Net-Zero America - michigan 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	7.705	9.814	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.022	0.069	0.329	0.84	0.936	0.942	0.942
Sale of space heating units by type - Electric Resistance	0.058	0.093	0.074	0.032	0.024	0.023	0.024
Sale of space heating units by type - Fossil	0.069	0.129	0.098	0.043	0.033	0.032	0.032
Sale of space heating units by type - Gas	0.851	0.708	0.5	0.085	0.007	0.002	0.002
Sales of cooking units - Electric Resistance	0.357	0.494	0.913	0.996	1	1	1
Sales of cooking units - Gas	0.643	0.506	0.087	0.004	0	0	0
Sales of water heating units by type - Electric Heat Pump	0	0.009	0.123	0.373	0.42	0.424	0.424
Sales of water heating units by type - Electric Resistance	0.133	0.258	0.343	0.536	0.573	0.575	0.575
Sales of water heating units by type - Gas Furnace	0.867	0.732	0.533	0.09	0.006	0	0
Sales of water heating units by type - Other	0	0.001	0.001	0.001	0.001	0.001	0.001

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	0.037	0.144	0.453	0.813	0.963	0.993	1
End-use technology sales by technology - LDV - gasoline	0.903	0.789	0.5	0.17	0.034	0.006	0
End-use technology sales by technology - LDV - hybrid	0.042	0.044	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	1610121333	4123847753	6687500858	10128303732	11025436461	10510978369
Number of public EV charging plugs - DC Fast Charging	242	0	2840.2	0	12507.4	0	20232.6
Number of public EV charging plugs - L2 Charging	857	0	68231.8	0	300472.8	0	486058.2

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Power generation capital investment - biomass power plant	0	0	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	0	0	0	0
Power generation capital investment - Solar PV - Base	0	0	0.127	3.761	1.418	3.658	1.593
Power generation capital investment - Solar PV - Constrained	0	0.126	0.092	3.157	1.109	4.223	2.145
Power generation capital investment - Wind - Base	0	0	10.525	8.152	9.943	0.935	1.105
Power generation capital investment - Wind - Constrained	0	0	9.728	1.893	0.139	0.288	4.168

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

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

variable_name	2020	2025	2030	2035	2040	2045	2050
HV transmission for wind and solar - base all	0	131.26	1434.4	3768	8013.3	9108.9	10034.7
HV transmission for wind and solar - base other intra-state	0	34.901	481.605	1134.2	2159.6	2460.9	2657.4
HV transmission for wind and solar - base spur intra-state	0	73.898	749.189	2045.6	5082.9	5709.9	6192
HV transmission for wind and solar - constrained all	0	156.112	3542.3	5149.4	6137.5	7471.3	9072
HV transmission for wind and solar - constrained other intra-state	0	58.213	1392.8	1776	2151.8	2668.6	3291.2
HV transmission for wind and solar - constrained spur intra-state	0	73.898	1993.3	2880.9	3161.4	3600.2	4225.4

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	0	0	0.942
Capital investment	0	0	0	0	0	0	14.815
Number of facilities - allam power w ccu	0	0	0	0	0	0	0
Number of facilities - beccs hydrogen	0	0	0	0	0	0	14
Number of facilities - diesel	0	0	0	0	0	0	0
Number of facilities - diesel ccu	0	0	0	0	0	0	0

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Number of facilities - power	0	0	0	0	0	0	0
Number of facilities - power ccu	0	0	0	0	0	0	0
Number of facilities - pyrolysis	0	0	0	0	0	0	2
Number of facilities - pyrolysis ccu	0	0	0	0	0	0	0
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	3.24	3.35	6.64	6.84	24.31
Annual - BECCS	0	0	0	0	0	17.24
Annual - Cement	0	3.24	3.35	6.64	6.84	7.07
Annual - NGCC	0	0	0	0	0	0
Cumulative - All	0	3.24	6.59	13.23	20.07	44.38
Cumulative - BECCS	0	0	0	0	0	17.24
Cumulative - Cement	0	3.24	6.59	13.23	20.07	27.14
Cumulative - NGCC	0	0	0	0	0	0

