Net-Zero America - south dakota state report v2

Larson et al. 2020

February 2021

Reading guide

IN DRAFT

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 ${\bf Table~1:~\it E-scenario~-PILLAR~1:~\it Efficiency/Electrification~-Residential}$

variable_name	2020	2025	2030	2035	2040	2045	2050
Residential HVAC investment in 2020s vs. REF -	0	0.63	0.659	0	0	0	0
Cumulative 5-yr							
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	0	0	0	0	0	0	0
Pump							
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

 ${\bf Table~2:~\it E-~scenario~-~\it PILLAR~1:~\it Efficiency/Electrification~-~\it Transportation}$

2020	2025	2030	2035	2040	2045	2050
0.981	0.982	0.979	0.97	0.956	0.935	0.916
0	0	0	0	0	0	0
0.002	0.002	0.003	0.003	0.003	0.003	0.003
0.001	0.001	0.001	0.001	0.002	0.002	0.002
0.001	0.001	0.002	0.002	0.002	0.002	0.003
0.015	0.013	0.016	0.024	0.037	0.057	0.076
0.019	0.022	0.022	0.021	0.019	0.018	0.017
0.025	0.043	0.049	0.06	0.073	0.087	0.098
0.919	0.886	0.87	0.856	0.838	0.818	0.801
0.034	0.043	0.053	0.059	0.066	0.073	0.079
0.001	0.004	0.004	0.003	0.003	0.003	0.003
0.001	0.001	0.001	0.001	0.001	0.001	0.001
0.652	0.635	0.616	0.596	0.58	0.565	0.552
0	0.001	0.003	0.007	0.009	0.01	0.01
0.34	0.355	0.37	0.385	0.397	0.408	0.417
0.004	0.004	0.005	0.006	0.007	0.008	0.009
0.002	0.002	0.002	0.003	0.003	0.004	0.005
0.003	0.003	0.003	0.003	0.004	0.005	0.007
	0.981 0 0.002 0.001 0.001 0.015 0.019 0.025 0.919 0.034 0.001 0.652 0 0 0.34 0.004 0.002	0.981 0.982 0 0 0.002 0.002 0.001 0.001 0.015 0.013 0.015 0.043 0.025 0.043 0.919 0.886 0.034 0.043 0.001 0.004 0.001 0.001 0.652 0.635 0 0.001 0.34 0.355 0.004 0.004 0.002 0.002	$\begin{array}{c ccccc} 0.981 & 0.982 & 0.979 \\ 0 & 0 & 0 \\ 0.002 & 0.002 & 0.003 \\ 0.001 & 0.001 & 0.001 \\ 0.001 & 0.001 & 0.002 \\ \hline \\ 0.015 & 0.013 & 0.016 \\ 0.019 & 0.022 & 0.022 \\ 0.025 & 0.043 & 0.049 \\ 0.919 & 0.886 & 0.87 \\ 0.034 & 0.043 & 0.053 \\ 0.001 & 0.004 & 0.004 \\ \hline \\ 0.001 & 0.001 & 0.001 \\ 0.001 & 0.001 & 0.001 \\ 0.652 & 0.635 & 0.616 \\ 0 & 0.001 & 0.003 \\ 0.34 & 0.355 & 0.37 \\ 0.004 & 0.004 & 0.005 \\ \hline \\ 0.002 & 0.002 & 0.002 \\ \hline \end{array}$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$

 ${\bf Table~3:~E\hbox{-}~scenario~-~PILLAR~6:~Land~carbon~sinks~-~Agriculture}$

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

 ${\bf Table~4:~\it E-~\it scenario~-~\it PILLAR~\it 6:~\it Land~\it carbon~\it sinks~-~\it Forests}$

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

${\bf Table~5:~E\hbox{--}scenario~-~PILLAR~1:~Efficiency/Electrification~-~Overview}$

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	0	2477968736	2547871904	0	0	0	0
5-yr							
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) -	0.688	0.705	0.782	0.806	0.832	0.856
Cumulative 5-yr						

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 -	0	0.653	0.813	0	0	0	0
Cumulative 5-yr							
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	0	0.007	0.096	0.292	0.327	0.329	0.33
Pump							
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

