Net-Zero America - kansas 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	3.008	4.041	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.048	0.207	0.762	0.907	0.919	0.919	0.917
Sale of space heating units by type - Electric Resistance	0.119	0.15	0.066	0.044	0.043	0.044	0.046
Sale of space heating units by type - Fossil	0.059	0.092	0.041	0.027	0.024	0.023	0.024
Sale of space heating units by type - Gas	0.774	0.551	0.131	0.022	0.014	0.014	0.014
Sales of cooking units - Electric Resistance	0.664	0.736	0.955	0.998	1	1	1
Sales of cooking units - Gas	0.336	0.264	0.045	0.002	0	0	0
Sales of water heating units by type - Electric Heat Pump	0	0.093	0.497	0.597	0.603	0.603	0.603
Sales of water heating units by type - Electric Resistance	0.273	0.419	0.395	0.396	0.397	0.397	0.397
Sales of water heating units by type - Gas Furnace	0.727	0.488	0.107	0.007	0	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	0.016	0.019	0.013	0.004	0.001	0	0
End-use technology sales by technology - LDV - EV	0.036	0.143	0.451	0.813	0.963	0.993	1
End-use technology sales by technology - LDV - gasoline	0.904	0.79	0.502	0.171	0.034	0.006	0
End-use technology sales by technology - LDV - hybrid	0.041	0.043	0.031	0.012	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	515051564	1319904016	2139222497	3240363011	3526857374	3362575908
Number of public EV charging plugs - DC Fast Charging	119	0	964.461	0	4237.2	0	6852.5
Number of public EV charging plugs - L2 Charging	786	0	23254.1	0	102163	0	165219.6

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	0	0	0	0	0
Power generation capital investment - biomass w/ccu allam power plant	0	0	0	0	0	0	0.042
Power generation capital investment - biomass w/ccu power plant	0	0	0	0	0	0	0.171
Power generation capital investment - Solar PV - Base	0	0	0	0	0	0	0.072
Power generation capital investment - Solar PV - Constrained	0	0.03	0	0.231	0	0	0.072
Power generation capital investment - Wind - Base	0	0	0.43	1.578	2.727	3.706	0.208
Power generation capital investment - Wind - Constrained	0	0.552	0.572	3.139	5.929	6.232	0.442

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	0	0	0	0	0	0
Power generation by technology - biomass w/ccu allam power plant	0	0	0	0	0	0	41.825
Power generation by technology - biomass w/ccu power plant	0	0	0	0	0	0	191.895

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	297.018	355.354	593.655	994.806	1621.1	1720.3
HV transmission for wind and solar - base other intra-state	0	75.24	123.525	274.342	440.595	678.775	692.942
HV transmission for wind and solar - base spur intra-state	0	111.683	121.734	177.11	312.276	605.46	623.841
HV transmission for wind and solar - constrained all	0	297.018	384.728	803.019	1607.2	2696.8	2902.1
HV transmission for wind and solar - constrained other intra-state	0	75.24	143.221	348.939	639.076	1036.6	1135.2
HV transmission for wind and solar - constrained spur intra-state	0	111.683	127.932	288.937	679.302	1093.3	1138.4

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Biomass purchases	0	0	0	0.434	0.434	0.804	0.99
Capital investment	0	0	0	0	6.241	0	7.993
Number of facilities - allam power w ccu	0	0	0	0	0	0	1
Number of facilities - beccs hydrogen	0	0	0	6	6	11	13
Number of facilities - diesel	0	0	0	0	0	0	0
Number of facilities - diesel ccu	0	0	0	0	0	0	1

