Future 5
Soft Constraints
Transfer Limit Hardening

NEEM-TX Subteam

SSC Meeting

July 8, 2011

F5 Subteam Recommendation

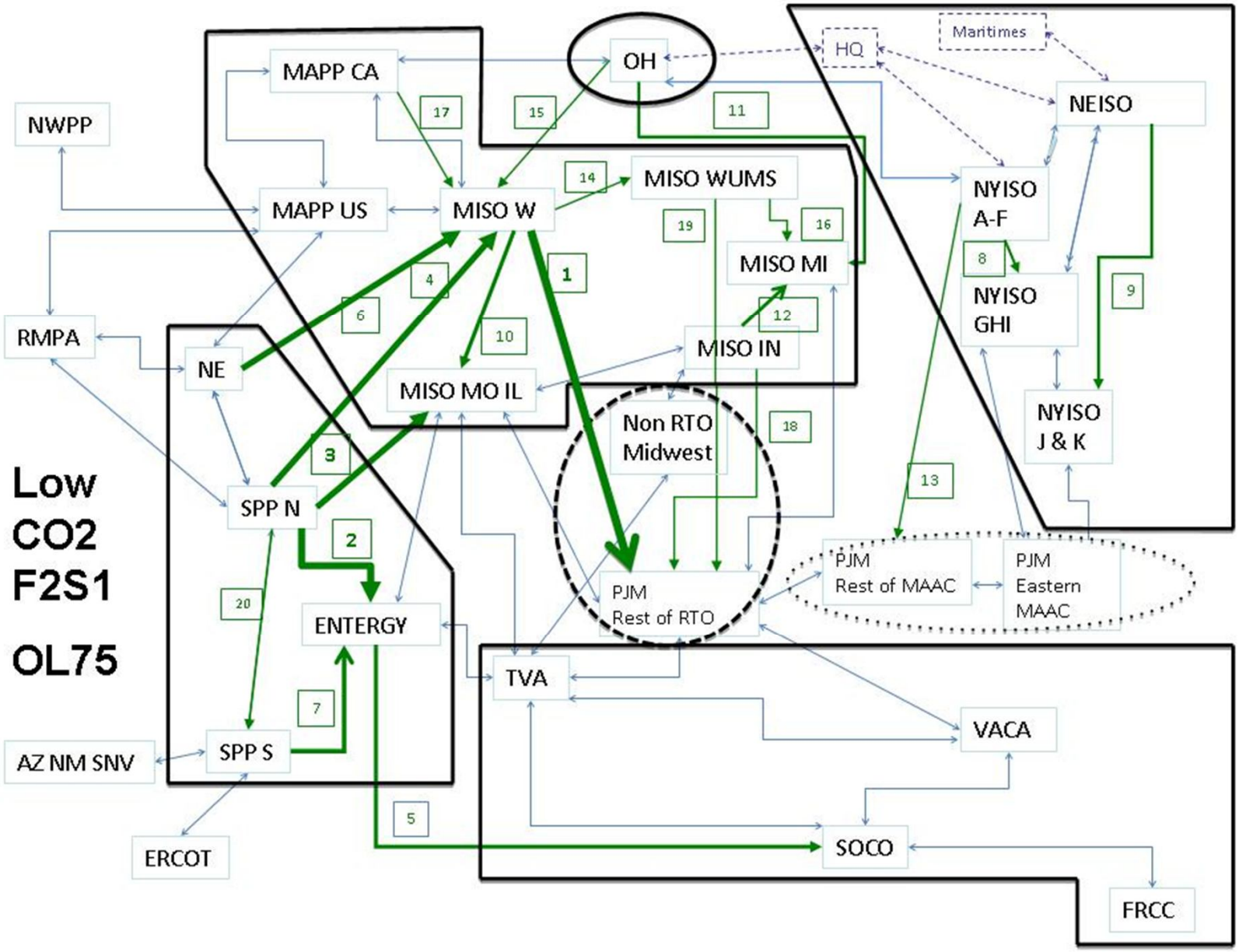
F5 OL25	RHC	Johnson	NGO	Average
NE_2_MISO_W	14706	13611	24173	17497
NE_2_SPP_N	12391	9688	10916	10998
MISO_W_2_PJM_ROR	12065	5396	10624	9362
SPP_N_2_ENT	11150	4802	6367	7440
SPP_S_2_ENT	6852	2159	3837	4282
MISO_MO-IL_2_MISO_IN	3485	3420	5483	4129
MISO_W_2_MISO_MO-IL	5768	2406	4045	4073
MISO_W_2_MISO_WUMS	3534	1002	1847	2127
SPP_N_2_SPP_S	577	0	4137	1571
PJM_ROR_2_VACAR	0	0	2595	865
NYISO_A-F_2_NYISO_G-I	307	1401	207	638
ENT_2_SOCO	0	0	1293	431
SPP_N_2_MISO_MO-IL	790	0	0	263
NEISO_2_NYISO_J-K	0	269	0	90
MISO_W_2_MAPP_CA	0	0	265	88
MISO_IN_2_MISO_MI	0	0	243	81
IESO_2_MISO_W	0	222	0	74
NYISO_J-K_2_PJM_E	0	211	0	70
MAPP_US_2_MAPP_CA	0	48	147	65
MISO_WUMS_2_MISO_MI	0	146	0	49
MISO_MI_2_MISO_WUMS	0	25	0	8

