Net-Zero America - south dakota 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	0.63	0.659	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.059	0.141	0.145	0.15	0.157	0.165	0.174
Sale of space heating units by type - Electric Resistance	0.187	0.23	0.227	0.225	0.219	0.211	0.203
Sale of space heating units by type - Fossil	0.157	0.201	0.193	0.187	0.183	0.18	0.182
Sale of space heating units by type - Gas	0.597	0.428	0.435	0.438	0.442	0.444	0.44
Sales of cooking units - Electric Resistance	0.711	0.711	0.711	0.711	0.711	0.711	0.711
Sales of cooking units - Gas	0.289	0.289	0.289	0.289	0.289	0.289	0.289
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	0.411	0.569	0.569	0.567	0.566	0.566	0.565
Sales of water heating units by type - Gas Furnace	0.588	0.431	0.431	0.433	0.434	0.434	0.435
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	0.981	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	0.019	0.022	0.022	0.021	0.019	0.018	0.017
End-use technology sales by technology - LDV - EV	0.025	0.043	0.049	0.06	0.073	0.087	0.098
End-use technology sales by technology - LDV - gasoline	0.919	0.886	0.87	0.856	0.838	0.818	0.801
End-use technology sales by technology - LDV - hybrid	0.034	0.043	0.053	0.059	0.066	0.073	0.079
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 3: *E- scenario - PILLAR 6: Land carbon sinks - Agriculture*

variable_name	2020	2030	2050
Carbon sink enhancement potential - Accelerate regeneration	0	0	662.523
Carbon sink enhancement potential - All (not counting overlap)	0	0	23645.8
Carbon sink enhancement potential - Avoid deforestation	0	0	1220.767
Carbon sink enhancement potential - Extend rotation length	0	0	508.78
Carbon sink enhancement potential - Improve plantations	0	0	72.272
Carbon sink enhancement potential - Increase retention of HWP	0	0	740.525
Carbon sink enhancement potential - Increase trees outside forests	0	0	4044.4
Carbon sink enhancement potential - Reforest cropland	0	0	7999.8
Carbon sink enhancement potential - Reforest pasture	0	0	7299.1
Carbon sink enhancement potential - Restore productivity	0	0	1097.577
Land impacted for carbon sink enhancement - Accelerate regeneration	0	0	267.022
Land impacted for carbon sink enhancement - All (not counting overlap)	0	0	4314.9
Land impacted for carbon sink enhancement - Avoid deforestation	0	0	327.698
Land impacted for carbon sink enhancement - Extend rotation length	0	0	280.277
Land impacted for carbon sink enhancement - Improve plantations	0	0	40.167
Land impacted for carbon sink enhancement - Increase retention of HWP	0	0	148.105
Land impacted for carbon sink enhancement - Increase trees outside forests	0	0	1140.885
Land impacted for carbon sink enhancement - Natural uptake	-2.82	0.391	0.112
Land impacted for carbon sink enhancement - Reforest cropland	0	0	2663.497
Land impacted for carbon sink enhancement - Reforest pasture	0	0	551.926
Land impacted for carbon sink enhancement - Restore productivity	0	0	619.374
Land impacted for carbon sink enhancement - Retained in Hardwood Products	-0.121	-0.251	-0.264
Land impacted for carbon sink enhancement - Total	-2.941	0.14	-0.152
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	0	0	1724.08

Table 4: *E- scenario - PILLAR 6: Land carbon sinks - Forests*

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	61.918
Business-as-usual carbon sink - Avoid deforestation	104.389
Business-as-usual carbon sink - Extend rotation length	153.331
Business-as-usual carbon sink - Improve plantations	15.253

Table 4: *E- 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	229.384
Business-as-usual carbon sink - Reforest cropland	302.237
Business-as-usual carbon sink - Reforest pasture	134.835
Business-as-usual carbon sink - Restore productivity	218.037
Business-as-usual carbon sink - Total impacted (over 30 years)	302.237

Table 5: *E- scenario - PILLAR 1: Efficiency/Electrification - Overview*

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.03	0.03	0.03	0.03	0.03	0.03	0.031
Final energy demand by sector - industry	0.163	0.172	0.176	0.178	0.183	0.186	0.191
Final energy demand by sector - residential	0.041	0.039	0.038	0.037	0.037	0.037	0.037
Final energy demand by sector - transportation	0.091	0.086	0.079	0.075	0.075	0.077	0.08