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	0	0	0	0	0	0
Number of facilities - power ccu	0	0	0	0	0	0	1
Number of facilities - pyrolysis	0	0	0	0	0	0	0
Number of facilities - pyrolysis ccu	0	0	0	0	0	0	1
Number of facilities - sng	0	0	0	0	0	0	0
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	0.01	8.54	11.86	19.2	22.97
Annual - BECCS	0	0	8.51	8.51	15.76	19.42
Annual - Cement	0	0	0	3.32	3.42	3.53
Annual - NGCC	0	0.01	0.03	0.02	0.02	0.02
Cumulative - All	0	0.01	8.55	20.41	39.61	62.58
Cumulative - BECCS	0	0	8.51	17.02	32.78	52.2
Cumulative - Cement	0	0	0	3.32	6.74	10.27
Cumulative - NGCC	0	0.01	0.04	0.06	0.08	0.1

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

variable_name	2025	2030	2035	2040	2045	2050
Annual	0	0	1.76	2.71	4.3	5.59
Injection wells	0	1	3	6	10	12
Resource characterization, appraisal and permitting costs cumulative	77.19	185.26	216.14	216.14	216.14	216.14
Wells and facilities construction costs cumulative	0	25.7	100.16	178.49	298.44	370.52

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

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	4984670.4	7374381.6	7596207.1	7852517.9	8338393.6
CO2 pipelines - Spur	0	30911.171	494165.049	715990.774	972301.3	1458177.6
CO2 pipelines - Trunk	0	4953758.891	6880217	6880217	6880217	6880217

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Jobs by economic sector - agriculture	858.797	859.177	862.328	1542.2	1068.9	1010.9	967.012
Jobs by economic sector - construction	7259.9	7087.4	8242.6	8490.7	8273.7	9417.7	9949
Jobs by economic sector - manufacturing	5718.2	9498.7	10948.9	13842.2	12819.9	10620.7	12644
Jobs by economic sector - mining	6924.2	5895.9	4715	3680.2	2449.2	1670.8	1017.9
Jobs by economic sector - other	606.879	588.657	604.379	794.965	998.463	1265.6	1674.8
Jobs by economic sector - pipeline	457.209	461.986	898.135	637.816	332.968	281.581	285.061
Jobs by economic sector - professional	4807	4807.6	4518.6	5657.6	5806.7	7080.9	7424
Jobs by economic sector - trade	4275.1	3965.9	3634.3	3759.6	3632	4016.7	4199.9
Jobs by economic sector - utilities	5724.2	5314.1	6897.4	6851.1	6241.5	7442.6	7284.5
Jobs by resource sector - Biomass	2076.4	2016.4	1965	3876.5	2915	3726.8	4269.8
Jobs by resource sector - CO2	0	40.245	4051.4	2478.3	673.025	946.295	1523.3
Jobs by resource sector - Coal	1460.7	374.725	0	0	0	0	0
Jobs by resource sector - Grid	6400.3	6177	6527.2	8657.8	9892.4	12196.2	11959.1
Jobs by resource sector - Natural Gas	4806.6	4633.9	3726.8	3006.6	2478.7	1988.4	1210.1
Jobs by resource sector - Nuclear	650.33	639.845	629.627	365.209	0.013	0.015	0.026
Jobs by resource sector - Oil	12613.3	11915.7	10519	9105.7	6609.4	4912.5	3139.3
Jobs by resource sector - Solar	3534.4	4543.1	5079.4	7264.5	8239.2	8409.9	12458.3
Jobs by resource sector - Wind	5089.4	8138.4	8823.3	10501.9	10815.7	10627.3	10886
Median wages - All	56238.1	56393.8	56747.2	56900.4	57507.1	58685.5	58808.7
Required Level of Education - Associates degree or some college	10709.8	11362	12517.5	13637	12731.4	13228.4	14163.9
Required Level of Education - Bachelors degree	8377.7	8681.3	8920.8	9626.8	8799.7	9042.2	9460
Required Level of Education - Doctoral degree	300.451	297.996	285.38	317.904	300.85	336.588	348.243
Required Level of Education - High school diploma or less	15205.2	16075	17520	19421.1	17711	17986.9	19178.3
Required Level of Education - Masters or professional degree	2038.3	2063.1	2078	2253.7	2080.4	2213.3	2295.7
Wage income - All	2060203110	2170112730	2345003851	2575260446	2393813976	2512399046	2672909831

