

Caterpillar Microgrid Technology

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Electrical Generating Systems Association

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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



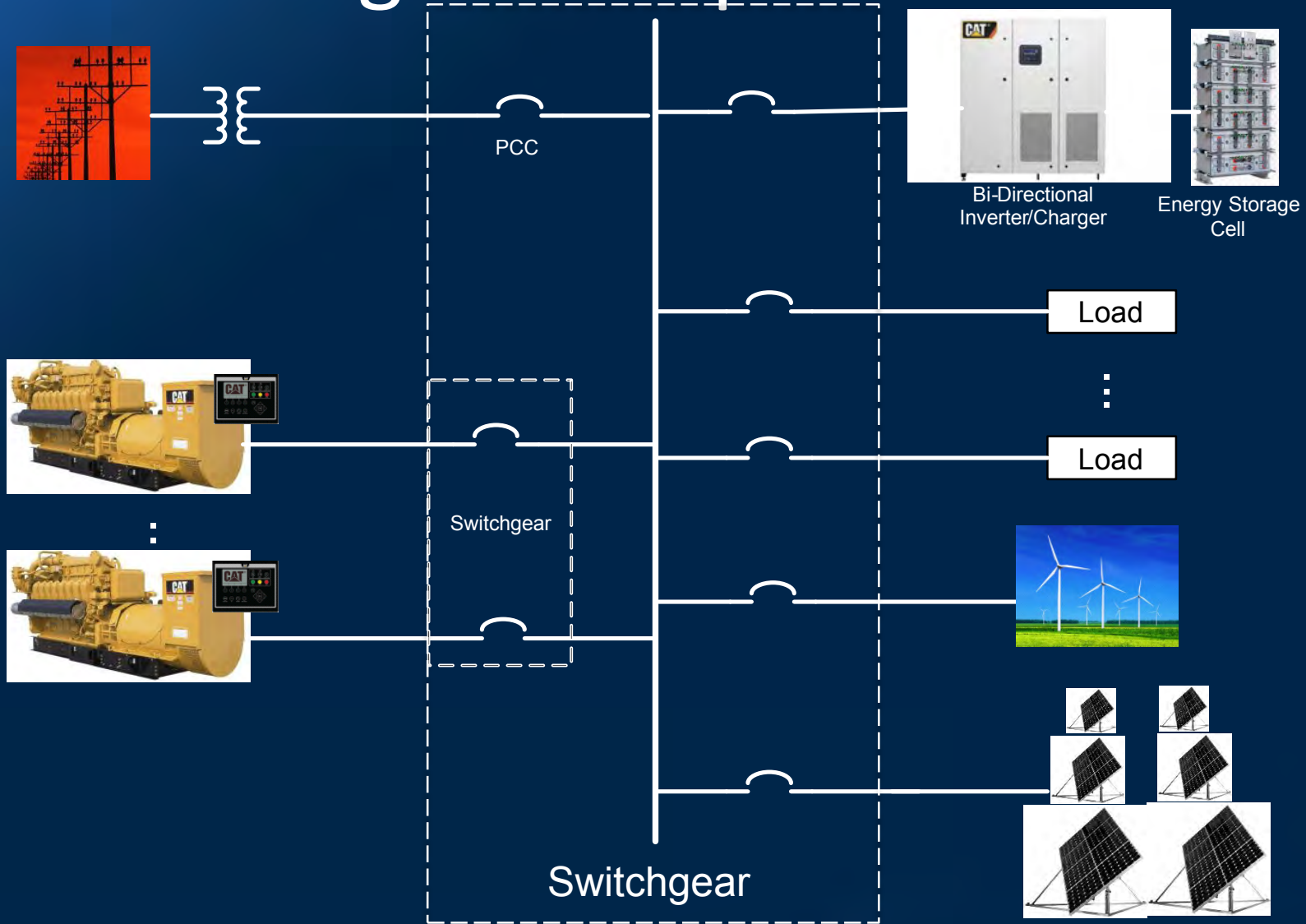
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Microgrid Components



