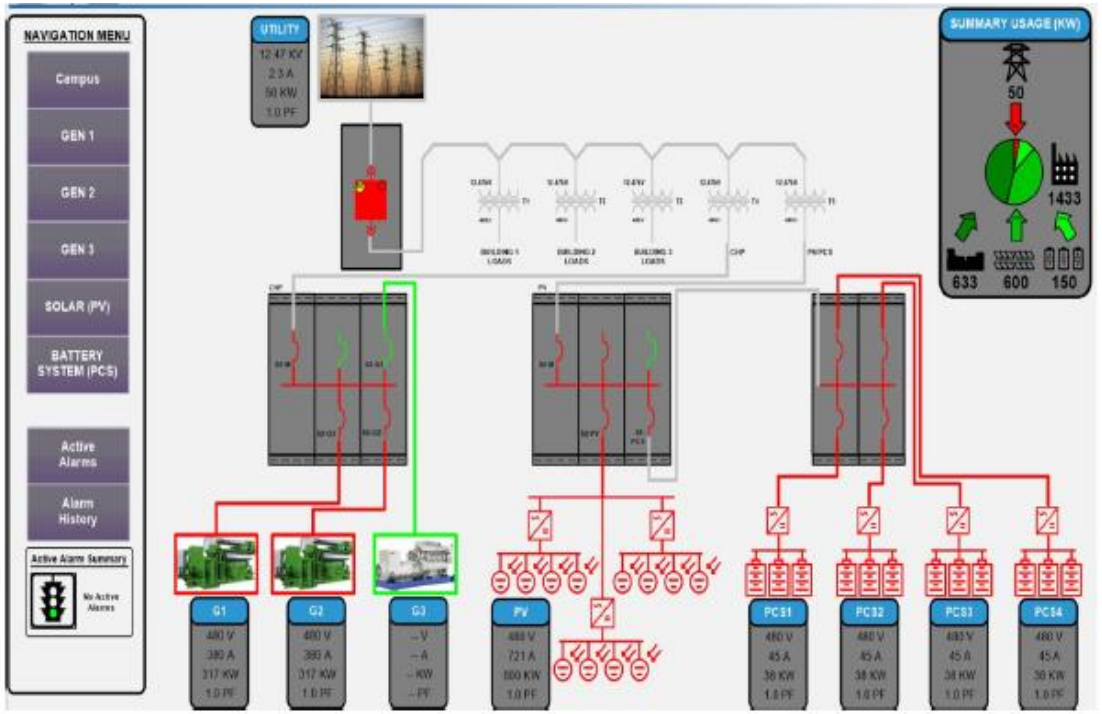
Only going to incentivize projects that minimize the amount of fossil fuels used

