CRA MRN-NEEM Workshop

November 8-9, 2010

CRA Charles River Associates

Agenda – Monday Nov 8th

11:00 AM	Overview of Task 5 Modeling Approach
12:00 PM	Working Lunch
12:30 PM	Coordination of MRN-NEEM Modeling and High Level Transmission Analysis in Task 5
2:00 PM	Overview of BAU Future and Discussion of Key Drivers
4:00 PM	MRN-NEEM Assumptions Document
6:00 PM	Recess

Agenda – Tuesday Nov 9th

8:00 AM	Sample Output Reports
10:00 AM	MRN and NEEM Technical Session
12:00 PM	Workshop Ends / Working Lunch
1-3:00 PM	Stakeholder Working Group Meeting

Overview of Task 5 Modeling Approach

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Task 5: Macroeconomic Analysis of Futures/Sensitivities

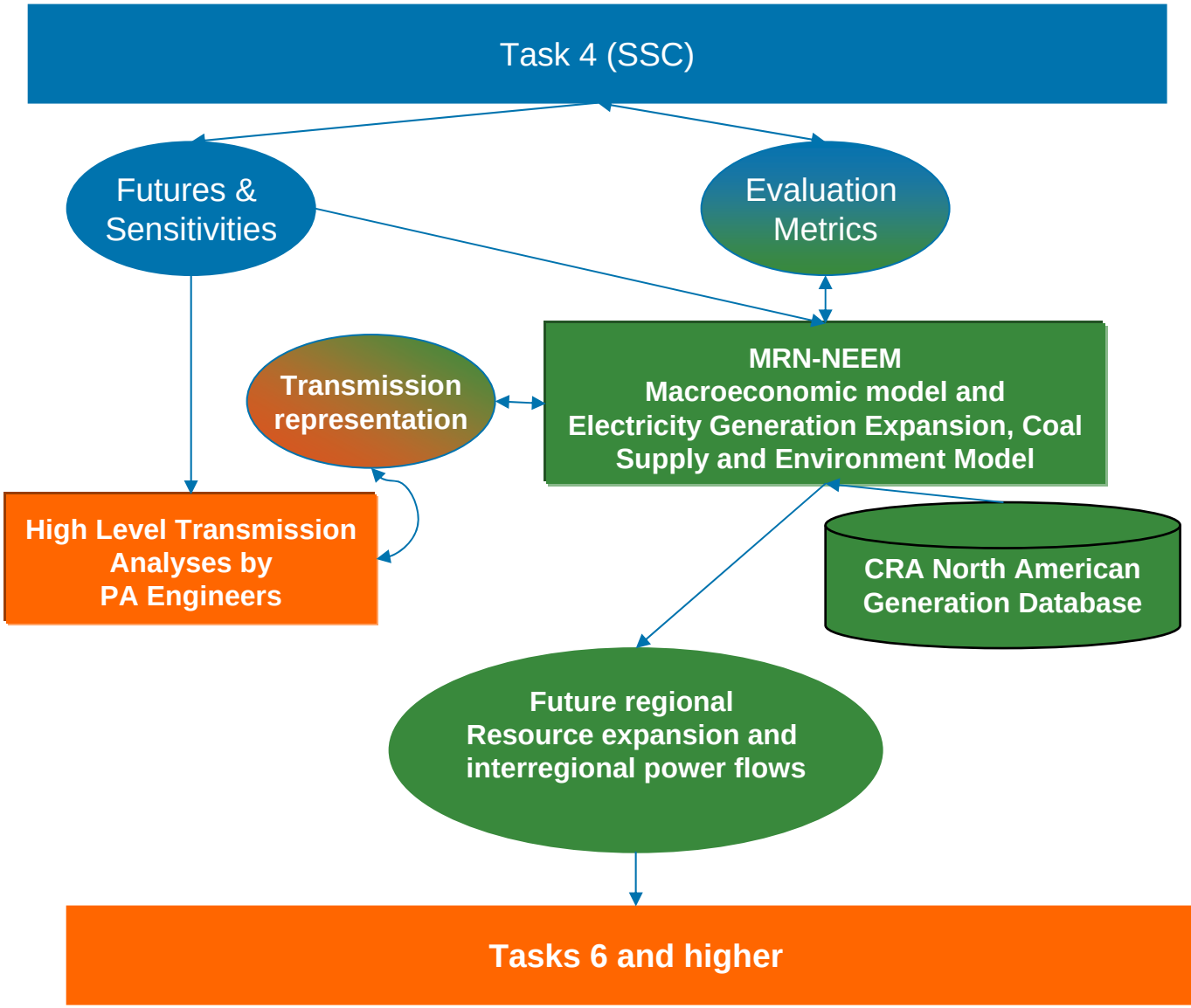
Objective:

- Develop an outlook of the Eastern Interconnection resource expansion through year 2030 under a wide range of macroeconomic futures and sensitivities

Methodology:

- Macroeconomic analysis of up to 8 Futures, up to 9 sensitivities for each future defined in Task 4
- For each Future and sensitivity develop a resource expansion plan
- Quantify the impact of the Future/Sensitivity on the electric power supply and other sectors of the US economy using agreed upon metrics
- CRA will rely on:
  - Macroeconomic futures and sensitivities defined by the SSC
  - CRA MRN-NEEM model
  - Generation and Transmission Database
  - High level transmission analysis provided by Planning Authorities engineers

CRA Modeling Tools and Data for Task 5



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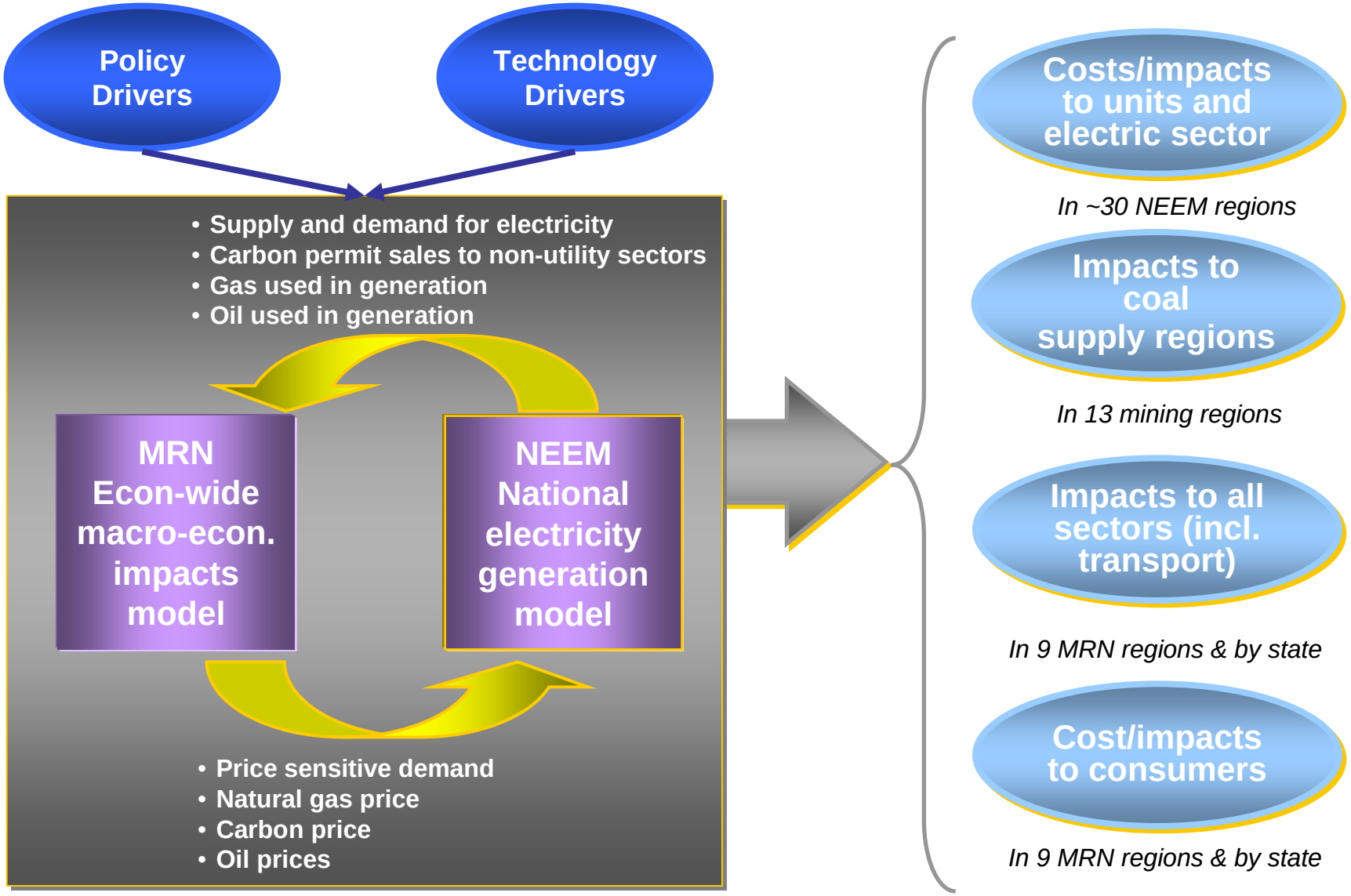
Information Exchange for Task 5

Information flow from CRA to SSC	Information flow from SSC to CRA
• Description of major drivers in CRA models (provided) • Electronic files for inputting information on primary drivers and sensitivities (provided) • Proposed definition of metrics for evaluation of Macroeconomic Futures and sensitivities • Technical comments on the implementability of SSC developed Macroeconomic Futures • Results of macroeconomic analyses • MRN-NEEM assumptions document (provided)	• Definition of Macroeconomic Futures in terms of combination of drivers and narratives on issues and themes • Comments and suggestions on metrics for evaluation of Macroeconomic Futures and sensitivities • Filled electronic files for inputting information on primary drivers and sensitivities

MRN-NEEM includes a detailed electric sector fully integrated with all other sectors of the U.S. economy



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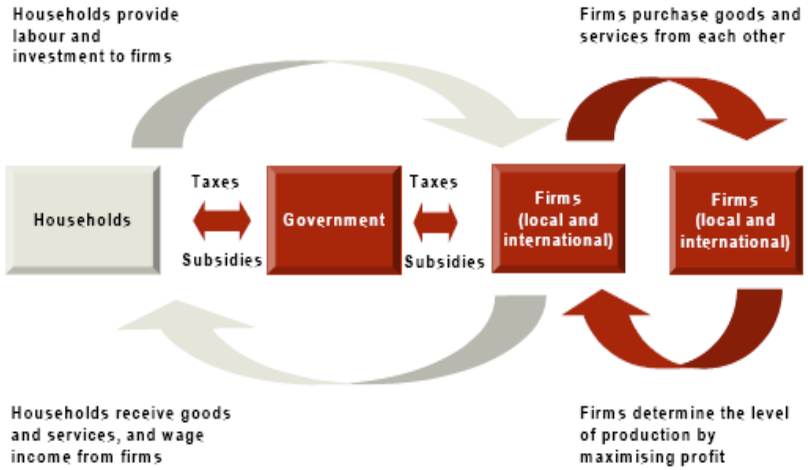
MRN Model Structure



MRN is a forward-looking, dynamic computable general equilibrium (CGE) model of the United States.

