

Caterpillar Microgrid Technology

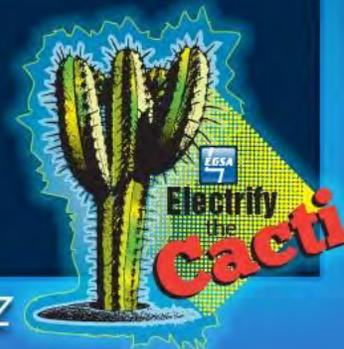
Paul Newman
Microgrid Sales Manager
North America - West



Electrical Generating Systems Association

Caterpillar: Confidential Green

2019 Fall Conference - Scottsdale, AZ



Microgrid Definition:

Any localized grid with its own power generation resources, loads and definable boundaries and acts as a single controllable entity qualifies as a microgrid.

A power grid that:

1. Can operate independently and
2. Operate in conjunction with the area's main electrical grid



Caterpillar has been involved
with Microgrids for 80+ years



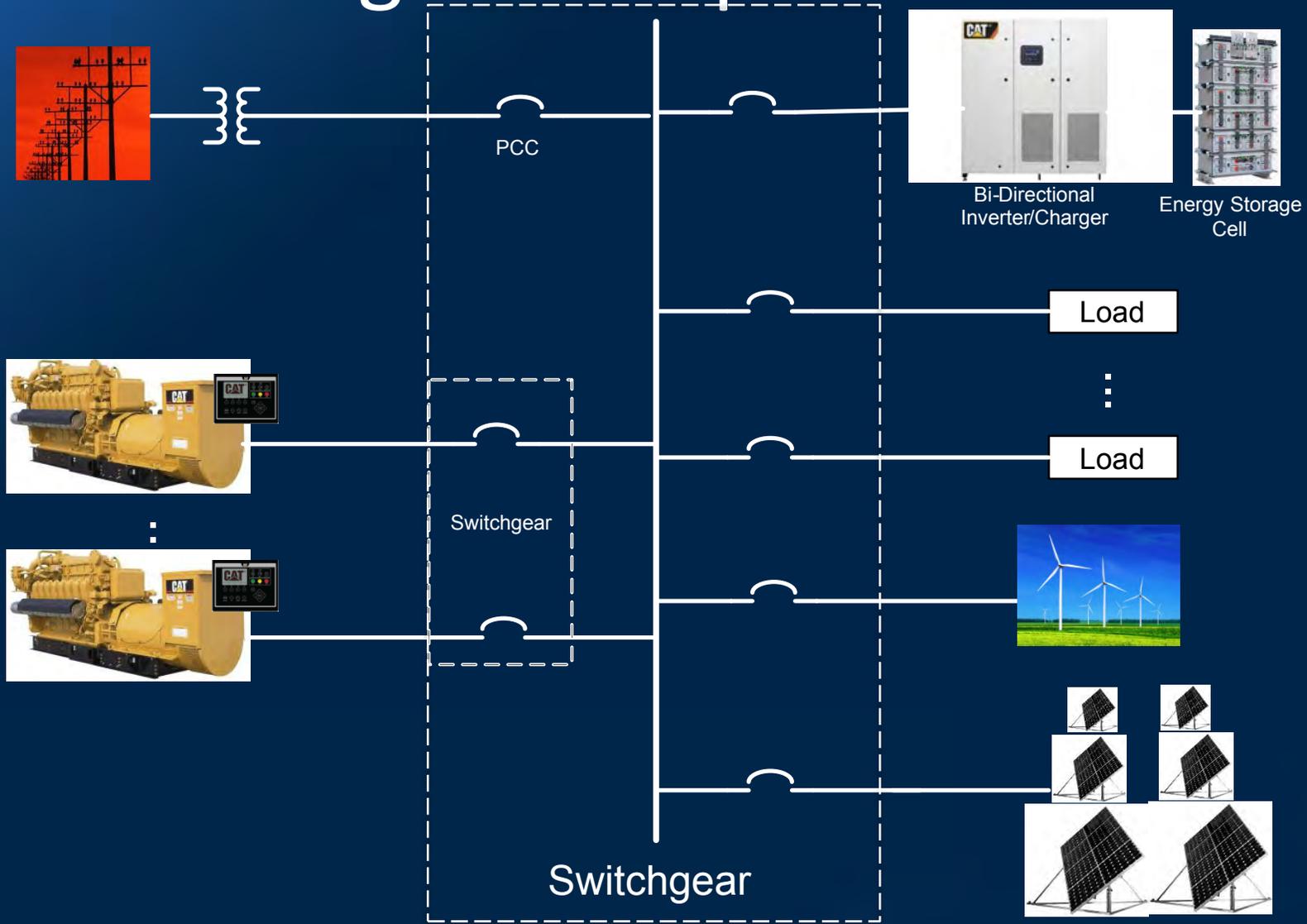
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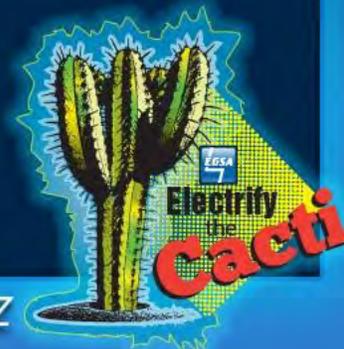
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Microgrid Components



