Overview of Task 9 Activity for EIPC Production Cost Modeling

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Overview

- CRA is using the GE MAPS model to evaluate the 2030 production cost of Scenarios 1, 2, and 3, along with six additional sensitivities.
  - GE MAPS is a detailed economic dispatch and production cost model that simulates the operation of the electric power system taking into account transmission topology.
  - The model footprint comprises the Eastern Interconnect, and includes the generating units and the transmission load flow and flowgates for each scenario from Tasks 7 and 8.

- Using the EIPC stakeholder-approved input assumptions into GE MAPS as approved in July, and the results of Task 7 and 8, CRA completed modeling of:
  - S3 Base (Business as Usual)
  - S2 Base (National RPS – State/Regional Implementation)
  - S1 Base (Combined Federal Climate and Energy Policy)

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Overview

- CRA has also completed modeling of the six sensitivities approved by the SSC:
  - S3 High Gas:
    - *All gas prices increased by 25%*
  - S3 High Load:
    - *All loads increased by 5%*
  - S1 High Load:
    - *All loads increased by 5%*
  - S1 High Spin Availability
    - *Reduce the spin requirement in MISO, SPP, PJM and IESO by 50% and modify CC operating parameters in all regions to increase operating flexibility*
  - S1 Flowgate Relief
    - *High Spin Availability changes above, plus increase by 50% the limits for 25 flowgates in MISO_W, MISO_MO-IL, and MAPP_US.*
  - S1 Reduced Wind
    - *Multiply wind capacity for every wind unit in MISO_W by 75%, in Nebraska by 61%, in SPP_N by 85%, and in MISO_MO_IL by 74%.*

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High-Level Summary of Results

S1, S2 & S3 Base

- Generation by Capacity Type for the EI in 2030 is shown below for S1 Base, S2 Base, and S3 Base
  - Overall results are fairly close to the Phase 1 Results

	Generation (TWh)			% of Total Supply		
	S1 Base	S2 Base	S3 Base	S1 Base	S2 Base	S3 Base
Coal	40	1,095	1,399	1%	30%	38%
Nuclear	1,087	875	886	36%	24%	24%
CC	755	532	831	25%	15%	23%
CT	39	32	43	1%	1%	1%
Steam Oil/Gas	6	13	15	0%	0%	0%
Hydro	211	228	193	7%	6%	5%
On-Shore Wind	722	476	217	24%	13%	6%
Off-Shore Wind	6	92	6	0%	3%	0%
Other Renewable	65	253	66	2%	7%	2%
Pump Storage Net	-8	-6	-4	0%	0%	0%
DR	4	0	1	0%	0%	0%
Total Generation	2,927	3,590	3,653	98%	99%	99%
External Supply	51	31	34	2%	1%	1%
Total	2,979	3,621	3,687	100%	100%	100%

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High-Level Summary of Results

S1, S2 & S3 Base

- EI 2030 Production Costs, Emissions, and Wind Curtailment are shown below for S1 Base, S2 Base, and S3 Base
  - Wind is curtailed when prices (LMPs) at the unit's location fall below $1/MWh.

	S1 Base	S2 Base	S3 Base
Production Costs (M$)			
Fuel	40,802	73,789	85,057
Variable O&M	6,430	15,502	18,411
Total	47,231	89,291	103,469
CO2	45,340	126	154
Total w/CO2	92,571	89,416	103,622
Emissions (short tons)			
NOx (000)	93	873	1,122
SO2 (000)	21	1,300	1,771
CO2 (millions)	358	1,391	1,792
Wind Curtailment			
Wind Curtailment (TWh)	131	30	1
Percent Curtailed	15%	5%	0%

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High-Level Summary of Results

S1, S2 & S3 Base

- Wind curtailment (TWh) in S1 Base takes place predominately in three NEEM regions.

