Transmission Expansion Advisory Committee

Paul McGlynn

January 21, 2009

- In November 2008 we discussed the results of retool analysis PJM completed of 2012
- Part of that discussion was related to the Susquehanna – Roseland line.
- PJM staff recently identified a modeling error in the case used for part of the analysis.
- Following are the results of updated analysis correcting the modeling issue.
- The updated analysis continues to demonstrate the need for the Susquehanna – Roseland line in 2012.

2012 Retool – Susquehanna to Roseland Project

Overload Reduction For Single Contingencies

Overloaded Facility			Without Susq- Roseld	With Susq- Roseld
Fr Name	To Name	kV		
BRIDGWTR	MIDDLSEX	230	2021	>2022
BUSHKILL	KITATINY	230	2013	>2022
MTN CRK	MO PARK	230	2017	>2022
PORTLAND	KITATINY	230	2019	>2022
GILBERT	MO-TOWN	230	2021	>2022
LK ILIFF	MONTVILE	230	2019	>2022
E WINDSR	SMITHBRG	230	2017	2022
MTN CRK	PORTLAND	230	2014	>2022
PORTLAND	GRYSTN Q	230	2020	>2022
BRANCHBG	READ-GTN	230	2012	>2022
WHIPPANY	ROSELAND	230	2014	>2022
READ-GTN	ROSELAND	230	2012	>2022

Overload Reduction For Single Contingencies

Overloaded Facility			Without Susq- Roseld	With Susq- Roseld
Fr Name	**To Name**	**kV**		
G GARDNR	CHESTER	230	2019	>2022
HOSENSAK	ELROY	230	2019	>2022
NEWTON	LK ILIFF	230	2018	>2022
RICHMOND	CAMDEN7	230	2015	2018
MONTVILE	ROSELAND	230	2014	>2022
KITATINY	POHATCNG	230	2016	>2022
COXSCRNR	LUMBRTN	230	2021	>2022
KITATINY	NEWTON	230	2017	>2022
WANEETA3	RICHMOND	230	2017	2019
GRYSTN Q	WHIPPANY	230	2012	>2022
W WHRTN	GRYSTN J	230	2016	>2022

Overload Reduction For Tower Contingencies

Overloaded Facility			Without Susq- Roseld	With Susq- Roseld
Fr Name	To Name	kV		
BRIDGWTR	MIDDLSEX	230	2012	>2022
PORTLAND	KITATINY	230	2013	>2022
SUSQHNA	JENK_SQU	230	>2022	2019
MTN CRK	PORTLAND	230	2012	>2022
PORTLAND	GRYSTN Q	230	2018	>2022
WARRNGTN	BUCKNGH2	230	2019	>2022
GILBERT	MO-TOWN	230	2019	>2022
JUNIA-H1	CUMBE-H2	230	2020	>2022
MCKLTON	THOROFAR	230	2022	>2022
FRCKVLLE	SIEGFRED	230	2021	>2022
MTN CRK	MO PARK	230	2012	2020
N WALES7	HARTMAN	230	2020	>2022
POHATCNG	W WHRTN	230	2021	>2022
BUSHKILL	KITATINY	230	2018	>2022

