Net-Zero America - california 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	27.681	36.53	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.06	0.234	0.708	0.817	0.823	0.822	0.822
Sale of space heating units by type - Electric Resistance	0.164	0.237	0.152	0.133	0.132	0.133	0.134
Sale of space heating units by type - Fossil	0.033	0.058	0.036	0.03	0.03	0.03	0.029
Sale of space heating units by type - Gas	0.743	0.47	0.103	0.019	0.015	0.015	0.015
Sales of cooking units - Electric Resistance	0.4	0.528	0.919	0.996	1	1	1
Sales of cooking units - Gas	0.6	0.472	0.081	0.004	0	0	0
Sales of water heating units by type - Electric Heat Pump	0	0.112	0.594	0.703	0.708	0.708	0.708
Sales of water heating units by type - Electric Resistance	0.175	0.313	0.272	0.264	0.264	0.264	0.264
Sales of water heating units by type - Gas Furnace	0.798	0.548	0.106	0.005	0	0	0
Sales of water heating units by type - Other	0.027	0.028	0.028	0.028	0.028	0.028	0.028

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	0.012	0.015	0.011	0.004	0.001	0	0
End-use technology sales by technology - LDV - EV	0.052	0.19	0.52	0.84	0.966	0.993	1
End-use technology sales by technology - LDV - gasoline	0.878	0.737	0.43	0.143	0.03	0.006	0
End-use technology sales by technology - LDV - hybrid	0.056	0.054	0.036	0.013	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	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	5550493414	15539817007	23053498332	35766080691	38007453972	36735998336
Number of public EV charging plugs - DC Fast Charging	4352	0	11879.8	0	38870.8	0	60439.5
Number of public EV charging plugs - L2 Charging	21478	0	285498.7	0	934154.6	0	1452500

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	0.007	0.811	0	0.169	0	0
Power generation capital investment - biomass w/ccu allam power plant	0	0	0	0.073	0.003	0.003	0.022
Power generation capital investment - biomass w/ccu power plant	0	0	0.556	0.001	0	0	0
Power generation capital investment - Offshore Wind - Base	0	0.292	0	0	0.987	1.09	7.319
Power generation capital investment - Offshore Wind - Constrained	0	0.153	0	0.119	0.769	1.256	6.347
Power generation capital investment - Solar PV - Base	0	4.104	10.48	19.759	29.19	38.571	39.937
Power generation capital investment - Solar PV - Constrained	0	13.59	9.203	26.756	27.794	30.218	38.767
Power generation capital investment - Wind - Base	0	0	0	0	0.06	0.103	0
Power generation capital investment - Wind - Constrained	0	0.068	0	0.657	1.245	0.43	0.3

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	13.453	1606.1	1606.1	1952.4	1952.4	1952.4
Power generation by technology - biomass w/ccu allam power plant	0	0	0	72.546	75.471	78.948	100.543
Power generation by technology - biomass w/ccu power plant	0	0	623.689	624.981	624.981	624.981	624.981

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	6637.7	10121.6	23853.1	43629.3	73698.4	122428
HV transmission for wind and solar - base other intra-state	0	5287.6	7577.9	16843.1	32193	56724.4	95064.7
HV transmission for wind and solar - base spur intra-state	0	625.797	1592.6	4122.2	7205	11625.4	20368.3
HV transmission for wind and solar - constrained all	0	7026.5	11583	22925.2	50442.2	76174.6	129035.1
HV transmission for wind and solar - constrained other intra-state	0	5129.6	8657.2	17288.5	40028.1	61297.9	100604.6
HV transmission for wind and solar - constrained spur intra-state	0	526.726	1213.5	3109.9	7020	10883.4	20349.1

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Biomass purchases	0	0.008	0.106	0.363	0.494	0.615	0.68
Capital investment	0	0	1.34	0	11.075	0	5.343

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Number of facilities - allam power w ccu	0	0	0	4	5	6	7
Number of facilities - beccs hydrogen	0	0	0	8	14	18	21
Number of facilities - diesel	0	0	0	1	1	1	1
Number of facilities - diesel ccu	0	0	0	4	6	7	8
Number of facilities - power	0	1	1	1	2	2	2
Number of facilities - power ccu	0	0	4	6	6	6	6
Number of facilities - pyrolysis	0	0	0	1	1	1	1
Number of facilities - pyrolysis ccu	0	0	0	4	6	7	8
Number of facilities - sng	0	1	1	1	1	1	1
Number of facilities - sng ccu	0	0	4	4	4	4	4

