

A high-speed train is captured in motion, blurred to convey speed. The train is moving from left to right. The background shows a sunset or sunrise with warm orange and yellow light. The train tracks and overhead power lines are visible. The overall scene is dynamic and modern.

A New Level of Resiliency: Understanding the New Jersey TransitGrid

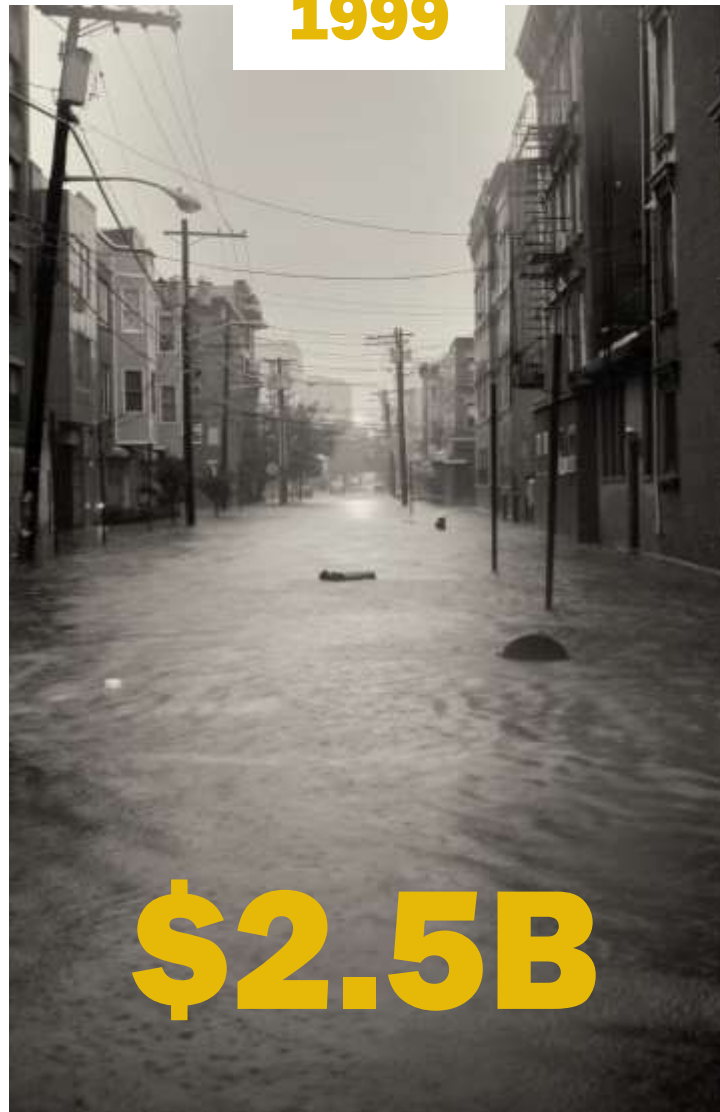
Roger Copeland, PE | Jacobs Engineering Group Inc.



Transit Resilience: **THE NEED**

Historical Grid **Impacts**

Hurricane Floyd
1999



Northeast Blackout
2003



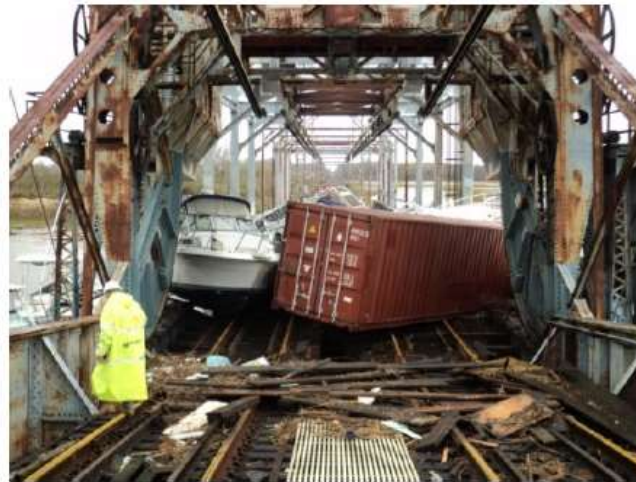
Hurricane Irene
2011



Superstorm Sandy
2012



STATEWIDE DAMAGE



March 2014 BPU-Rutgers Report

State of New Jersey
BOARD OF PUBLIC UTILITIES
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DIANNE SOLOMON
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MEMORANDUM

TO: Commissioner James S. Simpson
NJ Department of Transportation

FROM: Dianne Solomon, President
NJ Board of Public Utilities 

SUBJECT: NJ TransitGrid Feasibility Study

DATE: March 18, 2014

Over the last six months, staff from the New Jersey Board of Public Utilities (NJ BPU) worked closely with NJ Transit, the U.S. Department of Energy (USDOE), Sandia National Laboratories, emergency management agencies, and other stakeholders to advise and provide technical assistance in studying the feasibility of "NJ TransitGrid."

As you know, NJ TransitGrid would be the first microgrid of its kind in the State of New Jersey and nationally. The microgrid would be capable of providing highly reliable power to support the operations of NJ Transit, Amtrak, and the Port Authority's Trans-Hudson (PATH) system. In addition to providing resilient power for critical transit operations, NJ TransitGrid would provide increased in-state generation in a particularly "congested" area of the State and increase distributed generation, consistent with the Governor's Energy Master Plan. As you know Superstorm Sandy had an extremely devastating impact on New Jersey's electric distribution system. Over 2.8 million homes and businesses, totaling nearly 7 million people, across New Jersey were without power after the storm. It took 17,000 mutual aid workers from as far away as California almost

Predicted **one major hurricane / tropical storm every five years** capable of causing "relatively significant electrical outages"



Transit Resilience: **THE TASK**

Programmatic **Goals**

Ensure **continuity of service** in core sections of public transit operations during grid disturbances

Project must be **fiscally sustainable**

Recognize potential **environmental benefits**

Newark and South
Service Area

Proposed Power
Plant Site

Penn Station
New York

Morris & Essex

Newark
Penn Station

*Northeast
Corridor*

Not in Scope
Ancillary Facilities
Rail Passenger Stations
Bus Maintenance Facilities