- Subteam recommends using the “Average” transfer limit increases shown to the left for the remaining sensitivities of F5
- SSC previously agreed to use OL25 sensitivity results for F5 and F6

OL25 vs OL75

F5 OL75	RHC	Johnson	NGO	Average
SPP_N_2_ENT	6059	2247	3637	3981
MISO_MO-IL_2_MISO_IN	2431	2616	5375	3474
MISO_W_2_MISO_MO-IL	2979	882	2478	2113
SPP_S_2_ENT	3131	950	1394	1825
NE_2_MISO_W	889	1255	2630	1592
MISO_W_2_PJM_ROR	1542	942	1372	1285
NYISO_A-F_2_NYISO_G-I	324	1261	390	658
NE_2_SPP_N	282	569	898	583
SPP_N_2_MISO_MO-IL	749	721	0	490
MISO_W_2_MISO_WUMS	1311	0	0	437
MISO_MI_2_MISO_WUMS	0	156	151	102
NYISO_J-K_2_PJM_E	0	202	0	67
NEISO_2_NYISO_J-K	0	195	0	65
IESO_2_MISO_W	0	126	0	42
MISO_W_2_IESO	0	97	0	32
MISO_WUMS_2_MISO_MI	0	21	0	7

F5	OL25	OL75
NE_2_MISO_W	17,497	1,592
NE_2_SPP_N	10,998	583
MISO_W_2_PJM_ROR	9,362	1,285
SPP_N_2_ENT	7,440	3,981
SPP_S_2_ENT	4,282	1,825
MISO_MO-IL_2_MISO_IN	4,129	3,474
MISO_W_2_MISO_MO-IL	4,073	2,113
MISO_W_2_MISO_WUMS	2,127	437
SPP_N_2_SPP_S	1,571	0
PJM_ROR_2_VACAR	865	0
NYISO_A-F_2_NYISO_G-I	638	658
ENT_2_SOCO	431	0
SPP_N_2_MISO_MO-IL	263	490
NEISO_2_NYISO_J-K	90	65
MISO_W_2_MAPP_CA	88	0
MISO_IN_2_MISO_MI	81	0
IESO_2_MISO_W	74	42
NYISO_J-K_2_PJM_E	70	67
MAPP_US_2_MAPP_CA	65	0