Tucson Proving Grounds Case Study



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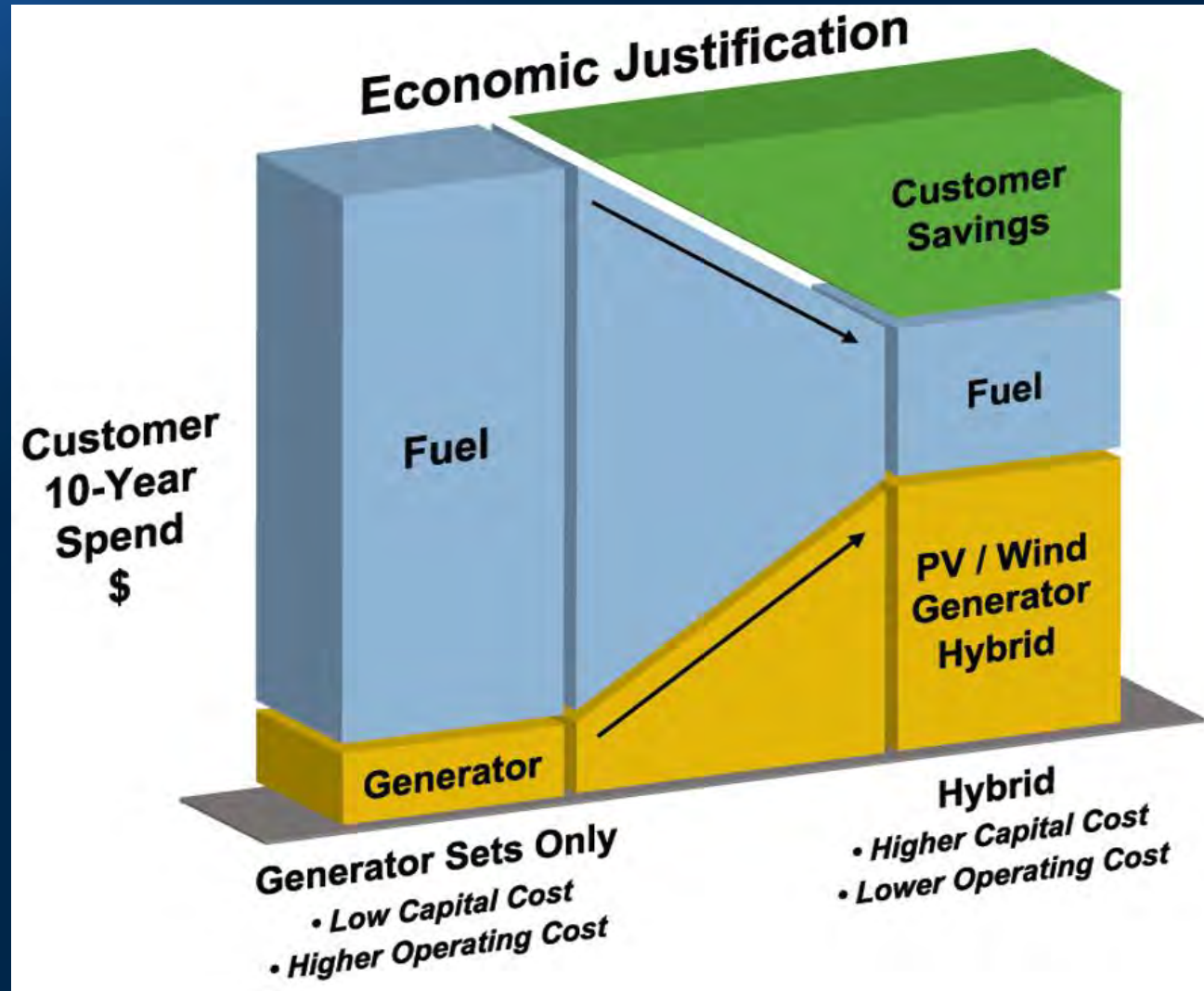


Microgrid at Tucson Proving Ground -- *Project Drivers*

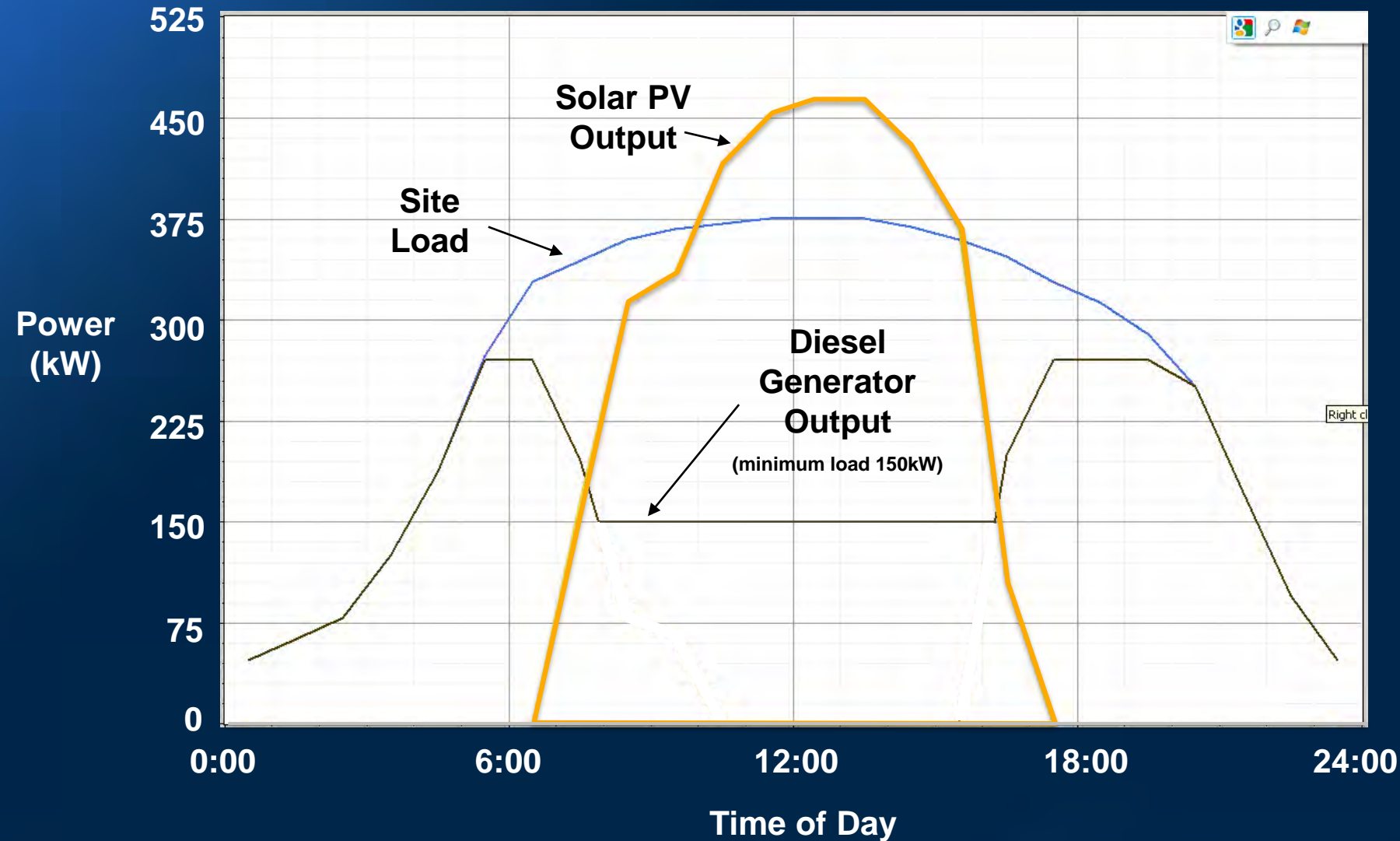
- No utility service at Tucson Proving Ground
- Grid extension is cost-prohibitive (8 miles to Green Valley)
- Site average load is ~ 300kW. Peak load is ~ 550kW.
- Traditional diesel prime power with 3 x C15 410ekW prime generator sets
- Diesel fuel consumption ~250,000 gallons per year
- Generator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



