

Supplementary Materials: Results

1. Scenario 1: VRE 30% (Solar: Wind = 1:1)

Table S1.1: No Residual Demand Duration

	No Residual Demand Duration [hrs]
VE Venezuela	8733
CO Colombia	8731
BR Brazil	8726
MZ Mozambique	8721
PY Paraguay	8711
CA Canada	3720
NZ New Zealand	2934
SD Sudan	2465
PE Peru	2231
GH Ghana	1051
SE Sweden	806
MY Malaysia	327
VN Vietnam	321
AR Argentina	285
IT Italy	164
TR Turkey	136
CL Chile	133
ES Spain	91
JP Japan	61
KR South Korea	59
NG Nigeria	48
FR France	35
TH Thailand	18
DE Germany	11
UA Ukraine	10
PL Poland	9
TN Tunisia	6
ID Indonesia	5
CN China	4
DZ Algeria	4
GB United Kingdom	2
MA Morocco	1
AU Australia	0
EG Egypt	0
IN India	0
IR Iran	0
LY Libya	0
MX Mexico	0
RU Russia	0
SA Saudi Arabia	0
US United States	0
ZA South Africa	0

Table S1.2: Curtailed VRE Energy

	Curtailed E [normalized]	Curtailed E [GWh]
MY Malaysia	19.236	321.927
SE Sweden	14.067	212.558
KR South Korea	5.275	326.919
AR Argentina	4.701	67.288
CL Chile	4.426	38.918
CO Colombia	4.219	34.261
GH Ghana	3.802	5.463
PY Paraguay	1.859	2.659
IT Italy	1.758	61.452
MA Morocco	0.931	3.337
JP Japan	0.816	89.824
NG Nigeria	0.530	1.625
DZ Algeria	0.466	3.301
TR Turkey	0.412	10.496
ES Spain	0.381	10.747
PL Poland	0.213	3.702
TN Tunisia	0.204	0.368
VN Vietnam	0.203	4.537
FR France	0.178	9.198
DE Germany	0.146	8.882
GB United Kingdom	0.136	4.859
TH Thailand	0.122	2.716
NZ New Zealand	0.120	0.555
SD Sudan	0.106	0.156
ZA South Africa	0.043	1.022
AU Australia	0.000	0.000
BR Brazil	0.000	0.000
CA Canada	0.000	0.000
CN China	0.000	0.000
EG Egypt	0.000	0.000
ID Indonesia	0.000	0.000
IN India	0.000	0.000
IR Iran	0.000	0.000
LY Libya	0.000	0.000
MX Mexico	0.000	0.000
MZ Mozambique	0.000	0.000
PE Peru	0.000	0.000
RU Russia	0.000	0.000
SA Saudi Arabia	0.000	0.000
UA Ukraine	0.000	0.000
US United States	0.000	0.000
VE Venezuela	0.000	0.000

Table S1.3: VRE Total Installed Capacity

	Capacity [normalized]	Capacity [GW]
MY Malaysia	1.490	24.930
SE Sweden	1.159	17.510
CO Colombia	1.152	9.358
TH Thailand	1.129	25.106
KR South Korea	1.120	69.383
VN Vietnam	1.114	24.890
GH Ghana	1.107	1.591
IT Italy	1.091	38.153
NG Nigeria	1.031	3.162
VE Venezuela	0.984	7.332
ES Spain	0.970	27.408
TR Turkey	0.962	24.534
PL Poland	0.962	16.681
IN India	0.941	140.974
PE Peru	0.937	5.212
ID Indonesia	0.931	26.277
JP Japan	0.929	102.185
MZ Mozambique	0.921	1.341
PY Paraguay	0.919	1.315
MX Mexico	0.915	30.427
TN Tunisia	0.901	1.628
UA Ukraine	0.900	13.063
NZ New Zealand	0.894	4.131
DE Germany	0.888	53.962
FR France	0.840	43.312
BR Brazil	0.792	48.041
ZA South Africa	0.781	18.573
DZ Algeria	0.770	5.461
SD Sudan	0.767	1.128
GB United Kingdom	0.764	27.358
IR Iran	0.760	23.566
SA Saudi Arabia	0.759	28.650
EG Egypt	0.755	14.180
US United States	0.743	342.208
MA Morocco	0.740	2.653
CN China	0.716	526.968
CA Canada	0.680	43.002
AU Australia	0.673	18.351
CL Chile	0.673	5.915
AR Argentina	0.664	9.510
RU Russia	0.653	69.428
LY Libya	0.630	1.848

Table S1.4: Peak Residual Demand

	Peak Demand [normalized]	Peak Demand [GW]
FR France	1.515	78.075
TN Tunisia	1.476	2.667
GB United Kingdom	1.474	52.784
DZ Algeria	1.465	10.386
LY Libya	1.439	4.220
SE Sweden	1.417	21.417
SA Saudi Arabia	1.397	52.705
JP Japan	1.389	152.888
ES Spain	1.340	37.854
EG Egypt	1.331	25.008
DE Germany	1.328	80.696
PL Poland	1.314	22.783
IT Italy	1.278	44.672
TH Thailand	1.273	28.315
MA Morocco	1.268	4.543
PY Paraguay	1.257	1.798
ID Indonesia	1.239	34.970
NG Nigeria	1.225	3.754
IR Iran	1.221	37.845
KR South Korea	1.220	75.627
MY Malaysia	1.209	20.241
UA Ukraine	1.205	17.498
AU Australia	1.205	32.866
AR Argentina	1.204	17.241
ZA South Africa	1.194	28.388
US United States	1.177	541.862
IN India	1.134	169.920
GH Ghana	1.106	1.589
MX Mexico	1.085	36.078
CO Colombia	1.070	8.686
PE Peru	1.048	5.833
TR Turkey	1.047	26.692
RU Russia	1.035	110.075
VN Vietnam	1.031	23.029
VE Venezuela	1.030	7.674
CL Chile	1.024	9.008
CN China	0.929	684.051
CA Canada	0.913	57.766
BR Brazil	0.826	50.077
NZ New Zealand	0.751	3.469
MZ Mozambique	0.543	0.791
SD Sudan	0.291	0.428

Table S1.5: Max Hourly Ramp Up Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
TN Tunisia	0.306	0.554
MY Malaysia	0.281	4.702
MA Morocco	0.264	0.947
KR South Korea	0.264	16.372
NG Nigeria	0.256	0.784
TH Thailand	0.245	5.454
MX Mexico	0.236	7.861
GB United Kingdom	0.235	8.420
IN India	0.231	34.575
IR Iran	0.230	7.119
JP Japan	0.227	24.946
LY Libya	0.225	0.661
ZA South Africa	0.222	5.274
PL Poland	0.220	3.818
FR France	0.216	11.142
ID Indonesia	0.210	5.920
DZ Algeria	0.208	1.474
UA Ukraine	0.204	2.963
SA Saudi Arabia	0.196	7.392
CN China	0.193	141.802
IT Italy	0.187	6.545
DE Germany	0.187	11.372
EG Egypt	0.187	3.511
ES Spain	0.184	5.194
TR Turkey	0.180	4.602
VN Vietnam	0.165	3.680
US United States	0.164	75.463
AR Argentina	0.162	2.325
AU Australia	0.152	4.132
CL Chile	0.124	1.088
GH Ghana	0.101	0.146
SE Sweden	0.089	1.338
MZ Mozambique	0.084	0.123
NZ New Zealand	0.074	0.340
PE Peru	0.064	0.358
SD Sudan	0.057	0.083
RU Russia	0.047	5.014
CA Canada	0.007	0.421
BR Brazil	0.000	0.000
CO Colombia	0.000	0.000
PY Paraguay	0.000	0.000
VE Venezuela	0.000	0.000