	Potential Wind Energy	Generated Onshore Wind Energy	Generated Offshore Wind Energy	Curtail-ment	Wind Generated as % of Demand	Curtail-ment Percent
ENT	1	1	0	0	0%	30%
FRCC	0	0	0	0	0%	
MAPP_US	32	28	0	4	97%	12%
MISO_IN	28	28	0	1	32%	2%
MISO_MI	24	24	0	0	27%	0%
MISO_MO-IL	32	23	0	8	25%	26%
MISO_W	261	196	0	65	150%	25%
MISO_WUMS	9	9	0	0	16%	1%
NE	55	33	0	22	109%	40%
NEISO	18	16	2	0	15%	2%
NonRTO_Midwest	0	0	0	0	0%	
NYISO_A-F	19	18	0	1	33%	5%
NYISO_G-I	1	1	0	0	4%	0%
NYISO_J-K	0	0	0	0	0%	
PJM_E	6	2	4	0	2%	1%
PJM_ROM	6	6	0	0	4%	0%
PJM_ROR	44	43	0	1	9%	1%
SOCO	0	0	0	0	0%	
SPP_N	146	125	0	21	163%	15%
SPP_S	148	143	0	5	92%	3%
TVA	0	0	0	0	0%	0%
VACAR	9	9	0	0	4%	0%
IESO	17	15	0	2	12%	13%
MAPP_CA	1	1	0	0	3%	0%
EI	859	722	6	131	24%	15%

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High-Level Summary of Results

S1, S2 & S3 Base

- Wind curtailment (TWh) in S2 Base takes place predominately in VACAR.

	Potential Wind Energy	Generated Onshore Wind Energy	Generated Offshore Wind Energy	Curtail-ment	Wind Generated as % of Demand	Curtail-ment Percent
ENT	0	0	0	0	0%	0%
FRCC	0	0	0	0	0%	
MAPP_US	25	25	0	0	69%	2%
MISO_IN	1	1	0	0	1%	0%
MISO_MI	9	9	0	0	8%	0%
MISO_MO-IL	3	3	0	0	2%	0%
MISO_W	86	81	0	5	48%	5%
MISO_WUMS	4	4	0	0	6%	0%
NE	9	9	0	0	22%	1%
NEISO	15	14	2	0	12%	0%
NonRTO_Midwest	0	0	0	0	0%	
NYISO_A-F	11	11	0	0	18%	0%
NYISO_G-I	0	0	0	0	1%	0%
NYISO_J-K	0	0	0	0	0%	
PJM_E	36	2	34	0	28%	0%
PJM_ROM	21	21	0	0	13%	0%
PJM_ROR	143	142	0	0	26%	0%
SOCO	1	1	0	0	0%	
SPP_N	40	39	0	1	40%	3%
SPP_S	93	90	0	4	46%	4%
TVA	0	0	0	0	0%	0%
VACAR	81	6	56	19	21%	24%
IESO	17	17	0	1	12%	3%
MAPP_CA	1	1	0	0	2%	2%
EI	598	476	92	30	16%	5%

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High-Level Summary of Results

S3 Sensitivities

- Generation by Capacity Type for the EI in 2030 is shown below for the S3 sensitivities
  - High Gas reduces generation by CCs and replaces it with mostly coal
  - High Load increases the generation of CCs, and to a lesser extent CTs and coal

	Generation (TWh)			% of Total Supply		
	S3 Base	S3 HiGas	S3 HiLoad	S3 Base	S3 HiGas	S3 HiLoad
Coal	1,399	1,465	1,437	38%	40%	37%
Nuclear	886	886	886	24%	24%	23%
CC	831	768	945	23%	21%	24%
CT	43	39	65	1%	1%	2%
Steam Oil/Gas	15	15	23	0%	0%	1%
Hydro	193	193	193	5%	5%	5%
On-Shore Wind	217	217	217	6%	6%	6%
Off-Shore Wind	6	6	6	0%	0%	0%
Other Renewable	66	71	67	2%	2%	2%
Pump Storage Net	-4	-6	-4	0%	0%	0%
DR	1	1	2	0%	0%	0%
Total Generation	3,653	3,655	3,837	99%	99%	99%
External Supply	34	34	34	1%	1%	1%
Total	3,687	3,689	3,871	100%	100%	100%

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High-Level Summary of Results

S3 Sensitivities

- 2030 EI Production Costs, Emissions, and Wind Curtailment are shown below for the S3 sensitivities.
  - High Gas increases production costs by 10% (higher gas costs) and CO_2 emissions by 2% (higher coal use).
  - High Load increases production costs by 9% (demand increase of 5% met by higher cost resources) and CO_2 emissions by 6%.

