Progressing the Energy Transition and Grid Resiliency with Low-Cost Peaking Power

International Gas Turbine Conference

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ETN Global

PROENERGY

11th International Gas Turbine Conference
Dispatchable technology & innovations for a carbon-neutral society

GRID RESILIENCE

RECOVER QUICKLY FROM DIFFICULT CONDITIONS

IMPACTS ON SOCIETY

RESILIENT DESIGN IS CRITICAL

PUBLIC SAFETY

Protecting life; more than 200 dead in Uri

Powering hospitals, water, and other critical infrastructure

REGIONAL ECONOMIC VALUE

Supporting financial growth and employment

Facilitating the flow of goods, services, capital

BUSINESS VALUE

Earning peak returns

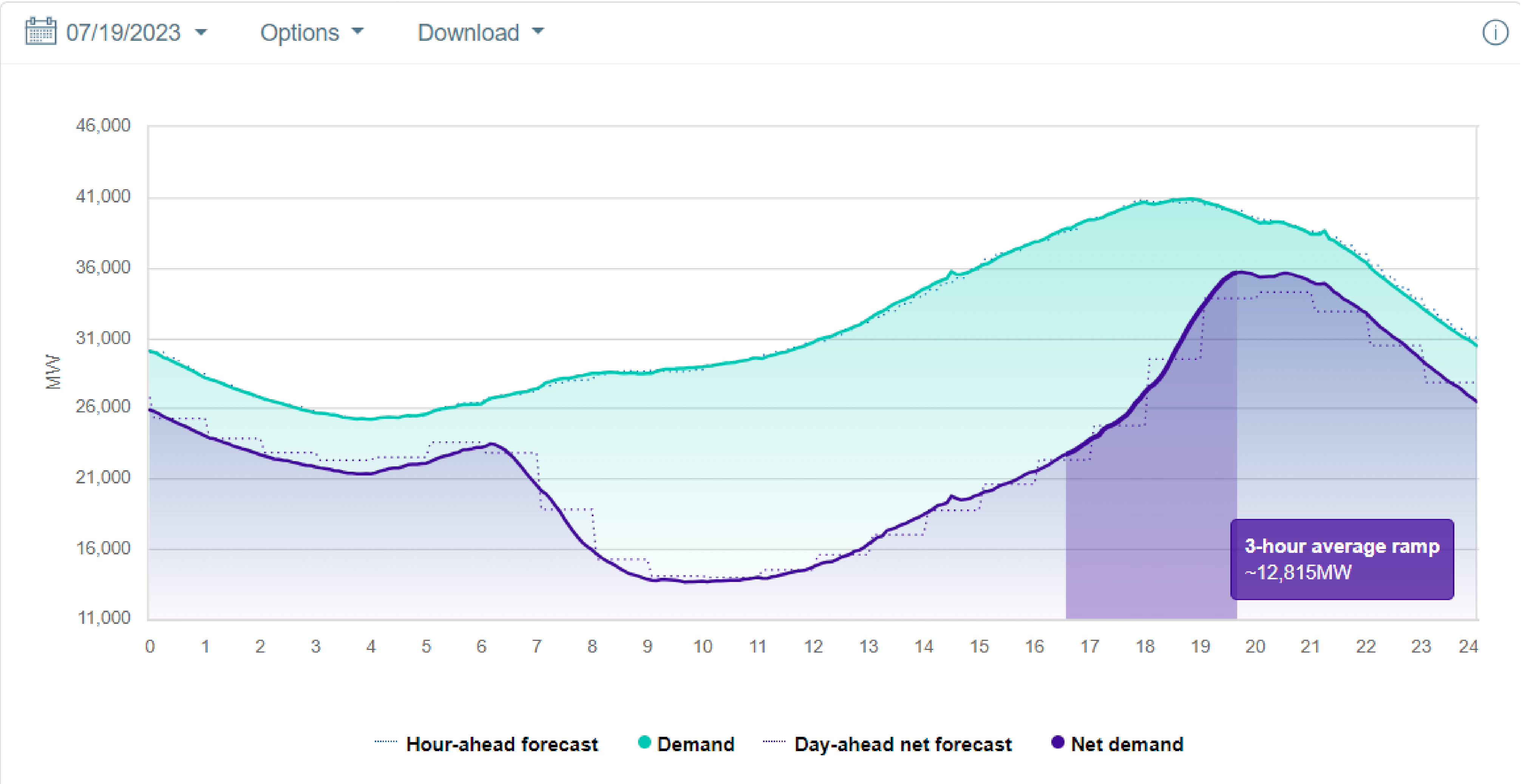
Avoiding costly penalties

Maintaining business resilience

CHALLENGES TO CAPACITY

ENERGY TRANSITION BRINGS VOLATILITY TO POWER DEMAND

System demand minus wind and solar, in 5-minute increments, compared to total system and forecasted demand.