33	0/			<u>.</u>			
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 -	0.004	0.025	0.127	0.304	0.382	0.397	0.4
hydrogen FC							
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 -	0.001	0.004	0.002	0.001	0	0	0
hydrogen FC							
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 -	0.002	0.013	0.063	0.152	0.191	0.199	0.2
hydrogen FC							
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	0	0	0	0	0	0	0
plant							
Power generation capital investment - biomass w/ccu	0	0	0	0	0	0	0
allam power plant							
Power generation capital investment - biomass w/ccu	0	0	0.023	0	0	0	0
power plant							
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 -	0	1.927	4.75	8.878	18.081	29.244	41.267
Constrained							

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	0	0	0	0	0	0	0
power plant							
Power generation by technology - biomass w/ccu power	0	0	25.984	25.984	25.984	25.984	25.984
plant							

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	0	0	0	0	0	0	0
intra-state							
HV transmission for wind and solar - base spur	0	161.429	391.48	652.079	819.274	1209.8	2203.9
intra-state							
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	0	0	0	0	0	0	0
intra-state							
HV transmission for wind and solar - constrained spur	0	212.119	391.788	1108.9	2900	7032.8	15468.1
intra-state							

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: $RE ext{-}$ 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 - revolute deforestation	-2310.018
energy grasses	-2010.010
Carbon sink enhancement potential - cropland measures	-11290.17
Carbon sink enhancement potential - Extend rotation	508.78
length	
Carbon sink enhancement potential - Improve	72.272
plantations	
Carbon sink enhancement potential - Increase retention of HWP	740.525
Carbon sink enhancement potential - Increase trees	4044.4
outside forests	0.45.05
Carbon sink enhancement potential - permanent	-645.95
Carbon sink enhancement potential - Reforest cropland	7999.8
Carbon sink enhancement potential - Reforest cropiand Carbon sink enhancement potential - Reforest pasture	7999.8
	1097.577
Carbon sink enhancement potential - Restore productivity	1097.577
Carbon sink enhancement potential - total	-14246.14
Land impacted for carbon sink enhancement - Accelerate	267.022
regeneration	207.022
Land impacted for carbon sink enhancement - All (not	4314.9
counting overlap)	1011.0
Land impacted for carbon sink enhancement - Avoid	327.698
deforestation	
Land impacted for carbon sink enhancement -	1397.032
corn-ethanol to energy grasses	
Land impacted for carbon sink enhancement - cropland	10094
measures	
Land impacted for carbon sink enhancement - Extend	280.277
rotation length	
Land impacted for carbon sink enhancement - Improve	40.167
plantations	
Land impacted for carbon sink enhancement - Increase	148.105
retention of HWP	1140.885
Land impacted for carbon sink enhancement - Increase trees outside forests	1140.885
Land impacted for carbon sink enhancement -	1073.931
permanent conservation cover	1073.931
Land impacted for carbon sink enhancement - Reforest	2663.497
cropland	2003.497
Land impacted for carbon sink enhancement - Reforest	551.926
pasture	301.320
Land impacted for carbon sink enhancement - Restore	619.374
productivity	310.0.4
Land impacted for carbon sink enhancement - total	12565
Land impacted for carbon sink enhancement - Total	1724.08
	1

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

${\bf Table~22:~\it RE-~scenario~-~\it PILLAR~1:~\it Efficiency/Electrification~-~\it Commercial}$

variable_name	2020	2025	2030	2035	2040	2045	2050
Commercial HVAC investment in 2020s - Cumulative	0	2507475761	2730539947	0	0	0	0
5-yr							
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

Electricity distribution peak load (capital invested) - 0.836 0.87 1.601 1.719 1.536 1.618 Cumulative 5-yr	variable_name	2025	2030	2035	2040	2045	2050
		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 -	0	0.651	0.8	0	0	0	0
Cumulative 5-yr							
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	0	0.002	0.008	0.027	0.074	0.133	0.168
Pump							
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	662.523
regeneration	
Carbon sink enhancement potential - All (not counting	23645.8
overlap)	
Carbon sink enhancement potential - Avoid deforestation	1220.767
Carbon sink enhancement potential - corn-ethanol to	-2310.018
energy grasses	

