EIPC SSC Modeling Working Group
MRN-NEEM Model Input Recommendations

The following is an inventory of consensus items and, where necessary, interpretations of the language used in the high-level Future descriptions. In the past, the MWG presented areas of consensus via subteams. Since this data gathering process is reaching conclusion, the information has been consolidated by Future and sensitivities, so that the SSC can have a more comprehensive understanding.

A detail description of the futures and sensitivities were not reiterated in detail. Therefore, the Scenario Planning Working Group High-Level Futures Descriptions (2.14.11) should be used as a reference when reviewing the modeling interpretations, consensus items, and recommended options. Periodically an interpretation of Futures and sensitivities has been clarified in an effort to justify the recommended data.

The "Recommended Options" section includes the points which the Modeling Work Group did not reach consensus on, and provides recommended options for the SSC to consider.

The accompanying list of approved sensitivities may be useful when reviewing this document as well. Three sensitivities have been made available for either the Clean Energy Standard or others the SSC has deemed necessary. These sensitivities were no longer necessary due to modeling interpretations and/or modeling approaches that could be conducted via post-processing. These sensitivities include Future 4 Sensitivities 4 and 7, and Future 8 Sensitivity 3. Two additional sensitivities may be available depending on how the SSC wishes to proceed with Future 5 Sensitivity 9 and Future 6 Sensitivity 8.

General Assumptions

1. Wherever the 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.

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 SSC asked the MWG to investigate the extent to which this value should be different for the various generation technologies, some of which might have higher or lower interconnection costs. The MWG has 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. We have not yet received feedback from RW Beck. The MWG is recommending 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.

Future 1 - Business as Usual

Base Case

This Future assumes that present trends continue into the future based on historical indices. The values to be used for the Base Case and Sensitivities 1-8 were approved by the SSC on February 7, 8, & 11, 2011.

A. Sensitivities 1-8 – (ALREADY APPROVED – summarized here for informational purposes)

1. **Sensitivity 1: Revised Transfer Capability -** Transfer limits adjusted through soft constraint approach using 75% of overload charges from the reference case; wheeling & hurdle rates remain the same. CRA agreed to alert the SSC if there were "red flags" after reviewing the results.
2. **Sensitivity 2: Transmission Sensitivity 1.2 -** 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. **Sensitivity 3: High Load Growth -** 1% per year increase over reference case load forecast.
4. **Sensitivity 4: Low Load Growth -** 1% per year reduction over reference case load forecast.
5. **Sensitivity 5: High Natural Gas Price -** Use the high case of the composite of AEO 2010/2011
6. **Sensitivity 6: 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
7. **Sensitivity 7: Higher PHEV levels**
   - 2x, 4x, 7x, 10x BAU base case for years 2015, 2020, 2025 and 2030, respectively (approved by SSC on February 7&8, 2011 but MWG recommends an adjustment, see decision points)
   - Assumes 37% of charging during peak hours
8. **Sensitivity 8: Low Cost Renewables -** Capital costs for wind onshore, wind offshore, photovoltaic, solar thermal, biomass, geothermal, and hydro reduced by 20%

B. Sensitivities 9-15: (NOT YET APPROVED)

1. **Sensitivity 9: Environmental Regulatory Curtailment (ERC) 1**
   - Delay new EPA regulations by 20 years
2. **Sensitivity 10: 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
3. **Sensitivity 11: ERC 3 - Less Aggressive EPA Regulations**
   - Delay new EPA regulations by 5 years.
4. **Sensitivity 12: ERC 4 - Even Less Aggressive EPA Regulations**
   - Delay new EPA regulations by 10 years.
5. **Sensitivity 13: 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

6. **Sensitivity 14: FM 2 - FM1 and All Fuel Subsidies Removed**
   - FM 1 specifications; and low gas price of $4.00/MMBtu (2010$) for all years
7. **Sensitivity 15: FM 3 - 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

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 Tax.
   - Initial Carbon Tax levels will start at $30 in 2015 and increase $7/year.
   - CRA will have the option of using sensitivities 7 and 8 to adjust the Carbon Tax level as necessary to achieve desired 42% reduction in Carbon emission levels (judged from 2005 baseline) by 2030 and 80% reduction by 2050.
   - Carbon Tax revenues will be recycled back to the economy.

