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WELLHEAD

Hybrid Energy Storage/EGT

**IEPR Commissioner Workshop on Renewable
Integration and Electric System Flexibility**

Sacramento

June 20, 2018

Hybrid Energy Storage – Electric Gas Turbine (EGT®)

Goal of hybridization – Maximize the flexibility of existing gas-fired generation by integrating energy storage capabilities

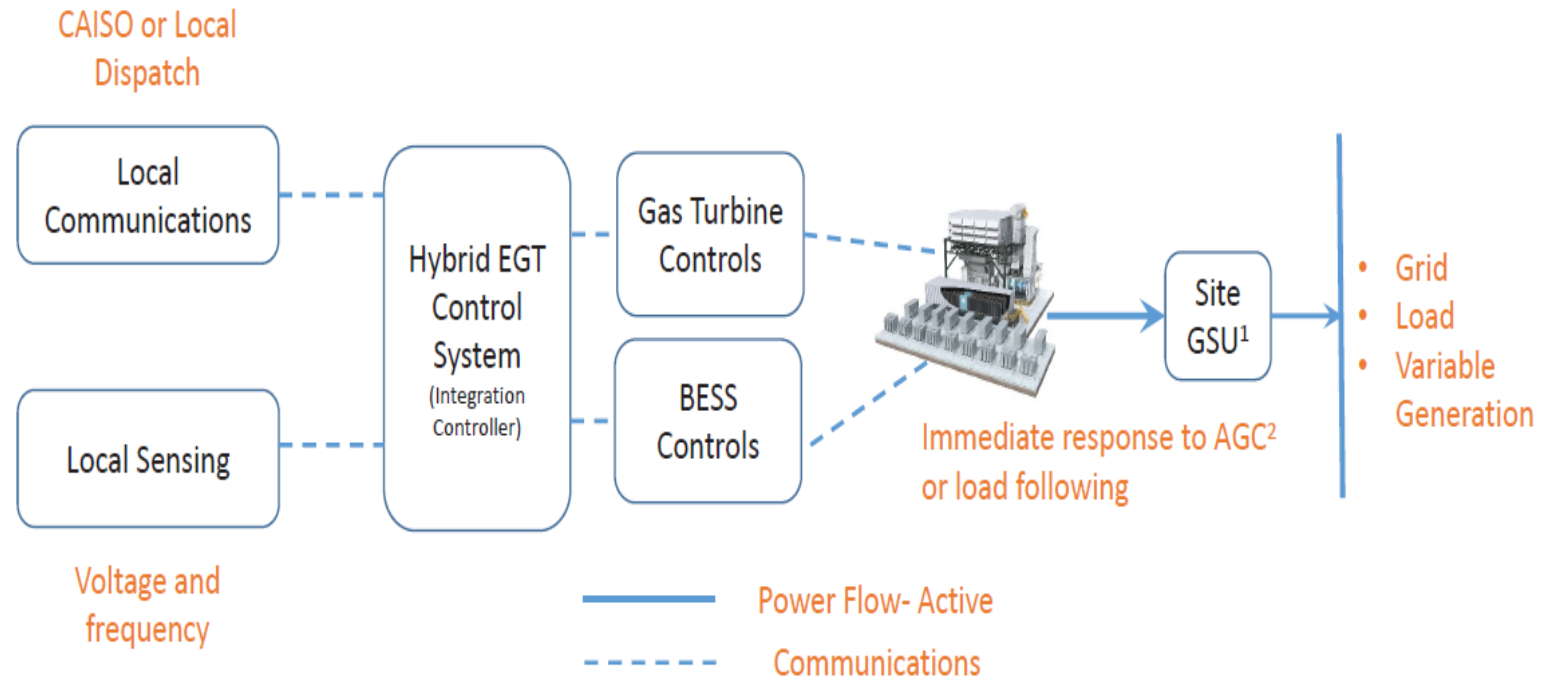
Flexibility benefits of the EGT®

- Eliminate Pmin (0.00 MW)
 - Full use of entire operating range between Pmin and Pmax without constraint
- Eliminate minimum run time (e.g. run 5 second or 5 hours)
- Eliminate minimum down time (i.e. immediate turn around time)
- Automated energy management (Battery SOC, Start/Stop of CT)
- Provides GHG-free spinning reserves
- Provides high-speed, high accuracy regulation
- Automated response (with or without fuel)
 - Primary frequency response
 - Voltage support