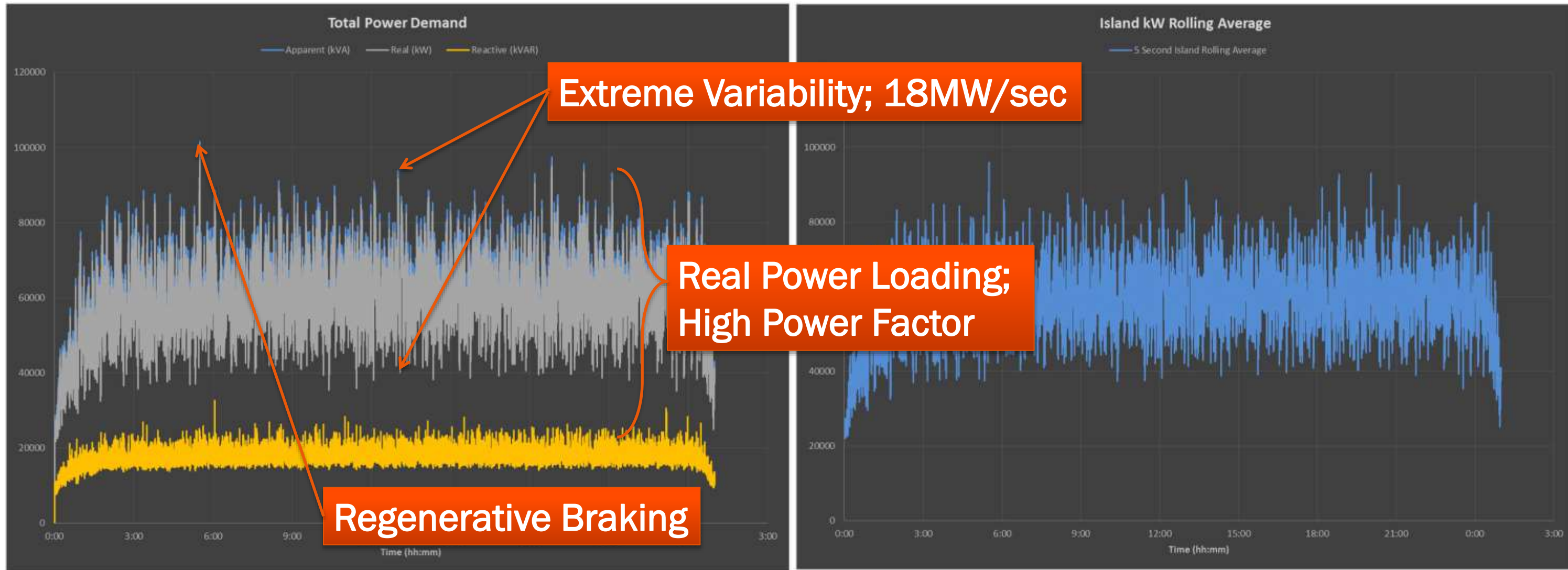
*Hudson-Bergen
Light Rail*

+ Bridge Signals & Switches



Transit Resilience: **THE CHALLENGE (S)**

Traction Power Loads



1 second time scale

5 second rolling average

What does a microgrid **need to succeed?**

Steady voltage

Steady frequency

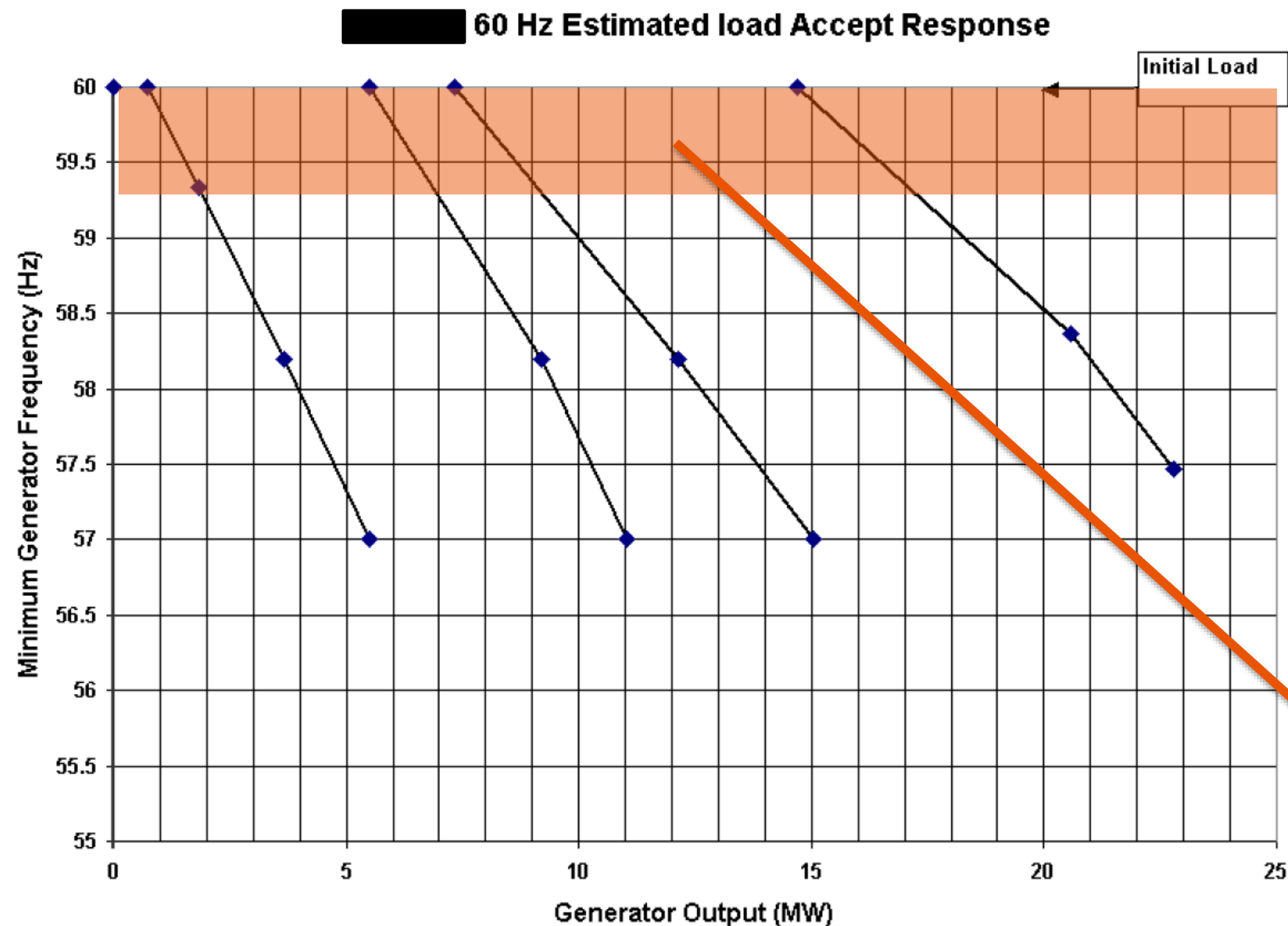


Traction Power Loads

- ALP- 46A Engines on M&E Line
- Single phase 7,500HP, power electronics
- 100MPH limits
- Limited to **$\pm 1\%$ of 60Hz**



