EIPC Phase I MRN-NEEM Model Inputs

The purpose of this document is to have a consolidated record of the MRN-NEEM modeling assumptions. The following description of model input assumptions has been developed from the Modeling Work Group MRN-NEEM Model Input Recommendations approved by the SSC at the March 28 & 29 meeting and from subsequent SSC meetings that directed additional changes. Additionally, more details and clarifications have been provided, when warranted, to assist in interpreting the results. Actual data for the model can be found through the links to Google Docs provided in each future.

General Assumptions

1. Wherever a Future or sensitivity called for medium, moderate or mid-level values, those values were assumed to be the same values as BAU.

2. Wherever "low natural gas price" was required, $4.50/MMBtu (2010$) was used for all study years.

3. Any adjustments to capital costs occur in 20% increments, unless specified otherwise.

4. Generation Capital Cost Adders to Represent Transmission Interconnection
   - For the BAU future, the SSC approved a $21.92/kW adder for all generation technologies to represent interconnection costs.
     - The MWG sought input from RW Beck on the extent to which interconnection costs are already included in the AEO 2010 capital cost values for each generation technology but did not receive feedback. Therefore, the MWG recommended that the SSC not adjust the approved $21.92/kW value given the absence of sufficient information to determine an appropriate cost-adder for the different generation technologies and regions, and the likely wide difference in costs between different locations within and among the NEEM regions. In addition, an accurate representation of differential transmission costs as a function of NEEM region and deployment level was determined to be outside the scope of what could be implemented in NEEM within the task schedule. Rather, the MWG recommends that the Planning Authorities, if necessary, consider possible differences in interconnection costs for remote generation during the high-level cost estimating for each future.

5. EPA regulations assumptions modified after release of EPA regulation proposals. Only BAU Base Run and soft constraint sensitivities (S1 and S2) contain old EPA regulations assumptions. Updated EPA regulation assumptions used for remaining sensitivities of BAU and remaining futures. (April 11 and April 29 webinars.)

6. U.S. Hydro potential – The U.S. hydro potential level used for all Futures 2-8 will be 50% of the NPD from ORNL study.
   - 50% of the total will be eliminated from the comprehensive list of dams presented at the March 28-29th meeting, beginning with the smallest ones. (April 11 webinar.)
7. PHEV penetration rates (number of vehicles) were set at a 4.7% sales growth rate over the study period for the BAU and all other Futures unless otherwise specified. (April 29 webinar.)

Future 1 - Business as Usual

Google docs spreadsheets of model inputs for Future 1 base case: http://bit.ly/lGOqBI
Google Docs spreadsheets of mod**el** inputs for Future 1 sensitivities: http://bit.ly/ihRoiB

A. Base Case – Unless otherwise noted, most of the BAU base case assumptions were decided upon at the February 7-8, 2011, SSC meeting.

For all of the following items, the SSC agreed to use the recommended data provided by the MWG (much of which was in the Google Docs spreadsheets as of January 31, 2011):

1. **NEEM Regions** – See EIPC NEEM Regions recommendations (January 18, 2011 webinar.)
2. **MRN Economic Assumptions** – see Google Docs spreadsheets.
3. **RGGI and EPA non-carbon regulations modeling** – See Table 22 and Table 27 of Google Docs spreadsheets.
4. **Oil prices & SO2/NOx Prices** – AEO 2011 prices.
5. **Demand Response, EERS** – June 2009 FERC National Assessment of DR potential.
6. **Load Forecasts**(base, high & low) net of DR & EERS
7. **PHEV & BEV levels** – AEO 2011 data.
8. **Existing Generation data** – See Google Docs spreadsheets.
9. **Class 4 Wind Shapes** – See slide 7 of the New Generation Sub-Team Supporting Info slides.
10. **PTC and ITC sunsets** – extended through model period.
11. **State RPS targets** – Will model voluntary RPS, modeling determined by states.
12. **Wind penetration rates** – 25% on regional basis.

The following items were agreed upon during the February 11, 2011 webinar, unless otherwise noted.

13. **Generation capital costs** – AEO 2011 for all capital costs.
14. **Capital cost learning assumptions** – For all generation other than wind: AEO 2011 where available, otherwise AEO 2010 learning rates. For wind, the SSC agreed upon a 10% learning rate over the period of study.
15. **Transmission cost adder** – $21.92/kW transmission adder for all technologies.
16. **Regional multiplier for capital costs** – For NEISO use 3-city (Burlington, Portland, Concord) for onshore wind and use 6-city average for all other technologies.
17. **Gas price forecast**– AEO 2011 data. Reserve margins, hurdle rates and wheeling charges – adopted adjusted numbers provided by PAs reflecting new NEEM regions.
18. **Intermittent resources contribution to reserve requirement** – Used PAs' input, including revisions for NYISO (15%), IESO (11%) and offshore wind (30%).
    a. SPP's wind contribution to reserve margins was increased to 15% for futures 2-8 at the request of SPP. BAU value was 6%.
19. **Class 3 wind shapes –** Creating Class 3 wind shapes by applying ratio of NREL C3 to C4+ capacity factors to CRA C4+ wind shapes:
    - CRA Class 4 data disaggregated by state in ISO-NE only
    - NREL Class 3 data not available by state
    - To consolidate to NEISO region, MWG recommends state by state weighting by Class 4 capacities.
20. **HQ & Maritimes hydro and wind –** The SSC agreed to the MWG's proxy method to include HQ & Maritimes hydro and wind. (See page 4 of the February 11 webinar summary.)
    • Existing resources modeled as BI fixed flows into neighboring regions
    • New resources modeled as pseudo-generators
        - Cost characteristics from AEO 2011

- Resource limits based on regional studies
- Hurdle/wheeling rates based on Ontario charges

• Model can allow import of capacity under increased transfer limit Sensitivities.
• High-level costs of transmission will be estimated by PA.