Table S1.6: Max Hourly Ramp Down Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
GH Ghana	-0.382	-0.549
MY Malaysia	-0.310	-5.182
TH Thailand	-0.285	-6.342
KR South Korea	-0.279	-17.294
SE Sweden	-0.256	-3.861
NG Nigeria	-0.255	-0.782
GB United Kingdom	-0.240	-8.599
TN Tunisia	-0.237	-0.428
ES Spain	-0.235	-6.630
IT Italy	-0.219	-7.650
PL Poland	-0.219	-3.792
VN Vietnam	-0.217	-4.859
IN India	-0.212	-31.709
PE Peru	-0.211	-1.173
MA Morocco	-0.202	-0.724
UA Ukraine	-0.201	-2.913
MX Mexico	-0.199	-6.630
EG Egypt	-0.198	-3.712
ID Indonesia	-0.196	-5.521
ZA South Africa	-0.182	-4.328
DE Germany	-0.179	-10.888
FR France	-0.173	-8.921
CL Chile	-0.172	-1.515
AU Australia	-0.170	-4.631
CN China	-0.169	-124.629
DZ Algeria	-0.168	-1.193
LY Libya	-0.168	-0.493
AR Argentina	-0.165	-2.362
TR Turkey	-0.162	-4.137
JP Japan	-0.161	-17.684
BR Brazil	-0.161	-9.737
US United States	-0.157	-72.078
VE Venezuela	-0.149	-1.107
IR Iran	-0.147	-4.559
SD Sudan	-0.146	-0.214
SA Saudi Arabia	-0.142	-5.357
PY Paraguay	-0.130	-0.186
NZ New Zealand	-0.120	-0.556
MZ Mozambique	-0.116	-0.169
CO Colombia	-0.116	-0.939
RU Russia	-0.062	-6.557
CA Canada	-0.050	-3.183

Table S1.7: Sum of Hourly Ramp Up Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
MY Malaysia	365.0	6108.5
GH Ghana	330.3	474.6
ID Indonesia	296.9	8379.9
NG Nigeria	294.4	902.5
TH Thailand	275.7	6130.2
IT Italy	269.0	9406.7
GB United Kingdom	229.3	8210.7
VN Vietnam	223.0	4983.2
LY Libya	219.5	643.8
MA Morocco	216.8	776.8
TN Tunisia	216.7	391.7
IN India	215.4	32278.6
ES Spain	213.4	6026.0
EG Egypt	209.2	3929.3
DZ Algeria	209.0	1481.7
PL Poland	192.6	3340.7
JP Japan	185.7	20439.5
FR France	183.5	9457.6
KR South Korea	179.1	11098.7
DE Germany	177.5	10785.5
ZA South Africa	175.9	4179.9
AR Argentina	175.1	2506.7
MX Mexico	174.9	5813.8
CN China	174.7	128606.5
TR Turkey	168.1	4285.3
CL Chile	163.6	1438.2
UA Ukraine	158.5	2300.9
SE Sweden	152.9	2310.2
US United States	151.3	69633.2
IR Iran	149.1	4619.9
AU Australia	134.7	3675.1
SA Saudi Arabia	133.5	5038.4
PE Peru	112.3	624.9
NZ New Zealand	102.7	474.7
SD Sudan	82.5	121.3
RU Russia	72.0	7658.8
CA Canada	22.8	1441.8
MZ Mozambique	0.4	0.6
BR Brazil	0.0	0.0
CO Colombia	0.0	0.0
PY Paraguay	0.0	0.0
VE Venezuela	0.0	0.0

Table S1.8: Sum of Hourly Ramp Down Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
MY Malaysia	-365.1	-6110.0
GH Ghana	-330.4	-474.8
ID Indonesia	-297.1	-8387.3
NG Nigeria	-294.5	-902.7
TH Thailand	-276.0	-6135.8
IT Italy	-269.2	-9414.3
GB United Kingdom	-229.5	-8215.8
VN Vietnam	-223.4	-4992.3
LY Libya	-219.5	-643.8
MA Morocco	-217.0	-777.5
TN Tunisia	-216.7	-391.7
IN India	-215.7	-32312.0
ES Spain	-213.3	-6025.2
EG Egypt	-209.2	-3929.9
DZ Algeria	-209.0	-1481.8
PL Poland	-192.6	-3341.3
JP Japan	-185.9	-20460.5
FR France	-183.5	-9455.7
KR South Korea	-179.0	-11094.0
DE Germany	-177.6	-10788.3
ZA South Africa	-175.7	-4176.8
AR Argentina	-175.3	-2509.3
MX Mexico	-175.1	-5818.6
CN China	-175.0	-128892.2
TR Turkey	-168.7	-4300.3
CL Chile	-163.8	-1440.4
UA Ukraine	-158.8	-2304.5
SE Sweden	-153.6	-2320.6
US United States	-151.8	-69870.5
IR Iran	-149.2	-4622.1
AU Australia	-135.0	-3682.3
SA Saudi Arabia	-133.5	-5035.7
PE Peru	-113.1	-629.1
NZ New Zealand	-103.3	-477.3
SD Sudan	-82.7	-121.6
RU Russia	-72.4	-7696.5
CA Canada	-23.7	-1497.3
PY Paraguay	-1.3	-1.8
CO Colombia	-1.1	-8.9
VE Venezuela	-1.1	-8.1
MZ Mozambique	-0.9	-1.4
BR Brazil	-0.8	-51.5

2. Scenario 2: VRE 50% (Solar: Wind = 1:1)

Table S2.1: No Residual Demand Duration

	No Residual Demand Duration [hrs]
MZ Mozambique	8752
BR Brazil	8749
VE Venezuela	8747
CO Colombia	8746
PY Paraguay	8734
CA Canada	8686
SD Sudan	8655
NZ New Zealand	8637
PE Peru	6998
SE Sweden	3809
GH Ghana	3394
MY Malaysia	2814
VN Vietnam	2145
ID Indonesia	2115
AR Argentina	1595
NG Nigeria	1414
CL Chile	1342
TR Turkey	1341
IT Italy	1326
KR South Korea	983
TH Thailand	974
CN China	963
JP Japan	935
ES Spain	791
PL Poland	634
FR France	618
TN Tunisia	602
IN India	565
UA Ukraine	517
MX Mexico	504
DE Germany	491
DZ Algeria	488
ZA South Africa	478
GB United Kingdom	412
SA Saudi Arabia	391
US United States	352
MA Morocco	311
IR Iran	279
RU Russia	258
LY Libya	218
AU Australia	204
EG Egypt	169

Table S2.2: Curtailed VRE Energy

	Curtailed E [normalized]	Curtailed E [GWh]
MY Malaysia	1688.25	28254
PE Peru	1677.08	9331
CO Colombia	504.30	4095
SE Sweden	502.14	7587
ID Indonesia	407.28	11496
PY Paraguay	250.08	358
KR South Korea	244.98	15183
GH Ghana	232.86	335
IT Italy	191.01	6679
VN Vietnam	179.32	4006
VE Venezuela	174.38	1299
TH Thailand	171.20	3806
JP Japan	133.48	14688
NG Nigeria	110.48	339
ES Spain	97.73	2760
TN Tunisia	91.59	166
PL Poland	78.02	1353
TR Turkey	77.03	1964
UA Ukraine	65.90	956
FR France	59.17	3049
BR Brazil	56.67	3436
DE Germany	55.23	3356
ZA South Africa	53.81	1279
DZ Algeria	50.55	358
NZ New Zealand	49.08	227
MZ Mozambique	47.24	69
MX Mexico	44.33	1474
GB United Kingdom	42.95	1538
SA Saudi Arabia	39.65	1496
CL Chile	34.25	301
AR Argentina	33.74	483
SD Sudan	29.42	43
IN India	26.55	3978
MA Morocco	20.97	75
US United States	19.92	9170
CA Canada	19.80	1253
CN China	17.91	13191
IR Iran	12.07	374
LY Libya	11.76	34
AU Australia	7.44	203
EG Egypt	5.19	98
RU Russia	2.64	280

