Net-Zero America - iowa state report v2

Larson et al. 2020

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Reading guide

IN DRAFT

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Table 1: *E- scenario - PILLAR 1: Efficiency/Electrification - Residential*

variable_name	2020	2025	2030	2035	2040	2045	2050
Residential HVAC investment in 2020s vs. REF - Cumulative 5-yr	0	2.728	3.428	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.043	0.093	0.342	0.831	0.919	0.925	0.923
Sale of space heating units by type - Electric Resistance	0.107	0.149	0.117	0.051	0.039	0.038	0.04
Sale of space heating units by type - Fossil	0.109	0.174	0.126	0.041	0.025	0.024	0.024
Sale of space heating units by type - Gas	0.741	0.584	0.414	0.077	0.017	0.013	0.013
Sales of cooking units - Electric Resistance	0.622	0.703	0.949	0.997	1	1	1
Sales of cooking units - Gas	0.378	0.297	0.051	0.003	0	0	0
Sales of water heating units by type - Electric Heat Pump	0	0.008	0.111	0.337	0.377	0.379	0.379
Sales of water heating units by type - Electric Resistance	0.253	0.406	0.465	0.595	0.619	0.621	0.62
Sales of water heating units by type - Gas Furnace	0.747	0.585	0.424	0.068	0.004	0	0
Sales of water heating units by type - Other	0	0	0	0	0	0	0

Table 2: *E- scenario - PILLAR 1: Efficiency/Electrification - Transportation*

variable_name	2020	2025	2030	2035	2040	2045	2050
End-use technology sales by technology - HDV - diesel	0.972	0.921	0.67	0.233	0.042	0.006	0
End-use technology sales by technology - HDV - EV	0.006	0.038	0.19	0.456	0.574	0.596	0.6
End-use technology sales by technology - HDV - gasoline	0.002	0.002	0.002	0.001	0	0	0
End-use technology sales by technology - HDV - hybrid	0.001	0.001	0.001	0	0	0	0
End-use technology sales by technology - HDV - hydrogen FC	0.004	0.025	0.127	0.304	0.382	0.397	0.4
End-use technology sales by technology - HDV - other	0.015	0.012	0.011	0.006	0.002	0	0
End-use technology sales by technology - LDV - diesel	0.017	0.02	0.013	0.004	0.001	0	0
End-use technology sales by technology - LDV - EV	0.034	0.136	0.439	0.808	0.962	0.993	1
End-use technology sales by technology - LDV - gasoline	0.908	0.799	0.514	0.175	0.034	0.006	0
End-use technology sales by technology - LDV - hybrid	0.039	0.042	0.03	0.011	0.003	0.001	0
End-use technology sales by technology - LDV - hydrogen FC	0.001	0.003	0.002	0.001	0	0	0
End-use technology sales by technology - LDV - other	0.001	0.001	0.001	0	0	0	0
End-use technology sales by technology - MDV - diesel	0.647	0.597	0.423	0.144	0.026	0.004	0
End-use technology sales by technology - MDV - EV	0.008	0.051	0.253	0.608	0.765	0.795	0.8
End-use technology sales by technology - MDV - gasoline	0.337	0.333	0.255	0.093	0.018	0.003	0
End-use technology sales by technology - MDV - hybrid	0.004	0.004	0.003	0.001	0	0	0
End-use technology sales by technology - MDV - hydrogen FC	0.002	0.013	0.063	0.152	0.191	0.199	0.2
End-use technology sales by technology - MDV - other	0.003	0.003	0.002	0.001	0	0	0
Light-duty vehicle capital costs - Cumulative 5-yr	0	710191864	1814323814	2949720993	4464417485	4863096405	4634426803
Number of public EV charging plugs - DC Fast Charging	103	0	1412.8	0	6288.1	0	10184
Number of public EV charging plugs - L2 Charging	260	0	34028.1	0	151450.3	0	245283.2

Table 3: *E- scenario - PILLAR 2: Clean Electricity - Generating capacity*

variable_name	2020	2025	2030	2035	2040	2045	2050
Power generation capital investment - biomass power plant	0	0.005	0.145	0	0	0	0
Power generation capital investment - biomass w/ccu allam power plant	0	0	0	0	0	0	0
Power generation capital investment - biomass w/ccu power plant	0	0	0	0	0	0	0
Power generation capital investment - Solar PV - Base	0	0.206	3.129	1.6	4.195	3.715	12.168
Power generation capital investment - Solar PV - Constrained	0	1.525	5.683	4.227	7.071	2.885	9.72
Power generation capital investment - Wind - Base	0	5.865	8.687	23.41	24.226	37.044	52.984
Power generation capital investment - Wind - Constrained	0	13.849	10.396	16.47	14.693	6.287	1.174

Table 4: *E- scenario - PILLAR 2: Clean Electricity - Generation*

variable_name	2020	2025	2030	2035	2040	2045	2050
Power generation by technology - biomass power plant	0	9.493	294.866	294.866	294.866	294.866	294.866
Power generation by technology - biomass w/ccu allam power plant	0	0	0	0	0	0	0
Power generation by technology - biomass w/ccu power plant	0	0	0	0	0	0	0

Table 5: *E- scenario - PILLAR 2: Clean Electricity - Transmission*

variable_name	2020	2025	2030	2035	2040	2045	2050
HV transmission for wind and solar - base all	0	910.754	1827.7	4477	8151.9	14478.2	26580.6
HV transmission for wind and solar - base other intra-state	0	198.374	408.961	1066.2	1836.7	3069.9	6002.7
HV transmission for wind and solar - base spur intra-state	0	329.797	790.886	1966.6	3402	5355.8	9442.5
HV transmission for wind and solar - constrained all	0	1255.6	2765.9	5758.5	9461.3	11400.4	13606.4
HV transmission for wind and solar - constrained other intra-state	0	161.446	342.38	1161.1	2788.4	3498.6	3928.5
HV transmission for wind and solar - constrained spur intra-state	0	531.774	1214	2193.9	3548.5	4166.4	5168.6

