

SUPPLEMENTARY MATERIAL

"Teaching power sector models social and political awareness"

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A Elements and Matrices for Scenario Definition

Table S1.: Social descriptors selected by ZIRIUS in [WJPH15]

Descriptor Type	Descriptor	ID
System external descriptors	A(I). Global development	A(I)
	A(II). World market prices for fossil fuels	A(II)
	A(III). Interest rate development	A(III)
	B. EU-integration	B
	C. Population development	C
System descriptors for economy	D. GDP-development	D
	E. Labour market development	E
	F. Tertiariation of the economy	F
	G. Innovation capability of the national economy	G
	H. Transnational trade flows	H
	I. International integration of the electricity grid	I
	J. Infrastructure development of the electricity grid	J
	K. Capacity development of renewable energies (Electricity)	K
	L. Tendency to centrality/de-centrality of the electricity generation and storage	L
System descriptors for politics	M. Market organisation of the electricity market	M
	N. Political stability in the energy field	N
	O. Steering instruments in the energy field	O
	P. Governance in infrastructure expansion	P
	Q. Planning law/ Public infrastructure planning	Q
	R. Governmental design objectives	R
System descriptors for society	S. Social-governmental development	S
	T. Welfare development	T
	U. Technology acceptance for energy technologies	U
	V. Individual energy consumption behavior	V
System descriptors for culture	W. Educational development	W
	X. Attitude of the population towards the energy turnaround/ NIMBY	X
	Y. Value orientation and objectives of the economy design	Y
Passive descriptors	Z. Media discourse	Z
	Efficiency development of household appliances	a
	Efficiency development of automobiles (Electric)	b
	Efficiency development of automobiles (Combustion engine)	c
	Efficiency development of private buildings	d
	Efficiency development in industry	e
	Efficiency development in whole sale field	f
	Grid-connected heat supply - district heat potential	g
	Investments in new automobile concepts and infrastructure	h
	Living trends (I)	i
	Investments in RE-expansion for heat	j
	Rebound in the individual consumption	k

Table S2.: Selected representative power system model parameters

Parameter Type	Parameter	ID
Power generation potentials	Usable areas	1
	Biomass imports allowed?	2
	Annually usable geothermal energy	3
	National vs. European supply security: assured capacity	4
	National vs. European supply security: share of nationally generated in nationally used energy	5
	Renewables Share	6
Technical Parameters	Efficiency	7
	Life time	8
	Availability	9
	Emission factors	10
Costs	Investment costs and fixed operation costs	11
	Variable costs	12
	Fuel prices	13
	CO ₂ certificate prices	14
	Interest rate	15
	Tear and wear costs	16
Scenario information	Annual conventional power demand	17
	Annual power demand of additional consumers	18
	Power generation: installed capacities	19
	Power generation: max. installable capacities	20
	Energy storage: installed capacities	21
	Energy storage: max. installable capacities	22
	Power transmission: installed capacities	23
	Power transmission: max. installable capacities	24
	Annual heat demand covered with CHP and heat pumps	25
Other parameters	Regions	26
	Electric load time series	27
	Heat load time series	28
	Load shifting characteristics of additional consumers	29