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

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

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

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	1578416.684	1582520.684	1692987.16	1698648.16	2603744.6
CO2 pipelines - Spur	0	201792.275	205895.775	316362.851	322023.751	1227119.5
CO2 pipelines - Trunk	0	1376624.109	1376624.109	1376624.109	1376624.109	1376624.109

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Jobs by economic sector - agriculture	749.809	775.246	973.042	712.013	420.165	131.107	1057.9
Jobs by economic sector - construction	7770.9	7459.8	10517.6	14668.5	16757.3	15262.1	15652.9
Jobs by economic sector - manufacturing	6643.1	13093.9	15886.4	20840.1	20379.6	16066.8	21000.2
Jobs by economic sector - mining	5904.1	4478.1	3234.6	2219.6	1393.9	828.483	472.833
Jobs by economic sector - other	418.497	374.404	642.019	1476.4	1637.4	1930.8	1950.3
Jobs by economic sector - pipeline	919.078	908.394	962.375	629.96	486.94	339.828	380.826
Jobs by economic sector - professional	4931.7	4463.3	6054.9	8285.2	9952.9	9303.2	10732.7
Jobs by economic sector - trade	4537.3	3638.9	4030.8	5166.3	5780	5505.4	5816.3
Jobs by economic sector - utilities	11543.3	10590.5	12006	14499.3	18070	14511.8	15534.1
Jobs by resource sector - Biomass	2097.4	2188.7	2401.7	1676.4	1058.5	505.408	4613.1
Jobs by resource sector - CO2	0	0	1567.6	160.418	270.043	348.156	1462.1
Jobs by resource sector - Coal	3706.6	1528.4	194.686	0	0	0	0
Jobs by resource sector - Grid	10172.2	9804.6	13684.5	21281.8	28444.5	23874.7	26299.5
Jobs by resource sector - Natural Gas	10154.2	9760.2	7780.7	6814.6	7236.2	4508.7	3489.1
Jobs by resource sector - Nuclear	2213.1	2009.2	1739.5	1253.3	585.559	339.748	0
Jobs by resource sector - Oil	9953.7	8746.9	7126	5367.3	3718.1	2557	1677.2
Jobs by resource sector - Solar	2615.5	5129.6	6140	12687.2	11538.2	13013.2	15390.5
Jobs by resource sector - Wind	2505.1	6614.9	13673.1	19256.4	22027.1	18732.7	19666.7
Median wages - All	61339.1	60836.6	61053.6	61280.9	62652.2	63520.8	63774.2
Required Level of Education - Associates degree or some college	13172.3	14038.4	16885.6	21656.3	24031.1	20579.6	23107.7
Required Level of Education - Bachelors degree	9577.8	9884	11372	14028.7	15264.3	13041.2	14783.4
Required Level of Education - Doctoral degree	312.013	294.019	351.823	441.967	494.596	445.423	502.445
Required Level of Education - High school diploma or less	18065.8	19294.7	23061	29100.5	31459	26666.9	30659.6
Required Level of Education - Masters or professional degree	2289.8	2271.3	2637.5	3269.9	3629.3	3146.5	3545.1
Wage income - All	2663308668	2785343242	3315838752	4197857017	4691605995	4058042211	4630272295

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	706.186
Carbon sink enhancement potential - All (not counting overlap)	58072.7
Carbon sink enhancement potential - Avoid deforestation	4918
Carbon sink enhancement potential - corn-ethanol to energy grasses	-1397.16
Carbon sink enhancement potential - cropland measures	-6319.734
Carbon sink enhancement potential - Extend rotation length	18660.2
Carbon sink enhancement potential - Improve plantations	2109.919
Carbon sink enhancement potential - Increase retention of HWP	12604.8
Carbon sink enhancement potential - Increase trees outside forests	2531.3
Carbon sink enhancement potential - permanent conservation cover	-222.033
Carbon sink enhancement potential - Reforest cropland	1652.45
Carbon sink enhancement potential - Reforest pasture	7319.2