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

variable_name	2025	2030	2035	2040	2045	2050
Annual - All	0	0.75	26.14	37.54	49.82	57.65
Annual - BECCS	0	0.62	10.59	15.29	19.98	22.53
Annual - Cement	0	0	6.71	9.95	13.69	14.14
Annual - NGCC	0	0.13	8.85	12.29	16.16	20.99
Cumulative - All	0	0.75	26.89	64.43	114.25	171.9
Cumulative - BECCS	0	0.62	11.21	26.5	46.48	69.01
Cumulative - Cement	0	0	6.71	16.66	30.35	44.49
Cumulative - NGCC	0	0.13	8.98	21.27	37.43	58.42

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

variable_name	2025	2030	2035	2040	2045	2050
Annual	0	0	28.18	41.56	53.36	80.14
Injection wells	0	0	62	92	122	174
Resource characterization, appraisal and permitting costs cumulative	250	900	1370	1370	1370	1370
Wells and facilities construction costs cumulative	0	0	1860	2760	3660	5220

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

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	5345576.6	7703028.9	8536785.7	9002471.6	9776287
CO2 pipelines - Spur	0	423958.739	2015665.8	2849423.7	3315109.5	4088924.9
CO2 pipelines - Trunk	0	4921618.1	5687362.1	5687362.1	5687362.1	5687362.1

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Jobs by economic sector - agriculture	749.677	807.233	1385.9	1883.3	1859.1	1652.6	1456.2
Jobs by economic sector - construction	72211.8	58142.8	61481.6	76373.5	88452.4	98057.6	134482.6
Jobs by economic sector - manufacturing	44137.2	45728.3	65320.1	80973	73649.3	64840.1	72018.9
Jobs by economic sector - mining	37899.3	32912	26356.2	20984.1	13552.1	9001.6	5319.8
Jobs by economic sector - other	10424.8	7992.9	9224.4	12621	16585.5	20592.6	33114
Jobs by economic sector - pipeline	2742.4	2737.9	3004.7	2338.4	1854.7	1424.8	1183.7
Jobs by economic sector - professional	30079	27553	28473.9	35760.1	40983.1	46257.9	64798.7
Jobs by economic sector - trade	26292.5	23487.6	23021.3	26403.1	29088.4	32629.7	46719.4
Jobs by economic sector - utilities	25311.2	32003.3	34619.8	51425.6	61771.3	69870.3	89340.2
Jobs by resource sector - Biomass	2461.1	2736.3	3641.5	5139	5464.6	6044.5	6279.5
Jobs by resource sector - CO2	0	127.033	5221.6	3729.8	3208.8	3424.6	4510.3
Jobs by resource sector - Coal	24.246	21.806	7.302	0	0	0	0
Jobs by resource sector - Grid	30513.2	43984.6	50183.6	87779	109694.8	127592.7	169012.5
Jobs by resource sector - Natural Gas	22779.2	24459.1	18977.6	17499	16092.5	13995.8	11074.2
Jobs by resource sector - Nuclear	1191.7	691.022	0	0	0	0	0
Jobs by resource sector - Oil	79520.1	74368.1	64968.5	55609.5	40007	29393	18443
Jobs by resource sector - Solar	104062.4	68196.3	77935.2	106738.8	126628.4	145178.1	216772.8
Jobs by resource sector - Wind	9296	16780.7	31952.7	32267.1	26699.9	18698.5	22341.3
Median wages - All	67847.8	69496.6	69306.5	70109.7	71265.8	72596.2	73491.7
Required Level of Education - Associates degree or some college	75553.1	70243.2	77778.5	96474.9	103857.5	110068.8	144678.8
Required Level of Education - Bachelors degree	53962.6	50530.7	53560.4	63482	65655.1	68043	87442.9
Required Level of Education - Doctoral degree	1910.9	1723.6	1739	2039.1	2180	2343.8	3146.3
Required Level of Education - High school diploma or less	105624	96899.4	107378.9	131957.8	140500.6	147387.2	191596
Required Level of Education - Masters or professional degree	12797.4	11968	12431.1	14808.3	15602.8	16484.4	21569.5
Wage income - All	16953542454	16080632386	17528528024	21649590157	23363754778	25000770909	32962388360