Elements and Matrices for Scenario Definition

Table S3.: Descriptors-DSM

ID	AD	AD	AD	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k		
A0	0	0.67	3.00	0	0.89	0.42	0.67	0.19	0.83	1.56	0	0	0	0	0	0.13	0.44	0	0	0.50	0.75	0	0	0	1.75	1.00	0.56	0.50	0	0	0	1.33	1.13	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0.33	0	0.33	0.44	0.92	0	0	1.50	0.59	0	0.39	0	0	0.42	0.50	0	0	0	0	0	0.39	0	0	0	0	1.67	0	2.00	1.00	1.33	1.00	0	0.67	0.89	1.78	
A100	0	0	0	0	0	0	0	0.25	0	0	0	0	0.22	0.41	0	0	0	0	0	0	1.29	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0	0	0	0		
B	0	0	0	0	0.63	0	0.22	1.00	0.96	1.96	2.04	0	0	0.48	0.30	0.44	0.85	0	0.88	0.58	1.06	0	0	0	1.44	0.17	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	
C	0	0	0	0	0	0.89	1.06	1.25	0.44	0	0	0	0	0	0	0	0	0	0	0.78	0	0	0	0.58	1.39	0	0	0.22	1.33	0	0	0	0	0	0	1.00	0.67	0.56	0		
D	0	0	0	0	0	0	1.39	1.25	0.44	0.92	0	0	0	0	0	0	0	0	0.67	0	0	0	0	0	1.17	0	0	0.72	0	0	0	0	0	0	1.50	1.33	0	2.00	0	0	
E	0	0	0	0	0	1.44	0.39	0	0	0.22	1.17	0	0	0	0	0	0	0	0.56	1.54	0.39	0	0	0	0	0.25	0.33	1.25	0	0	0	0	0	0.33	0	0	0.67	0	0		
F	0	0	0	0	0	0.22	0	0.17	0	0.44	0.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.39	0.78	0	0	0	0	0	0	0	0	0	0.67	0	0		
G	0	0	0	0	0	0.5	0	0	0	1.29	0	0	0	0.26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
H	0	0	0	0	0	0.79	0.50	1.31	0.47	0	0	0	0	0	0	0	0.42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
I	0	0	0	0	0	0	0	0.37	0	0	0	1.00	0.50	1.15	0.93	0	1.26	0	0.63	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
J	0	0	0	0	0	0.11	0	0	0.44	0	0	1.19	0.61	1.48	0.70	0.11	0.89	0	1.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
K	0	0	0	0	0	0	0	0	0.33	0	0	1.81	0.83	0	1.56	1.56	0.22	0.41	0	0.25	0.83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
L	0	0	0	0	0	0	0	0	0.33	0	0	1.30	0.78	1.11	0	0.44	0	0.37	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
M	0	0	0	0	0	0	0	0	0.33	0	0	1.15	0	0.11	0.74	0	0	0.78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
N	0	0	0	0	0	0	0	0.25	0.74	0	0.33	1.78	1.22	0.52	0.67	0	0.22	0.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.50	2	0	1.33	2.22	0		
O	0	0	0	0	0	0	0	0	0.44	0.17	0.56	0	0	0.22	0.52	0	0	0.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.33	1.56	0	1.78	0.50	1.33			
P	0	0	0	0	0	0.33	0	0	0.22	0	0.89	2.17	0.67	1.28	0.22	0	0.67	0	0.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Q	0	0	0	0	0	0	0	0	0.22	0	1.75	1.29	0	0.67	0	0.14	0.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
R	0	0	0	0	0	0.54	0	0	0.44	0	0	0.71	0.08	0	0.17	0.21	0.86	0.38	1.06	0	0.88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
S	0	0	0	0	0	1.52	0.33	1.00	0.08	0.52	1.5	0	0	0	0	0.15	0	0.11	0	0.75	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
T	0	0	0	0	0	1.06	0	0.50	1.13	0.44	0.69	0	0	0.38	0.5	0	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
U	0	0	0	0	0	0	0	0	0.44	0.41	0	0	0.46	1.28	0	0.33	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
V	0	0	0	0	0	0	0	0	0.36	0	0	0	0.33	0.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
W	0	0	0	0	0	1.04	0.67	0.94	0.67	0.85	0.54	0	0	0	0	0	0	0	0	0.22	1.83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
X	0	0	0	0	0	0	0	0	0.22	0	0.63	1.11	1.61	1.37	0	0.78	0.41	0	0.88	0.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Y	0	0	0	0	0	0.28	0	0	1.06	0.22	0	0	0.33	0	0	0	0	0	0.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.56	0	0	0.96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
i	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
j	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
k	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			

Table S4.: DMM: Descriptors to REMix parameters

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
A(I)	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
A(II)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A(III)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
G	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
J	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
K	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
O	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Q	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
U	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
V	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1
W	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0
e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0
f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0
g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
i	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
j	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
k	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table S5.: REMix Parameters-DSM: Indirect Influences

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	3.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1.04	0	0	0	0	0.48	0.96	0.96	0	0	0.96	0	0	0.85	0	0	5.58	2.34	0	0	0	0	3.84	2.20	0.48	2.04	0	0	0
5	2.82	0	0	0	0.48	6.46	1.30	1.30	0	0	1.30	0	0	1.22	0	0	6.79	4.84	0	0	0	0	6.25	4.94	0.48	3.33	2.67	1.67	2.17
6	6.47	0	0	0	6.69	19.56	2.63	2.63	0	0	2.63	0	0	2.68	0.61	0	20.75	14.71	0	0	0	0	19.33	8.70	11.02	4.52	12.94	11.36	7.97
7	0.78	0	0	0	0.26	0.78	0	0	0	0	0	0	0	0	0.50	0	4.39	2.50	0	0	0	0	0.26	0.78	0.26	0	2	2	0
8	0.78	0	0	0	0.26	0.78	0	0	0	0	0	0	0	0	0.50	0	4.39	2.50	0	0	0	0	0.26	0.78	0.26	0	2	2	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0.78	0	0	0	0.26	0.78	0	0	0	0	0	0	0	0	0.50	0	4.39	2.50	0	0	0	0	0.26	0.78	0.26	0	2	2	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	2.00	0	0	0	0.59	5.32	1.28	1.28	0	0	1.28	0	0.67	0.44	3.75	0	13.68	5.81	0	0	0	0	1.32	1.38	1.59	0	7.31	6.79	1.67
14	1.17	0	0	0	0.22	3.01	1.28	1.28	0	0	1.28	0	0.67	0.44	3.42	0	12.54	6.06	0	0	0	0	0.90	1.72	1.56	0.56	8.28	6.76	2.92
15	1.47	0	0	0	0.41	3.54	1.28	1.28	0	0	1.28	0	0.67	0.44	3.42	0	15.37	9.90	0	0	0	0	0.53	1.47	0.41	0	6.98	5.29	2.00
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	6.68	0	0	0	1.65	12.65	3.86	3.86	0	0	3.86	0	0.67	0.94	5.19	0	57.30	33.23	0	0	0	0	2.33	7.24	6.98	0.56	28.49	16.91	10.15
18	5.79	0	0	0	1.43	10.65	2.75	2.75	0	0	2.75	0	0.67	0.94	4.81	0	43.46	29.83	0	0	0	0	1.55	5.79	4.43	0.00	21.47	12.38	11.78
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	9.67	0	0	0	5.57	26.67	3.30	3.30	0	0	3.30	0	0	4.40	0.44	0	14.66	11.01	0	0	0	0	25.30	13.79	6.91	7.49	4.92	3.67	4.39
24	4.89	0	0	0	4.28	14.02	2.00	2.00	0	0	2.00	0	0	0.37	0	0	12.09	4.44	0	0	0	0	12.99	5.18	5.94	2.67	5.22	4.22	1.06
25	1.78	0	0	0	0	4.04	0.33	0.33	0	0	0.33	0	0	0.37	0	0	1.70	2.50	0	0	0	0	2.41	2.74	0	1.30	1.00	0	2.17
26	1.35	0	0	0	1.15	3.85	0.37	0.37	0	0	0.37	0	0	1.26	0	0	1.63	0.37	0	0	0	0	2.77	0.72	1.15	0	0	0	0
27	1.25	0	0	0	0.67	2.39	0.81	0.81	0	0	0.81	0	0	0	0	0	6.76	5.72	0	0	0	0	0.67	1.25	3.67	0	2.04	0.67	3.33
28	1.25	0	0	0	0.67	1.94	0.36	0.36	0	0	0.36	0	0	0	0	0	4.57	4.36	0	0	0	0	0.67	1.25	3.67	0	1.38	0	3.33
29	1.25	0	0	0	0.67	1.94	0.36	0.36	0	0	0.36	0	0	0	0	0	3.90	8.75	0	0	0	0	0.67	1.25	1.67	0	1.38	0	5.89