Table S2.3: VRE Total Installed Capacity

	Capacity [normalized]	Capacity [GW]
MY Malaysia	3.415	57.147
PE Peru	2.159	12.012
SE Sweden	2.141	32.356
CO Colombia	2.138	17.364
KR South Korea	1.966	121.862
TH Thailand	1.955	43.476
GH Ghana	1.941	2.789
VN Vietnam	1.933	43.178
IT Italy	1.897	66.317
NG Nigeria	1.762	5.401
VE Venezuela	1.706	12.706
ID Indonesia	1.696	47.867
ES Spain	1.653	46.692
TR Turkey	1.632	41.602
PL Poland	1.631	28.295
PY Paraguay	1.618	2.314
JP Japan	1.594	175.443
IN India	1.578	236.380
MZ Mozambique	1.551	2.260
MX Mexico	1.541	51.225
TN Tunisia	1.533	2.771
UA Ukraine	1.523	22.100
NZ New Zealand	1.507	6.962
DE Germany	1.499	91.064
FR France	1.420	73.156
BR Brazil	1.337	81.104
ZA South Africa	1.318	31.336
DZ Algeria	1.299	9.206
SD Sudan	1.287	1.892
GB United Kingdom	1.286	46.043
SA Saudi Arabia	1.277	48.182
IR Iran	1.271	39.385
EG Egypt	1.260	23.661
US United States	1.245	572.937
MA Morocco	1.240	4.443
CN China	1.198	881.871
CA Canada	1.138	71.994
CL Chile	1.130	9.936
AU Australia	1.123	30.637
AR Argentina	1.116	15.972
RU Russia	1.089	115.782
LY Libya	1.053	3.088

Table S2.4: Peak Residual Demand

	Peak Demand [normalized]	Peak Demand [GW]
TN Tunisia	1.425	2.576
GB United Kingdom	1.423	50.967
DZ Algeria	1.414	10.026
LY Libya	1.398	4.100
SA Saudi Arabia	1.349	50.892
DE Germany	1.288	78.270
IT Italy	1.283	44.867
TH Thailand	1.273	28.297
JP Japan	1.268	139.482
MY Malaysia	1.264	21.162
MA Morocco	1.252	4.485
PL Poland	1.238	21.475
EG Egypt	1.236	23.207
KR South Korea	1.225	75.946
ID Indonesia	1.179	33.279
FR France	1.179	60.739
ZA South Africa	1.167	27.729
NG Nigeria	1.146	3.513
AR Argentina	1.138	16.286
UA Ukraine	1.128	16.377
US United States	1.122	516.329
IR Iran	1.121	34.739
AU Australia	1.106	30.172
MX Mexico	1.084	36.034
IN India	1.066	159.781
ES Spain	1.065	30.069
PY Paraguay	1.017	1.454
PE Peru	0.965	5.366
TR Turkey	0.958	24.419
CO Colombia	0.943	7.654
VE Venezuela	0.885	6.594
RU Russia	0.858	91.189
VN Vietnam	0.839	18.751
CN China	0.797	587.125
CL Chile	0.786	6.916
CA Canada	0.785	49.643
BR Brazil	0.728	44.131
SE Sweden	0.719	10.868
GH Ghana	0.563	0.808
MZ Mozambique	0.433	0.631
NZ New Zealand	0.351	1.624
SD Sudan	0.169	0.249

Table S2.5: Max Hourly Ramp Up Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
MY Malaysia	0.408	6.826
TN Tunisia	0.401	0.726
KR South Korea	0.367	22.730
TH Thailand	0.338	7.518
LY Libya	0.330	0.966
SA Saudi Arabia	0.297	11.212
MA Morocco	0.296	1.061
IR Iran	0.295	9.157
ZA South Africa	0.294	6.994
DZ Algeria	0.294	2.083
PL Poland	0.292	5.065
ID Indonesia	0.286	8.078
DE Germany	0.286	17.366
IN India	0.283	42.401
EG Egypt	0.277	5.195
MX Mexico	0.272	9.051
JP Japan	0.253	27.806
GB United Kingdom	0.251	9.001
UA Ukraine	0.248	3.598
US United States	0.229	105.272
IT Italy	0.214	7.469
ES Spain	0.197	5.569
NG Nigeria	0.189	0.581
AR Argentina	0.177	2.538
AU Australia	0.172	4.692
FR France	0.166	8.555
CN China	0.158	116.658
TR Turkey	0.144	3.674
SE Sweden	0.134	2.023
CL Chile	0.110	0.966
VN Vietnam	0.104	2.315
PE Peru	0.100	0.555
NZ New Zealand	0.082	0.380
SD Sudan	0.080	0.117
GH Ghana	0.061	0.088
RU Russia	0.053	5.612
MZ Mozambique	0.045	0.065
PY Paraguay	0.000	0.000
BR Brazil	0.000	0.000
CA Canada	0.000	0.000
CO Colombia	0.000	0.000
VE Venezuela	0.000	0.000

Table S2.6: Max Hourly Ramp Down Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
MY Malaysia	-0.445	-7.450
TH Thailand	-0.442	-9.817
PE Peru	-0.383	-2.131
IN India	-0.340	-50.944
KR South Korea	-0.338	-20.942
IT Italy	-0.337	-11.782
ES Spain	-0.327	-9.240
PL Poland	-0.312	-5.411
UA Ukraine	-0.312	-4.526
NG Nigeria	-0.302	-0.925
DE Germany	-0.299	-18.137
MX Mexico	-0.295	-9.799
ZA South Africa	-0.282	-6.700
ID Indonesia	-0.281	-7.934
GB United Kingdom	-0.280	-10.017
TN Tunisia	-0.275	-0.497
CN China	-0.270	-198.459
JP Japan	-0.269	-29.563
TR Turkey	-0.266	-6.777
EG Egypt	-0.264	-4.950
PY Paraguay	-0.263	-0.376
VN Vietnam	-0.258	-5.762
FR France	-0.256	-13.167
GH Ghana	-0.253	-0.364
SA Saudi Arabia	-0.253	-9.563
CL Chile	-0.253	-2.222
AU Australia	-0.249	-6.800
BR Brazil	-0.248	-15.040
AR Argentina	-0.248	-3.549
IR Iran	-0.246	-7.631
VE Venezuela	-0.237	-1.765
US United States	-0.235	-108.214
MA Morocco	-0.235	-0.840
LY Libya	-0.234	-0.685
MZ Mozambique	-0.214	-0.312
DZ Algeria	-0.214	-1.520
CO Colombia	-0.194	-1.574
SE Sweden	-0.131	-1.979
RU Russia	-0.093	-9.927
SD Sudan	-0.085	-0.125
NZ New Zealand	-0.072	-0.335
CA Canada	-0.037	-2.357

Table S2.7: Sum of Hourly Ramp Up Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
MY Malaysia	362	6053
ID Indonesia	353	9957
TH Thailand	350	7789
NG Nigeria	329	1008
IT Italy	304	10639
IN India	296	44345
LY Libya	279	819
ES Spain	265	7493
TN Tunisia	263	475
GB United Kingdom	261	9334
EG Egypt	257	4825
DZ Algeria	256	1817
KR South Korea	248	15381
ZA South Africa	247	5862
MA Morocco	245	877
PL Poland	243	4218
MX Mexico	240	7991
JP Japan	229	25181
DE Germany	225	13675
CN China	223	163844
FR France	214	11051
UA Ukraine	210	3044
VN Vietnam	206	4593
IR Iran	205	6345
SA Saudi Arabia	198	7483
US United States	197	90762
TR Turkey	191	4882
AU Australia	189	5147
AR Argentina	178	2545
GH Ghana	170	245
CL Chile	165	1453
RU Russia	101	10703
SE Sweden	58	882
PE Peru	33	185
SD Sudan	3	4
NZ New Zealand	2	11
MZ Mozambique	0	0
PY Paraguay	0	0
BR Brazil	0	0
CA Canada	0	0
CO Colombia	0	0
VE Venezuela	0	0

