Eastern Interconnection Planning Collaborative

Coordination of MRN-NEEM Modeling and High Level Transmission Analysis in Task 5

December 30 Revision of the presentation at Macro Future Workshop November 8-9, 2010

Project Objectives – Phase I

- The Roll-Up
- Macroeconomic analyses of 8 resource expansion futures
  - Original proposal was that the Roll-Up would serve as the starting point
  - Adoption of a different “baseline infrastructure” would change that
- Macroeconomic analyses will provide useful information to the SSC in determining the 3 expansion scenarios to be chosen in Task 6
- EIPC to provide high-level transmission analysis for the futures of interest in the 8 macroeconomic analyses

NEEM Model Background

The Model **Does**:

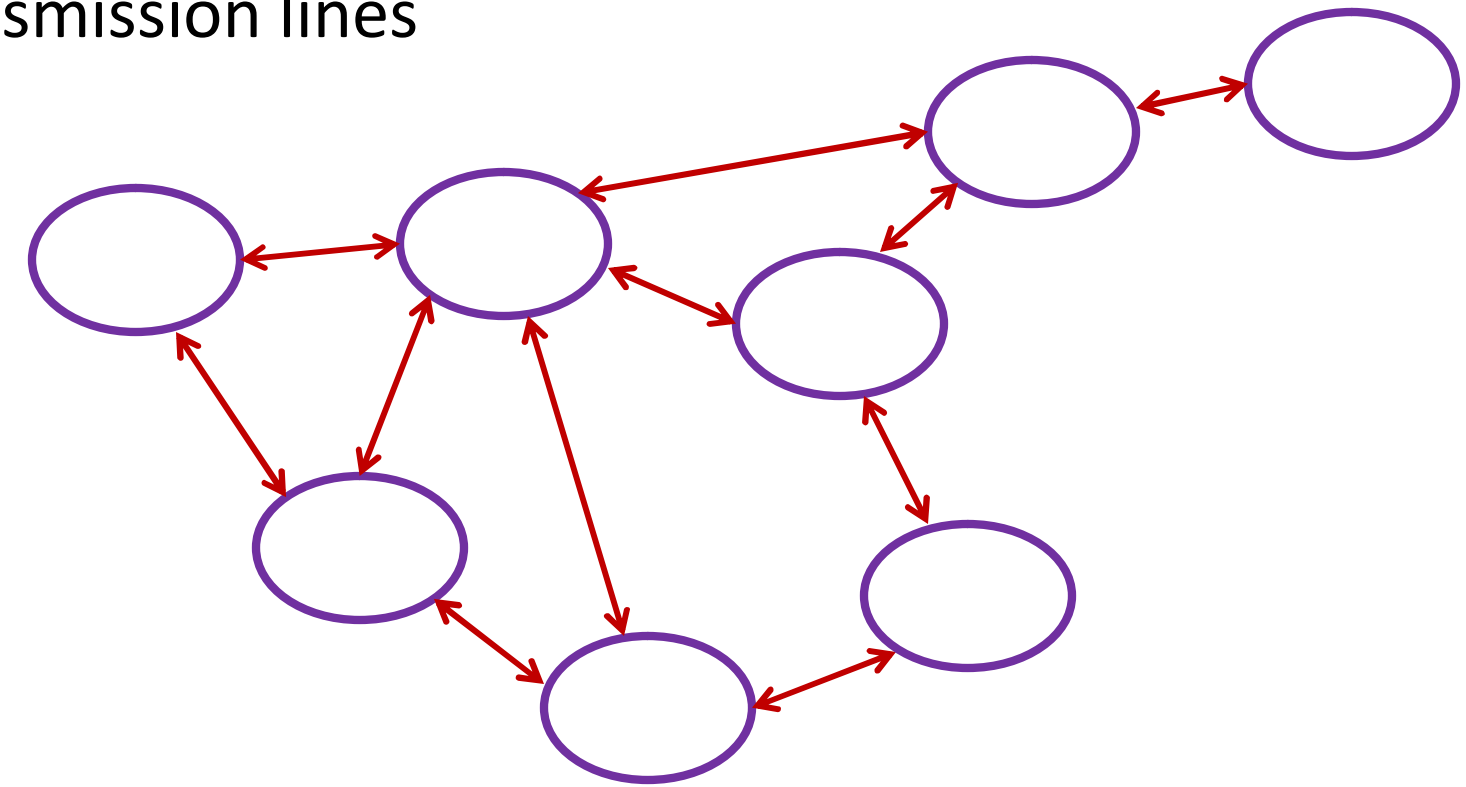
- Assess economics (prices, load impacts, generation expansion decisions) not transmission line power flows
- Produce resource expansion forecasts based upon economics over a long period of time (40 years)