2. **Ordering of Carbon Tax and Transmission Sensitivities**
   - CRA will run Carbon Tax and Transmission sensitivities iteratively as necessary to ensure that modeling approximately achieves the desired 42% reduction in Carbon emissions. See Stan Hadley-Tyler Ruthven document for more details.

3. **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")

4. **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

B. Sensitivities

1. **Sensitivity 1: Revised Transfer Capability -** Transfer limits allowed to increase
2. **Sensitivity 2: Transmission Sensitivity 2.2 -** Transfer limits allowed to increase

3. **Sensitivity 3: High Load Growth -** 1% per year increase over reference case load forecast.
4. **Sensitivity 4: Low Load Growth -** 1% per year reduction over reference case load forecast.
5. **Sensitivity 5: High Natural Gas Price -** Use the high case of the composite of AEO 2010/2011.
6. **Sensitivity 6: Low natural Gas Price - Price -** $4.50/MMBtu (2010$) for all years
7. **Sensitivity 7: Increased Carbon Tax -** Sensitivity to be used by CRA iteratively to determine appropriate Carbon Tax level to reach 42% reduction in Carbon emissions by 2030
8. **Sensitivity 8: Decreased Carbon Tax -** Sensitivity to be used by CRA iteratively to determine appropriate Carbon Tax level to reach 42% reduction in Carbon emissions by 2030

Future 3 - Federal Carbon Constraint: State and Regional Implementation

A. Base Case

This future assumes the same goals 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**
   - Super Regions are:
     - Northeast (NYISO, ISO-NE, HQ/Maritimes imports to NYISO and ISO-NE)
     - PJM (possibility of PJM being split into two super-regions – PJM East/PJM ROM and 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.
   - Super-regions are needed to ensure that solutions are "regional." The MWG considered modeling NEEM regions as policy compliance entities but determined that not enough flexibility would be available if NEEM regions were limited only to their region for desired policy targets
   - Consensus over super-regions for Futures 3 and 6 does not constitute consensus on intermittency regions.

2. **Carbon Constraint**
   - Carbon Constraint will be modeled as a Carbon Tax.
   - Initial Carbon Tax levels will start at $30 in 2015 and increase $7/year.
   - CRA will have the option of using sensitivities 7 and 8 to adjust the Carbon Tax level as necessary to achieve desired 42% reduction in Carbon emission levels (judged from 2005 baseline) by 2030 and 80% reduction by 2050.
   - Carbon Tax revenues will be recycled back to the economy.

3. **Ordering of Carbon Tax and Transmission Sensitivities**
   - CRA will run Carbon Tax and Transmission sensitivities iteratively as necessary to ensure that modeling approximately achieves the desired 42% reduction in Carbon emissions. See Stan Hadley-Tyler Ruthven document for more details.

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.

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

B. Sensitivities

1. **Sensitivity 1: Revised Transfer Capability -** Transfer limits adjusted within super-regions allowed to increase. Transfer limits between super-regions held constant.
2. **Sensitivity 2: High Load Growth -** 1% per year increase over reference case load forecast.
3. **Sensitivity 3: High Natural Gas Price -** Use a composite of AEO 2010/2011.
4. **Sensitivity 4: Low natural Gas Price -** $4.50/MMBtu (in 2010$) for all years
5. **Sensitivity 5: Increased Carbon Tax -** Sensitivity to be used by CRA iteratively to determine appropriate Carbon Tax level to reach 42% reduction in Carbon emissions by 2030
6. **Sensitivity 6: Decreased Carbon Tax -** Sensitivity to be used by CRA iteratively to determine appropriate Carbon Tax level to reach 42% reduction in Carbon emissions by 2030
7. **Sensitivity 7: Limited New/Upgraded Nuclear –** plus 20% increase in nuclear capital cost.
8. **Sensitivity 8: 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).