21. **MAPP CA and Ontario hydro potential –** The SSC agreed to model new hydro potential as outlined on page 5 of the February 11 webinar summary.

B. Sensitivities– Baseline infrastructure transfer limits to be used for sensitivities 3-16. (March 28-29 SSC meeting.)

1. **Revised Transfer Capability (75%) -** Transfer limits adjusted through soft constraint approach using 75% of overload charges from the reference case; wheeling & hurdle rates remain the same.
2. **Revised Transfer Capability (25%)** - Transfer limits adjusted through soft constraint approach using 25% of overload charges from reference case; wheeling & hurdle rates remain the same. Review Sensitivity #1 results to determine if how to proceed for the remaining Sensitivities.
3. **Revised characterization of EPA regulations** (April 11 webinar.)
4. **High Load Growth -** 1% per year increase over reference case load forecast.
5. **Low Load Growth -** 1% per year reduction over reference case load forecast.
6. **High Natural Gas Price-** Use the high case of the composite of AEO 2010/2011
7. **Extra high (accelerated) Natural Gas Prices** (April 29 webinar.)
8. **Extra Low Renewable Capital Costs –** Reduce capital costs of renewables by 32.5%. (April 29 webinar.)
9. **Increased EERS/RPS/DR targets**
   - EERS targets increased by 5 percentage points over the study period.
   - State RPS increased by 5 percentage points by target date.
     - For states with a solar carve-out, the solar carve out will be increased 1 percentage point and the non-solar RPS will be increased by 4 percentage points.
   - DR modeled as 5 percentage points increase over FERC BAU Study Scenario.
10. **Higher PHEV Levels** (March 28-29 SSC meeting.)
    - 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030.
    - Assumes smart charging: 14% of charging during peak hours
11. **Decreased Renewables Capital Costs –** Capital costs for wind onshore, wind offshore, photovoltaic, solar thermal, biomass, geothermal, and hydro reduced by 20%.
12. **Environmental Regulatory Curtailment (ERC) 1**
    - Delay new non-carbon EPA regulations beyond period of study.
13. **ERC 2 - Reduced RPS and EE/DR Requirements**
    - State RPS reduced by 5 % from target end date.
    - For states with a solar carve-out, the solar carve out will reduced 1 percentage point or reduced to 0 if solar carve out is less than 1%. Rest of RPS will be reduced the remaining amount so that the overall reduction is 5%.
    - EE requirements reduced by 5% from 2030 target end date.
    - DR requirements reduced by 5% from 2030 target end date.
14. **ERC 3 - Less Aggressive EPA Regulations**
    - Delay new EPA regulations by 5 years.
15. **Free Market (FM) 1 - No Policies/Regulations Past Expiration/Sunset Date and RPS Requirements Removed**
    - PTC not modeled (sunsets in 2013); ITC modeled at 10% only for solar (30% tax credit for solar and other technologies sunsets in 2016; 10% credit for solar does not sunset)

- RPS requirements removed

16. **FM 2 - FM1 and High Load Growth**
    - FM 1 specifications; and 1% per year increase over reference case load forecast

Future 2 - Federal Carbon Constraint: National Implementation

Google Docs spreadsheets of model inputs for Future 2: http://bit.ly/lmdIh6

A. Base Case

This future assumes full compliance with the Clean Air Act and Clean Water Act and significant near-term reduction in CO_2 and other pollutants such as SO_2, NOx, and mercury. This Future assumes congress legislates and the EPA implements regulations that result in no less than 42% reduction by 2030 economy-wide, and 80% reductions in CO2 economy-wide by 2050.

1. **Carbon Constraint**
   - Carbon Constraint will be modeled as a carbon price.
   - SSC specified that CRA start with a carbon price of $30 in 2015 and increase $7/year.
   - CRA will adjust the carbon price level as necessary to achieve desired 42% reduction in Carbon emission levels (judged from 2005 baseline) by 2030 and 80% reduction by 2050.
     - MRN-NEEM US CO2 emissions target is 3477.91 million metric tons in 2030 and 1199.28 in 2050.
   - Carbon price revenues will be recycled back to the economy.

2. **Nuclear**
   - Eliminate capacity addition constraints for nuclear everywhere except in NEEM region "NYISO J&K" (based on Future 2 language "Nuclear allowed to build or upgrade (in the entire Eastern Interconnect regardless of state restrictions)").
   - BAU Capital Costs Based on AEO 2011 ("Mid-Level nuclear costs").

3. **CCS Capacity Addition Limits**
   - Increase new capacity addition limits by 50% (based on Future 2 language "Carbon capture and sequestration (CCS) viable at some point in the duration of the study, with cost assumptions that are agreed to be reasonable.") As listed below.