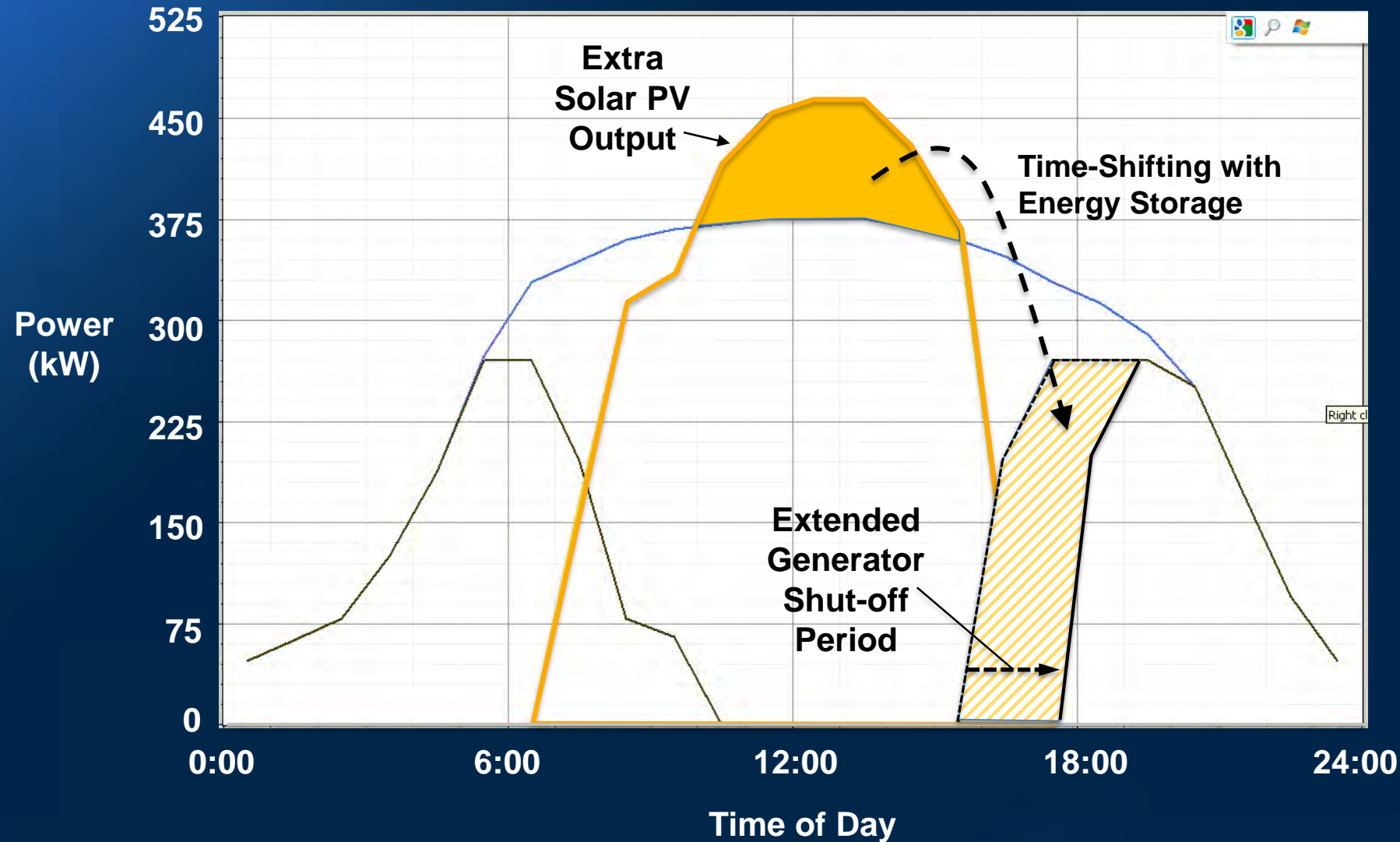
Remote Hybrid Microgrid – Economics



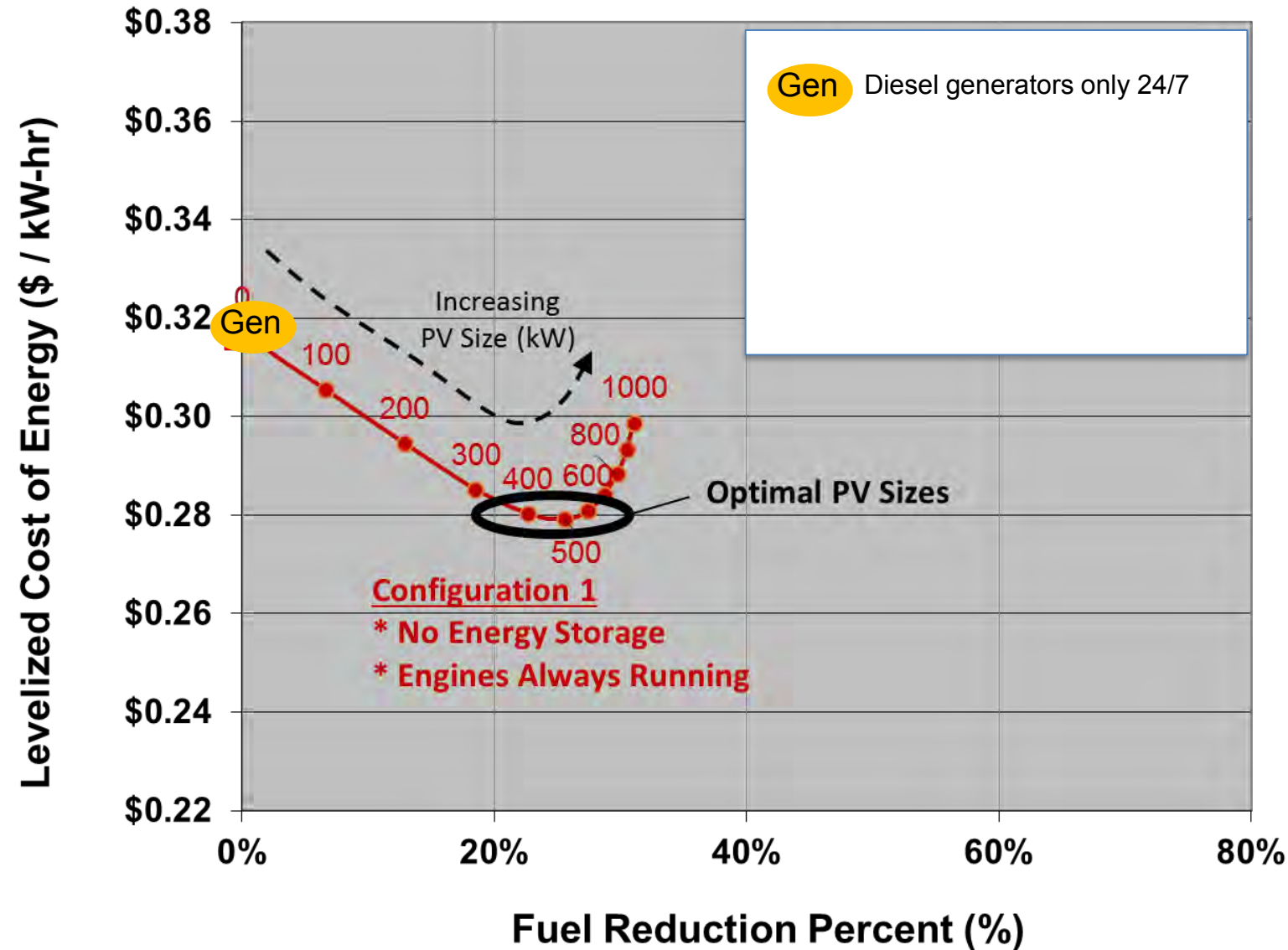
Typical Microgrid Operation: Daily Load & Generation Profiles



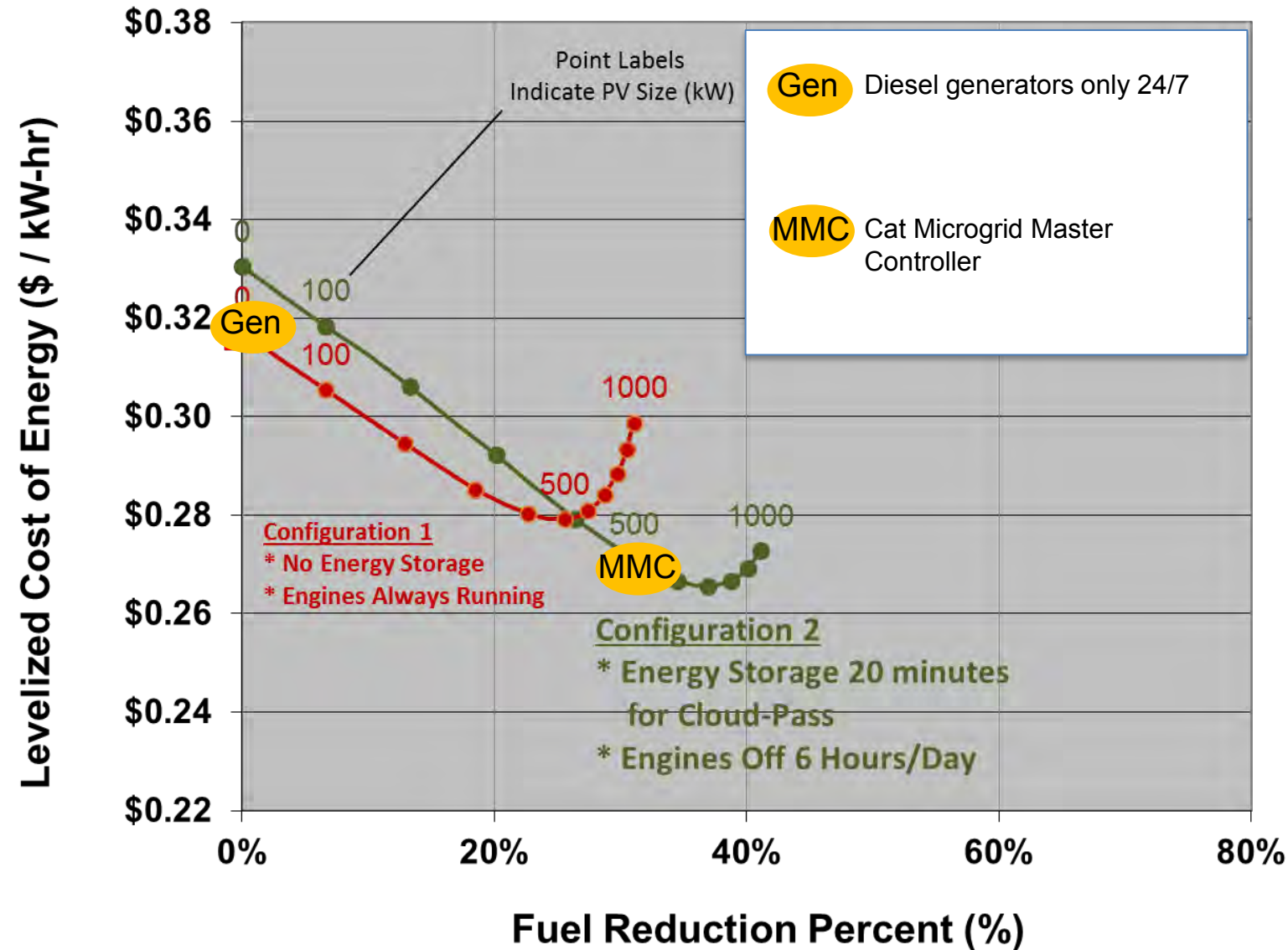
Typical Microgrid Operation: Daily Load & Generation Profiles