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	260.837
Carbon sink enhancement potential - All (not counting overlap)	69825.5
Carbon sink enhancement potential - Avoid deforestation	2691.839
Carbon sink enhancement potential - corn-ethanol to energy grasses	-1392.074
Carbon sink enhancement potential - cropland measures	-15650.658
Carbon sink enhancement potential - Extend rotation length	1663.38
Carbon sink enhancement potential - Improve plantations	78.301
Carbon sink enhancement potential - Increase retention of HWP	893.155
Carbon sink enhancement potential - Increase trees outside forests	6042.2
Carbon sink enhancement potential - permanent conservation cover	-935.703
Carbon sink enhancement potential - Reforest cropland	46850.1
Carbon sink enhancement potential - Reforest pasture	10220.6

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

variable_name	2050
Carbon sink enhancement potential - Restore productivity	1125.041
Carbon sink enhancement potential - total	-17978.435
Land impacted for carbon sink enhancement - Accelerate regeneration	105.128
Land impacted for carbon sink enhancement - All (not counting overlap)	16316.1
Land impacted for carbon sink enhancement - Avoid deforestation	722.593
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	825.73
Land impacted for carbon sink enhancement - cropland measures	15765.4
Land impacted for carbon sink enhancement - Extend rotation length	916.324
Land impacted for carbon sink enhancement - Improve plantations	43.518
Land impacted for carbon sink enhancement - Increase retention of HWP	178.631
Land impacted for carbon sink enhancement - Increase trees outside forests	1704.39
Land impacted for carbon sink enhancement - permanent conservation cover	1570.928
Land impacted for carbon sink enhancement - Reforest cropland	15598.309
Land impacted for carbon sink enhancement - Reforest pasture	772.838
Land impacted for carbon sink enhancement - Restore productivity	634.872
Land impacted for carbon sink enhancement - total	18162
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	4360.5

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	24.377
Business-as-usual carbon sink - Avoid deforestation	230.185
Business-as-usual carbon sink - Extend rotation length	501.292
Business-as-usual carbon sink - Improve plantations	16.526
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	342.69
Business-as-usual carbon sink - Reforest cropland	1770
Business-as-usual carbon sink - Reforest pasture	188.804
Business-as-usual carbon sink - Restore productivity	223.493
Business-as-usual carbon sink - Total impacted (over 30 years)	1770

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Natural gas consumption	236142.8	239649.9	202011.3	162021.4	121967.3	76737.7	53223.3
Oil consumption	85363.4	82339.9	73299.8	59246.9	45712.8	35054.2	26275.1

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.11	0.107	0.101	0.093	0.085	0.081	0.079
Final energy demand by sector - industry	0.174	0.182	0.189	0.19	0.195	0.204	0.206
Final energy demand by sector - residential	0.12	0.113	0.102	0.087	0.074	0.066	0.063
Final energy demand by sector - transportation	0.286	0.268	0.235	0.195	0.16	0.139	0.131

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	8255019321	8955450973	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	0.021	0.247	0.713	0.88	0.898	0.898	0.898
Sales of space heating units - Electric Resistance	0.045	0.057	0.07	0.092	0.097	0.097	0.097
Sales of space heating units - Fossil	0	0.017	0.003	0	0	0	0
Sales of space heating units - Gas Furnace	0.933	0.679	0.214	0.028	0.005	0.004	0.004
Sales of water heating units - Electric Heat Pump	0.007	0.107	0.538	0.647	0.653	0.653	0.653
Sales of water heating units - Electric Resistance	0.058	0.109	0.285	0.336	0.34	0.34	0.34
Sales of water heating units - Gas Furnace	0.929	0.774	0.17	0.011	0	0	0
Sales of water heating units - Other	0.006	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	1.982	2.046	3.348	3.559	3.354	3.515