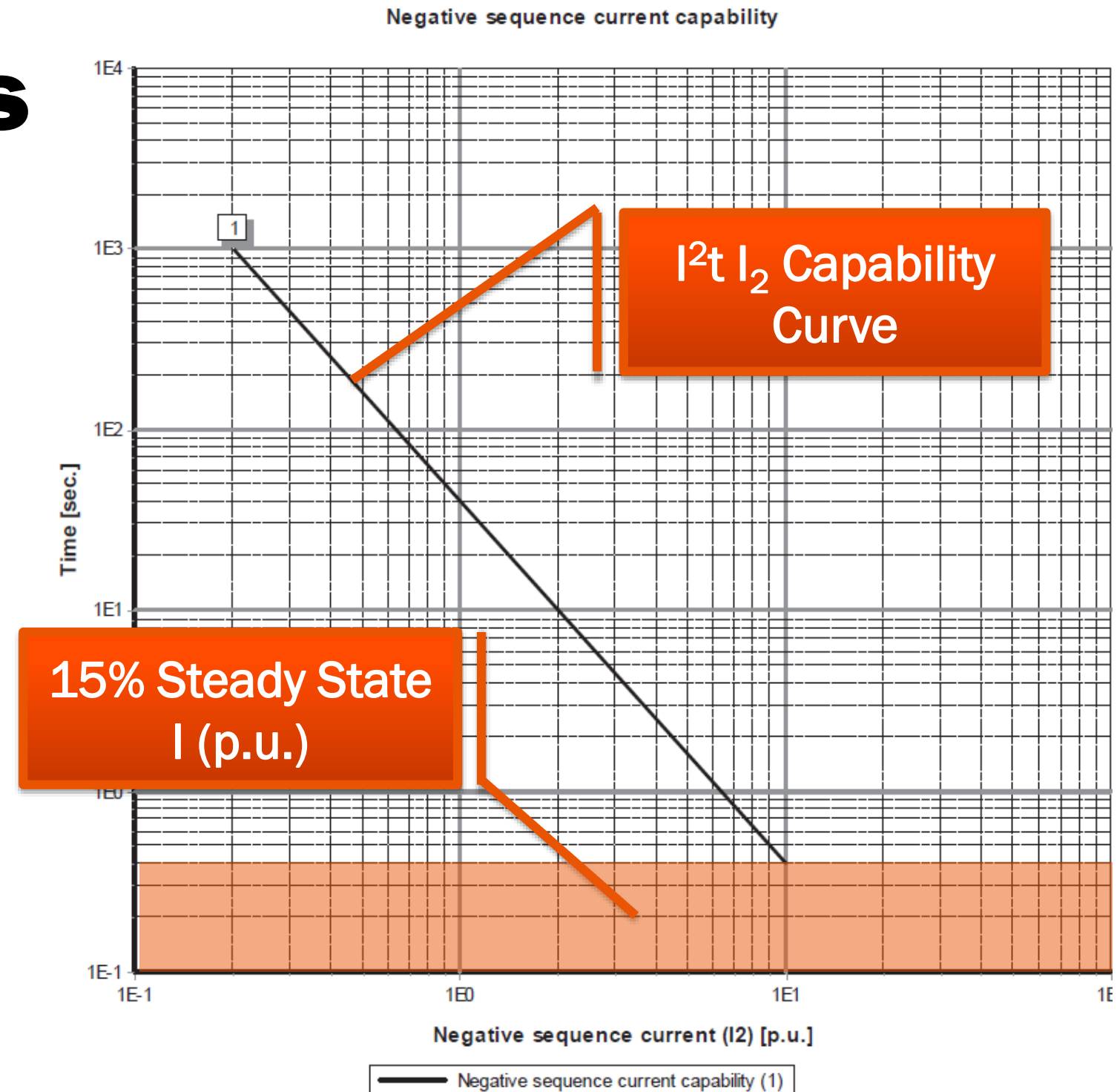
Traction Power Loads



Very Small
Equipment Step
Change Capability
at $\pm 1\%$

Traction Power Loads

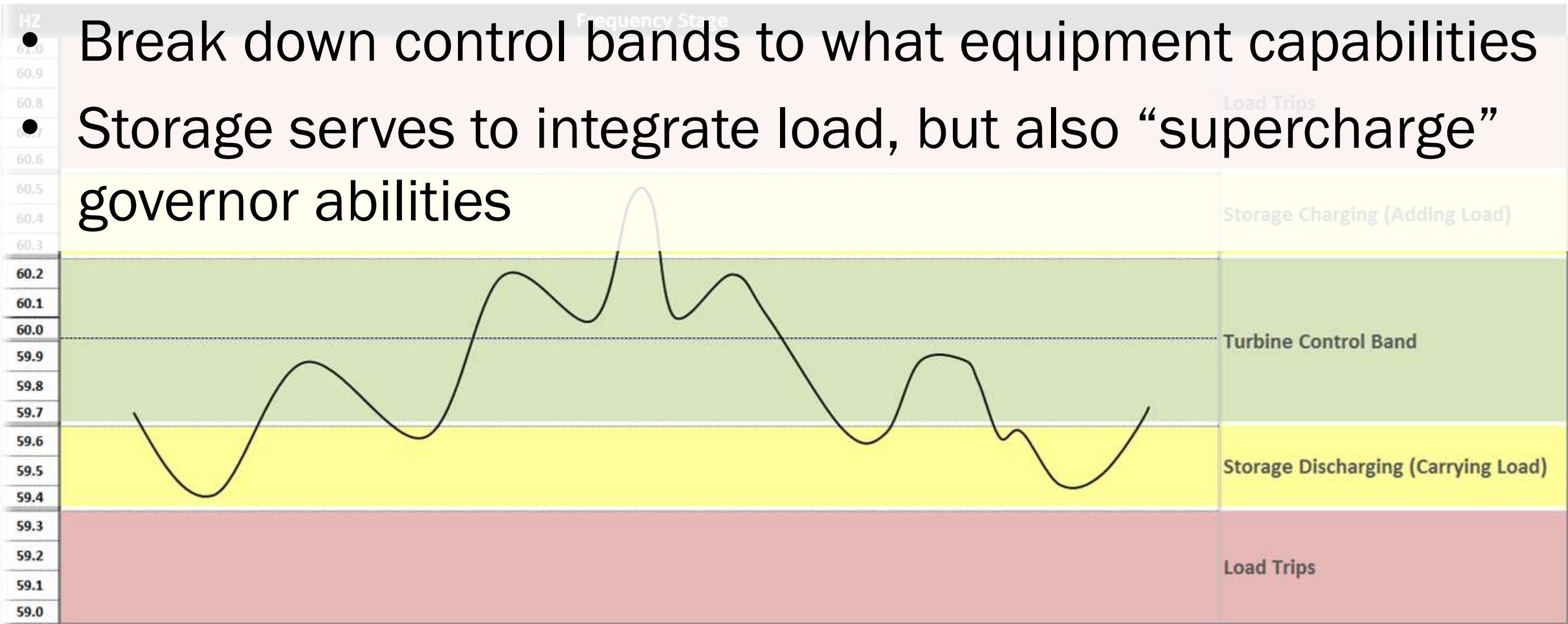
- Unbalanced M&E Line (large negative sequence); 20+MW
- Extremely hard to predict as trains pass phase gaps
- Try to stay in steady state capability range of equipment





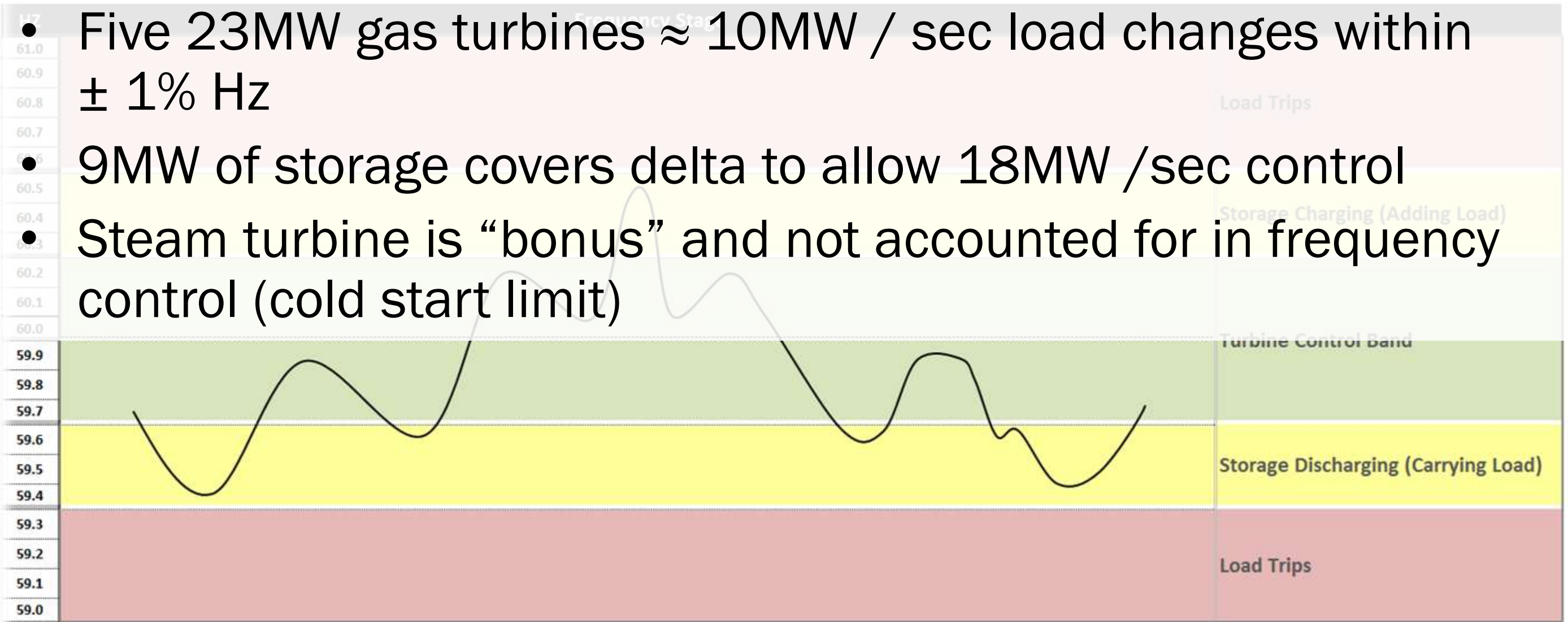
Transit Resilience: **THE SOLUTION**

Frequency Control



Frequency Control

- Five 23MW gas turbines $\approx 10\text{MW} / \text{sec}$ load changes within $\pm 1\% \text{ Hz}$
- 9MW of storage covers delta to allow $18\text{MW} / \text{sec}$ control
- Steam turbine is “bonus” and not accounted for in frequency control (cold start limit)



Negative Sequence

- Complicated issue!
- 58% I_1 to I_2 resultant vector
- Five 23MW gas turbines with oversized (40MVA) generators
- 15% continuous of 58% 40MVA I_1 provides ~17MVA of single phase support
- Load varies, to account for outages, also includes ~12MVA of SVC for support

Central Power Plant

- 2x1 combined cycle + 3 simple cycle peaking gas turbines
- 9MW of parallel storage
- 12MVAR STATCOM
- Blackstart provisions
- Four acres of solar PV
- Expandable to 6x3 combined cycle (future)

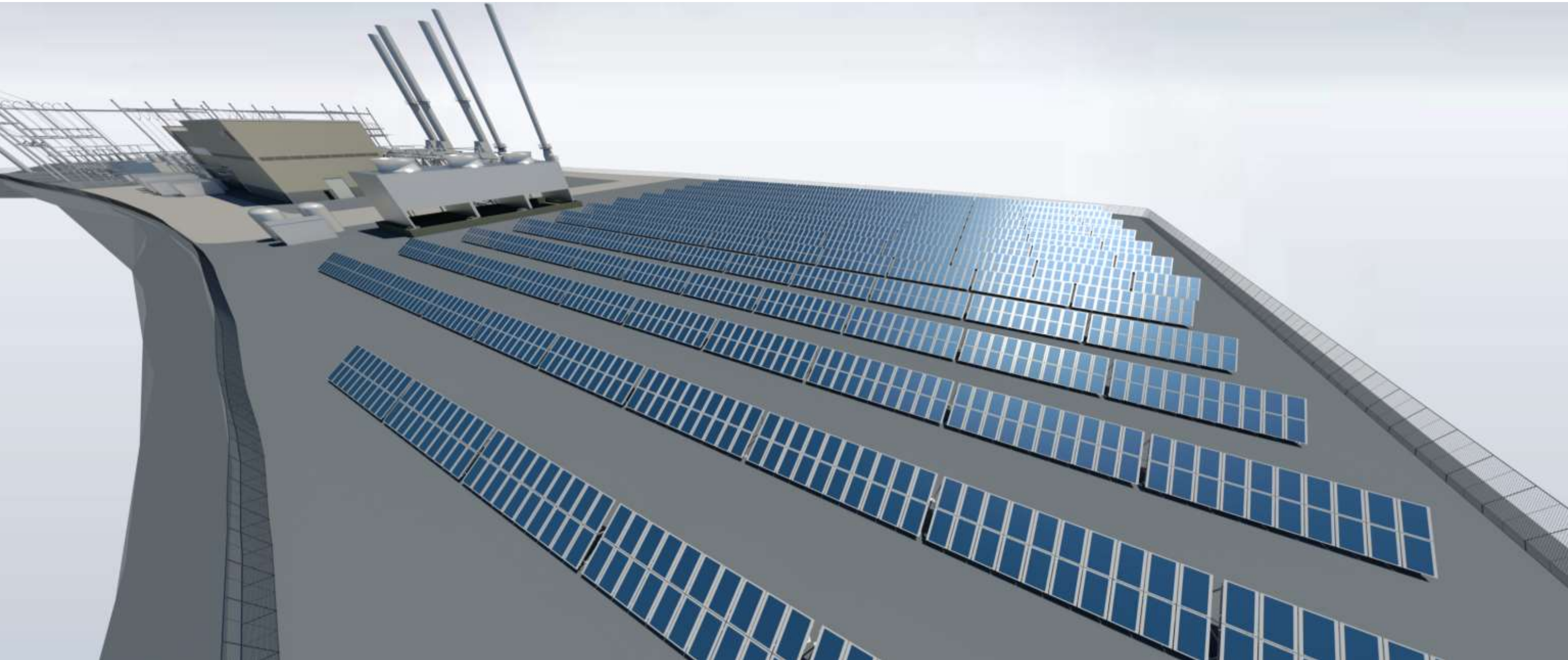
Central Power Plant Hybrid Combined Cycle