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

variable_name	2050
Carbon sink enhancement potential - Restore productivity	7570.6
Carbon sink enhancement potential - total	-7938.928
Land impacted for carbon sink enhancement - Accelerate regeneration	284.619
Land impacted for carbon sink enhancement - All (not counting overlap)	10982.7
Land impacted for carbon sink enhancement - Avoid deforestation	1320.162
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	583.306
Land impacted for carbon sink enhancement - cropland measures	4040.1
Land impacted for carbon sink enhancement - Extend rotation length	10279.6
Land impacted for carbon sink enhancement - Improve plantations	1172.644
Land impacted for carbon sink enhancement - Increase retention of HWP	2521
Land impacted for carbon sink enhancement - Increase trees outside forests	714.061
Land impacted for carbon sink enhancement - permanent conservation cover	403.839
Land impacted for carbon sink enhancement - Reforest cropland	550.167
Land impacted for carbon sink enhancement - Reforest pasture	553.444
Land impacted for carbon sink enhancement - Restore productivity	4272.102
Land impacted for carbon sink enhancement - total	5027.2
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	10685.1

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	65.999
Business-as-usual carbon sink - Avoid deforestation	420.542
Business-as-usual carbon sink - Extend rotation length	5623.6
Business-as-usual carbon sink - Improve plantations	445.308
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	143.568
Business-as-usual carbon sink - Reforest cropland	62.43
Business-as-usual carbon sink - Reforest pasture	135.206
Business-as-usual carbon sink - Restore productivity	1503.9
Business-as-usual carbon sink - Total impacted (over 30 years)	62.43

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Natural gas consumption	736328.2	747263.6	629901	505206.6	380312	239279.5	165958
Oil consumption	171013.2	161240.8	139413.7	107657.8	78962.4	56270.8	40159

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.316	0.311	0.299	0.277	0.251	0.231	0.22
Final energy demand by sector - industry	0.501	0.51	0.519	0.515	0.526	0.536	0.54
Final energy demand by sector - residential	0.562	0.524	0.489	0.423	0.347	0.286	0.245
Final energy demand by sector - transportation	0.808	0.75	0.656	0.541	0.437	0.372	0.341

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	29341409118	32039834758	0	0	0	0
Sales of cooking units - Electric Resistance	0.41	0.542	0.829	0.886	0.889	0.889	0.889
Sales of cooking units - Gas	0.59	0.458	0.171	0.114	0.111	0.111	0.111
Sales of space heating units - Electric Heat Pump	0.004	0.062	0.301	0.792	0.885	0.891	0.891
Sales of space heating units - Electric Resistance	0.016	0.035	0.055	0.097	0.105	0.106	0.106
Sales of space heating units - Fossil	0.025	0.024	0.005	0	0	0	0
Sales of space heating units - Gas Furnace	0.954	0.88	0.64	0.111	0.011	0.004	0.004
Sales of water heating units - Electric Heat Pump	0.002	0.014	0.144	0.43	0.484	0.488	0.488
Sales of water heating units - Electric Resistance	0.016	0.042	0.17	0.453	0.506	0.51	0.51
Sales of water heating units - Gas Furnace	0.981	0.943	0.685	0.116	0.008	0	0
Sales of water heating units - Other	0.001	0.002	0.002	0.002	0.002	0.002	0.002

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	5.191	5.329	9.383	9.986	8.848	9.244

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	7.41	7.885	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.014	0.086	0.09	0.096	0.099	0.102	0.107
Sale of space heating units by type - Electric Resistance	0.058	0.091	0.09	0.088	0.086	0.082	0.079
Sale of space heating units by type - Fossil	0.072	0.123	0.12	0.118	0.118	0.118	0.118
Sale of space heating units by type - Gas	0.856	0.7	0.7	0.698	0.697	0.697	0.697
Sales of cooking units - Electric Resistance	0.349	0.349	0.349	0.349	0.349	0.349	0.349
Sales of cooking units - Gas	0.651	0.651	0.651	0.651	0.651	0.651	0.651
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	0.133	0.251	0.249	0.249	0.249	0.248	0.248
Sales of water heating units by type - Gas Furnace	0.867	0.748	0.75	0.75	0.75	0.751	0.751
Sales of water heating units by type - Other	0	0.001	0.001	0.001	0.001	0.001	0.001