Table S2.8: Sum of Hourly Ramp Down Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
MY Malaysia	-362	-6050
ID Indonesia	-353	-9961
TH Thailand	-350	-7793
NG Nigeria	-329	-1008
IT Italy	-305	-10649
IN India	-296	-44360
LY Libya	-279	-819
ES Spain	-265	-7491
TN Tunisia	-263	-475
GB United Kingdom	-261	-9336
EG Egypt	-257	-4824
DZ Algeria	-256	-1817
KR South Korea	-248	-15371
ZA South Africa	-246	-5855
MA Morocco	-245	-878
PL Poland	-243	-4219
MX Mexico	-241	-7998
JP Japan	-229	-25190
DE Germany	-225	-13682
CN China	-223	-164229
FR France	-214	-11036
UA Ukraine	-210	-3046
VN Vietnam	-206	-4601
IR Iran	-205	-6350
SA Saudi Arabia	-198	-7479
US United States	-198	-91078
TR Turkey	-192	-4898
AU Australia	-189	-5152
AR Argentina	-178	-2548
GH Ghana	-170	-245
CL Chile	-165	-1454
RU Russia	-101	-10747
SE Sweden	-59	-891
PE Peru	-34	-190
SD Sudan	-3	-4
NZ New Zealand	-3	-13
PY Paraguay	-1	-1
CO Colombia	-1	-8
VE Venezuela	-1	-7
CA Canada	-1	-51
BR Brazil	-1	-45
MZ Mozambique	-1	-1



3. Scenario 3: VRE 70% (Solar: Wind = 1:1)

Table S3.1: No Residual Demand Duration

	No Residual Demand Duration [hrs]
MZ Mozambique	8755
BR Brazil	8750
PY Paraguay	8749
CO Colombia	8748
VE Venezuela	8748
PE Peru	8742
SD Sudan	8732
NZ New Zealand	8712
CA Canada	8710
SE Sweden	8565
GH Ghana	8298
CL Chile	7905
AR Argentina	5447
NG Nigeria	5266
TR Turkey	5013
VN Vietnam	4995
MY Malaysia	4337
IT Italy	4155
ID Indonesia	4060
KR South Korea	3809
TH Thailand	3494
IN India	3461
JP Japan	3391
ES Spain	3339
CN China	3203
PL Poland	3182
MX Mexico	2977
FR France	2915
ZA South Africa	2907
UA Ukraine	2884
DE Germany	2770
TN Tunisia	2698
GB United Kingdom	2628
DZ Algeria	2325
MA Morocco	2287
RU Russia	2260
SA Saudi Arabia	2215
IR Iran	2123
US United States	2051
LY Libya	1874
EG Egypt	1703
AU Australia	1602

Table S3.2: Curtailed VRE Energy

	Curtailed E [normalized]	Curtailed E [GWh]
PE Peru	17347.32	96513
MY Malaysia	10749.61	179902
CO Colombia	5769.32	46848
ID Indonesia	4899.91	138310
SE Sweden	2742.56	41441
GH Ghana	2327.32	3344
VN Vietnam	2303.61	51468
KR South Korea	2217.58	137433
TH Thailand	1946.54	43281
VE Venezuela	1743.24	12986
NG Nigeria	1646.67	5047
IT Italy	1632.43	57078
PY Paraguay	1606.36	2298
JP Japan	1288.34	141766
TR Turkey	1143.21	29147
PL Poland	1106.62	19194
BR Brazil	1103.41	66910
IN India	1060.75	158927
CL Chile	993.04	8732
ES Spain	866.16	24463
NZ New Zealand	827.17	3822
DE Germany	818.94	49754
TN Tunisia	816.94	1477
UA Ukraine	785.21	11397
MX Mexico	768.49	25544
ZA South Africa	735.82	17490
CN China	706.58	520284
GB United Kingdom	640.36	22928
FR France	630.55	32493
AR Argentina	576.20	8248
MZ Mozambique	547.13	797
DZ Algeria	532.53	3775
SA Saudi Arabia	520.47	19639
SD Sudan	448.59	659
MA Morocco	399.12	1430
US United States	374.65	172457
IR Iran	351.24	10885
CA Canada	345.08	21827
LY Libya	336.36	986
AU Australia	237.68	6483
RU Russia	188.54	20043
EG Egypt	162.36	3050

Table S3.3: VRE Total Installed Capacity

	Capacity [normalized]	Capacity [GW]
MY Malaysia	9.499	158.98
PE Peru	8.370	46.56
CO Colombia	5.210	42.31
ID Indonesia	3.908	110.31
SE Sweden	3.893	58.82
VN Vietnam	3.576	79.89
GH Ghana	3.560	5.11
KR South Korea	3.550	220.00
TH Thailand	3.471	77.17
IT Italy	3.222	112.65
NG Nigeria	3.052	9.36
VE Venezuela	2.949	21.97
PY Paraguay	2.704	3.87
TR Turkey	2.663	67.91
PL Poland	2.649	45.94
JP Japan	2.621	288.44
ES Spain	2.584	72.97
IN India	2.575	385.83
MX Mexico	2.404	79.89
TN Tunisia	2.382	4.31
UA Ukraine	2.369	34.38
NZ New Zealand	2.367	10.94
DE Germany	2.349	142.72
MZ Mozambique	2.340	3.41
BR Brazil	2.181	132.27
FR France	2.163	111.45
ZA South Africa	2.042	48.54
GB United Kingdom	1.969	70.50
DZ Algeria	1.953	13.85
SA Saudi Arabia	1.922	72.52
SD Sudan	1.921	2.82
IR Iran	1.876	58.14
CN China	1.862	1371.26
US United States	1.841	847.27
MA Morocco	1.840	6.59
CL Chile	1.824	16.04
EG Egypt	1.808	33.96
AR Argentina	1.696	24.27
CA Canada	1.676	105.98
AU Australia	1.631	44.48
RU Russia	1.571	166.98
LY Libya	1.551	4.55

Table S3.4: Peak Residual Demand

	Peak Demand [normalized]	Peak Demand [GW]
GB United Kingdom	1.367	48.948
TN Tunisia	1.357	2.453
LY Libya	1.350	3.960
DZ Algeria	1.349	9.563
SA Saudi Arabia	1.289	48.632
PL Poland	1.288	22.345
DE Germany	1.285	78.069
TH Thailand	1.277	28.385
KR South Korea	1.212	75.121
MA Morocco	1.174	4.207
ZA South Africa	1.129	26.834
EG Egypt	1.124	21.120
JP Japan	1.115	122.671
UA Ukraine	1.028	14.916
ID Indonesia	1.025	28.923
IR Iran	1.011	31.332
FR France	1.004	51.756
IT Italy	0.989	34.585
MY Malaysia	0.981	16.425
US United States	0.981	451.495
MX Mexico	0.973	32.349
AU Australia	0.946	25.814
ES Spain	0.897	25.335
IN India	0.886	132.800
NG Nigeria	0.715	2.191
CN China	0.669	492.666
PE Peru	0.664	3.692
PY Paraguay	0.643	0.920
VE Venezuela	0.635	4.733
CA Canada	0.634	40.119
BR Brazil	0.576	34.930
RU Russia	0.553	58.808
CO Colombia	0.546	4.437
TR Turkey	0.534	13.611
AR Argentina	0.518	7.420
CL Chile	0.450	3.958
SE Sweden	0.446	6.732
GH Ghana	0.406	0.583
VN Vietnam	0.377	8.426
MZ Mozambique	0.296	0.431
NZ New Zealand	0.150	0.691
SD Sudan	0.105	0.154