Overload Reduction For Tower Contingencies

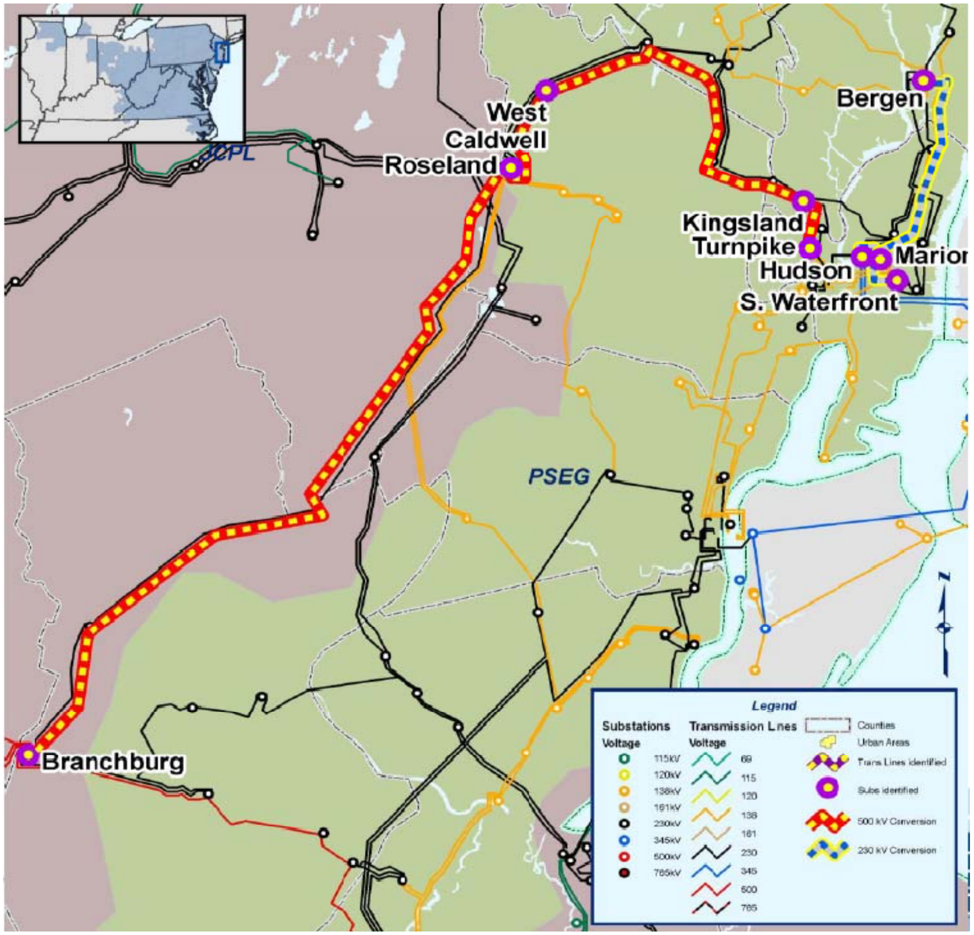
Overloaded Facility			Without Susq- Roseld	With Susq- Roseld
Fr Name	To Name	kV		
LK ILIFF	MONTVILE	230	2012	>2022
NEWTON	LK ILIFF	230	2012	>2022
HARTMAN	WARRNGT8	230	2022	>2022
MONTVILE	ROSELAND	230	2012	>2022
GRYSTN J	WHIPPANY	230	2021	>2022
KITATINY	POHATCNG	230	2012	2021
BRANCHBG	READ-GTN	230	2021	>2022
G GARDNR	CHESTER	230	2013	>2022
KITATINY	NEWTON	230	2012	2020
GILBERT	G GARDNR	230	2020	>2022
GRYSTN Q	WHIPPANY	230	2012	>2022
W WHRTN	GRYSTN J	230	2012	>2022
LEWISTWN	JUNIATA	230	2020	2020

- **BACKGROUND**

- 2013 PSEG thermal and reactive issues
- Two alternatives resolve reactive issues with the 500kV alternative is more robust resolving all near term thermal violations
- PJM recommended the 500kV alternative provided that no fatal flaws with this alternative were identified
- PJM Interconnection, LLC commissioned Burns and Roe to conduct a comparative independent evaluation and provide a recommended upgrade option based on permitting issues, technical risks, cost, schedule and overall complexity of both the 230 kV and 500 kV alternative system upgrades

PSE&G 500kV vs. 230kV Feasibility Study

- **<u>OPTION 1: 500 KV ALTERNATIVE</u>**
- **Summary Level Scope:**
- New Branchburg – Roseland overhead 500 kV circuit
- Convert overhead Roseland – Turnpike 138 kV to 500 kV circuit and extend to new 500 kV Hudson substation
- Convert overhead Hudson – Bergen circuit (F-1306) from 138 kV to 230 kV
- Upgrade Hudson substation for 80 kA
- Requires modifications to 9 substations