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	0.053	0.06	0.074	0.09	0.105	0.117
End-use technology sales by technology - LDV - gasoline	0.906	0.871	0.851	0.834	0.813	0.794	0.778
End-use technology sales by technology - LDV - hybrid	0.042	0.051	0.062	0.068	0.074	0.08	0.085
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	706.186
Carbon sink enhancement potential - All (not counting overlap)	0	0	58072.7
Carbon sink enhancement potential - Avoid deforestation	0	0	4918
Carbon sink enhancement potential - Extend rotation length	0	0	18660.2
Carbon sink enhancement potential - Improve plantations	0	0	2109.919
Carbon sink enhancement potential - Increase retention of HWP	0	0	12604.8
Carbon sink enhancement potential - Increase trees outside forests	0	0	2531.3
Carbon sink enhancement potential - Reforest cropland	0	0	1652.45
Carbon sink enhancement potential - Reforest pasture	0	0	7319.2
Carbon sink enhancement potential - Restore productivity	0	0	7570.6
Land impacted for carbon sink enhancement - Accelerate regeneration	0	0	284.619
Land impacted for carbon sink enhancement - All (not counting overlap)	0	0	10982.7
Land impacted for carbon sink enhancement - Avoid deforestation	0	0	1320.162
Land impacted for carbon sink enhancement - Extend rotation length	0	0	10279.6
Land impacted for carbon sink enhancement - Improve plantations	0	0	1172.644
Land impacted for carbon sink enhancement - Increase retention of HWP	0	0	2521
Land impacted for carbon sink enhancement - Increase trees outside forests	0	0	714.061
Land impacted for carbon sink enhancement - Natural uptake	-36.63	-17.676	-15.805
Land impacted for carbon sink enhancement - Reforest cropland	0	0	550.167
Land impacted for carbon sink enhancement - Reforest pasture	0	0	553.444
Land impacted for carbon sink enhancement - Restore productivity	0	0	4272.102
Land impacted for carbon sink enhancement - Retained in Hardwood Products	-2.058	-3.702	-3.848
Land impacted for carbon sink enhancement - Total	-38.688	-21.378	-19.653
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	0	0	10685.1

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	65.999
Business-as-usual carbon sink - Avoid deforestation	420.542
Business-as-usual carbon sink - Extend rotation length	5623.6
Business-as-usual carbon sink - Improve plantations	445.308

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	143.568
Business-as-usual carbon sink - Reforest cropland	62.43
Business-as-usual carbon sink - Reforest pasture	135.206
Business-as-usual carbon sink - Restore productivity	1503.9
Business-as-usual carbon sink - Total impacted (over 30 years)	62.43

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.316	0.316	0.313	0.306	0.298	0.298	0.306
Final energy demand by sector - industry	0.502	0.527	0.542	0.555	0.576	0.598	0.623
Final energy demand by sector - residential	0.562	0.526	0.505	0.49	0.48	0.473	0.466
Final energy demand by sector - transportation	0.808	0.759	0.697	0.659	0.657	0.674	0.697

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	29024778450	30108663239	0	0	0	0
Sales of cooking units - Electric Resistance	0.41	0.442	0.443	0.443	0.443	0.444	0.445
Sales of cooking units - Gas	0.59	0.558	0.557	0.557	0.557	0.556	0.555
Sales of space heating units - Electric Heat Pump	0.004	0.115	0.439	0.708	0.753	0.758	0.758
Sales of space heating units - Electric Resistance	0.016	0.043	0.09	0.172	0.228	0.237	0.238
Sales of space heating units - Fossil	0.025	0.025	0.013	0.002	0	0	0
Sales of space heating units - Gas Furnace	0.954	0.817	0.458	0.117	0.018	0.004	0.004
Sales of water heating units - Electric Heat Pump	0.002	0.003	0.003	0.003	0.003	0.003	0.003
Sales of water heating units - Electric Resistance	0.016	0.032	0.032	0.032	0.032	0.031	0.031
Sales of water heating units - Gas Furnace	0.981	0.963	0.963	0.963	0.963	0.963	0.963
Sales of water heating units - Other	0.001	0.002	0.002	0.002	0.002	0.002	0.002