Carbon Capture and Storage: Capacity Addition Limits (Appendix A, Exhibit 12)	2020	2025	2030
BAU CCS new build limits (Coal IGCC)	2 GW	12 GW	32 GW
Future 2 CCS new build limits (Coal IGCC)	3 GW	18 GW	48 GW
BAU CCS Retrofit limits	5 GW	25 GW	65 GW
Future 2 CCS Retrofit limits	7.5 GW	37.5 GW	97.5 GW

4. **Heat rates:** The heat rate efficiency increases from Future 3 will also apply to Future 2. See pages 6-7 of this document. (March 28-29 SSC meeting.)

5. **Wind/solar penetration limits, intermittency regions, capacity values** (March 28-29 meeting.)

- Four intermittency regions will be modeled.
    - Northeast (NYISO, NEISO), PJM+ (PJM, MISO, MAPP, Non-RTO Midwest), South (SPP, NE, ENT, SOCO, VACAR, TVA, FRCC), and Ontario.
- Reserve margin contribution will be the same as the BAU Future.
- 35% variable resource penetration limits will be used.
    - Incremental operation costs of penetration beyond 25% will be estimated in post-processing.

B. **Sensitivities**: The "hardened" OL75 transfer limits were used for sensitivities 3-12. (June 6 webinar.)

1. **Revised transfer capability (OL75)–** Set overload charges at 75% of weighted average shadow prices. (March 28-29 SSC meeting.)
2. **Revised transfer capability (OL25) –** Set overload charges at 25% of weighted average shadow prices. (March 28-29 SSC meeting.)
3. **Reduced Friction charges –** Reduce friction charges by 50% (April 29 webinar.)
4. **High Load Growth –** 1% per year increase over reference case load forecast.
5. **Low Load Growth –** 1% per year reduction over reference case load forecast.
6. **Extra High (accelerated) Natural Gas Price–** As specified by MWG (April 29 webinar).
7. **Low natural Gas Price -** $4.50/MMBtu (2010$) for all years.
8. **Modified lower carbon costs –** Costs remain flat after 20230. (July 8 webinar.)
9. **Lower Carbon Costs/Decreased Carbon Price –** Carbon Price decreased by 20% from baseline levels.
10. **Extra Low Renewable Capital Costs –** Reduce capital costs of renewables by 32.5%. (May 18-19 meeting.)
11. **Re-run of base case with hardened transfer limits** (May 18-19 meeting.)
12. **Increase variable resource penetration limits by 15 percentage points.** (July 8 webinar.)

Future 3 - Federal Carbon Constraint: State and Regional Implementation

Google Docs spreadsheets of model inputs for Future 3: http://bit.ly/iDeUQS

A. Base Case

This future assumes the same goals and data assumptions as defined in Future 2, except "Super-regions" will be designated to encourage selection of local resources first, to attempt meet the goals specified in the Future. All generation technologies may be used to achieve these goals including conventional fossil, carbon sequestration, nuclear, hydro, wind, solar, and Canadian resources.

1. **Super-Regions** (March 28-29 meeting.)
   - The 7 super-regions are:
     - Northeast (NYISO, ISO-NE, HQ/Maritimes imports to NYISO and ISO-NE)
     - PJM East/PJM ROM
     - PJM ROR
     - Midwest (MISO, MAPP CA and MAPP US, Non-RTO Midwest)
     - Southwest (SPP and Entergy)
     - Southeast (Southern, TVA, Carolinas and FRCC)
     - Ontario
   - For revised transfer capability sensitivities, transfer limits within a super-region will be allowed to expand and transfer limits between super-regions will be held constant.

2. **Variable resource penetration limits, capacity values** (March 28-29 meeting.)
   - Seven intermittency regions will be modeled identical to the 7 super-regions.
   - Variable resource penetration limits will be set at 35%.
     - Incremental operation costs of penetration beyond 25% will be estimated in post-processing.
   - Reserve margin contribution will be the same as in the BAU Future.

3. **Carbon Constraint**
   - CRA will apply the carbon price level developed from Future 2 to ensure consistency in this assumption between Futures 2 and 3.

4. **Renewables Capital Cost** – BAU costs for renewables.

5. **Nuclear Capital Cost** – Mid-Level nuclear costs were assumed to be the BAU Costs Based on AEO 2011.

6. **Heat Rate Assumptions** – Adjust 2015+ heat rates in Table 7 by another 50% of original increment between BAU 2010 and 2015+ heat rates to incentivize improved efficiency of fossil fuel plants. See table below.

Technology	2010 Heat Rate - HHV (Btu/kWh)	2015+ Heat Rate - HHV (Btu/kWh)	Future 3 2015+ Heat Rate - HHV (Btu/kWh)
Nuclear	10,488	10,488	10,488
Advanced Coal	9,200	8,800	**8,600**
CC	7,050	6,430	**6,120**
CT	9,750	9,750	9750
IGCC	8,700	8,700	8700
IGCC w/seq	10,700	10,235	**10,002**
Wind	NA	NA	NA
Wind Offshore	NA	NA	NA
Photovoltaic	NA	NA	NA
Solar Thermal	NA	NA	NA
Landfill Gas	13,648	13,648	13,648
Biomass	13,500	13,500	13,500
Geothermal	NA	NA	NA

7. **CCS capacity addition limit –** The CCS capacity addition limits from Future 2 apply to this Future, as well. See page 4. (March 28-29 SSC meeting.)

8. **Nuclear –** Costs and assumptions related to nuclear will be identical to those of Future 2, since the related language in both Futures expresses that constraints should be lifted.