Selection of Optimum PV & Energy Storage Size

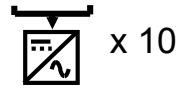


Selection of Optimum PV & Energy Storage Size

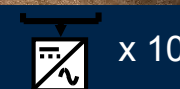


TPG Microgrid System Diagram

PV Fixed Array 250kW



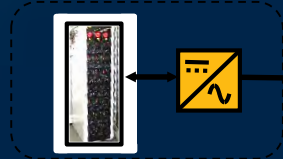
PV Tracking Array 250kW



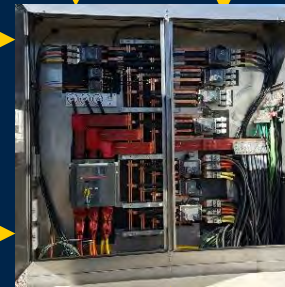
Energy Storage
Lithium Ion Battery
250kW / 10 min



Energy Storage
Ultra-capacitor
250kW / 30 sec



3 x Cat C15
410ekW Prime



Cat
Switchgear



Site
Prime
Power
Loads

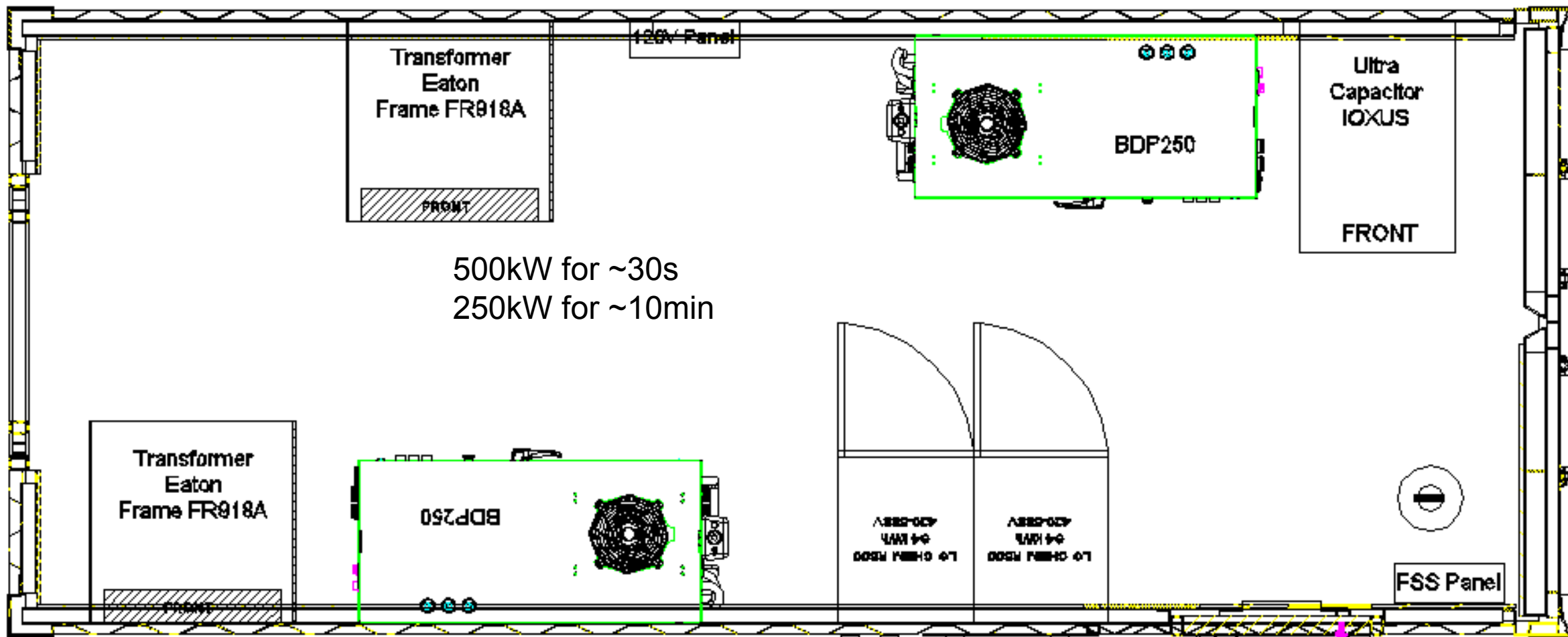


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20' Hybrid