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	2.832	3.067	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.028	0.276	0.291	0.313	0.326	0.337	0.35
Sale of space heating units by type - Electric Resistance	0.124	0.139	0.136	0.133	0.131	0.121	0.106
Sale of space heating units by type - Fossil	0.061	0.07	0.071	0.071	0.068	0.067	0.069
Sale of space heating units by type - Gas	0.787	0.515	0.502	0.484	0.475	0.475	0.475
Sales of cooking units - Electric Resistance	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Sales of cooking units - Gas	0.34	0.34	0.34	0.34	0.34	0.34	0.34
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	0.273	0.424	0.423	0.422	0.422	0.422	0.421
Sales of water heating units by type - Gas Furnace	0.727	0.575	0.576	0.577	0.577	0.578	0.578
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	0.016	0.02	0.022	0.02	0.018	0.017	0.016
End-use technology sales by technology - LDV - EV	0.033	0.052	0.06	0.073	0.09	0.104	0.116
End-use technology sales by technology - LDV - gasoline	0.907	0.872	0.852	0.835	0.814	0.795	0.779
End-use technology sales by technology - LDV - hybrid	0.042	0.05	0.062	0.067	0.073	0.079	0.084
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	260.837
Carbon sink enhancement potential - All (not counting overlap)	0	0	69825.5
Carbon sink enhancement potential - Avoid deforestation	0	0	2691.839
Carbon sink enhancement potential - Extend rotation length	0	0	1663.38
Carbon sink enhancement potential - Improve plantations	0	0	78.301
Carbon sink enhancement potential - Increase retention of HWP	0	0	893.155
Carbon sink enhancement potential - Increase trees outside forests	0	0	6042.2
Carbon sink enhancement potential - Reforest cropland	0	0	46850.1
Carbon sink enhancement potential - Reforest pasture	0	0	10220.6
Carbon sink enhancement potential - Restore productivity	0	0	1125.041
Land impacted for carbon sink enhancement - Accelerate regeneration	0	0	105.128
Land impacted for carbon sink enhancement - All (not counting overlap)	0	0	16316.1
Land impacted for carbon sink enhancement - Avoid deforestation	0	0	722.593
Land impacted for carbon sink enhancement - Extend rotation length	0	0	916.324
Land impacted for carbon sink enhancement - Improve plantations	0	0	43.518
Land impacted for carbon sink enhancement - Increase retention of HWP	0	0	178.631
Land impacted for carbon sink enhancement - Increase trees outside forests	0	0	1704.39
Land impacted for carbon sink enhancement - Natural uptake	-6.75	0.507	0.145
Land impacted for carbon sink enhancement - Reforest cropland	0	0	15598.309
Land impacted for carbon sink enhancement - Reforest pasture	0	0	772.838
Land impacted for carbon sink enhancement - Restore productivity	0	0	634.872
Land impacted for carbon sink enhancement - Retained in Hardwood Products	-0.146	-0.303	-0.319
Land impacted for carbon sink enhancement - Total	-6.896	0.204	-0.174
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	0	0	4360.5

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	24.377
Business-as-usual carbon sink - Avoid deforestation	230.185
Business-as-usual carbon sink - Extend rotation length	501.292
Business-as-usual carbon sink - Improve plantations	16.526

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	342.69
Business-as-usual carbon sink - Reforest cropland	1770
Business-as-usual carbon sink - Reforest pasture	188.804
Business-as-usual carbon sink - Restore productivity	223.493
Business-as-usual carbon sink - Total impacted (over 30 years)	1770

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.11	0.11	0.109	0.108	0.107	0.108	0.111
Final energy demand by sector - industry	0.174	0.186	0.192	0.198	0.205	0.212	0.22
Final energy demand by sector - residential	0.12	0.113	0.109	0.106	0.105	0.106	0.106
Final energy demand by sector - transportation	0.286	0.27	0.247	0.233	0.233	0.24	0.25