B REMix Model - Myopic vs Static Implementation

Objective Function

In the objective function (eq. B.1) costs of all used technologies (*Techs*) are summarised to overall system costs per optimisation year, which are constituted by investment (C_{Invest}), operation (C_{Op}), fuel (C_{Fuel}), and pollution ($C_{Pollution}$) costs, as well as penalties for not supplied power ($C_{NotSupplPower}$). Investment costs of pre-installed capacities are not considered in the optimisation process; for newly added capacities these are considered by applying the method of equivalent annual cost over amortisation time. Operation costs contain fixed and variable costs - dependent on the added and utilised capacities respectively, as well as, tear and wear costs - proportional to the power change.

$$\min \left\{ \sum_{tech} \sum_{node} \left[C_{Invest}^{tech,node,year} + \sum_{time} \left(C_{Op}^{tech,node,time,year} + C_{Fuel}^{tech,node,time,year} + C_{Pollution}^{tech,node,time,year} \right) \right] + C_{NotSupplPower} \right\} \quad (B.1)$$

$\forall year \in OptimisedYears$

Model Enhancement: Myopic approach

Starting from the existing static model, the possibility of using added capacities from earlier simulations is introduced. For instance, capacities added in 2020 are part of the pre-installed capacities in 2030, as long as their lifetime has not expired. New capacities can be added in 2030, which are taken into account for 2050. The approach is thus based on the forwarding of added capacities from earlier simulations ($P_{CapsAdded}^{year'}$), which together with the still available pre-installed capacities ($P_{CapsInst}^{year}$) represent the total input capacities ($P_{CapsTotal}^{year}$) for the optimised year (see eq. B.2 and Fig. S1). With this goal in mind, a technological lifetime per technology and age is defined.

$$P_{CapsTotal}^{tech,node,year} = P_{CapsInst}^{tech,node,year} + \sum_{year'} P_{CapsAdded}^{tech,node,year'} \mid year' + LifeTime > year \quad (B.2)$$