Tucson Proving Grounds Case Study

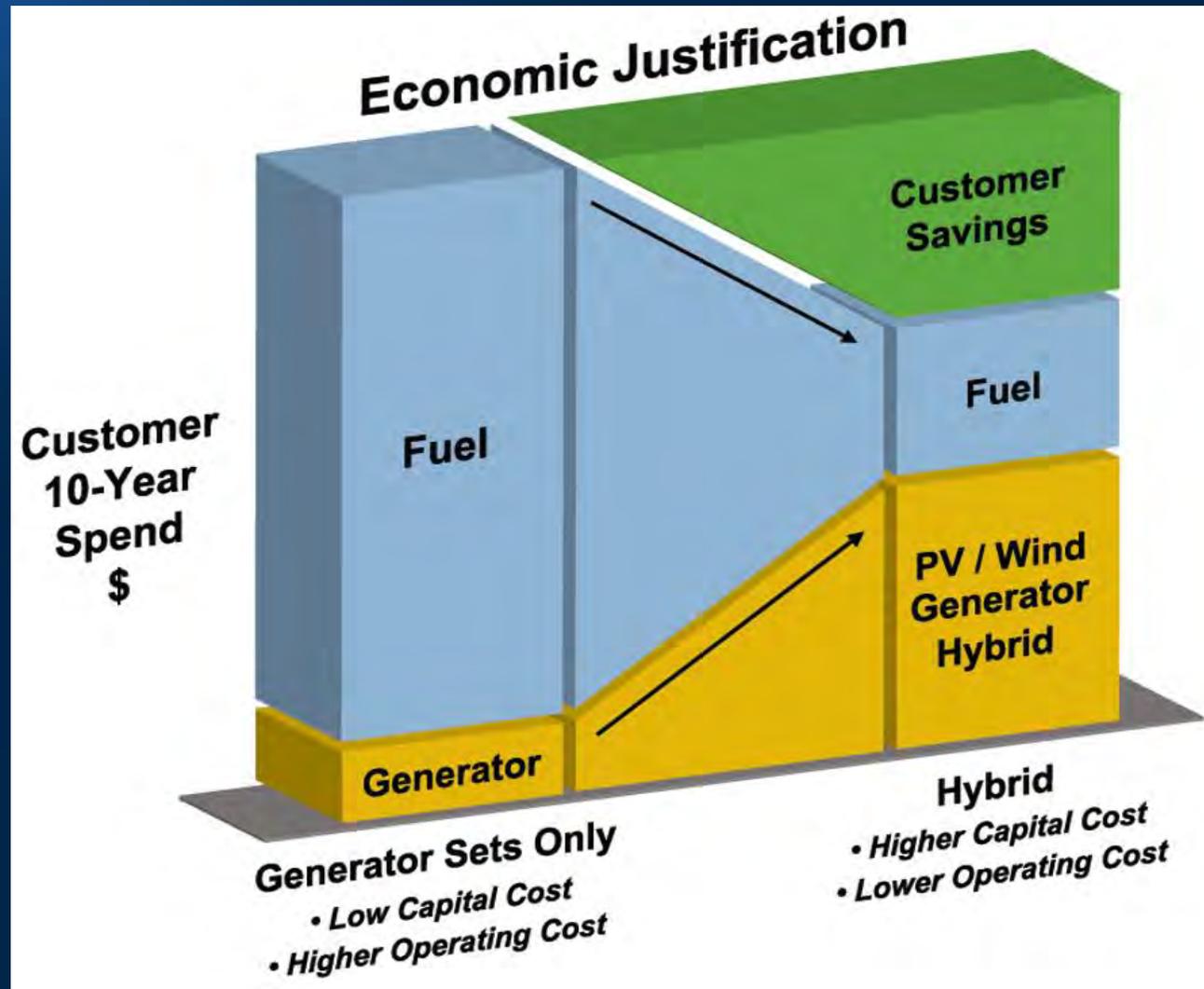


Microgrid at Tucson Proving Ground -- *Project Drivers*

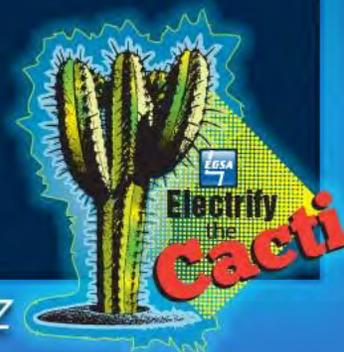
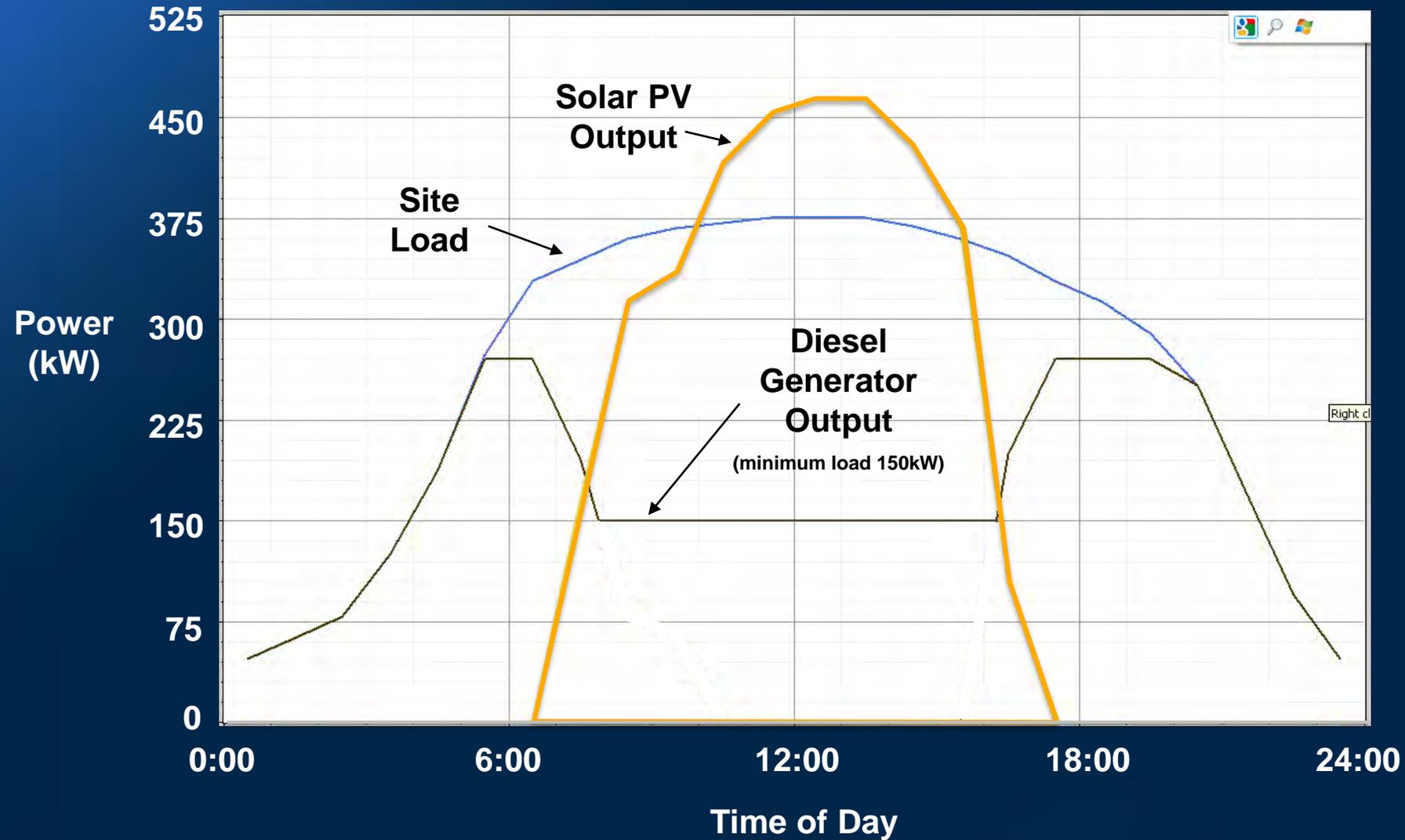
- No utility service at Tucson Proving Ground
- Grid extension is cost-prohibitive (8 miles to Green Valley)
- Site average load is ~ 300kW. Peak load is ~ 550kW.
- Traditional diesel prime power with 3 x C15 410ekW prime generator sets
- Diesel fuel consumption ~250,000 gallons per year
- Generator set operation 11,000 hours per year