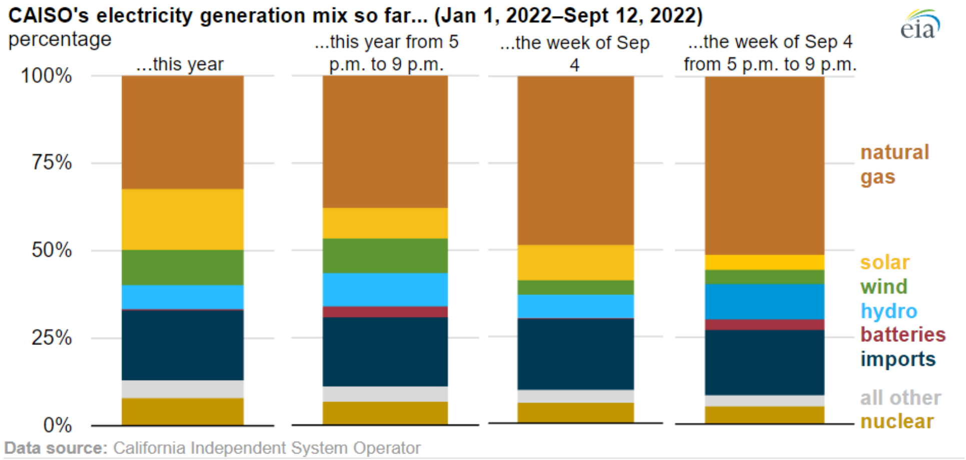


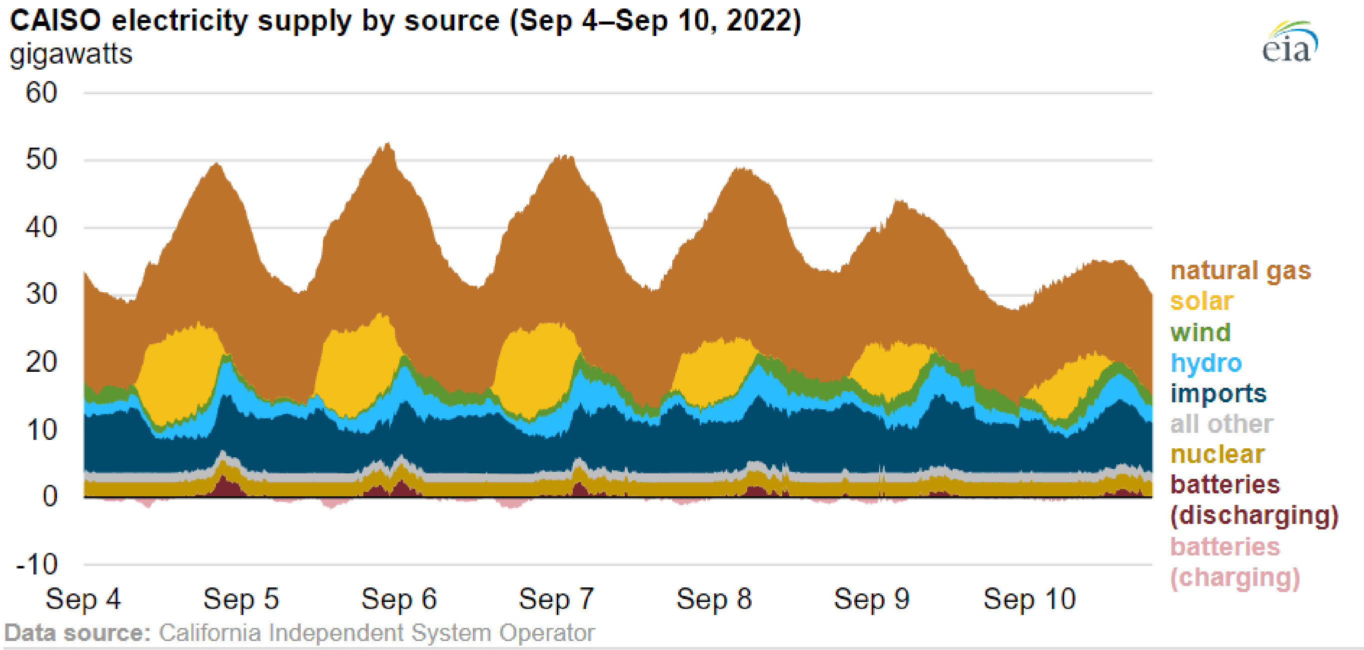
ELEVATED WEATHER EXTREMES

PEAKER RESILIENCE IS A FUNCTION OF CLIMATIC STRESS

CALIFORNIA ISO

CLIMATIC STRESS DRIVES PEAKING DEMAND





California ISO

U.S. Energy Information Administration - EIA - Independent Statistics and Analysis