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	6561.3
Carbon sink enhancement potential - All (not counting overlap)	72255.3
Carbon sink enhancement potential - Avoid deforestation	8320.3
Carbon sink enhancement potential - corn-ethanol to energy grasses	0
Carbon sink enhancement potential - cropland measures	-6064.271
Carbon sink enhancement potential - Extend rotation length	22918.4
Carbon sink enhancement potential - Improve plantations	2267.347
Carbon sink enhancement potential - Increase retention of HWP	10947
Carbon sink enhancement potential - Increase trees outside forests	3386.5

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

variable_name	2050
Carbon sink enhancement potential - permanent conservation cover	-70.841
Carbon sink enhancement potential - Reforest cropland	503.536
Carbon sink enhancement potential - Reforest pasture	4272.5
Carbon sink enhancement potential - Restore productivity	13078.4
Carbon sink enhancement potential - total	-6135.112
Land impacted for carbon sink enhancement - Accelerate regeneration	2644.51
Land impacted for carbon sink enhancement - All (not counting overlap)	14510.7
Land impacted for carbon sink enhancement - Avoid deforestation	2233.463
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	0
Land impacted for carbon sink enhancement - cropland measures	5738.1
Land impacted for carbon sink enhancement - Extend rotation length	12625.3
Land impacted for carbon sink enhancement - Improve plantations	1260.12
Land impacted for carbon sink enhancement - Increase retention of HWP	2189.4
Land impacted for carbon sink enhancement - Increase trees outside forests	955.287
Land impacted for carbon sink enhancement - permanent conservation cover	110.676
Land impacted for carbon sink enhancement - Reforest cropland	167.648
Land impacted for carbon sink enhancement - Reforest pasture	323.069
Land impacted for carbon sink enhancement - Restore productivity	7380.3
Land impacted for carbon sink enhancement - total	5848.8
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	15268.4

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	613.209
Business-as-usual carbon sink - Avoid deforestation	711.478
Business-as-usual carbon sink - Extend rotation length	6906.9
Business-as-usual carbon sink - Improve plantations	478.527
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	192.068
Business-as-usual carbon sink - Reforest cropland	19.024
Business-as-usual carbon sink - Reforest pasture	78.926
Business-as-usual carbon sink - Restore productivity	2598.1
Business-as-usual carbon sink - Total impacted (over 30 years)	19.024

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Natural gas consumption	1629826	1654031	1394255	1118250	841801.7	529633.4	367339.9
Oil consumption	578667.8	546334.4	473811.1	370883.4	276724	202260.3	141530.1

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.793	0.798	0.775	0.732	0.7	0.692	0.702
Final energy demand by sector - industry	1.021	1.057	1.074	1.125	1.184	1.218	1.259
Final energy demand by sector - residential	0.878	0.82	0.708	0.579	0.478	0.418	0.385
Final energy demand by sector - transportation	3.056	2.945	2.657	2.291	1.958	1.742	1.635

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	120477695119	131958287417	0	0	0	0
Sales of cooking units - Electric Resistance	0.275	0.417	0.782	0.854	0.858	0.858	0.858
Sales of cooking units - Gas	0.725	0.583	0.218	0.146	0.142	0.142	0.142
Sales of space heating units - Electric Heat Pump	0.017	0.209	0.629	0.756	0.767	0.767	0.767
Sales of space heating units - Electric Resistance	0.114	0.143	0.196	0.222	0.226	0.226	0.226
Sales of space heating units - Fossil	0	0	0	0	0	0	0
Sales of space heating units - Gas Furnace	0.869	0.648	0.175	0.023	0.007	0.007	0.007
Sales of water heating units - Electric Heat Pump	0.006	0.115	0.575	0.68	0.685	0.685	0.685
Sales of water heating units - Electric Resistance	0.02	0.069	0.262	0.307	0.309	0.309	0.309
Sales of water heating units - Gas Furnace	0.968	0.81	0.157	0.007	0	0	0
Sales of water heating units - Other	0.005	0.006	0.006	0.006	0.006	0.006	0.006

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	12.639	13.045	29.279	31.569	24.569	25.754