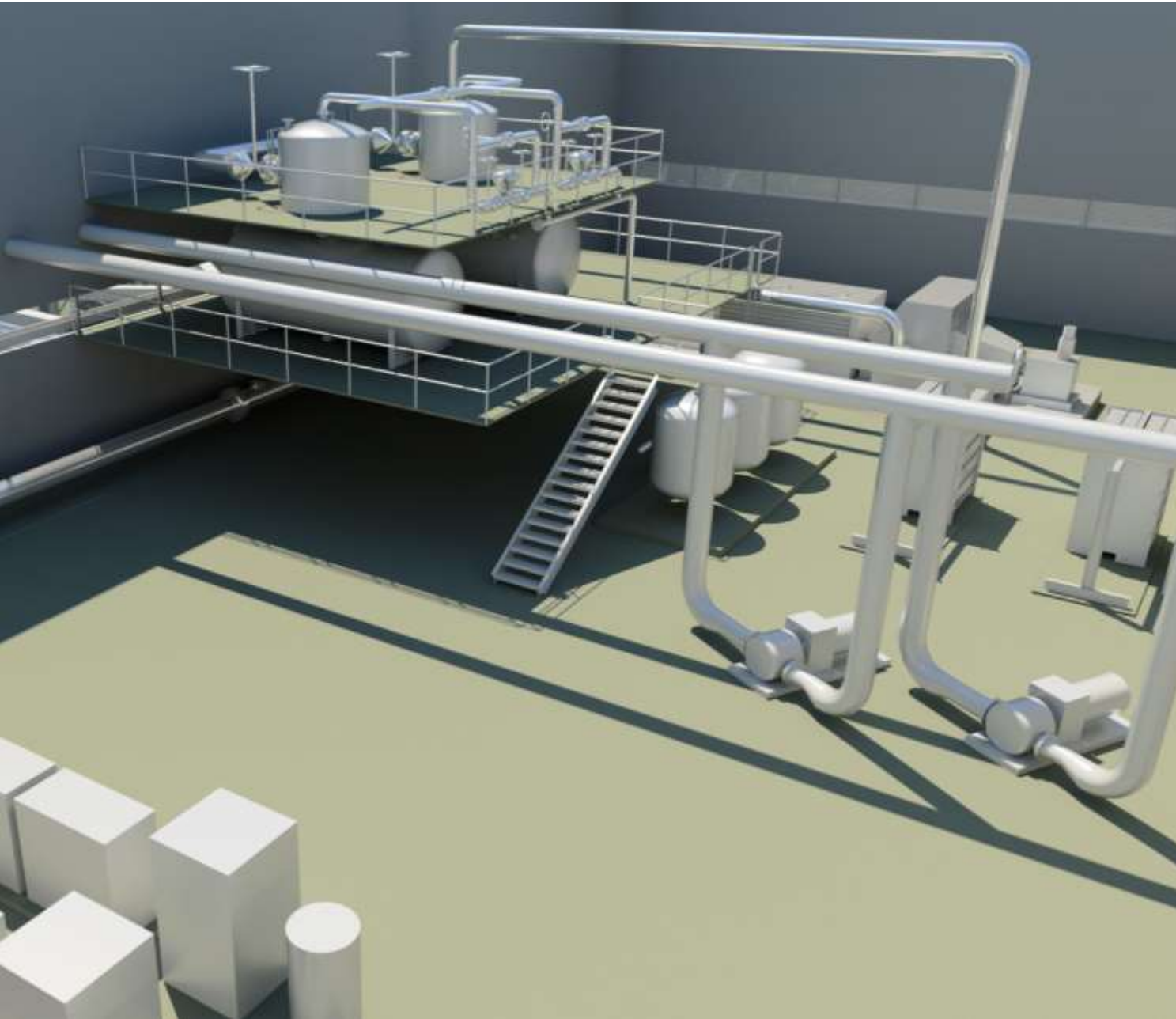
Central Power Plant Gas Turbine Tech



Central Power Plant Four-Acre Solar Farm



Central Power Plant Combined Cycle

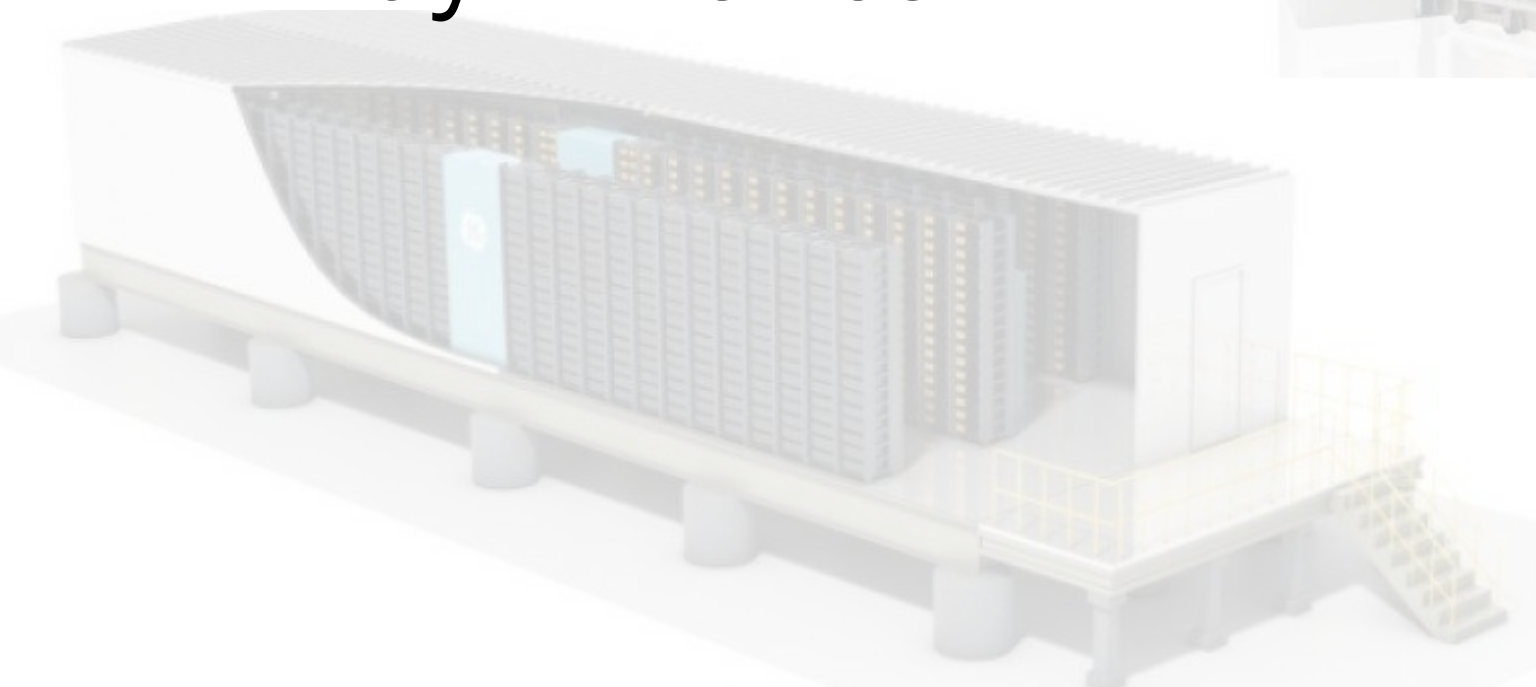
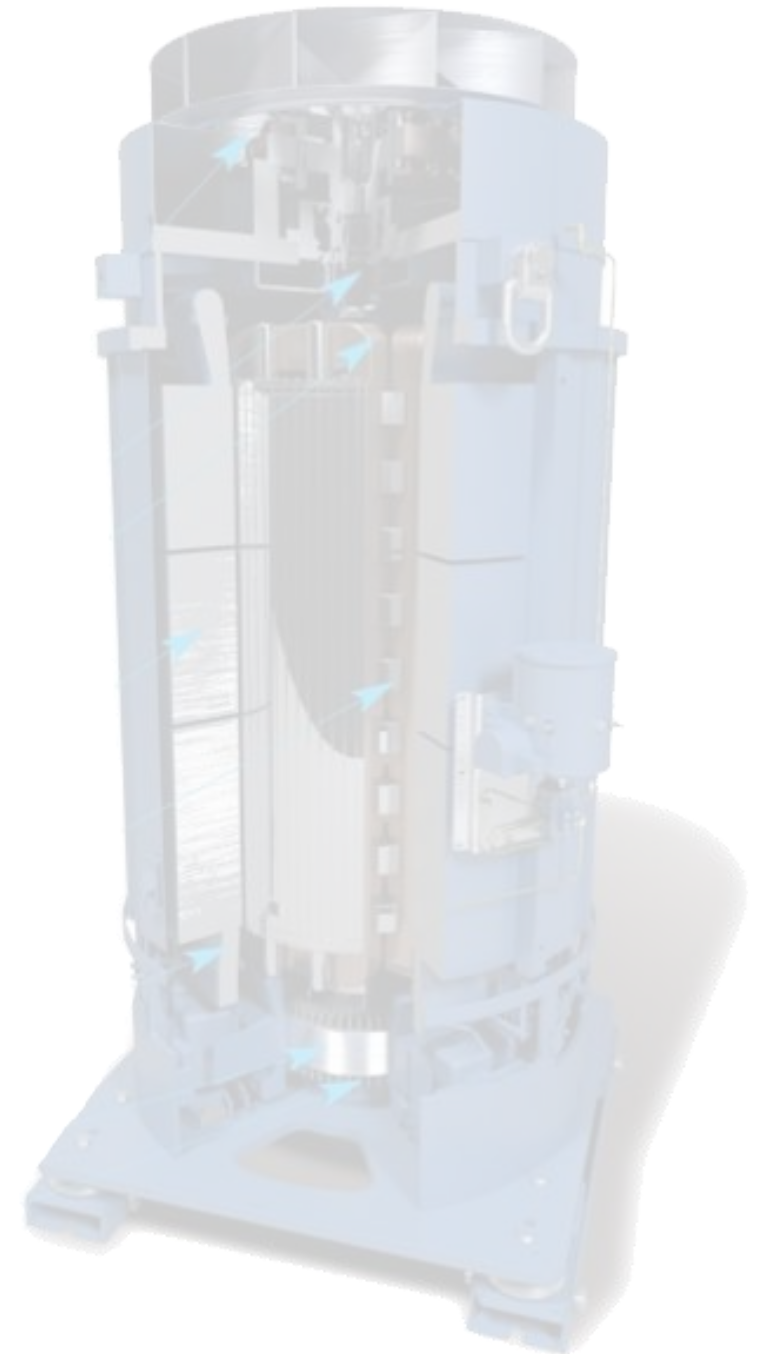