Total Estimated Cost: $1,190 Million

Total Elapsed Schedule: 4.5 – 5 Years

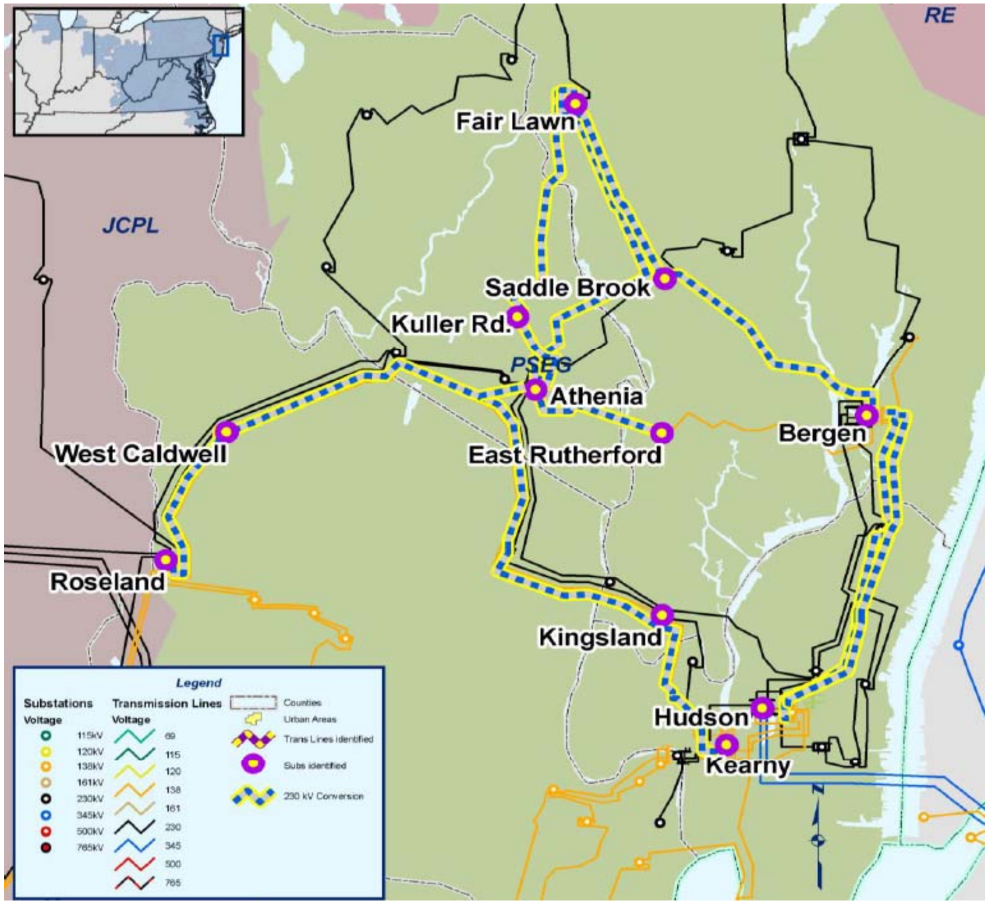
(including permitting, engineering, procurement and construction)

- **<u>OPTION 2: 230 KV ALTERNATIVE</u>**
- **Summary level Scope:**
- Modify overhead Roseland – Kearny 230 kV circuit looping it into the Athenia Substation
- Convert overhead Roseland – Kearny 138 kV circuit to 230 kV
- Re-conductor 7 individual underground 138kV circuits (totaling 38.5 miles) for 230 kV service
- Upgrade Hudson substation for 80 kA
- Convert overhead Hudson – Bergen circuits (F-1306 & E-1305) from 138 kV to 230 kV
- Requires modifications to 12 substations

Total Estimated Cost: $907 Million

Total Elapsed Schedule: 5 – 5.5 Years

(including permitting, engineering, procurement and construction)



- **Option 1: 500 kV Alternative Risk Factors**
  - **Permitting / Environmental:**
    - Permitting: There are no regulatory issues that would prevent the necessary permits from being granted.
    - Public Opposition: Opposition to the Susquehanna - Roseland 500 kV line continues to intensify and increases difficulty risk to public approval of the Branchburg – Hudson line. FERC backstop option is available but would adding time to permitting approval process.
    - Koppers Superfund Site: The Hudson 500 kV substation requires land acquisition and completion of remediation work. The smaller footprint provided by a GIS would reduce time or possibly eliminate the need for remediation. This would also allow for an shorter overall construction duration
    - Great Swamp National Wildlife Refuge: The new 500 kV Branchburg-Roseland line is located along the boundary of the Great Swamp which may involve review by the US Fish and Wildlife Service.
  - **Construction Issues:**
    - Hackensack River Crossing: The Hudson 500 kV substation will require an overhead river crossing to connect the 230 kV Hudson and 345 kV Farragat lines. Some of the existing overhead lines may need to be relocated to support this option.
    - Hackensack River Crossing: This overhead line will require ~300 foot towers and FAA Authorization due to height and proximity to Newark Airport.