Tucson Proving Grounds Satellite View

TPG Offices and Shop
Areas

Tinaja Tank

Underground Power Cable

Existing Powerhouse



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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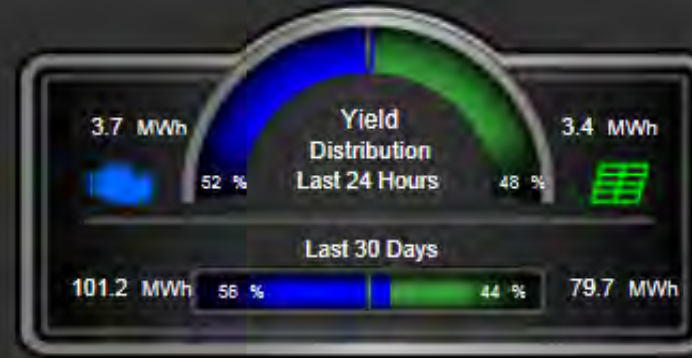
LOW COST MODE



LOAD

(P) 355 kW $\frac{4}{4}$ 
(Q) 100 kVAr
(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 $\frac{1}{1}$
(PF) -0.04 87 % 87 %

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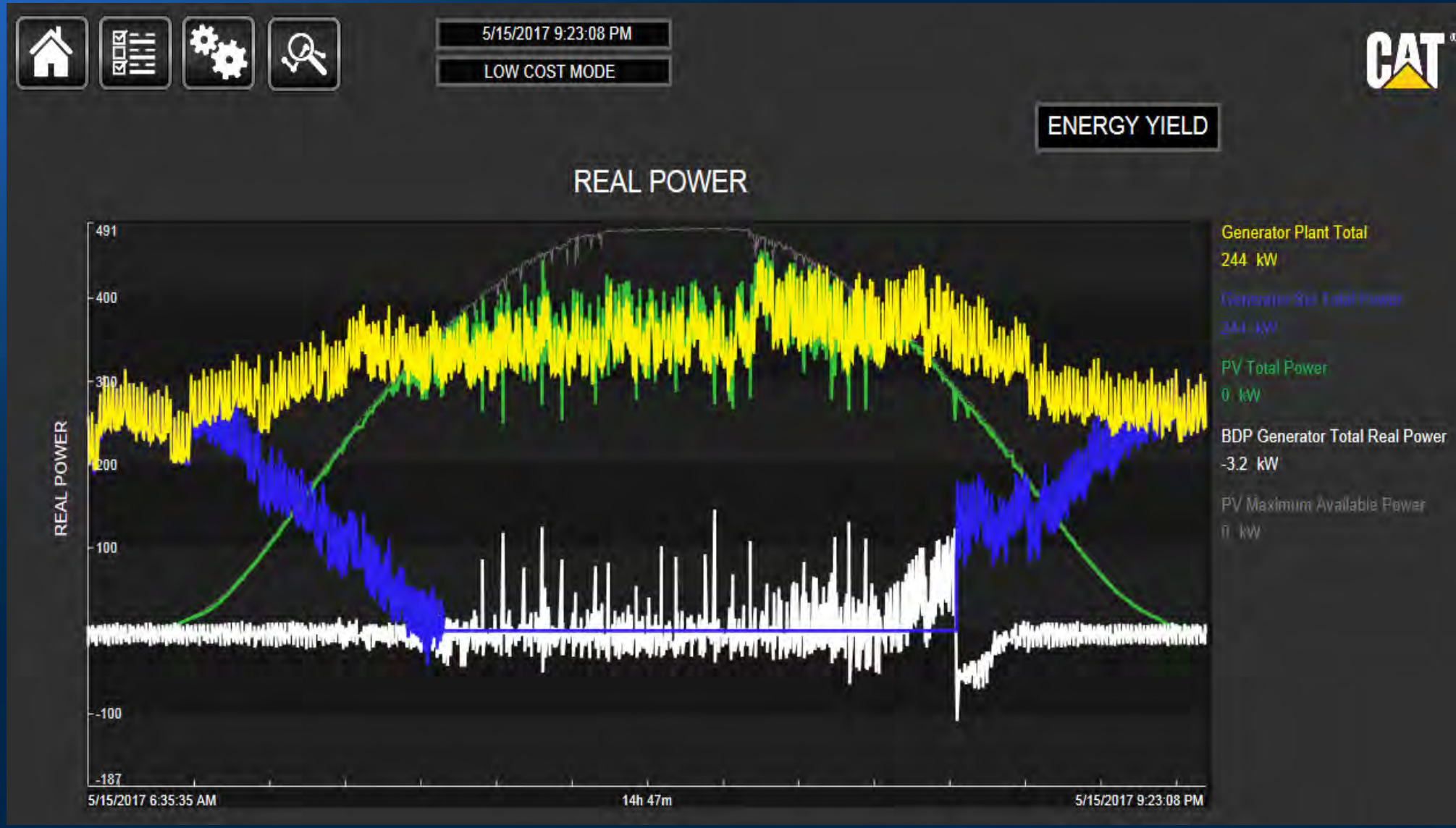


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Tucson Proving Grounds: Remote Monitoring Interface