Table 6: *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	2477968736	2547871904	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	0.045	0.131	0.445	0.703	0.745	0.75	0.75
Sales of space heating units - Electric Resistance	0.073	0.064	0.108	0.184	0.237	0.245	0.245
Sales of space heating units - Fossil	0.061	0.025	0.019	0.009	0.001	0	0
Sales of space heating units - Gas Furnace	0.821	0.781	0.428	0.104	0.017	0.005	0.005
Sales of water heating units - Electric Heat Pump	0.011	0.008	0.008	0.008	0.008	0.008	0.008
Sales of water heating units - Electric Resistance	0.097	0.071	0.071	0.07	0.07	0.071	0.07
Sales of water heating units - Gas Furnace	0.874	0.911	0.911	0.911	0.911	0.911	0.911
Sales of water heating units - Other	0.018	0.01	0.01	0.01	0.01	0.01	0.01

Table 7: *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	0.688	0.705	0.782	0.806	0.832	0.856

Table 8: *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	0.653	0.813	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.067	0.12	0.356	0.811	0.895	0.901	0.896
Sale of space heating units by type - Electric Resistance	0.185	0.236	0.187	0.081	0.061	0.06	0.063
Sale of space heating units by type - Fossil	0.156	0.211	0.151	0.052	0.032	0.029	0.031
Sale of space heating units by type - Gas	0.592	0.433	0.306	0.057	0.012	0.01	0.009
Sales of cooking units - Electric Resistance	0.715	0.775	0.962	0.998	1	1	1
Sales of cooking units - Gas	0.285	0.225	0.038	0.002	0	0	0
Sales of water heating units by type - Electric Heat Pump	0	0.007	0.096	0.292	0.327	0.329	0.33
Sales of water heating units by type - Electric Resistance	0.411	0.571	0.599	0.659	0.67	0.671	0.67
Sales of water heating units by type - Gas Furnace	0.588	0.421	0.305	0.049	0.003	0	0
Sales of water heating units by type - Other	0	0	0	0	0	0	0

Table 9: *RE- scenario - PILLAR 1: Efficiency/Electrification - Transportation*

variable_name	2020	2025	2030	2035	2040	2045	2050
End-use technology sales by technology - HDV - diesel	0.972	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	0.019	0.021	0.014	0.004	0.001	0	0
End-use technology sales by technology - LDV - EV	0.029	0.121	0.415	0.798	0.961	0.993	1
End-use technology sales by technology - LDV - gasoline	0.916	0.816	0.539	0.185	0.036	0.006	0
End-use technology sales by technology - LDV - hybrid	0.034	0.038	0.029	0.011	0.003	0.001	0
End-use technology sales by technology - LDV - hydrogen FC	0.001	0.004	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	244262451	623784304	1014523138	1535336778	1672606948	1593870718
Number of public EV charging plugs - DC Fast Charging	54	0	519.285	0	2314.8	0	3749.7
Number of public EV charging plugs - L2 Charging	74	0	12512.1	0	55775.5	0	90347.5

Table 10: *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	0	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	0.023	0	0	0	0
Power generation capital investment - Solar PV - Base	0	0	0	0	0	0.094	0
Power generation capital investment - Wind - Base	0	0.537	4.505	4.271	2.85	6.724	12.677
Power generation capital investment - Wind - Constrained	0	1.927	4.75	8.878	18.081	29.244	41.267

Table 11: *RE- 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	0
Power generation by technology - biomass w/ccu power plant	0	0	25.984	25.984	25.984	25.984	25.984

Table 12: *RE- scenario - PILLAR 2: Clean Electricity - Transmission*

variable_name	2020	2025	2030	2035	2040	2045	2050
HV transmission for wind and solar - base all	0	455.643	1023.2	1691.1	2568.3	4662.9	8417.9
HV transmission for wind and solar - base other intra-state	0	0	0	0	0	0	0
HV transmission for wind and solar - base spur intra-state	0	161.429	391.48	652.079	819.274	1209.8	2203.9
HV transmission for wind and solar - constrained all	0	561.959	1265.1	3784.8	7975.5	17238.7	38912.2
HV transmission for wind and solar - constrained other intra-state	0	0	0	0	0	0	0
HV transmission for wind and solar - constrained spur intra-state	0	212.119	391.788	1108.9	2900	7032.8	15468.1