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	4.634	4.706	5.779	5.969	5.982	6.151

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	7.673	9.612	0	0	0	0
Sale of space heating units by type - Electric Heat Pump	0.022	0.054	0.083	0.175	0.391	0.655	0.809
Sale of space heating units by type - Electric Resistance	0.058	0.094	0.091	0.084	0.067	0.045	0.034
Sale of space heating units by type - Fossil	0.069	0.132	0.129	0.117	0.093	0.064	0.047
Sale of space heating units by type - Gas	0.851	0.72	0.698	0.624	0.45	0.235	0.11
Sales of cooking units - Electric Resistance	0.355	0.371	0.43	0.586	0.803	0.936	0.983
Sales of cooking units - Gas	0.645	0.629	0.57	0.414	0.197	0.064	0.017
Sales of water heating units by type - Electric Heat Pump	0	0.004	0.017	0.058	0.158	0.285	0.36
Sales of water heating units by type - Electric Resistance	0.133	0.255	0.262	0.294	0.37	0.468	0.525
Sales of water heating units by type - Gas Furnace	0.867	0.74	0.72	0.647	0.471	0.246	0.114
Sales of water heating units by type - Other	0	0.001	0.001	0.001	0.001	0.001	0.001

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	0.115	0.252	0.477	0.716	0.874
End-use technology sales by technology - LDV - gasoline	0.92	0.878	0.802	0.675	0.47	0.253	0.112
End-use technology sales by technology - LDV - hybrid	0.043	0.052	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	259915227	547373136	1847287387	5816788845	8473137821
Number of public EV charging plugs - DC Fast Charging	242	0	872.478	0	4634	0	12959
Number of public EV charging plugs - L2 Charging	857	0	20960	0	111325.5	0	311320

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	706.186
Carbon sink enhancement potential - All (not counting overlap)	58072.7
Carbon sink enhancement potential - Avoid deforestation	4918
Carbon sink enhancement potential - corn-ethanol to energy grasses	-1397.16
Carbon sink enhancement potential - cropland measures	-6319.734
Carbon sink enhancement potential - Extend rotation length	18660.2
Carbon sink enhancement potential - Improve plantations	2109.919
Carbon sink enhancement potential - Increase retention of HWP	12604.8
Carbon sink enhancement potential - Increase trees outside forests	2531.3
Carbon sink enhancement potential - permanent conservation cover	-222.033
Carbon sink enhancement potential - Reforest cropland	1652.45
Carbon sink enhancement potential - Reforest pasture	7319.2
Carbon sink enhancement potential - Restore productivity	7570.6
Carbon sink enhancement potential - total	-7938.928
Land impacted for carbon sink enhancement - Accelerate regeneration	284.619
Land impacted for carbon sink enhancement - All (not counting overlap)	10982.7
Land impacted for carbon sink enhancement - Avoid deforestation	1320.162
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	583.306
Land impacted for carbon sink enhancement - cropland measures	4040.1
Land impacted for carbon sink enhancement - Extend rotation length	10279.6
Land impacted for carbon sink enhancement - Improve plantations	1172.644
Land impacted for carbon sink enhancement - Increase retention of HWP	2521
Land impacted for carbon sink enhancement - Increase trees outside forests	714.061
Land impacted for carbon sink enhancement - permanent conservation cover	403.839
Land impacted for carbon sink enhancement - Reforest cropland	550.167
Land impacted for carbon sink enhancement - Reforest pasture	553.444
Land impacted for carbon sink enhancement - Restore productivity	4272.102
Land impacted for carbon sink enhancement - total	5027.2
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	10685.1