9. **Economic assumptions and other inputs from MRN -** The Future 2 carbon prices, natural gas prices and electricity demands from the Future 2 MRN run were used in Future 3, to allow for a more direct comparison between Future 2 and Future 3 cases (rather than try to evaluate case differences that also include the impact of changes in carbon prices, electricity demand and natural gas prices between these regional and national Futures). (From CRA memo presented at July 8 webinar.)

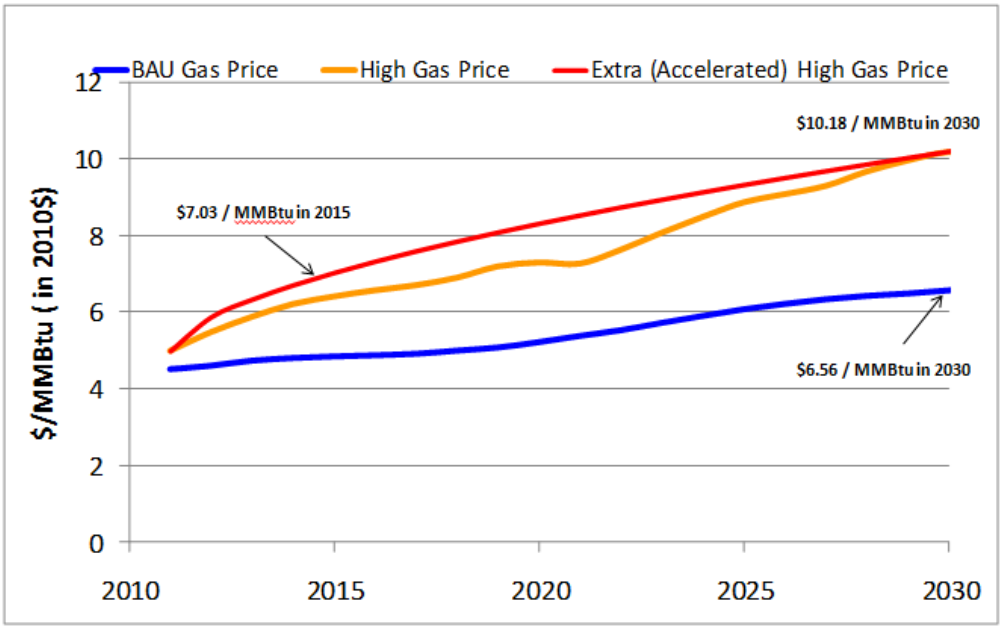
B. **Sensitivities**: The "hardened" OL75 transfer limits were used for sensitivities 3-13 (June 6 webinar).

1. **Revised transfer capability (OL75) –** Set overload charges at 75% of weighted average shadow prices, within super-regions.

- Use as basis for hardening transmission limits for remainder of sensitivities. (June 6 webinar.)

2. **RE-RUN OF NEEM FOR SCENARIO DEVELOPMENT** (June 21 webinar) – *Formerly: reduce friction charges by 50%. (April 29 webinar.)*
3. **High Load Growth –** 1% per year increase over reference case load forecast.
4. **Low Load Growth –** 1% per year reduction over reference case load forecast.
5. **Extra High (accelerated) Natural Gas Price –** As shown in diagram below. (April 29 webinar.)
6. **Low natural Gas Price –** $4.50/MMBtu (in 2010$) for all years.
7. **Modified lower carbon costs –** Costs remain flat after 20230. (July 8 webinar.)
8. **Lower Carbon Costs/Decreased Carbon Price –** Carbon Price decreased by 20% from baseline levels.
9. **Limited New/Upgraded Nuclear –**Add 20% increase in nuclear capital cost.
10. **Increased Imported Canadian Hydro**
    - HQ/Maritimes Hydro
        - Capacity factors for existing flows will be increased to 95%
            - Capacity factors for hydro pseudo-generators will be set at 75% (18 hours at full capacity, 6 hours at zero capacity).
        - Ontario and Manitoba Hydro
            - Capacity factors for existing and new hydro will be set at 75% (18 hours at full capacity, 6 hours at zero capacity).
11. **Extra Low Renewable Capital Costs --** Reduce capital costs of renewables by 32.5%. (May 18-19 meeting.)
12. **Re-run of base case with hardened transfer limits** (May 18-19 meeting.)
13. **Increase variable resource penetration limits by 15 percentage points.** (July 8 webinar.)

Accelerated Natural Gas Price Curve



Future 4 - Aggressive Energy Efficiency, Demand Response, Distributed Generation, and Smart Grid

Google Docs spreadsheets of model inputs for Future 4: http://bit.ly/kq7r6D

A. Base Case

This Future's overall energy demand is drastically reduced through energy efficiency, demand response, and distributed generation. Both the peak and energy demand forecasts are reduced by 1%/yr from the BAU reference case. Demand response is assumed to be at the full participation level in the FERC 2009 study. The full participation level assumes advanced metering infrastructure (smart grid) universally deployed. Costs of energy efficiency, demand response, and distributed generation~~,~~ and advanced meter infrastructure (smart grid) will be included via post processing. The task of gathering cost data is still ongoing, but not needed to run the NEEM/MRN model.