Table 13: *RE- scenario - PILLAR 3: Bioenergy and Hydrogen - Bioconversion*

variable_name	2020	2025	2030	2035	2040	2045	2050
Biomass purchases	0	0	0.001	0.074	0.074	0.093	1.276
Capital investment	0	0	0.02	0	1.043	0	23.389
Number of facilities - allam power w ccu	0	0	0	0	0	0	0
Number of facilities - beccs hydrogen	0	0	0	2	2	3	12
Number of facilities - diesel	0	0	0	0	0	0	0
Number of facilities - diesel ccu	0	0	0	0	0	0	0
Number of facilities - power	0	0	0	0	0	0	0
Number of facilities - power ccu	0	0	1	1	1	1	1
Number of facilities - pyrolysis	0	0	0	0	0	0	0
Number of facilities - pyrolysis ccu	0	0	0	0	0	0	10
Number of facilities - sng	0	0	0	0	0	0	0
Number of facilities - sng ccu	0	0	1	1	1	1	1

Table 14: *RE- scenario - PILLAR 4: CO2 capture, use, storage - CO2 capture*

variable_name	2025	2030	2035	2040	2045	2050
Annual - All	0	0.03	1.45	1.45	1.81	20.38
Annual - BECCS	0	0.03	1.45	1.45	1.81	20.38
Annual - Cement	0	0	0	0	0	0
Annual - NGCC	0	0	0	0	0	0
Cumulative - All	0	0.03	1.48	2.93	4.74	25.12
Cumulative - BECCS	0	0.03	1.48	2.93	4.74	25.12
Cumulative - Cement	0	0	0	0	0	0
Cumulative - NGCC	0	0	0	0	0	0

Table 15: *RE- scenario - PILLAR 4: CO2 capture, use, storage - CO2 storage*

variable_name	2025	2030	2035	2040	2045	2050
Annual	0	1.1	1.76	3.61	6.02	8.39
Injection wells	0	1	5	9	14	18
Resource characterization, appraisal and permitting costs cumulative	44.28	132.85	177.14	177.14	177.14	177.14
Wells and facilities construction costs cumulative	0	36.86	143.65	255.99	428.04	531.42

Table 16: *RE- scenario - PILLAR 4: CO2 capture, use, storage - CO2 transportation*

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	82490.228	1853860.12	1853841.12	1972030.634	3964874.1
CO2 pipelines - Spur	0	82490.228	191545.043	191526.443	309716.357	2302560.3
CO2 pipelines - Trunk	0	0	1662314.777	1662314.777	1662314.777	1662314.777

Table 17: *RE- scenario - IMPACTS - Jobs*

variable_name	2020	2025	2030	2035	2040	2045	2050
Jobs by economic sector - agriculture	1820.7	1820.7	1821.9	1878.7	1056.3	252.493	1241.6
Jobs by economic sector - construction	1976.6	2382.5	3423	5290.4	4970.8	6712	11980.5
Jobs by economic sector - manufacturing	1942.6	2681.1	3032.8	3656.5	3137	2500	4113.9
Jobs by economic sector - mining	622.696	501.751	400.044	310.742	227.873	204.273	174.677
Jobs by economic sector - other	137.577	174.294	278.532	399.767	453.839	653.548	1076.5