Technology has now been deployed at SCE's Center and Grapeland sites

- Primary use case has changed from a Peaker to a Reliability Center
 - GHG-free spinning reserves
 - GHG free voltage support
 - High-speed, accurate regulation

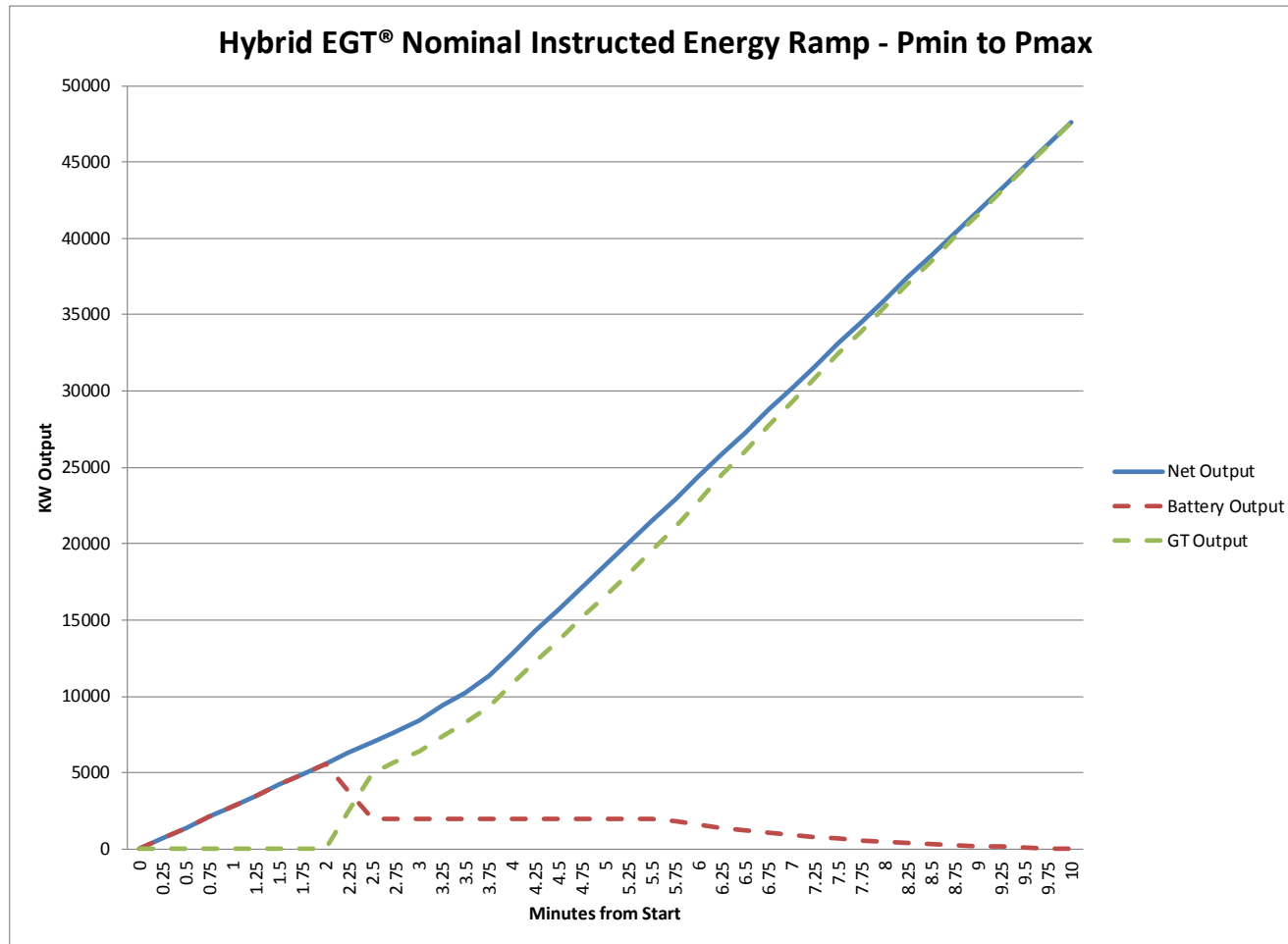
Hybrid EGT[®] Control Diagram



1, Generator Step-up Transformer

2, Automatic Generation Control

Hybrid EGT® Variable Ramping for Instructed Energy



Benefits in the CAISO market

Current dispatch example without EGT

- CCGTs hold back MW for spinning reserves (34% in 2017¹). Simple example:
 - 500 MW CCGT runs at 330 MW for energy
 - 170 MW reserved for contingencies
- CTs dispatched & held on-line at Pmin when required for flexi-ramp and local constraints such as voltage support
 - Pmin energy is not needed and may result in renewable curtailment
- CTs are dispatched for energy to meet peak