1. **Economic Adjustments**
   - Future 4, with aggressive energy efficiency, has an assumed significant decline in electricity demand growth from the BAU. The MRN model would see this decline as necessitating a decline in GDP. After technical discussions with the MWG, it was recommended that the BAU MRN inputs be used in the modeling of the Future 4 cases to mitigate this concern. (From CRA memo presented at July 8 webinar.)

B. Sensitivities: The baseline infrastructure transfer limits were used for all sensitivities.

1. **Higher PHEV Levels** (March 28-29 SSC meeting.)
   - 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030.
   - Assumes smart charging: 14% of charging during peak hours
2. **Higher PHEV Levels with Modified Load Shape** (March 28-29 SSC meeting.)
   - 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030.
   - Assumes 37% of charging during peak hours
3. **Additional 1% mandated energy consumption reductions and comparable increase in DR**.
   - Both peak and energy demand forecasts are 2%/yr less than the BAU reference case.
   - DR is assumed to be at the full participation level in the FERC 2009 study, plus 1%/yr additional DR growth.

Future 5 - National RPS Top-Down Implementation

Google Docs spreadsheets of model inputs for Future 5: http://bit.ly/lBwyeD

A. Base Case

This future assumes a national Renewable Portfolio Standard (RPS) is established requiring each load-serving entity to obtain 30% of its electricity from renewable resources by 2030.

1. **Federal RPS**
   - RPS starts at 0% in 2010 and increases 1.5%/year to 30% by 2030.
   - Qualifying resources include existing and new hydro, wind, biomass, solar and landfill gas
   - RPS must be met by acquiring Renewable Energy Credits (RECs). No Alternative Compliance Payment (ACP) will be used for RPS compliance
   - Existing state RPS policies will not be adjusted from their BAU values

2. **Tax Credits –** Production Tax Credit and Investment Tax Credit will be removed.

3. **RPS and Canadian resources –** Canadian load will be covered by national RPS and all Canadian qualifying resources can be utilized to meet RPS obligations, with the exception of Ontario, which will not be covered by the RPS and will be prohibited from trading RECs. (March 28-29 meeting.)

4. **Wind/solar penetration limits, intermittency regions, capacity values** (March 28-29 meeting.)
   - Four intermittency regions will be modeled.
     - Northeast (NYISO, NEISO), PJM+ (PJM, MISO, MAPP, Non-RTO Midwest), South (SPP, NE, ENT, SOCO, VACAR, TVA, FRCC), and Ontario.
   - Reserve margin contribution will be the same as the BAU Future.
   - 35% variable resource penetration limits will be used.
     - Incremental operation costs of penetration beyond 25% will be estimated in post-processing.

B. Sensitivities: The "hardened" OL25 transfer limits were used for sensitivities 3-10 (June 6 webinar).

1. **Revised transfer limits (OL75)–** Set overload charges at 75% of weighted average shadow prices. (March 28-29 SSC meeting.)
2. **Revised transfer limits (OL25) –** Set overload charges at 25% of weighted average shadow prices. (March 28-29 SSC meeting.)
3. **High Load Growth -** 1% per year increase over reference case load forecast.
4. **High Natural Gas Price-** Use the high case of the composite of AEO 2010/2011.
5. **Clean Energy Standard (CES)**(March 28-29)
   - Clean Energy Standard modeling methodology identical to Federal RPS.
   - CES starts at 50% in 2020 and increases 10% every 5 years to 80% by 2035.
   - Qualifying resources include existing and new hydro, wind, biomass, solar, landfill gas and nuclear. Coal with Carbon Capture and Sequestration and Natural Gas partially qualify:
     - Coal with CCS is awarded a credit in proportion to the amount of Carbon Capture.

    - Natural Gas is awarded half a credit.
  - CES must be met by acquiring Clean Energy Credits (CECs). No ACP will be used for RPS compliance.
  - National RPS will not be modeled during this sensitivity but existing state RPS policies will not be adjusted from their BAU values.
6. **NO SENSITIVITY RUN –** The sensitivity originally proposed as F5S6 was later removed – this is here as a placeholder for consistency in numbering. (July 8 webinar.)
7. **Higher PHEV Levels with Modified Load Shape** (March 28-29 SSC meeting.)
  - 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030.
  - Assumes 37% of charging during peak hours.
8. **Reduced hurdle rates** – Reduce hurdle rates by 50%. (April 29 webinar.)
9. **Force in more offshore wind** – Force in 20 GW offshore wind: 19.5 GW Atlantic wind, 0.5 GW Great Lakes wind. To be distributed as follows (May 18-19 meeting):

10. **Re-run of base case with hardened transfer limits** (May 18-19 meeting.)

Future 6 - National RPS State/Regional Implementation

Google Docs spreadsheets of model inputs for Future 6: http://bit.ly/lE4m3P

A. Base Case

This future assumes the same goals as defined in Future 5, except Super-regions will be designated to encourage selection of local resources first to attempt meet the goals.

1. **Super-Regions** (March 28-29 meeting.)
   - The 7 super-regions are:
     - Northeast (NYISO, ISO-NE, HQ/Maritimes imports to NYISO and ISO-NE)
     - PJM East/PJM ROM
     - PJM ROR)
     - Midwest (MISO, MAPP CA and MAPP US)
     - Southwest (SPP and Entergy)
     - Southeast (Southern, TVA, Carolinas and FRCC)
     - Ontario
   - For revised transfer capability sensitivities, transfer limits within a super-region will be allowed to expand and transfer limits between a super-region will be held constant.