NONDISPATCHABLE RESOURCE RISKS

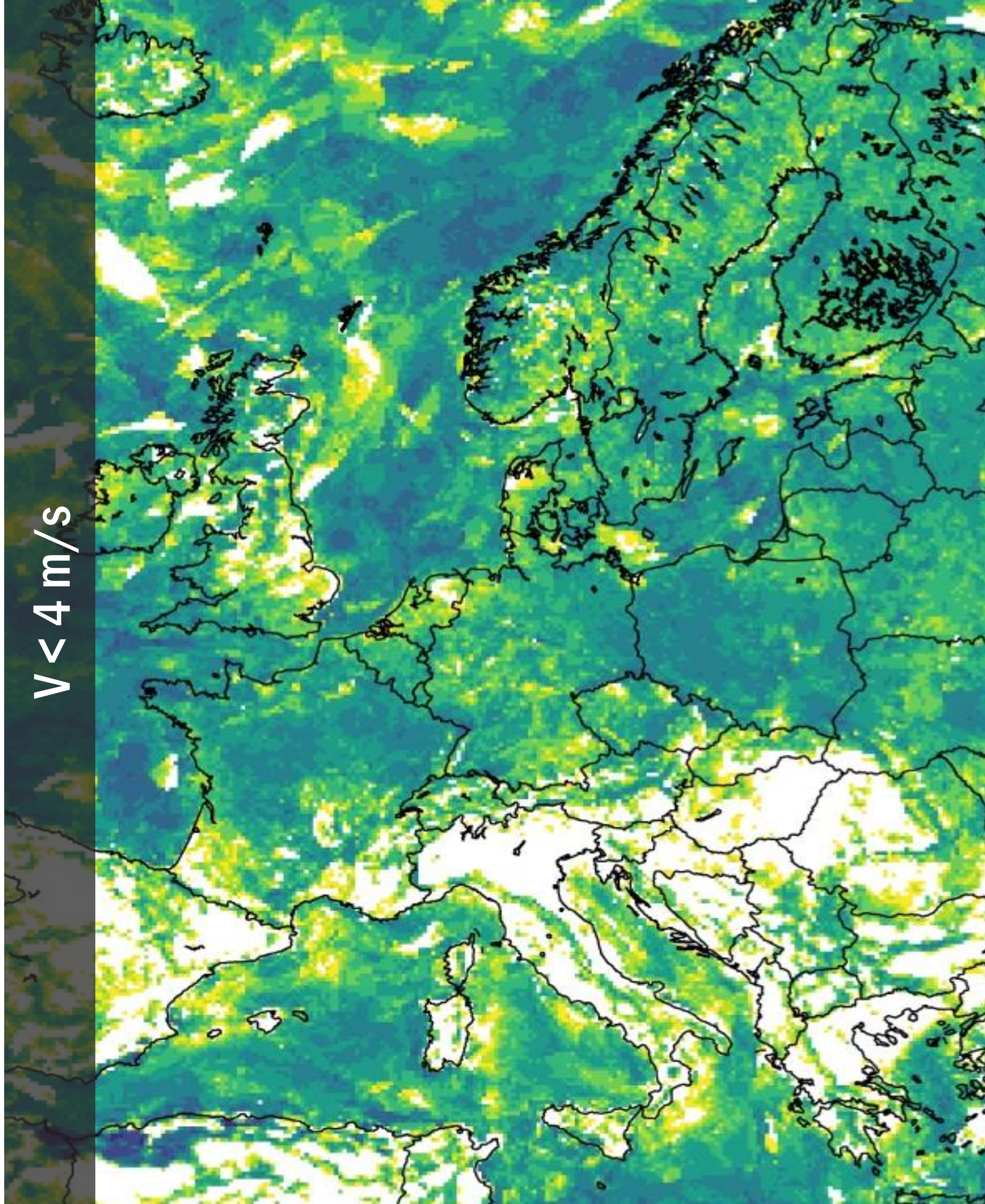
WEATHER HAPPENS!
Whether We Like It or Not

Wind Shortage in Europe

- UK electricity price spikes to $553/MWh
- Retired coal and nuclear no longer available
- Wind output reduced 2/3 expected for 10 days

New statistics show we should expect long periods of high winds and low winds:
https://www.nature.com/articles/s41598-019-56286-1

“We are not receiving enough renewable production”



APPLYING RESILIENCE TO PEAKING FACILITIES

Power Infrastructure

Generation facility, fuel supply, transmission, people, networks

Traditional vs. Current Peaker Philosophy

Renewables increase baseload volatility

Aging baseload increases peaker capacity factors (>1,500 hours/year)

CAPEX Sensitivity

Risk in over-designing

ENERGY STORAGE: LITHIUM-ION (NMC/LFP) BATTERIES

Consider MW AND MWh for storage applications

Utility Scale Storage Investigation: 200 MW/400 MWh in Texas

- 2-hour system
- 3.5 acres (14,164 m2) not including HV or stormwater
- 5x larger than LM6000 power density