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	65.999
Business-as-usual carbon sink - Avoid deforestation	420.542
Business-as-usual carbon sink - Extend rotation length	5623.6
Business-as-usual carbon sink - Improve plantations	445.308
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	143.568
Business-as-usual carbon sink - Reforest cropland	62.43
Business-as-usual carbon sink - Reforest pasture	135.206
Business-as-usual carbon sink - Restore productivity	1503.9
Business-as-usual carbon sink - Total impacted (over 30 years)	62.43

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Final energy demand by sector - commercial	0.316	0.311	0.304	0.297	0.288	0.275	0.26
Final energy demand by sector - industry	0.501	0.51	0.521	0.522	0.536	0.546	0.548
Final energy demand by sector - residential	0.562	0.525	0.498	0.472	0.439	0.392	0.339
Final energy demand by sector - transportation	0.809	0.757	0.687	0.629	0.583	0.53	0.468

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	29338494707	32023142232	0	0	0	0
Sales of cooking units - Electric Resistance	0.41	0.458	0.498	0.605	0.754	0.845	0.877
Sales of cooking units - Gas	0.59	0.542	0.502	0.395	0.246	0.155	0.123
Sales of space heating units - Electric Heat Pump	0.004	0.049	0.075	0.161	0.364	0.615	0.762
Sales of space heating units - Electric Resistance	0.016	0.034	0.036	0.043	0.06	0.082	0.095
Sales of space heating units - Fossil	0.025	0.027	0.026	0.02	0.011	0.005	0.003
Sales of space heating units - Gas Furnace	0.954	0.889	0.863	0.776	0.565	0.298	0.141
Sales of water heating units - Electric Heat Pump	0.002	0.009	0.023	0.07	0.184	0.329	0.415
Sales of water heating units - Electric Resistance	0.016	0.037	0.051	0.097	0.21	0.353	0.438
Sales of water heating units - Gas Furnace	0.981	0.953	0.925	0.831	0.604	0.316	0.146
Sales of water heating units - Other	0.001	0.002	0.002	0.002	0.002	0.002	0.002

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	4.209	4.229	5.79	5.993	8.361	8.822

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	2.692	7.268	8.629	37.645	2.368
Power generation capital investment - Wind - Base	0	14.831	10.064	6.559	1.259	1.908

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	110.489	2236.6	5791.6	10344.7	28262.2	29357.4
HV transmission for wind and solar - base other intra-state	0	14.218	427.111	920.348	1769	5074.5	5074.5
HV transmission for wind and solar - base spur intra-state	0	73.898	1406.9	4147.5	7589.5	21606.5	22198

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	706.186
Carbon sink enhancement potential - All (not counting overlap)	58072.7
Carbon sink enhancement potential - Avoid deforestation	4918
Carbon sink enhancement potential - corn-ethanol to energy grasses	-1397.16
Carbon sink enhancement potential - cropland measures	-6319.734
Carbon sink enhancement potential - Extend rotation length	18660.2
Carbon sink enhancement potential - Improve plantations	2109.919
Carbon sink enhancement potential - Increase retention of HWP	12604.8
Carbon sink enhancement potential - Increase trees outside forests	2531.3
Carbon sink enhancement potential - permanent conservation cover	-222.033
Carbon sink enhancement potential - Reforest cropland	1652.45
Carbon sink enhancement potential - Reforest pasture	7319.2
Carbon sink enhancement potential - Restore productivity	7570.6
Carbon sink enhancement potential - total	-7938.928
Land impacted for carbon sink enhancement - Accelerate regeneration	284.619
Land impacted for carbon sink enhancement - All (not counting overlap)	10982.7
Land impacted for carbon sink enhancement - Avoid deforestation	1320.162
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	583.306
Land impacted for carbon sink enhancement - cropland measures	4040.1
Land impacted for carbon sink enhancement - Extend rotation length	10279.6
Land impacted for carbon sink enhancement - Improve plantations	1172.644
Land impacted for carbon sink enhancement - Increase retention of HWP	2521
Land impacted for carbon sink enhancement - Increase trees outside forests	714.061
Land impacted for carbon sink enhancement - permanent conservation cover	403.839
Land impacted for carbon sink enhancement - Reforest cropland	550.167
Land impacted for carbon sink enhancement - Reforest pasture	553.444
Land impacted for carbon sink enhancement - Restore productivity	4272.102
Land impacted for carbon sink enhancement - total	5027.2
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	10685.1