It is based on the theoretical concept of an equilibrium in which macro-level outcomes (e.g., consumption and investment) are driven by the decisions of self-interested consumers and producers.

The basic structure of CGE models, such as MRN, is built around a circular flow of goods and payments between households, firms, and the government

- MRN starting point: the inputs and outputs of commodities in the U.S. economy based on a Social Accounting Matrix (SAM) developed for each state by the Minnesota IMPLAN Group, Inc. (MIG).
- CRA adjusts the original SAM data to make them consistent with state-level energy data from the U.S. Energy Information Administration (EIA), which are more accurate than the corresponding IMPLAN data with respect to energy flows in the U.S. economy.
- The SAM that results from the combination of IMPLAN and EIA data exactly matches the intensities of commodity use for the modeled production and consumption sectors for any regional aggregation of states.
- In addition, the SAM completes the circular flow with an account of factor incomes, household savings, trade, and institutional transfers.
- SAM represents a “snapshot” of the economy at the current point along a dynamic growth path.
- MRN develops a Business as Usual (BAU) case: it simulates the dynamic growth path into the future in the absence of major changes to policies that are “on the books” today.

NEEM Simulates Optimal System Expansion

- Mix and timing of new generation additions
- Dispatching units to meet demand
- Operating, mothballing, or retiring of units
- Retrofitting existing units with pollution control equipment
- Switching fuels (between types/grades of coal)
- NOx and SOx allowance sales and purchases
- Scheduling maintenance for generating units
- Inter-regional energy transactions
- NEEM has embedded coal supply and transportation model
  - Retrofitting units leads to coal switching
  - Carbon regulation affects coal-fired generation
  - Both factors influence coal production by region and prices

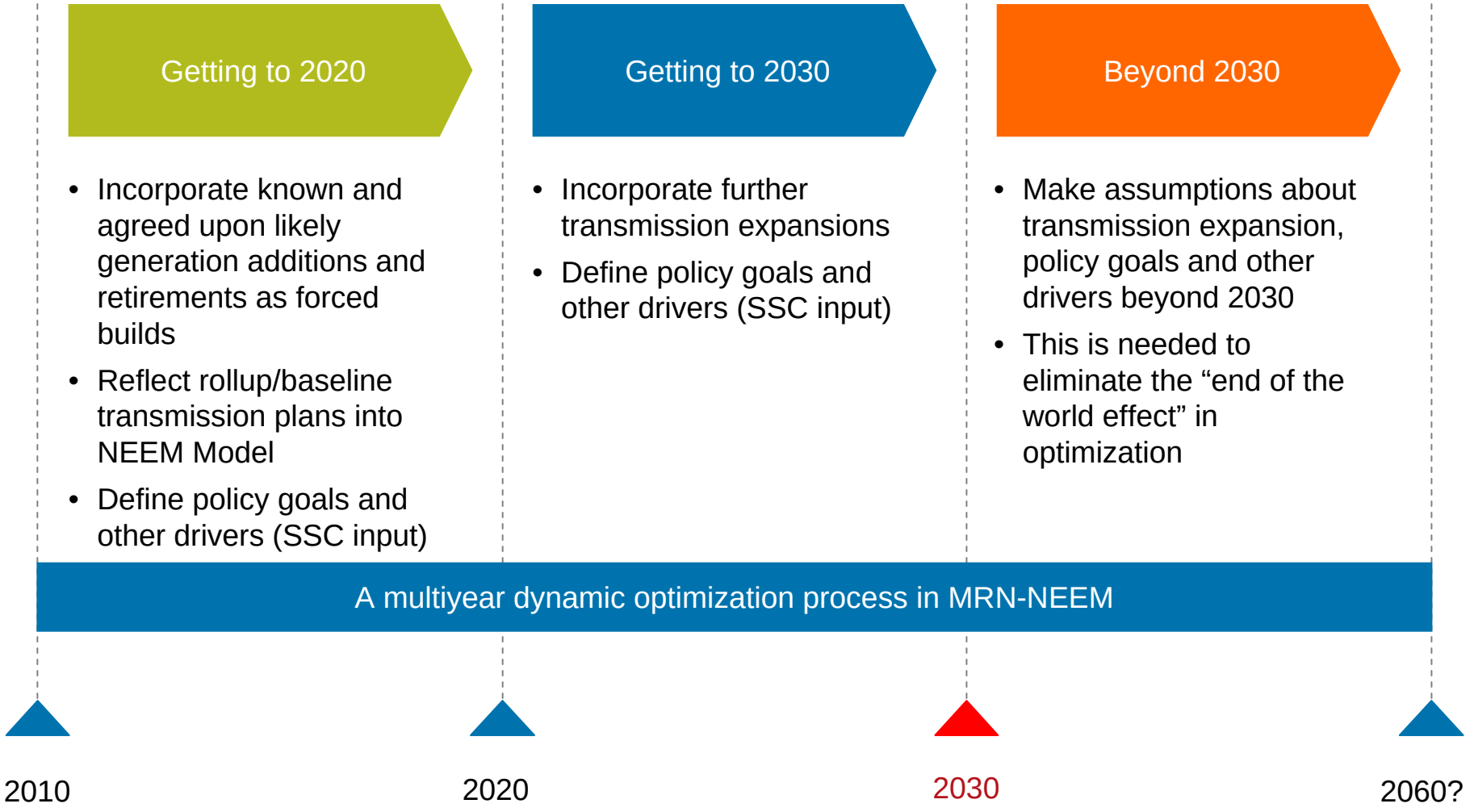
Key inputs

- Existing unit-level information
  - Capacity
  - Fuel type
  - Heat rate
  - Emission rates
  - Pollution control equipment
  - Fixed and variable O&M costs
- New generation options
  - Generation type/fuel type
  - Heat rate (for thermal)
  - Availability profiles for renewables
  - System integration costs for renewables
  - Emission rates
  - Capital, fixed and variable O&M costs
  - Capital charge rates
  - Timing on availability
  - Regional potential
- Transmission representation
  - NEEM regions and transfer limits between them
- Environmental regulations
  - SO_2/NO_X/Hg caps
  - CO_2 prices
  - Renewable portfolio standards
- Fuels
  - Coal supply curves
  - Seasonal delivered natural gas prices
  - Uranium, biomass and fuel oil prices
- Electricity Demand
  - Regional peak demand
  - Regional annual demand by load block
- Resource Adequacy
  - Regional reserve margin requirements

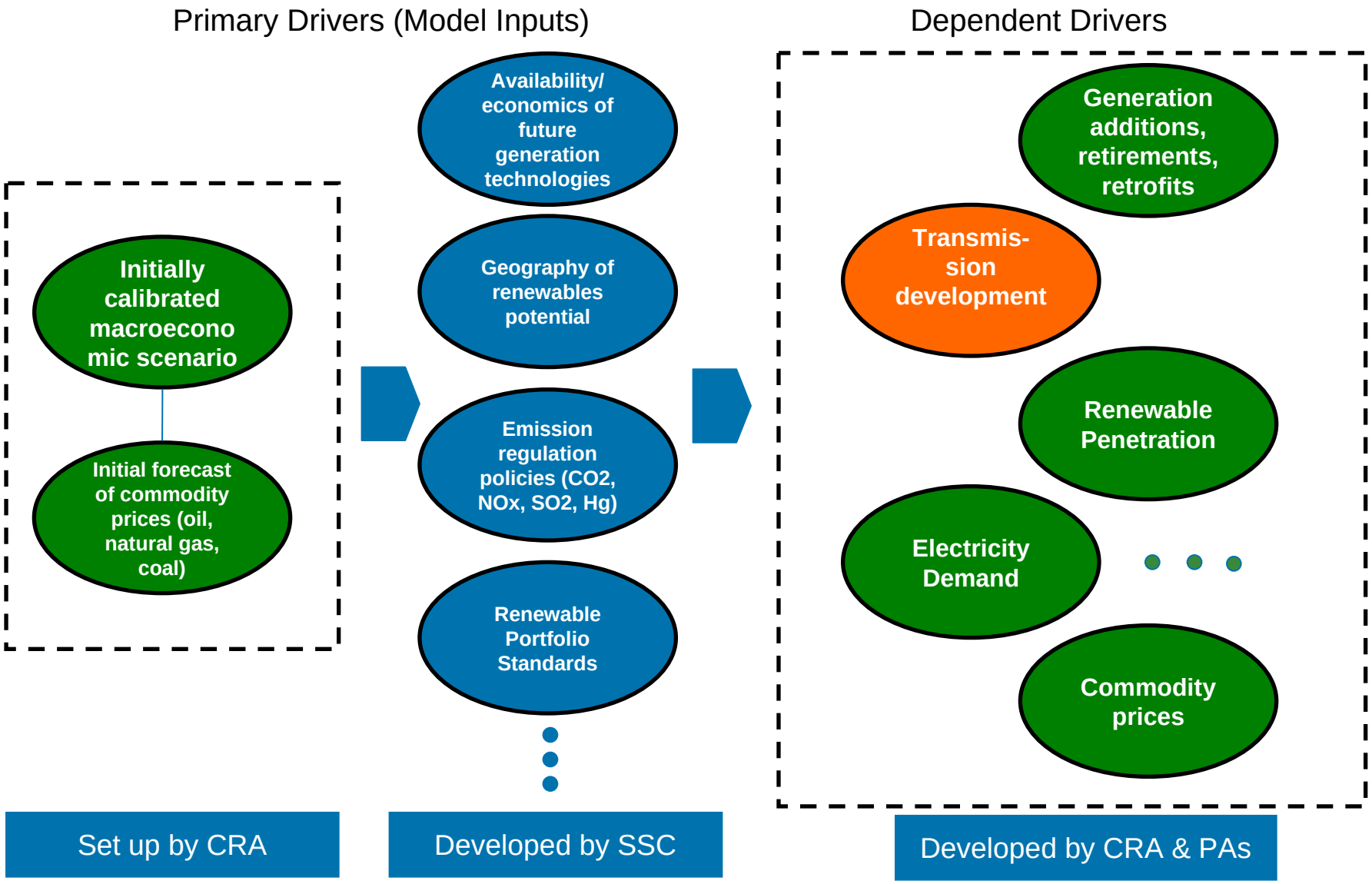
Key outputs

- Electric sector results (national and regional)
  - New capacity additions and retirements
  - Wholesale electricity prices by region, year & load block
  - Environmental allowance prices (for NOx, SOx and Hg)
  - Capacity prices
  - Coal prices by coal type
  - Environmental retrofits
  - Power interchange between power regions
  - High level transmission congestion
  - REC prices (for RPS)
- Generation within NEEM region results
  - Generation and capacity factor by major technology
  - Emissions and emission rates (CO2, NOx, SOx)
  - Fuel consumption
  - Energy and capacity revenues
  - Costs (fuel, VOM/FOM, allowance costs, depreciation on new capital)

