Data Mining CO2 Analysis

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Additional Analysis of Results

- Three year EIPC study produced mountain of data
- DOE requested small study to data-mine for added insights
- Survey of EIPC/EISPC/SSC leaders raised 13 topics

High Priority Topics

1. How do Phase 2 results compare to Phase 1?
2. Were there significant changes in earlier years within various regions?
3. When costs are integrated, how do results compare?
4. Do some regions face over-reliance on certain fuels or technologies?
5. What are the gas sector Inter-relationships in the different regions?

Medium Priority Topics	**Low Priority Topics**
6. Reserve Requirement Impacts	10. Regional vs national implementation
7. Wind Curtailment details	11. Load growth sensitivities
8. Demand Response analysis	12. Environmental Policy sensitivities
9. "No Regrets" lines	13. Technology sensitivity impacts

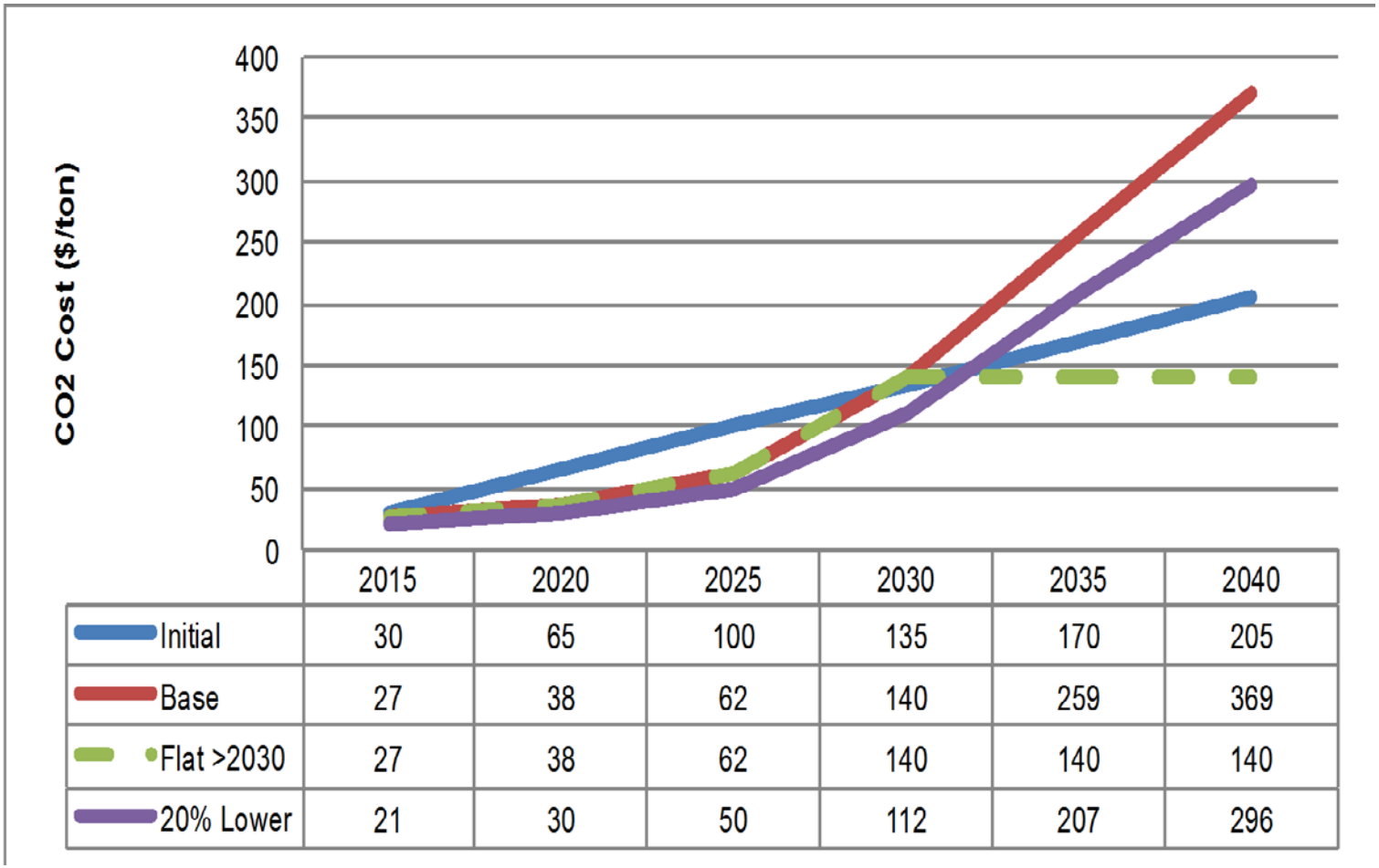
Topic 14 - Follow-on with Navigant

- We are working with Ralph Luciani of Navigant to examine how the various inputs to the modeling effort have changed since Phase 1 was done.
- This will include a discussion of the EPA Clean Power Plan and the sensitivities in Phase 1 that reduced CO_2 emissions.