Transit Resilience: **ENERGY STORAGE**

Energy Storage Options

- Duty cycle limits
- Recharge rates limited
- Buy America





Transit Resilience: **AIR PERMIT ANOMALIES**

Air Permitting

- Emissions control in isoc drastically limited, no DLE control when in frequency control
- Post combustion controls enabled but not able to follow drastically dynamic load due to PID control
- Local EPA officials may not understand these limits



MACT

JJJJ

LAER

SD
SD
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W

GHG

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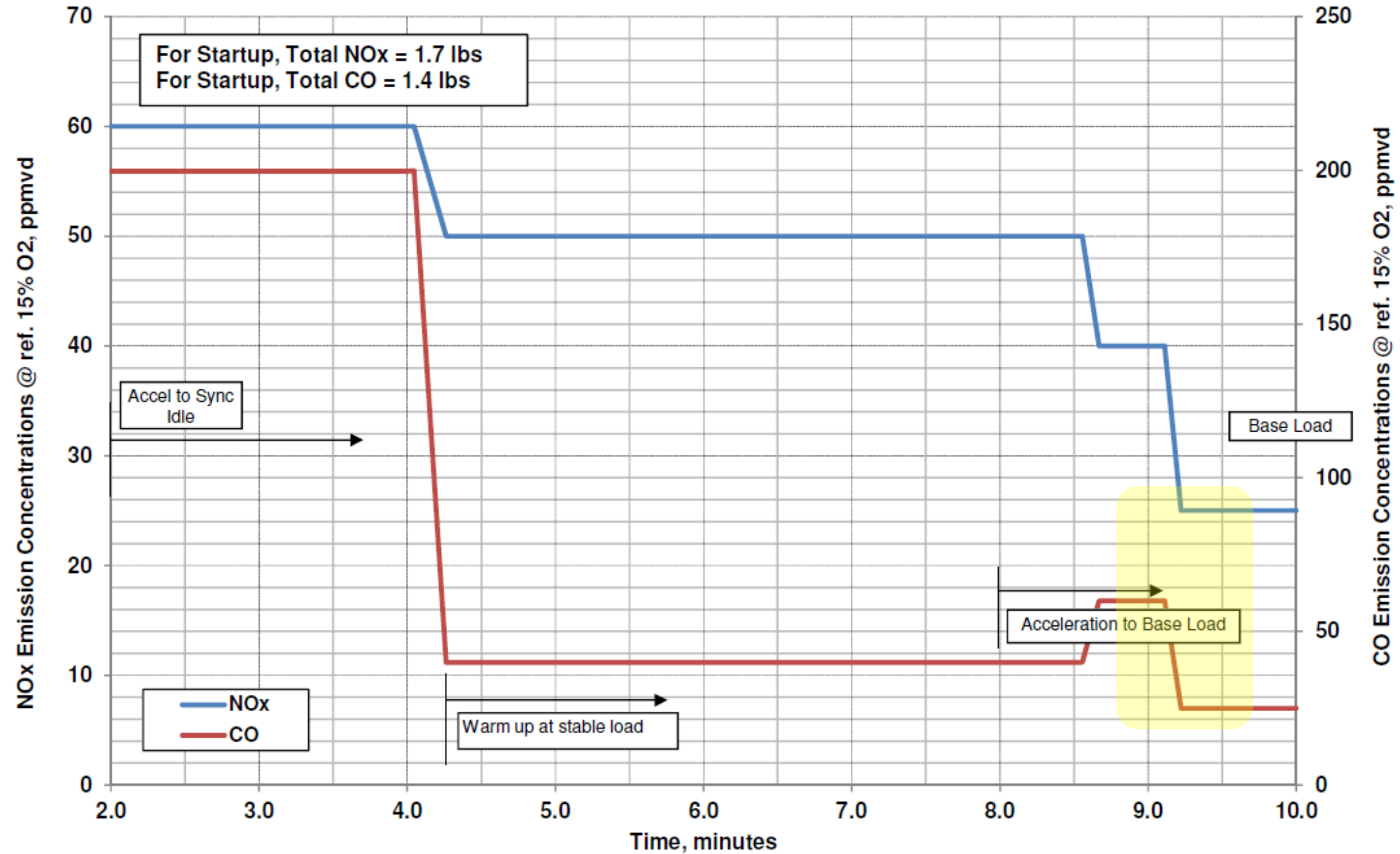
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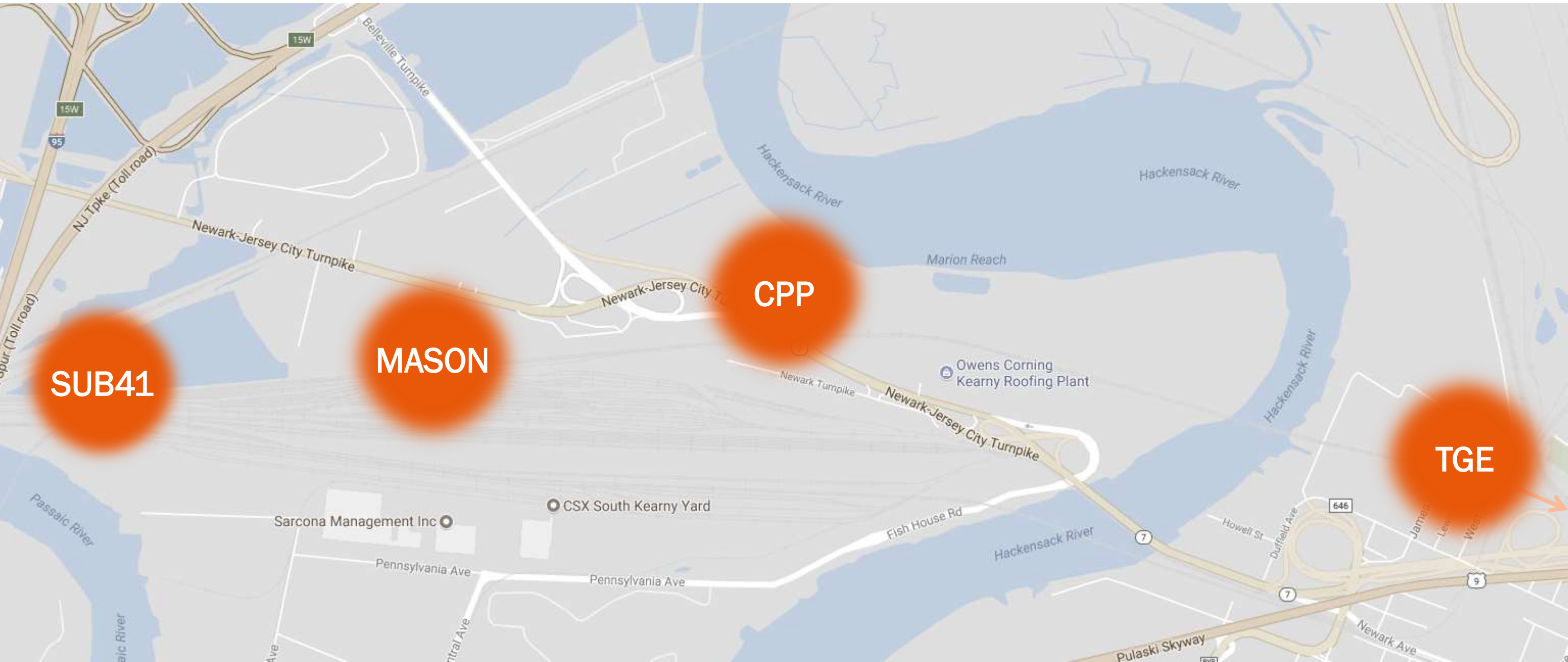
Air Permitting