Time Domain in the MRN-NEEM Analysis in this Project



SSC Inputs on Task 5: a preview of forthcoming discussions



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Overview of BAU Future and Discussion of Key Drivers

Inputs Discussion

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Key Input Driver Categories in MRN-NEEM

- Electricity Demand Forecast
- Generation Technologies - Costs and Characteristics
- Fuel Economics
- Transmission Grid
- Environmental and Renewables Policies

Key Input Driver Categories in MRN-NEEM

- Electricity Demand Forecast
  - Demand and peak demand over time
  - Region-specific
  - Can vary with GDP forecast and/or carbon policy impact
  - Energy efficiency, DSM, PHEVs
- Generation Technologies - Costs and Characteristics
  - End of life issues with coal and nuclear units
  - New unit fixed and variable costs
  - New unit performance / efficiency
  - Constraints on new unit penetration, US and regional
- Fuel Economics
  - Natural gas
- Transmission Grid
  - Transfer limits among NEEM regions
- Environmental and Renewables Policies
  - Air pollution, climate / GHG, renewable portfolio standards (RPS) or renewables subsidies, energy efficiency

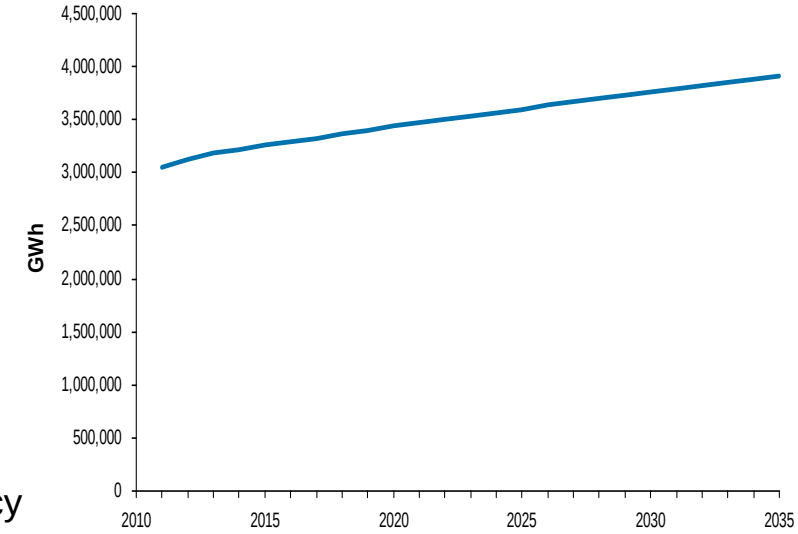
Electricity Demand Forecast

- Electricity Demand Forecast
  - FERC 714 and RTO forecasts through 2020
  - AEO 2010 growth rates after 2020
  - 2006 load shape
  - Peak demand grows 1:1 with energy demand after 2020, but differently in the near-term
- If multiple NEEM regions map to a single AEO region, we preserve differential growth between the NEEM regions
- MRN-NEEM will build the optimal mix of generation to meet energy demand and reserve margin
  - This is a key driver of capacity expansion

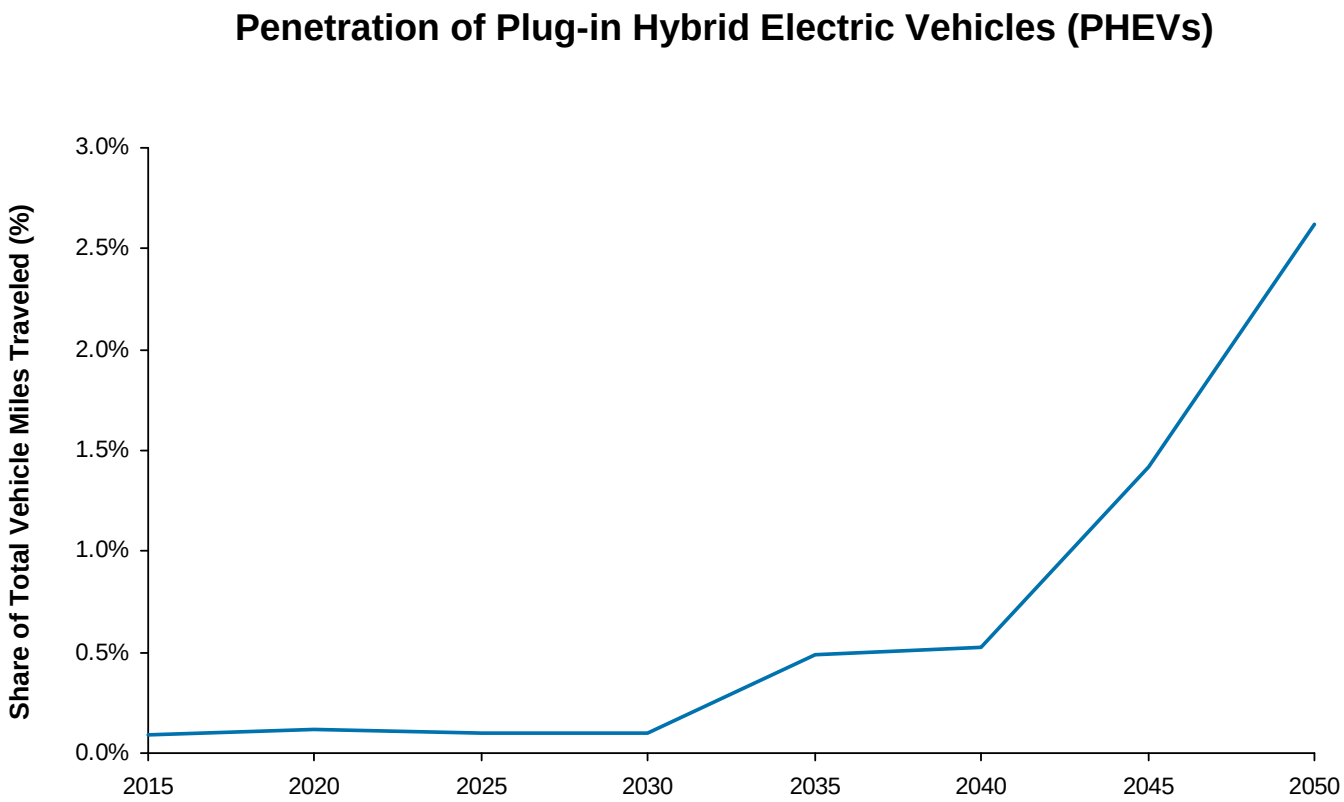
BAU Demand in the Eastern Interconnection

- BAU EI load taken from:
  - FERC Form 714,
  - RTO forecasts,
  - AEO 2010
- It is possible to alter these using MRN-NEEM to reflect different GDP growth trajectories (for a modified BAU)
- The data sources that we rely on include some impact of energy efficiency / DSM
  - Stakeholders can provide pre-energy efficiency demand, if desired
  - We could then model energy efficiency in a variety of ways including building pseudo-generators in NEEM

BAU Load in the Eastern Interconnection



The BAU PHEV Assumptions will Affect Electricity Demand



Note: The VMT of the PHEVs includes battery and gasoline operation

Source: AEO 2010, CRA Analysis

Existing Nuclear and Coal Unit End of Life Issues

- The retirement of key, existing baseload technologies is an important dynamic
- Existing coal refurbishes at 60 years, requiring capital expenditure equal to 15% of a new unit
  - Source: CRA Assumption
- Existing nuclear units retire at 60 years of age
  - NRC license constraint

Key Generation Technologies

- CCGT
- CT
- Advanced Coal
- Nuclear
- IGCC
- IGCC with carbon capture
- Wind (regional classes, by capacity factor, by interconnection cost)
- Solar PV and Solar Thermal
- Landfill Gas
- Geothermal
- Biomass
- DSM
- Other resources

New Unit Costs are Key Determinants of Capacity Expansion Plan

- Capital costs, fixed O&M, variable O&M
- Coal, nuclear, CC, CT, wind/renewables
- For capital costs, we propose starting with AEO 2010 and applying adders for items like contingency, gas pipeline cost, transmission hookup, rail spur, etc.
  - This will give us a single capital cost
  - NEEM can accept capital costs that change over time
- Operating costs could also be based on AEO 2010

New Unit Performance and Efficiencies also Matter

- Heat rates (coal, gas, nuclear, biomass)
  - Can change over time
  - Possible source: AEO 2010
- Renewables capacity factors (and shapes)
  - NREL EWITS database for wind
  - Wind capacity factors could be based on 2004-2006 data
  - We use 2006 wind shapes to sync with load shape

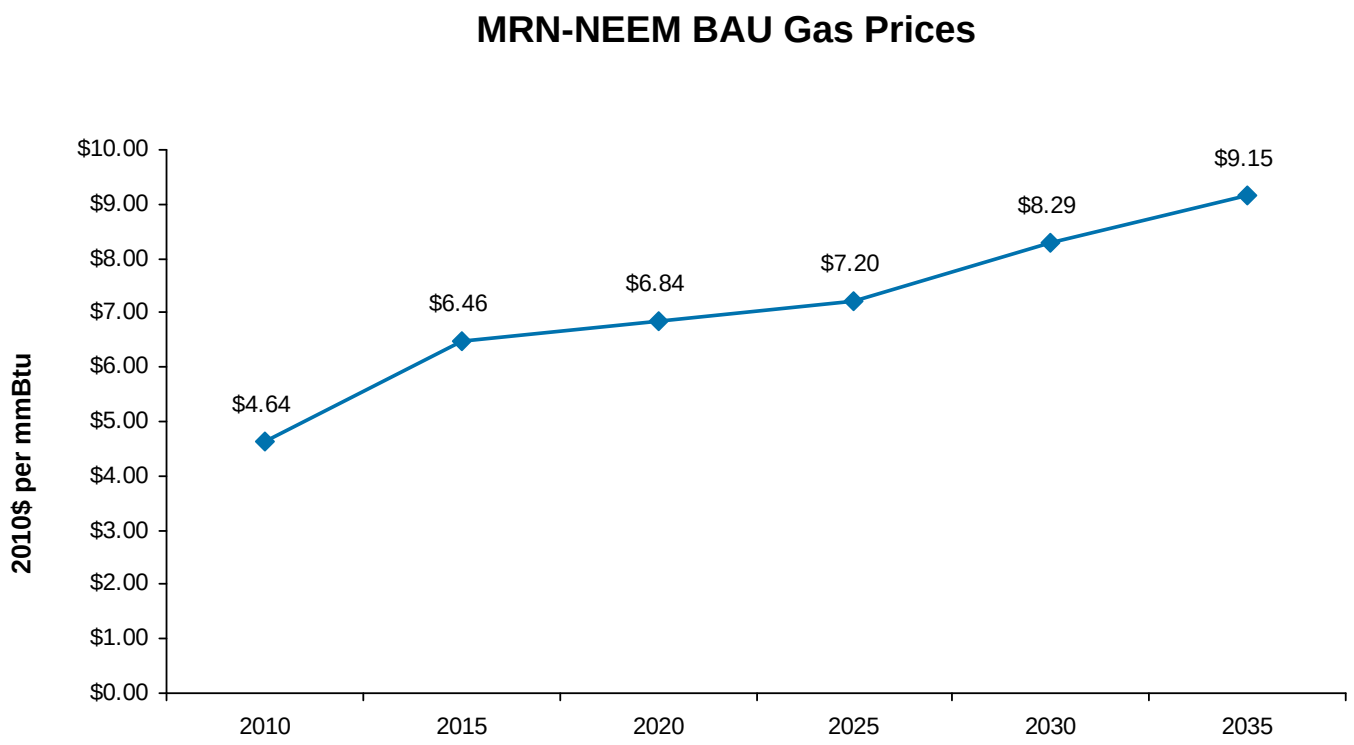
NEEM Can Accept a Variety of Constraints on Capacity Expansion, Nationally or Regionally