Phase 1 Sensitivities

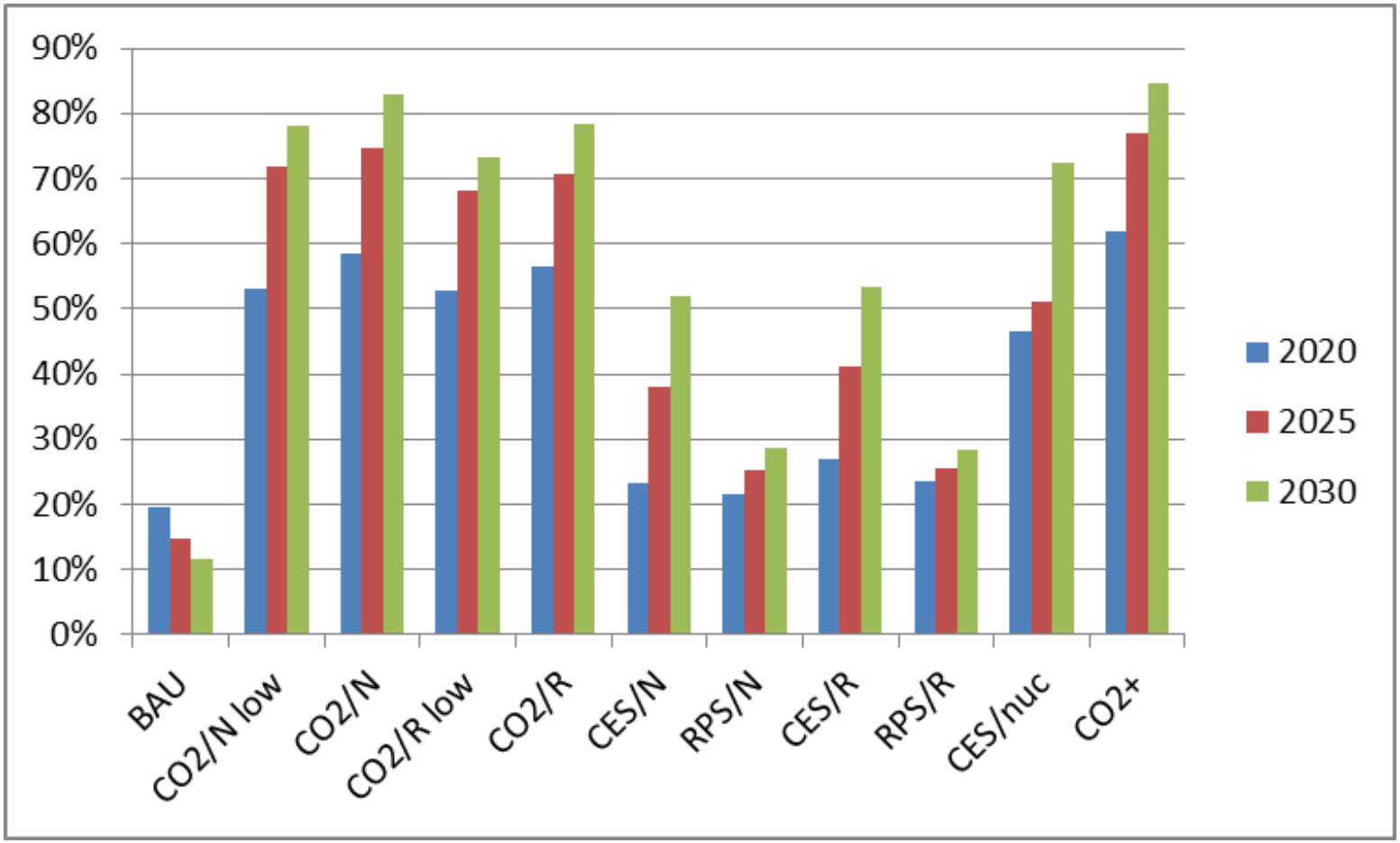
- A number of Phase 1 sensitivities result in significant CO_2 emissions reductions, but the ones designed specifically to reduce CO_2 go much farther than the proposed EPA rule.
- Futures 2 and 3 was designed to achieve 42% economy-wide reductions by 2030.
  - A CO_2 price was determined iteratively using the MRN model.
  - The electricity sector's reductions were disproportionate to the rest of the economy.