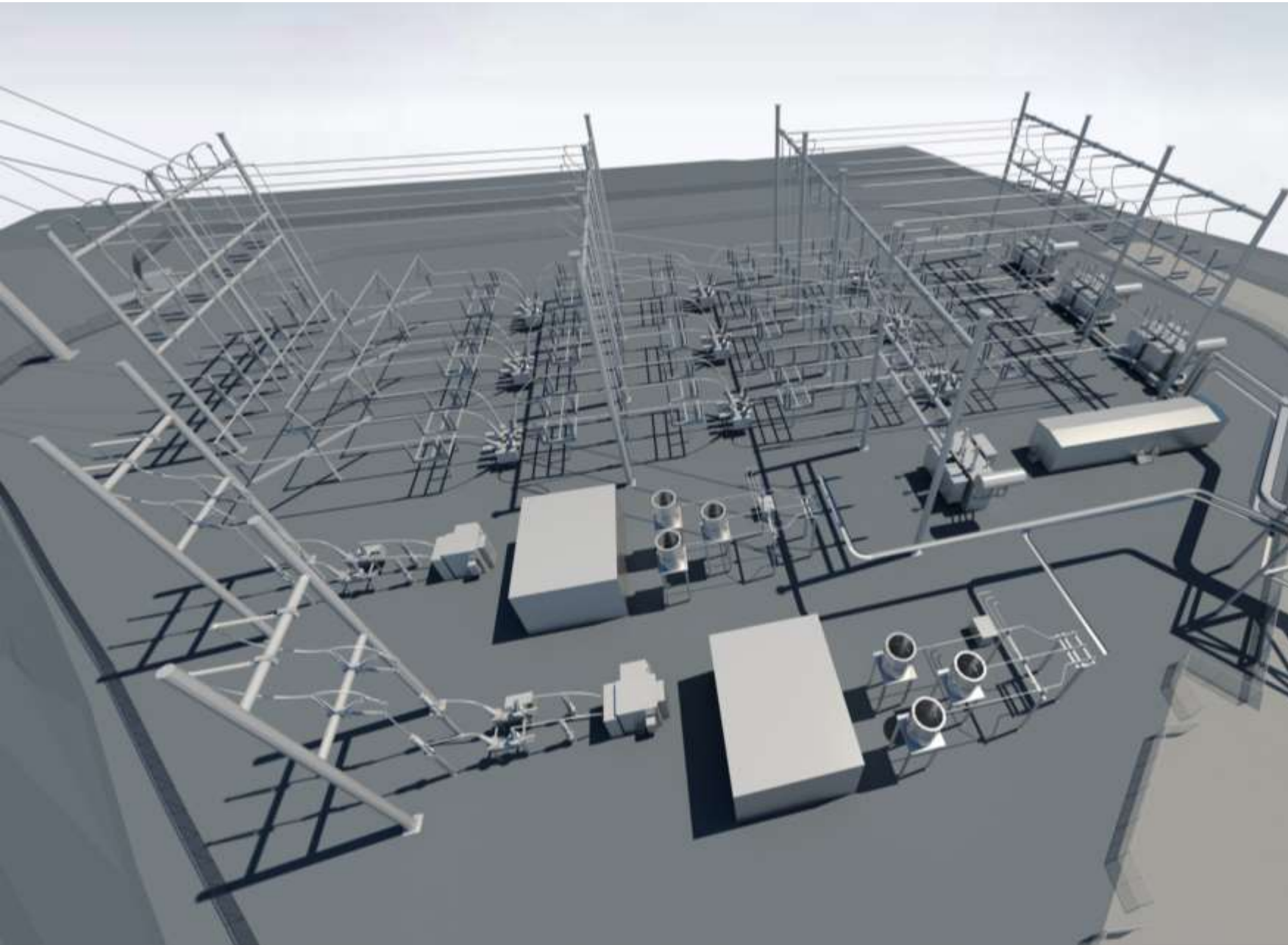


Transit Resilience: **CONNECTING THE LOADS**

Project Details



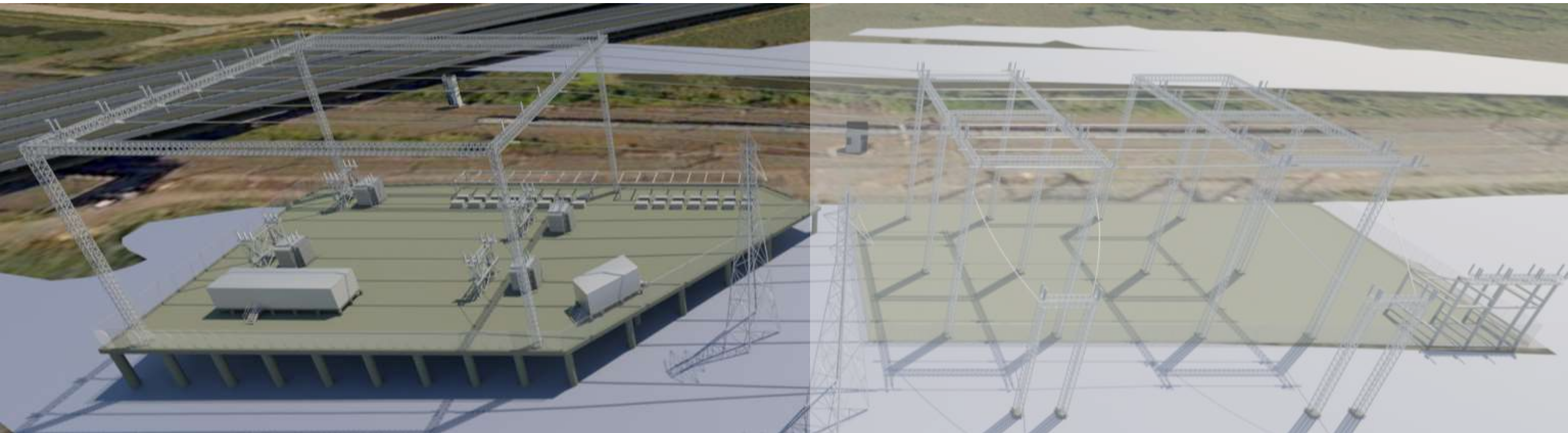
Central Power Plant Substations



- 230kV 1.5 breaker substation
- 2x30MW static frequency converters

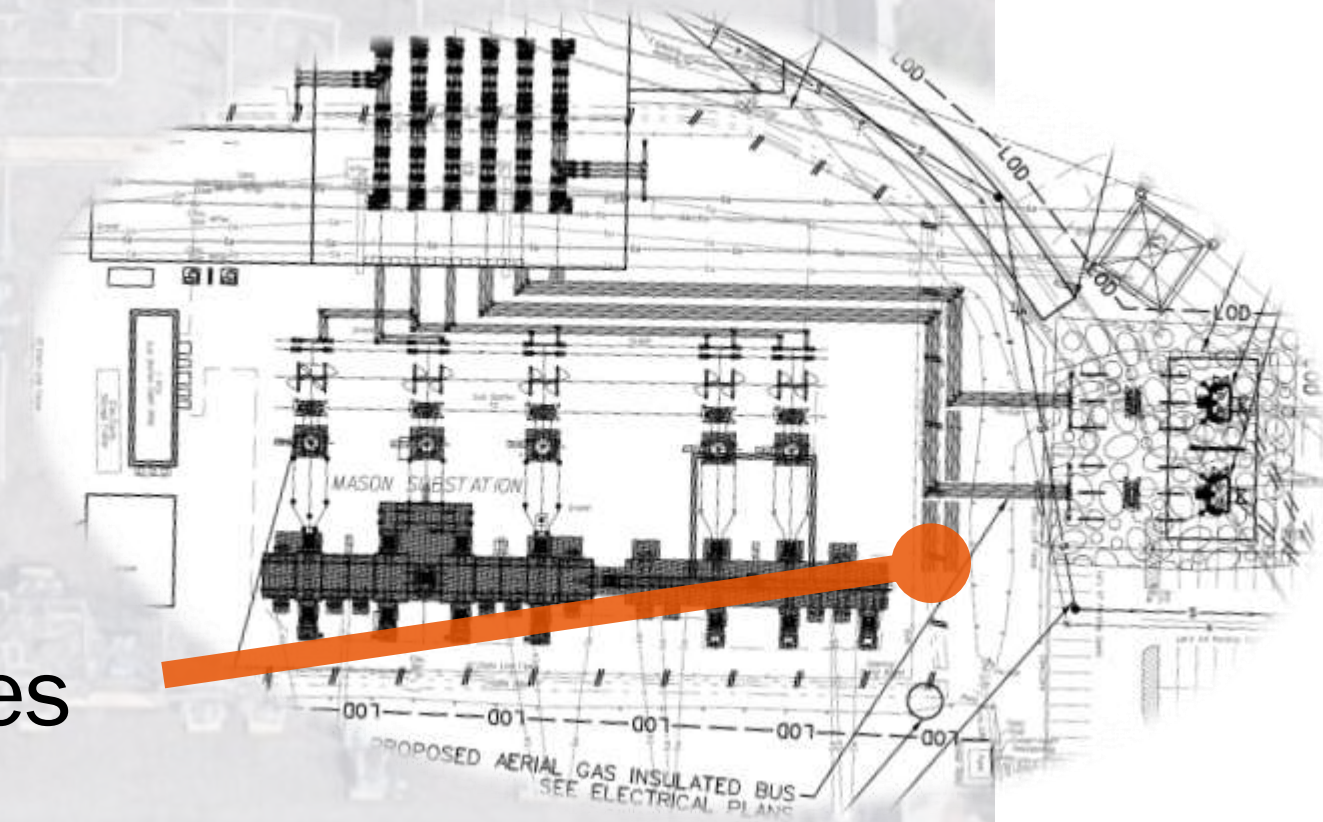
Amtrak's **Substation 41**

- New lattice structure
- Connection to existing
- New platform
- New connections to catenary systems