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	27.495	36.242	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.06	0.143	0.197	0.353	0.592	0.748	0.803
Sale of space heating units by type - Electric Resistance	0.164	0.253	0.243	0.215	0.173	0.145	0.136
Sale of space heating units by type - Fossil	0.033	0.063	0.061	0.053	0.041	0.034	0.031
Sale of space heating units by type - Gas	0.743	0.541	0.5	0.38	0.194	0.073	0.03
Sales of cooking units - Electric Resistance	0.398	0.414	0.469	0.614	0.816	0.941	0.984
Sales of cooking units - Gas	0.602	0.586	0.531	0.386	0.184	0.059	0.016
Sales of water heating units by type - Electric Heat Pump	0	0.019	0.074	0.232	0.475	0.633	0.689
Sales of water heating units by type - Electric Resistance	0.175	0.321	0.316	0.302	0.282	0.269	0.265
Sales of water heating units by type - Gas Furnace	0.798	0.632	0.582	0.438	0.215	0.069	0.018
Sales of water heating units by type - Other	0.027	0.028	0.028	0.028	0.028	0.028	0.028

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	0.974	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	0.012	0.017	0.02	0.016	0.01	0.005	0.002
End-use technology sales by technology - LDV - EV	0.023	0.056	0.137	0.289	0.517	0.741	0.884
End-use technology sales by technology - LDV - gasoline	0.904	0.856	0.766	0.628	0.425	0.227	0.101
End-use technology sales by technology - LDV - hybrid	0.059	0.066	0.072	0.064	0.046	0.026	0.012
End-use technology sales by technology - LDV - hydrogen FC	0.001	0.004	0.003	0.002	0.002	0.001	0
End-use technology sales by technology - LDV - other	0.001	0.001	0.001	0.001	0	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	1127959142	1859111204	6770580051	19756280673	29317649547
Number of public EV charging plugs - DC Fast Charging	4352	0	5460.9	0	15809.1	0	38711.4
Number of public EV charging plugs - L2 Charging	21478	0	131237.7	0	379928.9	0	930325.3

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	6561.3
Carbon sink enhancement potential - All (not counting overlap)	72255.3
Carbon sink enhancement potential - Avoid deforestation	8320.3
Carbon sink enhancement potential - corn-ethanol to energy grasses	0
Carbon sink enhancement potential - cropland measures	-6064.271
Carbon sink enhancement potential - Extend rotation length	22918.4
Carbon sink enhancement potential - Improve plantations	2267.347
Carbon sink enhancement potential - Increase retention of HWP	10947
Carbon sink enhancement potential - Increase trees outside forests	3386.5
Carbon sink enhancement potential - permanent conservation cover	-70.841
Carbon sink enhancement potential - Reforest cropland	503.536
Carbon sink enhancement potential - Reforest pasture	4272.5
Carbon sink enhancement potential - Restore productivity	13078.4
Carbon sink enhancement potential - total	-6135.112
Land impacted for carbon sink enhancement - Accelerate regeneration	2644.51
Land impacted for carbon sink enhancement - All (not counting overlap)	14510.7
Land impacted for carbon sink enhancement - Avoid deforestation	2233.463
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	0
Land impacted for carbon sink enhancement - cropland measures	5738.1
Land impacted for carbon sink enhancement - Extend rotation length	12625.3
Land impacted for carbon sink enhancement - Improve plantations	1260.12
Land impacted for carbon sink enhancement - Increase retention of HWP	2189.4
Land impacted for carbon sink enhancement - Increase trees outside forests	955.287
Land impacted for carbon sink enhancement - permanent conservation cover	110.676
Land impacted for carbon sink enhancement - Reforest cropland	167.648
Land impacted for carbon sink enhancement - Reforest pasture	323.069
Land impacted for carbon sink enhancement - Restore productivity	7380.3
Land impacted for carbon sink enhancement - total	5848.8
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	15268.4

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	613.209
Business-as-usual carbon sink - Avoid deforestation	711.478
Business-as-usual carbon sink - Extend rotation length	6906.9
Business-as-usual carbon sink - Improve plantations	478.527
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	192.068
Business-as-usual carbon sink - Reforest cropland	19.024
Business-as-usual carbon sink - Reforest pasture	78.926
Business-as-usual carbon sink - Restore productivity	2598.1
Business-as-usual carbon sink - Total impacted (over 30 years)	19.024

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.793	0.8	0.806	0.802	0.788	0.77	0.758
Final energy demand by sector - industry	1.021	1.058	1.081	1.146	1.217	1.253	1.293
Final energy demand by sector - residential	0.878	0.825	0.766	0.706	0.626	0.537	0.459
Final energy demand by sector - transportation	3.06	2.97	2.767	2.59	2.445	2.267	2.054