If we cannot show a carbon reduction then we will not do the project

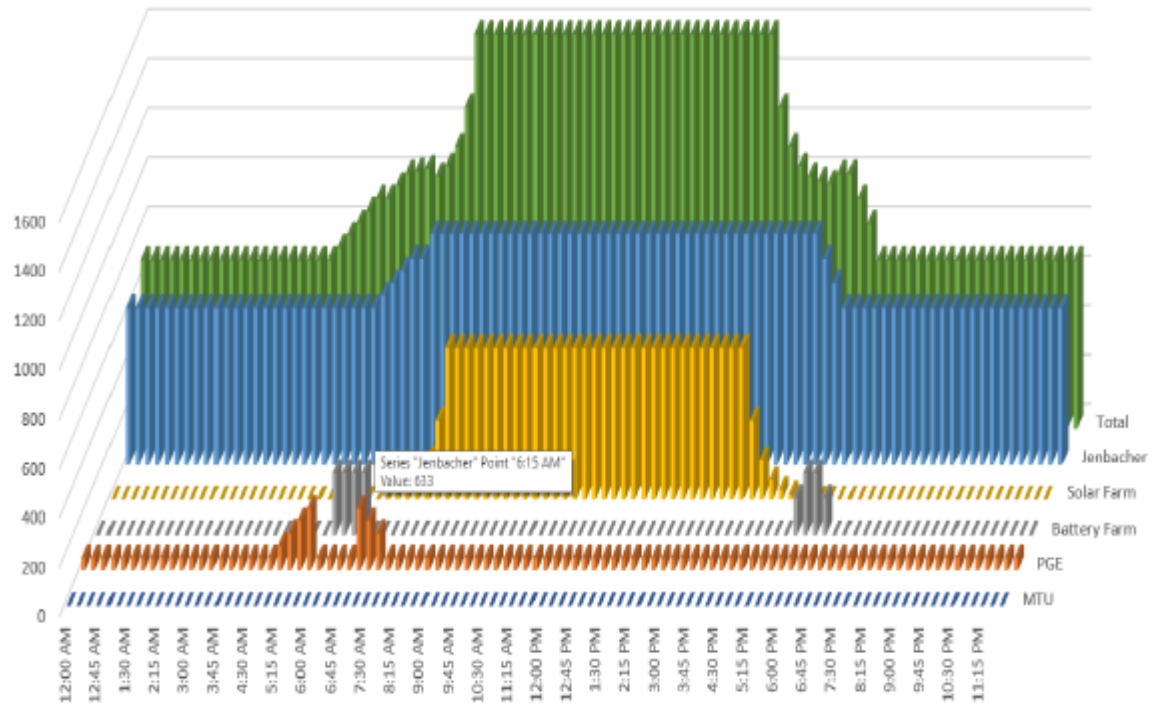
How can we add a renewable energy component to this project?