$705/kW capacity

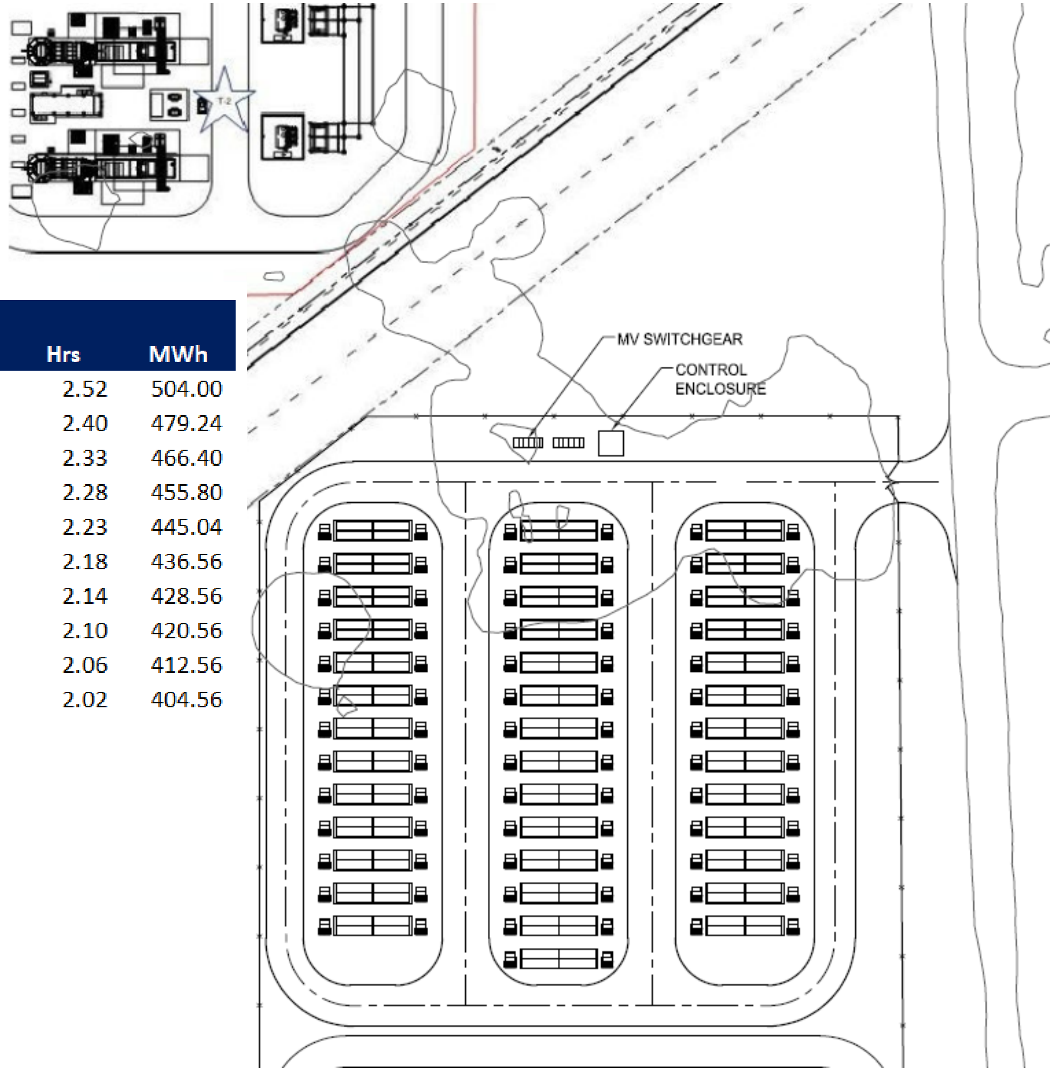
83% to 88% round-trip efficiency

50% average resting state of charge required

LTSA = adding capacity + inspections (10 years)

- $192K/mo = $0.96/kW-mo with 2%/year escalation
  - To maintain energy over 10 years with daily cycling
- Additional VOM of $10.75/MWh
- Includes 30% additional space for module addition

Scenario 2				
Year	% Overbuild	MW	Hrs	MWh
1	26.00%	200.00	2.52	504.00
2	19.81%	200.00	2.40	479.24
3	16.60%	200.00	2.33	466.40
4	13.95%	200.00	2.28	455.80
5	11.26%	200.00	2.23	445.04
6	9.14%	200.00	2.18	436.56
7	7.14%	200.00	2.14	428.56
8	5.14%	200.00	2.10	420.56
9	3.14%	200.00	2.06	412.56
10	1.14%	200.00	2.02	404.56



ENERGY STORAGE MAY NOT HOLD UP TO SCRUTINY

80% renewable energy in California requires 9.6 million MWh of storage; 100% renewables requires 36.3 million MWh[1]

80% renewable energy in USA requires a $2.5 trillion dollar battery system[1], not including renewable buildout and thermal retirement

500K gal water per ton of lithium needed to mine in South America

41gCO_2/kwh lifecycle CO_2[2]

- 104 to 407g/kwh[3] with overnight charging from coal
- 502g/kWh for LM6000

PROS

- Strong public support
- Flexible operation
- Portable
- Fast installation
- Low emissions*