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	120136893576	130140225436	0	0	0	0
Sales of cooking units - Electric Resistance	0.275	0.31	0.361	0.497	0.686	0.802	0.843
Sales of cooking units - Gas	0.725	0.69	0.639	0.503	0.314	0.198	0.157
Sales of space heating units - Electric Heat Pump	0.017	0.13	0.178	0.316	0.534	0.687	0.745
Sales of space heating units - Electric Resistance	0.114	0.133	0.14	0.158	0.188	0.212	0.222
Sales of space heating units - Fossil	0	0	0	0	0	0	0
Sales of space heating units - Gas Furnace	0.869	0.737	0.683	0.526	0.278	0.102	0.033
Sales of water heating units - Electric Heat Pump	0.006	0.027	0.079	0.23	0.461	0.613	0.666
Sales of water heating units - Electric Resistance	0.02	0.032	0.054	0.117	0.214	0.278	0.301
Sales of water heating units - Gas Furnace	0.968	0.936	0.861	0.647	0.318	0.102	0.027
Sales of water heating units - Other	0.005	0.006	0.006	0.006	0.006	0.006	0.006

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	9.307	9.316	16.204	17.032	25.595	27.344

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	26.178	28.757	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.04	0.254	0.263	0.278	0.291	0.306	0.328
Sale of space heating units by type - Electric Resistance	0.169	0.227	0.223	0.217	0.21	0.195	0.173
Sale of space heating units by type - Fossil	0.034	0.05	0.05	0.05	0.049	0.049	0.05
Sale of space heating units by type - Gas	0.757	0.469	0.464	0.455	0.45	0.449	0.449
Sales of cooking units - Electric Resistance	0.393	0.393	0.393	0.393	0.393	0.393	0.393
Sales of cooking units - Gas	0.607	0.607	0.607	0.607	0.607	0.607	0.607
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	0.175	0.322	0.322	0.322	0.322	0.321	0.321
Sales of water heating units by type - Gas Furnace	0.798	0.65	0.65	0.65	0.651	0.651	0.651
Sales of water heating units by type - Other	0.027	0.028	0.028	0.028	0.028	0.028	0.028

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	0.981	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	0.012	0.016	0.021	0.02	0.018	0.016	0.016
End-use technology sales by technology - LDV - EV	0.048	0.072	0.08	0.099	0.12	0.135	0.148
End-use technology sales by technology - LDV - gasoline	0.882	0.843	0.817	0.794	0.771	0.753	0.739
End-use technology sales by technology - LDV - hybrid	0.056	0.064	0.078	0.083	0.088	0.091	0.094
End-use technology sales by technology - LDV - hydrogen FC	0.001	0.004	0.003	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 26: *REF scenario - PILLAR 6: Land carbon sinks - Agriculture*

variable_name	2020	2030	2050
Carbon sink enhancement potential - Accelerate regeneration	0	0	6561.3
Carbon sink enhancement potential - All (not counting overlap)	0	0	72255.3
Carbon sink enhancement potential - Avoid deforestation	0	0	8320.3
Carbon sink enhancement potential - Extend rotation length	0	0	22918.4
Carbon sink enhancement potential - Improve plantations	0	0	2267.347
Carbon sink enhancement potential - Increase retention of HWP	0	0	10947
Carbon sink enhancement potential - Increase trees outside forests	0	0	3386.5
Carbon sink enhancement potential - Reforest cropland	0	0	503.536
Carbon sink enhancement potential - Reforest pasture	0	0	4272.5
Carbon sink enhancement potential - Restore productivity	0	0	13078.4
Land impacted for carbon sink enhancement - Accelerate regeneration	0	0	2644.51
Land impacted for carbon sink enhancement - All (not counting overlap)	0	0	14510.7
Land impacted for carbon sink enhancement - Avoid deforestation	0	0	2233.463
Land impacted for carbon sink enhancement - Extend rotation length	0	0	12625.3
Land impacted for carbon sink enhancement - Improve plantations	0	0	1260.12
Land impacted for carbon sink enhancement - Increase retention of HWP	0	0	2189.4
Land impacted for carbon sink enhancement - Increase trees outside forests	0	0	955.287
Land impacted for carbon sink enhancement - Natural uptake	-13.69	-7.629	-6.353
Land impacted for carbon sink enhancement - Reforest cropland	0	0	167.648
Land impacted for carbon sink enhancement - Reforest pasture	0	0	323.069
Land impacted for carbon sink enhancement - Restore productivity	0	0	7380.3
Land impacted for carbon sink enhancement - Retained in Hardwood Products	-1.787	-2.999	-3.157
Land impacted for carbon sink enhancement - Total	-15.477	-10.628	-9.51
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	0	0	15268.4