$\forall year \in OptimisedYears, \forall tech \in Techs, \forall node \in Node$

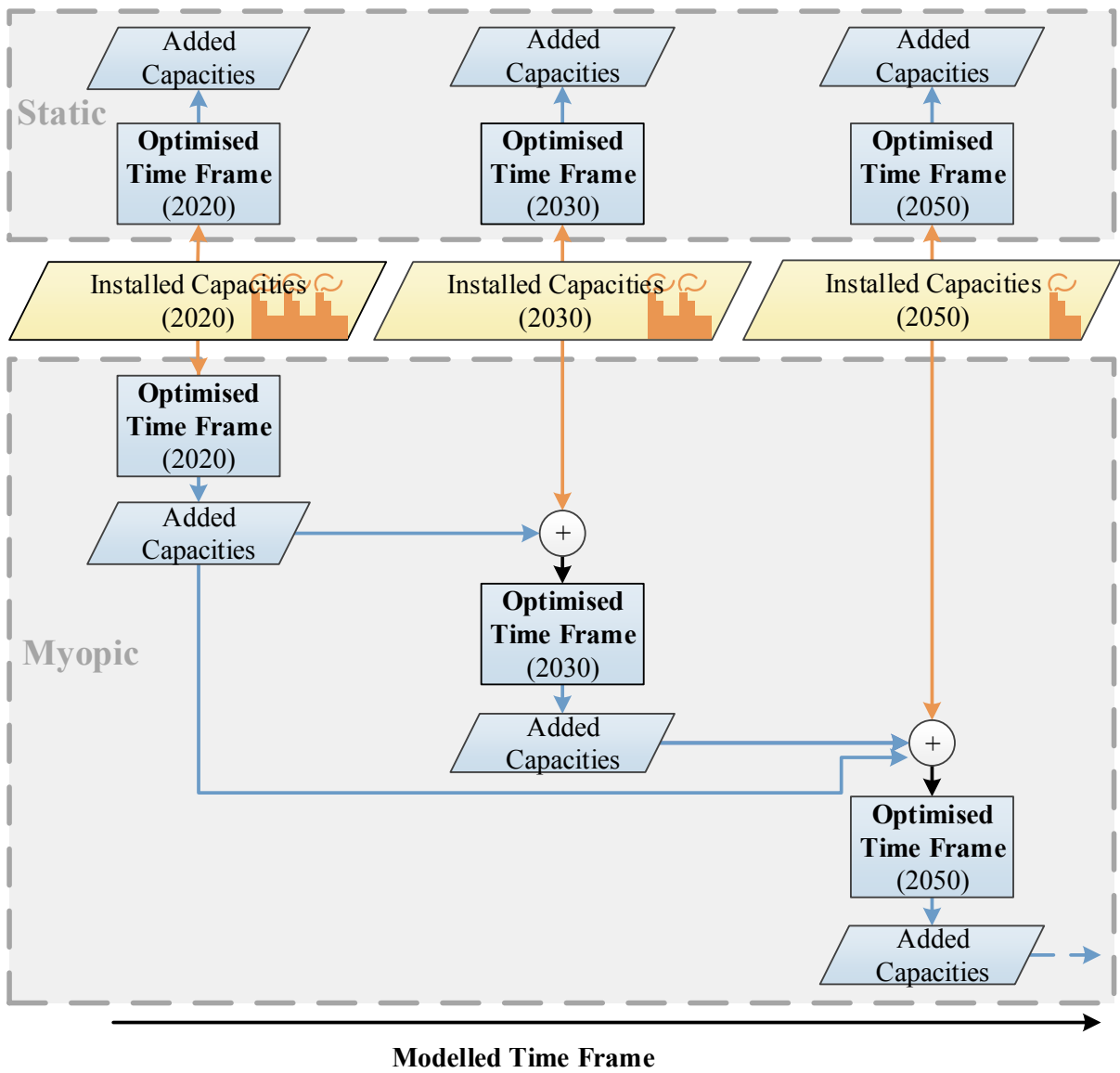


Figure S1.: Scheme of static and myopic optimisation procedures

C Assumptions and Parametrisation

To limit the required computational time, some assumptions and simplifications were made. The influence of electric cars and demand side management was not taken into account endogenously. Heat production and demand, as well as CHP, and energy conversion from geothermal or wave and tidal applications were not considered. Moreover, non-European import or export was not modelled. Further assumptions are detailed in the following lines. All used numerical values that can be published can be found in the supplementary material.

RE-share

The RE-share of final electricity consumption is assumed to at least reach the EU-climate targets, and is defined accordingly for each region. In the REMix module utilised to define the RE-share only the solar and wind generation capacity share could be set, so that the RE-share coming from biomass and hydraulic sources had to be taken into account separately. Based on the National Renewable Energy Action Plans (NREAP) [Eur11b], the regional RE-share for 2020 is defined. From the technology-specific energy production contained in the NREAPs, a European renewable energy share of 41.3% in 2020 is calculated, of which 18.5% originated in solar and wind. For 2030 and 2050 the EU-goals, as mentioned in the Roadmap 2050 for the scenario 'Diversified Supply Technologies' (European Commission 2011) - which best matches with the current assumptions-, are used to extrapolate the RE-share in each model region. The selected EU-goals correspond to 51.2% and 59.1% of RE-sources in final electricity generation. RE-shares in Switzerland and Austria are already high in 2020. Due to limited potentials, no scaling after 2020 is applied. Since these countries have a small share in the total European electricity consumption, and national RE-shares are set as minimum condition, no significant variation of the results is expected through this simplification.

Back-up Capacity

Back-up capacity to ensure momentary load coverage in the EU is aimed to be reached in a global framework. Thus, peak loads are set to be covered within Europe, and not necessarily in single regions.

Transmission lines

Existing transmission lines are assumed to persist during the studied time frame, without need for replacement. Alternating (AC) and direct current (DC) transmission lines are considered in REMix. Installed transmission capacities for both types are set according to the TYNDP [ENT14] for 2020 and 2030, and are maintained constant till 2050. Additionally, DC-

transmission capacity can be optimised from 2030 on, so that necessary infrastructure expansion can take place. Pricing and losses are differentiated for land and sea lines.

Technologies

If not otherwise described for single technologies, power plant deployment paths were defined based on the Platts' data base from 2015 [pla15]. Power plants in operation or standby were aggregated in technology and age groups, and were assumed to retire at the end of their technological lifetime. Plants retiring before 2015 according to this assumption, were set to stop operating in 2020.