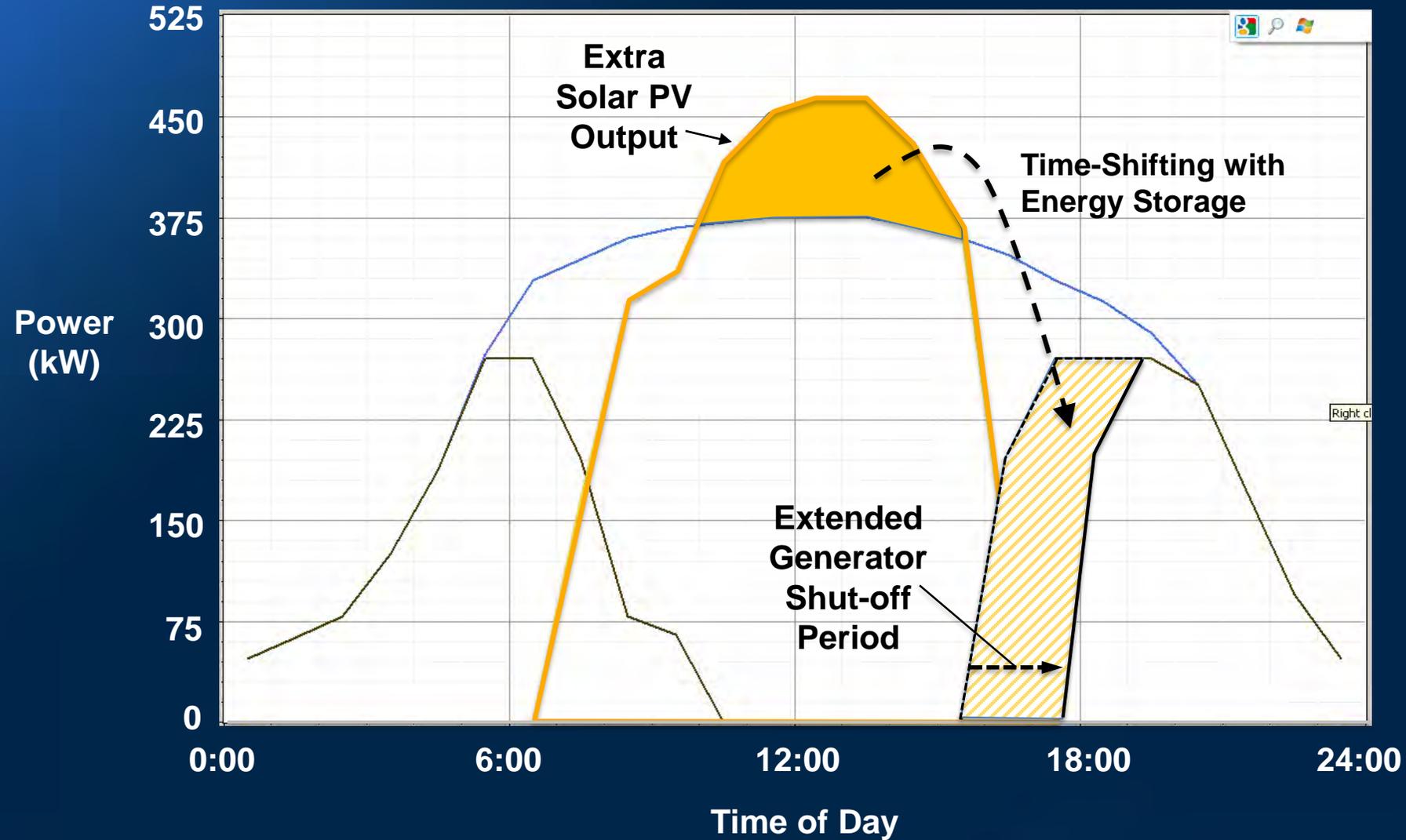
Remote Hybrid Microgrid – Economics



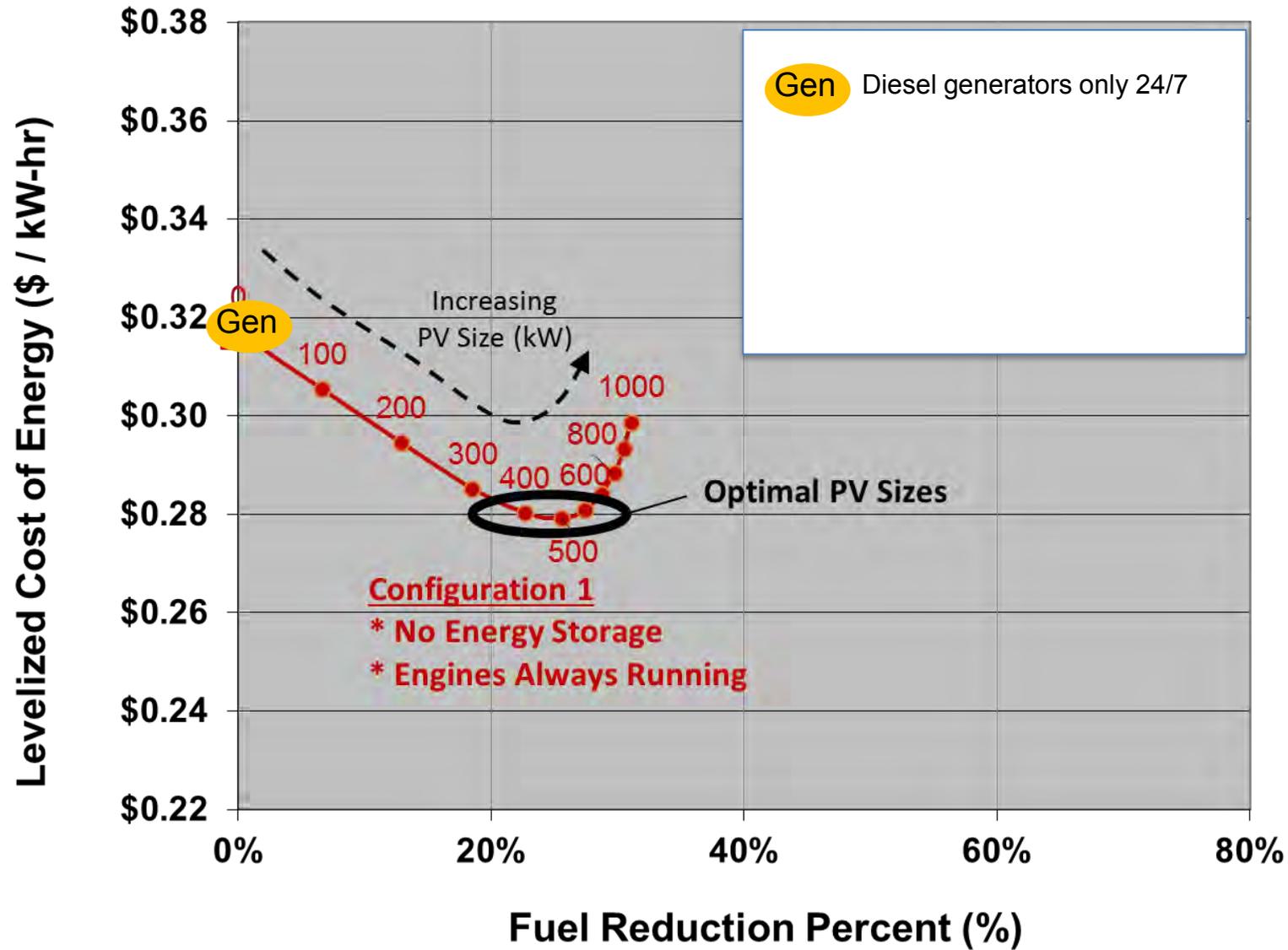
Typical Microgrid Operation: Daily Load & Generation Profiles