 ${\bf Table~26:~REF~scenario~-~PILLAR~6:~Land~carbon~sinks~-~Agriculture~(continued)}$

variable_name	2050
Carbon sink enhancement potential - cropland measures	-11290.178
Carbon sink enhancement potential - Extend rotation	508.78
length	
Carbon sink enhancement potential - Improve	72.272
plantations	
Carbon sink enhancement potential - Increase retention	740.525
of HWP	
Carbon sink enhancement potential - Increase trees	4044.4
outside forests	
Carbon sink enhancement potential - permanent	-645.95
conservation cover	
Carbon sink enhancement potential - Reforest cropland	7999.8
Carbon sink enhancement potential - Reforest pasture	7299.1
Carbon sink enhancement potential - Restore	1097.577
productivity	
Carbon sink enhancement potential - total	-14246.145
Land impacted for carbon sink enhancement - Accelerate	267.022
regeneration	
Land impacted for carbon sink enhancement - All (not	4314.9
counting overlap)	1011.0
Land impacted for carbon sink enhancement - Avoid	327.698
deforestation	021.000
Land impacted for carbon sink enhancement -	1397.032
corn-ethanol to energy grasses	
Land impacted for carbon sink enhancement - cropland	10094
measures	10001
Land impacted for carbon sink enhancement - Extend	280.277
rotation length	
Land impacted for carbon sink enhancement - Improve	40.167
plantations	
Land impacted for carbon sink enhancement - Increase	148.105
retention of HWP	
Land impacted for carbon sink enhancement - Increase	1140.885
trees outside forests	
Land impacted for carbon sink enhancement -	1073.931
permanent conservation cover	
Land impacted for carbon sink enhancement - Reforest	2663.497
cropland	
Land impacted for carbon sink enhancement - Reforest	551.926
pasture	
Land impacted for carbon sink enhancement - Restore	619.374
productivity	
Land impacted for carbon sink enhancement - total	12565
Land impacted for carbon sink enhancement - Total	1724.08
impacted (over 30 years)	

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	0	2507372344	2734738987	0	0	0	0
5-yr							
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) -	0.676	0.691	0.924	0.965	1.37	1.455
Cumulative 5-yr						

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	662.523
regeneration	
Carbon sink enhancement potential - All (not counting	23645.8
overlap)	
Carbon sink enhancement potential - Avoid deforestation	1220.767
Carbon sink enhancement potential - corn-ethanol to	-2310.018
energy grasses	
Carbon sink enhancement potential - cropland measures	-11290.178
Carbon sink enhancement potential - Extend rotation	508.78
length	
Carbon sink enhancement potential - Improve	72.272
plantations	
Carbon sink enhancement potential - Increase retention	740.525
of HWP	
Carbon sink enhancement potential - Increase trees	4044.4
outside forests	
Carbon sink enhancement potential - permanent	-645.95
conservation cover	
Carbon sink enhancement potential - Reforest cropland	7999.8
Carbon sink enhancement potential - Reforest pasture	7299.1
Carbon sink enhancement potential - Restore	1097.577
productivity	
Carbon sink enhancement potential - total	-14246.145
Land impacted for carbon sink enhancement - Accelerate	267.022
regeneration	
Land impacted for carbon sink enhancement - All (not	4314.9
counting overlap)	
Land impacted for carbon sink enhancement - Avoid	327.698
deforestation	
Land impacted for carbon sink enhancement -	1397.032
corn-ethanol to energy grasses	
Land impacted for carbon sink enhancement - cropland	10094
measures	
Land impacted for carbon sink enhancement - Extend	280.277
rotation length	
Land impacted for carbon sink enhancement - Improve	40.167
plantations	
Land impacted for carbon sink enhancement - Increase	148.105
retention of HWP	
Land impacted for carbon sink enhancement - Increase	1140.885
trees outside forests	
Land impacted for carbon sink enhancement -	1073.931
permanent conservation cover	
Land impacted for carbon sink enhancement - Reforest	2663.497
cropland	
Land impacted for carbon sink enhancement - Reforest	551.926
pasture	
Land impacted for carbon sink enhancement - Restore	619.374
productivity	
Land impacted for carbon sink enhancement - total	12565
Land impacted for carbon sink enhancement - Total	1724.08
impacted (over 30 years)	1