CONS

- Short discharge time (2 to 4 hours)
- Short lifespan (7 to 15 years)
- High water consumption (Li mining)
- May increase total emissions

[1] Clean air task force, Boston-based energy policy think tank).
[2] Jolliet O. Saadé-Sbeih, M., Shaked, S., Jolliet, A., & Crettaz, P. Environmental lifecycle assessment. CRC Press, 2015
[3] Hittinger E. Azevedo I. Bulk Energy Storage Increases United States Electricity System Emissions. Envion. Sci. Technol., Vol 49, No. 5, pp 3202-3210, 2015

TURNKEY EPC

COMPLETE WITH BOP FOR $775/kW

- SCR/CO
- GSU
- Water treatment
- Water storage
- Anti-Icing
- Inlet fogging
- Performance guarantees and warranty

CASE STUDY: 5 KEY AREAS OF RESILIENCE

HO CLARKE POWERS THROUGH STORM

HO Clarke

POWER STATION

6x LM6000PC standardized PowerFLX facility

Vertical integration, including turbine, EPC, O&M

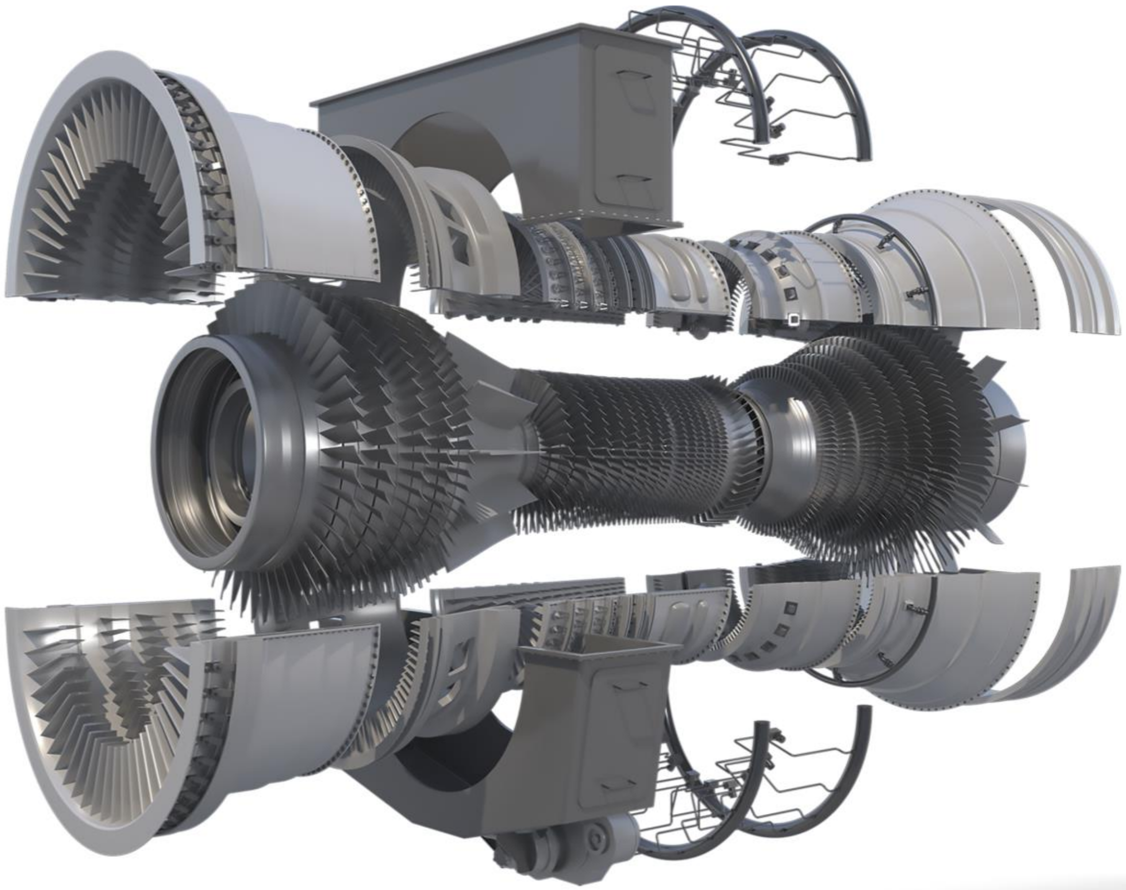
CASE STUDY: KEY AREA 1

GAS TURBINE TECHNOLOGY

Aeroderivative

LM6000PC vs. Industrial Frame

- Low turnkey $/kW with PROENERGY PowerFLX
- Fast start <10 min.
- Rapid ramp rates, low turndown
- No maintenance penalty for frequent starts
- 48 MW “blocks”, N+1 redundancy