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	613.209
Business-as-usual carbon sink - Avoid deforestation	711.478
Business-as-usual carbon sink - Extend rotation length	6906.9
Business-as-usual carbon sink - Improve plantations	478.527
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	192.068
Business-as-usual carbon sink - Reforest cropland	19.024
Business-as-usual carbon sink - Reforest pasture	78.926
Business-as-usual carbon sink - Restore productivity	2598.1
Business-as-usual carbon sink - Total impacted (over 30 years)	19.024

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.793	0.809	0.826	0.837	0.86	0.902	0.96
Final energy demand by sector - industry	1.021	1.088	1.143	1.208	1.279	1.368	1.47
Final energy demand by sector - residential	0.878	0.827	0.784	0.756	0.74	0.729	0.719
Final energy demand by sector - transportation	3.057	2.998	2.847	2.765	2.8	2.893	3.001

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	119229450955	123202874114	0	0	0	0
Sales of cooking units - Electric Resistance	0.275	0.29	0.29	0.29	0.29	0.289	0.289
Sales of cooking units - Gas	0.725	0.71	0.71	0.71	0.71	0.711	0.711
Sales of space heating units - Electric Heat Pump	0.017	0.242	0.616	0.692	0.697	0.697	0.696
Sales of space heating units - Electric Resistance	0.114	0.153	0.219	0.261	0.291	0.296	0.297
Sales of space heating units - Fossil	0	0	0	0	0	0	0
Sales of space heating units - Gas Furnace	0.869	0.606	0.165	0.046	0.012	0.007	0.007
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	0.02	0.024	0.024	0.024	0.024	0.024	0.024
Sales of water heating units - Gas Furnace	0.968	0.962	0.962	0.962	0.962	0.961	0.961
Sales of water heating units - Other	0.005	0.006	0.006	0.006	0.006	0.006	0.006

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	11.446	11.71	20.692	21.995	18.419	19.141

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

variable_name	2025	2030	2035	2040	2045	2050
Power generation capital investment - Offshore Wind - Base	0.292	0	0	1.571	9.82	13.498
Power generation capital investment - Solar PV - Base	13.688	13.424	28.606	46.871	44.565	58.423
Power generation capital investment - Wind - Base	0	0	0.063	0.24	0.154	0.11

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	6718.5	11155.2	24204.6	49050.2	91394.4	153629.1
HV transmission for wind and solar - base other intra-state	0	4914.4	7676.6	16693.9	35325.7	67480.1	99982.5
HV transmission for wind and solar - base spur intra-state	0	1427.9	2897	5693.2	11037.1	20283.6	36831.8

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	6561.3
Carbon sink enhancement potential - All (not counting overlap)	72255.3
Carbon sink enhancement potential - Avoid deforestation	8320.3
Carbon sink enhancement potential - corn-ethanol to energy grasses	0
Carbon sink enhancement potential - cropland measures	-6064.271
Carbon sink enhancement potential - Extend rotation length	22918.4
Carbon sink enhancement potential - Improve plantations	2267.347
Carbon sink enhancement potential - Increase retention of HWP	10947
Carbon sink enhancement potential - Increase trees outside forests	3386.5
Carbon sink enhancement potential - permanent conservation cover	-70.841
Carbon sink enhancement potential - Reforest cropland	503.536
Carbon sink enhancement potential - Reforest pasture	4272.5
Carbon sink enhancement potential - Restore productivity	13078.4
Carbon sink enhancement potential - total	-6135.112
Land impacted for carbon sink enhancement - Accelerate regeneration	2644.51
Land impacted for carbon sink enhancement - All (not counting overlap)	14510.7
Land impacted for carbon sink enhancement - Avoid deforestation	2233.463
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	0
Land impacted for carbon sink enhancement - cropland measures	5738.1
Land impacted for carbon sink enhancement - Extend rotation length	12625.3
Land impacted for carbon sink enhancement - Improve plantations	1260.12
Land impacted for carbon sink enhancement - Increase retention of HWP	2189.4
Land impacted for carbon sink enhancement - Increase trees outside forests	955.287
Land impacted for carbon sink enhancement - permanent conservation cover	110.676
Land impacted for carbon sink enhancement - Reforest cropland	167.648
Land impacted for carbon sink enhancement - Reforest pasture	323.069
Land impacted for carbon sink enhancement - Restore productivity	7380.3
Land impacted for carbon sink enhancement - total	5848.8
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	15268.4