Table 17: *RE- scenario - IMPACTS - Jobs (continued)*

variable_name	2020	2025	2030	2035	2040	2045	2050
Jobs by economic sector - pipeline	103.165	102.802	89.468	303.212	86.757	110.546	497.119
Jobs by economic sector - professional	1432.4	1673.6	2467.7	3438.5	3651.5	4890.7	9468.5
Jobs by economic sector - trade	1525.8	1498.9	1772.1	2110.5	2048.2	2595.8	4558
Jobs by economic sector - utilities	1830.7	2188.7	2836.5	4802.4	4445.9	6191.3	11658.7
Jobs by resource sector - Biomass	4393.1	4261.2	4146	4253.8	2535.9	1005.9	5600.2
Jobs by resource sector - CO2	0	23.518	60.678	1988.4	356.393	749.544	4099.6
Jobs by resource sector - Coal	189.912	60.882	0	0	0	0	0
Jobs by resource sector - Grid	2725	3463.6	4769.4	6848.4	7760.6	10845.4	18517
Jobs by resource sector - Natural Gas	809.533	803.631	633.893	560.458	468.167	447.585	321.068
Jobs by resource sector - Nuclear	0	0	0	0	0	0	0
Jobs by resource sector - Oil	1375.7	1229.3	1023.1	789.234	580.525	430.816	312.287
Jobs by resource sector - Solar	219.152	521.991	613.448	896.762	929.549	916.943	1173.1
Jobs by resource sector - Wind	1679.8	2660.4	4875.5	6853.7	7447	9714.3	14746.2
Median wages - All	52886.9	53946.3	55469.9	57236.8	59078.9	61497.2	62410.8
Required Level of Education - Associates degree or some college	2993.8	3549.6	4569	6608.5	6148.2	7728.3	14138.2
Required Level of Education - Bachelors degree	2133.1	2449.3	3096.9	4278	4048.4	5035.4	9332.5
Required Level of Education - Doctoral degree	75.997	86.341	117.574	160.901	161.69	209.51	399.227
Required Level of Education - High school diploma or less	5663.6	6337.2	7558.8	10062.8	8678.3	9818.8	18434.7
Required Level of Education - Masters or professional degree	525.639	601.957	779.742	1080.5	1041.5	1318.6	2464.9
Wage income - All	602523590	702650216	894340801	1270208977	1186283119	1482867551	2794339067

Table 18: *RE- scenario - PILLAR 6: Land carbon sinks - Agriculture*

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	662.523
Carbon sink enhancement potential - All (not counting overlap)	23645.8
Carbon sink enhancement potential - Avoid deforestation	1220.767
Carbon sink enhancement potential - corn-ethanol to energy grasses	-2310.018
Carbon sink enhancement potential - cropland measures	-11290.178
Carbon sink enhancement potential - Extend rotation length	508.78
Carbon sink enhancement potential - Improve plantations	72.272
Carbon sink enhancement potential - Increase retention of HWP	740.525
Carbon sink enhancement potential - Increase trees outside forests	4044.4
Carbon sink enhancement potential - permanent conservation cover	-645.95
Carbon sink enhancement potential - Reforest cropland	7999.8
Carbon sink enhancement potential - Reforest pasture	7299.1
Carbon sink enhancement potential - Restore productivity	1097.577
Carbon sink enhancement potential - total	-14246.145
Land impacted for carbon sink enhancement - Accelerate regeneration	267.022
Land impacted for carbon sink enhancement - All (not counting overlap)	4314.9
Land impacted for carbon sink enhancement - Avoid deforestation	327.698
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	1397.032
Land impacted for carbon sink enhancement - cropland measures	10094
Land impacted for carbon sink enhancement - Extend rotation length	280.277
Land impacted for carbon sink enhancement - Improve plantations	40.167
Land impacted for carbon sink enhancement - Increase retention of HWP	148.105
Land impacted for carbon sink enhancement - Increase trees outside forests	1140.885
Land impacted for carbon sink enhancement - permanent conservation cover	1073.931
Land impacted for carbon sink enhancement - Reforest cropland	2663.497
Land impacted for carbon sink enhancement - Reforest pasture	551.926
Land impacted for carbon sink enhancement - Restore productivity	619.374
Land impacted for carbon sink enhancement - total	12565
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	1724.08

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	61.918
Business-as-usual carbon sink - Avoid deforestation	104.389
Business-as-usual carbon sink - Extend rotation length	153.331
Business-as-usual carbon sink - Improve plantations	15.253
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	229.384
Business-as-usual carbon sink - Reforest cropland	302.237
Business-as-usual carbon sink - Reforest pasture	134.835
Business-as-usual carbon sink - Restore productivity	218.037
Business-as-usual carbon sink - Total impacted (over 30 years)	302.237