CO_2 Prices in the Study



	2015	2020	2025	2030	2035	2040
Initial	30	65	100	135	170	205
Base	27	38	62	140	259	369
Flat >2030	27	38	62	140	140	140
20% Lower	21	30	50	112	207	296

% Reductions by Sensitivity



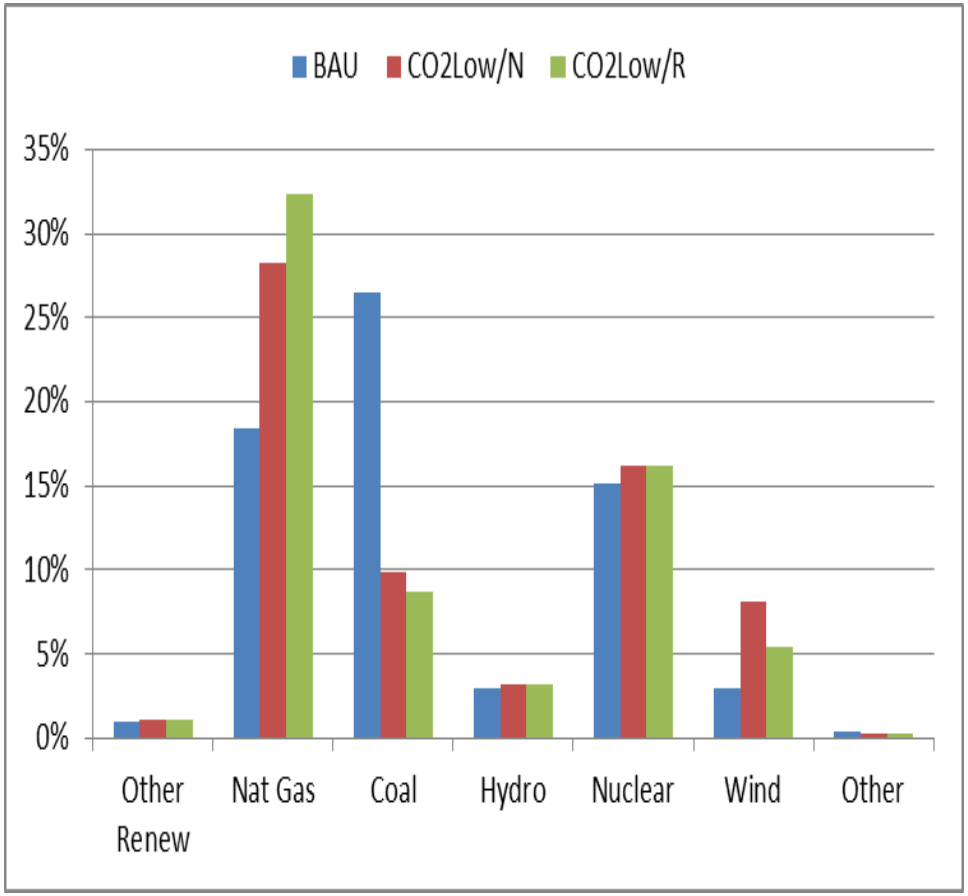
The CO_2 Futures

- The electricity sector saw a 78% reduction between 2005 and 2030 levels in the national implementation of the CO_2 restrictions (F2S11) and a 73% in the regional implementation (F3S12).
- This occurred because of the high CO_2 price ($140/ton) needed to achieve the economy-wide reductions.
- This is much larger than the EPA Clean Power Plan target of 30%.

Low CO_2 Price Sensitivities

- The prices were still very high ($112/ton) and electricity sector reductions were still extreme; national (F2S9) 78%, regional (F3S8) 73%
- 2020 reductions were 53% with carbon at $30/ton.