MISO_WUMS_2_MISO_MI	49	7
MISO_MI_2_MISO_WUMS	8	102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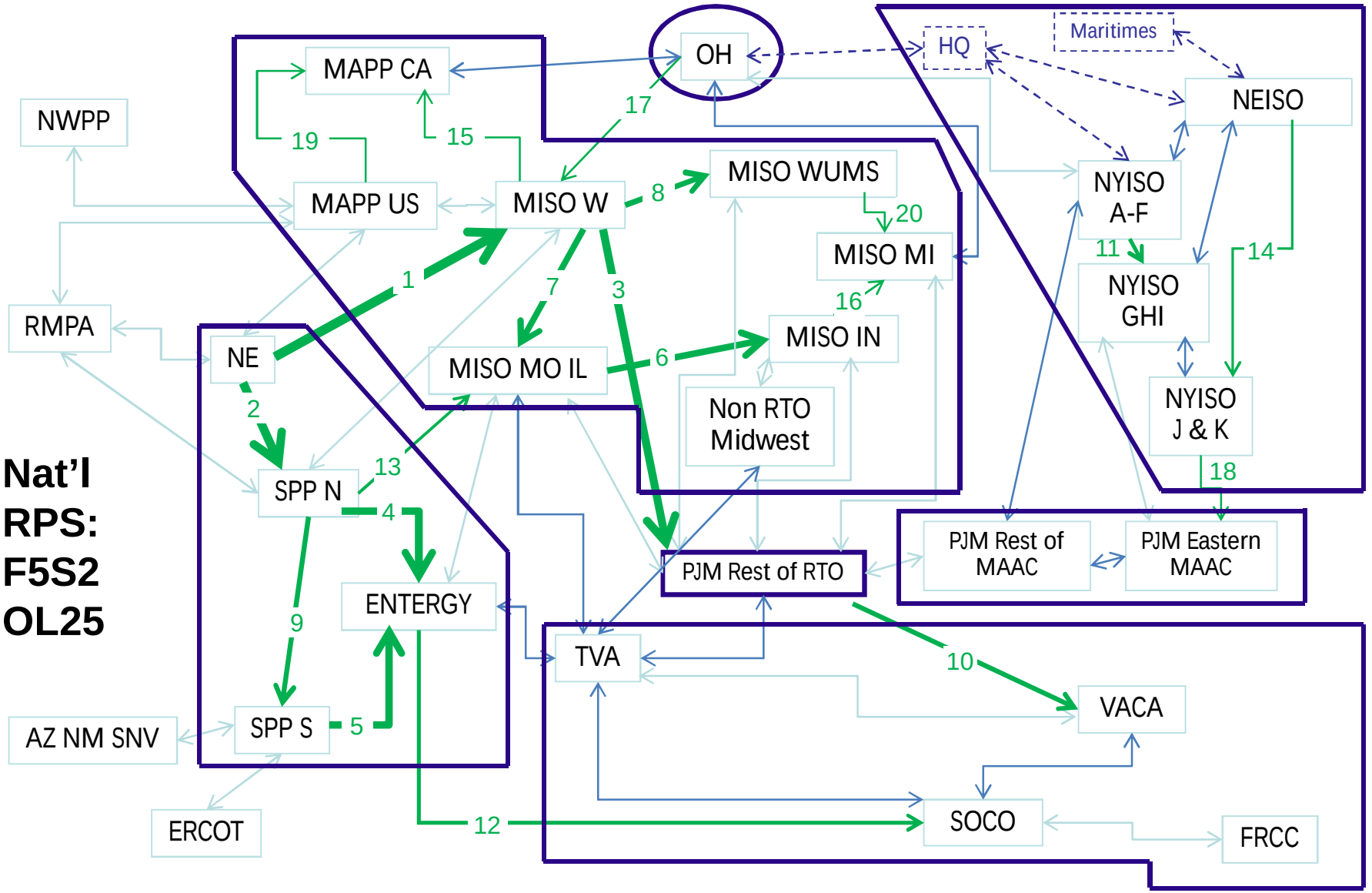
Nat'l
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OL 25	F1S2	F2S2	F5S2
NE_2_MISO_W	0	5,612	17,497
NE_2_SPP_N	2,911	3,355	10,998
MISO_W_2_PJM_ROR	0	31,421	9,362
SPP_N_2_ENT	0	16,272	7,440
SPP_S_2_ENT	0	5,132	4,282
MISO_MO-IL_2_MISO_IN	0	4,104	4,129
MISO_W_2_MISO_MO-IL	0	4,954	4,073
MISO_W_2_MISO_WUMS	0	5,698	2,127
SPP_N_2_SPP_S	0	1,069	1,571
PJM_ROR_2_VACAR	0	460	865
NYISO_A-F_2_NYISO_G-I	1,059	2,271	638
ENT_2_SOCO	0	4,497	431
SPP_N_2_MISO_MO-IL	0	7,084	263
NEISO_2_NYISO_J-K	57	825	90
MISO_W_2_MAPP_CA	2,341	0	88
MISO_IN_2_MISO_MI	0	0	81
IESO_2_MISO_W	107	35	74
NYISO_J-K_2_PJM_E	54	44	70
MAPP_US_2_MAPP_CA	0	0	65
MISO_WUMS_2_MISO_MI	10,054	15,406	49
MISO_MI_2_MISO_WUMS	0	0	8
MISO_MI_2_MISO_IN	1,456	8,251	0
IESO_2_MISO_MI	0	2,904	0
PJM_ROR_2_PJM_ROM	0	1,787	0
IESO_2_NYISO_A-F	191	358	0
NYISO_G-I_2_NYISO_J-K	0	70	0
SPP_N_2_NE	0	64	0
SPP_N_2_MISO_W	0	32	0
MAPP_CA_2_MISO_W	0	1	0
MISO_WUMS_2_MISO_W	3,101	0	0
SPP_S_2_SPP_N	320	0	0
NEISO_2_NYISO_G-I	157	0	0
IESO_2_MAPP_CA	48	0	0
NEISO_2_NYISO_A-F	19	0	0
Total TX Increase	**21,876**	**121,707**	**64,203**