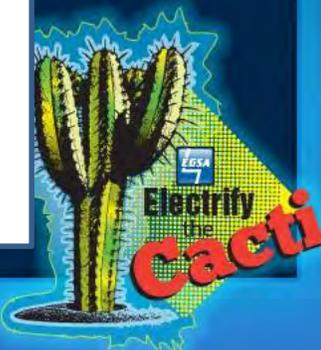
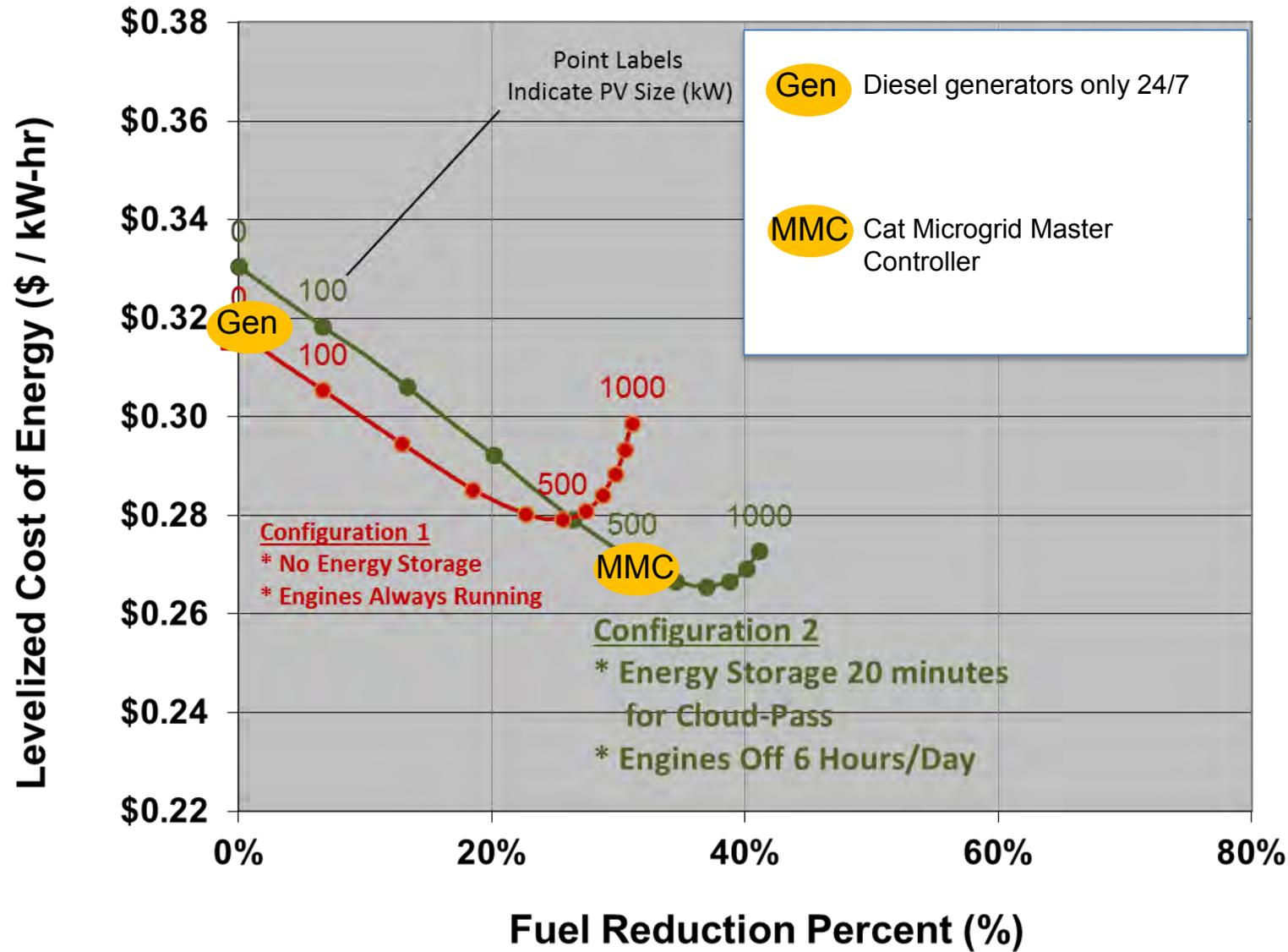
Typical Microgrid Operation: Daily Load & Generation Profiles