2. **Variable resource penetration limits, capacity values** (March 28-29 meeting.)
   - Seven intermittency regions will be modeled identical to the 7 super-regions.
   - Variable resource penetration limits will be set at 35%.
     - Incremental operation costs of penetration beyond 25% will be estimated in post-processing.
   - Reserve margin contribution will be the same as in the BAU Future.

3. **Regional RPS**
   - Super-region RPS starts at 0% in 2010 and increases 1.5%/year to 30% by 2030.
   - Qualifying resources include existing and new hydro, wind, biomass, solar and landfill gas.
   - Super-region RPS can be met by acquiring Renewable Energy Credits (RECs) produced from renewable energy resources located within the super-region or through an ACP.
     - ACP for all super-regions will be set at $200/Mwh. (March 28-29 meeting.)
     - ACP revenues will not be recycled back into a region's economy.
   - In addition to the super-region RPS, the model will also have a constraint of a national 30% by 2030 RPS identical to that used in Future 5 (i.e. no ACP).
     - To the extent that certain super-regions use their ACP to achieve their super-region RPS, the other super-regions will build beyond their 30% level so that interconnect-wide, 30% of energy will come from renewable resources.
   - Existing state RPS policies will not be adjusted from their BAU values.

4. **Tax Credits**
   - Production Tax Credit and Investment Tax Credit will be removed.

5. **RPS and Canadian resources –** Canadian load will be covered by national RPS and all Canadian qualifying resources can be utilized to meet RPS obligations, with the exception of Ontario, which will not be covered by the RPS and will be prohibited from trading RECs. (March 28-29 meeting.)

6. **Economic assumptions/MRN inputs:** Like Futures 2 and 3 above, to allow a more direct comparison between Future 5 (national) and Future 6 (regional) cases, the Future 5 gas prices and electricity demands from the Future 5 MRN run are used in Future 6. (From CRA memo presented at July 8 webinar.)

B. **Sensitivities:** The "hardened" OL25 transfer limits were used for sensitivities 2-10 (June 6 webinar).

1. **Revised transfer limits (OL25)–** Set overload charges at 25% of weighted average shadow prices, within super-regions. (March 28-29 SSC meeting.)
2. **High Load Growth –** 1% per year increase over reference case load forecast.
3. **High Natural Gas Price –** Use a composite of AEO 2010/2011.
4. **Clean Energy Standard (CES)** (March 28-29)
   - Super Region Clean Energy Standard modeling methodology identical to Federal RPS.
   - Regional CES starts at 50% in 2020 and increases 10% every 5 years to 80% by 2035.
   - Qualifying resources include existing and new hydro, wind, biomass, solar, landfill gas and nuclear. Coal with Carbon Capture and Sequestration and Natural Gas partially qualify:
     - Coal with CCS is awarded a credit in proportion to the amount of Carbon Capture.
     - Natural Gas is awarded half a credit.
   - Regional CES to be met by acquiring Clean Energy Credits (CECs) from resources within the super-region or by paying ACP.
     - ACP for all super-regions will be set at $200/Mwh. (March 28-29 meeting.)
     - ACP revenues will not be recycled back into a region's economy.
   - In addition to the super-region CES, the model will also have a constraint of a national 80% by 2035 CES identical to that used in Future 5 (i.e. no ACP).
   - National RPS will not be modeled during this sensitivity but existing state RPS policies will not be adjusted from their BAU values.
5. **NO SENSITIVITY RUN –** The sensitivity originally proposed as F6S5 was later removed – this is here as a placeholder for consistency in numbering. (July 8 webinar.)
6. **Increased Imported Canadian Hydro**
   - HQ/Maritimes Hydro
     - Capacity factors for existing flows will be increased to 95%.
     - Capacity factors for hydro pseudo-generators will be set at 75% (18 hours at full capacity, 6 hours at zero capacity).
   - Ontario and Manitoba Hydro
     - Capacity factors for existing and new hydro will be set at 75% (18 hours at full capacity, 6 hours at zero capacity).
7. **Higher PHEV Levels with Modified Load Shape** (March 28-29 SSC meeting.)
   - 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030.
   - Assumes 37% of charging during peak hours.
8. **RE-RUN OF NEEM FOR SCENARIO DEVELOPMENT** (June 21 webinar)
9. **Force in more offshore wind** – Force in 20 GW offshore wind (19.5 GW Atlantic wind, 0.5 GW Great Lakes wind.) (April 29 webinar.)
10. **Re-run of base case with hardened transfer limits** (May 18-19 meeting.)

Future 7 - Nuclear Resurgence

Google Docs spreadsheets of model inputs for Future 7: http://bit.ly/mTI5gX

A. Base Case

This future assumes there will be a significant number of nuclear facilities developed in the Eastern Interconnect including the extension of existing plants, the construction of new large facilities. Small modular nuclear facilities are not included since this type of technology was not included in the BAU.

1. **Nuclear Capacity Additions**
   - Future 7 Base Case has a total 12 nuclear plants to be built with a capacity of 23,144 MW.
   - Three nuclear plants (Vogtle 3 and 4, Watts Bar 2, and Summer 2, 3) with a total of 5,734 MW are in the BAU.
   - In addition to the forced builds in the BAU, nuclear units with COLA or another indication that construction is highly likely are included. This results in a forcing nine additional nuclear power plants in this nuclear resurgence with a capacity of 17,390 MW.