OL 25 Results

- F1S1 is based on old BAU assumptions (EPA regs, landfill gas, etc.)
- TLH-specified transmission increase was not used for F1
- Significantly less TX additions in F5 than in F2

NEEM/TX Subteam Notes

- Large difference between F2S2 results and F5S2 results due to no increase in marginal costs for fossil generation in F5
  - F5 places a 30% renewable energy requirement on the Eastern Interconnection (minus Ontario)
    - Can be met with wind, hydro, biomass, solar, geothermal, landfill gas
  - Model will build renewables to meet the requirement wherever it is cheapest to do so (Southwest)

Shadow Prices

Shadow Prices	F1B	F2B	F5B
SPP_N_2_ENT	$ -	$ 25.96	$ 12.98
SPP_S_2_ENT	$ 0.08	$ 25.94	$ 12.83
MISO_W_2_PJM_ROR	$ -	$ 13.39	$ 9.36
MISO_W_2_MISO_WUMS	$ 0.05	$ 11.10	$ 9.31
SPP_N_2_MISO_MO-IL	$ -	$ 22.08	$ 7.17
MISO_W_2_MISO_MO-IL	$ -	$ 10.38	$ 6.82
MISO_W_2_MAPP_CA	$ 1.70	$ 3.51	$ 3.66
MISO_W_2_IESO	$ -	$ 0.79	$ 3.59
NE_2_SPP_N	$ 1.24	$ 1.78	$ 3.18
SPP_N_2_MISO_W	$ -	$ 12.02	$ 2.89
MAPP_US_2_MAPP_CA	$ 0.57	$ 3.49	$ 2.85
MAPP_CA_2_IESO	$ -	$ 0.23	$ 2.68
MISO_MO-IL_2_PJM_ROR	$ -	$ 3.07	$ 2.54
MAPP_CA_2_MISO_W	$ 1.38	$ 10.05	$ 2.40
NYISO_A-F_2_NYISO_G-I	$ 1.51	$ 12.57	$ 2.17
NEISO_2_NYISO_J-K	$ 2.03	$ 11.28	$ 1.75
MISO_MO-IL_2_MISO_IN	$ 0.06	$ 1.01	$ 1.58
SPP_N_2_NE	$ 0.02	$ 0.45	$ 1.55
NEISO_2_NYISO_G-I	$ 1.59	$ 11.15	$ 1.50
NE_2_MISO_W	$ -	$ 12.28	$ 1.39
IESO_2_MISO_MI	$ 1.59	$ 41.04	$ 1.30

- F2B – very high shadow prices between large low-carbon potential regions (wind) relative to other regions
  - Wind regions have low marginal cost hours while fossil regions are hard hit by Carbon Tax
  - F5B – high shadow prices between regions with best (wind) potential relative to other regions
  - No carbon tax decreases shadow price between wind to no-wind regions
  - Lower shadow prices due to lower wind build

OL25: F2 vs. F5 New and Retired Capacity

New Build Capacity (MW)