- Maximum penetration per NEEM region
  - For wind, we base this on NREL's WinDS model (base case)
- Cumulative penetration over time
  - To reflect siting constraints or pre-conceptions about the maximum trajectory of penetration
  - Generally not used for all technologies and regions
- Annual limits
  - Typically used at the US-level to reflect constraints on annual builds due to labor, vendor expertise, etc.
- These are important assumptions and difficult to establish
  - We seek stakeholder input for the EIPC analysis

Natural Gas Prices are the Key Fuel Price Input

- Natural Gas Prices:
  - Affect coal retirements
  - Affect viability of renewables
  - Affect CC and CT penetration
- Natural Gas Price Data Sources
  - AEO 2010 in BAU
  - Basis differentials based on forward market trends
  - Under other futures (e.g., carbon policy), gas prices will respond within MRN-NEEM
    - Typically, under carbon policy, gas prices increase in the short- to medium-term under carbon policy and then fall (relative to BAU)

AEO 2010 Natural Gas Prices at Henry Hub



Source: AEO 2010

The Transmission Grid can Constrain the Location and Level of New Builds

- Specified as transfer limits among the NEEM regions
- Use of dummy regions to reflect joint constraints, etc.
  - Region A and region B both transfer to region C, but the total transfer to region C is restricted to…
- Complex joint constraints can also be specified
- Transfer limits developed as discussed in EIPC presentation

Polices potentially have a large impact on capacity expansion and retirements

Environmental Policies in BAU:

- SO_2 and NO_x policy should be defined by SSC
- Utility MACT policy assumptions should be made
- Coal ash regulations
- Cooling water regulations
- RGGI – Regional Greenhouse Gas Initiative (modeled as price)
- No Federal carbon policy
- Local and regional RPS policies
- No Federal RES
- EE policies

Key Inputs We Need to Model BAU

1. Policies
   - RPS requirements (MWh) by NEEM region over time and any contributions of EE/DR
   - EE/DR impacts on BAU load growth
   - RGGI prices
   - Choice of SO_2/NO_x policy
   - Utility MACT requires which retrofit technologies?
   - Concurrence on retrofit cost assumptions
   - Technology costs in response to coal ash and water intake regulations
2. Fuel prices and Emission Prices
   - Henry Hub natural gas prices
   - Can specify all emissions prices, if desired

Key Inputs We Need to Model BAU

3. Demand and Load Growth
   - Energy and peak demand by NEEM region over time, net of EE/DR impacts
4. Energy Efficiency / Demand Response
   - Impact of existing mandates by NEEM region
5. Discount / Inflation Rates
   - MRN-NEEM's real discount rate is 5%
   - All analysis is in real terms
6. New Infrastructure Development
   - Transfer limits implied by roll-up case
   - All generation builds (and retirements) that should be forced in NEEM
   - Constraints on new builds, US and regional over time

Key Inputs We Need to Model BAU

7. New Sources of Generation
   - Capital cost, fixed O&M, variable O&M over time for all new generation technologies
   - Performance for all new generation technologies over time
     - E.g., wind capacity factors and shapes, fossil heat rates, etc.
   - PHEVs mentioned (penetration assumptions)

MRN-NEEM Assumptions Document

Discussion, Q&A

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Purpose of MRN-NEEM Assumptions Document

- To present and explain the major inputs to MRN-NEEM
- To give stakeholders an idea of the relationship between MRN and NEEM and how they are integrated

Overview of MRN-NEEM Assumptions Document

- Overview of MRN and NEEM and MRN-NEEM model integration
- NEEM inputs and data sources
- Overview of MRN and general equilibrium models
- MRN inputs and data sources

Assumptions Document - Tables

Assumptions Document - Figures

Assumptions Document – Exhibits A and B

Exhibits in Appendix A

Appendix A, Exhibit 1 - Mapping of Control Entities to NEEM Regions (for load mapping)

Appendix A, Exhibit 2 - Mapping of BA's to NEEM Regions (for generator mapping)

Appendix A, Exhibit 3 - Forced New Builds

Appendix A, Exhibit 4 - Forced Retirements

Appendix A, Exhibit 5 - Regional Multipliers

Appendix A, Exhibit 6 - New Resource Limits

Appendix A, Exhibit 7 - Retrofit Costs Source Information

Appendix A, Exhibit 8 - Forced Retrofits

Appendix A, Exhibit 9 - Natural Gas Prices, Base Case

Appendix A, Exhibit 10 - Natural Gas Basis Point Mapping

Appendix A, Exhibit 11 - Wheeling Charges and Transmission Costs

Exhibits in Appendix B

Sectoral mapping of IMPLAN Sectors based on NAICS 2002

Other Assumptions

- CCS retrofit costs
- Costs to transport and store CO_2 (plant/basin pairings by region)
- Domestic and International Offsets
  - If modeling cap-and-trade, we need offset supply curves domestically and internationally
  - Not necessary if modeling CO_2 policy as a tax (carbon price is input)
- All-In Capital costs include some adders and can vary over time
- Capacity factors of wind by NEEM region

Sample Output Reports

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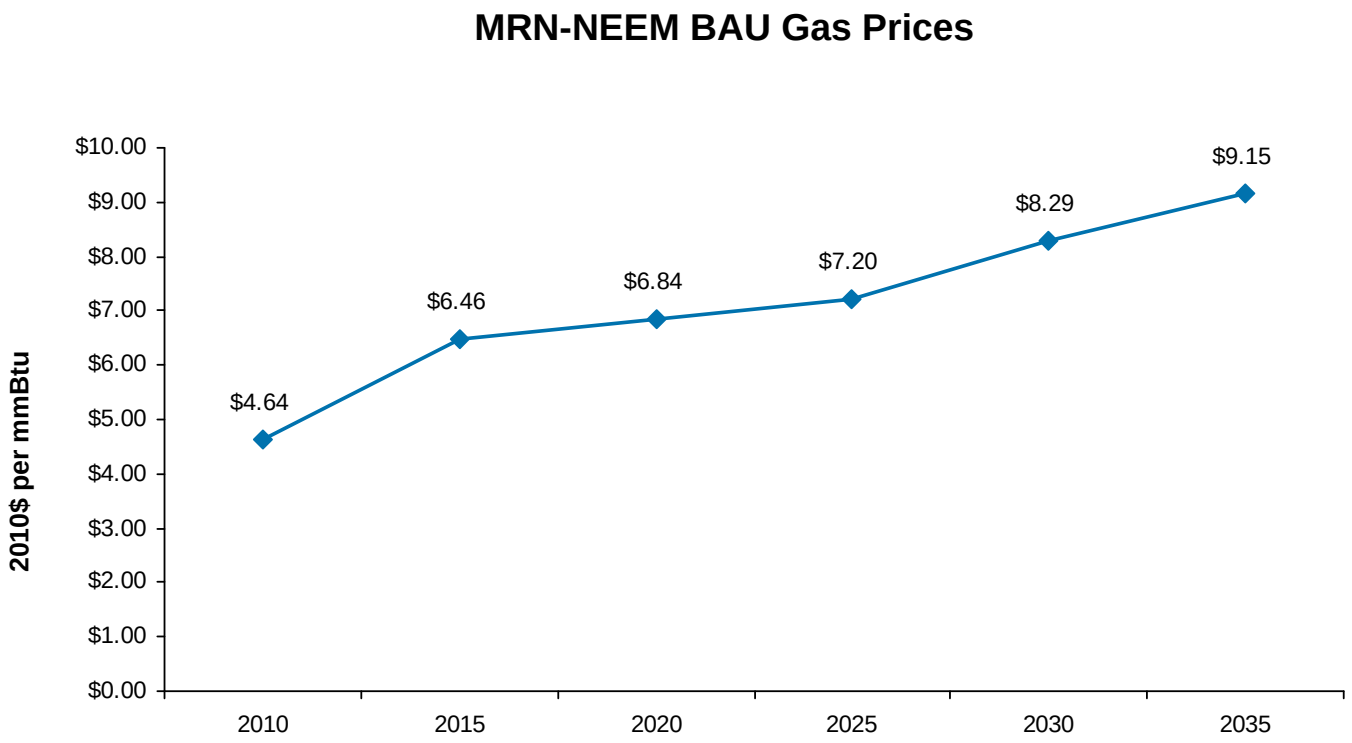
Key MRN-NEEM Outputs

- For each 5-year period from 2015 through 2035
  - Natural gas and coal prices
    - For BAU, gas prices will be AEO 2010 (input prices = output prices)
    - For BAU, coal prices will be based on CRA supply curves and demand (prices are outputs)
    - For other futures, gas prices and coal prices will be calculated by MRN-NEEM (coal/gas prices are outputs)
  - Emission prices (SO_2, NO_x, CO_2)
    - *If not specified as inputs in the Future – can either specify the cap (quantity) or price, not both.*

Key MRN-NEEM Outputs (…cont)

- For each 5-year period from 2015 through 2035
  - By NEEM region:
    - Electricity demand (GWh)
      - For BAU, input electricity demand = output electricity demand (with small PHEV load added)
      - For other futures, demand is an output of MRN-NEEM; GHG policy will typically lower demand
      - EE/DSM affects demand, peak shifting (Autonomous EE Improvement, "AEEI" can be altered in BAU and other futures)
    - PHEV electricity consumption
    - New generation capacity (MW) by type (e.g., nuclear, wind)
    - Retirements (MW) by type
    - Emissions (SO_2, NO_x, CO_2), allowance prices, and pollution control retrofits
    - Energy output (GWh) by generator type
    - Fuel consumption by electric generators by type of fuel
    - Average market price for energy; on-peak, off-peak, all-hours
    - Average energy flows to adjacent NEEM regions
  - Shadow prices on transfer paths between NEEM regions
    - Indicates value of increasing transfer limit by 1 MWh, all else equal, by load block