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

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 and dynamic pricing were made the default tariff. 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**
   - When MRN-NEEM equilibrate, the inputs are adjusted slightly in the iterative process such that the input variables (e.g., load, natural gas prices, GDP) respond to influences defined by the future. Consequently, a significant decline in load due to aggressive energy efficiency would appear as a significant negative impact to the economy. To counter this effect, the BAU GDP and other macroeconomic parameters will be used in the MRN-NEEM Future 4 Base Case and not be allowed to adjust.

2. **Central Generation Externalities**
   - Increase cost of non-renewable generation by increasing the cost of capital by 5 percentage points to limit centralized generation.
     - High-level future description calls for: "Compensation and planning parity between distributed resources (both low and zero carbon generation and Demand Resources) and centralized generation including consideration of all applicable externalities."

B. Sensitivities

1. **Sensitivity 1: Revised Transfer Capability -** Transfer limits allowed to increase
2. **Sensitivity 2: High Load Growth -** 1% per year increase over reference case load forecast.
3. **Sensitivity 3: High Natural Gas Price -** Use the high case of the composite of AEO 2010/2011.
4. ***Sensitivity 4: Lower EE Performance*** – REMOVE/REPLACE. This will be evaluated off line, through post processing of EE/DR/smart grid/storage/DG costs. This sensitivity is freed up for use as one of the Clean Energy Standard sensitivities.
5. **Sensitivity 5: Higher PHEV Levels**
   - 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030 (See Decision Points)
   - Assumes smart charging: 14% of charging during peak hours
6. **Sensitivity 6: Higher PHEV Peak –**
   - 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030 (See Decision Points)
   - Assumes 37% of charging during peak hours
7. ***Sensitivity 7: Increased Economy Activity –*** REMOVE/REPLACE. The demand sub-team agrees this sensitivity is not needed since the GDP from the BAU is being used for the base case and NEEM/MRN is equilibrated only once for each future.
8. **Sensitivity 8: Low Natural Gas Price -** $4.50/MMBtu (in 2010$) for all years

9. **Sensitivity 9: 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

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.
     - High level future description calls for: "Extension of tax credits equalized for all new renewable resources."
     - EISPC position was to remove all tax credits.

Sensitivities

1. **Sensitivity 1: Revised Transfer Capability -** Transfer limits allowed to increase.
2. **Sensitivity 2: Transmission Sensitivity 2.2** - Transfer limits allowed to increase.
3. **Sensitivity 3: High Load Growth -** 1% per year increase over reference case load forecast.
4. **Sensitivity 4: Low Load Growth -** 1% per year reduction over reference case load forecast.
5. **Sensitivity 5: High Natural Gas Price -** Use the high case of the composite of AEO 2010/2011.
6. **Sensitivity 6: Low Natural gas Price -** $4.50/MMBtu (in 2010$) for all years.
7. **Sensitivity 7: Low cost of renewable resources -** Capital costs for wind onshore, wind offshore, photovoltaic, solar thermal, biomass, geothermal, and hydro reduced by 20%.
8. **Sensitivity 8: High cost of renewable resources -** Capital costs for wind onshore, wind offshore, photovoltaic, solar thermal, biomass, geothermal, and hydro increased by 20%
9. ***Sensitivity 9: Increased deployment of flexible resources (DR, storage)* -** DR cannot be explicitly modeled in MRN-NEEM but the load can be adjusted to capture the effects of DR and the costs can be estimated via post processing. Storage additions are not included in the model because the model uses a load duration curve and therefore cannot accurately assess when storage may be needed. Nor is it possible to estimate the amount of storage needed via post processing. See the "Recommended Options" section..
10. **Sensitivity 10: Modified load block shapes in recognition of increased PHEV levels -** It was interpreted that this sensitivity sought to understand the impacts of higher PHEV targets charging during peak hours
    - 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030. (See Recommended Options)

    Assumes 37% of charging during peak hours.
11. **Sensitivity X: Clean Energy Standard**
    - 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.