Selection of Optimum PV & Energy Storage Size



Selection of Optimum PV & Energy Storage Size



TPG Microgrid System Diagram

PV Fixed Array 250kW



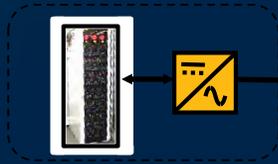
PV Tracking Array 250kW



Energy Storage
Lithium Ion Battery
250kW / 10 min



Energy Storage
Ultra-capacitor
250kW / 30 sec

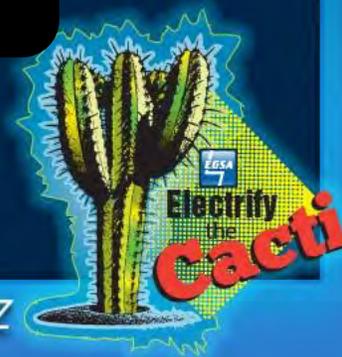


3 x Cat C15
410kW Prime

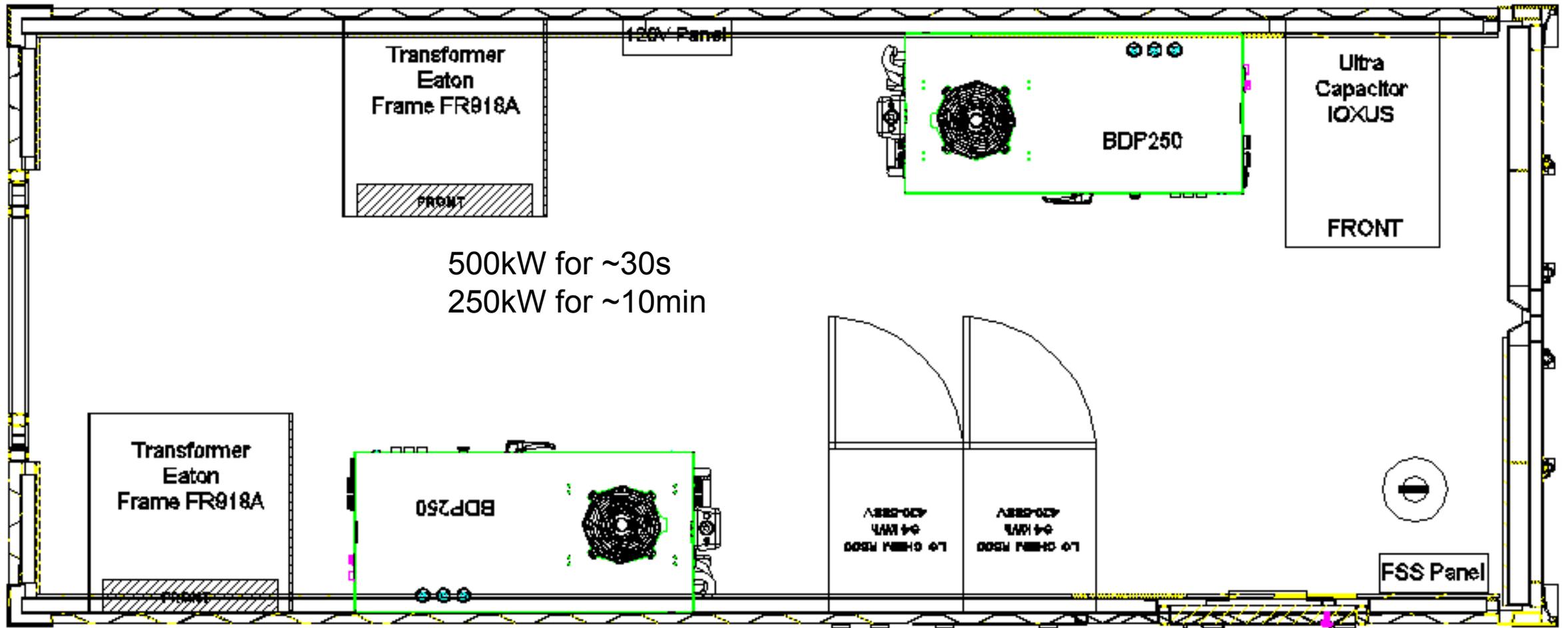


Site
Prime
Power
Loads

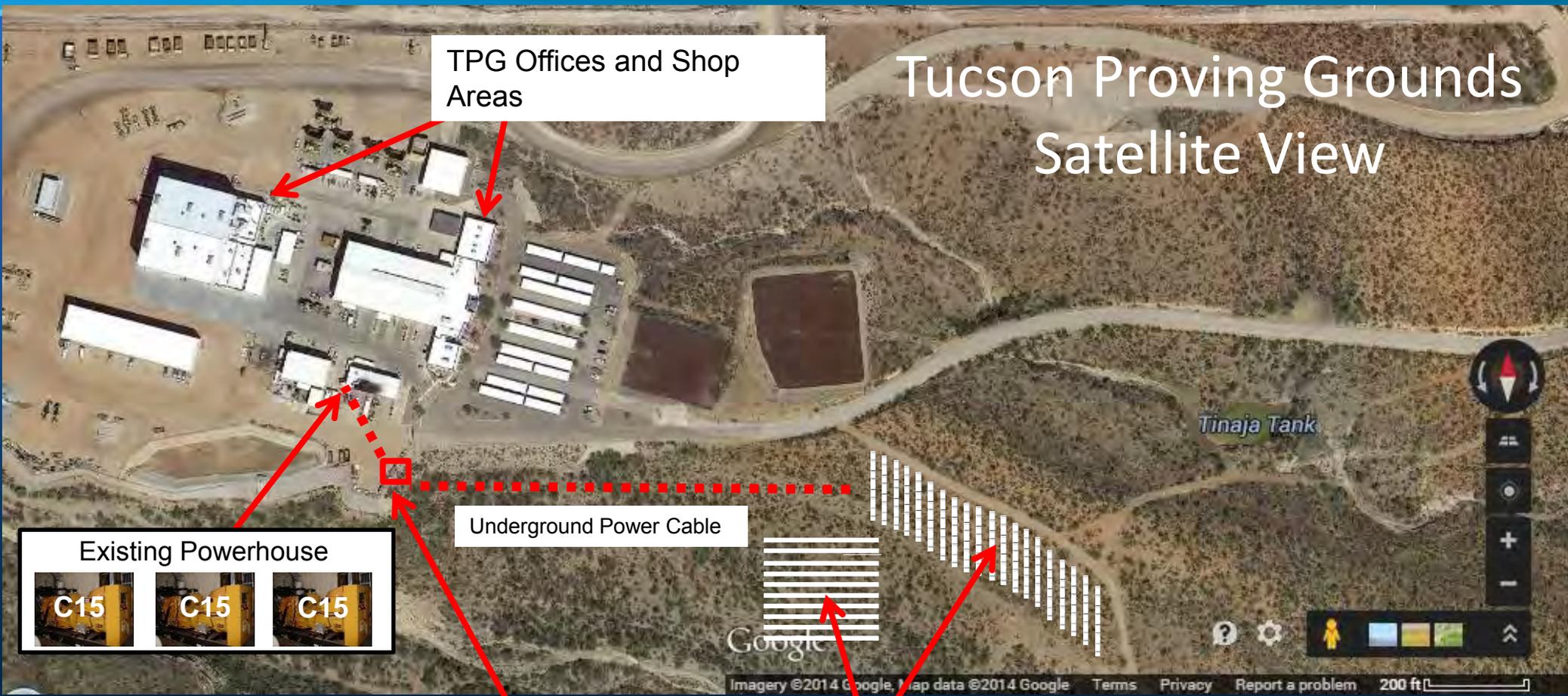
Cat
Switchgear



20' Hybrid



Tucson Proving Grounds Satellite View



TPG Offices and Shop Areas

Existing Powerhouse

C15 C15 C15

Underground Power Cable

Tinaja Tank

Energy Storage:
Lithium Ion Battery
250kW
Ultracap 250kW
in 20' Enclosure