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	8159929523	8376924836	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	0.021	0.206	0.483	0.711	0.748	0.753	0.753
Sales of space heating units - Electric Resistance	0.045	0.064	0.108	0.184	0.234	0.242	0.243
Sales of space heating units - Fossil	0	0.02	0.015	0.007	0.001	0	0
Sales of space heating units - Gas Furnace	0.933	0.711	0.394	0.099	0.016	0.005	0.005
Sales of water heating units - Electric Heat Pump	0.007	0.008	0.008	0.008	0.008	0.008	0.008
Sales of water heating units - Electric Resistance	0.058	0.07	0.07	0.07	0.07	0.07	0.07
Sales of water heating units - Gas Furnace	0.929	0.912	0.912	0.912	0.912	0.912	0.912
Sales of water heating units - Other	0.006	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	1.738	1.773	1.902	1.948	2.499	2.606

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	2.989	4.022	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.048	0.101	0.165	0.347	0.632	0.825	0.893
Sale of space heating units by type - Electric Resistance	0.119	0.166	0.156	0.129	0.085	0.057	0.047
Sale of space heating units by type - Fossil	0.059	0.102	0.097	0.079	0.051	0.032	0.026
Sale of space heating units by type - Gas	0.774	0.63	0.582	0.445	0.231	0.087	0.033
Sales of cooking units - Electric Resistance	0.663	0.672	0.702	0.784	0.897	0.967	0.991
Sales of cooking units - Gas	0.337	0.328	0.298	0.216	0.103	0.033	0.009
Sales of water heating units by type - Electric Heat Pump	0	0.016	0.062	0.195	0.4	0.536	0.585
Sales of water heating units by type - Electric Resistance	0.273	0.423	0.42	0.412	0.403	0.398	0.397
Sales of water heating units by type - Gas Furnace	0.727	0.56	0.518	0.393	0.198	0.066	0.018
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	0.016	0.02	0.021	0.017	0.011	0.005	0.002
End-use technology sales by technology - LDV - EV	0.018	0.045	0.114	0.251	0.476	0.715	0.874
End-use technology sales by technology - LDV - gasoline	0.921	0.879	0.803	0.676	0.471	0.254	0.112
End-use technology sales by technology - LDV - hybrid	0.043	0.051	0.058	0.053	0.04	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	83274469	175079931	591145866	1860527901	2710480373
Number of public EV charging plugs - DC Fast Charging	119	0	297.621	0	1570.9	0	4389
Number of public EV charging plugs - L2 Charging	786	0	7175.9	0	37876.8	0	105823.1

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	260.837
Carbon sink enhancement potential - All (not counting overlap)	69825.5
Carbon sink enhancement potential - Avoid deforestation	2691.839
Carbon sink enhancement potential - corn-ethanol to energy grasses	-1392.074
Carbon sink enhancement potential - cropland measures	-15650.658
Carbon sink enhancement potential - Extend rotation length	1663.38
Carbon sink enhancement potential - Improve plantations	78.301
Carbon sink enhancement potential - Increase retention of HWP	893.155
Carbon sink enhancement potential - Increase trees outside forests	6042.2
Carbon sink enhancement potential - permanent conservation cover	-935.703
Carbon sink enhancement potential - Reforest cropland	46850.1
Carbon sink enhancement potential - Reforest pasture	10220.6
Carbon sink enhancement potential - Restore productivity	1125.041
Carbon sink enhancement potential - total	-17978.435
Land impacted for carbon sink enhancement - Accelerate regeneration	105.128
Land impacted for carbon sink enhancement - All (not counting overlap)	16316.1
Land impacted for carbon sink enhancement - Avoid deforestation	722.593
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	825.73
Land impacted for carbon sink enhancement - cropland measures	15765.4
Land impacted for carbon sink enhancement - Extend rotation length	916.324
Land impacted for carbon sink enhancement - Improve plantations	43.518
Land impacted for carbon sink enhancement - Increase retention of HWP	178.631
Land impacted for carbon sink enhancement - Increase trees outside forests	1704.39
Land impacted for carbon sink enhancement - permanent conservation cover	1570.928
Land impacted for carbon sink enhancement - Reforest cropland	15598.309
Land impacted for carbon sink enhancement - Reforest pasture	772.838
Land impacted for carbon sink enhancement - Restore productivity	634.872
Land impacted for carbon sink enhancement - total	18162
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	4360.5