PSE&G 500kV vs. 230kV Feasibility Study

- **<u>Option 1: 500 kV Alternative Risk Factors continued</u>**
  - **<u>Construction Planning and Outage Sequencing</u>**
    - Simultaneous Line Outages:
      - All four transmission lines in the Roseland – Hudson right of way will be required for safety during 500 kV monopole erection [includes the two circuits that will be replaced and the two adjacent circuits (for safety)].
    - Construction Schedule: conceptual level schedule developed for duration estimate. A more definitive system outage and reliability studies must be completed.
  - **<u>Positive Aspects</u>**
    - New Construction: predominantly new construction requiring relatively short duration outages. The fewer number of, and shorter duration of outages required for Option 1 should result in higher system reliability during construction as compared to Option 2.
    - Distribution System Impacts: Option 1 will have less impacts on the PSE&G distribution system due to the limited amount of work in substations at distribution system voltage levels
    - Adequate Right-of-Way: Based on preliminary analysis, there is sufficient space within existing right-of-way's to accommodate the new and upgraded overhead lines

- **Option 2: 230 kV Alternative Risk Factors**

  - **Permitting / Environmental**
    - Possible Dielectric Oil Spills: The condition of underground piping cannot be fully evaluated without first removing existing conductors. High stresses imposed on the piping system during cable removal and installation could result in the failure of pipe segments with hidden or undetected existing deterioration resulting in increased risk for underground leaks and dielectric fluid spills during construction.
    - Unplanned Replacement of Underground Piping: Any need to replace piping and/or manholes determined after removing the existing conductors will require roadway closures, excavation, and permitting, resulting in significant unanticipated delays and extended periods of reduced system reliability. Wetlands permitting would be required for the replacement of any of the three circuit crossing beneath the Passaic River
    - Local Inconvenience: Removal and replacement of underground cable will create significant traffic disruption in congested urban areas of New Jersey

  - **Construction Issues:**
    - Underground Piping System Design Life: existing underground piping system is approx 60 years in age. The condition of underground components including piping and manholes cannot be fully assessed without first committing to this option and removing existing conductors and dielectric fluid. Any unexpected pipe replacement would result in extensive construction delays and the need for unplanned for environmental permitting.

- **Option 2: 230 kV Alternative Risk Factors**
  - **Construction Issues (continued)**
    - Larger Conductor Diameter: Larger conductors will require a switch in insulation to use existing pipe diameter. This will necessitate the switch from a mineral oil to a synthetic based dielectric fluid and the possible need for pumping and pressurization system design changes.
    - Substation Modifications: Space is severely limited at two substations (Athenia and Bergen) for 138kV to 230kV conversion, requiring complicated modifications and possible extended outage durations
    - Transformer Procurement: Replacement of approximately 21 power transformers presently connected at 138 kV will be required. A definitive system reliability and outage sequence plan/schedule need to be completed to identify when both mobile and/or new transformers will be required. Long lead time procurement for this equipment may present schedule and planning challenges
  - **Construction Planning and Outage Sequencing**
    - System reliability: Maintaining system reliability will be a challenge during the multi-year Re-conductoring plan. Two substations are presently served by only two underground lines; replacement of each line will leave each station connected to only one feed source. Further study is required to develop a construction sequencing and outage duration plan that maintains acceptable system reliability
    - Increased fault levels: Increased fault levels resulting from higher voltages in the distribution system need to be evaluated to determine the capability of existing distribution equipment and for the need to upgrade equipment within the PSE&G distribution system.
  - **Positive Aspects**
    - A majority of the transmission line upgrades are underground and therefore less visible to the public
    - Fewer permits required and reduced public scrutiny expected when compared to Option 1
    - With the use of GIS equipment, it may be possible to construct the Hudson 230 kV substation at the existing location eliminating the need to work at the Koppers superfund site.