2. **Nuclear Costs Assumptions**
   - Existing nuclear units' capacity is uprated by 8.7% at a capital cost of $2,600/kW. These capital costs will be considered via post processing.
   - Nuclear 2010 capital costs are reduced by 20%.
   - No adjustment to BAU transmission adders or nuclear learning assumptions.

3. **Nuclear Capacity Limits**
   - Remove capacity addition limits for nuclear everywhere in EI except NYISO Zone J&K.
   - Based on initial values from CRA, the BAU future assumes selection of new nuclear capacity on an economic basis that exceeds forced builds described above would not begin until 2025.This future assumes the selection could occur as early as 2020. Therefore, the nuclear capacity addition limits have been shifted by one time slice from 2020 onward as described in the table below. This approach is based on language in the SPWG's Future 7 high level description: "Additional nuclear facilities would become available as early as 2020 with shorter lead times assumed due to streamlined regulations."

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Nuclear Capacity Addition Limits – BAU	0	F1	F2	F2+15	F2+50	F2+100	F2+150	F2+200	F2+250
Nuclear Capacity Addition Limits - Future 7	0	F1	F2+15	F2+50	F2+100	F2+150	F2+200	F2+250	F2+300

Note: F1 = 2011-2015 nuclear forced builds; F2 = F1 + (2016-2020 nuclear forced builds)

B. **<u>Sensitivities:</u>** The baseline infrastructure transfer limits were used for sensitivities 2-4 (July 28-29 SSC meeting).

1. **Revised transfer limits –** Set overload charges at 25% of weighted average shadow prices, between NEEM regions. (March 28-29 SSC meeting.)
2. **High Load Growth -** 1% per year increase over reference case load forecast.
3. **EPA Carbon Limitation (electric sector only)**
   - A Carbon Price will be utilized on the electric sector only set equivalent to 50% of the final Carbon Price levels used in Future 2.
4. **Modular Nuclear (SMR) –** Change size from 600 MW down to 120 MW. (May 18-19 SSC meeting.)
   - Capital cost same as large scale nuclear
   - Aggressive implementation start after 2020
     - Construction lead time 7 years
     - Learning rate at 15%

Future 8 - Combined Federal Climate and Energy Policy Future

Google Docs spreadsheets of model inputs for Future 8: http://bit.ly/lHOo3K

A. Base Case

This future appears to be a combination of Futures 2 and 5, yet there are subtle differences. Future 2 carbon goals are 42% reduction by 2030 and 80% reduction by 2050. This Future's carbon goals are slightly more aggressive. Future 2 RPS goals are 30% by 2030. This future is slightly less. The future specifies that the electricity sector is responsible for 60% of the total emission reductions. It is not possible to accurately specify the modeling inputs to achieve this request. Also, the future specifies carbon cap and trade but will not be modeled as such given time constraints, limited MRN-NEEM runs per future, and concerns over accurately specifying banking and offsets. This future also incorporates the lower load from Future 4 to reflect an increase in energy efficiency and demand response.

1. **Carbon Constraint**
   - Carbon Constraint will be modeled as a Carbon Price.
   - Carbon Price levels will be identical to the final Future 2 Carbon Price. Target is to achieve a 50% reduction in Carbon emission levels (judged from 2005 baseline) by 2030 and 80% reduction by 2050, but by using the carbon price developed in Future 2 there may be a slight deviation from the target.

2. **Federal RPS**
   - RPS starts at 0% in 2010 and increases 1.25 percentage points per year to 25% by 2030.
   - Qualifying resources include existing and new hydro, wind, biomass, solar and landfill gas
   - RPS must be met by acquiring Renewable Energy Credits (RECs). No Alternative Compliance Payment (ACP) will be used for RPS compliance.
   - Existing state RPS policies will not be adjusted from their BAU values.

3. **RPS and Canadian resources –**Canadian load will be covered by national RPS and all Canadian qualifying resources can be utilized to meet RPS obligations, with the exception of Ontario, which will not be covered by the RPS and will be prohibited from trading RECs. (March 28-29 meeting.)

4. **Wind/solar penetration limits, intermittency regions, capacity values** (March 28-29 meeting.)
   - Four intermittency regions will be modeled.
     - Northeast (NYISO, NEISO), PJM+ (PJM, MISO, MAPP, Non-RTO Midwest), South (SPP, NE, ENT, SOCO, VACAR, TVA, FRCC), and Ontario.
   - Reserve margin contribution will be the same as the BAU Future.
   - 35% variable resource penetration limits will be used.
     - Incremental operation costs of penetration beyond 25% will be estimated in post-processing.

5. **Load growth assumptions** (July 8 webinar.)
   - The combined load growth impact of carbon price and EE/DR in Future 8 should be equivalent to the load growth impacts of the Future 4 assumptions on EE and DR. The load forecast from Future 4, with energy efficiency and demand response targets, is used here in Future 8. The MRN model would see the decline in energy demand from aggressive energy efficiency and demand response as a decline in GDP. Therefore, it is recommended that the MRN-NEEM equilibrate with the BAU load forecast, CO2 prices from Future 2, and RPS

targets specified above. The MRN inputs will then be held constant and the lower demand be incorporated into the NEEM model. This process is similar to Future 4 where the MRN BAU assumptions were held constant and used in NEEM.