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	24.377
Business-as-usual carbon sink - Avoid deforestation	230.185
Business-as-usual carbon sink - Extend rotation length	501.292
Business-as-usual carbon sink - Improve plantations	16.526
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	342.69
Business-as-usual carbon sink - Reforest cropland	1770
Business-as-usual carbon sink - Reforest pasture	188.804
Business-as-usual carbon sink - Restore productivity	223.493
Business-as-usual carbon sink - Total impacted (over 30 years)	1770

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.11	0.107	0.104	0.1	0.095	0.09	0.086
Final energy demand by sector - industry	0.174	0.182	0.19	0.193	0.2	0.209	0.211
Final energy demand by sector - residential	0.12	0.114	0.109	0.103	0.094	0.083	0.074
Final energy demand by sector - transportation	0.287	0.27	0.245	0.226	0.212	0.195	0.175

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	8252719958	8961461592	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	0.021	0.16	0.214	0.369	0.617	0.798	0.87
Sales of space heating units - Electric Resistance	0.045	0.055	0.057	0.062	0.073	0.086	0.094
Sales of space heating units - Fossil	0	0.02	0.019	0.014	0.007	0.002	0.001
Sales of space heating units - Gas Furnace	0.933	0.765	0.711	0.555	0.303	0.114	0.036
Sales of water heating units - Electric Heat Pump	0.007	0.025	0.074	0.216	0.435	0.582	0.634
Sales of water heating units - Electric Resistance	0.058	0.077	0.097	0.154	0.245	0.308	0.331
Sales of water heating units - Gas Furnace	0.929	0.888	0.819	0.621	0.312	0.104	0.028
Sales of water heating units - Other	0.006	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	1.641	1.664	2.054	2.121	3.021	3.187

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	0	0	0	0	0.093
Power generation capital investment - Wind - Base	0.117	0.849	4.307	12.652	27.868	36.631

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	281.201	401.87	1031.7	2800.5	7031.1	13805.7
HV transmission for wind and solar - base other intra-state	0	87.043	176.396	468.116	1093.6	2566.3	4629.1
HV transmission for wind and solar - base spur intra-state	0	113.274	138.826	346.819	1222.5	3118.7	6092.9

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	260.837
Carbon sink enhancement potential - All (not counting overlap)	69825.5
Carbon sink enhancement potential - Avoid deforestation	2691.839
Carbon sink enhancement potential - corn-ethanol to energy grasses	-1392.074
Carbon sink enhancement potential - cropland measures	-15650.658
Carbon sink enhancement potential - Extend rotation length	1663.38
Carbon sink enhancement potential - Improve plantations	78.301
Carbon sink enhancement potential - Increase retention of HWP	893.155
Carbon sink enhancement potential - Increase trees outside forests	6042.2
Carbon sink enhancement potential - permanent conservation cover	-935.703
Carbon sink enhancement potential - Reforest cropland	46850.1
Carbon sink enhancement potential - Reforest pasture	10220.6
Carbon sink enhancement potential - Restore productivity	1125.041
Carbon sink enhancement potential - total	-17978.435
Land impacted for carbon sink enhancement - Accelerate regeneration	105.128
Land impacted for carbon sink enhancement - All (not counting overlap)	16316.1
Land impacted for carbon sink enhancement - Avoid deforestation	722.593
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	825.73
Land impacted for carbon sink enhancement - cropland measures	15765.4
Land impacted for carbon sink enhancement - Extend rotation length	916.324
Land impacted for carbon sink enhancement - Improve plantations	43.518
Land impacted for carbon sink enhancement - Increase retention of HWP	178.631
Land impacted for carbon sink enhancement - Increase trees outside forests	1704.39
Land impacted for carbon sink enhancement - permanent conservation cover	1570.928
Land impacted for carbon sink enhancement - Reforest cropland	15598.309
Land impacted for carbon sink enhancement - Reforest pasture	772.838
Land impacted for carbon sink enhancement - Restore productivity	634.872
Land impacted for carbon sink enhancement - total	18162
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	4360.5