Table 6: *E- scenario - PILLAR 3: Bioenergy and Hydrogen - Bioconversion*

variable_name	2020	2025	2030	2035	2040	2045	2050
Biomass purchases	0	0.123	0.233	0.235	0.235	1.453	3.667
Capital investment	0	0	0.158	0	0.025	0	62.164
Number of facilities - allam power w ccu	0	0	0	0	0	0	0
Number of facilities - beccs hydrogen	0	0	0	0	0	19	31
Number of facilities - diesel	0	0	0	1	1	2	2
Number of facilities - diesel ccu	0	0	0	0	0	0	0

Table 6: *E- scenario - PILLAR 3: Bioenergy and Hydrogen - Bioconversion (continued)*

variable_name	2020	2025	2030	2035	2040	2045	2050
Number of facilities - power	0	1	1	1	1	1	1
Number of facilities - power ccu	0	0	0	0	0	0	0
Number of facilities - pyrolysis	0	0	0	1	1	2	2
Number of facilities - pyrolysis ccu	0	0	0	0	0	0	28
Number of facilities - sng	0	1	1	1	1	2	2
Number of facilities - sng ccu	0	0	0	0	0	0	0

Table 7: *E- scenario - PILLAR 4: CO2 capture, use, storage - CO2 capture*

variable_name	2025	2030	2035	2040	2045	2050
Annual - All	0	3.25	3.35	3.32	26.46	57.99
Annual - BECCS	0	0	0	0	23.04	54.46
Annual - Cement	0	3.24	3.35	3.32	3.42	3.53
Annual - NGCC	0	0.01	0	0	0	0
Cumulative - All	0	3.25	6.6	9.92	36.38	94.37
Cumulative - BECCS	0	0	0	0	23.04	77.5
Cumulative - Cement	0	3.24	6.59	9.91	13.33	16.86
Cumulative - NGCC	0	0.01	0.01	0.01	0.01	0.01

Table 8: *E- scenario - PILLAR 4: CO2 capture, use, storage - CO2 storage*

variable_name	2025	2030	2035	2040	2045	2050
Annual	0	0	0	0	0	0
Injection wells	0	0	0	0	0	0
Resource characterization, appraisal and permitting costs cumulative	0	0.01	0.01	0.01	0.01	0.01
Wells and facilities construction costs cumulative	0	0	0.01	0.01	0.02	0.02

Table 9: *E- scenario - PILLAR 4: CO2 capture, use, storage - CO2 transportation*

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	4192352.272	5208550.722	5173644.722	6365920.5	8542858.5
CO2 pipelines - Spur	0	39123.685	157071.873	122165.373	1314441.7	3491379.6
CO2 pipelines - Trunk	0	4153228.286	5051478.849	5051478.849	5051478.849	5051478.849

Table 10: *E- scenario - IMPACTS - Jobs*

variable_name	2020	2025	2030	2035	2040	2045	2050
Jobs by economic sector - agriculture	6917.7	6918.5	7066.7	7048.8	3936.9	2193	3480
Jobs by economic sector - construction	9136.9	11439.9	16019.4	20793.5	27026.6	36102.6	56878.5
Jobs by economic sector - manufacturing	7388.1	10063.8	11218	13661.7	12170.5	10800.7	15717.5
Jobs by economic sector - mining	2370.1	1792.6	1250.1	879.863	599.59	398.798	273.223
Jobs by economic sector - other	734.637	948.018	1518.4	2117.1	3230.8	4391.8	8198.1
Jobs by economic sector - pipeline	416.855	418.274	868.557	411.142	238.588	205.659	316.239
Jobs by economic sector - professional	6364.6	7856.8	9624	14553.4	18984.7	27777.6	44883.4
Jobs by economic sector - trade	6253.6	6346	6829.3	8852.4	10696.5	14510.9	23876.1
Jobs by economic sector - utilities	8872.4	9973.8	12746.4	16840.5	21336.9	30273.2	47297.9
Jobs by resource sector - Biomass	16701.1	16205.1	16153.6	15910.9	9407.3	8320.8	15993.4
Jobs by resource sector - CO2	0	0	4128.8	939.447	52.616	325.503	1578
Jobs by resource sector - Coal	2446.3	1406	316.887	0	0	0	0
Jobs by resource sector - Grid	12216.6	15006.7	17366.6	28428.4	38097.6	54803.6	87224.9
Jobs by resource sector - Natural Gas	3793.3	3506.1	3071.2	2721.9	2297.2	2336.5	2017
Jobs by resource sector - Nuclear	205.443	0	0	0	0	0	0
Jobs by resource sector - Oil	4116	3739.7	3173.7	2517.4	1960.9	1552.4	1239.4
Jobs by resource sector - Solar	2167.3	3174.7	6544.5	6748.5	10259.4	10166.9	23668.1
Jobs by resource sector - Wind	6808.7	12719.6	16385.8	27891.9	36146.1	49148.5	69200.1
Median wages - All	54357.7	55379.2	56489.6	58047.2	59983.5	61880.6	62770.8
Required Level of Education - Associates degree or some college	13112	15575.8	19438.7	25250.9	30500.5	40249.2	63815.2
Required Level of Education - Bachelors degree	9083.6	10547.5	12609.1	16591.4	19854.6	26535.5	42160.3
Required Level of Education - Doctoral degree	327.944	387.992	468.088	658.365	826.229	1164	1870.5
Required Level of Education - High school diploma or less	23678	26619	31469.7	38405.4	41865.9	51647.3	81806.2
Required Level of Education - Masters or professional degree	2253.3	2627.5	3155.4	4252.4	5173.8	7058.2	11268.7
Wage income - All	2634033684	3088008563	3793044769	4943608041	5892254270	7838297423	12613547993