Table 20: *RE- scenario - IMPACTS - Fossil fuel industries*

variable_name	2020	2025	2030	2035	2040	2045	2050
Natural gas consumption	68233.7	69247.1	58371.4	46816.3	35242.6	22173.4	15378.9
Oil consumption	26698.7	25998.6	23416.5	19290.5	15273.4	12106.5	9454.4

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.03	0.03	0.029	0.027	0.025	0.024	0.023
Final energy demand by sector - industry	0.163	0.17	0.174	0.174	0.176	0.178	0.179
Final energy demand by sector - residential	0.041	0.039	0.037	0.033	0.028	0.025	0.022
Final energy demand by sector - transportation	0.091	0.085	0.076	0.064	0.054	0.048	0.045

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	2507475761	2730539947	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	0.045	0.077	0.302	0.778	0.862	0.868	0.868
Sales of space heating units - Electric Resistance	0.073	0.058	0.084	0.12	0.127	0.127	0.127
Sales of space heating units - Fossil	0.061	0.022	0.004	0	0	0	0
Sales of space heating units - Gas Furnace	0.821	0.843	0.61	0.101	0.01	0.005	0.005
Sales of water heating units - Electric Heat Pump	0.011	0.018	0.145	0.42	0.469	0.472	0.472
Sales of water heating units - Electric Resistance	0.097	0.08	0.203	0.47	0.518	0.521	0.521
Sales of water heating units - Gas Furnace	0.874	0.892	0.644	0.103	0.006	0	0
Sales of water heating units - Other	0.018	0.01	0.007	0.007	0.007	0.007	0.007

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	0.836	0.87	1.601	1.719	1.536	1.618

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	0.651	0.8	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.067	0.102	0.117	0.168	0.285	0.428	0.508
Sale of space heating units by type - Electric Resistance	0.185	0.239	0.235	0.224	0.197	0.164	0.148
Sale of space heating units by type - Fossil	0.156	0.217	0.215	0.202	0.171	0.137	0.121
Sale of space heating units by type - Gas	0.592	0.442	0.432	0.406	0.347	0.271	0.223
Sales of cooking units - Electric Resistance	0.714	0.721	0.747	0.816	0.912	0.972	0.992
Sales of cooking units - Gas	0.286	0.279	0.253	0.184	0.088	0.028	0.008
Sales of water heating units by type - Electric Heat Pump	0	0.002	0.008	0.027	0.074	0.133	0.168
Sales of water heating units by type - Electric Resistance	0.411	0.57	0.571	0.575	0.59	0.608	0.619
Sales of water heating units by type - Gas Furnace	0.588	0.428	0.421	0.397	0.336	0.258	0.213
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	0.019	0.022	0.021	0.017	0.011	0.006	0.002
End-use technology sales by technology - LDV - EV	0.015	0.039	0.102	0.232	0.454	0.7	0.868
End-use technology sales by technology - LDV - gasoline	0.929	0.89	0.822	0.701	0.496	0.27	0.118
End-use technology sales by technology - LDV - hybrid	0.035	0.044	0.05	0.047	0.037	0.023	0.011
End-use technology sales by technology - LDV - hydrogen FC	0.001	0.004	0.003	0.003	0.002	0.001	0.001
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	39111129	83077178	279687781	882839090	1285262646
Number of public EV charging plugs - DC Fast Charging	54	0	155.74	0	854.71	0	2401.7
Number of public EV charging plugs - L2 Charging	74	0	3752.5	0	20594.1	0	57867.5

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	662.523
Carbon sink enhancement potential - All (not counting overlap)	23645.8
Carbon sink enhancement potential - Avoid deforestation	1220.767
Carbon sink enhancement potential - corn-ethanol to energy grasses	-2310.018