Conventional Power Plants

These include: Internal-Combustion engine (IC), lignite and coal fired, nuclear, gas turbine, and Combined-Cycle Gas-Turbine (CCGT) power plants. An efficiency differentiation based on the year the plant entered operation is made. Age aggregations are done in nine-year steps, with plants built before 1970 summarised within a group. Planned nuclear phase-out was also considered on basis of country-specific policies as described in [Wor15].

Hydroelectric and Pumped-Storage Power Plants

Hydroelectric and pumped-storage capacities - with very long lifetimes and limited potential, because of geographical limitations and high economical expenses - were assumed to be constant over the studied time frame. Hence, only historically installed capacities were considered and further construction was not allowed in the model. Installed capacities for conventional hydroelectric storage are extracted from [NPS⁺12].

Biomass

This technology has a limited potential, and is increasingly applied as CHP-plant, which implies a decrease in the efficiency for electricity production. Therefore, even if capacities would increase, it would not directly derive into higher share in electricity production. Based on this, biomass capacity for electricity production is assumed to be replaced at the end of its lifetime, so that capacities are kept constant over the whole time frame.

Concentrating Solar Power (CSP)

Three different CSP-technologies are defined according to their operational flexibility, as in [Sch12]: basic, medium and high. These translate into solar multiples of 1.5, 2.5 and 3.5, and storage size corresponding to a power-block operation-time of 8, 12 and 18 hours, respectively. CSP pre-installed capacities are assigned to the basic flexibility technology according to their characteristics. Optimisation is allowed for all CSP-technologies.

Fluctuating Renewable Energy

Run-of-river existing applications are extracted from [NPS⁺12]. Optimisation is allowed for all fluctuating RE-technologies including photovoltaic, onshore and offshore wind. The used normalised time series for hourly-available potential-definition stem from 2006, which has been proven to be a representative reference year in [Tre15].

Storage Technologies

Three storage technologies are defined for type differentiation in duration and frequency of the power supply. Pre-installed capacities are only given for pumped-storage applications (medium-term). For the other two technologies no capacities exist to date, however, capacity optimisation is allowed with no limitations for lithium-ion batteries (short to medium-term); and maximal potentials are provided for hydrogen storage (long-term) from [Sch12].

Table S6.: Maximum installable capacity of offshore wind [MW]

Region	Year	MaxInstallable
Austria	2020	0
Belgium	2020	5579.64
Czech Republic	2020	0
DAMP1	2020	0
DAMP2	2020	0
DAMP3	2020	0
DAMP4	2020	0
DAMP5	2020	0
DAMP6	2020	0
DEnBW1	2020	0
DEnBW2	2020	0
Denmark_E	2020	20937.14
Denmark_W	2020	103018.93
DTPS0	2020	57648.16
DTPS1	2020	0
DTPS2	2020	0
DTPS3	2020	0
DTPS4	2020	0
DTPS5	2020	0
DTPS6	2020	0
DVET0	2020	14343.22
DVET1	2020	0
DVET2	2020	0
DVET3	2020	0
DVET4	2020	0
Finland	2020	97748.75
France	2020	252036.7
Ireland	2020	222688.87
Italy	2020	165640.98
Liechtenstein	2020	0
Luxembourg	2020	0
Netherlands	2020	91851.66
Norway	2020	387828.81
Poland	2020	49796.13
Portugal	2020	37778.21
Slovakia	2020	0
Spain	2020	101755.97
Sweden	2020	220970.25
Switzerland	2020	0
UK	2020	830014.1
Austria	2030	0
Belgium	2030	5579.64
Czech Republic	2030	0
DAMP1	2030	0
DAMP2	2030	0
DAMP3	2030	0
DAMP4	2030	0
DAMP5	2030	0
DAMP6	2030	0
DEnBW1	2030	0
DEnBW2	2030	0
Denmark_E	2030	20937.14
Denmark_W	2030	103018.93
DTPS0	2030	57648.16
DTPS1	2030	0
DTPS2	2030	0
DTPS3	2030	0
DTPS4	2030	0
DTPS5	2030	0
DTPS6	2030	0
DVET0	2030	14343.22
DVET1	2030	0
DVET2	2030	0
DVET3	2030	0
DVET4	2030	0

Table S7.: Maximum installable capacity of offshore wind (continued) [MW]