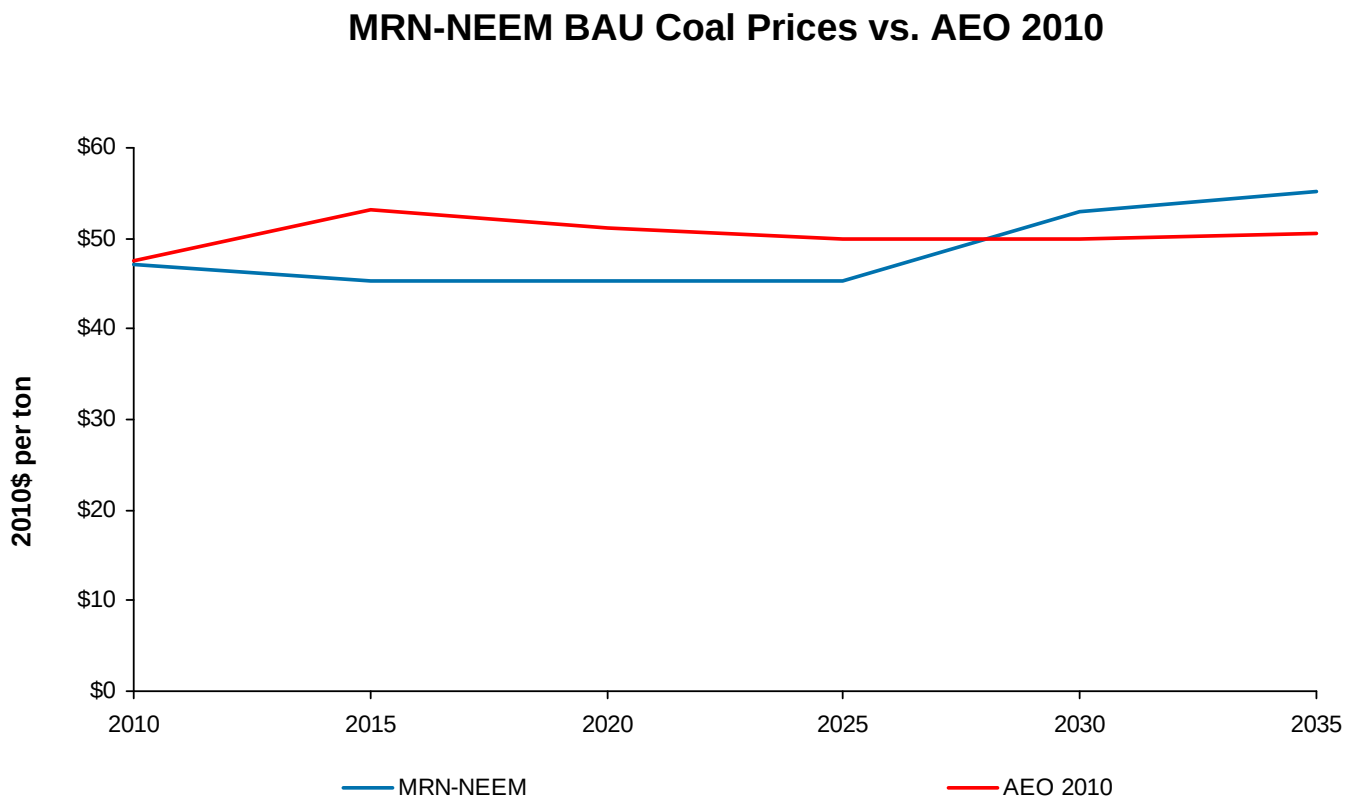
Exhibit 1 – Gas Price Forecast (Henry Hub)



In BAU, the output gas prices are the same as the input gas prices. This is not true under a carbon policy future.

Sources: AEO 2010

Exhibit 2 – Northern Appalachian Coal Price Forecast



Sources: CRA analysis

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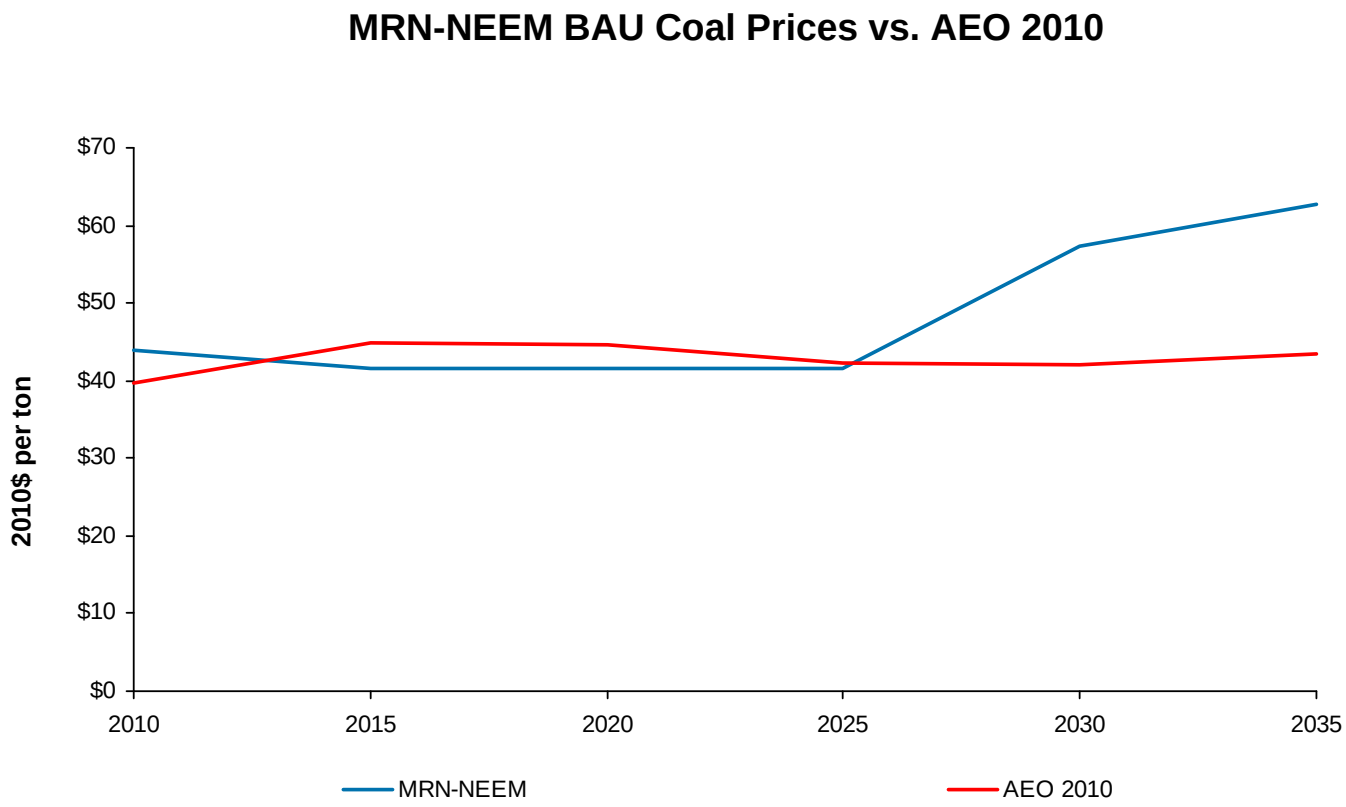
Exhibit 3 – Illinois Basin Coal Price Forecast



Sources: CRA analysis

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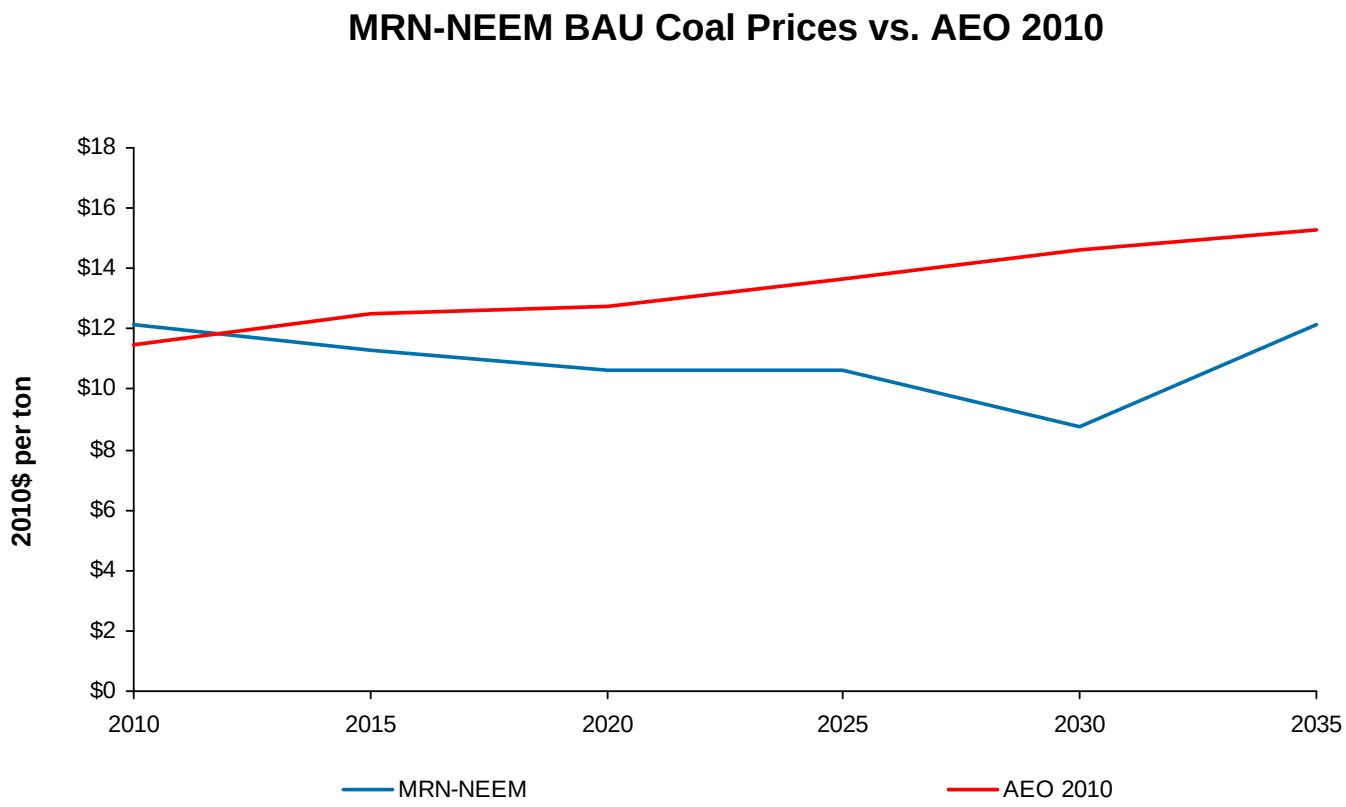
Exhibit 4 – Powder River Basin Coal Price Forecast