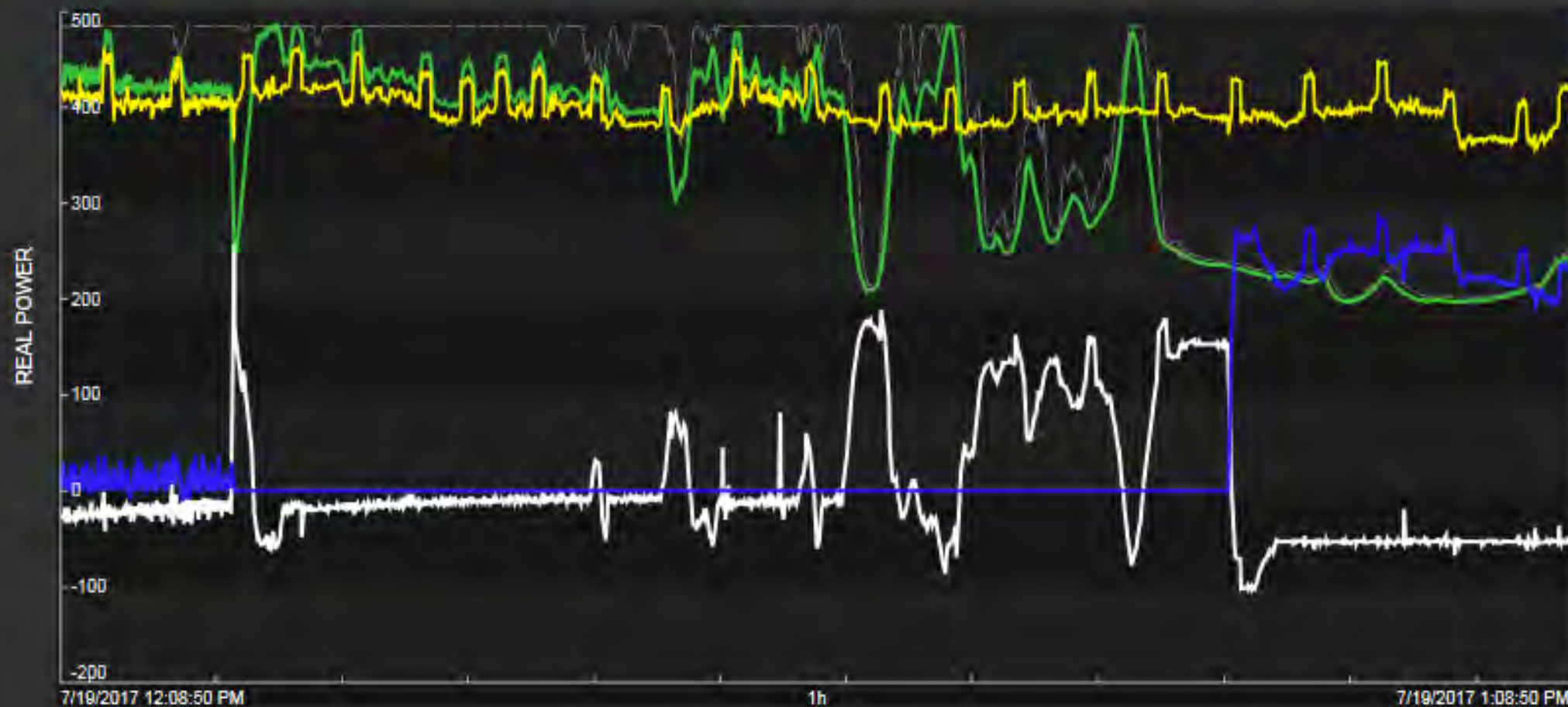
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LOW COST MODE



ENERGY YIELD

REAL POWER



Generator Plant Total

373 kW

Generator Set Total Power

239 kW

PV Total Power

243 kW

BDP Generator Total Real Power

-51 kW

PV Maximum Available Power

353 kW



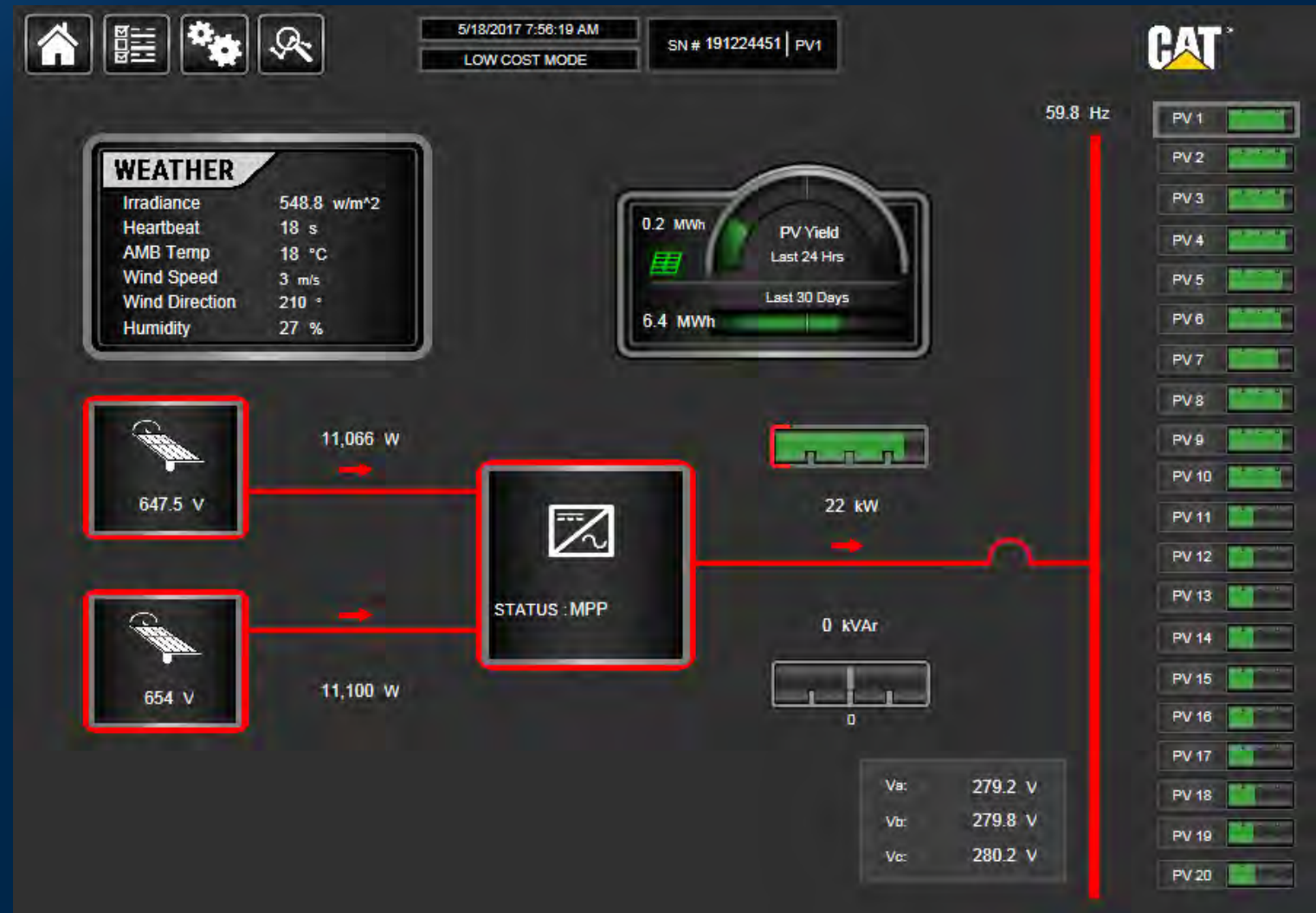
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Tucson Proving Grounds: Remote Monitoring Interface