Region	Year	MaxInstallable
Finland	2030	97748.75
France	2030	252036.7
Ireland	2030	222688.87
Italy	2030	165640.98
Liechtenstein	2030	0
Luxembourg	2030	0
Netherlands	2030	91851.66
Norway	2030	387828.81
Poland	2030	49796.13
Portugal	2030	37778.21
Slovakia	2030	0
Spain	2030	101755.97
Sweden	2030	220970.25
Switzerland	2030	0
UK	2030	830014.1
Austria	2050	0
Belgium	2050	5579.64
Czech Republic	2050	0
DAMP1	2050	0
DAMP2	2050	0
DAMP3	2050	0
DAMP4	2050	0
DAMP5	2050	0
DAMP6	2050	0
DEnBW1	2050	0
DEnBW2	2050	0
Denmark_E	2050	20937.14
Denmark_W	2050	103018.93
DTPS0	2050	57648.16
DTPS1	2050	0
DTPS2	2050	0
DTPS3	2050	0
DTPS4	2050	0
DTPS5	2050	0
DTPS6	2050	0
DVET0	2050	14343.22
DVET1	2050	0
DVET2	2050	0
DVET3	2050	0
DVET4	2050	0
Finland	2050	97748.75
France	2050	252036.7
Ireland	2050	222688.87
Italy	2050	165640.98
Liechtenstein	2050	0
Luxembourg	2050	0
Netherlands	2050	91851.66
Norway	2050	387828.81
Poland	2050	49796.13
Portugal	2050	37778.21
Slovakia	2050	0
Spain	2050	101755.97
Sweden	2050	220970.25
Switzerland	2050	0
UK	2050	830014.1

Table S8.: Maximum installable capacity of photovoltaic [MW]

Region	Year	MaxInstallable
Austria	2020	11411.1
Belgium	2020	19783.3
Czech Republic	2020	15503.57
DAMP1	2020	1552.93
DAMP2	2020	7028.99
DAMP3	2020	4303.33
DAMP4	2020	5563.17
DAMP5	2020	6591.76
DAMP6	2020	1953.05
DEnBW1	2020	2612.88
DEnBW2	2020	7352.5
Denmark_E	2020	3746.77
Denmark_W	2020	6018.86
DTPS0	2020	0
DTPS1	2020	3215.25
DTPS2	2020	4443.87
DTPS3	2020	6256.98
DTPS4	2020	3854.5
DTPS5	2020	5552.99
DTPS6	2020	4805.93
DVET0	2020	0
DVET1	2020	10873.8
DVET2	2020	1773.14
DVET3	2020	7900.52
DVET4	2020	7850.79
Finland	2020	12335.32
France	2020	88871.92
Ireland	2020	4659.2
Italy	2020	47728.95
Liechtenstein	2020	62.69
Luxembourg	2020	698.06
Netherlands	2020	14345.41
Norway	2020	3008.7
Poland	2020	35372.88
Portugal	2020	12744.79
Slovakia	2020	8906.75
Spain	2020	77702.93
Sweden	2020	18005.82
Switzerland	2020	2005.6
UK	2020	58322.1
Austria	2030	11411.1
Belgium	2030	19783.3
Czech Republic	2030	15503.57
DAMP1	2030	1552.93
DAMP2	2030	7028.99
DAMP3	2030	4303.33
DAMP4	2030	5563.17
DAMP5	2030	6591.76
DAMP6	2030	1953.05
DEnBW1	2030	2612.88
DEnBW2	2030	7352.5
Denmark_E	2030	3746.77
Denmark_W	2030	6018.86
DTPS0	2030	0
DTPS1	2030	3215.25
DTPS2	2030	4443.87
DTPS3	2030	6256.98
DTPS4	2030	3854.5
DTPS5	2030	5552.99
DTPS6	2030	4805.93
DVET0	2030	0
DVET1	2030	10873.8
DVET2	2030	1773.14
DVET3	2030	7900.52
DVET4	2030	7850.79

Table S9.: Maximum installable capacity of photovoltaic (continued) [MW]

Region	Year	MaxInstallable
Finland	2030	12335.32
France	2030	88871.92
Ireland	2030	4659.2
Italy	2030	47728.95
Liechtenstein	2030	62.69
Luxembourg	2030	698.06
Netherlands	2030	14345.41
Norway	2030	3008.7
Poland	2030	35372.88
Portugal	2030	12744.79
Slovakia	2030	8906.75
Spain	2030	77702.93
Sweden	2030	18005.82
Switzerland	2030	2005.6
UK	2030	58322.1
Austria	2050	11411.1
Belgium	2050	19783.3
Czech Republic	2050	15503.57
DAMP1	2050	1552.93
DAMP2	2050	7028.99
DAMP3	2050	4303.33
DAMP4	2050	5563.17
DAMP5	2050	6591.76
DAMP6	2050	1953.05
DEnBW1	2050	2612.88
DEnBW2	2050	7352.5
Denmark_E	2050	3746.77
Denmark_W	2050	6018.86
DTPS0	2050	0
DTPS1	2050	3215.25
DTPS2	2050	4443.87
DTPS3	2050	6256.98
DTPS4	2050	3854.5
DTPS5	2050	5552.99
DTPS6	2050	4805.93
DVET0	2050	0
DVET1	2050	10873.8
DVET2	2050	1773.14
DVET3	2050	7900.52
DVET4	2050	7850.79
Finland	2050	12335.32
France	2050	88871.92
Ireland	2050	4659.2
Italy	2050	47728.95
Liechtenstein	2050	62.69
Luxembourg	2050	698.06
Netherlands	2050	14345.41
Norway	2050	3008.7
Poland	2050	35372.88
Portugal	2050	12744.79
Slovakia	2050	8906.75
Spain	2050	77702.93
Sweden	2050	18005.82
Switzerland	2050	2005.6
UK	2050	58322.1