Table S3.5: Max Hourly Ramp Up Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
TN Tunisia	0.508	0.918
KR South Korea	0.501	31.025
TH Thailand	0.475	10.555
MY Malaysia	0.433	7.254
LY Libya	0.426	1.250
PL Poland	0.403	6.988
SA Saudi Arabia	0.383	14.465
DE Germany	0.380	23.106
ID Indonesia	0.372	10.496
ZA South Africa	0.364	8.655
DZ Algeria	0.360	2.551
EG Egypt	0.346	6.500
IN India	0.323	48.434
GB United Kingdom	0.322	11.540
IR Iran	0.295	9.129
MA Morocco	0.288	1.032
JP Japan	0.288	31.656
UA Ukraine	0.284	4.124
US United States	0.260	119.454
MX Mexico	0.239	7.950
NG Nigeria	0.226	0.692
FR France	0.223	11.498
AR Argentina	0.219	3.136
IT Italy	0.213	7.437
GH Ghana	0.203	0.291
SE Sweden	0.193	2.916
AU Australia	0.186	5.062
ES Spain	0.182	5.138
CL Chile	0.156	1.372
VN Vietnam	0.144	3.218
CN China	0.140	103.062
RU Russia	0.083	8.840
NZ New Zealand	0.074	0.340
TR Turkey	0.058	1.484
SD Sudan	0.053	0.077
PE Peru	0.016	0.092
MZ Mozambique	0.010	0.015
BR Brazil	0.000	0.000
CA Canada	0.000	0.000
CO Colombia	0.000	0.000
PY Paraguay	0.000	0.000
VE Venezuela	0.000	0.000

Table S3.6: Max Hourly Ramp Down Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
KR South Korea	-0.500	-30.96
MY Malaysia	-0.441	-7.37
ES Spain	-0.431	-12.19
PL Poland	-0.424	-7.35
ZA South Africa	-0.422	-10.04
TH Thailand	-0.403	-8.96
MX Mexico	-0.397	-13.20
IT Italy	-0.391	-13.68
IN India	-0.382	-57.22
TN Tunisia	-0.370	-0.67
DE Germany	-0.362	-21.98
UA Ukraine	-0.328	-4.76
SA Saudi Arabia	-0.318	-12.01
EG Egypt	-0.314	-5.89
US United States	-0.308	-141.94
PE Peru	-0.307	-1.71
JP Japan	-0.302	-33.27
IR Iran	-0.301	-9.31
CN China	-0.293	-215.50
LY Libya	-0.290	-0.85
AU Australia	-0.287	-7.81
DZ Algeria	-0.279	-1.98
ID Indonesia	-0.274	-7.73
MA Morocco	-0.272	-0.97
GB United Kingdom	-0.267	-9.57
FR France	-0.258	-13.32
NG Nigeria	-0.247	-0.76
BR Brazil	-0.240	-14.55
GH Ghana	-0.187	-0.27
SE Sweden	-0.176	-2.66
PY Paraguay	-0.175	-0.25
TR Turkey	-0.171	-4.36
CL Chile	-0.169	-1.49
VE Venezuela	-0.166	-1.23
VN Vietnam	-0.155	-3.46
MZ Mozambique	-0.148	-0.22
AR Argentina	-0.124	-1.78
RU Russia	-0.105	-11.20
CO Colombia	-0.105	-0.85
CA Canada	-0.061	-3.84
NZ New Zealand	-0.057	-0.26
SD Sudan	-0.053	-0.08

Table S3.7: Sum of Hourly Ramp Up Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
TH Thailand	312	6947
LY Libya	307	901
EG Egypt	272	5101
TN Tunisia	269	487
DZ Algeria	266	1885
MY Malaysia	260	4348
ID Indonesia	256	7239
ZA South Africa	249	5915
KR South Korea	245	15182
IN India	244	36619
GB United Kingdom	236	8432
PL Poland	235	4068
ES Spain	227	6400
MX Mexico	227	7531
SA Saudi Arabia	224	8468
IT Italy	223	7811
MA Morocco	222	795
DE Germany	218	13220
IR Iran	216	6682
JP Japan	194	21392
US United States	194	89407
AU Australia	194	5278
UA Ukraine	182	2636
FR France	169	8686
NG Nigeria	162	497
CN China	147	108581
RU Russia	83	8874
VN Vietnam	69	1539
TR Turkey	67	1712
GH Ghana	22	32
CL Chile	19	169
AR Argentina	18	263
SE Sweden	4	63
NZ New Zealand	1	5
SD Sudan	1	1
PE Peru	0	0
MZ Mozambique	0	0
BR Brazil	0	0
CA Canada	0	0
CO Colombia	0	0
PY Paraguay	0	0
VE Venezuela	0	0

Table S3.8: Sum of Hourly Ramp Down Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
TH Thailand	-312	-6946
LY Libya	-307	-901
EG Egypt	-271	-5098
TN Tunisia	-269	-487
DZ Algeria	-266	-1885
MY Malaysia	-260	-4348
ID Indonesia	-256	-7239
ZA South Africa	-248	-5902
KR South Korea	-245	-15186
IN India	-245	-36650
GB United Kingdom	-236	-8432
PL Poland	-235	-4068
MX Mexico	-227	-7542
ES Spain	-227	-6401
SA Saudi Arabia	-224	-8464
IT Italy	-223	-7811
MA Morocco	-222	-795
DE Germany	-218	-13220
IR Iran	-216	-6687
US United States	-195	-89760
JP Japan	-194	-21392
AU Australia	-194	-5278
UA Ukraine	-182	-2638
FR France	-168	-8649
NG Nigeria	-162	-497
CN China	-148	-108983
RU Russia	-84	-8915
VN Vietnam	-69	-1543
TR Turkey	-68	-1726
GH Ghana	-22	-32
CL Chile	-20	-173
AR Argentina	-19	-269
SE Sweden	-5	-68
NZ New Zealand	-1	-5
PE Peru	-1	-4
VE Venezuela	-1	-5
PY Paraguay	-1	-1
CA Canada	-1	-41
SD Sudan	-1	-1
BR Brazil	-1	-36
CO Colombia	-1	-5
MZ Mozambique	0	0

4. Scenario 4: VRE 70% (Solar: Wind = 1:2)

Table S4.1: No Residual Demand Duration

	No Residual Demand Duration [hrs]
MZ Mozambique	8754
BR Brazil	8750
PY Paraguay	8750
SD Sudan	8749
CO Colombia	8748
VE Venezuela	8748
PE Peru	8744
CA Canada	8726
NZ New Zealand	8706
SE Sweden	8586
GH Ghana	8372
CL Chile	8044
AR Argentina	4997
NG Nigeria	4649
VN Vietnam	4573
TR Turkey	4450
MY Malaysia	4163
IT Italy	3874
ID Indonesia	3574
KR South Korea	3205
PL Poland	3133
JP Japan	3046
TH Thailand	2996
ES Spain	2984
FR France	2915
DE Germany	2872
TN Tunisia	2761
CN China	2560
GB United Kingdom	2513
UA Ukraine	2334
DZ Algeria	2315
ZA South Africa	2312
EG Egypt	2172
MA Morocco	2084
IN India	1930
MX Mexico	1764
LY Libya	1734
US United States	1667
SA Saudi Arabia	1659
RU Russia	1428
AU Australia	1289
IR Iran	1159