2020 Eastern Interconnection Generation

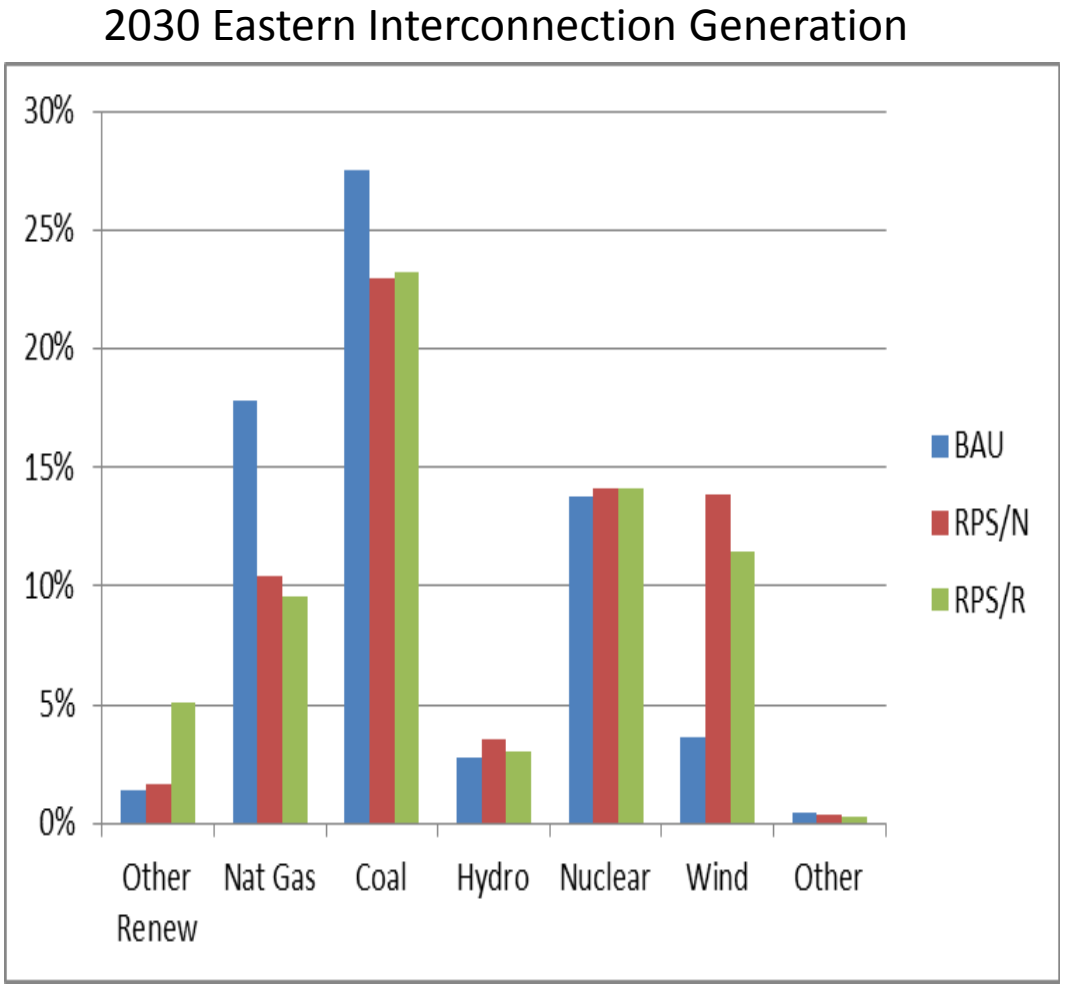


Combined Federal Policy

- Future 8 modeled a combination of a federal RPS and CO_2 limitations.
- These futures provided the greatest amount of CO_2 reductions, with an 85% reduction when paired with aggressive EE/DR/DG assumptions (F8S7).

Renewable Portfolio Standard (RPS)

- Both the national (F5S10) and regional (F6S10) implementations achieved 29% reductions.
- Both natural gas and coal were displaced by wind and other renewables.



RPS

- However, these treat all non-renewable generation equally, so we ended up with a lot of coal and a lot of wind, which is not realistic if the goal is CO_2 reductions.
- Also, in Phase 2, we found that there was significant curtailments associated with F6S10, so we did not achieve all of the reductions indicated in Phase 1.

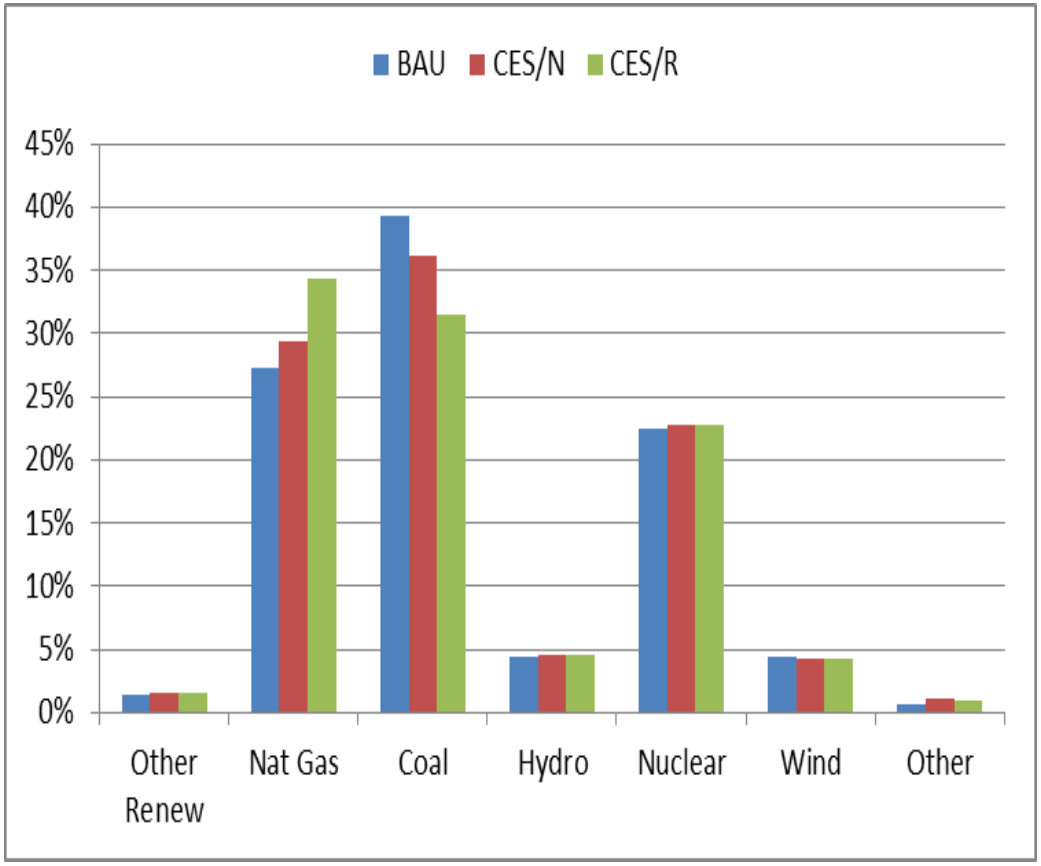
Clean Energy Standard (CES)