Table 11: *E- scenario - PILLAR 6: Land carbon sinks - Agriculture*

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	229.739
Carbon sink enhancement potential - All (not counting overlap)	42352
Carbon sink enhancement potential - Avoid deforestation	2429.442
Carbon sink enhancement potential - corn-ethanol to energy grasses	-8418.372
Carbon sink enhancement potential - cropland measures	-21596.599
Carbon sink enhancement potential - Extend rotation length	1848.066
Carbon sink enhancement potential - Improve plantations	69.514
Carbon sink enhancement potential - Increase retention of HWP	1220.626
Carbon sink enhancement potential - Increase trees outside forests	5956.6
Carbon sink enhancement potential - permanent conservation cover	-708.299
Carbon sink enhancement potential - Reforest cropland	18344.8
Carbon sink enhancement potential - Reforest pasture	10878.7

Table 11: *E- scenario - PILLAR 6: Land carbon sinks - Agriculture (continued)*

variable_name	2050
Carbon sink enhancement potential - Restore productivity	1374.571
Carbon sink enhancement potential - total	-30723.269
Land impacted for carbon sink enhancement - Accelerate regeneration	92.593
Land impacted for carbon sink enhancement - All (not counting overlap)	8305
Land impacted for carbon sink enhancement - Avoid deforestation	652.139
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	4190.6
Land impacted for carbon sink enhancement - cropland measures	11910.1
Land impacted for carbon sink enhancement - Extend rotation length	1018.069
Land impacted for carbon sink enhancement - Improve plantations	38.634
Land impacted for carbon sink enhancement - Increase retention of HWP	244.125
Land impacted for carbon sink enhancement - Increase trees outside forests	1680.33
Land impacted for carbon sink enhancement - permanent conservation cover	1288.266
Land impacted for carbon sink enhancement - Reforest cropland	6107.742
Land impacted for carbon sink enhancement - Reforest pasture	822.601
Land impacted for carbon sink enhancement - Restore productivity	775.683
Land impacted for carbon sink enhancement - total	17389
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	3126.9

Table 12: *E- scenario - PILLAR 6: Land carbon sinks - Forests*

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	21.471
Business-as-usual carbon sink - Avoid deforestation	207.741
Business-as-usual carbon sink - Extend rotation length	556.954
Business-as-usual carbon sink - Improve plantations	14.671
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	337.835
Business-as-usual carbon sink - Reforest cropland	693.074
Business-as-usual carbon sink - Reforest pasture	200.961
Business-as-usual carbon sink - Restore productivity	273.063
Business-as-usual carbon sink - Total impacted (over 30 years)	693.074

Table 13: *E- scenario - IMPACTS - Fossil fuel industries*

variable_name	2020	2025	2030	2035	2040	2045	2050
Natural gas consumption	337968.3	342987.6	289119.1	231885.5	174559.9	109827.2	76173.3
Oil consumption	84438.5	84120	77796.9	66840.2	56058.4	47508.7	40376.9

Table 14: *E- scenario - PILLAR 1: Efficiency/Electrification - Overview*

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.119	0.116	0.111	0.104	0.096	0.09	0.087
Final energy demand by sector - industry	0.698	0.727	0.74	0.738	0.743	0.749	0.755
Final energy demand by sector - residential	0.158	0.149	0.141	0.125	0.107	0.092	0.082
Final energy demand by sector - transportation	0.288	0.269	0.235	0.195	0.158	0.136	0.127

Table 15: *E- scenario - PILLAR 1: Efficiency/Electrification - Commercial*

variable_name	2020	2025	2030	2035	2040	2045	2050
Commercial HVAC investment in 2020s - Cumulative 5-yr	0	9054860306	9856719931	0	0	0	0
Sales of cooking units - Electric Resistance	0.448	0.571	0.84	0.893	0.896	0.896	0.896
Sales of cooking units - Gas	0.552	0.429	0.16	0.107	0.104	0.104	0.104
Sales of space heating units - Electric Heat Pump	0.025	0.076	0.301	0.779	0.865	0.87	0.87
Sales of space heating units - Electric Resistance	0.041	0.058	0.083	0.119	0.125	0.125	0.125
Sales of space heating units - Fossil	0.025	0.02	0.004	0	0	0	0
Sales of space heating units - Gas Furnace	0.909	0.847	0.613	0.102	0.01	0.005	0.005
Sales of water heating units - Electric Heat Pump	0.006	0.018	0.145	0.42	0.47	0.473	0.473
Sales of water heating units - Electric Resistance	0.055	0.079	0.203	0.47	0.517	0.52	0.52
Sales of water heating units - Gas Furnace	0.93	0.893	0.645	0.103	0.006	0	0
Sales of water heating units - Other	0.009	0.009	0.007	0.007	0.007	0.007	0.007

Table 16: *E- scenario - PILLAR 1: Efficiency/Electrification - Electricity demand*

variable_name	2025	2030	2035	2040	2045	2050
Electricity distribution peak load (capital invested) - Cumulative 5-yr	3.024	3.153	5.468	5.857	5.071	5.32