	S3 Base	S3 HiGas	S3 HiLoad
Production Costs (M$)			
Fuel	85,057	94,326	93,317
Variable O&M	18,411	19,072	19,407
Total	103,469	113,397	112,724
CO2	154	150	178
Total w/CO2	103,622	113,547	112,902
% Increase	-	10%	9%
Emissions (short tons)			
NOx (000)	1,122	1,171	1,184
SO2 (000)	1,771	1,988	1,880
CO2 (millions)	1,792	1,833	1,899
% Increase	-	2%	6%
Wind Curtailment			
Wind Curtailment (TWh)	1	1	1
Percent Curtailed	0%	0%	0%

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High-Level Summary of Results

S1 Sensitivities

- Generation by Capacity Type for the EI in 2030 is shown below for the S1 sensitivities.
  - High Load increases the generation of CCs, and to a lesser extent CTs and wind.
  - High Spin Availability reduces CC generation (used for spin) and reduces wind curtailment.
  - Adding Flowgate Relief further reduces wind curtailment.
  - Reduced Wind replaces the reduced wind generation with mostly CC generation.

	S1 Generation (TWh)					% of Total Supply				
	Base	High Load	High Spin Avail	+Flow-gate Relief	Re-duced Wind	Base	High Load	High Spin Avail	+Flow-gate Relief	Re-duced Wind
Coal	40	46	41	42	43	1%	1%	1%	1%	1%
Nuclear	1,087	1,090	1,091	1,091	1,089	36%	35%	37%	37%	37%
CC	755	854	725	719	786	25%	27%	24%	24%	26%
CT	39	56	43	42	44	1%	2%	1%	1%	1%
Steam Oil/Gas	6	8	7	7	7	0%	0%	0%	0%	0%
Hydro	211	214	212	212	211	7%	7%	7%	7%	7%
On-Shore Wind	722	735	733	743	672	24%	23%	25%	25%	23%
Off-Shore Wind	6	6	6	6	6	0%	0%	0%	0%	0%
Other Renewable	65	69	71	71	67	2%	2%	2%	2%	2%
Pump Storage Net	-8	-8	-6	-6	-10	0%	0%	0%	0%	0%
DR	4	5	4	3	3	0%	0%	0%	0%	0%
Total Generation	2,927	3,075	2,929	2,933	2,917	98%	98%	98%	98%	98%
External Supply	51	52	52	52	51	2%	2%	2%	2%	2%
Total	2,979	3,127	2,980	2,984	2,969	100%	100%	100%	100%	100%

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High-Level Summary of Results

S1 Sensitivities

- 2030 EI Production Costs, Emissions, and Wind Curtailment are shown below for the S1 sensitivities.
  - High Load increases prod costs by 14% and CO_2 emissions by 15% *(higher CC generation)*.
  - High Spin Availability decreases prod costs by 4% and CO_2 by 5% *(CC replaced with wind)*.
  - Adding Flowgate Relief further decreases prod costs and CO_2 emissions by a small amount.
  - Reduced Wind increases prod costs and CO_2 emissions by 5% *(less wind)*.

	S1 Base	High Load	High Spin Avail	+Flow-gate Relief	Reduced Wind
Production Costs (M$)					
Fuel	40,802	45,805	39,552	39,385	42,630
Variable O&M	6,430	6,932	6,457	6,443	6,536
Total	47,231	52,737	46,010	45,828	49,165
CO2	45,340	52,360	43,153	42,825	47,586
Total w/CO2	92,571	105,097	89,163	88,654	96,751
% Increase	-	14%	-4%	-4%	5%
Emissions (short tons)					
NOx (000)	93	113	92	92	99
SO2 (000)	21	25	21	21	23
CO2 (millions)	358	413	340	338	375
% Increase in CO2	-	15%	-5%	-6%	5%
Wind Curtailment					
Wind Curtailment (TWh)	131	119	120	110	64
Percent Curtailed	15%	14%	14%	13%	9%
% Change in Curtailment		-10%	-9%	-16%	-51%

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High-Level Summary of Results

S1 Sensitivities

- 2030 Wind Curtailment by region is shown below for the S1 Sensitivities.
  - Curtailment is reduced by about 10 TWh (15% to 14%) in High Load and High Spin Availability.
  - Curtailment is reduced another 10 TWh in Flowgate Relief (14% to 13%). *Percentage reductions in certain regions (e.g., MAPP_US and MISO_MO-IL) are more significant*.
  - With 14% less wind potential, Reduced Wind decreases curtailment by about 65 TWh.