Sources: CRA analysis

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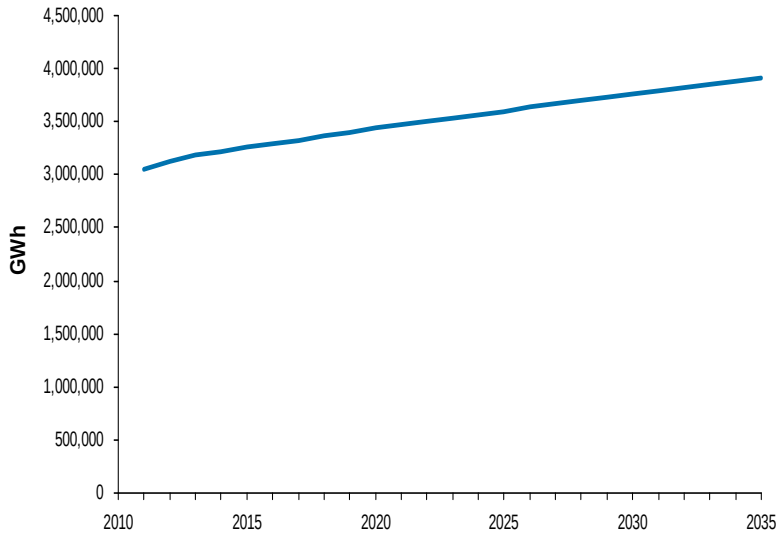
Exhibit 5 – Annual Energy Demand

- In BAU, output demand = input demand
- BAU EI load taken from FERC Form 714, RTO forecasts, and AEO 2010
  - Does not exclude impact of forecasted EE and DSM
- Changes to input assumptions will change load forecast in MRN-NEEM. Examples of inputs affecting load forecast
  - Environmental policy, its impact on GDP, and EE/conservation/demand destruction
  - Energy efficiency (AEEI), which can be changed for a modified BAU
  - Natural gas prices, which can be changed for a modified BAU

BAU Load in the Eastern Interconnection



Sources: CRA analysis

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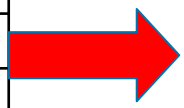
Exhibit 6: New Capacity Additions by 2020 (MW)

	Coal	CC	CT	Wind	Solar - PV
AE	695	-	5,052	-	-
ECAR	1,215	1,381	7,792	683	-
EMO	-	-	-	-	-
ENT	1,515	-	-	288	-
FRCC	-	4,365	4,476	-	35
MAPP_US	319	-	95	933	-
NI	-	573	1,607	523	-
PJM_SW	-	1,926	-	87	2,000
PJM_W	-	-	-	365	-
SCIL	1,800	-	-	239	-
SOCO	-	823	360	-	-
SPP_N	322	-	-	282	-
SPP_S	660	-	60	379	-
TVA	750	-	5,540	-	-
VACAR	800	2,254	4,684	900	18



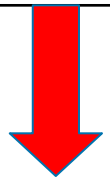
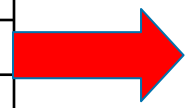


Exhibit 7: Retirements by 2020 (MW)

	Coal	CC	Steam Oil/Gas
AE	589	-	-
ECAR	3,417	-	-
EMO	240	-	-
ENT	347	-	4,873
FRCC	-	-	-
MAPP_US	2,217	-	-
NI	496	-	-
PJM_SW	498	-	-
PJM_W	622	-	-
SCIL	723	-	-
SOCO	3,318	-	-
SPP_N	607	-	-
SPP_S	2	-	-



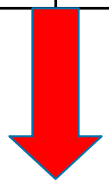


Exhibit 8: New Capacity Additions by 2030 (MW)

	Coal	CC	CT	Wind	Solar - PV
AE	695	-	5,052	-	-
ECAR	1,215	4,080	14,298	683	-
EMO	-	-	939	-	-
ENT	1,515	-	-	288	-
FRCC	-	6,876	6,787	-	35
MAPP_US	1,932	-	369	5,064	-
NI	1,627	573	4,724	523	-
PJM_SW	-	2,380	-	3,302	2,000
PJM_W	-	-	-	365	-
SCIL	1,800	-	-	239	-
SOCO	3,946	823	2,349	-	-
SPP_N	322	875	754	3,736	-
SPP_S	660	866	60	7,678	-
TVA	2,811	-	7,512	-	-
VACAR	800	5,758	8,358	900	18

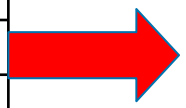


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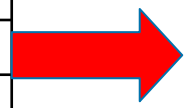
Exhibit 9: Retirements by 2030 (MW)

	Coal	CC	Steam Oil/Gas
AE	589	-	-
ECAR	3,417	-	-
EMO	240	-	-
ENT	347	-	4,873
FRCC	-	-	-
MAPP_US	2,300	-	-
NI	496	-	-
PJM_SW	1,242	-	-
PJM_W	622	-	-
SCIL	723	-	-
SOCO	3,947	-	-
SPP_N	607	-	-
SPP_S	2	-	-



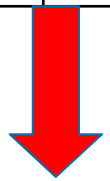
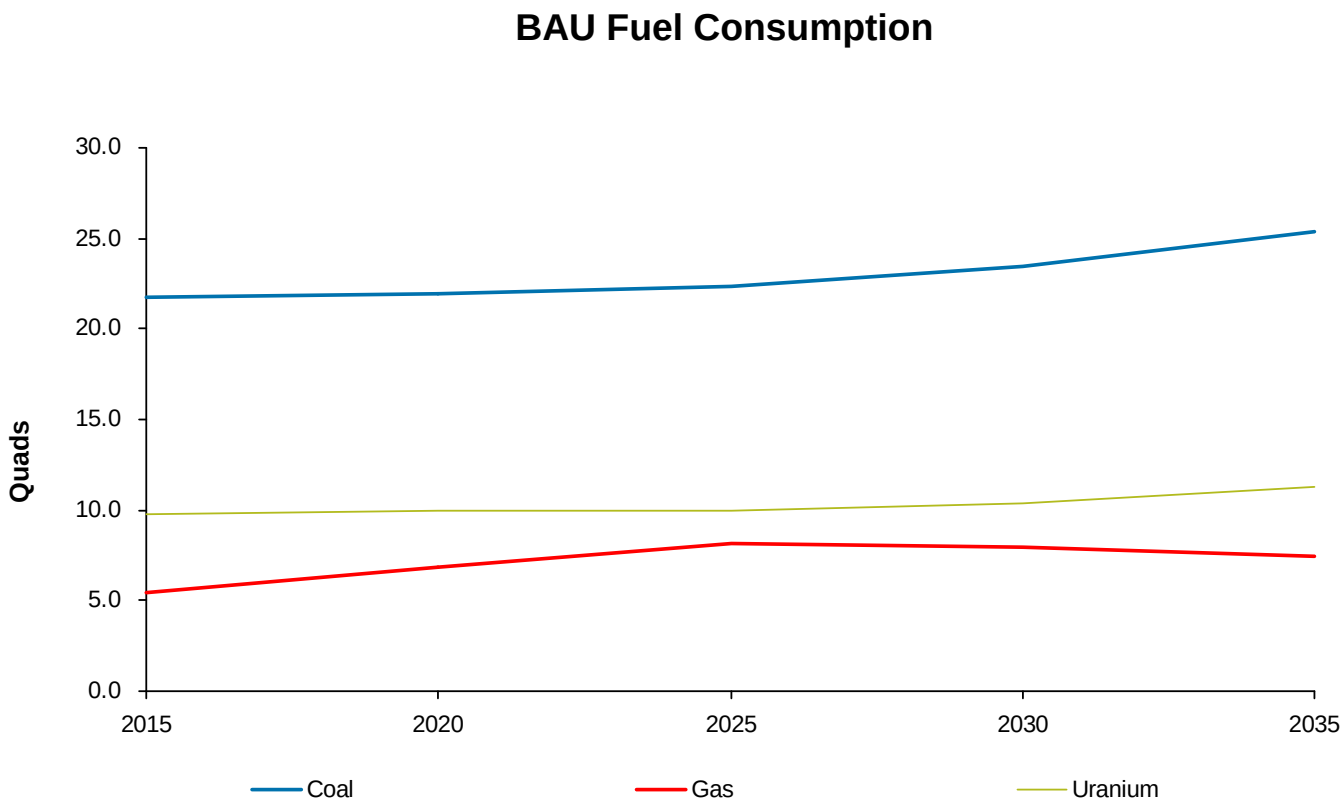


Exhibit 10: Fuel Consumption



Sources: CRA analysis

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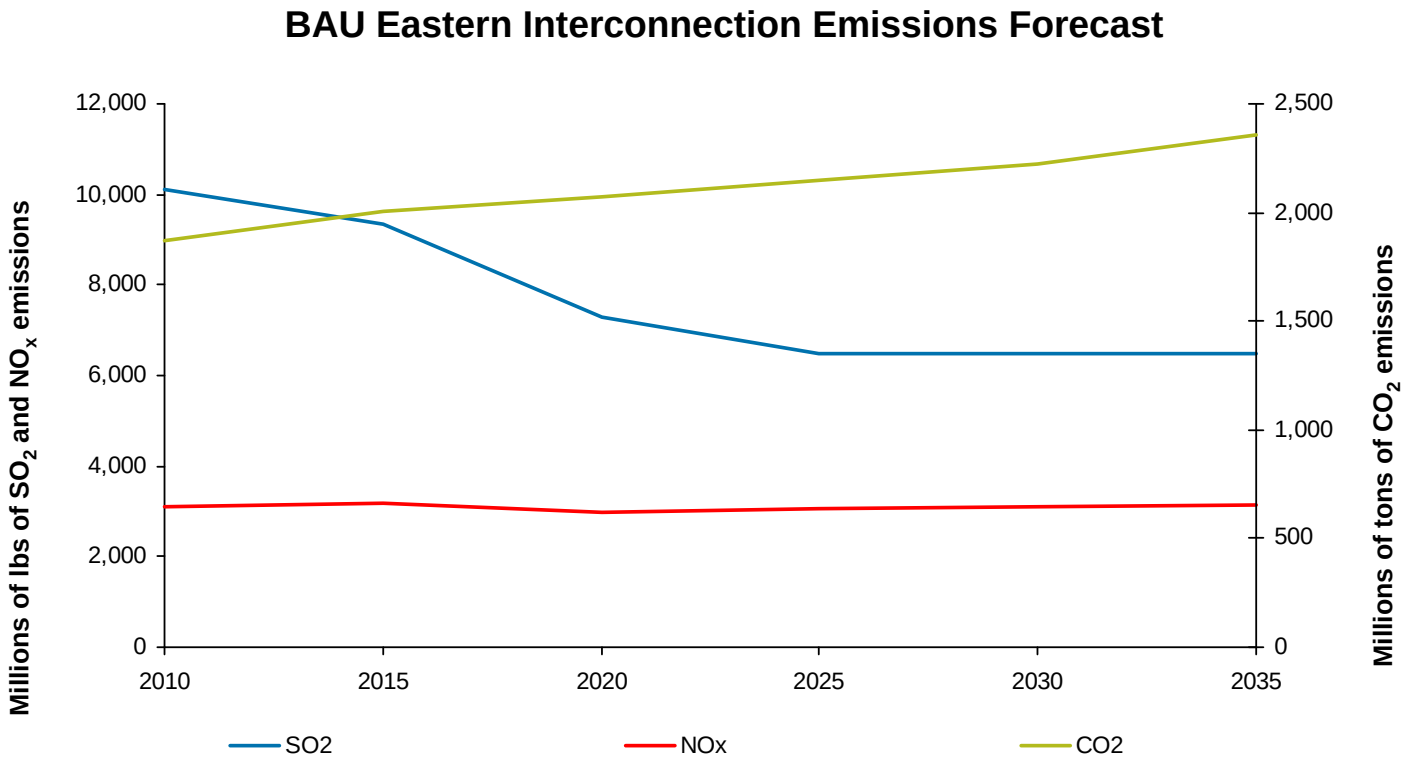
Exhibit 11 – Emissions over time



Note: Hg emissions are not shown here.