- **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)

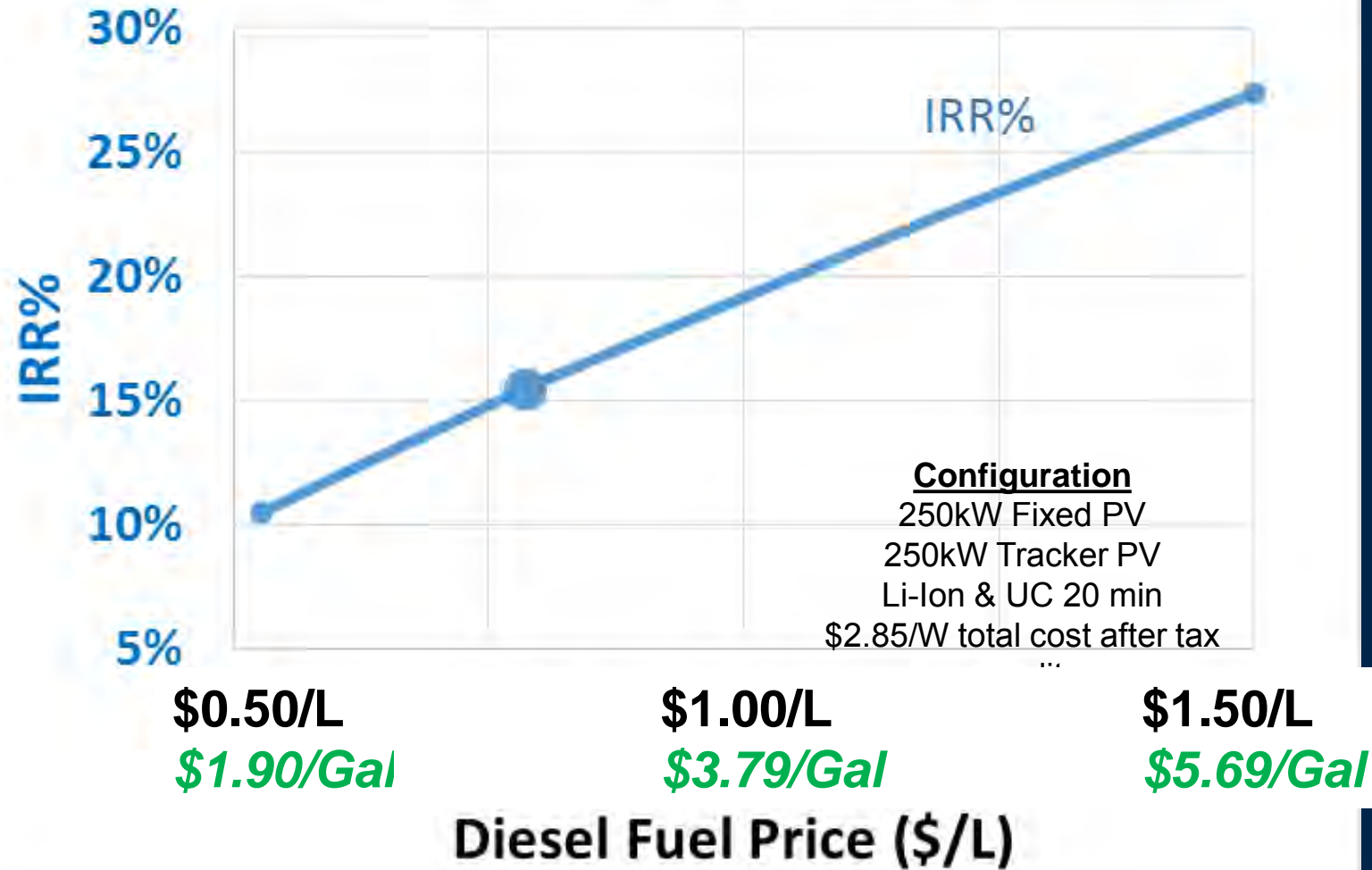
Reduces Fuel Cost 33%

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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