	Potential Wind(TWh)		Curtailment (Twh)					Curtailment Percentage				
	Base & Others	Reduced Wind	Base	High Load	High Spin Avail	+Flow-gate Relief	Re-duced Wind	Base	High Load	High Spin Avail	+Flow-gate Relief	Re-duced Wind
ENT	1	1	0	0	0	0	0	30%	27%	33%	17%	23%
FRCC	0	0	0	0	0	0	0					
MAPP_US	32	32	4	3	3	2	3	12%	10%	11%	6%	10%
MISO_IN	28	28	1	0	0	1	1	2%	2%	2%	2%	2%
MISO_MI	24	24	0	0	0	0	0	0%	0%	0%	0%	0%
MISO_MO-IL	32	24	8	8	8	5	5	26%	24%	25%	15%	21%
MISO_W	261	196	65	61	62	57	26	25%	23%	24%	22%	13%
MISO_WUMS	9	9	0	0	0	0	0	1%	0%	0%	0%	0%
NE	55	34	22	21	21	19	9	40%	38%	37%	33%	26%
NEISO	18	18	0	0	0	0	0	2%	1%	1%	1%	2%
NonRTO_Midwest	0	0	0	0	0	0	0					
NYISO_A-F	19	19	1	1	1	1	1	5%	4%	4%	4%	5%
NYISO_G-I	1	1	0	0	0	0	0	0%	0%	0%	0%	0%
NYISO_J-K	0	0	0	0	0	0	0					
PJM_E	6	6	0	0	0	0	0	1%	0%	0%	0%	1%
PJM_ROM	6	6	0	0	0	0	0	0%	0%	0%	0%	0%
PJM_ROR	44	44	1	0	0	0	0	1%	1%	1%	1%	1%
SOCO	0	0	0	0	0	0	0					
SPP_N	146	124	21	18	17	14	12	15%	12%	12%	10%	10%
SPP_S	148	148	5	5	5	10	4	3%	3%	4%	7%	2%
TVA	0	0	0	0	0	0	0	0%	0%	0%	0%	0%
VACAR	9	9	0	0	0	0	0	0%	0%	0%	0%	0%
IESO	17	17	2	1	1	1	2	13%	8%	6%	6%	12%
MAPP_CA	1	1	0	0	0	0	0	0%	0%	0%	0%	0%
EI	859	742	131	119	120	110	64	15%	14%	14%	13%	9%

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High-Level Summary of Results

S1 Sensitivities

- Congestion in High Spin Availability in comparison to further adding Flowgate Relief is shown below.
  - Binding hours and congestion on the 25 modified flowgates in three regions (MISO_W, MISO_MO-IL , and MAPP_US) are reduced substantially.
  - Roughly half of the decrease is offset by increased congestion on other flowgates in these three regions or between one of these three regions and another region.
  - The net flow from MISO/SPP to PJM ROR is about the same.

	No. of Flow-gates	No. of Binding Hours			Congestion K$ (a)		
		HiSpin Avail	Flowgate Relief	Decrease	HiSpin Avail	Flowgate Relief	Decrease
25 Modified Flowgates in 3 NEEM Regions	25	23,404	845	22,559	6,724	75	6,649
Flowgates in the 3 NEEM Regions	144	37,486	21,966	15,520	7,966	2,278	5,687
Flowgates in or between the 3 NEEM Regions	239	45,408	34,840	10,568	8,040	3,879	4,161
		HiSpin Avail	Flowgate Relief	Increase			
Net MISO Flows and SPP DC Flows into PJM ROR (TWh)		121	121	(0)			

*(a) Average Shadow Price when Binding * No. of Binding Hours, summed across flowgates. Congestion figures are for the forward direction.*

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