Sources: CRA analysis and AEO 2010

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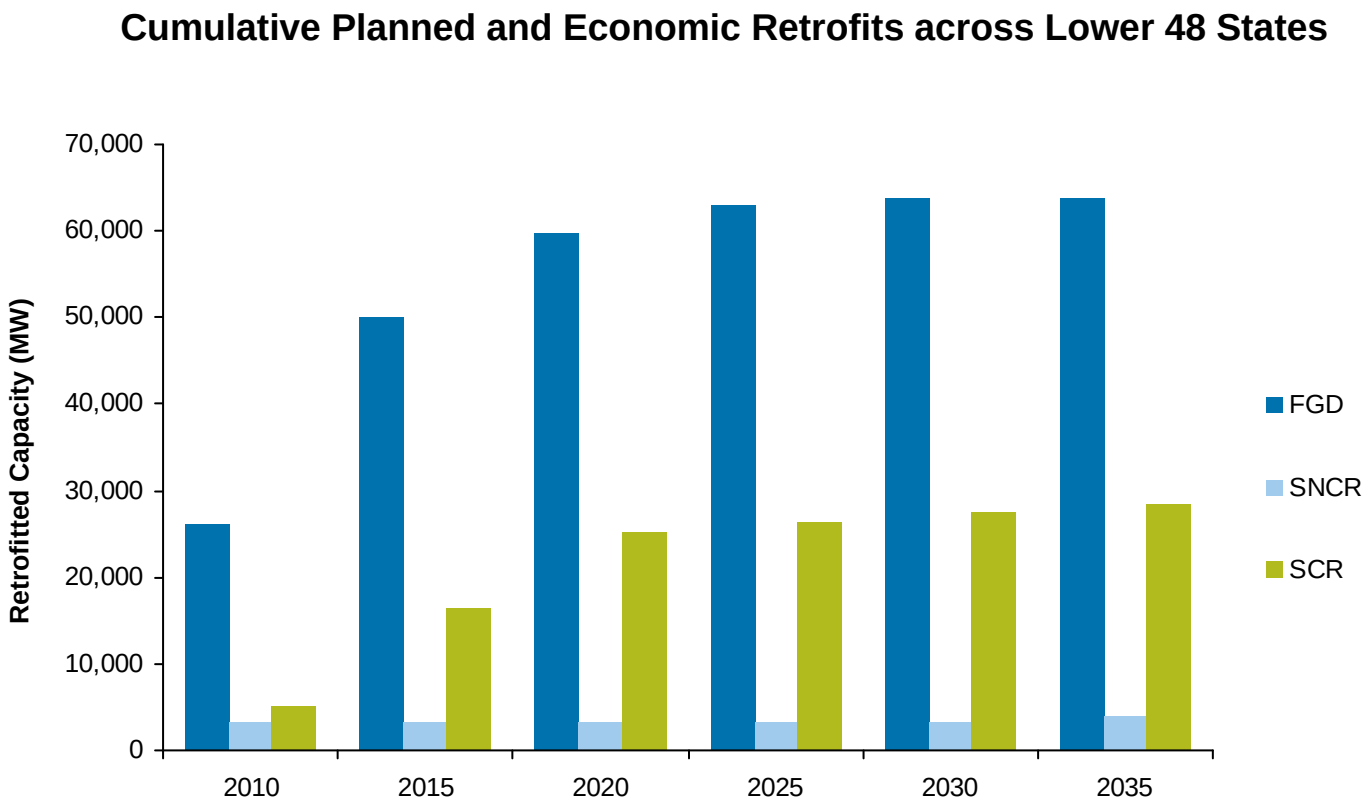
Exhibit 12: New Retrofits



Note: Retrofits in this graph are USA-wide, excluding HI and AK

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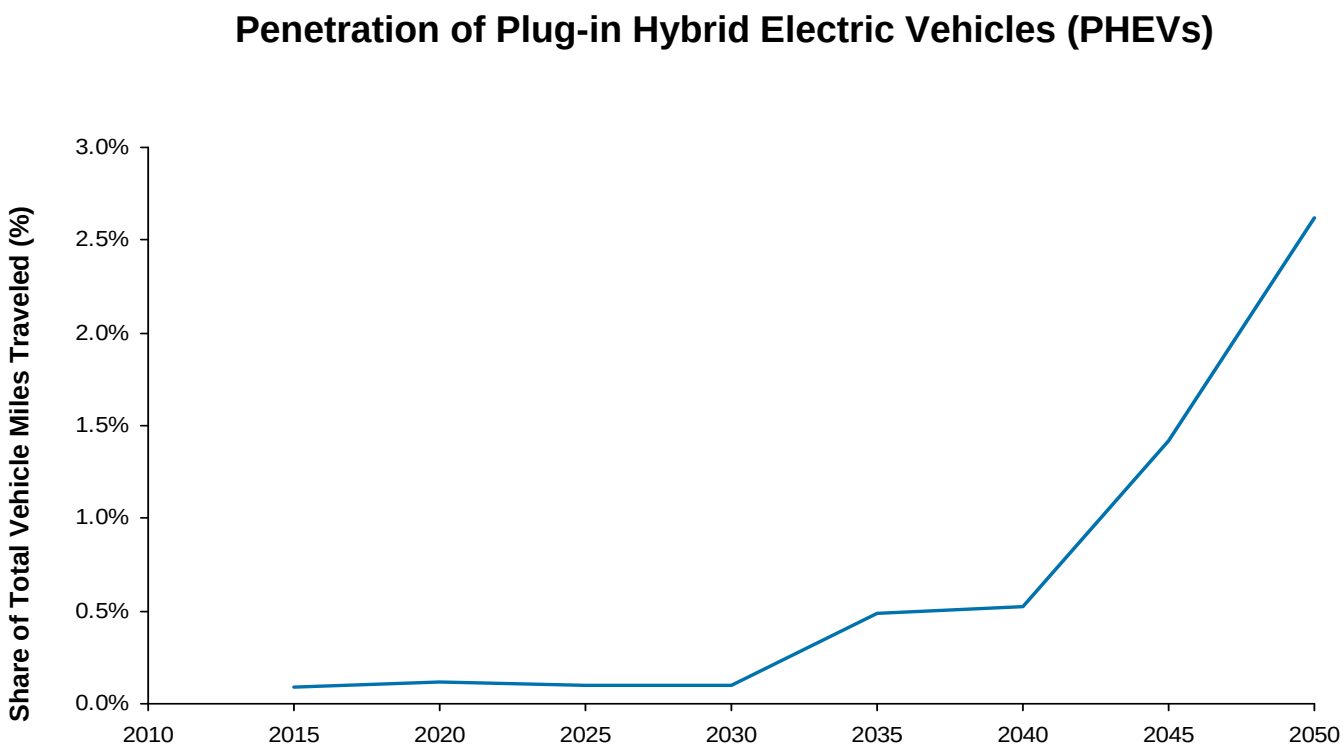
Exhibit 13 – Plug-in Hybrid Electric Vehicles



In BAU, PHEV penetration is the same as AEO 2010's assumptions. Under a carbon future, the PHEV penetration will increase.

Source: AEO 2010

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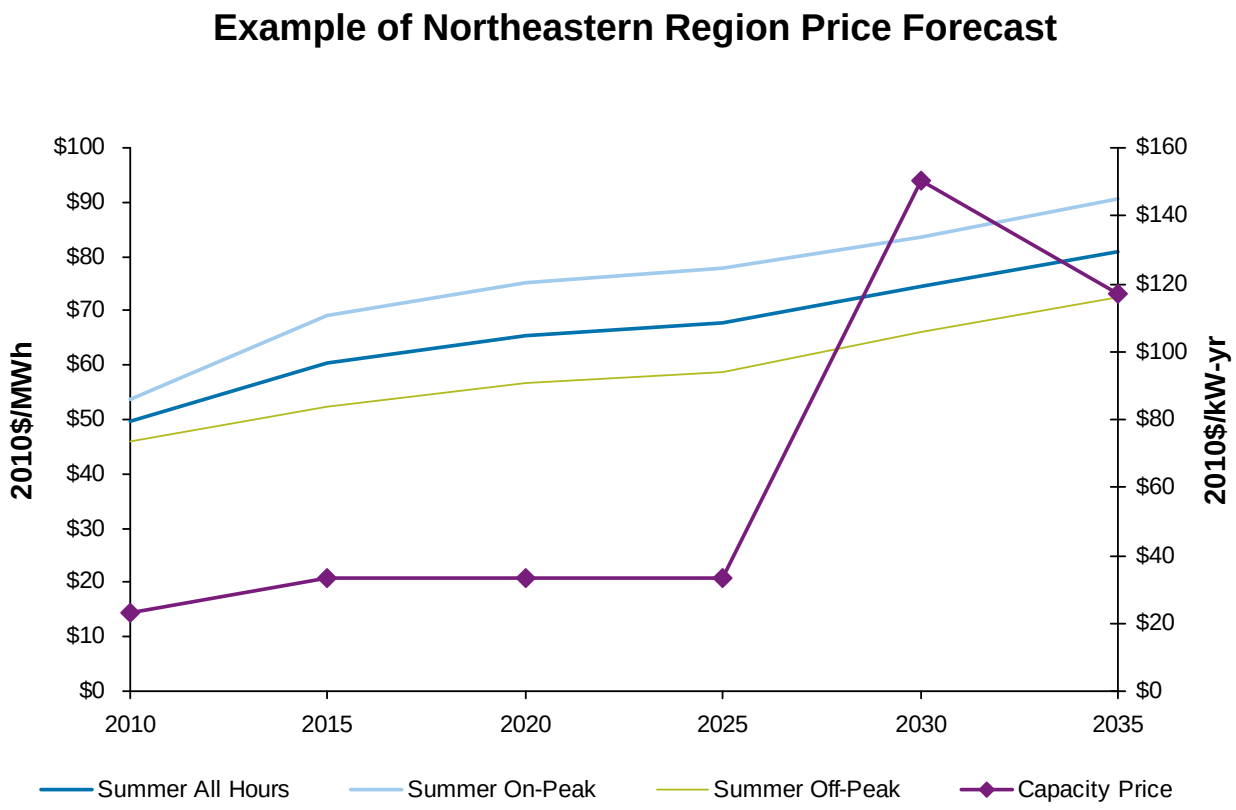
Exhibit 14 – Regional Price Forecast (Northeast)