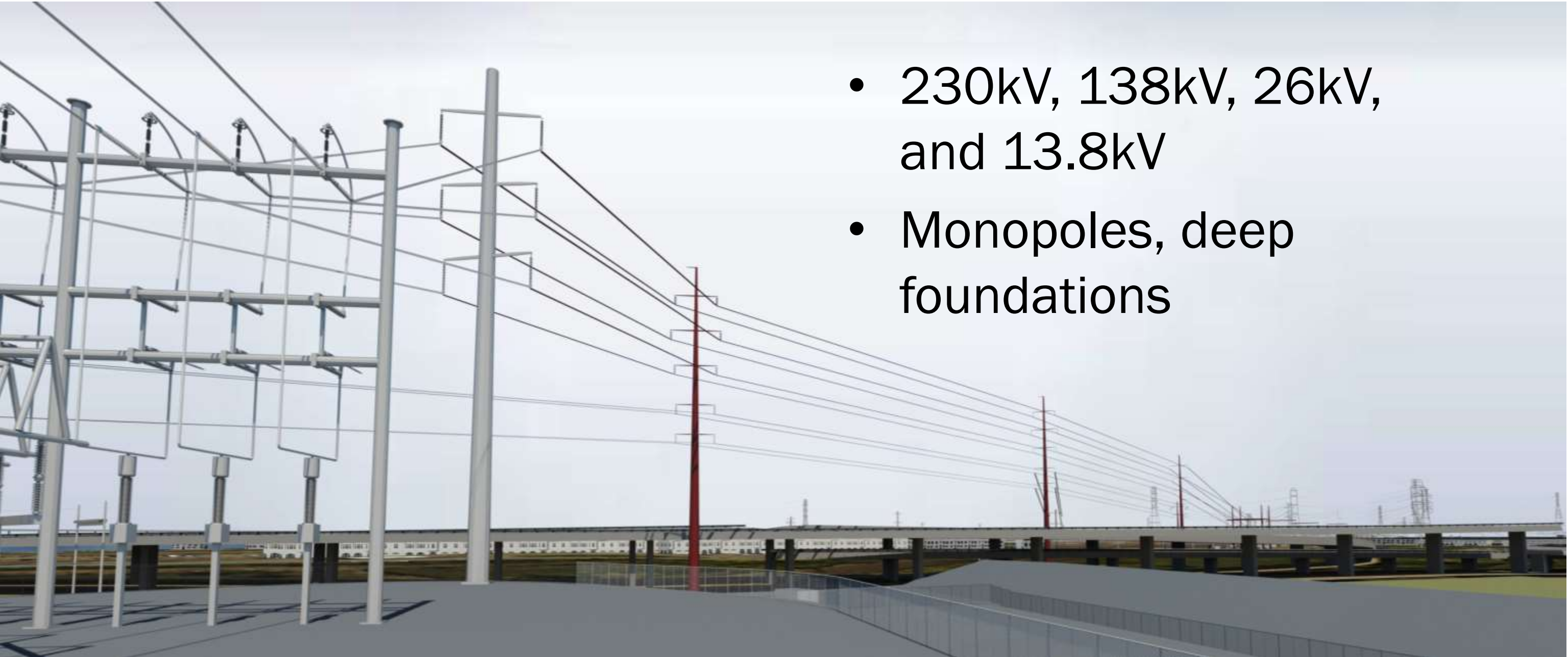


Mason Substation

- Connection to PJM grid
- PSE&G redevelopment of a new Mason Substation
 - **NOT IN CONTRACT**
- Existing air substation for traction power
- PSE&G developing GIS 1.5 breaker substation
- TRANSITGRID to connect via redundant 230kV underground lines