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

variable_name	2050
Carbon sink enhancement potential - cropland measures	-11290.178
Carbon sink enhancement potential - Extend rotation length	508.78
Carbon sink enhancement potential - Improve plantations	72.272
Carbon sink enhancement potential - Increase retention of HWP	740.525
Carbon sink enhancement potential - Increase trees outside forests	4044.4
Carbon sink enhancement potential - permanent conservation cover	-645.95
Carbon sink enhancement potential - Reforest cropland	7999.8
Carbon sink enhancement potential - Reforest pasture	7299.1
Carbon sink enhancement potential - Restore productivity	1097.577
Carbon sink enhancement potential - total	-14246.145
Land impacted for carbon sink enhancement - Accelerate regeneration	267.022
Land impacted for carbon sink enhancement - All (not counting overlap)	4314.9
Land impacted for carbon sink enhancement - Avoid deforestation	327.698
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	1397.032
Land impacted for carbon sink enhancement - cropland measures	10094
Land impacted for carbon sink enhancement - Extend rotation length	280.277
Land impacted for carbon sink enhancement - Improve plantations	40.167
Land impacted for carbon sink enhancement - Increase retention of HWP	148.105
Land impacted for carbon sink enhancement - Increase trees outside forests	1140.885
Land impacted for carbon sink enhancement - permanent conservation cover	1073.931
Land impacted for carbon sink enhancement - Reforest cropland	2663.497
Land impacted for carbon sink enhancement - Reforest pasture	551.926
Land impacted for carbon sink enhancement - Restore productivity	619.374
Land impacted for carbon sink enhancement - total	12565
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	1724.08

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	61.918
Business-as-usual carbon sink - Avoid deforestation	104.389
Business-as-usual carbon sink - Extend rotation length	153.331
Business-as-usual carbon sink - Improve plantations	15.253
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	229.384
Business-as-usual carbon sink - Reforest cropland	302.237
Business-as-usual carbon sink - Reforest pasture	134.835
Business-as-usual carbon sink - Restore productivity	218.037
Business-as-usual carbon sink - Total impacted (over 30 years)	302.237

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.03	0.03	0.029	0.028	0.027	0.027	0.026
Final energy demand by sector - industry	0.163	0.171	0.174	0.176	0.179	0.181	0.183
Final energy demand by sector - residential	0.041	0.039	0.037	0.036	0.034	0.032	0.031
Final energy demand by sector - transportation	0.091	0.086	0.079	0.073	0.069	0.064	0.058

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	2507372344	2734738987	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	0.045	0.063	0.078	0.125	0.236	0.377	0.459
Sales of space heating units - Electric Resistance	0.073	0.055	0.057	0.062	0.073	0.085	0.092
Sales of space heating units - Fossil	0.061	0.025	0.025	0.022	0.018	0.014	0.013
Sales of space heating units - Gas Furnace	0.821	0.856	0.84	0.791	0.673	0.524	0.436
Sales of water heating units - Electric Heat Pump	0.011	0.011	0.019	0.047	0.113	0.196	0.245
Sales of water heating units - Electric Resistance	0.097	0.074	0.082	0.108	0.172	0.253	0.3
Sales of water heating units - Gas Furnace	0.874	0.905	0.889	0.836	0.707	0.543	0.447
Sales of water heating units - Other	0.018	0.01	0.01	0.009	0.009	0.008	0.008

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	0.676	0.691	0.924	0.965	1.37	1.455

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	0.519	0.39	0	0.205
Power generation capital investment - Wind - Base	1.958	9.015	7.522	14.984	42.792	106.192

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	516.945	1165.9	2097.6	4744.9	10927.9	26430.2
HV transmission for wind and solar - base other intra-state	0	0	0	0	0	0	0
HV transmission for wind and solar - base spur intra-state	0	182.689	449.811	697.346	1165.8	2882	9022.9

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	662.523
Carbon sink enhancement potential - All (not counting overlap)	23645.8
Carbon sink enhancement potential - Avoid deforestation	1220.767
Carbon sink enhancement potential - corn-ethanol to energy grasses	-2310.018
Carbon sink enhancement potential - cropland measures	-11290.178
Carbon sink enhancement potential - Extend rotation length	508.78
Carbon sink enhancement potential - Improve plantations	72.272
Carbon sink enhancement potential - Increase retention of HWP	740.525
Carbon sink enhancement potential - Increase trees outside forests	4044.4
Carbon sink enhancement potential - permanent conservation cover	-645.95
Carbon sink enhancement potential - Reforest cropland	7999.8
Carbon sink enhancement potential - Reforest pasture	7299.1
Carbon sink enhancement potential - Restore productivity	1097.577
Carbon sink enhancement potential - total	-14246.145
Land impacted for carbon sink enhancement - Accelerate regeneration	267.022
Land impacted for carbon sink enhancement - All (not counting overlap)	4314.9
Land impacted for carbon sink enhancement - Avoid deforestation	327.698
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	1397.032
Land impacted for carbon sink enhancement - cropland measures	10094
Land impacted for carbon sink enhancement - Extend rotation length	280.277
Land impacted for carbon sink enhancement - Improve plantations	40.167
Land impacted for carbon sink enhancement - Increase retention of HWP	148.105
Land impacted for carbon sink enhancement - Increase trees outside forests	1140.885
Land impacted for carbon sink enhancement - permanent conservation cover	1073.931
Land impacted for carbon sink enhancement - Reforest cropland	2663.497
Land impacted for carbon sink enhancement - Reforest pasture	551.926
Land impacted for carbon sink enhancement - Restore productivity	619.374
Land impacted for carbon sink enhancement - total	12565
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	1724.08

