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: $2.5B
- Northeast Blackout 2003: $6B
- Hurricane Irene 2011: $7.5B
- Superstorm Sandy 2012: $35B
STATEWIDE DAMAGE
March 2014 BPU-Rutgers Report

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**
Not in Scope

Ancillary Facilities
Rail Passenger Stations
Bus Maintenance Facilities

Bridge Signals & Switches
Transit Resilience:
THE CHALLENGE (S)
Traction Power Loads

1 second time scale

5 second rolling average

Extreme Variability; 18MW/sec

Real Power Loading; High Power Factor

Regenerative Braking
What does a microgrid need to succeed?

Steady voltage
Steady frequency

Piece of cake, right?
Traction Power Loads

• ALP- 46A Engines on M&E Line
• Single phase 7,500HP, power electronics
• 100MPH limits
• Limited to ±1% of 60Hz
Traction Power Loads

Very Small Equipment Step Change Capability at +/-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

- Break down control bands to what equipment capabilities
- Storage serves to integrate load, but also “supercharge” governor abilities
Frequency Control

- Five 23MW gas turbines ≈ 10MW / sec load changes within ± 1% Hz
- 9MW of storage covers delta to allow 18MW /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
Air Permitting

For Startup, Total NOx = 1.7 lbs
For Startup, Total CO = 1.4 lbs

Accel to Sync
Idle

Base Load

Acceleration to Base Load

Warm up at stable load

NOx Emission Concentrations @ ref. 15% O2, PpmvD

CO Emission Concentrations @ ref. 15% O2, PpmvD

Time, minutes
Transit Resilience: CONNECTING THE LOADS
Project Details

SUB41
MASON
CPP
TGE
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

- 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