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	613.209
Business-as-usual carbon sink - Avoid deforestation	711.478
Business-as-usual carbon sink - Extend rotation length	6906.9
Business-as-usual carbon sink - Improve plantations	478.527
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	192.068
Business-as-usual carbon sink - Reforest cropland	19.024
Business-as-usual carbon sink - Reforest pasture	78.926
Business-as-usual carbon sink - Restore productivity	2598.1
Business-as-usual carbon sink - Total impacted (over 30 years)	19.024

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	0.012	0.833	0	0	0	0
Power generation capital investment - biomass w/ccu allam power plant	0	0	0	0.105	0.017	0.003	0.03

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Power generation capital investment - biomass w/ccu power plant	0	0	1.314	0.033	0.129	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	22.525	1657.7	1657.7	1657.7	1657.7	1657.7
Power generation by technology - biomass w/ccu allam power plant	0	0	0	104.517	121.936	124.747	155.069
Power generation by technology - biomass w/ccu power plant	0	0	1475.1	1512.2	1657	1657	1657

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Biomass purchases	0	0.009	0.112	0.456	0.648	0.708	0.723
Capital investment	0	0	2.024	0	17.617	0	2.526
Number of facilities - allam power w ccu	0	0	0	4	5	6	6
Number of facilities - beccs hydrogen	0	0	0	12	18	20	21
Number of facilities - diesel	0	0	0	2	2	2	2
Number of facilities - diesel ccu	0	0	0	4	5	6	6
Number of facilities - power	0	2	2	2	2	2	2
Number of facilities - power ccu	0	0	4	6	7	7	7
Number of facilities - pyrolysis	0	0	0	2	2	2	2
Number of facilities - pyrolysis ccu	0	0	0	4	5	6	6
Number of facilities - sng	0	2	2	2	2	2	2
Number of facilities - sng ccu	0	0	4	4	4	4	4

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

variable_name	2025	2030	2035	2040	2045	2050
Annual - All	0	1.48	30.2	45.03	54.56	60.95
Annual - BECCS	0	1.47	16.68	25.22	27.91	28.54
Annual - Cement	0	0	6.71	9.95	13.69	14.14
Annual - NGCC	0	0.01	6.82	9.85	12.97	18.27
Cumulative - All	0	1.48	31.68	76.71	131.27	192.22
Cumulative - BECCS	0	1.47	18.15	43.37	71.28	99.82
Cumulative - Cement	0	0	6.71	16.66	30.35	44.49
Cumulative - NGCC	0	0.01	6.83	16.68	29.65	47.92

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

variable_name	2025	2030	2035	2040	2045	2050
Annual	0	0	34.25	57.03	61.06	75.24
Injection wells	0	0	66	96	128	182
Resource characterization, appraisal and permitting costs cumulative	250	918.39	1410	1410	1410	1410
Wells and facilities construction costs cumulative	0	0	1945.5	2886.9	3828.3	5460

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

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	5345004.1	8000288.1	8774308.7	9117378	9670929.9
CO2 pipelines - Spur	0	423386.418	2312925	3086945.6	3430015.9	3983567.8
CO2 pipelines - Trunk	0	4921618.1	5687362.1	5687362.1	5687362.1	5687362.1

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	6561.3
Carbon sink enhancement potential - All (not counting overlap)	72255.3
Carbon sink enhancement potential - Avoid deforestation	8320.3
Carbon sink enhancement potential - corn-ethanol to energy grasses	0
Carbon sink enhancement potential - cropland measures	-6064.158
Carbon sink enhancement potential - Cropland to woody energy crops	0
Carbon sink enhancement potential - Extend rotation length	22918.4
Carbon sink enhancement potential - Improve plantations	2267.347
Carbon sink enhancement potential - Increase retention of HWP	10947
Carbon sink enhancement potential - Increase trees outside forests	3386.5
Carbon sink enhancement potential - pasture to energy crops	0
Carbon sink enhancement potential - permanent conservation cover	-70.828
Carbon sink enhancement potential - Reforest cropland	503.536
Carbon sink enhancement potential - Reforest pasture	4272.5
Carbon sink enhancement potential - Restore productivity	13078.4
Carbon sink enhancement potential - total	-6134.987
Land impacted for carbon sink enhancement - Accelerate regeneration	2644.51