Table S4.2: Curtailed VRE Energy

	Curtailed E [normalized]	Curtailed E [GWh]
PE Peru	8183	45529
MY Malaysia	4900	82007
CO Colombia	2665	21639
KR South Korea	2024	125438
NG Nigeria	1892	5799
PY Paraguay	1857	2656
GH Ghana	1841	2645
ID Indonesia	1831	51677
SE Sweden	1677	25332
IT Italy	1660	58052
PL Poland	1470	25502
TH Thailand	1183	26299
TN Tunisia	1152	2083
DE Germany	1076	65384
JP Japan	1037	114069
VN Vietnam	998	22298
VE Venezuela	939	6996
ES Spain	900	25406
NZ New Zealand	737	3405
TR Turkey	726	18517
SD Sudan	723	1062
FR France	710	36569
MZ Mozambique	704	1025
ZA South Africa	701	16654
GB United Kingdom	608	21763
DZ Algeria	575	4074
CL Chile	551	4845
UA Ukraine	516	7487
IN India	469	70299
BR Brazil	376	22779
MA Morocco	369	1322
MX Mexico	353	11736
AR Argentina	328	4698
SA Saudi Arabia	318	11986
EG Egypt	318	5965
LY Libya	305	894
CN China	300	220810
US United States	241	110970
CA Canada	136	8621
IR Iran	130	4028
AU Australia	118	3205
RU Russia	53	5596

Table S4.3: VRE Total Installed Capacity

	Capacity [normalized]	Capacity [GW]
MY Malaysia	6.712	112.32
PE Peru	5.190	28.88
CO Colombia	4.083	33.15
GH Ghana	3.504	5.03
KR South Korea	3.460	214.44
TH Thailand	3.439	76.47
SE Sweden	3.289	49.70
NG Nigeria	3.257	9.98
IT Italy	3.253	113.75
VN Vietnam	3.181	71.08
PY Paraguay	2.716	3.89
VE Venezuela	2.662	19.83
PL Poland	2.657	46.08
TR Turkey	2.620	66.81
ES Spain	2.594	73.26
ID Indonesia	2.559	72.22
JP Japan	2.528	278.23
TN Tunisia	2.481	4.48
MZ Mozambique	2.472	3.60
IN India	2.466	369.45
MX Mexico	2.272	75.53
DE Germany	2.247	136.48
UA Ukraine	2.227	32.33
NZ New Zealand	2.180	10.07
FR France	2.112	108.84
ZA South Africa	2.003	47.61
SD Sudan	1.959	2.88
BR Brazil	1.930	117.03
DZ Algeria	1.922	13.62
EG Egypt	1.826	34.29
SA Saudi Arabia	1.824	68.82
GB United Kingdom	1.809	64.77
IR Iran	1.745	54.09
MA Morocco	1.741	6.24
CN China	1.731	1274.65
US United States	1.721	792.37
CL Chile	1.599	14.06
AU Australia	1.572	42.87
AR Argentina	1.504	21.53
LY Libya	1.493	4.38
CA Canada	1.431	90.52
RU Russia	1.355	144.07

Table S4.4: Peak Residual Demand

	Peak Demand [normalized]	Peak Demand [GW]
GB United Kingdom	1.341	48.029
LY Libya	1.306	3.830
PL Poland	1.283	22.255
TN Tunisia	1.280	2.313
DE Germany	1.270	77.144
DZ Algeria	1.256	8.905
SA Saudi Arabia	1.248	47.108
TH Thailand	1.238	27.537
KR South Korea	1.139	70.602
JP Japan	1.103	121.402
MA Morocco	1.092	3.912
ZA South Africa	1.091	25.929
EG Egypt	1.085	20.371
ID Indonesia	1.082	30.540
UA Ukraine	1.047	15.200
MY Malaysia	1.047	17.525
FR France	1.000	51.534
IT Italy	0.975	34.096
AU Australia	0.971	26.485
IR Iran	0.962	29.807
MX Mexico	0.908	30.169
IN India	0.896	134.211
US United States	0.855	393.476
ES Spain	0.833	23.520
NG Nigeria	0.686	2.102
PE Peru	0.650	3.618
CN China	0.595	437.877
CA Canada	0.561	35.464
RU Russia	0.559	59.433
VE Venezuela	0.526	3.921
AR Argentina	0.505	7.231
BR Brazil	0.487	29.508
TR Turkey	0.485	12.361
CO Colombia	0.466	3.786
SE Sweden	0.438	6.611
GH Ghana	0.400	0.575
VN Vietnam	0.365	8.161
CL Chile	0.365	3.212
PY Paraguay	0.361	0.517
NZ New Zealand	0.300	1.386
MZ Mozambique	0.151	0.220
SD Sudan	0.054	0.080

Table S4.5: Max Hourly Ramp Up Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
KR South Korea	0.419	25.975
TN Tunisia	0.416	0.751
MY Malaysia	0.399	6.673
TH Thailand	0.332	7.375
LY Libya	0.313	0.917
PL Poland	0.303	5.248
ID Indonesia	0.296	8.357
MA Morocco	0.285	1.023
SA Saudi Arabia	0.276	10.418
DZ Algeria	0.270	1.914
GB United Kingdom	0.264	9.455
FR France	0.263	13.549
ZA South Africa	0.262	6.237
UA Ukraine	0.262	3.807
DE Germany	0.259	15.760
IN India	0.251	37.539
EG Egypt	0.248	4.662
IR Iran	0.244	7.576
IT Italy	0.213	7.431
NG Nigeria	0.195	0.597
GH Ghana	0.193	0.277
US United States	0.186	85.733
AR Argentina	0.184	2.640
MX Mexico	0.184	6.116
AU Australia	0.179	4.881
JP Japan	0.158	17.401
SE Sweden	0.149	2.257
ES Spain	0.142	3.998
CL Chile	0.138	1.214
CN China	0.126	92.527
VN Vietnam	0.113	2.517
NZ New Zealand	0.065	0.298
TR Turkey	0.060	1.533
RU Russia	0.053	5.609
SD Sudan	0.027	0.040
MZ Mozambique	0.023	0.033
PE Peru	0.014	0.075
BR Brazil	0.000	0.000
CA Canada	0.000	0.000
CO Colombia	0.000	0.000
PY Paraguay	0.000	0.000
VE Venezuela	0.000	0.000

Table S4.6: Max Hourly Ramp Down Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
MY Malaysia	-0.452	-7.57
TN Tunisia	-0.410	-0.74
PL Poland	-0.385	-6.68
TH Thailand	-0.382	-8.50
KR South Korea	-0.364	-22.56
IT Italy	-0.342	-11.95
ZA South Africa	-0.338	-8.03
LY Libya	-0.332	-0.97
DE Germany	-0.330	-20.03
IN India	-0.328	-49.10
ES Spain	-0.321	-9.06
PE Peru	-0.302	-1.68
DZ Algeria	-0.300	-2.13
VN Vietnam	-0.292	-6.53
EG Egypt	-0.285	-5.36
MX Mexico	-0.283	-9.42
UA Ukraine	-0.275	-3.99
SA Saudi Arabia	-0.274	-10.33
GB United Kingdom	-0.264	-9.47
ID Indonesia	-0.260	-7.34
FR France	-0.258	-13.30
JP Japan	-0.255	-28.07
AU Australia	-0.248	-6.78
MA Morocco	-0.245	-0.88
NG Nigeria	-0.243	-0.74
US United States	-0.238	-109.75
CN China	-0.233	-171.37
IR Iran	-0.209	-6.49
BR Brazil	-0.207	-12.57
GH Ghana	-0.180	-0.26
TR Turkey	-0.145	-3.71
CL Chile	-0.132	-1.16
VE Venezuela	-0.126	-0.94
AR Argentina	-0.118	-1.69
SE Sweden	-0.100	-1.51
PY Paraguay	-0.086	-0.12
RU Russia	-0.085	-9.01
CO Colombia	-0.084	-0.68
MZ Mozambique	-0.075	-0.11
NZ New Zealand	-0.060	-0.28
CA Canada	-0.039	-2.46
SD Sudan	-0.027	-0.04