Table 17: *RE- scenario - PILLAR 1: Efficiency/Electrification - Residential*

variable_name	2020	2025	2030	2035	2040	2045	2050
Residential HVAC investment in 2020s vs. REF - Cumulative 5-yr	0	2.623	2.758	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.034	0.114	0.117	0.123	0.127	0.132	0.139
Sale of space heating units by type - Electric Resistance	0.109	0.145	0.143	0.141	0.139	0.134	0.128
Sale of space heating units by type - Fossil	0.111	0.165	0.161	0.158	0.155	0.154	0.155
Sale of space heating units by type - Gas	0.746	0.576	0.579	0.578	0.578	0.58	0.577
Sales of cooking units - Electric Resistance	0.618	0.618	0.618	0.618	0.618	0.618	0.618
Sales of cooking units - Gas	0.382	0.382	0.382	0.382	0.382	0.382	0.382
Sales of water heating units by type - Electric Heat Pump	0	0	0	0	0	0	0
Sales of water heating units by type - Electric Resistance	0.253	0.402	0.401	0.4	0.4	0.4	0.4
Sales of water heating units by type - Gas Furnace	0.747	0.598	0.599	0.599	0.599	0.6	0.6
Sales of water heating units by type - Other	0	0	0	0	0	0	0

Table 18: *RE- scenario - PILLAR 1: Efficiency/Electrification - Transportation*

variable_name	2020	2025	2030	2035	2040	2045	2050
End-use technology sales by technology - HDV - diesel	0.981	0.982	0.979	0.97	0.956	0.935	0.916
End-use technology sales by technology - HDV - EV	0	0	0	0	0	0	0
End-use technology sales by technology - HDV - gasoline	0.002	0.002	0.003	0.003	0.003	0.003	0.003
End-use technology sales by technology - HDV - hybrid	0.001	0.001	0.001	0.001	0.002	0.002	0.002
End-use technology sales by technology - HDV - hydrogen FC	0.001	0.001	0.002	0.002	0.002	0.002	0.003
End-use technology sales by technology - HDV - other	0.015	0.013	0.016	0.024	0.037	0.057	0.076
End-use technology sales by technology - LDV - diesel	0.017	0.021	0.022	0.021	0.019	0.017	0.016
End-use technology sales by technology - LDV - EV	0.03	0.049	0.056	0.069	0.084	0.099	0.11
End-use technology sales by technology - LDV - gasoline	0.911	0.877	0.858	0.842	0.822	0.803	0.786
End-use technology sales by technology - LDV - hybrid	0.039	0.048	0.059	0.065	0.071	0.077	0.083
End-use technology sales by technology - LDV - hydrogen FC	0.001	0.004	0.004	0.003	0.003	0.003	0.003
End-use technology sales by technology - LDV - other	0.001	0.001	0.001	0.001	0.001	0.001	0.001
End-use technology sales by technology - MDV - diesel	0.652	0.635	0.616	0.596	0.58	0.565	0.552
End-use technology sales by technology - MDV - EV	0	0.001	0.003	0.007	0.009	0.01	0.01
End-use technology sales by technology - MDV - gasoline	0.34	0.355	0.37	0.385	0.397	0.408	0.417
End-use technology sales by technology - MDV - hybrid	0.004	0.004	0.005	0.006	0.007	0.008	0.009
End-use technology sales by technology - MDV - hydrogen FC	0.002	0.002	0.002	0.003	0.003	0.004	0.005
End-use technology sales by technology - MDV - other	0.003	0.003	0.003	0.003	0.004	0.005	0.007

Table 19: *RE- scenario - PILLAR 6: Land carbon sinks - Agriculture*

variable_name	2020	2030	2050
Carbon sink enhancement potential - Accelerate regeneration	0	0	229.739
Carbon sink enhancement potential - All (not counting overlap)	0	0	42352
Carbon sink enhancement potential - Avoid deforestation	0	0	2429.442
Carbon sink enhancement potential - Extend rotation length	0	0	1848.066
Carbon sink enhancement potential - Improve plantations	0	0	69.514
Carbon sink enhancement potential - Increase retention of HWP	0	0	1220.626
Carbon sink enhancement potential - Increase trees outside forests	0	0	5956.6
Carbon sink enhancement potential - Reforest cropland	0	0	18344.8
Carbon sink enhancement potential - Reforest pasture	0	0	10878.7
Carbon sink enhancement potential - Restore productivity	0	0	1374.571
Land impacted for carbon sink enhancement - Accelerate regeneration	0	0	92.593
Land impacted for carbon sink enhancement - All (not counting overlap)	0	0	8305
Land impacted for carbon sink enhancement - Avoid deforestation	0	0	652.139
Land impacted for carbon sink enhancement - Extend rotation length	0	0	1018.069
Land impacted for carbon sink enhancement - Improve plantations	0	0	38.634
Land impacted for carbon sink enhancement - Increase retention of HWP	0	0	244.125
Land impacted for carbon sink enhancement - Increase trees outside forests	0	0	1680.33
Land impacted for carbon sink enhancement - Natural uptake	3.55	-2.544	-2.275
Land impacted for carbon sink enhancement - Reforest cropland	0	0	6107.742
Land impacted for carbon sink enhancement - Reforest pasture	0	0	822.601
Land impacted for carbon sink enhancement - Restore productivity	0	0	775.683
Land impacted for carbon sink enhancement - Retained in Hardwood Products	-0.199	-0.358	-0.373
Land impacted for carbon sink enhancement - Total	3.351	-2.902	-2.647
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	0	0	3126.9

Table 20: *RE- scenario - PILLAR 6: Land carbon sinks - Forests*

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	21.471
Business-as-usual carbon sink - Avoid deforestation	207.741
Business-as-usual carbon sink - Extend rotation length	556.954
Business-as-usual carbon sink - Improve plantations	14.671

Table 20: *RE- scenario - PILLAR 6: Land carbon sinks - Forests (continued)*

variable_name	2050
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	337.835
Business-as-usual carbon sink - Reforest cropland	693.074
Business-as-usual carbon sink - Reforest pasture	200.961
Business-as-usual carbon sink - Restore productivity	273.063
Business-as-usual carbon sink - Total impacted (over 30 years)	693.074