Future 6 - National RPS State/Regional Implementation

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**
   - Super-Regions are:
     - Northeast (NYISO, ISO-NE, HQ/Maritimes imports to NYISO and ISO-NE)
     - PJM (possibility of PJM being split into two super-regions – PJM East/PJM ROM and 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.
   - Super-regions are needed to ensure that solutions are "regional." The MWG considered modeling NEEM regions as policy compliance entities but determined that not enough flexibility would be available if NEEM regions were limited only to their region for desired policy targets.
   - Consensus over super-regions for Futures 3 and 6 does not constitute consensus on intermittency regions.

2. **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 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.

3. **Tax Credits**
   - Production Tax Credit and Investment Tax Credit will be removed.
     - High level future description calls for: "Extension of tax credits equalized for all new renewable resources."
     - EISPC position was to remove all tax credits.

B. Sensitivities

1. **Sensitivity 1: Revised Transfer Capability -** Transfer limits within super-regions allowed to increase. Transfer limits between super-regions held constant.
2. **Sensitivity 2: High Load Growth -** 1% per year increase over reference case load forecast.

3. **Sensitivity 3: Low Load Growth -** 1% per year reduction over reference case load forecast.
4. **Sensitivity 4: High Natural Gas Price -** Use a composite of AEO 2010/2011.
5. **Sensitivity 5: Low natural Gas Price -** $4.50/MMBtu (in 2010$) for all years
6. **Sensitivity 6: Low cost of renewable resources -** Capital costs for wind onshore, wind offshore, photovoltaic, solar thermal, biomass, geothermal, and hydro reduced by 20%
7. **Sensitivity 7: High cost of renewable resources -** Capital costs for wind onshore, wind offshore, photovoltaic, solar thermal, biomass, geothermal, and hydro increased by 20%
8. **Sensitivity 8: Increased deployment of flexible resources (DR, storage) -** DR cannot be explicitly modeled in MRN-NEEM but the load can be adjusted to capture the effects of DR and the costs can be estimated via post processing. Storage additions are not included in the model because the model uses a load duration curve and therefore cannot accurately assess when storage may be needed. Nor is it possible to estimate the amount of storage needed via post processing. Therefore, see Recommended Options for this sensitivity.
9. **Sensitivity 9: 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).
10. **Sensitivity 10: Modified load block shapes in recognition of increased PHEV levels -** It was interpreted that this sensitivity sought to understand the impacts of higher PHEV targets charging during peak hours.
    - 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030 (See Recommended Options, No. 4).
    - Assumes 37% of charging during peak hours.

Future 7 - Nuclear Resurgence

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.
   - 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. Sensitivities

1. **Sensitivity 1: Revised Transfer Capability** - Transfer limits allowed to increase.
2. **Sensitivity 2: Low Load Growth** - 1% per year decrease over reference case load forecast.
3. **Sensitivity 3: High Load Growth** - 1% per year increase over reference case load forecast.
4. **Sensitivity 4: Low Coal Prices and Low Gas Prices**

- Natural gas price at $4.50/MMBtu (2010$) for all years; coal prices are endogenously determined in NEEMS. To the extent that coal competes against low natural gas prices, coal prices are also depressed as a result.

5. **Sensitivity 5: EPA Carbon Limitation (electric sector only)**
   - A Carbon Tax will be utilized on the electric sector only set equivalent to 50% of the final Carbon Tax levels used in Future 2.
6. **Sensitivity 6: High Uranium and Disposal Costs and High Capital Costs –** Increase in nuclear capital cost relative to the Future 7 base case. Because the Future 7 base case uses reduced capital costs for nuclear relative to the BAU, the nuclear capital costs used in this sensitivity will be the same as those used in the BAU base. This constitutes a roughly 20% increase in nuclear capital costs relative to other runs in Future 7.
7. **Sensitivity 7: Include Only Nuclear Plants with Loan Guarantees** - This sensitivity includes only the nuclear units from the BAU currently under construction or with nuclear loan guarantees. Only 2 nuclear plants have loan guarantees with a capacity of 3,404 MW. Consequently, this sensitivity includes a total of 9 plants or 14 units (17,390 MW) less than this future base case and 10 plants or 16 units (19,720 MW) less than the BAU.