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- The load reduction in Future 8 will be assumed to be due to a combination of the price elasticity impact of the carbon prices and a set of EE programs. (Future 4 assumes that all demand changes are due to EE programs.) The amount due to carbon prices will be set based on the reduction in demands in Future 2 (15% by 2030) and the remaining amount attributed to EE programs (7% by 2030).

B. **<u>Sensitivities</u>**: The "hardened" OL75 transfer limits were used for sensitivities 3-4 (July 28-29 SSC meeting).

1. **Revised transfer limits –** Set overload charges at 75% of weighted average shadow prices.
2. **Revised transfer limits –** Set overload charges at 25% of weighted average shadow prices.
3. **Lower cost renewable resources–**Reduce capital costs of renewables by 20%.
4. **Increase RPS to 40% --** RPS starts at 0% in 2010 increasing 2%/year to 40% in 2030. Intermittency penetration limit increased to 45% (July 8 webinar.)

References and Data Links as Backup to MWG Recommendations

REFERENCE	MODEL INPUT
Google doc of Future 1 model inputs: https://spreadsheets0.google.com/pub?hl=en&hl=en&key=0AmntJmtV--gtdGhpZmN5Sjd0X1ZoUEF0dmQxVm9xWFE&output=html	Future 1 (BAU) base case data
Google doc of Future 1 Sensitivities model inputs: https://spreadsheets.google.com/ccc?key=0AmntJmtV--gtdF8tZEtNZE1BakFlWFRCNVNPQVU1LUE&hl=en&authkey=CKvlnsQG#gid=0	Future 1 (BAU) Sensitivities data
Google doc of Future 2 model inputs: https://spreadsheets.google.com/ccc?key=0AmntJmtV--gtdEladlNxUHBUZTFYbTVCb3FjN2FFTmc&hl=en&authkey=CJWdsK0D	Future 2 (National carbon policy)
Google doc of Future 3 model inputs: https://spreadsheets.google.com/ccc?key=0AmntJmtV--gtdFN4dG1wZlNNLXU2a3VVRDZfak0tOGc&hl=en&authkey=CJvl61E	Future 3 (Regional carbon policy)
Google doc of Future 4 model inputs: https://spreadsheets.google.com/ccc?key=0AmntJmtV--gtdDZxMERUT1h6eXl2d0JfS293TS1IZmc&hl=en&authkey=CI61284D	Future 4 (Aggressive EE/RE/DR/DG)
Google doc of Future 5 model inputs: https://spreadsheets.google.com/ccc?key=0AmntJmtV--gtdGN3blZsZnRTTmJPQ1ltc1pLLVljWUE&hl=en&authkey=CJqtg4MB	Future 5 (National RPS)
Google doc of Future 6 model inputs: https://spreadsheets.google.com/ccc?key=0AmntJmtV--gtdDdvVm9VWDNORC1GenZvS3pETW1tS3c&hl=en&authkey=CNG8-JwH	Future 6 (Regional RPS)
Google doc of Future 7 model inputs: https://spreadsheets.google.com/ccc?key=0AmntJmtV--gtdEFTMFNCeUtCYUJFSHdPT3A3QktjRXc&hl=en&authkey=CJy4j8wE	Future 7 (Nuclear resurgence)
Google doc of Future 8 model inputs: https://spreadsheets.google.com/ccc?key=0AmntJmtV--gtdER4QTVmYTZnd093LTk5M3pJNWNPWlE&hl=en&authkey=CNv0vLII	Future 8 (Combined policies)
AEO 2010 http://www.eia.doe.gov/oiaf/aeo/assumption/index.html AEO 2011 http://www.eia.doe.gov/forecasts/aeo/	BAU generation capital costs and all operating characteristics, fuel prices, CCS capital costs, transmission adder, others?
NREL, EWITS? Or reEDS? http://www.nrel.gov/wind/integrationdatasets/eastern/methodology.html	Existing and new wind generation shapes
FERC National Action Plan and Assessment of Demand, 2009 – http://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential.asp	Demand Response (DR) in BAU, F4, F8
CRA and input from Joe Bryson, EPA	EPA regulations for CAIR (Hg, SO2, NOx), cooling water, coal ash
Energy Modeling Forum, "Overview of 22 US Transition Scenarios" http://www.eipconline.com/uploads/fawcettOverview22transitio	basis of starting carbon price in F2, F3, F8

n_studies.pdf	
Revised ORNL-DOE US Hydro (NPD) assessment – http://www.eipconline.com/SSC_Meetings.html	basis of US hydro development potential
NERC, "Methods to Model and Calculate Capacity Contributions of Variable Generation for Resource Adequacy Planning," March 2011 (see figure 5) http://www.nerc.com/files/IVGTF1- 2.pdf	reserve margin contribution of variable generation resource capacity
Clean Energy Standards Fact Sheet – http://blogs.cfr.org/levi/files/2011/01/SOTU-factsheet-CES.pdf	basis of CES targets and qualifying resources
MWG in consultation with PAs	Super-regions
CRA	nuclear builds in BAU & F7
NREL, *Eastern Wind Integration Transmission Study*, Jan. 2010 http://www.nrel.gov/wind/systemsintegration/ewits.html	Basis for intermittency regions & wind penetration rates options
NREL Nebraska wind study http://www.nrel.gov/wind/systemsintegration/pdfs/2010/ne_study_executive_summary.pdf	Basis for intermittency regions & wind penetration rates options