Table 21: *RE- scenario - PILLAR 1: Efficiency/Electrification - Overview*

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.118	0.119	0.119	0.117	0.116	0.116	0.12
Final energy demand by sector - industry	0.698	0.736	0.756	0.769	0.79	0.805	0.826
Final energy demand by sector - residential	0.158	0.15	0.146	0.144	0.143	0.143	0.143
Final energy demand by sector - transportation	0.289	0.271	0.248	0.234	0.233	0.24	0.249

Table 22: *RE- scenario - PILLAR 1: Efficiency/Electrification - Commercial*

variable_name	2020	2025	2030	2035	2040	2045	2050
Commercial HVAC investment in 2020s - Cumulative 5-yr	0	8949349673	9212281274	0	0	0	0
Sales of cooking units - Electric Resistance	0.448	0.478	0.479	0.478	0.479	0.479	0.48
Sales of cooking units - Gas	0.552	0.522	0.521	0.522	0.521	0.521	0.52
Sales of space heating units - Electric Heat Pump	0.025	0.13	0.446	0.704	0.747	0.751	0.752
Sales of space heating units - Electric Resistance	0.041	0.063	0.108	0.184	0.235	0.243	0.244
Sales of space heating units - Fossil	0.025	0.022	0.017	0.008	0.001	0	0
Sales of space heating units - Gas Furnace	0.909	0.784	0.43	0.104	0.017	0.005	0.005
Sales of water heating units - Electric Heat Pump	0.006	0.008	0.008	0.008	0.008	0.008	0.008
Sales of water heating units - Electric Resistance	0.055	0.07	0.07	0.07	0.07	0.07	0.07
Sales of water heating units - Gas Furnace	0.93	0.912	0.912	0.912	0.913	0.912	0.912
Sales of water heating units - Other	0.009	0.01	0.01	0.01	0.01	0.01	0.01

Table 23: *RE- scenario - PILLAR 1: Efficiency/Electrification - Electricity demand*

variable_name	2025	2030	2035	2040	2045	2050
Electricity distribution peak load (capital invested) - Cumulative 5-yr	2.548	2.621	2.792	2.877	2.992	3.08

Table 24: *REF scenario - PILLAR 1: Efficiency/Electrification - Residential*

variable_name	2020	2025	2030	2035	2040	2045	2050
Residential HVAC investment in 2020s vs. REF - Cumulative 5-yr	0	2.719	3.373	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.043	0.078	0.103	0.186	0.379	0.615	0.751
Sale of space heating units by type - Electric Resistance	0.107	0.15	0.146	0.136	0.111	0.079	0.062
Sale of space heating units by type - Fossil	0.109	0.178	0.174	0.158	0.121	0.078	0.055
Sale of space heating units by type - Gas	0.741	0.594	0.577	0.521	0.39	0.228	0.132
Sales of cooking units - Electric Resistance	0.621	0.631	0.666	0.757	0.884	0.963	0.99
Sales of cooking units - Gas	0.379	0.369	0.334	0.243	0.116	0.037	0.01
Sales of water heating units by type - Electric Heat Pump	0	0.004	0.014	0.049	0.133	0.239	0.301
Sales of water heating units by type - Electric Resistance	0.253	0.404	0.409	0.429	0.477	0.539	0.575
Sales of water heating units by type - Gas Furnace	0.747	0.592	0.576	0.522	0.39	0.222	0.123
Sales of water heating units by type - Other	0	0	0	0	0	0	0

Table 25: *REF scenario - PILLAR 1: Efficiency/Electrification - Transportation*

variable_name	2020	2025	2030	2035	2040	2045	2050
End-use technology sales by technology - HDV - diesel	0.974	0.96	0.913	0.798	0.582	0.321	0.137
End-use technology sales by technology - HDV - EV	0.005	0.015	0.041	0.108	0.236	0.394	0.51
End-use technology sales by technology - HDV - gasoline	0.002	0.002	0.002	0.002	0.002	0.001	0.001
End-use technology sales by technology - HDV - hybrid	0.001	0.001	0.001	0.001	0.001	0.001	0
End-use technology sales by technology - HDV - hydrogen FC	0.003	0.01	0.027	0.072	0.157	0.263	0.34
End-use technology sales by technology - HDV - other	0.015	0.013	0.015	0.019	0.022	0.02	0.011
End-use technology sales by technology - LDV - diesel	0.017	0.021	0.021	0.017	0.011	0.006	0.002
End-use technology sales by technology - LDV - EV	0.017	0.043	0.11	0.245	0.468	0.71	0.872
End-use technology sales by technology - LDV - gasoline	0.923	0.883	0.81	0.684	0.479	0.259	0.114
End-use technology sales by technology - LDV - hybrid	0.04	0.049	0.055	0.051	0.039	0.024	0.012
End-use technology sales by technology - LDV - hydrogen FC	0.001	0.004	0.003	0.003	0.002	0.001	0
End-use technology sales by technology - LDV - other	0.001	0.001	0.001	0.001	0.001	0	0
End-use technology sales by technology - MDV - diesel	0.648	0.622	0.577	0.494	0.356	0.196	0.084
End-use technology sales by technology - MDV - EV	0.007	0.019	0.055	0.143	0.314	0.526	0.68
End-use technology sales by technology - MDV - gasoline	0.338	0.347	0.347	0.319	0.244	0.142	0.063
End-use technology sales by technology - MDV - hybrid	0.004	0.004	0.005	0.005	0.004	0.003	0.001
End-use technology sales by technology - MDV - hydrogen FC	0.002	0.005	0.014	0.036	0.079	0.132	0.17
End-use technology sales by technology - MDV - other	0.003	0.003	0.003	0.003	0.003	0.002	0.001
Light-duty vehicle capital costs - Cumulative 5-yr	0	0	113833518	241532317	813395776	2566699744	3736950068
Number of public EV charging plugs - DC Fast Charging	103	0	425.048	0	2322.8	0	6522.8
Number of public EV charging plugs - L2 Charging	260	0	10237.4	0	55945	0	157103.7