Future 8 - Combined Federal Climate and Energy Policy Future

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.

1. **Carbon Constraint**
   - Carbon Constraint will be modeled as a Carbon Tax.
   - Carbon Tax levels will be identical to the final Future 2 Carbon Tax. Target is to achieve a 50% reduction in Carbon emission levels (judged from 2005 baseline) by 2030 and 80% reduction by 2050.

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.

B. Sensitivities

1. **Sensitivity 1: Revised Transfer Capability** - Transfer limits allowed to increase.
2. **Sensitivity 2: Transmission Sensitivity 2.2** - Transfer limits allowed to increase.
3. **Sensitivity 3: Increased economic activity with Change in Relationship between GDP and Load Growth** - This sensitivity would require MRN-NEEM to re-equilibrated. Therefore, this is a free sensitivity since MRN-NEEM can be run only once for each future.
4. **Sensitivity 4: Increase RPS to 40% or Lower Gas Prices** - Increasing the RPS to 40% or lowering the gas prices are not substitutes for each other. The MWG has no recommendation regarding this sensitivity since it was not clear what driver behavior was being investigated. See Recommended Options.

Recommended Options for Non-consensus Items

1. Transfer Limits to Be Used for BAU Sensitivities 3-15

The MWG hopes to have a recommendation at the SSC meeting but wants to first see the results of the BAU base run and BAU sensitivities 1 and 2. For the remaining futures, the MWG will work to develop recommendations after examining the initial future outputs.

The following options are proposed:

- **Option A**: Fixed transfer limits from the baseline infrastructure (Future 1)
- **Option B:** Sensitivity 1 (F1S1)
- **Option C**: Sensitivity 2 (FIS2)

2. Hydro Potential (Futures 2-8)

Hydro potential data was not available when the BAU modeling assumptions were being developed. Oakridge National Lab (ORNL) has since agreed to release their preliminary data from their Hydropower Resource Assessment on US Non-Powered Dams (NPD) which assessed over 80,000 dams of which approximately 54,000 have the potential for hydroelectric power. This data has gone through various reviews from industry members and the final report will be released at the National Hydro Association meeting in Washington DC on April 5, 2011. Attached is the preliminary hydro potential by NEEM region and capacity range. Note, 9,000 NPDs have been eliminated due to questionable energy data, of which the majority were less than 1 MW.
The following options are proposed.

- **Option A**: Use hydro potential for NPD described in the attached table for Futures 2-8.
- **Option B**: Include the hydro potential for NPD described in the attached table as one sensitivity in Futures 3 and 6 which involve State/Regional Implementation. (This option depends on freeing up 2 sensitivities that could be used for this purpose.)
- **Option C:** Do not include any hydro potential.

3. Specify Methodology for Transmission Sensitivities (Futures 2-8)

- All Futures have at least one transmission sensitivity. Futures 2, 5, and 8 have two transmission sensitivities.
- The MWG hopes to have a recommendation, or options for, the specific methodology to be used for these sensitivities at the SSC meeting but wants to first see the results of the BAU base run and BAU Sensitivities 1 (F1S1) (revised transfer capability - overload charges at 75% of average shadow prices) and 2 (F1S2) (revised transfer capability overload charges at 25% of average shadow prices).

4. Higher PHEV Levels (Futures 2-8)

Proposed Clean Energy Standard electric vehicle targets are slightly higher in the earlier years than targets approved by the SSC for the BAU high PHEV sensitivity.