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

						- 0	
variable_name	2020	2025	2030	2035	2040	2045	2050
Power generation capital investment - biomass power	0	0	0	0	0	0	0
plant							
Power generation capital investment - biomass w/ccu	0	0	0	0	0	0	0
allam power plant							
Power generation capital investment - biomass w/ccu	0	0	0.03	0	0	0	0
power plant							

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	0	0	0	0	0	0	0
power plant							
Power generation by technology - biomass w/ccu power	0	0	33.978	33.978	33.978	33.978	33.978
plant							

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

2050
19.23
46
318.85
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	662.523
regeneration	
Carbon sink enhancement potential - All (not counting	23645.8
overlap)	
Carbon sink enhancement potential - Avoid deforestation	1220.767
Carbon sink enhancement potential - corn-ethanol to	-3016.208
energy grasses	
Carbon sink enhancement potential - cropland measures	-10766.281
Carbon sink enhancement potential - Cropland to woody	0
energy crops	
Carbon sink enhancement potential - Extend rotation	508.78
length	
Carbon sink enhancement potential - Improve	72.272
plantations	
Carbon sink enhancement potential - Increase retention	740.525
of HWP	
Carbon sink enhancement potential - Increase trees	4044.4
outside forests	
Carbon sink enhancement potential - pasture to energy	0
crops	
Carbon sink enhancement potential - permanent	-609.214
conservation cover	
Carbon sink enhancement potential - Reforest cropland	7999.8
Carbon sink enhancement potential - Reforest pasture	7299.1
Carbon sink enhancement potential - Restore	1097.577
productivity	
Carbon sink enhancement potential - total	-14391.704
Land impacted for carbon sink enhancement - Accelerate	267.022
regeneration	
Land impacted for carbon sink enhancement - All (not	4314.9
counting overlap)	
Land impacted for carbon sink enhancement - Avoid	327.698
deforestation	
Land impacted for carbon sink enhancement -	2159.4
corn-ethanol to energy grasses	
Land impacted for carbon sink enhancement - cropland	18732.8
measures	

 ${\bf Table\ 41:}\ RE+\ scenario\ -\ PILLAR\ 6:\ Land\ carbon\ sinks\ -\ Agriculture\ (continued)$

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

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

Carbon sink enhancement potential - Extend rotation length Carbon sink enhancement potential - Improve plantations Carbon sink enhancement potential - Improve plantations Carbon sink enhancement potential - Increase retention of HWP Carbon sink enhancement potential - Increase retention of HWP Carbon sink enhancement potential - Increase trees outside forests Carbon sink enhancement potential - Permanent conservation cover Carbon sink enhancement potential - Reforest cropland carbon sink enhancement potential - Reforest pasture 7299.8 Carbon sink enhancement potential - Restore productivity Carbon sink enhancement potential - Restore 1097.577 Carbon sink enhancement potential - total 1097.577 Land impacted for carbon sink enhancement - Accelerate regeneration 1098 Land impacted for carbon sink enhancement - Avoid 327.698 deforestation 1098 Land impacted for carbon sink enhancement - cropland 10994 measures 1099. Land impacted for carbon sink enhancement - Extend 10994 measures 10994 Land impacted for carbon sink enhancement - Improve plantations 10994 Land impacted for carbon sink enhancement - Improve plantations 10994 Land impacted for carbon sink enhancement - Increase retention of HWP 10994 Land impacted for carbon sink enhancement - Increase 1140.885 trees outside forests 1140.885 Land impacted for carbon sink enhancement - Increase 1140.885 Land impacted for carbon sink enhancement - Increase 1140.885 Land impacted for carbon sink enhancement - Increase 1140.885	variable_name	2050
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permanent conservation cover		
		1073.931
	Land impacted for carbon sink enhancement - Reforest	2663.497
cropland		
Land impacted for carbon sink enhancement - Reforest 551.926		551.926
pasture		
Land impacted for carbon sink enhancement - Restore 619.374		619.374
productivity		
Land impacted for carbon sink enhancement - total 12565		
Land impacted for carbon sink enhancement - Total 1724.08		1724.08
impacted (over 30 years)	impacted (over 30 years)	

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	0
HWP	
Business-as-usual carbon sink - Increase trees outside	229.384
forests	
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