Table 26: *REF scenario - PILLAR 6: Land carbon sinks - Agriculture*

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	229.739
Carbon sink enhancement potential - All (not counting overlap)	42352
Carbon sink enhancement potential - Avoid deforestation	2429.442
Carbon sink enhancement potential - corn-ethanol to energy grasses	-8418.372
Carbon sink enhancement potential - cropland measures	-21596.599
Carbon sink enhancement potential - Extend rotation length	1848.066
Carbon sink enhancement potential - Improve plantations	69.514
Carbon sink enhancement potential - Increase retention of HWP	1220.626
Carbon sink enhancement potential - Increase trees outside forests	5956.6
Carbon sink enhancement potential - permanent conservation cover	-708.299
Carbon sink enhancement potential - Reforest cropland	18344.8
Carbon sink enhancement potential - Reforest pasture	10878.7
Carbon sink enhancement potential - Restore productivity	1374.571
Carbon sink enhancement potential - total	-30723.269
Land impacted for carbon sink enhancement - Accelerate regeneration	92.593
Land impacted for carbon sink enhancement - All (not counting overlap)	8305
Land impacted for carbon sink enhancement - Avoid deforestation	652.139
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	4190.6
Land impacted for carbon sink enhancement - cropland measures	11910.1
Land impacted for carbon sink enhancement - Extend rotation length	1018.069
Land impacted for carbon sink enhancement - Improve plantations	38.634
Land impacted for carbon sink enhancement - Increase retention of HWP	244.125
Land impacted for carbon sink enhancement - Increase trees outside forests	1680.33
Land impacted for carbon sink enhancement - permanent conservation cover	1288.266
Land impacted for carbon sink enhancement - Reforest cropland	6107.742
Land impacted for carbon sink enhancement - Reforest pasture	822.601
Land impacted for carbon sink enhancement - Restore productivity	775.683
Land impacted for carbon sink enhancement - total	17389
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	3126.9

Table 27: *REF scenario - PILLAR 6: Land carbon sinks - Forests*

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	21.471
Business-as-usual carbon sink - Avoid deforestation	207.741
Business-as-usual carbon sink - Extend rotation length	556.954
Business-as-usual carbon sink - Improve plantations	14.671
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	337.835
Business-as-usual carbon sink - Reforest cropland	693.074
Business-as-usual carbon sink - Reforest pasture	200.961
Business-as-usual carbon sink - Restore productivity	273.063
Business-as-usual carbon sink - Total impacted (over 30 years)	693.074

Table 28: *REF scenario - PILLAR 1: Efficiency/Electrification - Overview*

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.119	0.116	0.113	0.11	0.106	0.102	0.098
Final energy demand by sector - industry	0.698	0.728	0.742	0.746	0.756	0.762	0.767
Final energy demand by sector - residential	0.158	0.15	0.143	0.137	0.13	0.12	0.108
Final energy demand by sector - transportation	0.289	0.271	0.246	0.226	0.211	0.194	0.173

Table 29: *REF scenario - PILLAR 1: Efficiency/Electrification - Commercial*

variable_name	2020	2025	2030	2035	2040	2045	2050
Commercial HVAC investment in 2020s - Cumulative 5-yr	0	9054534162	9867437135	0	0	0	0
Sales of cooking units - Electric Resistance	0.448	0.493	0.531	0.63	0.769	0.855	0.885
Sales of cooking units - Gas	0.552	0.507	0.469	0.37	0.231	0.145	0.115
Sales of space heating units - Electric Heat Pump	0.025	0.066	0.089	0.163	0.343	0.568	0.7
Sales of space heating units - Electric Resistance	0.041	0.055	0.058	0.065	0.082	0.101	0.111
Sales of space heating units - Fossil	0.025	0.023	0.022	0.017	0.01	0.005	0.004
Sales of space heating units - Gas Furnace	0.909	0.856	0.832	0.754	0.565	0.325	0.185
Sales of water heating units - Electric Heat Pump	0.006	0.013	0.026	0.068	0.171	0.301	0.377
Sales of water heating units - Electric Resistance	0.055	0.074	0.087	0.128	0.228	0.354	0.428
Sales of water heating units - Gas Furnace	0.93	0.903	0.878	0.795	0.593	0.338	0.187
Sales of water heating units - Other	0.009	0.01	0.01	0.009	0.008	0.007	0.007

Table 30: *REF scenario - PILLAR 1: Efficiency/Electrification - Electricity demand*

variable_name	2025	2030	2035	2040	2045	2050
Electricity distribution peak load (capital invested) - Cumulative 5-yr	2.474	2.537	3.299	3.445	4.737	5.02

Table 31: *E+ scenario - PILLAR 2: Clean Electricity - Generating capacity*

variable_name	2025	2030	2035	2040	2045	2050
Power generation capital investment - Solar PV - Base	0	12.493	9.101	12.224	7.816	10.931
Power generation capital investment - Wind - Base	7.403	10.957	28.186	50.977	72.481	59.066

Table 32: *E+ scenario - PILLAR 2: Clean Electricity - Transmission*

variable_name	2020	2025	2030	2035	2040	2045	2050
HV transmission for wind and solar - base all	0	1034.7	2719.9	7077.7	16360.1	31005	47360
HV transmission for wind and solar - base other intra-state	0	233.901	517.423	1720	3687.7	7009.1	12184.6
HV transmission for wind and solar - base spur intra-state	0	397.318	1440.6	3275.8	6461.5	11595.5	17184.5