- **Option A**: Demand Sub-team recommends going to a 3x, 6x, 9x, 10x BAU base case for years 2015, 2020, 2025 and 2030 for consistency between all high PHEV sensitivities as described on March 15, 2011 webinar to SSC
- **Option B**: Keep BAU high PHEV sensitivity as is, but change the other high PHEV sensitivities to 3x, 6x, 9x, 10x

- **Option C**: Only Clean Energy Standard Future assumes 3x, 6x, 9x, 10x

5. **DC Line Modeling (Futures 2, 5 and 8)**
   - **Option A**: No explicit modeling of DC lines in Phase I of the EIPC process. During Phase II, DC lines could be selected in deciding the appropriate transmission overlay.
     - Modeling of DC lines will be difficult and involve substantial judgment calls by the SSC that could hamper the models attempts to reach the most economic solution for a given future.
     - The appropriate arena for deciding on transmission technology is in Phase II of the process
   - **Option B**: Steve Gaw Proposal: In futures 2, 5 and 8 (national implementation futures) the model will have a limited option of selecting DC lines. Methodology is still under development. The methodology could operate similarly to the manner in which HQ transfers are modeled (i.e. pseudo-generators)
     - Only modeling DC lines in Phase II of the process will hamper attempts to achieve the most economic generation selection. Utilizing DC lines would allow intermittent generators to avoid intermittent penetration limits that would not be operationally constraining given the use of DC lines.
     - Judgment calls on placement of DC lines could be minimized by basing placement on previous studies (e.g. EWITS)

6. **Friction Charges (Futures 3 and 6)**
   - **Option A** (EISPC Proposal): For regional Futures 3 and 6, eliminate friction charges within super-regions in the base case. Wheeling rates within super-regions will be unchanged. Wheeling rates and friction charges between super-regions will also not be changed.
     - Decreased friction charges within super-regions represents regional integration of markets that could develop in a more regionally focused future
   - **Option B** (NEEM/TX Subteam Proposal): Do not eliminate friction charges within super-regions in the base case -- keep base-run friction charges in Futures 3 and 6 identical to friction charges in Futures 2 and 5, respectively.
     - Certain stakeholders do not believe that reducing the friction charge will lead to meaningful differences in model outputs.
     - Certain stakeholders believe that changing the friction charges would reduce comparability between national and regional Futures.

7. **Carbon Tax Revenues (Future 3)**
   - **Option A**: Carbon Tax revenues recycled only to regional economy.
     - Keeping Carbon Tax revenues recycled to the economy increases comparability between Futures 2 and 3.
     - Modeling is complex and regions would have to select regionally preferred technologies (i.e. "pick winners").
   - **Option B**: Carbon Tax revenues recycled partially to regional economy and partially to support regionally preferred clean energy technology
     - High level future description explicitly calls for this option:
       - "For a Carbon tax-based implementation states handle the tax revenues and redirect them to clean energy projects."
     - Giving regions a choice on how to use their carbon tax revenues creates a more region-specific future.

8. **Offshore Wind Incentive (Future 4)**
   - **Option A** (EISPC Proposal): No incentive for offshore wind.
     - Focus of future is energy efficiency, demand response and distributed generation thus no other technologies should be incented.
   - **Option B**: Offshore Wind capital costs decreased by 20%.
     - High level future description calls for: "Preference for local resource. May include offshore wind."

9. **RPS and Canadian Resources (Futures 5, 6 and 8)**
   - **Option A**: Canadian load covered by national RPS and all Canadian qualifying resources can be utilized to meet RPS obligations.
     - Canadian resources currently being used to satisfy state RPS targets.
     - Canada likely to pursue similar renewable targets as the U.S.
     - Simplifies modeling issues.
   - **Option B**: Canadian regions not covered by RPS and some restrictions placed on the amount of Canadian resources that can be used to meet U.S. RPS targets.
     - Interested stakeholders will develop option further, if necessary, based on examination of results of the BAU model runs.

10. **Super-region RPS Alternative Compliance Payment (Future 6)**
    - **Option A** (EISPC Proposal): Set ACP for all super-regions at $100/MWh.
      - $100/MWh represents highest existing state RPS ACP (not including solar carve-outs).
      - Setting the ACP at $100/MWh will provide a large incentive for super-regions to build renewables while still maintaining an element of cost control that exists in all state RPS policies and proposed national RPS policies.
    - **Option B**: Set ACP for all super-regions at $200/MWh
      - $200/MWh approximates the average levelized cost of solar PV in 2016.
      - Setting the ACP at the levelized cost of solar PV provides a proxy for regions that would/could meet their RPS obligations through purchases of distributed solar energy.