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	61.918
Business-as-usual carbon sink - Avoid deforestation	104.389
Business-as-usual carbon sink - Extend rotation length	153.331
Business-as-usual carbon sink - Improve plantations	15.253
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	229.384
Business-as-usual carbon sink - Reforest cropland	302.237
Business-as-usual carbon sink - Reforest pasture	134.835
Business-as-usual carbon sink - Restore productivity	218.037
Business-as-usual carbon sink - Total impacted (over 30 years)	302.237

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	0	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	0.03	0	0	0	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	0	0	0	0	0	0
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	33.978	33.978	33.978	33.978	33.978

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Biomass purchases	0	0	0.002	0.179	0.229	1.333	1.877
Capital investment	0	0	0.026	0	2.751	0	20.33
Number of facilities - allam power w ccu	0	0	0	0	0	0	0
Number of facilities - beccs hydrogen	0	0	0	3	4	19	19
Number of facilities - diesel	0	0	0	0	0	0	0
Number of facilities - diesel ccu	0	0	0	0	0	1	1
Number of facilities - power	0	0	0	0	0	0	0
Number of facilities - power ccu	0	0	1	1	1	1	1
Number of facilities - pyrolysis	0	0	0	0	0	0	8
Number of facilities - pyrolysis ccu	0	0	0	0	0	1	1
Number of facilities - sng	0	0	0	0	0	0	0
Number of facilities - sng ccu	0	0	1	1	1	2	2

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

variable_name	2025	2030	2035	2040	2045	2050
Annual - All	0	0.03	2.95	3.79	22.01	22.3
Annual - BECCS	0	0.03	2.95	3.79	22.01	22.3
Annual - Cement	0	0	0	0	0	0
Annual - NGCC	0	0	0	0	0	0
Cumulative - All	0	0.03	2.98	6.77	28.78	51.08
Cumulative - BECCS	0	0.03	2.98	6.77	28.78	51.08
Cumulative - Cement	0	0	0	0	0	0
Cumulative - NGCC	0	0	0	0	0	0

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

variable_name	2025	2030	2035	2040	2045	2050
Annual	0	1.85	6.42	13.07	18.71	19.23
Injection wells	0	3	12	22	37	46
Resource characterization, appraisal and permitting costs cumulative	44.28	203.71	318.85	318.85	318.85	318.85
Wells and facilities construction costs cumulative	0	95.83	373.48	665.58	1112.9	1381.7

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

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	64158.428	2061690.12	2139550.493	3634558.5	3613854.5
CO2 pipelines - Spur	0	64158.428	295393.543	373254.416	1868261.8	1847558.8
CO2 pipelines - Trunk	0	0	1766295.777	1766295.777	1766295.777	1766295.777

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	662.523
Carbon sink enhancement potential - All (not counting overlap)	23645.8
Carbon sink enhancement potential - Avoid deforestation	1220.767
Carbon sink enhancement potential - corn-ethanol to energy grasses	-3016.208
Carbon sink enhancement potential - cropland measures	-10766.281
Carbon sink enhancement potential - Cropland to woody energy crops	0
Carbon sink enhancement potential - Extend rotation length	508.78
Carbon sink enhancement potential - Improve plantations	72.272
Carbon sink enhancement potential - Increase retention of HWP	740.525
Carbon sink enhancement potential - Increase trees outside forests	4044.4
Carbon sink enhancement potential - pasture to energy crops	0
Carbon sink enhancement potential - permanent conservation cover	-609.214
Carbon sink enhancement potential - Reforest cropland	7999.8
Carbon sink enhancement potential - Reforest pasture	7299.1
Carbon sink enhancement potential - Restore productivity	1097.577
Carbon sink enhancement potential - total	-14391.704
Land impacted for carbon sink enhancement - Accelerate regeneration	267.022
Land impacted for carbon sink enhancement - All (not counting overlap)	4314.9
Land impacted for carbon sink enhancement - Avoid deforestation	327.698
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	2159.4
Land impacted for carbon sink enhancement - cropland measures	18732.8