Table 33: *E+ scenario - PILLAR 6: Land carbon sinks - Agriculture*

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	229.739
Carbon sink enhancement potential - All (not counting overlap)	42352
Carbon sink enhancement potential - Avoid deforestation	2429.442
Carbon sink enhancement potential - corn-ethanol to energy grasses	-8418.372
Carbon sink enhancement potential - cropland measures	-21596.599
Carbon sink enhancement potential - Extend rotation length	1848.066
Carbon sink enhancement potential - Improve plantations	69.514
Carbon sink enhancement potential - Increase retention of HWP	1220.626
Carbon sink enhancement potential - Increase trees outside forests	5956.6
Carbon sink enhancement potential - permanent conservation cover	-708.299
Carbon sink enhancement potential - Reforest cropland	18344.8
Carbon sink enhancement potential - Reforest pasture	10878.7
Carbon sink enhancement potential - Restore productivity	1374.571
Carbon sink enhancement potential - total	-30723.269
Land impacted for carbon sink enhancement - Accelerate regeneration	92.593
Land impacted for carbon sink enhancement - All (not counting overlap)	8305
Land impacted for carbon sink enhancement - Avoid deforestation	652.139
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	4190.6
Land impacted for carbon sink enhancement - cropland measures	11910.1
Land impacted for carbon sink enhancement - Extend rotation length	1018.069
Land impacted for carbon sink enhancement - Improve plantations	38.634
Land impacted for carbon sink enhancement - Increase retention of HWP	244.125
Land impacted for carbon sink enhancement - Increase trees outside forests	1680.33
Land impacted for carbon sink enhancement - permanent conservation cover	1288.266
Land impacted for carbon sink enhancement - Reforest cropland	6107.742
Land impacted for carbon sink enhancement - Reforest pasture	822.601
Land impacted for carbon sink enhancement - Restore productivity	775.683
Land impacted for carbon sink enhancement - total	17389
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	3126.9

Table 34: *E+ scenario - PILLAR 6: Land carbon sinks - Forests*

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	21.471
Business-as-usual carbon sink - Avoid deforestation	207.741
Business-as-usual carbon sink - Extend rotation length	556.954
Business-as-usual carbon sink - Improve plantations	14.671
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	337.835
Business-as-usual carbon sink - Reforest cropland	693.074
Business-as-usual carbon sink - Reforest pasture	200.961
Business-as-usual carbon sink - Restore productivity	273.063
Business-as-usual carbon sink - Total impacted (over 30 years)	693.074

Table 35: *RE+ scenario - PILLAR 2: Clean Electricity - Generating capacity*

variable_name	2020	2025	2030	2035	2040	2045	2050
Power generation capital investment - biomass power plant	0	0.005	0.13	0	0	0	0
Power generation capital investment - biomass w/ccu allam power plant	0	0	0	0	0.012	0	0
Power generation capital investment - biomass w/ccu power plant	0	0	0	0	8.021	0.797	0

Table 36: *RE+ scenario - PILLAR 2: Clean Electricity - Generation*

variable_name	2020	2025	2030	2035	2040	2045	2050
Power generation by technology - biomass power plant	0	9.515	263.961	263.961	263.961	263.961	263.961
Power generation by technology - biomass w/ccu allam power plant	0	0	0	0	11.489	11.489	11.489
Power generation by technology - biomass w/ccu power plant	0	0	0	0	9002.7	9897.4	9897.4

Table 37: *RE+ scenario - PILLAR 3: Bioenergy and Hydrogen - Bioconversion*

variable_name	2020	2025	2030	2035	2040	2045	2050
Biomass purchases	0	0.293	0.315	0.318	2.989	4.014	8.196
Capital investment	0	0	0.141	0	28.151	0	77.424
Number of facilities - allam power w ccu	0	0	0	0	1	1	1
Number of facilities - beccs hydrogen	0	0	0	0	25	39	49
Number of facilities - diesel	0	0	0	1	2	2	2
Number of facilities - diesel ccu	0	0	0	0	1	1	1
Number of facilities - power	0	1	1	1	1	1	1
Number of facilities - power ccu	0	0	0	0	7	8	8
Number of facilities - pyrolysis	0	0	0	1	2	2	2
Number of facilities - pyrolysis ccu	0	0	0	0	0	1	44
Number of facilities - sng	0	1	1	1	1	1	1
Number of facilities - sng ccu	0	0	0	0	0	0	0

Table 38: *RE+ scenario - PILLAR 4: CO2 capture, use, storage - CO2 capture*

variable_name	2025	2030	2035	2040	2045	2050
Annual - All	0	3.24	3.35	41.11	55.5	96.14
Annual - BECCS	0	0	0	37.79	52.08	92.61
Annual - Cement	0	3.24	3.35	3.32	3.42	3.53
Annual - NGCC	0	0.01	0	0	0	0
Cumulative - All	0	3.24	6.59	47.7	103.2	199.34
Cumulative - BECCS	0	0	0	37.79	89.87	182.48
Cumulative - Cement	0	3.24	6.59	9.91	13.33	16.86
Cumulative - NGCC	0	0.01	0.01	0.01	0.01	0.01

Table 39: *RE+ scenario - PILLAR 4: CO2 capture, use, storage - CO2 storage*

variable_name	2025	2030	2035	2040	2045	2050
Annual	0	0	0	0	0	0
Injection wells	0	0	0	0	0	0
Resource characterization, appraisal and permitting costs cumulative	0	0.01	0.02	0.02	0.02	0.02
Wells and facilities construction costs cumulative	0	0	0.02	0.03	0.06	0.07

Table 40: *RE+ scenario - PILLAR 4: CO2 capture, use, storage - CO2 transportation*