Future	Sensitivity	Region	Type	2015	2020	2025	2030	2035	2040	Total New Build
National: Carbon	OL25	EI	Wind	22,195	115,320	148,951	10,180	19,518	14,192	330,356
National: RPS	OL25	EI	Wind	22,195	35,673	68,268	71,170	13,081	12,191	222,578
National: Carbon	OL25	EI	Combined Cycle	75,250	38,353	2	2			113,605
National: RPS	OL25	EI	Combined Cycle	28,789	7,698	851	2,677	24,875	26,748	91,637
National: Carbon	OL25	EI	Coal	7,859						7,859
National: RPS	OL25	EI	Coal	7,859				943	8,450	17,252
National: Carbon	OL25	EI	Nuclear	2,741	4,530	3,094	20,597	31,603	38,369	100,933
National: RPS	OL25	EI	Nuclear	2,741	4,530					7,271
								Aggregate National: Carbon		552,753
								Aggregate National: RPS		338,738

Retirements (MW)

Future	Sensitivity	Region	Type	2015	2020	2025	2030	2035	2040	Total Retirements
National: Carbon	OL25	EI	Wind					1,452		1,452
National: RPS	OL25	EI	Wind					2,106		2,106
National: Carbon	OL25	EI	Combined Cycle	7,125	3,010	2,245	9,722	27,890	23,431	73,424
National: RPS	OL25	EI	Combined Cycle	4,131	339	486	524			5,479
National: Carbon	OL25	EI	Coal	137,792	62,493	40,567	9,930	2	3	250,787
National: RPS	OL25	EI	Coal	69,869	24,910	9,547	2,124			106,451
National: Carbon	OL25	EI	Nuclear		615		1,488	26,576	19,706	48,384
National: RPS	OL25	EI	Nuclear		615		1,488	26,576	19,706	48,384
								Aggregate National: Carbon		374,047
								Aggregate National: RPS		162,421

OL75: F2 vs. F5 New and Retired Capacity

New Build Capacity (MW)

Future	Sensitivity	Region	Type	2015	2020	2025	2030	2035	2040	Total New Build
National: Carbon	OL75	EI	Wind	22,195	99,802	84,332	87,545	37,007	11,968	342,850
National: RPS	OL75	EI	Wind	22,195	35,623	70,195	73,286	13,518	11,340	226,158
National: Carbon	OL75	EI	Combined Cycle	81,045	39,769	52	1	1		120,867
National: RPS	OL75	EI	Combined Cycle	28,083	8,309	1,274	2,431	28,137	26,991	95,225
National: Carbon	OL75	EI	Coal	7,859						7,859
National: RPS	OL75	EI	Coal	7,859				943	9,020	17,821
National: Carbon	OL75	EI	Nuclear	2,741	4,530	5,655	19,162	30,637	38,563	101,288
National: RPS	OL75	EI	Nuclear	2,741	4,530					7,271
								Aggregate National: Carbon		572,863
								Aggregate National: RPS		346,475

Retirements (MW)

Future	Sensitivity	Region	Type	2015	2020	2025	2030	2035	2040	Total Retirements
National: Carbon	OL75	EI	Wind					302		302
National: RPS	OL75	EI	Wind					2,106		2,106
National: Carbon	OL75	EI	Combined Cycle	7,159	3,010	2,175	11,585	26,847	31,109	81,885
National: RPS	OL75	EI	Combined Cycle	4,602	339	530	528			5,998
National: Carbon	OL75	EI	Coal	144,856	62,883	30,546	12,535	3	19	250,842
National: RPS	OL75	EI	Coal	70,408	23,990	9,331	1,934	735		106,398
National: Carbon	OL75	EI	Nuclear		615		1,488	26,576	19,706	48,384
National: RPS	OL75	EI	Nuclear		615		1,488	26,576	19,706	48,384
								Aggregate National: Carbon		381,414
								Aggregate National: RPS		162,887

NEEM/TX Subteam Notes

- Significantly lower wind build in F5 vs F2
  - 216 GW (F5S2) vs 313 GW (F2S2)
  - 20% wind generation (F5S2) vs 31% wind (F2S2)
  - In F2, Carbon Tax makes wind lowest cost generation; in F5 wind is largely only built to meet RPS
    - F2 builds as much wind as it can in midwest and southwest (both South and Midwest/PJM intermittency regions hit the 35% limit)
    - F5 builds only as much wind as it needs to hit RPS targets (30% national, various state targets)
  - To meet RPS, significant wind built in Southwest; Midwest gets significantly less wind (15 GW vs 130 GW)

Aggregate Tx Increase (MW) called for by TLH methodology

		OL75	OL25
F2	**Carbon: National**	39,915	121,706
F3	**Carbon: Regional**	3,741	
F5	**RPS: National**	16,754	64,203