The Model **Does Not**:

- Represent transmission lines, but instead represents transfer capabilities between regions
- Automatically alter transfer capability over the 40 year period (the transfer capability used is fixed)

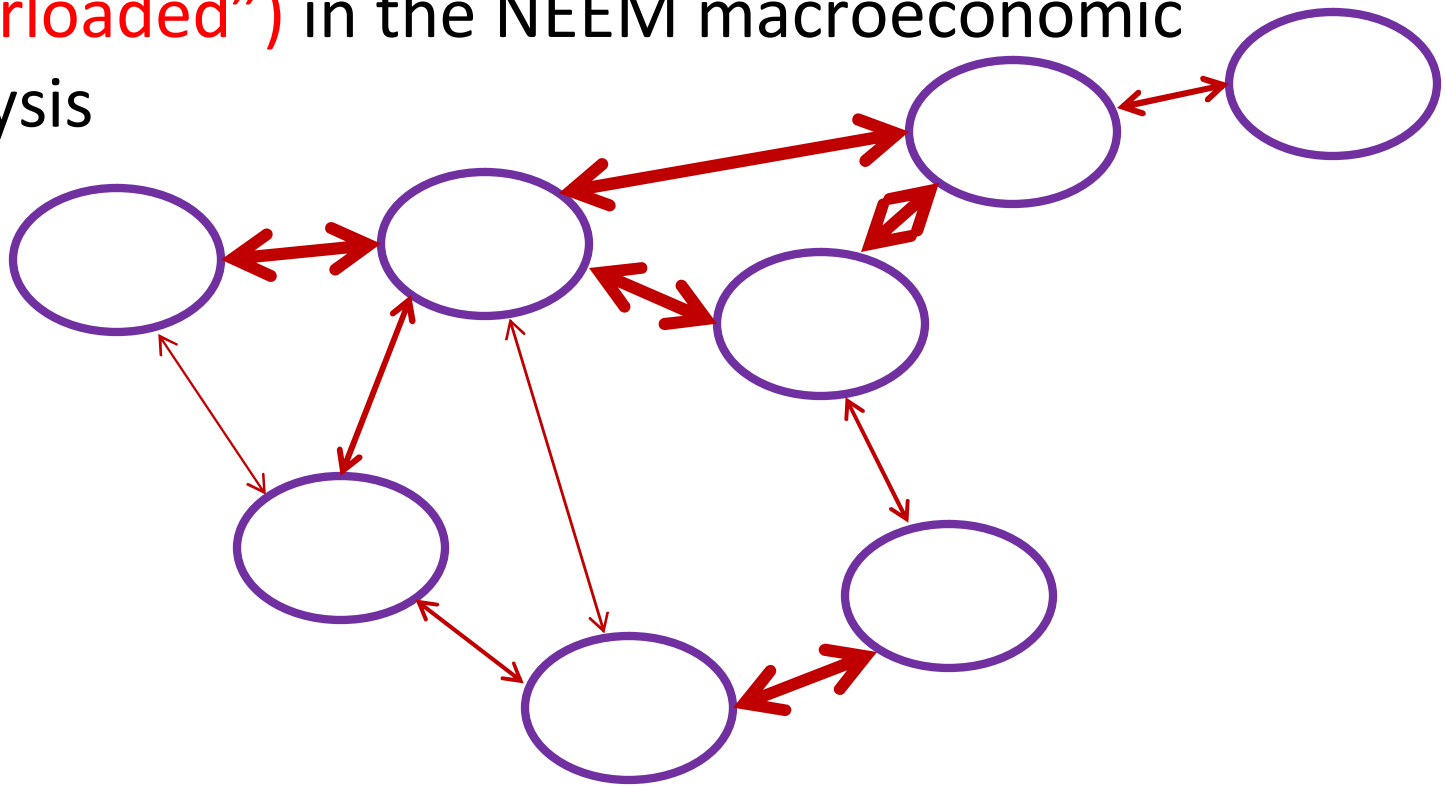
NEEM: Pipe and Bubble Example

- Red arrows depict transfer capability, not transmission lines



Pipe and Bubble Example

- Specific transfer limits can be expanded (or "overloaded") in the NEEM macroeconomic analysis