- A CES sensitivity was included in each of the RPS scenarios. This included renewables, gas-fired CCs and nuclear and required 70% of electricity to come from these sources by 2030.
- These resulted in CO_2 emissions reductions of 52% in the national implementation (F5S5) and 54% in the regional (F6S4).
- A CES sensitivity in the nuclear resurgence future (F7S3) resulted in a 72% reduction.

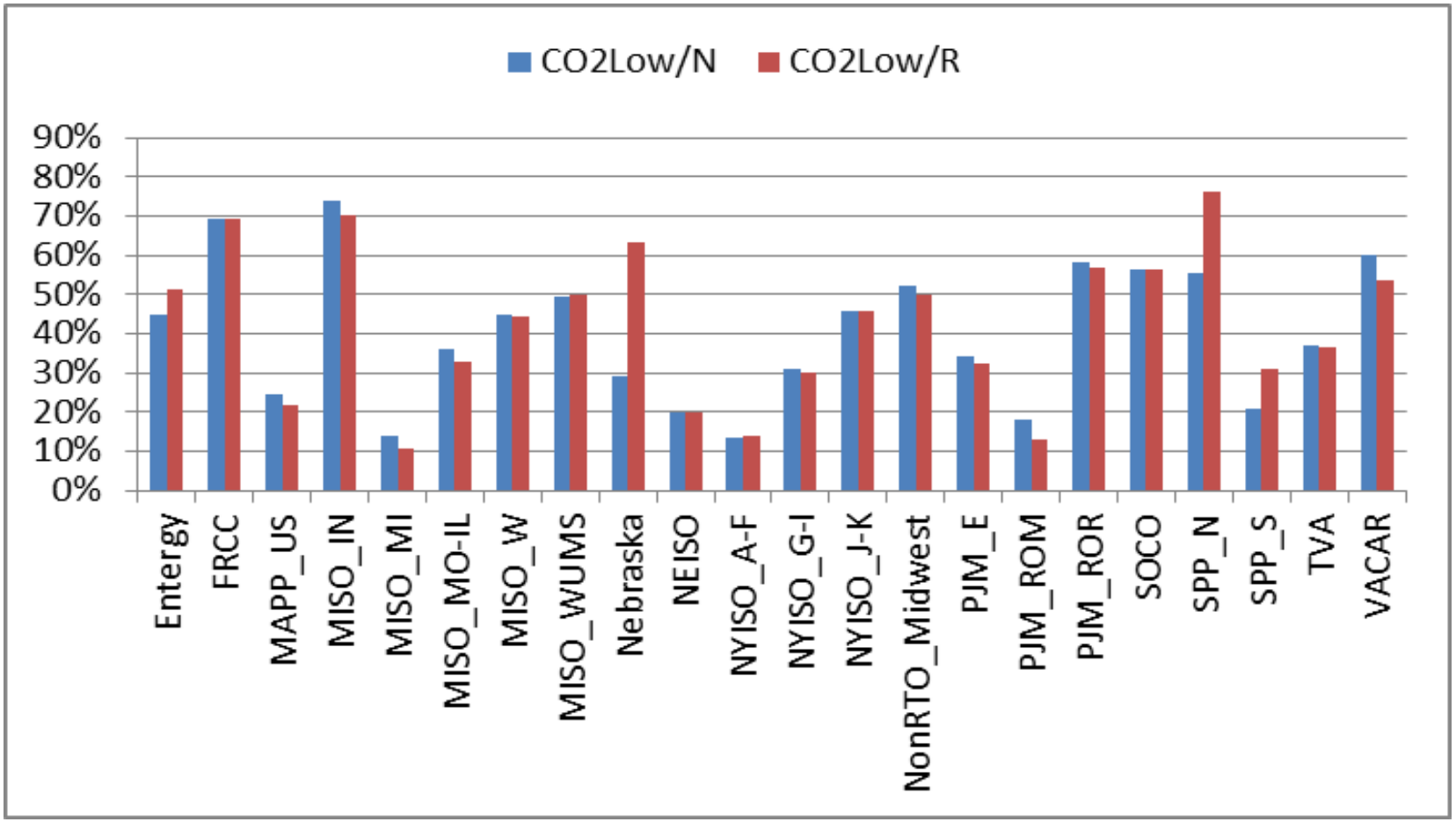
2020 CES vs. BAU

- The CES cases produce slightly lower CO_2 reductions in 2020 than the EPA rule does in 2030.
- This is done by substituting natural gas for coal.