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

variable_name	2050
Land impacted for carbon sink enhancement - Cropland to woody energy crops	32.748
Land impacted for carbon sink enhancement - Extend rotation length	280.277
Land impacted for carbon sink enhancement - Improve plantations	40.167
Land impacted for carbon sink enhancement - Increase retention of HWP	148.105
Land impacted for carbon sink enhancement - Increase trees outside forests	1140.885
Land impacted for carbon sink enhancement - pasture to energy crops	169.634
Land impacted for carbon sink enhancement - permanent conservation cover	1014.303
Land impacted for carbon sink enhancement - Reforest cropland	2663.497
Land impacted for carbon sink enhancement - Reforest pasture	551.926
Land impacted for carbon sink enhancement - Restore productivity	619.374
Land impacted for carbon sink enhancement - total	22108.8
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	1724.08

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	61.918
Business-as-usual carbon sink - Avoid deforestation	104.389
Business-as-usual carbon sink - Extend rotation length	153.331
Business-as-usual carbon sink - Improve plantations	15.253
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	229.384
Business-as-usual carbon sink - Reforest cropland	302.237
Business-as-usual carbon sink - Reforest pasture	134.835
Business-as-usual carbon sink - Restore productivity	218.037
Business-as-usual carbon sink - Total impacted (over 30 years)	302.237

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	662.523
Carbon sink enhancement potential - All (not counting overlap)	23645.8
Carbon sink enhancement potential - Avoid deforestation	1220.767
Carbon sink enhancement potential - corn-ethanol to energy grasses	-2310.018
Carbon sink enhancement potential - cropland measures	-11290.178
Carbon sink enhancement potential - Extend rotation length	508.78
Carbon sink enhancement potential - Improve plantations	72.272
Carbon sink enhancement potential - Increase retention of HWP	740.525
Carbon sink enhancement potential - Increase trees outside forests	4044.4
Carbon sink enhancement potential - permanent conservation cover	-645.95
Carbon sink enhancement potential - Reforest cropland	7999.8
Carbon sink enhancement potential - Reforest pasture	7299.1
Carbon sink enhancement potential - Restore productivity	1097.577
Carbon sink enhancement potential - total	-14246.145
Land impacted for carbon sink enhancement - Accelerate regeneration	267.022
Land impacted for carbon sink enhancement - All (not counting overlap)	4314.9
Land impacted for carbon sink enhancement - Avoid deforestation	327.698
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	1397.032
Land impacted for carbon sink enhancement - cropland measures	10094
Land impacted for carbon sink enhancement - Extend rotation length	280.277
Land impacted for carbon sink enhancement - Improve plantations	40.167
Land impacted for carbon sink enhancement - Increase retention of HWP	148.105
Land impacted for carbon sink enhancement - Increase trees outside forests	1140.885
Land impacted for carbon sink enhancement - permanent conservation cover	1073.931
Land impacted for carbon sink enhancement - Reforest cropland	2663.497
Land impacted for carbon sink enhancement - Reforest pasture	551.926
Land impacted for carbon sink enhancement - Restore productivity	619.374
Land impacted for carbon sink enhancement - total	12565
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	1724.08

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	61.918
Business-as-usual carbon sink - Avoid deforestation	104.389
Business-as-usual carbon sink - Extend rotation length	153.331
Business-as-usual carbon sink - Improve plantations	15.253
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	229.384
Business-as-usual carbon sink - Reforest cropland	302.237
Business-as-usual carbon sink - Reforest pasture	134.835
Business-as-usual carbon sink - Restore productivity	218.037
Business-as-usual carbon sink - Total impacted (over 30 years)	302.237