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	24.377
Business-as-usual carbon sink - Avoid deforestation	230.185
Business-as-usual carbon sink - Extend rotation length	501.292
Business-as-usual carbon sink - Improve plantations	16.526
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	342.69
Business-as-usual carbon sink - Reforest cropland	1770
Business-as-usual carbon sink - Reforest pasture	188.804
Business-as-usual carbon sink - Restore productivity	223.493
Business-as-usual carbon sink - Total impacted (over 30 years)	1770

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	0.004	0.02	0	0	0	0
Power generation capital investment - biomass w/ccu allam power plant	0	0	0	0	0	0.009	0
Power generation capital investment - biomass w/ccu power plant	0	0	0	0	13.679	21.5	9.816

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	7.298	46.304	46.304	46.304	46.304	46.304
Power generation by technology - biomass w/ccu allam power plant	0	0	0	0	0	8.964	8.964
Power generation by technology - biomass w/ccu power plant	0	0	0	0	15352.6	39483.6	50500.1

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Biomass purchases	0	0.056	0.145	0.147	1.078	3.555	4.269
Capital investment	0	0	0.025	0	11.853	0	39.137
Number of facilities - allam power w ccu	0	0	0	0	0	1	1
Number of facilities - beccs hydrogen	0	0	0	0	0	14	14
Number of facilities - diesel	0	0	0	1	1	1	1
Number of facilities - diesel ccu	0	0	0	0	0	1	1
Number of facilities - power	0	1	1	1	1	1	1
Number of facilities - power ccu	0	0	0	0	12	32	40
Number of facilities - pyrolysis	0	0	0	1	1	1	1
Number of facilities - pyrolysis ccu	0	0	0	0	0	1	2
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	0	0.03	18.53	57.73	69.01
Annual - BECCS	0	0	0	15.19	54.29	65.46
Annual - Cement	0	0	0	3.32	3.42	3.53
Annual - NGCC	0	0	0.03	0.03	0.02	0.02
Cumulative - All	0	0	0.03	18.56	76.29	145.3
Cumulative - BECCS	0	0	0	15.19	69.48	134.94
Cumulative - Cement	0	0	0	3.32	6.74	10.27
Cumulative - NGCC	0	0	0.03	0.06	0.08	0.1

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

variable_name	2025	2030	2035	2040	2045	2050
Annual	0	0.92	3.21	7.13	9.85	10.03
Injection wells	0	2	7	12	20	25
Resource characterization, appraisal and permitting costs cumulative	77.19	216.14	277.89	277.89	277.89	277.89
Wells and facilities construction costs cumulative	0	51.4	200.31	356.97	596.89	741.05

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

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	5206254.4	7551451.9	10714551.7	12655426.5	13113607.8
CO2 pipelines - Spur	0	30849.571	61881.341	951609	2892483.5	3350665.7
CO2 pipelines - Trunk	0	5175404.891	7489570	9762943.1	9762943.1	9762943.1

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	260.837
Carbon sink enhancement potential - All (not counting overlap)	69825.5
Carbon sink enhancement potential - Avoid deforestation	2691.839
Carbon sink enhancement potential - corn-ethanol to energy grasses	-5191.198
Carbon sink enhancement potential - cropland measures	-14089.035
Carbon sink enhancement potential - Cropland to woody energy crops	0
Carbon sink enhancement potential - Extend rotation length	1663.38
Carbon sink enhancement potential - Improve plantations	78.301
Carbon sink enhancement potential - Increase retention of HWP	893.155
Carbon sink enhancement potential - Increase trees outside forests	6042.2
Carbon sink enhancement potential - pasture to energy crops	0
Carbon sink enhancement potential - permanent conservation cover	-833.592
Carbon sink enhancement potential - Reforest cropland	46850.1
Carbon sink enhancement potential - Reforest pasture	10220.6
Carbon sink enhancement potential - Restore productivity	1125.041