CASE STUDY: KEY AREA 2

BALANCE OF PLANT

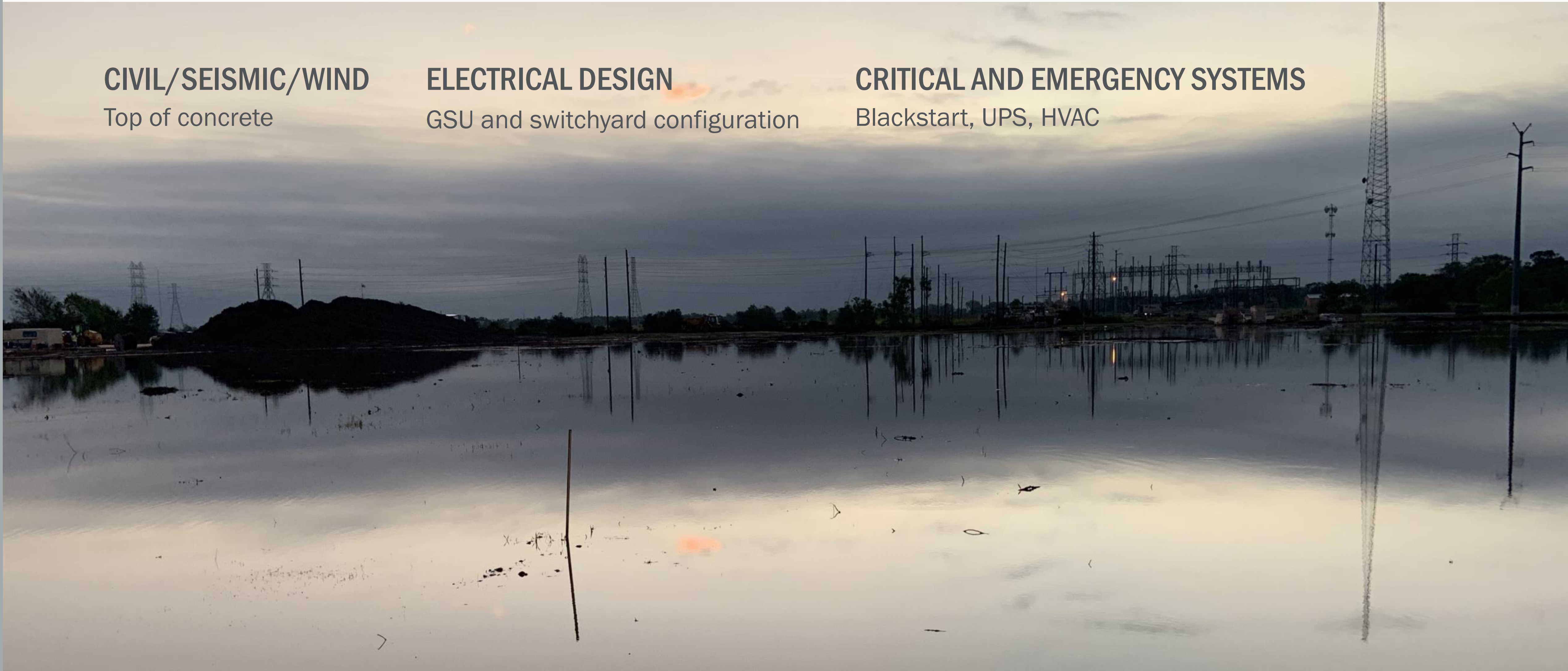
DUAL-FUEL CAPABILITY
Storage

GAS SUPPLY
Heating, compression

WATER STORAGE
Tankage vs. treatment capacity

CASE STUDY: KEY AREA 2

BALANCE OF PLANT



CIVIL/SEISMIC/WIND
Top of concrete

ELECTRICAL DESIGN
GSU and switchyard configuration

CRITICAL AND EMERGENCY SYSTEMS
Blackstart, UPS, HVAC

WINTERIZATION

TURBINE ANTI-ICING SYSTEM

Package Air Recirculation