Hybrid Power: A more complicated math problem

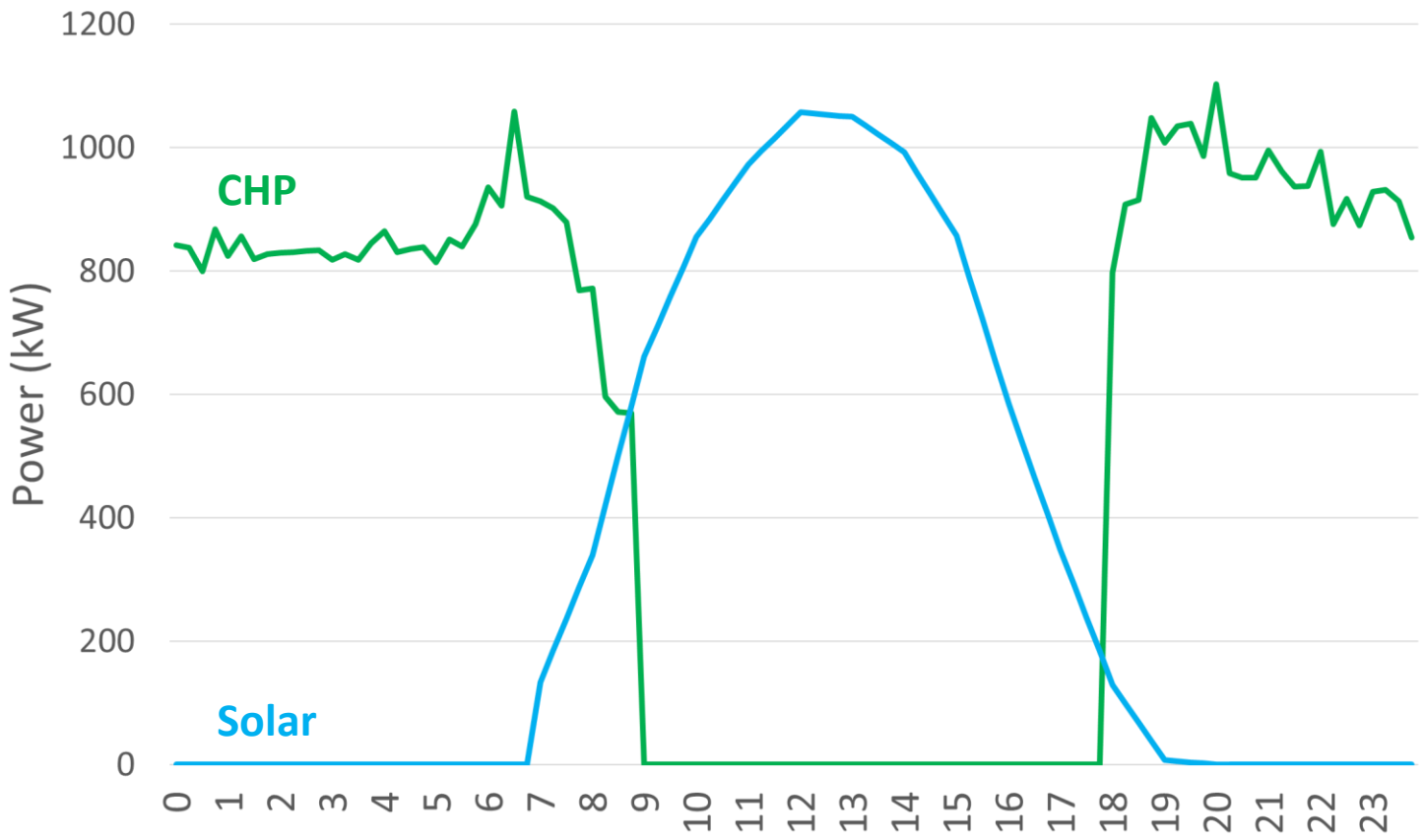
Illustrative Single Line Diagram



Illustrative Operational Load Profile



Mullica Hill Hospital Hybrid Microgrid



Design considerations

- ❑ Technical
- ❑ Commercial
- ❑ Regulatory
- ❑ Timing

NREL Case Study: California Hospital

THE MATH OF ONSITE POWER IS CHANGING

	Base case	CHP only	PV + battery	CHP + PV + battery
CHP system size (kWe)	0	4540	0	3300
PV system size (kWe)	0	0	18,400	5,844
Battery power size (kWe)	0	0	2,820	720
Battery energy size (kWhe)	0	0	13,200	1,440
Firm Backup Power (kWe)	0	4,540	550	3300
Emissions (tonne CO2/year)	15,980	15,190	9,400	11,043
% Emissions Reduction	0	4.9%	41.2%	30.9%
Life Cycle Cost ($M)	86.3	55.4	66.2	51.5
% Savings from base	0	35.5%	23.3%	40.3%

Menu of onsite power options

Pittsburgh International Airport: A Hybrid Microgrid in Action

The Design Challenge

- ✓ Provide resilience to a grid outage
- ✓ Reduce energy costs
- ✓ Improve sustainability
- ✓ Upgrade infrastructure
- ✓ Create a tailored solution for PIT
- ✓ No upfront capex

The Winning Solution

- ✓ 3 forms of electricity supply
- ✓ 20 MW of Jenbacher gensets
- ✓ 3 MW of solar
- ✓ Electric utility connection
- ✓ Seamless transition
- ✓ Advanced load shedding
- ✓ Onsite natural gas supply
- ✓ Uniquely Pennsylvanian

Simplified SLD

- **4.3MW, 13.8kV, Jenbacher J624**
- **Integral Power Modules**

3MW PV
Solar

Multiple feeds &
Xformers from
utility MV

4160V

G G G G G

Switchgear/Electrical building
- Gen paralleling switchgear
- LV power distribution