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

variable_name	2050
Carbon sink enhancement potential - total	-20113.825
Land impacted for carbon sink enhancement - Accelerate regeneration	105.128
Land impacted for carbon sink enhancement - All (not counting overlap)	16316.1
Land impacted for carbon sink enhancement - Avoid deforestation	722.593
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	3055
Land impacted for carbon sink enhancement - cropland measures	27815.1
Land impacted for carbon sink enhancement - Cropland to woody energy crops	992.348
Land impacted for carbon sink enhancement - Extend rotation length	916.324
Land impacted for carbon sink enhancement - Improve plantations	43.518
Land impacted for carbon sink enhancement - Increase retention of HWP	178.631
Land impacted for carbon sink enhancement - Increase trees outside forests	1704.39
Land impacted for carbon sink enhancement - pasture to energy crops	2545
Land impacted for carbon sink enhancement - permanent conservation cover	1396.545
Land impacted for carbon sink enhancement - Reforest cropland	15598.309
Land impacted for carbon sink enhancement - Reforest pasture	772.838
Land impacted for carbon sink enhancement - Restore productivity	634.872
Land impacted for carbon sink enhancement - total	35804
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	4360.5

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	24.377
Business-as-usual carbon sink - Avoid deforestation	230.185
Business-as-usual carbon sink - Extend rotation length	501.292
Business-as-usual carbon sink - Improve plantations	16.526
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	342.69
Business-as-usual carbon sink - Reforest cropland	1770
Business-as-usual carbon sink - Reforest pasture	188.804
Business-as-usual carbon sink - Restore productivity	223.493
Business-as-usual carbon sink - Total impacted (over 30 years)	1770

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	260.837
Carbon sink enhancement potential - All (not counting overlap)	69825.5
Carbon sink enhancement potential - Avoid deforestation	2691.839
Carbon sink enhancement potential - corn-ethanol to energy grasses	-1392.074
Carbon sink enhancement potential - cropland measures	-15650.658
Carbon sink enhancement potential - Extend rotation length	1663.38
Carbon sink enhancement potential - Improve plantations	78.301
Carbon sink enhancement potential - Increase retention of HWP	893.155
Carbon sink enhancement potential - Increase trees outside forests	6042.2
Carbon sink enhancement potential - permanent conservation cover	-935.703
Carbon sink enhancement potential - Reforest cropland	46850.1
Carbon sink enhancement potential - Reforest pasture	10220.6
Carbon sink enhancement potential - Restore productivity	1125.041
Carbon sink enhancement potential - total	-17978.435
Land impacted for carbon sink enhancement - Accelerate regeneration	105.128
Land impacted for carbon sink enhancement - All (not counting overlap)	16316.1
Land impacted for carbon sink enhancement - Avoid deforestation	722.593
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	825.73
Land impacted for carbon sink enhancement - cropland measures	15765.4
Land impacted for carbon sink enhancement - Extend rotation length	916.324
Land impacted for carbon sink enhancement - Improve plantations	43.518
Land impacted for carbon sink enhancement - Increase retention of HWP	178.631
Land impacted for carbon sink enhancement - Increase trees outside forests	1704.39
Land impacted for carbon sink enhancement - permanent conservation cover	1570.928

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

variable_name	2050
Land impacted for carbon sink enhancement - Reforest cropland	15598.309
Land impacted for carbon sink enhancement - Reforest pasture	772.838
Land impacted for carbon sink enhancement - Restore productivity	634.872
Land impacted for carbon sink enhancement - total	18162
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	4360.5

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	24.377
Business-as-usual carbon sink - Avoid deforestation	230.185
Business-as-usual carbon sink - Extend rotation length	501.292
Business-as-usual carbon sink - Improve plantations	16.526
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	342.69
Business-as-usual carbon sink - Reforest cropland	1770
Business-as-usual carbon sink - Reforest pasture	188.804
Business-as-usual carbon sink - Restore productivity	223.493
Business-as-usual carbon sink - Total impacted (over 30 years)	1770