Sources: CRA analysis and AEO 2010

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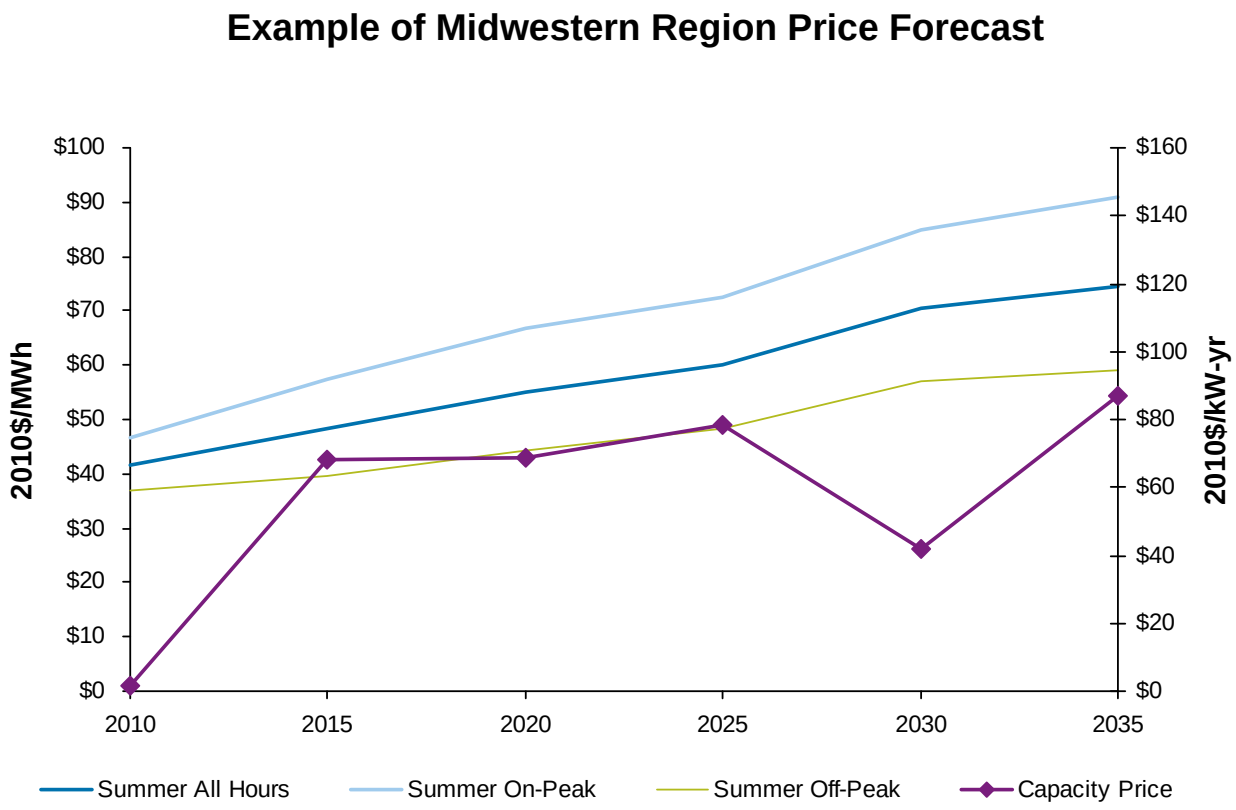
Exhibit 15 – Regional Price Forecast (Midwest)



Sources: CRA analysis and AEO 2010

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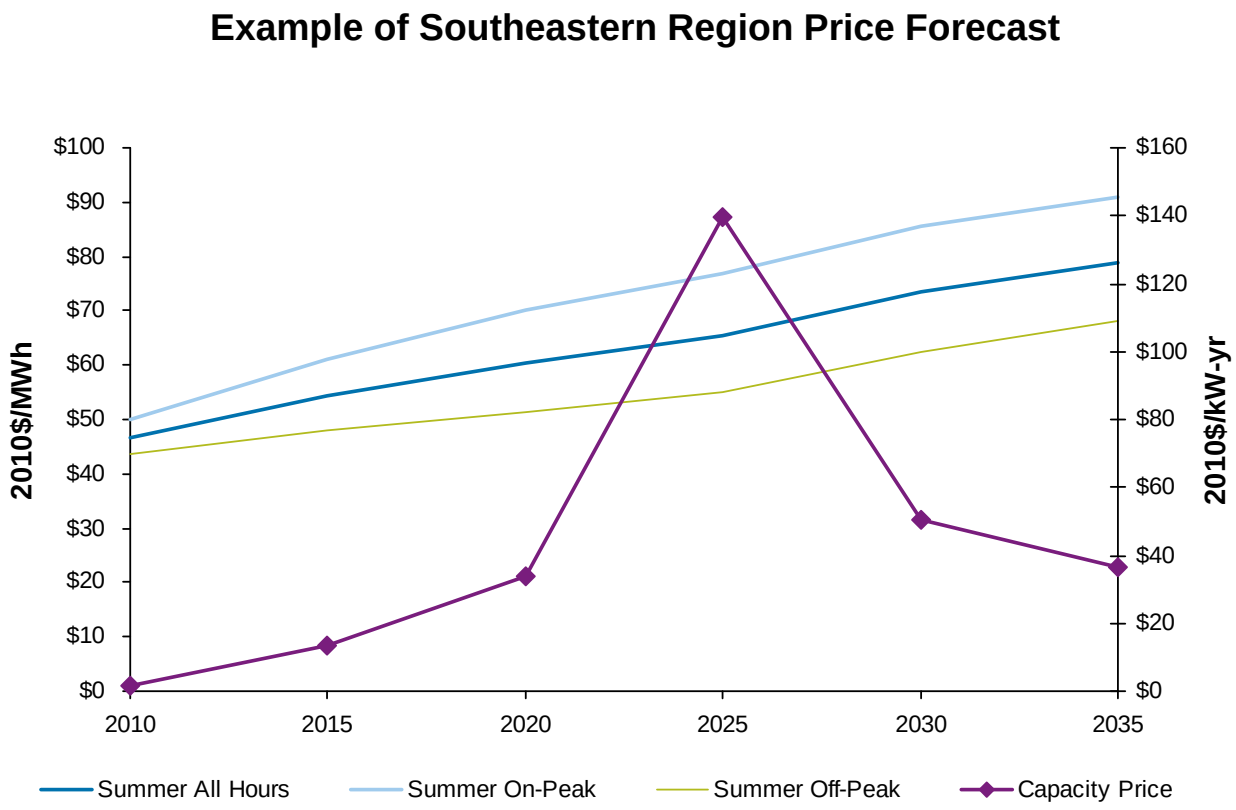
Exhibit 16 – Regional Price Forecast (Southeast)



Sources: CRA analysis and AEO 2010

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Exhibit 17 – 2030 Annual Flows Between Regions (GWh)

		DESTINATION											
		AE	AZ_NM_SNV_Coal	ECAR	EMO	ENT	ERCOT	FRCC	HQ	HQ_Dummy	MAPP_CA	MAPP_US	NEISO
ORIGIN	AE	-	-	-	-	-	-	-	-	-	-	-	-
	AZ_NM_SNV_Coal	-	-	-	-	-	-	-	-	-	-	-	-
	ECAR	15,879	-	-	-	-	-	-	-	-	-	-	-
	EMO	-	-	-	-	14,564	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	-	-	-	-	-	-
	ERCOT	-	-	-	-	-	-	-	-	-	-	-	-
	FRCC	-	-	-	-	-	-	-	-	-	-	-	-
	HQ	-	-	-	-	-	-	-	-	12,198	-	-	-
	HQ_Dummy	-	-	-	-	-	-	-	-	-	-	-	9,855
	MAPP_CA	-	-	-	-	-	-	-	-	-	-	6,934	-
	MAPP_US	-	-	-	1,869	-	-	-	-	-	2,219	-	-
	NEISO	-	-	-	-	-	-	-	-	-	-	-	-
	NI	-	-	15,571	-	-	-	-	-	-	-	-	-
	NWPP_Coal	-	1,160	-	-	-	-	-	-	-	-	219	-
	NYISO_Upstate	-	-	-	-	-	-	-	-	-	-	-	-
	NYISO_Downstate	-	-	-	-	-	-	-	-	-	-	-	-
	NYISO_Capital	-	-	-	-	-	-	-	-	-	-	-	-
	NYISO_NYC	-	-	-	-	-	-	-	-	-	-	-	-
	NYISO_LIPA	-	-	-	-	-	-	-	-	-	-	-	42
	NYISO_Dummy1_Up	-	-	-	-	-	-	-	-	-	-	-	-
	NYISO_Dummy1_Down	-	-	-	-	-	-	-	-	-	-	-	-
	NYISO_Dummy2_In	-	-	-	-	-	-	-	-	-	-	-	-
	NYISO_Dummy2_Out	-	-	-	-	-	-	-	-	-	-	-	7,453

Note: Non-existent links are blacked out.
ECAR will be represented as MI, MISO_E, PJM_Midwest, and NonRTO_Midwest in Task 5 modeling; PJM_D and NE will also be separated from VACAR and MAPP_US, respectively.

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Exhibit 18 – 2030 Shadow Price on Transfer Flow, Lowest Summer Load Block ($/MWh)

ORIGIN	DESTINATION: AE	AZ_NM_SNV_Coal	ECAR	EMO	ENT	NWPP_Coal
AE	-	-	-	-	-	-
AZ_NM_SNV_Coal	-	-	-	-	-	(1.67)
ECAR	-	-	-	-	-	-
EMO	-	-	-	-	(11.16)	-
ENT	-	-	-	-	-	-
ERCOT	-	-	-	-	-	-
FRCC	-	-	-	-	-	-
HQ	-	-	-	-	-	-
HQ_Dummy	-	-	-	-	-	-
MAPP_CA	-	-	-	-	-	-
MAPP_US	-	-	-	-	-	(22.32)
NEISO	-	-	-	-	-	-
NI	-	-	(10.39)	-	-	-
NWPP_Coal	-	-	-	-	-	-
NYISO_Upstate	-	-	-	-	-	-
NYISO_Downstate	-	-	-	-	-	-
NYISO_Capital	-	-	-	-	-	-
NYISO_NYC	-	-	-	-	-	-
NYISO_LIPA	-	-	-	-	-	-
NYISO_Dummy1_Up	-	-	-	-	-	-
NYISO_Dummy1_Down	-	-	-	-	-	-
NYISO_Dummy2_In	-	-	-	-	-	-
NYISO_Dummy2_Out	-	-	-	-	-	-

Note: Non-existent links are blacked out.
ECAR will be represented as MI, MISO_E, PJM_Midwest, and NonRTO_Midwest in Task 5 modeling; PJM_D and NE will also be separated from VACAR and MAPP_US, respectively.

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Exhibit 19 – New builds relative to maximum penetration limits

- We will create a report that will…
  - Show cumulative new builds by 2020 and 2030 for each technology type, expressed as a percentage of maximum penetration
  - This table will be formatted by region
  - We could also report the raw MW

MRN-NEEM Technical Session

NEEM, MRN, and Integration of MRN-NEEM

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In this section, CRA will…

- Present technical information about NEEM modeling
- Present technical information about MRN modeling
- Discuss the integration of the MRN and NEEM models into MRN-NEEM
- Answer questions about the models