11. **Increased Deployment of Flexible Resources (DR, Storage) (Future 5 Sensitivity 9, and Future 6 Sensitivity 8)**

It was assumed that the purpose these sensitivities was to assess how DR and storage are used as intermittent resources increase on the system. However, DR cannot be explicitly modeled in MRN-NEEM but the load can be adjusted to capture the effects of DR and the costs can be estimated via post processing. Storage additions are not included in the model because the model uses a load duration curve therefore cannot accurately assess when storage may be needed. Nor is it possible to estimate the amount of storage needed via post processing. The MWG has formulated a possible option: .

- **Option A -** Increase deployment of flexible resources by increasing the variable resource penetration limits by 15% in absolute terms relative to the base value of this future. This adjustment would reflect the extent to which system flexibility can facilitate greater penetration of variable resources at equivalent integration costs.
  - The intention of the sensitivity is to show the impact of flexibility resources on variable resource integration. This approach does not capture the intent of the sensitivities since increases in DR and storage are typically a side effect of increased penetration of intermittent resources.
  - Pursuing this option raises the concern that increasing the variable resource penetration limit without increasing cost may give misleading results.

12. Wind/Solar Penetration Limits, Intermittency Regions, Capacity Values (Futures 2, 3, 5, 6, and 8)

MWG recommends that Futures 1/4/7 have consistent values for penetration limits, intermittency regions, capacity values as specified below because these futures are unlikely to produce transmission expansion significantly above BAU levels.

- **Futures 1/4/7 Recommendation**: BAU values for all inputs 25% wind/solar penetration limit (CRA MRN-NEEM Assumptions Table 14)
- 14 intermittency regions (SPP, PJM, MAPP_CA, MAPP_US, MISO, NR MW, NY, NEISO, ENT, TVA, VACAR, SOCO, FRCC, IESO)
- BAU contribution of variable resources to reserve margin, CRA MRN-NEEM Assumptions Table 5, based on planning authority input

However, the MWG could not reach consensus on the appropriate values for Futures 2/3/5/6/8. The two proposed options, and justifications for each, are described below.

Futures 2/3/5/6/8: Recommended Options

- **Option A: Uniform Approach for Futures 2/3/5/6/8 (Regional and National Implementation)**
  - 25% wind/solar penetration limit
  - 6 intermittency regions, same as super-regions
  - BAU capacity values

Justification for Option A:

1. **Certain stakeholders believe that increased penetration of intermittent resources will lead to increased integration costs that are not accounted for by the model.** While it may be technically feasible for intermittent resources to provide more than 25% of annual energy to a certain region, this will not be possible without significant changes to the electric system. Given that the model cannot account for these increased costs associated with these changes, these stakeholders prefer to keep the intermittency limit at the BAU value.

2. **Certain stakeholders believe that the 25% of annual energy penetration limit is already very aggressive.** It is likely to lead to situations in which intermittent resources are providing more than 50% of power during certain load blocks that could lead to potential ramping and operations problems with nuclear and other baseload generators. The costs associated with these issues will not be accounted for by the model.

3. **Finally, significantly changing the penetration limits and penetration regions between futures will greatly decrease stakeholders ability to compare the different futures against each other.** Given that the key difference for regional futures is transmission expansion limitations, further differentiations would dilute future comparability and decrease the usefulness of the modeling exercise.

- **Option B: Vary Penetration Limit, Intermittency Regions, and Capacity Values**

  - **Futures 3/6** (Regional Implementation):
  - 50% wind/solar penetration limit

- 6 intermittency regions, same as super regions
- BAU capacity values

○ **Futures 2/5/8** (National Implementation):
- 50% wind/solar penetration limit
- 4 intermittency regions: PJM/MISO/MAPP, South (SPP/ENT/SOCO/FRCC/VACAR), Northeast (NYISO/NEISO) and Ontario
- Modified capacity values for onshore wind

Justification for Option B:

1. The national implementation futures will have a greater degree of transmission expansion (especially between regions). Therefore the intermittency regions should be expanded relative to the super regions.