Multiple feeds
& Xformers
from MV

4160V

Switchgear,
meters, bus

4160V 13.8kV

13.8kV 4160V

Site loads

Site loads

Engines vs. Solar vs. Hybrid

Engine Only

23 MW @$1,500 / kW - $34.5 M

Emissions @ 800 Lb CO2 per MWh – 80,000 tons per year

Land needed – 1 acre

1.3 football fields

Capacity factor = ~95%

Solar Only

23 MW @$1,800 / kW - $41 M

Emissions @ 0 Lb CO2 per MWh – 0 tons per year

Land needed – 92 acre

123 football fields

Capacity factor = ~15%

Hybrid Power

20 MW @$1,500/ kW - $30 M

3MW @ $1,800 / kW - $5.4 M

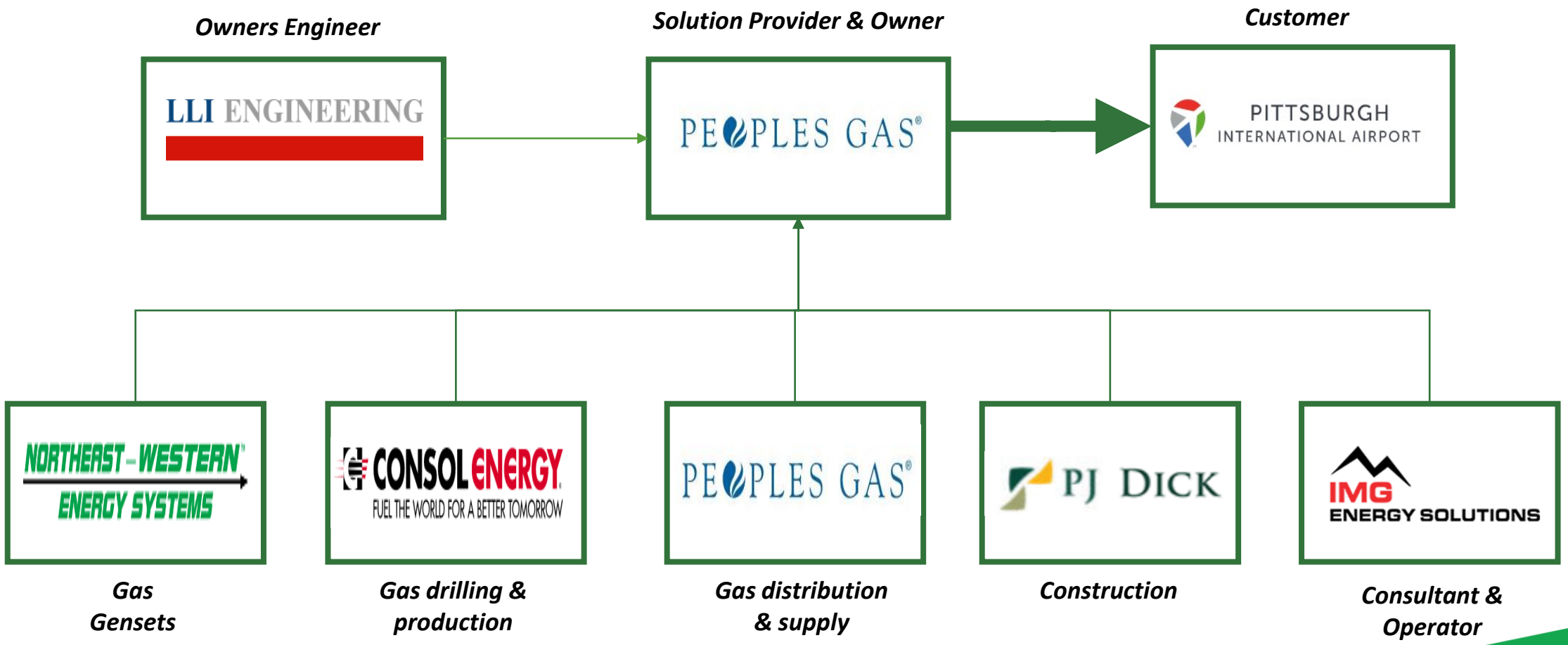
Emissions @ 700 Lb CO2 per MWh – 70,000 tons per year