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	65.999
Business-as-usual carbon sink - Avoid deforestation	420.542
Business-as-usual carbon sink - Extend rotation length	5623.6
Business-as-usual carbon sink - Improve plantations	445.308
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	143.568
Business-as-usual carbon sink - Reforest cropland	62.43
Business-as-usual carbon sink - Reforest pasture	135.206
Business-as-usual carbon sink - Restore productivity	1503.9
Business-as-usual carbon sink - Total impacted (over 30 years)	62.43

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	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	0	0	0	0	0

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

variable_name	2020	2025	2030	2035	2040	2045	2050
Biomass purchases	0	0	0	0	0	0	2.226
Capital investment	0	0	0	0	0	0	24.042
Number of facilities - allam power w ccu	0	0	0	0	0	0	0
Number of facilities - beccs hydrogen	0	0	0	0	0	0	18
Number of facilities - diesel	0	0	0	0	0	0	1
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	0	0	0	0	0
Number of facilities - pyrolysis	0	0	0	0	0	0	8
Number of facilities - pyrolysis ccu	0	0	0	0	0	0	1
Number of facilities - sng	0	0	0	0	0	0	1
Number of facilities - sng ccu	0	0	0	0	0	0	0

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

variable_name	2025	2030	2035	2040	2045	2050
Annual - All	0	3.24	3.35	6.64	6.84	28.44
Annual - BECCS	0	0	0	0	0	21.37
Annual - Cement	0	3.24	3.35	6.64	6.84	7.07
Annual - NGCC	0	0	0	0	0	0
Cumulative - All	0	3.24	6.59	13.23	20.07	48.51
Cumulative - BECCS	0	0	0	0	0	21.37
Cumulative - Cement	0	3.24	6.59	13.23	20.07	27.14
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	0	0	0	0	0
Injection wells	0	0	0	0	0	0
Resource characterization, appraisal and permitting costs cumulative	0	0	0	0	0	0
Wells and facilities construction costs cumulative	0	0	0	0	0	0

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

variable_name	2025	2030	2035	2040	2045	2050
CO2 pipelines - All	0	1576900.684	1580971.684	1691449.16	2036745.16	2845631.6
CO2 pipelines - Spur	0	200276.375	204346.875	314824.351	320455.251	1129341.5
CO2 pipelines - Trunk	0	1376624.109	1376624.109	1376624.109	1716290.109	1716290.109

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	706.186
Carbon sink enhancement potential - All (not counting overlap)	58072.7
Carbon sink enhancement potential - Avoid deforestation	4918
Carbon sink enhancement potential - corn-ethanol to energy grasses	-1617.212
Carbon sink enhancement potential - cropland measures	-5932.097
Carbon sink enhancement potential - Cropland to woody energy crops	0
Carbon sink enhancement potential - Extend rotation length	18660.2
Carbon sink enhancement potential - Improve plantations	2109.919
Carbon sink enhancement potential - Increase retention of HWP	12604.8
Carbon sink enhancement potential - Increase trees outside forests	2531.3
Carbon sink enhancement potential - pasture to energy crops	0
Carbon sink enhancement potential - permanent conservation cover	-207.19
Carbon sink enhancement potential - Reforest cropland	1652.45
Carbon sink enhancement potential - Reforest pasture	7319.2
Carbon sink enhancement potential - Restore productivity	7570.6