– Uses ambient heat from the CTG enclosure, redirected to the inlet filter house

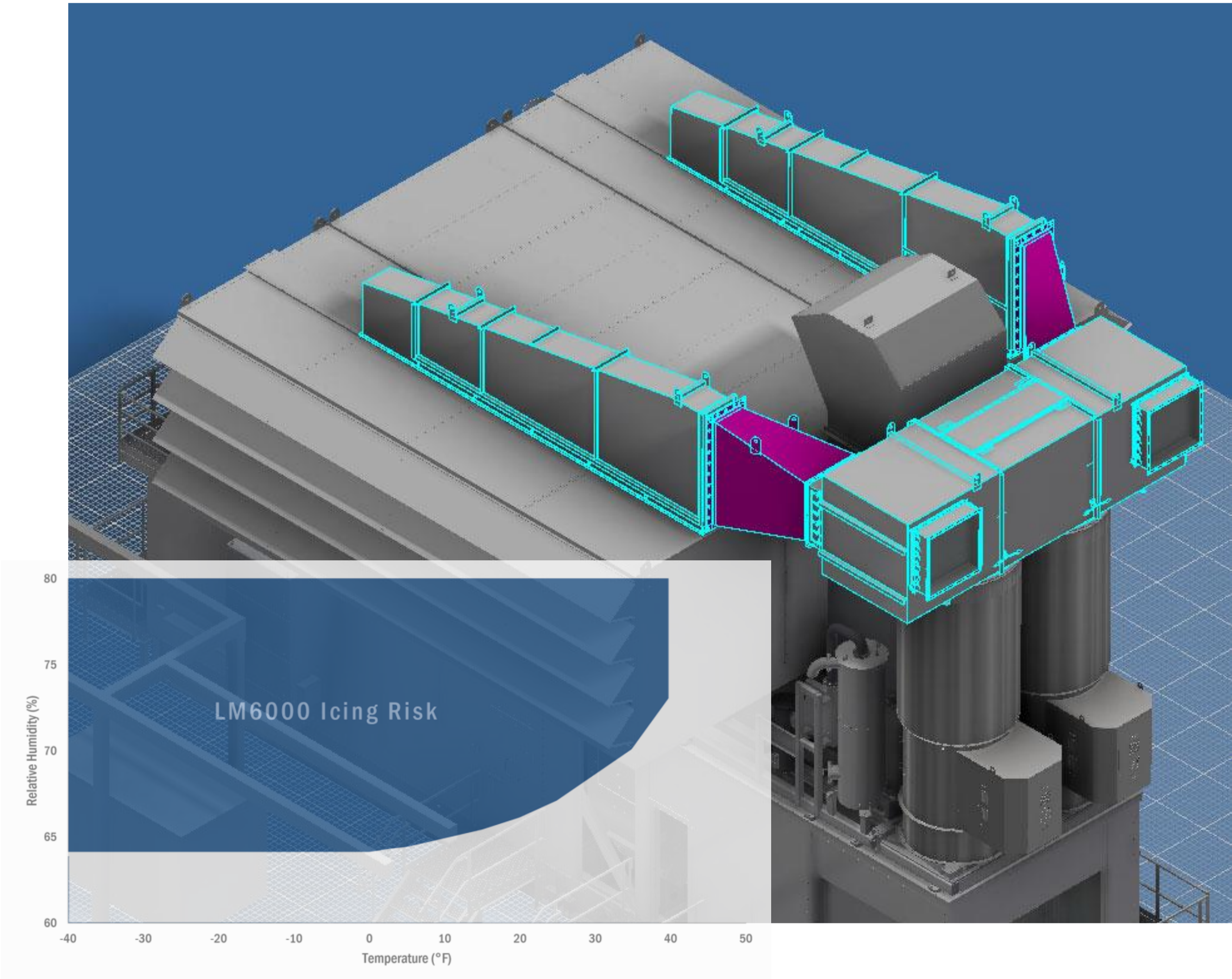
Other options

– CDP bleed air inlet heating
– External glycol heating

Plant Heat Trace and Insulation

Enclosures for aux skids

Parasitic Loss Summary	Package Air Recirculation	Glycol System
Spring, Summer, Fall Losses	0 kW	165 kW (coil dP)
Winter (Operational Losses)	135 kW (draft fan / leakage)	265 kW (heater)