Table S10.: Maximum installable capacity of Run-of-river [MW]

Region	Year	MaxInstallable
Austria	2020	14281.07
Belgium	2020	140
Czech Republic	2020	979.15
DAMP1	2020	159.94
DAMP2	2020	1132.66
DAMP3	2020	92.25
DAMP4	2020	154.14
DAMP5	2020	543.57
DAMP6	2020	379.96
DEnBW1	2020	50.28
DEnBW2	2020	1384.54
Denmark_E	2020	0.48
Denmark_W	2020	10.64
DTPS0	2020	0
DTPS1	2020	138.96
DTPS2	2020	138.17
DTPS3	2020	276.73
DTPS4	2020	66.41
DTPS5	2020	648.11
DTPS6	2020	1118.94
DVET0	2020	0
DVET1	2020	324.64
DVET2	2020	0.64
DVET3	2020	85.12
DVET4	2020	76.41
Finland	2020	4058.46
France	2020	23816.38
Ireland	2020	166.03
Italy	2020	38082.12
Liechtenstein	2020	0.35
Luxembourg	2020	44
Netherlands	2020	68
Norway	2020	34813.51
Poland	2020	4593.45
Portugal	2020	9714.26
Slovakia	2020	2809.84
Spain	2020	32143.05
Sweden	2020	20363.56
Switzerland	2020	7084.61
UK	2020	4895
Austria	2030	14281.07
Belgium	2030	140
Czech Republic	2030	979.15
DAMP1	2030	159.94
DAMP2	2030	1132.66
DAMP3	2030	92.25
DAMP4	2030	154.14
DAMP5	2030	543.57
DAMP6	2030	379.96
DEnBW1	2030	50.28
DEnBW2	2030	1384.54
Denmark_E	2030	0.48
Denmark_W	2030	10.64
DTPS0	2030	0
DTPS1	2030	138.96
DTPS2	2030	138.17
DTPS3	2030	276.73
DTPS4	2030	66.41
DTPS5	2030	648.11
DTPS6	2030	1118.94
DVET0	2030	0
DVET1	2030	324.64
DVET2	2030	0.64
DVET3	2030	85.12
DVET4	2030	76.41

Table S11.: Maximum installable capacity of Run-of-river (continued) [MW]

Region	Year	MaxInstallable
Finland	2030	4058.46
France	2030	23816.38
Ireland	2030	166.03
Italy	2030	38082.12
Liechtenstein	2030	0.35
Luxembourg	2030	44
Netherlands	2030	68
Norway	2030	34813.51
Poland	2030	4593.45
Portugal	2030	9714.26
Slovakia	2030	2809.84
Spain	2030	32143.05
Sweden	2030	20363.56
Switzerland	2030	7084.61
UK	2030	4895
Austria	2050	14281.07
Belgium	2050	140
Czech Republic	2050	979.15
DAMP1	2050	159.94
DAMP2	2050	1132.66
DAMP3	2050	92.25
DAMP4	2050	154.14
DAMP5	2050	543.57
DAMP6	2050	379.96
DEnBW1	2050	50.28
DEnBW2	2050	1384.54
Denmark_E	2050	0.48
Denmark_W	2050	10.64
DTPS0	2050	0
DTPS1	2050	138.96
DTPS2	2050	138.17
DTPS3	2050	276.73
DTPS4	2050	66.41
DTPS5	2050	648.11
DTPS6	2050	1118.94
DVET0	2050	0
DVET1	2050	324.64
DVET2	2050	0.64
DVET3	2050	85.12
DVET4	2050	76.41
Finland	2050	4058.46
France	2050	23816.38
Ireland	2050	166.03
Italy	2050	38082.12
Liechtenstein	2050	0.35
Luxembourg	2050	44
Netherlands	2050	68
Norway	2050	34813.51
Poland	2050	4593.45
Portugal	2050	9714.26
Slovakia	2050	2809.84
Spain	2050	32143.05
Sweden	2050	20363.56
Switzerland	2050	7084.61
UK	2050	4895

Table S12.: Maximum installable capacity of onshore wind [MW]