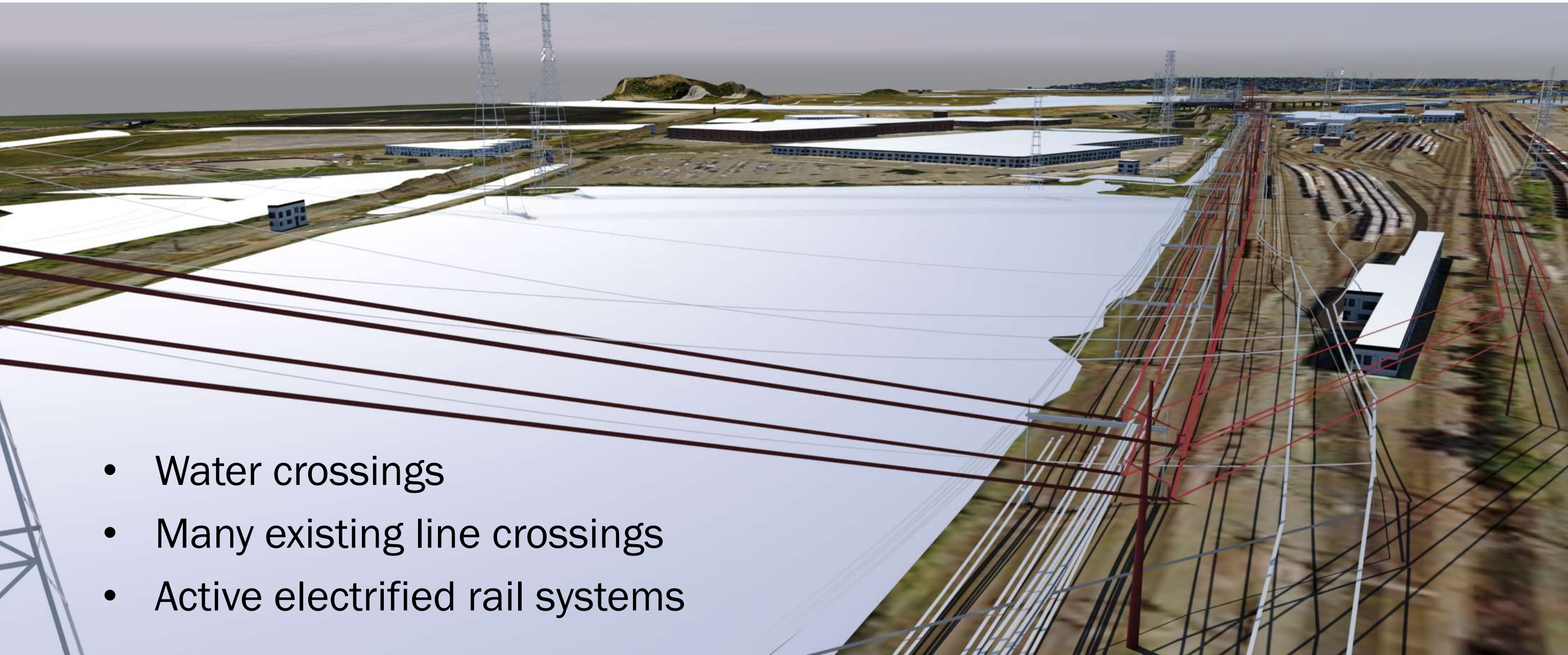


Transmission & Distribution



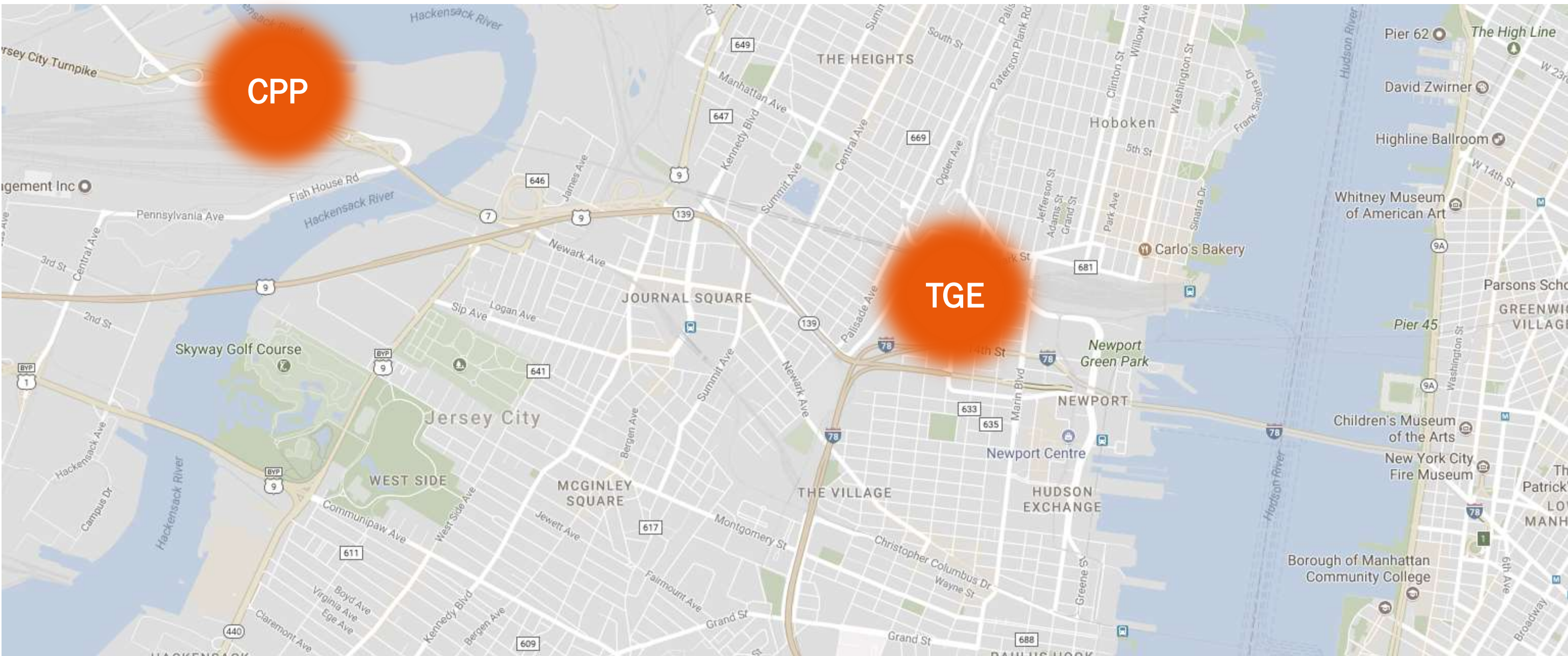
- 230kV, 138kV, 26kV, and 13.8kV
- Monopoles, deep foundations

Transmission & Distribution



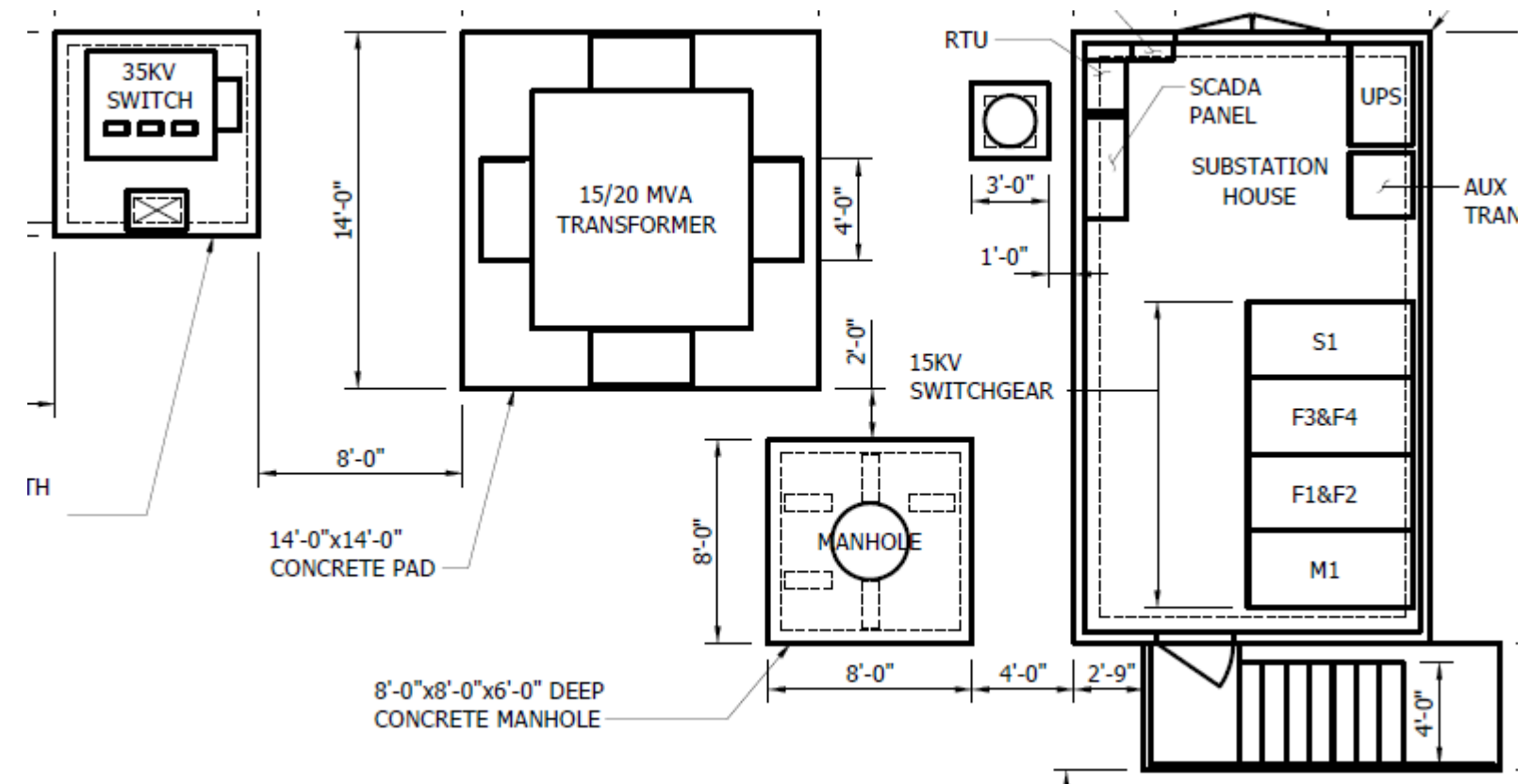
- Water crossings
- Many existing line crossings
- Active electrified rail systems

TRANSITGRID **East Substation**



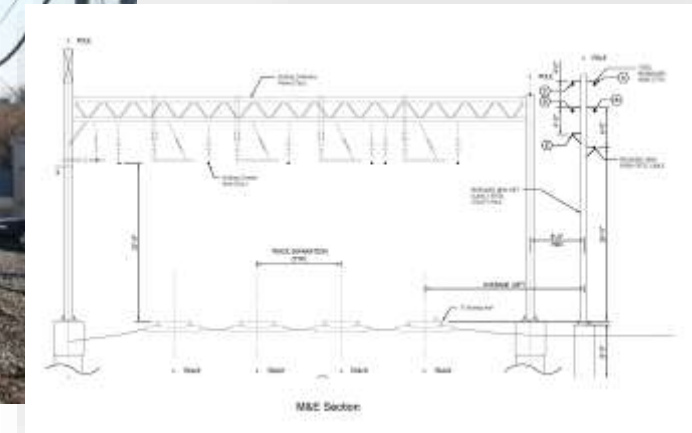
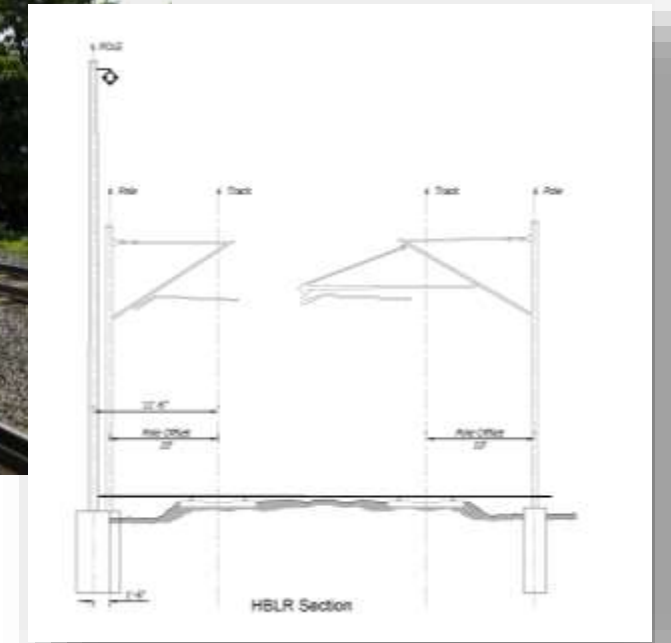
TRANSITGRID **East Substation**

- 26kV metal clad switching station
- Connection to Hoboken Yard
- Connection to HBLR North & South
- Service to Weehawken vent shaft



Transmission & Distribution

- ~20 miles of new distribution along active rail lines
- Nights / weekend work
- Agency coordination



“

If it wasn't hard, everyone
would do it. It's the hard that
makes it great. ”

Tom Hanks

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