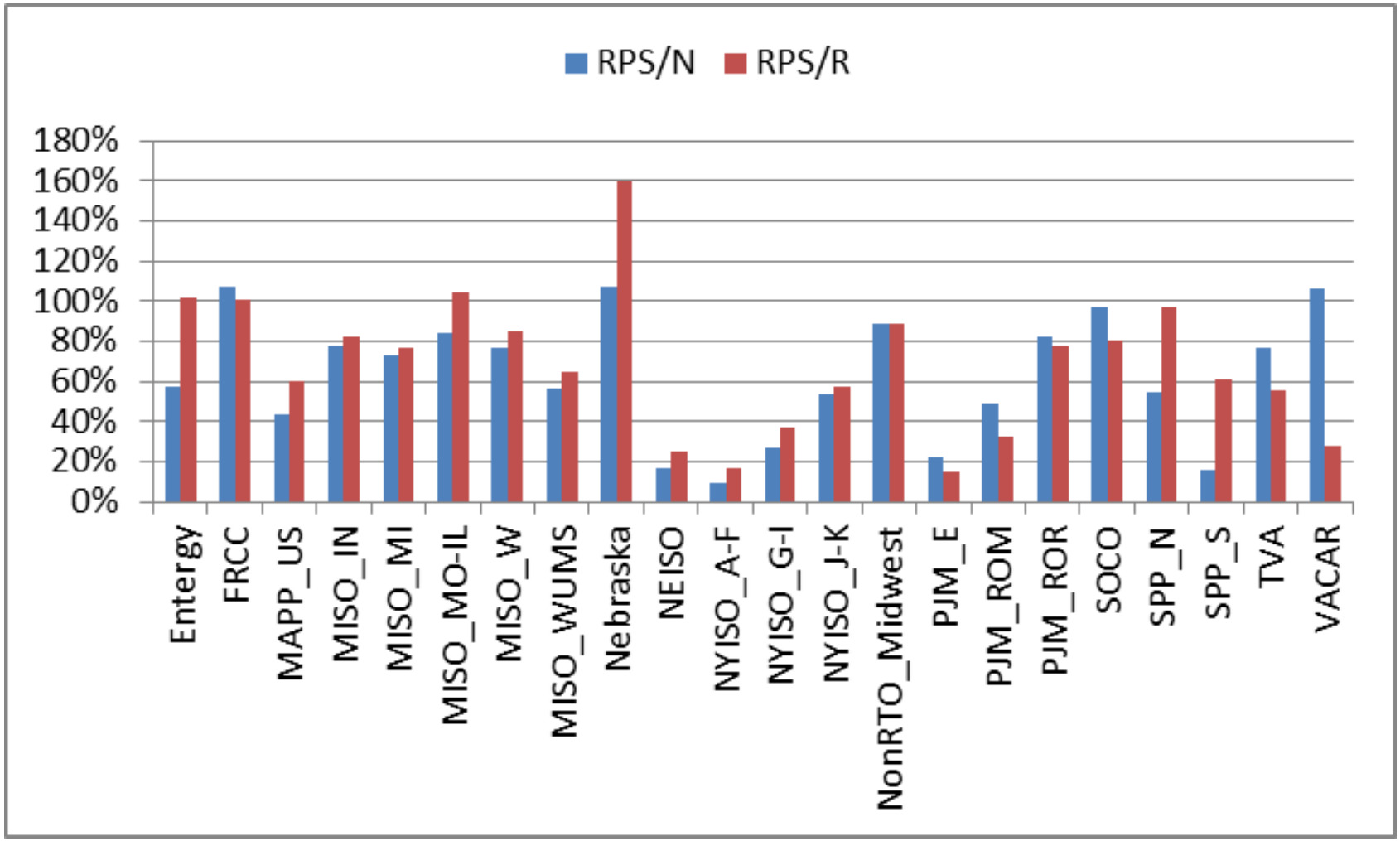
2020 Eastern Interconnection Generation



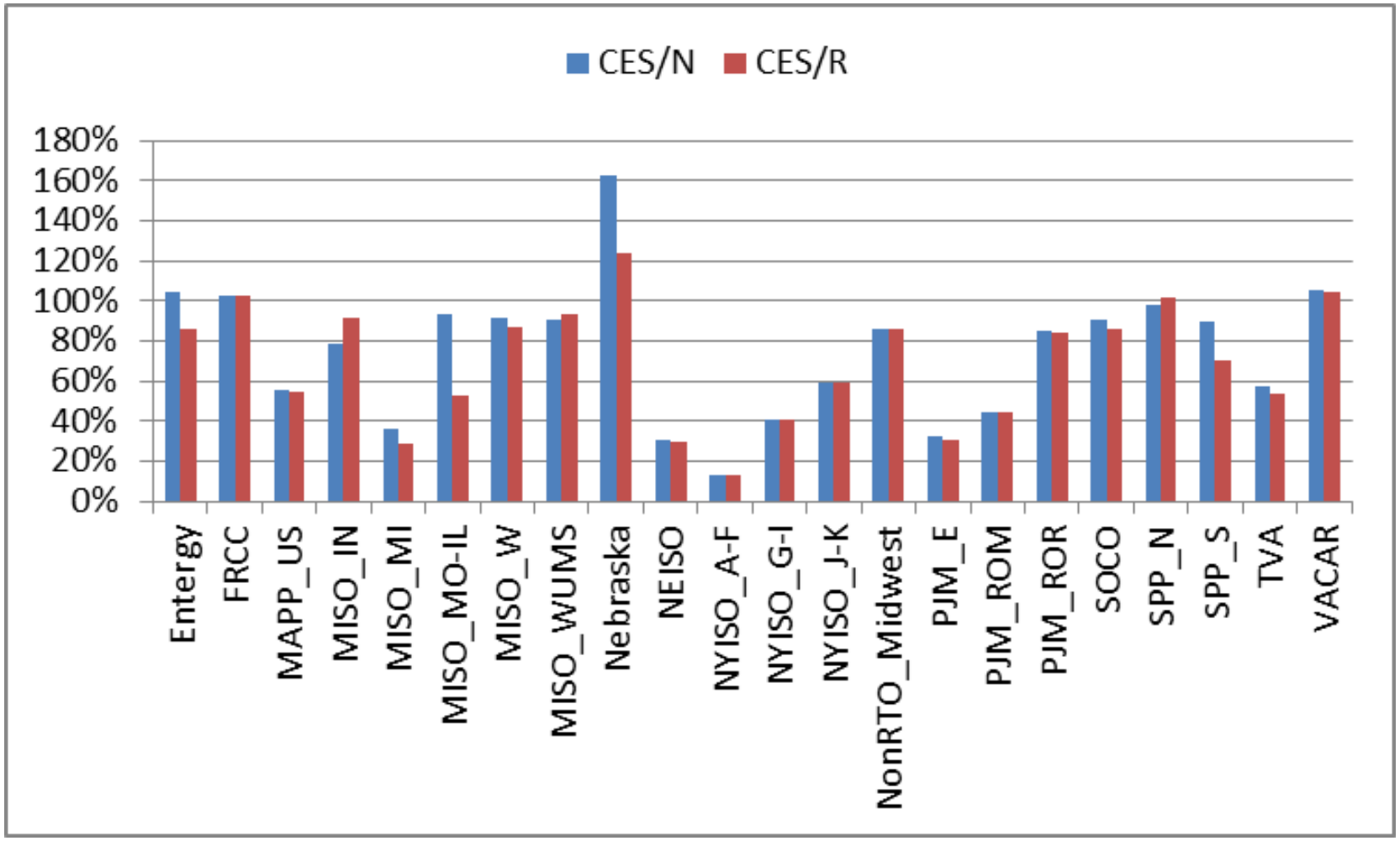
Regional Emissions – CO_2 Low (2020)



Regional Emissions – RPS (2030)



Regional Emissions – CES (2020)