NEEM Model Initial Set-up – Step 1

NEEM Regions ("Bubbles")

- EIPC PAs review and adjust regions in the NEEM model
  - Provide recommendation to stakeholders
- SSC may provide adjustments to the original NEEM regions
- Regions are the same for all macro runs

NEEM Model Initial Set-up – Step 2

"BASELINE INFRASTRUCTURE"

- **Resource additions** and retirements that are included in the Roll-Up case are confirmed or removed by SSC to develop the resource baseline infrastructure – e.g. removal of "less likely" resources
  - NEEM will pick resources to be added from that point
- Remember the focus of NEEM analysis is resource additions, not transmission

NEEM Model Initial Set-up – Step 3

Initial Transfer Capabilities

- Limits between "bubbles" are set in NEEM for all load blocks of every year analyzed
- EIPC develops initial transfer limits (pipes) based upon information obtained from multiple sources including, but not limited to:
    - Linear analysis performed on the Roll-Up model (if baseline infrastructure model does not solve)
    - Linear analysis performed on the baseline infrastructure model (model solution and removal of reliability projects is a concern)
    - Historical OASIS postings, and/or
    - Previous studies performed

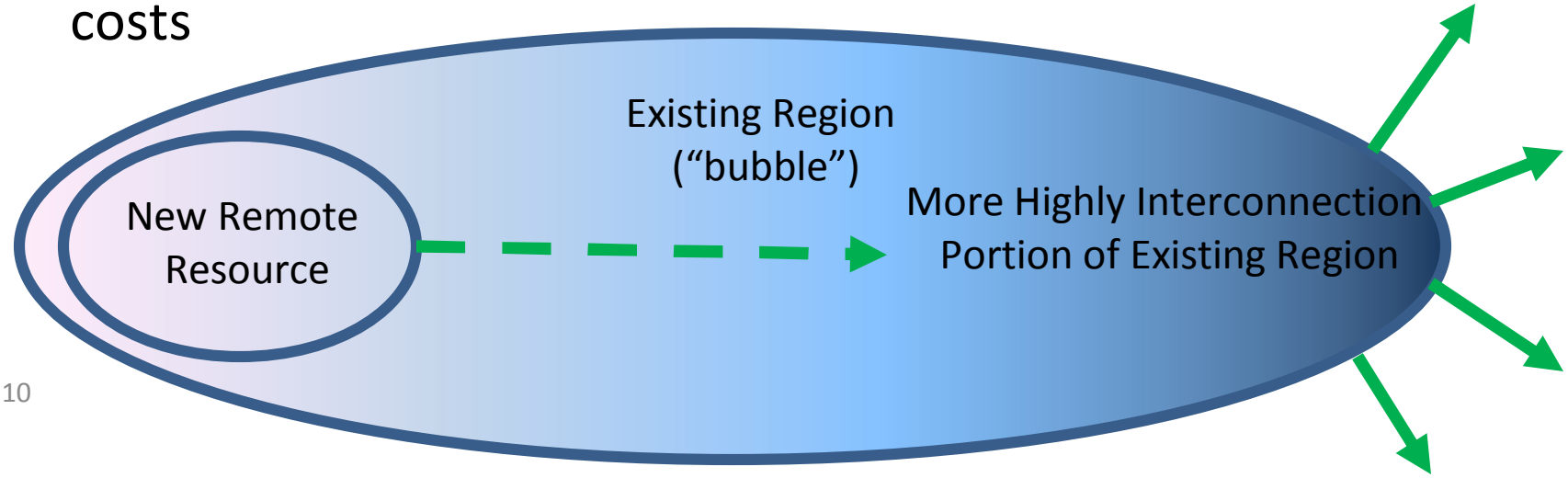
NEEM Model Initial Set-up – Step 3

Initial Transfer Capabilities (continued)

- Some transfer limits between bubbles may be stability constrained and cannot be appropriately determined using linear analyses
- Used as the same starting point for all macro runs