Land needed – 13 acre

17 football fields

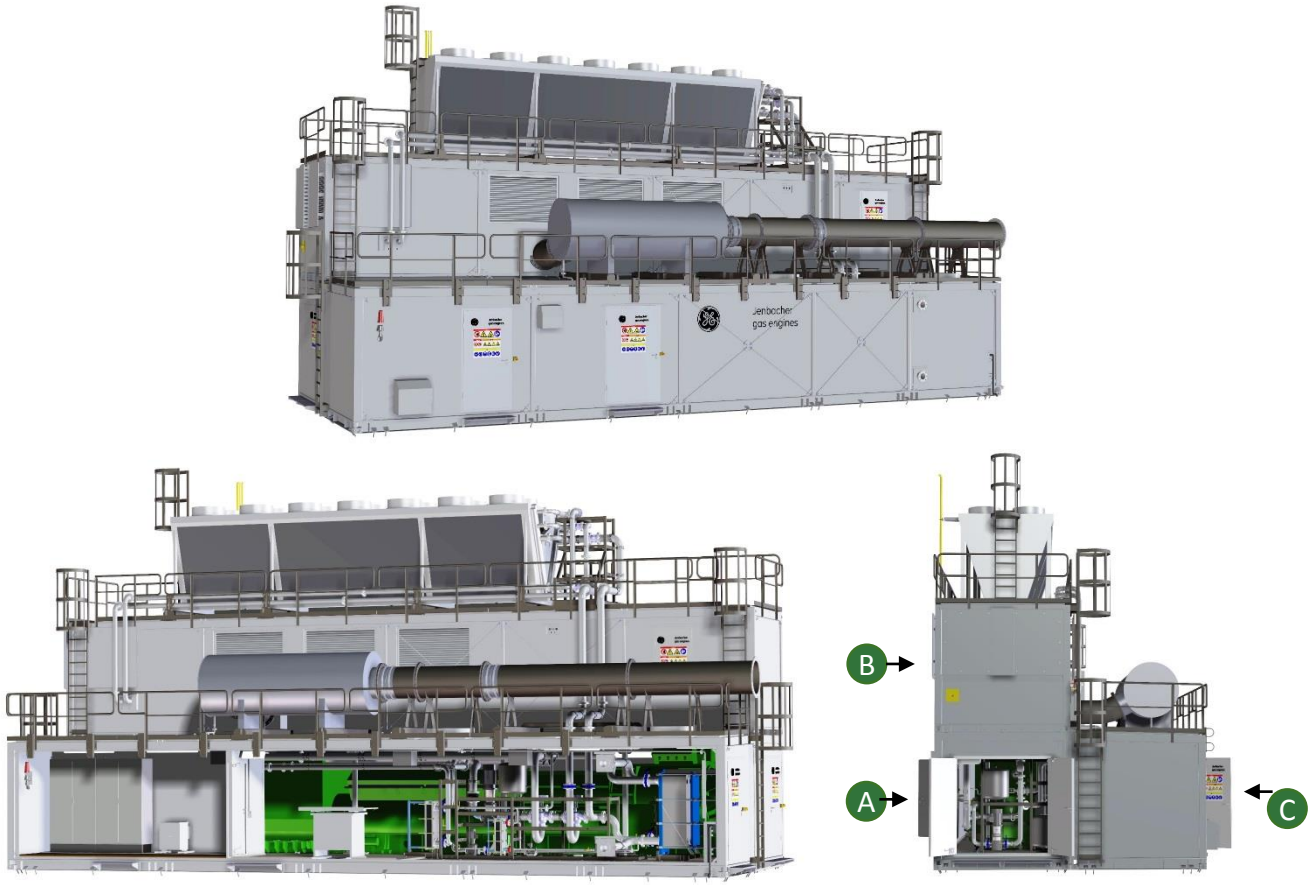
Capacity factor = ~85%

The Delivery Team



Power Island Design Approach

Use Integrated Power Modules (IPMS) to reduce design & execution risk



Key facts

- ✓ One containerized solution = **3 modules**
  - A **Engine Module**
  - B **Ventilation Module**
  - C **Auxiliary Module**
- ✓ Electrical Output = **4.4MW**
- ✓ Electrical Efficiency = **>45% (natural gas)**
- ✓ Assembly time at site = **1 week per containerized package**
- ✓ Order to COD = **12 months**
- ✓ Dimensions of single module = **56 ft x 10 ft x 10.5 ft**
- ✓ **Engine**: V-24, 150L, lean burn, 1500rpm w/ gearbox, dual stage turbocharging, SCR, COP (continuous) rated

Integrated Power Module (IPM)