Table S4.7: Sum of Hourly Ramp Up Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
TH Thailand	287	6376
MY Malaysia	261	4372
LY Libya	253	743
ID Indonesia	247	6967
TN Tunisia	230	415
IN India	228	34126
DZ Algeria	216	1529
KR South Korea	209	12957
EG Egypt	208	3913
ZA South Africa	202	4799
PL Poland	201	3483
GB United Kingdom	196	7008
IT Italy	195	6824
ES Spain	188	5317
DE Germany	187	11386
MA Morocco	181	648
SA Saudi Arabia	180	6776
MX Mexico	174	5789
AU Australia	168	4592
JP Japan	164	18049
IR Iran	159	4917
UA Ukraine	156	2270
US United States	154	70845
FR France	153	7890
NG Nigeria	149	455
CN China	147	108032
RU Russia	75	7923
TR Turkey	63	1616
VN Vietnam	61	1372
AR Argentina	18	256
GH Ghana	17	25
CL Chile	16	139
SE Sweden	3	49
NZ New Zealand	1	3
SD Sudan	0	0
MZ Mozambique	0	0
PE Peru	0	0
BR Brazil	0	0
CA Canada	0	0
CO Colombia	0	0
PY Paraguay	0	0
VE Venezuela	0	0

Table S4.8: Sum of Hourly Ramp Down Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
TH Thailand	-287	-6378
MY Malaysia	-261	-4372
LY Libya	-253	-743
ID Indonesia	-247	-6967
TN Tunisia	-230	-415
IN India	-228	-34155
DZ Algeria	-216	-1529
KR South Korea	-209	-12957
EG Egypt	-208	-3911
ZA South Africa	-201	-4783
PL Poland	-201	-3483
GB United Kingdom	-196	-7008
IT Italy	-195	-6824
ES Spain	-188	-5316
DE Germany	-187	-11386
MA Morocco	-181	-648
SA Saudi Arabia	-180	-6776
MX Mexico	-174	-5799
AU Australia	-168	-4594
JP Japan	-164	-18049
IR Iran	-159	-4923
UA Ukraine	-156	-2270
US United States	-155	-71232
FR France	-152	-7856
NG Nigeria	-149	-455
CN China	-147	-108390
RU Russia	-75	-7954
TR Turkey	-64	-1629
VN Vietnam	-62	-1383
AR Argentina	-18	-260
GH Ghana	-17	-25
CL Chile	-16	-142
SE Sweden	-4	-53
NZ New Zealand	-1	-5
PE Peru	-1	-4
CA Canada	-1	-36
VE Venezuela	-1	-4
BR Brazil	-1	-30
CO Colombia	0	-4
PY Paraguay	0	-1
MZ Mozambique	0	0
SD Sudan	0	0



5. Scenario 5: VRE 70% (Solar: Wind = 2:1)

Table 5.1: No Residual Demand Duration

	No Residual Demand Duration [hrs]
MZ Mozambique	8756
BR Brazil	8751
PY Paraguay	8749
CO Colombia	8748
VE Venezuela	8748
PE Peru	8738
CA Canada	8733
NZ New Zealand	8690
SD Sudan	8687
SE Sweden	8547
GH Ghana	8267
CL Chile	7794
AR Argentina	6197
NG Nigeria	5532
TR Turkey	5378
VN Vietnam	5235
IT Italy	4434
MY Malaysia	4426
ID Indonesia	4349
KR South Korea	4134
ZA South Africa	3960
ES Spain	3937
IN India	3916
CN China	3887
TH Thailand	3877
JP Japan	3845
MX Mexico	3820
TN Tunisia	3694
MA Morocco	3655
IR Iran	3631
SA Saudi Arabia	3535
PL Poland	3454
FR France	3440
EG Egypt	3419
UA Ukraine	3385
RU Russia	3339
AU Australia	3284
DZ Algeria	3273
LY Libya	3267
US United States	3221
DE Germany	3155
GB United Kingdom	3083

Table 5.2: Curtailed VRE Energy

	Curtailed E [normalized]	Curtailed E [GWh]
PE Peru	35624	198193
MY Malaysia	22407	375000
CO Colombia	12286	99763
ID Indonesia	11056	312064
VN Vietnam	5706	127488
SE Sweden	5297	80034
GH Ghana	4831	6941
TH Thailand	4671	103860
KR South Korea	4341	269046
VE Venezuela	4308	32093
BR Brazil	3798	230325
IN India	3768	564567
TR Turkey	3367	85851
NG Nigeria	3235	9917
MX Mexico	3035	100878
IT Italy	3029	105902
JP Japan	2930	322410
PY Paraguay	2852	4079
CL Chile	2691	23661
ZA South Africa	2578	61286
CN China	2506	1845016
ES Spain	2372	66982
UA Ukraine	2291	33256
IR Iran	1978	61287
SA Saudi Arabia	1880	70952
NZ New Zealand	1851	8554
PL Poland	1846	32021
AR Argentina	1742	24930
TN Tunisia	1700	3073
DE Germany	1481	89990
GB United Kingdom	1459	52230
US United States	1242	571633
MA Morocco	1232	4415
FR France	1222	62955
DZ Algeria	1220	8652
CA Canada	1168	73867
LY Libya	1159	3398
MZ Mozambique	1123	1635
AU Australia	1108	30214
SD Sudan	1096	1611
EG Egypt	891	16730
RU Russia	828	88038

Table 5.3: VRE Total Installed Capacity

	Capacity [normalized]	Capacity [GW]
MY Malaysia	15.22	254.75
PE Peru	14.77	82.16
CO Colombia	7.68	62.38
ID Indonesia	6.61	186.63
SE Sweden	5.28	79.80
VN Vietnam	4.79	106.96
GH Ghana	4.52	6.49
TH Thailand	4.49	99.86
KR South Korea	4.46	276.57
VE Venezuela	3.89	28.97
IT Italy	3.78	132.07
NG Nigeria	3.55	10.87
IN India	3.43	513.68
TR Turkey	3.33	84.98
JP Japan	3.27	360.28
PY Paraguay	3.23	4.63
MX Mexico	3.23	107.24
ES Spain	3.17	89.41
BR Brazil	3.08	186.93
PL Poland	3.08	53.44
UA Ukraine	3.08	44.68
NZ New Zealand	2.94	13.57
DE Germany	2.83	171.69
TN Tunisia	2.70	4.89
ZA South Africa	2.66	63.15
GB United Kingdom	2.60	93.13
CN China	2.54	1869.54
MZ Mozambique	2.46	3.59
FR France	2.46	126.59
IR Iran	2.45	75.99
CL Chile	2.43	21.35
SA Saudi Arabia	2.38	89.98
CA Canada	2.24	141.53
DZ Algeria	2.21	15.66
MA Morocco	2.20	7.89
US United States	2.19	1009.66
AR Argentina	2.19	31.34
SD Sudan	2.16	3.17
EG Egypt	2.05	38.49
RU Russia	1.98	210.56
AU Australia	1.93	52.69
LY Libya	1.92	5.64