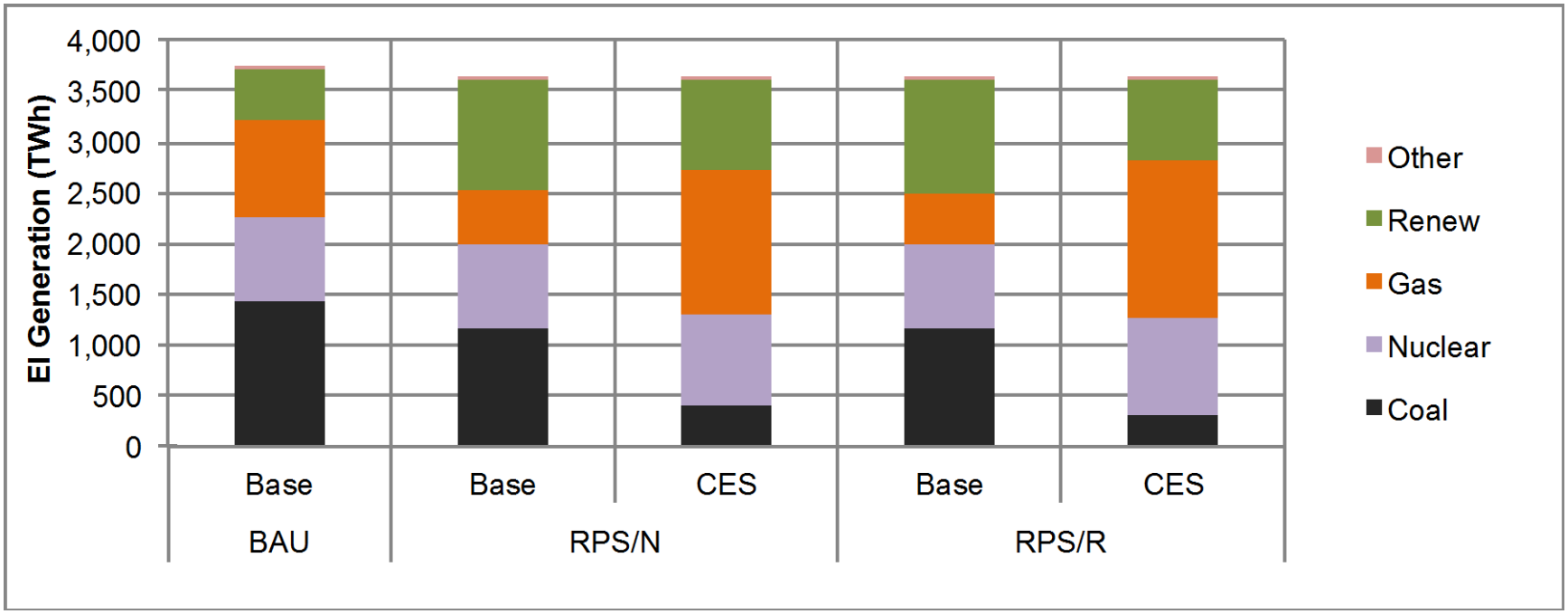


Topic 12 - Environmental Policy Results

- Carbon pricing largely decarbonized electric sector by 2035.
  - Had largest impact on nuclear among all policies studied
- Reductions or delays in EPA policies increased coal.
  - Delays alone largely at expense of gas
  - If RPS or PTC reduced, then at expense of renewables
- Lifting maximum fraction of power from variable generation (from 35% to 50%) increased wind but just in high wind regions near cap.
- Increasing EE/DR lowered fossil generation rather than renewable.
- Clean Energy Standard reduced coal and CO_2 emissions versus Renewable Portfolio Standard.

Clean Energy Standard reduced coal generation and CO_2 more than RPS

- EI generation in 2030 shows large gas increase at expense of coal and some renewables



	BAU	RPS/N		RPS/R	
	Base	Base	CES	Base	CES
EI 2015-2030 CO2 Emissions (MMT)	26,031	23,272	20,697	23,012	19,791
EI 2030 CO2 Emissions (MMT)	1716	1310	864	1316	826

Topic 10 - National vs. Regional Implementation: CO_2

- **Midwest:** regional has less wind, more natural gas and reduced exports than national
- **Northeast:** little change between national and regional
- **PJM_MAAC:** little change until post-2030
- **PJM_ROR:** regional has more wind and is a net exporter
- **Southeast:** regional imports less, generates more from natural gas
- **Southwest:** national has a high amount of wind and large exports; regional has much less wind, more natural gas and no exports

Topic 10 - National vs. Regional Implementation: RPS

- **Midwest:** regional has less wind, more natural gas and coal than national
- **Northeast:** regional has more natural gas and lower imports
- **PJM_MAAC:** regional has more off-shore wind, less coal and natural gas generation
- **PJM_ROR:** regional has more wind, less natural gas and is a net exporter
- **Southeast:** regional has more off-shore wind and other renewables, less coal and natural gas
- **Southwest:** regional has much less wind, more coal and natural gas, and no exports

Topic 4 - Regional reliance on a single technology

- Ten regions get >2/3 of generation from one source in CO2+
  - Much from variable or baseload resources
- BAU and RPS have six regions
  - Based largely on thermal resources

CO2+ High-Reliant Regions

	Region	Technology	Share of Generation
1	MAPP_CA	Hydro	92%
2	SPP_N	Wind	85%
3	NonRTO_Midwest	Comb. Cycle	84%
4	MISO_W	Wind	83%
5	NYISO_J-K	Comb. Cycle	83%
6	SPP_S	Wind	81%
7	NYISO_G-I	Nuclear	74%
8	MAPP_US	Wind	72%
9	FRCC	Nuclear	69%
10	NE	Wind	68%

BAU High-Reliant Regions

	Region	Technology	Share of Generation
1	NonRTO_Midwest	Coal	93%
2	NYISO_J-K	Comb. Cycle	80%
3	MISO_MO-IL	Coal	77%
4	MISO_IN	Coal	76%
5	SPP_N	Coal	75%
6	NE	Coal	68%

RPS High-Reliant Regions

	Region	Technology	Share of Generation
1	MAPP_CA	Hydro	96%
2	NonRTO_Midwest	Coal	91%
3	MISO_IN	Coal	82%
4	NYISO_J-K	Comb. Cycle	81%
5	MISO_MO-IL	Coal	74%
6	NYISO_G-I	Nuclear	70%

Topic 11 - Load Growth Sensitivities

- Natural gas is the marginal capacity
  - Increases under Hi Load; decreases under Low Load
- Since transmission system is not changed within a future, transfers between regions do not change much with added load