From the SPWG's high level definition for the national RPS Futures: "The main defining characteristic of this scenario is the deployment of significant amounts of renewable energy at the locations with the lowest cost renewable resources. … There is also likely to be a need for significant enhancements to the nation's electric transmission system to achieve this scenario."

- With a 25% Intermittency Limit, NEEM will in all likelihood build local intermittent renewables up to this limit. This is especially likely in regions with ample supply of low cost intermittent renewable resources.
- With a 30% RPS, there will be no intermittent renewable power available for export between regions (and little "need for significant enhancements to the nation's electric transmission system").
- This would prevent NEEM from effectively deploying the least cost resources available within the interconnection for meeting compliance obligations and abatement targets.
- This result is contrary the purpose of this future.

In order to promote effective deployment of least cost resources and to reflect the transmission build-out called for in the national implementation futures, the intermittency regions should be expanded relative to the regional implementation futures. The proposed approach is to retain the 6-region "super region" approach for the regional implementation futures (3 & 6) and to use a 4-region intermittency region framework for the national implementation futures (2, 5 and 8).

Note: Expanding the intermittency regions does not force a specific result with regard to transmission or capacity expansion. It only allows for the model to choose the least expensive resource over a broader region and reflects a more coordinated approach to wind integration.

2. Expanded Interregional transmission allows for a greater degree of generation/resource sharing, improved system flexibility, and better leveraging of geographic diversity. This means the system can integrate more variable resources at the same cost and therefore the maximum penetration level should be increased.

Prior studies have shown transmission can facilitate very high Variable Energy Resource (VER) penetration rates. In the U.S., the Eastern Wind Integration and Transmission Study, 30% wind (wind energy/total energy) was reliably accommodated across the Eastern U.S. Interconnect, with regions like SPP reliably accommodating much higher penetrations:

The NREL-funded Nebraska wind integration study also found that 40% wind could be readily accommodated within the current SPP footprint at very low cost (<$2/MWh of wind) without any negative impact on reliability.

Similarly, a number of studies in Europe have found looked at very high wind penetrations, including some exceeding 50% of energy, and found them to be achievable on power systems that are less well-suited for wind integration than the U.S. power system is; these European power systems are smaller and have power plants that are less flexible than ours, and their wind resources have less diversity and more variability than ours.

The proposed approach is to increase the penetration limit to 50% for both the regional and national implementation futures (2,3,5,6 and 8). It should be noted that this suggestion is based on the central assumptions of the futures and should apply to all runs in these futures.

3. Also, the system will be able to manage variability more effectively, and therefore the capacity value for variable resources should also be increased.

Expanded transmission increases the deliverability of variable resources (reduced curtailment rates, balancing requirements, etc). This means that the capacity value of wind, measured, for example, by wind's impact on system loss of load expectation (effective load carrying capability), is increased through transmission expansion. This impact should be reflected in the base runs for the national implementation futures where a large transmission build-out is expected.

The proposed approach is to increase the BAU contributions of variable resources by a factor of 1.38 for the national implementation futures (2, 5, and 8) where additional inter-regional transmission is expected based on the future narrative. This is consistent with data in the *Eastern Wind Interconnection Study*, January, 1010.

Feedback from the planning authorities has indicated this is could be an appropriate approach for adjusting capacity value of variable resources in those futures where additional transmission expansion is expected.

13. Increase RPS to 40% or Lower Gas Prices (Future 8 Sensitivity 4)

Increasing the RPS to 40% or lowering the gas prices are not substitutes for each other. The MWG has no recommendation regarding this sensitivity since it was not clear what driver behavior was being investigated. Consequently the MWG proposes the following options.

- **Option A** - Increase RPS to 40% by 2030. This would be accomplished by increasing targets 2%/yr.
- **Option B** - Lower Natural Gas price. This would be accomplished by using $4.50/MMBTU (2010$) for all years.