Solar Panel Arrays: Cat-Branded Thin Film manufactured by First Solar

- 250 kW Fixed-tilt
- 250 kW Single-Axis Tracker





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LOW COST MODE



LOAD

(P) 355 kW $\frac{4}{4}$

(Q) 100 kVAr $\frac{4}{4}$

(PF) 0.97

355 kW



HIGH VOLTAGE

478 V

60.2 Hz

0 kW



361 kW



480 kW

-4 kW



GEN

(P) 0 kW $\frac{0}{3}$

(Q) 0 kVAr

(PF) 0

MMC in Control

PV

(P) 361 kW $\frac{20}{20}$

(Q) 0 kVAr

(PF) 1

ESS

(P) -4 kW

(Q) 100 kVAr

(PF) -0.04

87% | 87%

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Tucson Proving Grounds: Remote Monitoring Interface



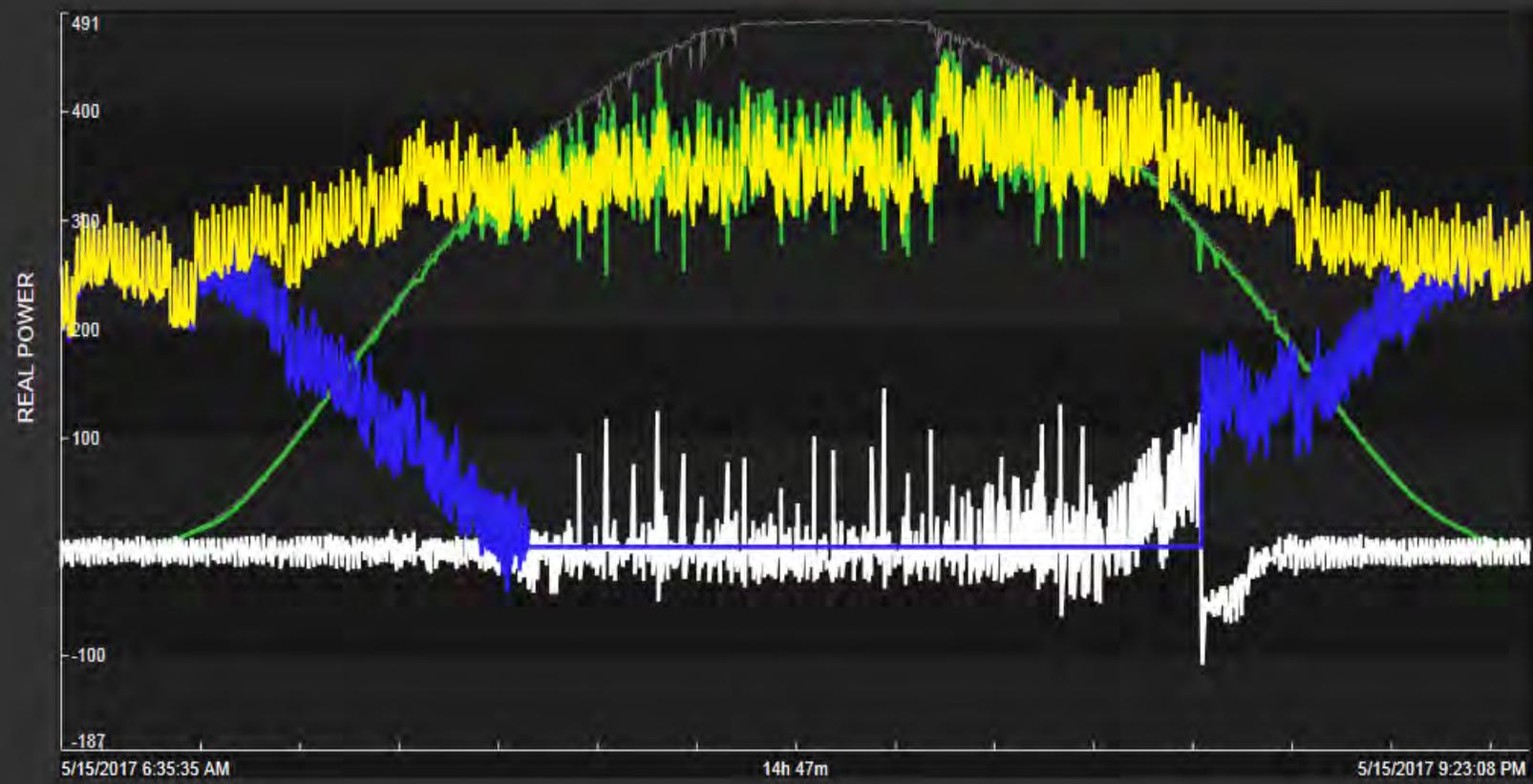
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LOW COST MODE