Table 5.4: Peak Residual Demand

	Peak Demand [normalized]	Peak Demand [GW]
GB United Kingdom	1.400	50.137
TN Tunisia	1.400	2.530
DZ Algeria	1.394	9.884
LY Libya	1.385	4.061
JP Japan	1.336	147.038
SA Saudi Arabia	1.312	49.487
PL Poland	1.291	22.389
DE Germany	1.290	78.365
TH Thailand	1.279	28.446
MA Morocco	1.211	4.340
EG Egypt	1.148	21.564
IT Italy	1.133	39.621
KR South Korea	1.131	70.105
ZA South Africa	1.096	26.047
US United States	1.041	479.385
FR France	1.032	53.196
IR Iran	1.032	31.976
MX Mexico	1.028	34.158
ID Indonesia	0.999	28.192
MY Malaysia	0.980	16.397
UA Ukraine	0.977	14.174
AU Australia	0.969	26.425
ES Spain	0.967	27.299
IN India	0.899	134.753
PY Paraguay	0.810	1.159
NG Nigeria	0.746	2.287
CN China	0.712	524.187
CA Canada	0.705	44.590
VE Venezuela	0.698	5.203
PE Peru	0.673	3.742
BR Brazil	0.618	37.449
RU Russia	0.618	65.645
CO Colombia	0.599	4.865
TR Turkey	0.593	15.129
AR Argentina	0.529	7.568
CL Chile	0.507	4.458
SE Sweden	0.449	6.789
GH Ghana	0.409	0.587
MZ Mozambique	0.406	0.592
VN Vietnam	0.384	8.572
NZ New Zealand	0.165	0.764
SD Sudan	0.152	0.223

Table 5.5: Max Hourly Ramp Up Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
TN Tunisia	0.621	1.12
KR South Korea	0.563	34.91
LY Libya	0.550	1.61
TH Thailand	0.519	11.53
SA Saudi Arabia	0.506	19.09
ZA South Africa	0.490	11.65
DZ Algeria	0.475	3.37
PL Poland	0.475	8.24
GB United Kingdom	0.467	16.72
DE Germany	0.458	27.81
IR Iran	0.457	14.15
MY Malaysia	0.456	7.63
EG Egypt	0.445	8.36
JP Japan	0.439	48.29
ID Indonesia	0.402	11.34
IN India	0.397	59.42
MX Mexico	0.365	12.15
US United States	0.351	161.57
MA Morocco	0.334	1.20
IT Italy	0.314	10.99
UA Ukraine	0.293	4.25
NG Nigeria	0.280	0.86
ES Spain	0.268	7.57
AU Australia	0.250	6.82
FR France	0.233	12.02
AR Argentina	0.226	3.23
SE Sweden	0.225	3.39
CN China	0.209	153.87
GH Ghana	0.204	0.29
VN Vietnam	0.161	3.60
CL Chile	0.159	1.40
RU Russia	0.089	9.45
TR Turkey	0.078	2.00
NZ New Zealand	0.077	0.36
SD Sudan	0.076	0.11
PE Peru	0.019	0.10
BR Brazil	0.000	0.00
CA Canada	0.000	0.00
CO Colombia	0.000	0.00
MZ Mozambique	0.000	0.00
PY Paraguay	0.000	0.00
VE Venezuela	0.000	0.00

Table 5.6: Max Hourly Ramp Down Rate

	Ramp Rate [normalized]	Ramp Rate [GW/hr]
KR South Korea	-0.536	-33.23
DE Germany	-0.510	-31.00
IT Italy	-0.506	-17.69
PL Poland	-0.506	-8.77
ZA South Africa	-0.486	-11.55
ES Spain	-0.483	-13.65
MX Mexico	-0.479	-15.93
SA Saudi Arabia	-0.471	-17.77
TH Thailand	-0.464	-10.31
MY Malaysia	-0.435	-7.28
TN Tunisia	-0.430	-0.78
EG Egypt	-0.419	-7.87
DZ Algeria	-0.411	-2.91
CN China	-0.410	-302.05
UA Ukraine	-0.405	-5.88
LY Libya	-0.398	-1.17
AU Australia	-0.392	-10.70
US United States	-0.388	-178.48
IN India	-0.385	-57.62
MA Morocco	-0.375	-1.34
IR Iran	-0.369	-11.45
FR France	-0.358	-18.45
GB United Kingdom	-0.353	-12.63
JP Japan	-0.332	-36.57
PE Peru	-0.310	-1.73
TR Turkey	-0.297	-7.56
ID Indonesia	-0.284	-8.02
BR Brazil	-0.267	-16.16
NG Nigeria	-0.266	-0.81
PY Paraguay	-0.252	-0.36
SE Sweden	-0.217	-3.28
MZ Mozambique	-0.203	-0.30
GH Ghana	-0.192	-0.28
CL Chile	-0.192	-1.69
VE Venezuela	-0.189	-1.40
VN Vietnam	-0.165	-3.69
RU Russia	-0.152	-16.12
AR Argentina	-0.147	-2.10
CO Colombia	-0.127	-1.03
CA Canada	-0.123	-7.80
SD Sudan	-0.076	-0.11
NZ New Zealand	-0.063	-0.29

Table 5.7: Sum of Hourly Ramp Up Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
LY Libya	365	1071
DZ Algeria	337	2386
TH Thailand	320	7109
TN Tunisia	313	567
EG Egypt	302	5678
GB United Kingdom	270	9670
ID Indonesia	266	7506
PL Poland	265	4590
ZA South Africa	264	6284
KR South Korea	262	16246
MY Malaysia	259	4341
SA Saudi Arabia	258	9748
MA Morocco	257	920
DE Germany	252	15321
IN India	247	36991
IT Italy	246	8584
MX Mexico	243	8065
IR Iran	240	7425
ES Spain	238	6716
US United States	222	102349
JP Japan	214	23592
AU Australia	205	5582
UA Ukraine	202	2932
FR France	180	9271
NG Nigeria	172	527
CN China	153	112446
RU Russia	91	9691
VN Vietnam	73	1626
TR Turkey	71	1810
GH Ghana	26	37
CL Chile	22	196
AR Argentina	19	267
SE Sweden	5	76
SD Sudan	2	3
NZ New Zealand	1	7
PE Peru	0	0
BR Brazil	0	0
CA Canada	0	0
CO Colombia	0	0
MZ Mozambique	0	0
PY Paraguay	0	0
VE Venezuela	0	0

Table 5.8: Sum of Hourly Ramp Down Rates

	Ramp Rate Sum [normalized]	Ramp Rate Sum [GW/hr]
LY Libya	-365	-1071
DZ Algeria	-337	-2386
TH Thailand	-319	-7102
TN Tunisia	-313	-566
EG Egypt	-302	-5677
GB United Kingdom	-270	-9671
ID Indonesia	-266	-7506
PL Poland	-265	-4590
ZA South Africa	-264	-6275
KR South Korea	-262	-16254
MY Malaysia	-259	-4341
SA Saudi Arabia	-258	-9743
MA Morocco	-257	-921
DE Germany	-252	-15321
IN India	-247	-37041
IT Italy	-246	-8590
MX Mexico	-243	-8085
IR Iran	-240	-7427
ES Spain	-238	-6715
US United States	-223	-102697
JP Japan	-214	-23592
AU Australia	-205	-5582
UA Ukraine	-202	-2935
FR France	-179	-9247
NG Nigeria	-172	-527
CN China	-153	-112923
RU Russia	-92	-9741
VN Vietnam	-73	-1626
TR Turkey	-72	-1824
GH Ghana	-26	-37
CL Chile	-23	-200
AR Argentina	-19	-274
SE Sweden	-5	-83
SD Sudan	-2	-3
NZ New Zealand	-1	-7
PY Paraguay	-1	-1
VE Venezuela	-1	-6
PE Peru	-1	-4
CA Canada	-1	-45
BR Brazil	-1	-39
CO Colombia	-1	-5
MZ Mozambique	0	-1