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

variable_name	2050
Land impacted for carbon sink enhancement - All (not counting overlap)	14510.7
Land impacted for carbon sink enhancement - Avoid deforestation	2233.463
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	0
Land impacted for carbon sink enhancement - cropland measures	11339.7
Land impacted for carbon sink enhancement - Cropland to woody energy crops	0.251
Land impacted for carbon sink enhancement - Extend rotation length	12625.3
Land impacted for carbon sink enhancement - Improve plantations	1260.12
Land impacted for carbon sink enhancement - Increase retention of HWP	2189.4
Land impacted for carbon sink enhancement - Increase trees outside forests	955.287
Land impacted for carbon sink enhancement - pasture to energy crops	21.13
Land impacted for carbon sink enhancement - permanent conservation cover	110.657
Land impacted for carbon sink enhancement - Reforest cropland	167.648
Land impacted for carbon sink enhancement - Reforest pasture	323.069
Land impacted for carbon sink enhancement - Restore productivity	7380.3
Land impacted for carbon sink enhancement - total	11471.8
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	15268.4

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	613.209
Business-as-usual carbon sink - Avoid deforestation	711.478
Business-as-usual carbon sink - Extend rotation length	6906.9
Business-as-usual carbon sink - Improve plantations	478.527
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	192.068
Business-as-usual carbon sink - Reforest cropland	19.024
Business-as-usual carbon sink - Reforest pasture	78.926
Business-as-usual carbon sink - Restore productivity	2598.1
Business-as-usual carbon sink - Total impacted (over 30 years)	19.024

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	6561.3
Carbon sink enhancement potential - All (not counting overlap)	72255.3
Carbon sink enhancement potential - Avoid deforestation	8320.3
Carbon sink enhancement potential - corn-ethanol to energy grasses	0
Carbon sink enhancement potential - cropland measures	-6064.271
Carbon sink enhancement potential - Extend rotation length	22918.4
Carbon sink enhancement potential - Improve plantations	2267.347
Carbon sink enhancement potential - Increase retention of HWP	10947
Carbon sink enhancement potential - Increase trees outside forests	3386.5
Carbon sink enhancement potential - permanent conservation cover	-70.841
Carbon sink enhancement potential - Reforest cropland	503.536
Carbon sink enhancement potential - Reforest pasture	4272.5
Carbon sink enhancement potential - Restore productivity	13078.4
Carbon sink enhancement potential - total	-6135.112
Land impacted for carbon sink enhancement - Accelerate regeneration	2644.51
Land impacted for carbon sink enhancement - All (not counting overlap)	14510.7
Land impacted for carbon sink enhancement - Avoid deforestation	2233.463
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	0
Land impacted for carbon sink enhancement - cropland measures	5738.1
Land impacted for carbon sink enhancement - Extend rotation length	12625.3
Land impacted for carbon sink enhancement - Improve plantations	1260.12
Land impacted for carbon sink enhancement - Increase retention of HWP	2189.4
Land impacted for carbon sink enhancement - Increase trees outside forests	955.287
Land impacted for carbon sink enhancement - permanent conservation cover	110.676
Land impacted for carbon sink enhancement - Reforest cropland	167.648

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

variable_name	2050
Land impacted for carbon sink enhancement - Reforest pasture	323.069
Land impacted for carbon sink enhancement - Restore productivity	7380.3
Land impacted for carbon sink enhancement - total	5848.8
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	15268.4

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	613.209
Business-as-usual carbon sink - Avoid deforestation	711.478
Business-as-usual carbon sink - Extend rotation length	6906.9
Business-as-usual carbon sink - Improve plantations	478.527
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	192.068
Business-as-usual carbon sink - Reforest cropland	19.024
Business-as-usual carbon sink - Reforest pasture	78.926
Business-as-usual carbon sink - Restore productivity	2598.1
Business-as-usual carbon sink - Total impacted (over 30 years)	19.024