ENERGY YIELD

REAL POWER



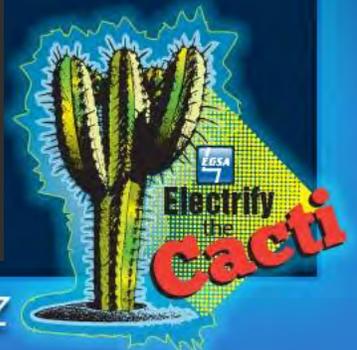
Generator Plant Total
244 kW

Generator Set Total Power
244 kW

PV Total Power
0 kW

BDP Generator Total Real Power
-3.2 kW

PV Maximum Available Power
0 kW



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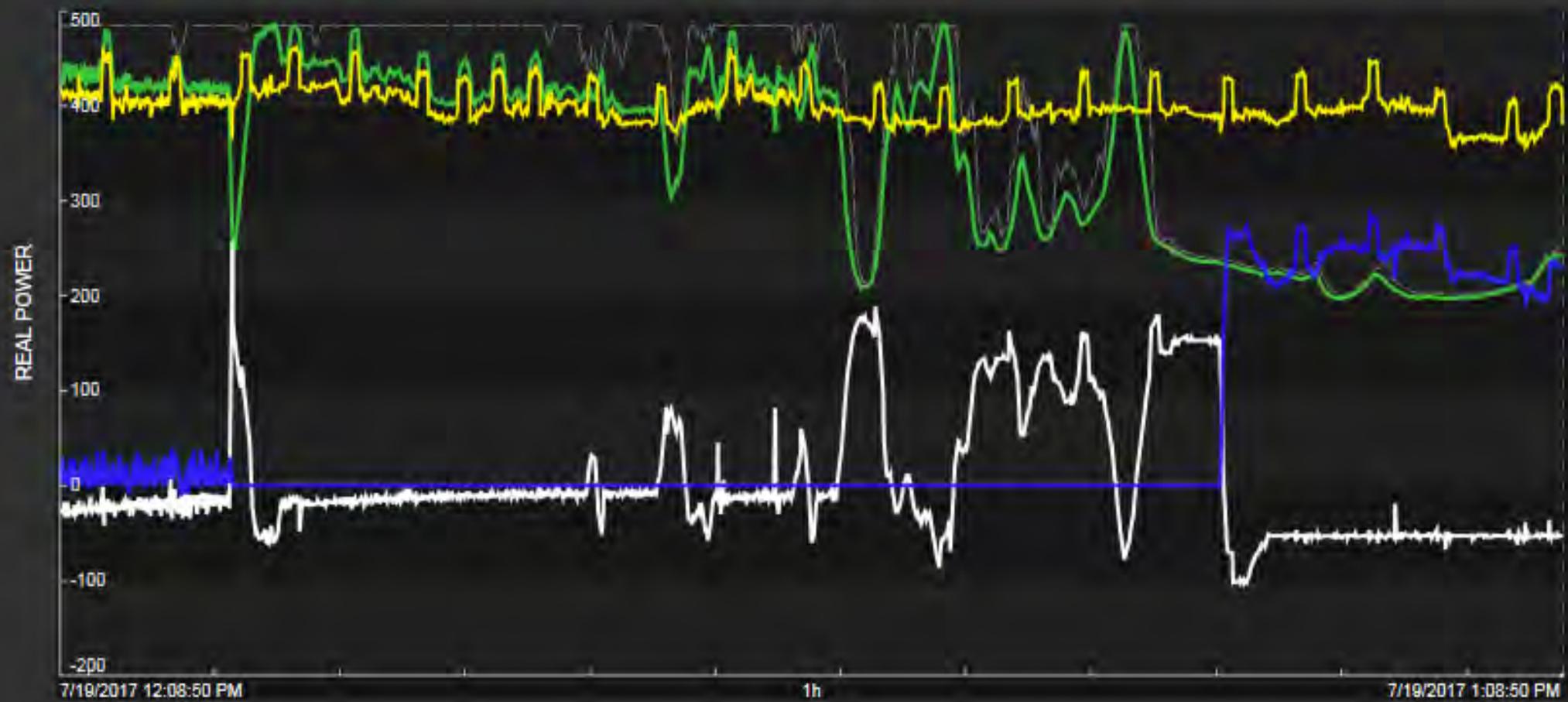


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LOW COST MODE



ENERGY YIELD

REAL POWER



Generator Plant Total
373 kW

Generator Set Total Power
330 kW

PV Total Power
243 kW

BDP Generator Total Real Power
-51 kW

PV Maximum Available Power
153 kW



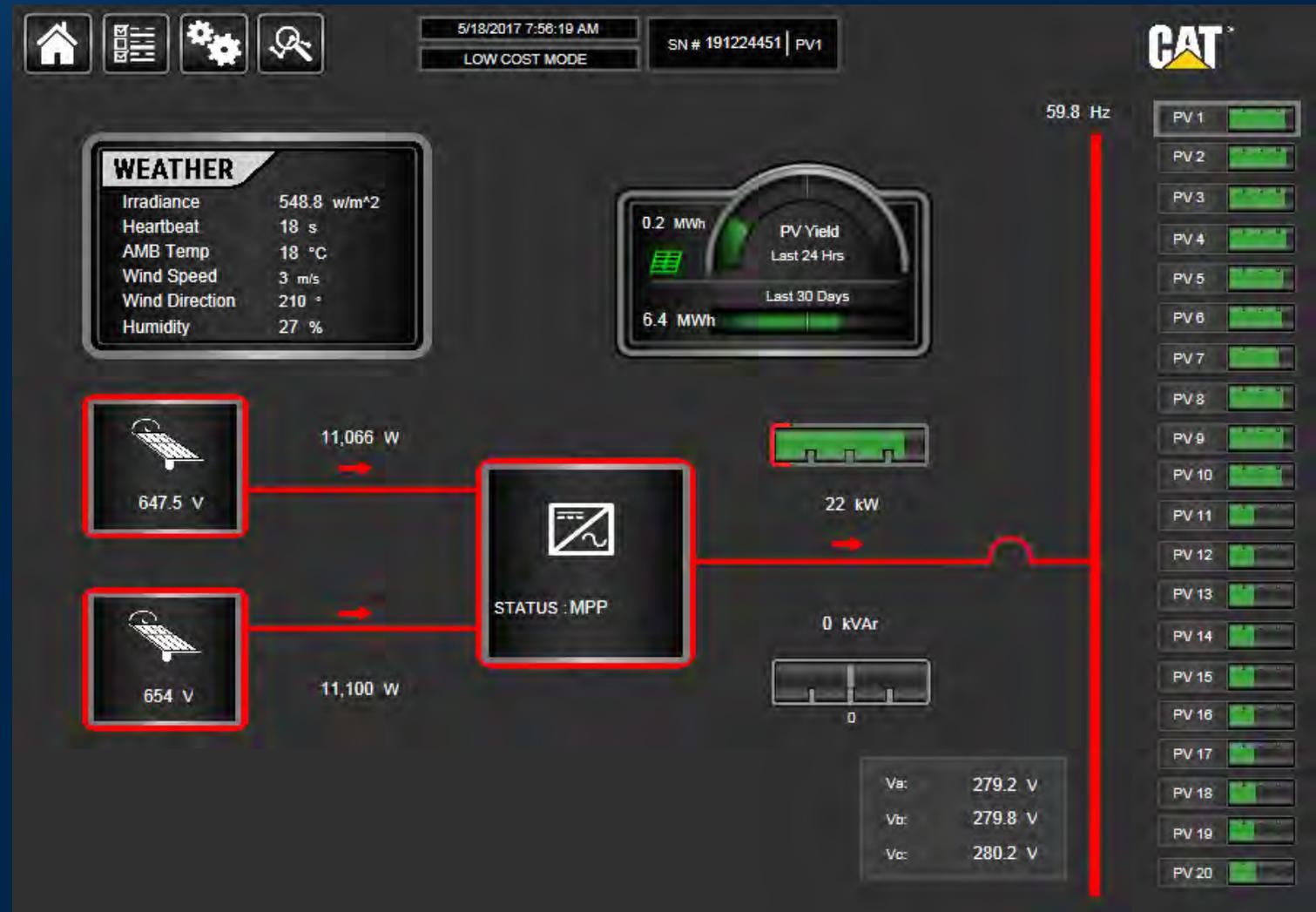
Tucson Proving Grounds: Remote Monitoring Interface