Outside the IPM

Inside the IPM

Delegation of Responsibility

Our Scope

- ✓ JMC 624 H01 13.8 kV generator & containers
- ✓ SCR & Oxidation Catalyst
- ✓ Urea Tanks with Anti-Freezing Protection
- ✓ Lube oil systems
- ✓ Exhaust stack
- ✓ Engine control system w/generator protection relays
- ✓ Control room
- ✓ Remote messaging & data transfer capabilities
- ✓ Generator protection
- ✓ Grid monitoring device
- ✓ Medium voltage junction box
- ✓ Low temp & high temp radiators
- ✓ Transportation to site & duties
- ✓ Assembly supervision
- ✓ Commissioning

Customer Scope

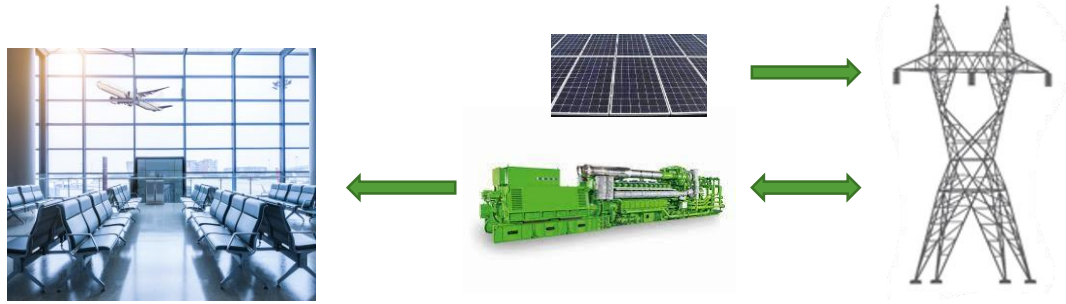
- ✓ Laying foundation
- ✓ Mechanical piping to/from IPM
- ✓ Electrical connections to/from IPM
- ✓ Step-up transformer
- ✓ Crane rental
- ✓ Three (3) skilled workers for mechanical & electrical assembly

Installation of a 20 MW power plant in 30 days

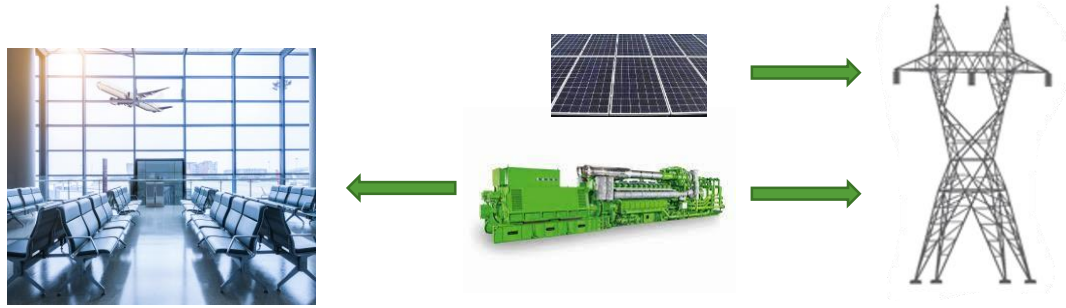
Day	Activities	Crane used
1	Positioning of crane, checking of foundations, preparation of tools, safety mtg	500 ton
2	Positioning of engine module 1-5, supplying of Infra module to foundation	500 ton
3	Positioning of infrastructure module 1-5	500 ton
4	Sealing of modules	500 ton
5	Installation of generators in engine modules 1-5, preparing of ventilation modules	500 ton
6	Positioning of ventilation-module 1-5, incl. assembly to other modules	500 ton
7-17	Mechanical completion of the containers, incl. all piping connections (water, gas and exhaust), setting V-cooler on top	40 ton
18-29	Final container assembly (finishing works incl. all internal cabling), cleaning	None
30	Electro-mechanical completion	None