NEEM Model Initial Set-up – Step 4

- SSC has the option to define a resource within an existing region (bubble) but remote from the existing bulk system
  - Cost of interconnection to the bulk system added to the resource capacity cost
  - Important when there is a large difference in interconnection costs



MRN-NEEM Analysis and Possible Transmission Adjustment by SSC – Step 5

1. CRA performs the initial run of MRN-NEEM for each future macroeconomic case defined by the SSC
2. Results provided to SSC before any sensitivities are run:
   - Shadow prices for binding constraints (pipes)
   - Energy and capacity prices within regions
   - Number of binding hours on transfers between regions (pipes)
   - Average flow between regions (through pipes)
   - Future generation additions and retirements by region as bounded by all the inputs
   - Based on shadow prices estimates can be made of overload costs on flows between regions above initial transfer limits
3. CRA runs sensitivity #1 in which transfer limits are treated as "soft constraints," flows are allowed to exceed transfer limits at an overload charge. The magnitude and duration of the overloads are identified. CRA provides results to SSC

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MRN-NEEM Analysis and Possible Transmission Adjustment by SSC – Step 5

4. SSC either (i) picks the initial starting point transfer limits treated as "hard constraints" as in the original future case run or (ii) treat these transfer limits as "soft constraints" as in sensitivity #1 for the remainder of the sensitivities and using the same overload charges
5. CRA proceeds with MRN-NEEM runs for the remaining sensitivities #2 through #9 using the method selected at step 4
6. If SSC selects approach 4.(ii), EIPC will develop an estimate of expanded transfer limits – one per pipe – based on the results of MRN-NEEM runs for sensitivities (1) through (9) and then perform a high level transmission analysis of these expanded transfer limits and provide a cost estimate for transmission additions needed to reach the increased level of transfer

What is the Soft Constrained Approach in Transmission Modeling?

- A widely used approach in which transmission constraints are allowed to be violated, subject to the overload cost proportional to the level of overload
- Overload costs are added to the objective function. The optimization algorithm then balances the cost of generation redispatch needed to maintain transmission flows within limits against overload costs. If redispatch is less expensive than overload, transmission constraint will be obeyed. If overload costs are less than the cost of redispatch, the constraint will be violated
- Allowing a transmission constraint to overload provides the means to explore the following:
  - which resources might be used if transfer limits were increased?
  - what is the overload level of the constraint, i.e. what might be the needed transfer capability increase?

Why the Soft Constraint Approach?

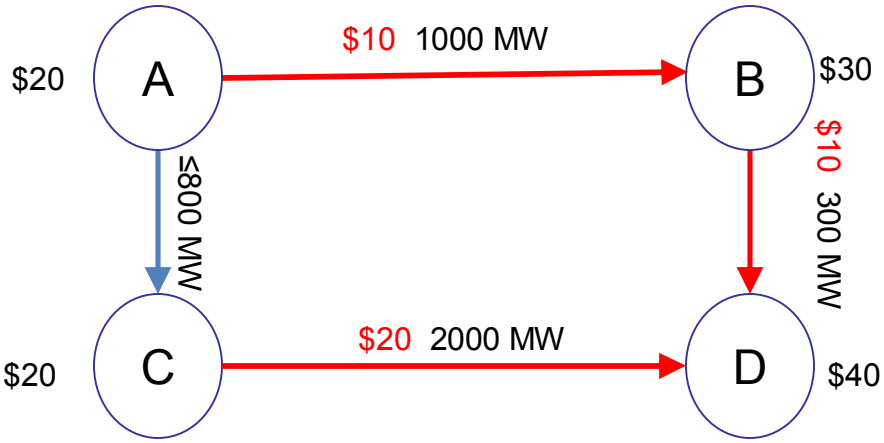
- Reflects the transfer capability of the existing infrastructure (no overload charges on flows within limits)
- Allows the model to overload constraints and explore the resource potential beyond existing transmission limitations
- The overload charges are based on the value placed on the use of transmission by the economics of the baseline system. This balances the constrained and the coppersheet approaches

How the Soft Constraint Approach Works?

Constrained Case Run Results

Zone energy prices are shown next to bubbles.
Constrained pipes are shown in red, along with transfer limits and shadow prices.
Unconstrained pipes are shown in blue.

The picture corresponds to a single snapshot in time. In NEEM there are 20 snapshots (time blocks) per year resulting in 20 picture like that for each year-run.