- **PHASE 1**

- 1.1MW-hr annually
- 37% Fuel reduction
- 18.5% Single Axis Tracker energy capture advantage
- 8% PV Curtailment

- **PHASE 2**

- Interconnect 2nd facility
- PV ready carports
- Additional ESS
- Higher renewable penetration



Tucson Proving Grounds Microgrid – 2015 *Financials*

Installed Cost before Tax Credit	\$2.20M
- minus Federal Tax Credit	-\$0.65M
<u>- minus Arizona Tax Credit</u>	<u>-\$0.05M</u>
Effective Project Cost after Tax Credit	\$1.50M (\$2.85/W)

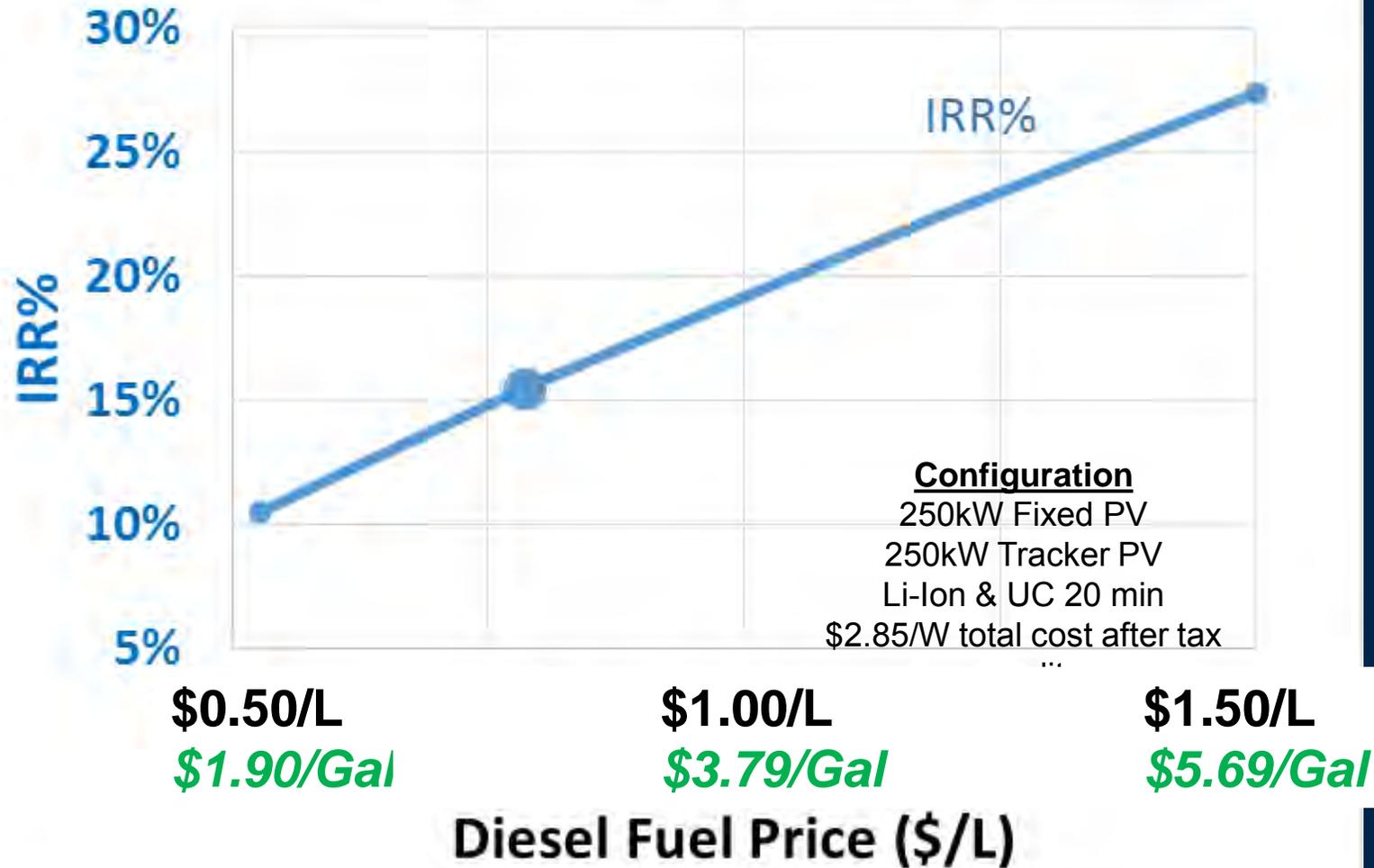
Reduces Fuel Cost 33%

Reduces Genset Maintenance & Repair Cost 25%

Project IRR: 15% at diesel fuel price \$0.79/L (\$2.98/gallon)



Tucson Proving Grounds Solar PV Project Financial Sensitivities



Thank You!



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