PSE&G 500kV vs. 230kV Feasibility Study

- **General Permitting Considerations**

- 500kV: Environmental Permitting is more extensive
  - Permitting within the Great Swamp National Wildlife Refuge will require development of mitigation plans and a joint EPA and US Fish and Wildlife Services permit review will be required if more than 5 acres are disturbed.
  - Full individual wetlands permits (as compared to general permit) will be required since more than 1 acre of wetlands will be disturbed.

- 230kV: Significant risk for oil spills and resulting contamination and remediation due to extensive work on the aging underground transmission system.

- Both 500kV and 230kV: NJDEP Freshwater Wetlands Permitting is the critical path permit if use of the Koppers Superfund site is ultimately required
  - Approximate 1.5 years required for planning, permit submittal, review, and approval
  - The "Remedial Action Work Plan" will have to be completed to construct in this location

- Other significant permits (non critical path) include:
  - NJDEP Storm water Discharge Permit
  - NJDEP Stream Encroachment Permit
  - FAA Notice of Construction/Alteration required for structures over 200 feet in height
  - Local Planning and Zoning Board Approvals, no significant issues identified per local codes

- **Cost Estimate**

- Option 1 – 500kV Estimated Total Cost = $ 1,190 Million
- Option 2 – 230kV Estimated Total Cost = $ 907 Million

- **Basis for Cost Estimate:**

- Engineer, Procure and Construct Contracting Method with the substation modification and transmission work included in separate contracting packages
- PSE&G procures equipment directly to avoid contractor mark-up
- Construction and outage schedule assumptions as defined below
- Overall contingency of 25% included in the total estimated cost
- Estimate level of accuracy: +/- 30%
- No escalation is included in the current estimate

Construction Schedule and Assumptions

- **Queue O66 and associated network upgrades in service prior to energization of these options.**

Option 1 – 500kV

- **Total Elapsed Schedule: 4.5 – 5 Years (**including permitting, engineering, procurement and construction)
- 1.5 years - conceptual design and permitting prior to the onset of construction; and that public opposition does not delay issuance of permits required for construction
- 3 - 3.5 years - construction duration following receipt of all permits with the first outage required a minimum of 1 year from the onset of construction
- Release for engineering and procurement work in parallel with permitting to maintain schedule to assure long lead time procurement is not on the project critical path
- Assumes parallel work on substations and transmission line construction prior to the onset of activities requiring outages. Outage work limited to the September – April time frame
- "Typical" outage scheduling and durations assumed to develop schedule estimate. A definitive outage sequencing plan and system contingency analysis need to be performed to refine this schedule

Option 2- 230kV

- **Total Elapsed Schedule: 5 – 5.5 Years (**including permitting, engineering, procurement and construction)
- Circuit Re-conductoring represents the project critical path. However, this work does not require long lead time permitting. Planning, engineering and cable procurement activities can begin immediately with the first circuit being taken out of service approximately 6 - 10 months from the beginning of the project.
- Lead time for cable procurement should not delay the project due to the sequential nature of the project
- Parallel re-conductoring of up to 2 circuits considered acceptable in the schedule analysis. A definitive outage sequencing plan and system contingency analysis need to be performed to refine the cable installation sequence
- It is assumed all underground conduit is serviceable and does not need to be replaced
- Substation engineering and equipment procurement will begin in parallel with the re-conductoring work
- Outage work limited to the September – April time frame
- "Typical" outage scheduling and durations assumed to develop schedule estimate. A definitive outage sequencing plan and system contingency analysis need to be performed to refine this schedule