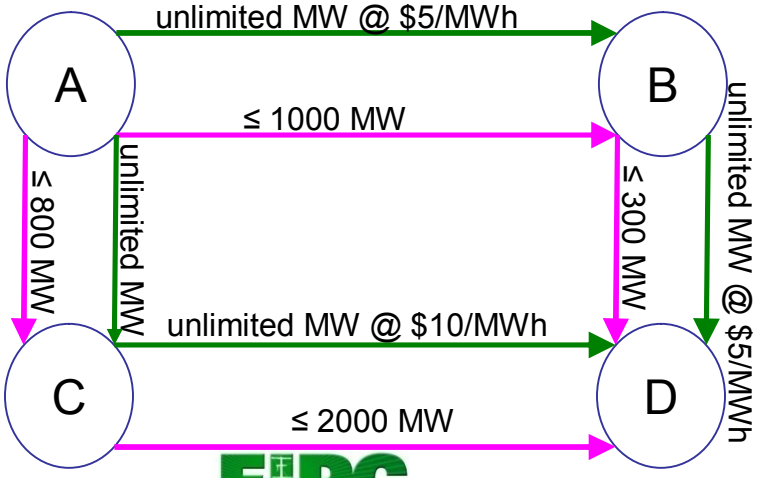
Soft Constrained Case Set-up

All pipes are split into two:
– a limited in flow (pink) pipe as in the Constrained Run; and
– an unlimited (green) pipe.

When a red pipe is split, the flow over a green pipe is subject to the overload charge set below the shadow price determined in the Constrained Run. (In this example charges are set at 50% of shadow prices)

When a blue pipe is split, no overload charge is assessed on the green pipe flow (shadow price for an unconstrained flow is zero)

A green pipe is a proxy used to track the overload flows which are indicative of the need for transmission expansion



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How will the NEEM Optimization Process the Soft Constrained Case?

- NEEM algorithm effectively conducts two interdependent optimizations: (1) generation dispatch optimization and (2) optimal generation expansion
- The dispatch optimization will first use “pink” pipes because they are free of overload charges and only then will weigh in the balance between the overload costs and the cost of generation redispatch. If the overload costs are lower, optimization will use less expensive generation and overload transmission, i.e. use “green” pipes
- The generation expansion optimization will take into account the extent to which a “green pipe flow” is less expensive than generation redispatch and develop generation resources accordingly

Setting Overload Charges - 1

- Overload charge does not (and does not intend to) reflect the cost of increasing the transfer limit. Overload charge reflects the marginal value (a reduction in redispatch costs if transfer limit is increased)
- Overload charges should be set below shadow prices:
  - If overload charge is set at or above shadow prices, the outcome will be identical to the Constrained Case (flow from a pink pipe would never spill over to the green pipe because it is more expensive than generation redispatch)
  - If overload charge is set at zero, the set-up will be as for the coppersheet run (it does not cost anything to spill over from the pink pipe to the green pipe)
  - Setting overload charge below the shadow price creates an incentive in the MRN-NEEM to overload the constraint (it costs money to spill over into the green pipe but not as much as to avoid doing it)