Operating Modes

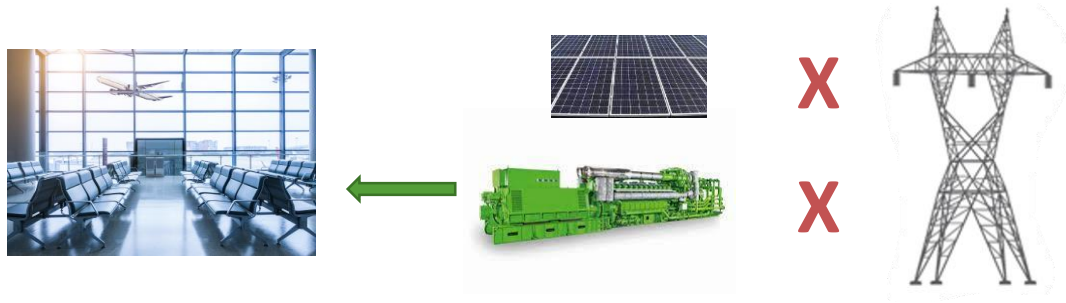
1) PV export, gensets load following, grid parallel



2) PV export, gensets net export, grid parallel

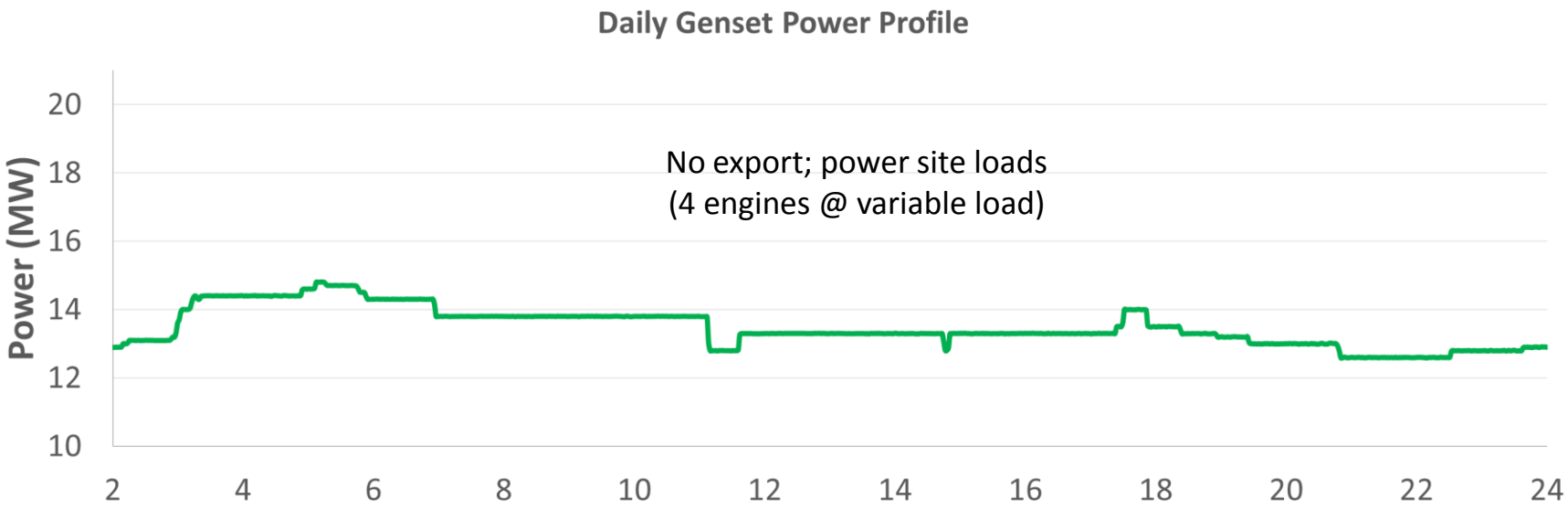


3) Island mode, grid outage, no PV generation

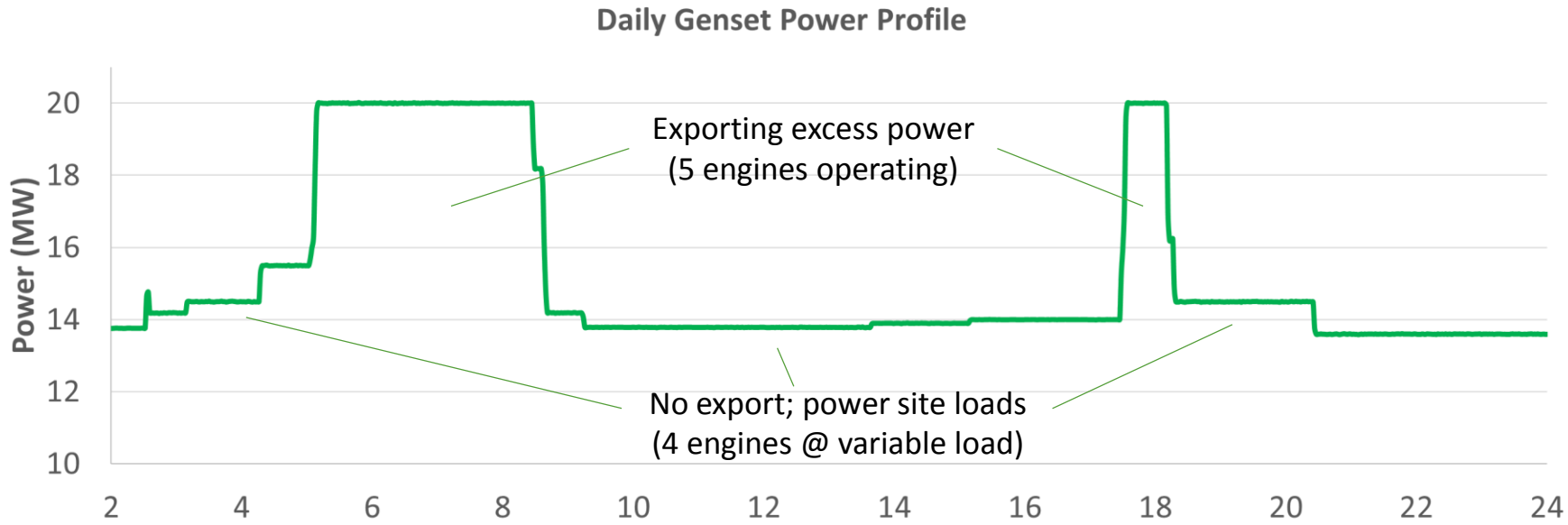


Operating Modes

Load following day (from 2-27-22)



Exporting day (from 2-18-22)



Energy Sell Back

ASSUME:

- SITE RETAINS CAPACITY VALUE
- SELLS ONLY ENERGY TO THE GRID
- PJM WEST PRICING (CME FUTURES)
- 9 MW EXCESS POWER TO SELL
- ON PEAK SALES ONLY

REVENUE OPPORTUNITY:

- CME FUTURES PRICE - $55.00/MWH
- 3,100 HOURS OF POWER SALES

- VALUE DERIVED **$1,500,000 PER YEAR**

Easy to Complex

MARKET REALITIES

- HYBRID MICROGRIDS ARE GETTING MORE COMPLEX
- CLIENTS ARE LOOKING FOR MORE INNOVATIVE SOLUTIONS
- THE NEED FOR INCORPORATING MORE **“GREEN”** RESOURCES IS BEING COMING MORE COST COMPETITIVE

EXAMPLE PROJECT

- **CLIENT:** (CONFIDENTIAL)
- **LOCATION:** CALIFORNIA
- **STATUS:** FINISHED SCHEMATIC DESIGN- PERMIT PACKAGE DUE BY JUNE, IFC SET DUE BY END OF YEAR.
- MAJOR COMPONENTS
  - 5 MW SOLAR
  - 8 MW ORC
  - 8 MW FUEL CELLS
  - 2 MWH ENERGY STORAGE
  - 10 MW ENGINES (COFIRED ON H_2 & NG)
  - CARBON SEQUESTRATION

The path forward

- **The market is changing … embrace it in a pragmatic way that works for your business**
- **Need a strong partner that understands all the technologies**
- **Listen to clients to determine what is their motivation (the 3R's)**
- **No one pursues a project unless it meets their financial hurdles; so be sure to understand their value proposition (i.e., energy savings, value of "green" to their customers, added sales…)**
- **It takes a team to make these projects work**