Dispatch with EGT® available for spinning reserves and local constraints

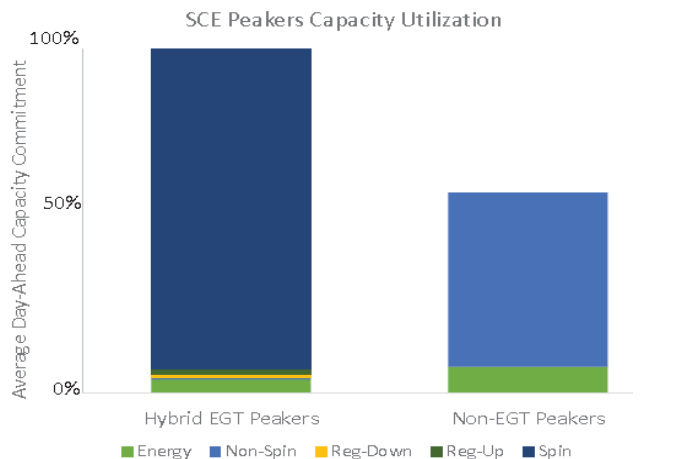
- EGTs provide GHG-free spinning reserve unless energy is required
- 100% of CCGT operating range is now available for energy
 - CCGT can run at 500 MW, ~20-30 btu/kwh better heat rate for the system, and lower the system GHG as much as 38,000 MT/EGT per year²
 - CCGTs have larger downward ramp capability for flexi-ramp
- System Pmin burden is reduced
- Peak energy can now be met with most efficient resources
- EGTs provide reduced local emissions, benefit Disadvantaged Communities

1, CAISO 2017 Annual Report on Market Issues and Performance

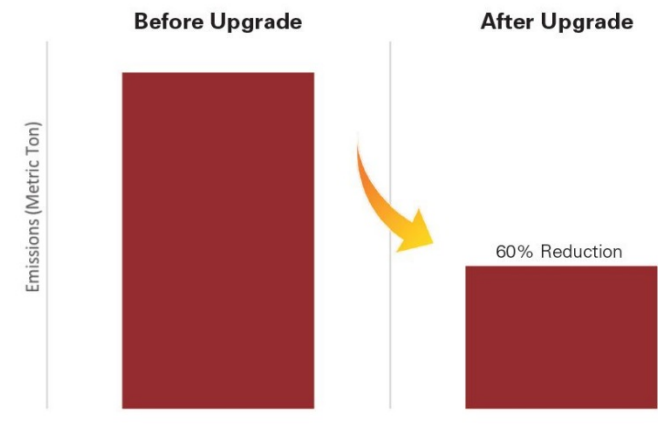
2, Wellhead estimates

System and Environmental Benefits (Calculated by SCE)

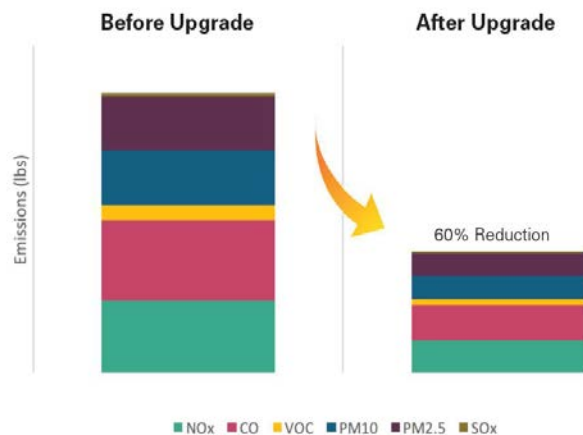
Reliability



EGT Site GHG



EGT Site Emissions



EGT Site Water Usage

The Hybrid EGT has an optimized emissions control system that reduces water consumption in the combustor.

Based on operating forecasts for the next decade, we expect:

- **A 45% reduction in consumption**
- **Savings of as much as one million gallons annually per EGT**

Example: Historical Peaker Usage and Usage Forecast of Hybrid EGT (Annual Average)