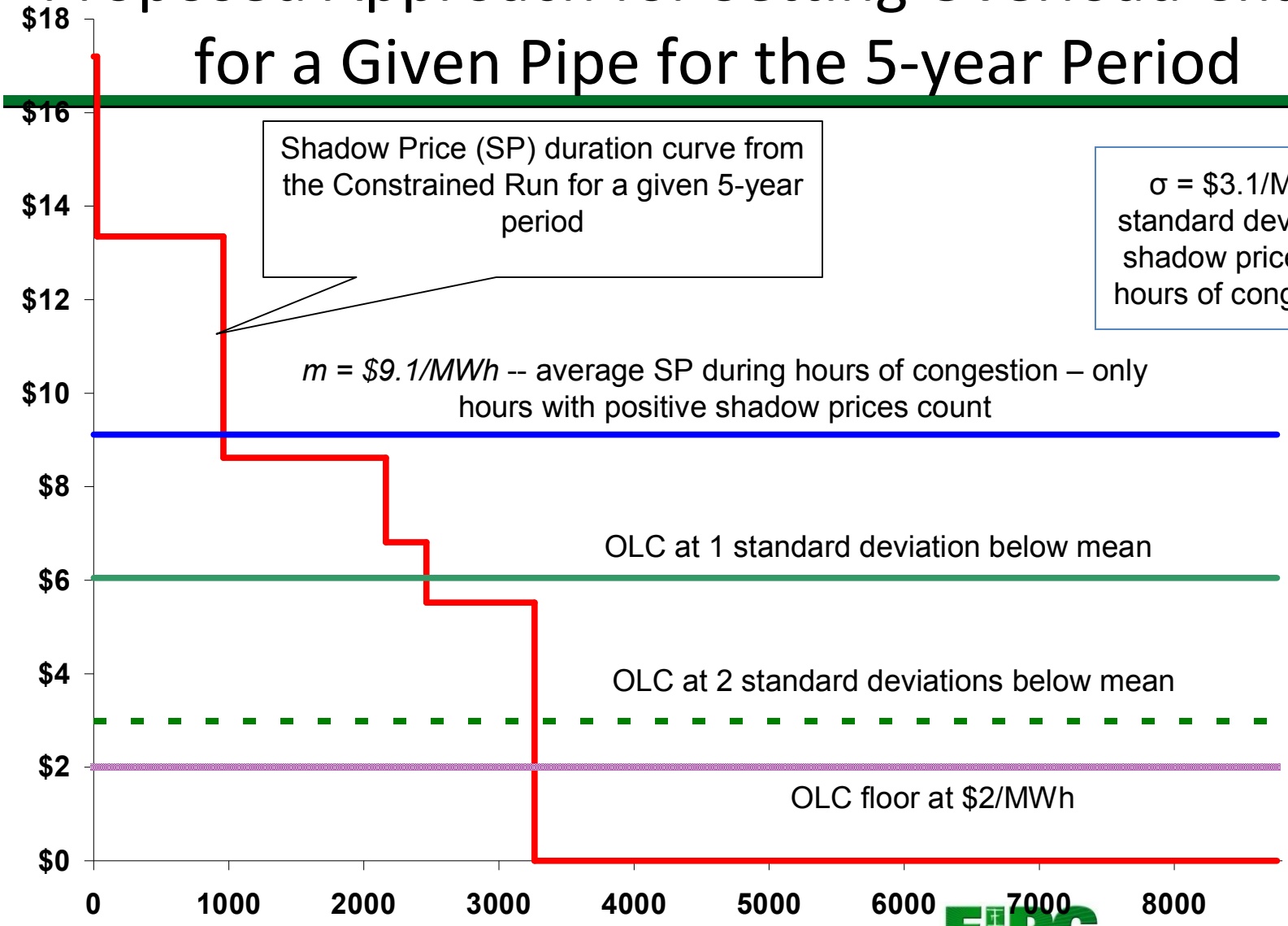
Setting overload charges - 2

- In the Constrained Run shadow prices are determined for each pipe, each time block, each 5-year period
- For the Soft Constrained Run, the overload charge cannot be set by block (due to modeling limitations). Will set one charge per 5-year period for the pipe
- Taking the average of shadow prices across time blocks would be “on average” the same as setting the charge at shadow prices. We need to use a charge that is below average shadow prices
- A standard deviation around the average provides a statistical measure of the range of shadow price spread. For some futures, use of two standard deviation spread may be considered

Setting Overload Charges - 3

- If the average shadow price during hours of congestion is less than $2/MWh, the overload charge (OLC) will be set equal to the average shadow price
- If the average shadow price is above $2/MWh, CRA and EIPC recommend setting the overload charge (OLC) as a average shadow price less one standard deviation of shadow prices during hours of congestion
- For the National RPS Future and National Carbon Future, SSC may instruct CRA to use set OLS as average shadow price less two standard deviations
- If the resulting OLC drops below $2, EIPC recommends keeping the charge at $2
  - The level is arbitrary and is set low enough to facilitate moving additional power while not ignoring transmission limits
- For a given future, CRA will prepare only one set of runs for a single set of overload charges. No alternative cases with different overload charges will be prepared. The overall number of MRN-NEEM sensitivities run by CRA is bounded by 72 (8 Futures x 9 Sensitivities)

Proposed Approach for Setting Overload Charge for a Given Pipe for the 5-year Period



The same overload charge will apply to ALL time blocks within the 5-year period

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Questions and Discussion