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	4269704.272	5411861.722	10384973.7	11660981.2	13729664.7
CO2 pipelines - Spur	0	39123.285	191545.073	1958685.6	3234693	5303375.6
CO2 pipelines - Trunk	0	4230580.286	5220315.849	8426289.1	8426289.1	8426289.1

Table 41: *RE+ scenario - PILLAR 6: Land carbon sinks - Agriculture*

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	229.739
Carbon sink enhancement potential - All (not counting overlap)	42352
Carbon sink enhancement potential - Avoid deforestation	2429.442
Carbon sink enhancement potential - corn-ethanol to energy grasses	-11313.354
Carbon sink enhancement potential - cropland measures	-19749.676
Carbon sink enhancement potential - Cropland to woody energy crops	0
Carbon sink enhancement potential - Extend rotation length	1848.066
Carbon sink enhancement potential - Improve plantations	69.514
Carbon sink enhancement potential - Increase retention of HWP	1220.626
Carbon sink enhancement potential - Increase trees outside forests	5956.6
Carbon sink enhancement potential - pasture to energy crops	0
Carbon sink enhancement potential - permanent conservation cover	-646.19
Carbon sink enhancement potential - Reforest cropland	18344.8
Carbon sink enhancement potential - Reforest pasture	10878.7
Carbon sink enhancement potential - Restore productivity	1374.571

Table 41: *RE+ scenario - PILLAR 6: Land carbon sinks - Agriculture (continued)*

variable_name	2050
Carbon sink enhancement potential - total	-31709.219
Land impacted for carbon sink enhancement - Accelerate regeneration	92.593
Land impacted for carbon sink enhancement - All (not counting overlap)	8305
Land impacted for carbon sink enhancement - Avoid deforestation	652.139
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	5651.6
Land impacted for carbon sink enhancement - cropland measures	21333.7
Land impacted for carbon sink enhancement - Cropland to woody energy crops	871.946
Land impacted for carbon sink enhancement - Extend rotation length	1018.069
Land impacted for carbon sink enhancement - Improve plantations	38.634
Land impacted for carbon sink enhancement - Increase retention of HWP	244.125
Land impacted for carbon sink enhancement - Increase trees outside forests	1680.33
Land impacted for carbon sink enhancement - pasture to energy crops	518.46
Land impacted for carbon sink enhancement - permanent conservation cover	1175.302
Land impacted for carbon sink enhancement - Reforest cropland	6107.742
Land impacted for carbon sink enhancement - Reforest pasture	822.601
Land impacted for carbon sink enhancement - Restore productivity	775.683
Land impacted for carbon sink enhancement - total	29550.9
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	3126.9

Table 42: *RE+ scenario - PILLAR 6: Land carbon sinks - Forests*

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	21.471
Business-as-usual carbon sink - Avoid deforestation	207.741
Business-as-usual carbon sink - Extend rotation length	556.954
Business-as-usual carbon sink - Improve plantations	14.671
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	337.835
Business-as-usual carbon sink - Reforest cropland	693.074
Business-as-usual carbon sink - Reforest pasture	200.961
Business-as-usual carbon sink - Restore productivity	273.063
Business-as-usual carbon sink - Total impacted (over 30 years)	693.074

Table 43: *B+ scenario - PILLAR 6: Land carbon sinks - Agriculture*

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	229.739
Carbon sink enhancement potential - All (not counting overlap)	42352
Carbon sink enhancement potential - Avoid deforestation	2429.442
Carbon sink enhancement potential - corn-ethanol to energy grasses	-8418.372
Carbon sink enhancement potential - cropland measures	-21596.599
Carbon sink enhancement potential - Extend rotation length	1848.066
Carbon sink enhancement potential - Improve plantations	69.514
Carbon sink enhancement potential - Increase retention of HWP	1220.626
Carbon sink enhancement potential - Increase trees outside forests	5956.6
Carbon sink enhancement potential - permanent conservation cover	-708.299
Carbon sink enhancement potential - Reforest cropland	18344.8
Carbon sink enhancement potential - Reforest pasture	10878.7
Carbon sink enhancement potential - Restore productivity	1374.571
Carbon sink enhancement potential - total	-30723.269
Land impacted for carbon sink enhancement - Accelerate regeneration	92.593
Land impacted for carbon sink enhancement - All (not counting overlap)	8305
Land impacted for carbon sink enhancement - Avoid deforestation	652.139
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	4190.6
Land impacted for carbon sink enhancement - cropland measures	11910.1
Land impacted for carbon sink enhancement - Extend rotation length	1018.069
Land impacted for carbon sink enhancement - Improve plantations	38.634
Land impacted for carbon sink enhancement - Increase retention of HWP	244.125
Land impacted for carbon sink enhancement - Increase trees outside forests	1680.33
Land impacted for carbon sink enhancement - permanent conservation cover	1288.266

Table 43: *B+ scenario - PILLAR 6: Land carbon sinks - Agriculture (continued)*

variable_name	2050
Land impacted for carbon sink enhancement - Reforest cropland	6107.742
Land impacted for carbon sink enhancement - Reforest pasture	822.601
Land impacted for carbon sink enhancement - Restore productivity	775.683
Land impacted for carbon sink enhancement - total	17389
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	3126.9

Table 44: *B+ scenario - PILLAR 6: Land carbon sinks - Forests*

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	21.471
Business-as-usual carbon sink - Avoid deforestation	207.741
Business-as-usual carbon sink - Extend rotation length	556.954
Business-as-usual carbon sink - Improve plantations	14.671
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	337.835
Business-as-usual carbon sink - Reforest cropland	693.074
Business-as-usual carbon sink - Reforest pasture	200.961
Business-as-usual carbon sink - Restore productivity	273.063
Business-as-usual carbon sink - Total impacted (over 30 years)	693.074