January 20, 2009

Conclusions and Recommendations

- 500kV Option 1 represents the lower risk system upgrade alternative with less system impact during construction and a shorter overall construction schedule when compared to Option 2:
  - Option 1 involves more new construction. However, outage and cutover requirements are generally less complicated and of shorter duration for new construction
  - Option 1 is all overhead. The majority of the outages for the adjacent lines will be short for monopole erection, longer duration outages will only be required for the line being rebuilt for the higher voltages. Additionally overhead lines can be restored more quickly if emergency conditions arise
  - Option 2 will require multiple transfers from permanent power to temporary power and then back to a higher voltage permanent feeds adding to reliability concerns.
  - Because of the nature of underground cables and splicing during the construction of Option 2, substations will be operating without one of their normal feeds with reduced reliability for months at a time
- While technically feasible, Option 2 presents elevated environmental and schedule risks due to the age of the underground piping system that cannot be full quantified prior to the onset of construction.
- A definitive outage sequencing and duration plan along with a system reliability study need to be completed for each option to verify the construction sequencing, and outage durations assumptions developed by Burns and Roe in completing the evaluation.
- Engineering studies need to be commissioned to further define substation upgrade configurations and footprints especially for the Athenia and Hudson substations to confirm the feasibility of the upgrades defined for Option 1 and 2 respectively.

2009 RTEP Assumptions

- Power flow models for world load, capacity and topology will be based on the most recent ERAG MMWG power flow base case.
- PJM topology will be based on the ERAG MMWG 2008 Series Summer 2014 base case – updated with RTEP upgrades approved as part of the 2008 RTEP.
- Long term firm transmission service will be consistent with operations.
- Generation outage rates will be based on the most recent Reserve Requirement Study performed by PJM.
- Generation outage rates for future PJM units will be estimated based on class average rates.

- Load will be modeled consistent with the 2009 PJM Load Forecast Report.
- PJM RTO Peak (for 2014): 155,498 MW
  - PJM South Peak: 21,518 MW
  - PJM West Peak: 67,989 MW
  - PJM Mid-Atlantic: 65,991 MW

    *Note – All loads are Non Coincident Peaks
- Load Management will be modeled consistent with the 2009 Load Forecast Report
  - Used in LDA under study in load deliverability analysis

- All existing generation expected to be in service for the year being studied will be modeled.
- Future generation with a signed Interconnection Service Agreement will be modeled along with any associated upgrades.
- Generation with a signed ISA will contribute to and be allowed to back-off problems.
- Generation with a signed Facility Study Agreement (FSA) will be modeled along with any associated network upgrades.
- Generation with a signed FSA will be modeled off-line except for generation deliverability testing to contribute to problems.
- Generation with a signed FSA, but not an ISA, will not be allowed to back-off problems.
- If the PJM load exceeds the sum of the available generation and generation with an executed ISA then queued generation that has an executed FSA will be turned on to meet firm interchange.
- Additional generation information will be posted to the TEAC page.

New Generation – Since 2008 RTEP Initiated

- **Mid-Atlantic**
  - New generation with a signed ISA – 500 MW
  - New generation with a signed FSA – 3500 MW
- **Southern**
  - New generation with a signed ISA – 500 MW
  - New generation with a signed FSA – 650 MW
- **West**
  - New generation with a signed ISA – 1000 MW
  - New generation with a signed FSA – 900 MW

2014 RTEP Interchange

2014 RTEP IINTERCHANGE		
FROM	**TO**	**MW**
PJM	AMIL/AMRN	-148
PJM	CIN	580
PJM	EKPC	0
PJM	FE	368
PJM	IP	0
PJM	LGEE	-154
PJM	OVEC	-2316
PJM	ALTW	264
PJM	ALTE	155
PJM	CPLE	198
PJM	CPLW	250
PJM	DUKE	63
PJM	MEC	1370
PJM	MECS	574
PJM	NIPS	0
PJM	NYIS	1957
PJM	WEC	930
PJM	TVA	918
TOTAL		**5009**

- All PJM bulk electric system facilities 100 kV and greater, all tie lines to neighboring systems and all lower voltage facilities operated by PJM will be monitored.
- Contingency analysis will include all bulk electric system facilities 100 kV and greater, all tie lines to neighboring systems and all lower voltage facilities operated by PJM.
- Thermal and voltage limits will be consistent with those used in operations.

- Analysis of 2014 through 2024
- Started developing 2014 case back in December
- 2014 Base case development nearing completion
- Retool of previous RTEP analyses
- Initial efforts will focus on 2012 and 2013 followed by 2010 and 2011
- Previous RTEP base case update
- Retool will evaluate backbone and significant lower voltage transmission facilities
- Future TEAC and Subregional RTEP Committee meetings will be scheduled as we complete analysis