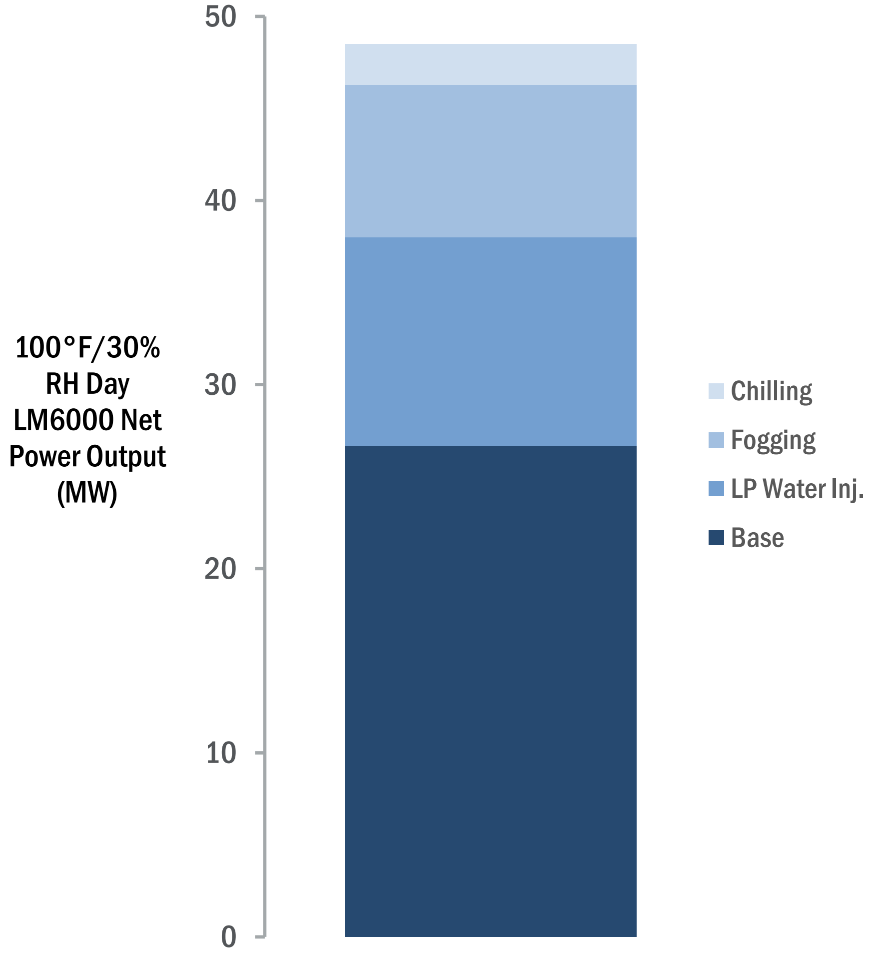


PERFORMANCE AUGMENTATION

MAXIMIZE OUTPUT IN HOT WEATHER

Inlet Fogging Vs. Inlet Chilling

- Inlet fogging increases mass flow due to added water vapor + reduces inlet temperature due to evaporative cooling
- Fogging uses same water source as LP water injection and NO_x water injection
- Notable CAPEX savings over chilling systems, though cost of water must be considered



CASE STUDY: KEY AREA 5

OPERATIONS STRATEGY

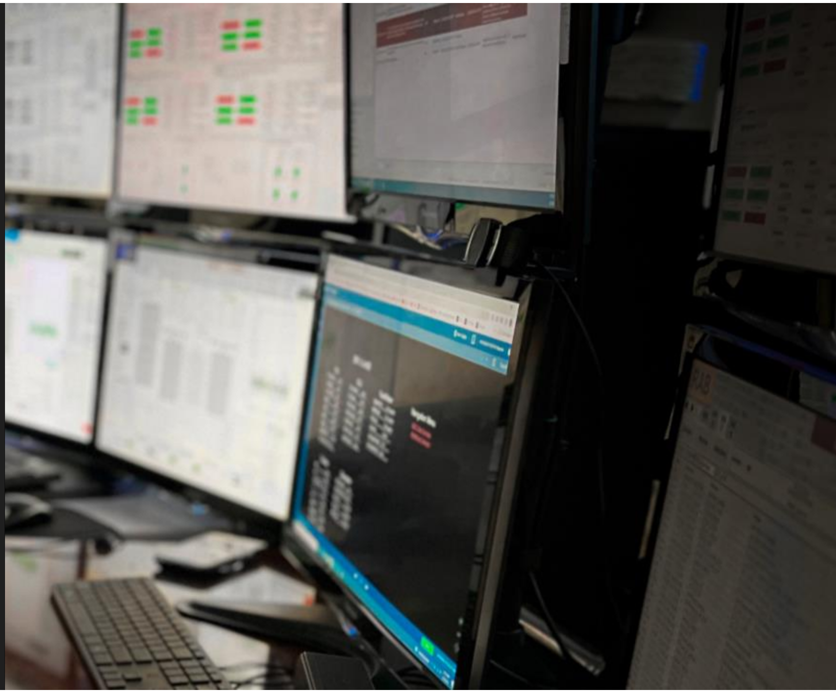
PROTOCOLS
for operations and asset management

REMOTE OPERATIONS
monitoring, and diagnostics

ROAMING TECHNICIANS
for the fleet

CENTRALIZED
and well-stocked spares pool

REDUCED DOWNTIME
with quick engine exchanges



POWERFUL RESULTS

THE VALUE OF RESILIENCY

Winter Storm Uri

H.O. Clarke Power Station was 100% available

- 141 hours (~6 days) of operation during the storm and subsequent recovery period
- Over 60% of ERCOT capacity was unavailable

Delivered power to more than 200,000 homes

BEST-IN-CLASS PERFORMANCE

RELIABILTY STATISTICS FROM YEAR 1 OF OPERATION

NET CAPACITY FACTOR

HO Clarke full site	11.7%	HO Clarke contracted	12.2%	HO Clarke merchant	6.3%
Topaz full site	8.3%	Topaz contracted	9.0%	Topaz merchant	5.7%

START RELIABILITY

HO Clarke full site	98.0%	HO Clarke contracted	97.9%	HO Clarke merchant	98.8%
Topaz full site	97.9%	Topaz contracted	97.7%	Topaz merchant	98.5%

EQUIVALENT AVAILABILITY FACTOR

HO Clarke full site	97.2%	HO Clarke contracted	97.0%	HO Clarke merchant	99.4%
Topaz full site	99.4%	Topaz contracted	99.4%	Topaz merchant	99.6%

EQUIVALENT FORCED OUTAGE RATE DEMAND

HO Clarke full site	1.4%	HO Clarke contracted	1.4%	HO Clarke merchant	0.8%
Topaz full site	1.8%	Topaz contracted	2.0%	Topaz merchant	0.7%

RESILIENCE IN THE FUTURE

REFUELING

Thank You

PROENERGY

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