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

variable_name	2050
Carbon sink enhancement potential - total	-7756.499
Land impacted for carbon sink enhancement - Accelerate regeneration	284.619
Land impacted for carbon sink enhancement - All (not counting overlap)	10982.7
Land impacted for carbon sink enhancement - Avoid deforestation	1320.162
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	924.404
Land impacted for carbon sink enhancement - cropland measures	7445.7
Land impacted for carbon sink enhancement - Cropland to woody energy crops	19.892
Land impacted for carbon sink enhancement - Extend rotation length	10279.6
Land impacted for carbon sink enhancement - Improve plantations	1172.644
Land impacted for carbon sink enhancement - Increase retention of HWP	2521
Land impacted for carbon sink enhancement - Increase trees outside forests	714.061
Land impacted for carbon sink enhancement - pasture to energy crops	77.92
Land impacted for carbon sink enhancement - permanent conservation cover	376.842
Land impacted for carbon sink enhancement - Reforest cropland	550.167
Land impacted for carbon sink enhancement - Reforest pasture	553.444
Land impacted for carbon sink enhancement - Restore productivity	4272.102
Land impacted for carbon sink enhancement - total	8844.8
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	10685.1

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	65.999
Business-as-usual carbon sink - Avoid deforestation	420.542
Business-as-usual carbon sink - Extend rotation length	5623.6
Business-as-usual carbon sink - Improve plantations	445.308
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	143.568
Business-as-usual carbon sink - Reforest cropland	62.43
Business-as-usual carbon sink - Reforest pasture	135.206
Business-as-usual carbon sink - Restore productivity	1503.9
Business-as-usual carbon sink - Total impacted (over 30 years)	62.43

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

variable_name	2050
Carbon sink enhancement potential - Accelerate regeneration	706.186
Carbon sink enhancement potential - All (not counting overlap)	58072.7
Carbon sink enhancement potential - Avoid deforestation	4918
Carbon sink enhancement potential - corn-ethanol to energy grasses	-1397.16
Carbon sink enhancement potential - cropland measures	-6319.734
Carbon sink enhancement potential - Extend rotation length	18660.2
Carbon sink enhancement potential - Improve plantations	2109.919
Carbon sink enhancement potential - Increase retention of HWP	12604.8
Carbon sink enhancement potential - Increase trees outside forests	2531.3
Carbon sink enhancement potential - permanent conservation cover	-222.033
Carbon sink enhancement potential - Reforest cropland	1652.45
Carbon sink enhancement potential - Reforest pasture	7319.2
Carbon sink enhancement potential - Restore productivity	7570.6
Carbon sink enhancement potential - total	-7938.928
Land impacted for carbon sink enhancement - Accelerate regeneration	284.619
Land impacted for carbon sink enhancement - All (not counting overlap)	10982.7
Land impacted for carbon sink enhancement - Avoid deforestation	1320.162
Land impacted for carbon sink enhancement - corn-ethanol to energy grasses	583.306
Land impacted for carbon sink enhancement - cropland measures	4040.1
Land impacted for carbon sink enhancement - Extend rotation length	10279.6
Land impacted for carbon sink enhancement - Improve plantations	1172.644
Land impacted for carbon sink enhancement - Increase retention of HWP	2521
Land impacted for carbon sink enhancement - Increase trees outside forests	714.061
Land impacted for carbon sink enhancement - permanent conservation cover	403.839

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

variable_name	2050
Land impacted for carbon sink enhancement - Reforest cropland	550.167
Land impacted for carbon sink enhancement - Reforest pasture	553.444
Land impacted for carbon sink enhancement - Restore productivity	4272.102
Land impacted for carbon sink enhancement - total	5027.2
Land impacted for carbon sink enhancement - Total impacted (over 30 years)	10685.1

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

variable_name	2050
Business-as-usual carbon sink - Accelerate regeneration	65.999
Business-as-usual carbon sink - Avoid deforestation	420.542
Business-as-usual carbon sink - Extend rotation length	5623.6
Business-as-usual carbon sink - Improve plantations	445.308
Business-as-usual carbon sink - Increase retention of HWP	0
Business-as-usual carbon sink - Increase trees outside forests	143.568
Business-as-usual carbon sink - Reforest cropland	62.43
Business-as-usual carbon sink - Reforest pasture	135.206
Business-as-usual carbon sink - Restore productivity	1503.9
Business-as-usual carbon sink - Total impacted (over 30 years)	62.43