Region	Year	MaxInstallable
Austria	2020	14918.52
Belgium	2020	3173.21
CZECH REPUBLIC	2020	13827.47
DAMP1	2020	1381.81
DAMP2	2020	811.97
DAMP3	2020	1467.16
DAMP4	2020	1428.29
DAMP5	2020	2793.67
DAMP6	2020	1664.52
DEnBW1	2020	1150.05
DEnBW2	2020	5881.02
Denmark_E	2020	1437.52
Denmark_W	2020	6381.29
DTPS0	2020	0
DTPS1	2020	2485.56
DTPS2	2020	2943.34
DTPS3	2020	4263.53
DTPS4	2020	2503.54
DTPS5	2020	3820.35
DTPS6	2020	4646.14
DVET0	2020	0
DVET1	2020	8547.27
DVET2	2020	165.8
DVET3	2020	5077.54
DVET4	2020	4386.77
Finland	2020	70300.8
France	2020	110017.05
Ireland	2020	13348.48
Italy	2020	62138.07
Liechtenstein	2020	20.79
Luxembourg	2020	342.88
Netherlands	2020	5321.4
Norway	2020	72966.56
Poland	2020	58838.95
Portugal	2020	21747.86
Slovakia	2020	8226.62
Spain	2020	130898.31
Sweden	2020	89858.62
Switzerland	2020	7078.99
UK	2020	37062.63
Austria	2030	14918.52
Belgium	2030	3173.21
Czech Republic	2030	13827.47
DAMP1	2030	1381.81
DAMP2	2030	811.97
DAMP3	2030	1467.16
DAMP4	2030	1428.29
DAMP5	2030	2793.67
DAMP6	2030	1664.52
DEnBW1	2030	1150.05
DEnBW2	2030	5881.02
Denmark_E	2030	1437.52
Denmark_W	2030	6381.29
DTPS0	2030	0
DTPS1	2030	2485.56
DTPS2	2030	2943.34
DTPS3	2030	4263.53
DTPS4	2030	2503.54
DTPS5	2030	3820.35
DTPS6	2030	4646.14
DVET0	2030	0
DVET1	2030	8547.27
DVET2	2030	165.8
DVET3	2030	5077.54
DVET4	2030	4386.77

Table S13.: Maximum installable capacity of onshore wind (continued) [MW]

Region	Year	MaxInstallable
Finland	2030	70300.8
France	2030	110017.05
Ireland	2030	13348.48
Italy	2030	62138.07
Liechtenstein	2030	20.79
Luxembourg	2030	342.88
Netherlands	2030	5321.4
Norway	2030	72966.56
Poland	2030	58838.95
Portugal	2030	21747.86
Slovakia	2030	8226.62
Spain	2030	130898.31
Sweden	2030	89858.62
Switzerland	2030	7078.99
UK	2030	37062.63
Austria	2050	14918.52
Belgium	2050	3173.21
CZECH REPUBLIC	2050	13827.47
DAMP1	2050	1381.81
DAMP2	2050	811.97
DAMP3	2050	1467.16
DAMP4	2050	1428.29
DAMP5	2050	2793.67
DAMP6	2050	1664.52
DEnBW1	2050	1150.05
DEnBW2	2050	5881.02
Denmark_E	2050	1437.52
Denmark_W	2050	6381.29
DTPS0	2050	0
DTPS1	2050	2485.56
DTPS2	2050	2943.34
DTPS3	2050	4263.53
DTPS4	2050	2503.54
DTPS5	2050	3820.35
DTPS6	2050	4646.14
DVET0	2050	0
DVET1	2050	8547.27
DVET2	2050	165.8
DVET3	2050	5077.54
DVET4	2050	4386.77
Finland	2050	70300.8
France	2050	110017.05
Ireland	2050	13348.48
Italy	2050	62138.07
Liechtenstein	2050	20.79
Luxembourg	2050	342.88
Netherlands	2050	5321.4
Norway	2050	72966.56
Poland	2050	58838.95
Portugal	2050	21747.86
Slovakia	2050	8226.62
Spain	2050	130898.31
Sweden	2050	89858.62
Switzerland	2050	7078.99
UK	2050	37062.63

Table S14.: Maximum installable capacity of CSP [MW]

Region	MaxInstallable
Austria	0
Belgium	0
CzechRep	0
DAMP1	0
DAMP2	0
DAMP3	0
DAMP4	0
DAMP5	0
DAMP6	0
DEnBW1	0
DEnBW2	0
DTPS0	0
DTPS1	0
DTPS2	0
DTPS3	0
DTPS4	0
DTPS5	0
DTPS6	0
DVET0	0
DVET1	0
DVET2	0
DVET3	0
DVET4	0
Denmark_E	0
Denmark_W	0
Finland	0
France	18636
Ireland	0
Italy	103164
Liechtenstein	0
Luxemburg	0
Netherlands	0
Norway	0
Poland	0
Portugal	324299
Slovakia	0
Spain	1241499
Sweden	0
Switzerland	0
UK	0

Table S15.: Maximum installable capacity of Hydrogen storage [MW]

Region	Year	MaxInstallableConverter	MaxInstallableStorage
Austria	2020	99999999	99999999
Belgium	2020	99999999	99999999
Czech Republic	2020	99999999	99999999
DAMP1	2020	99999999	99999999
DAMP2	2020	99999999	99999999
DAMP3	2020	99999999	99999999
DAMP4	2020	99999999	99999999
DAMP5	2020	99999999	99999999
DAMP6	2020	99999999	99999999
DEnBW1	2020	99999999	99999999
DEnBW2	2020	99999999	99999999
Denmark_E	2020	99999999	99999999
Denmark_W	2020	99999999	99999999
DTPS0	2020	99999999	99999999
DTPS1	2020	99999999	99999999
DTPS2	2020	99999999	99999999
DTPS3	2020	99999999	99999999
DTPS4	2020	99999999	99999999
DTPS5	2020	99999999	99999999
DTPS6	2020	99999999	99999999
DVET0	2020	99999999	99999999
DVET1	2020	99999999	99999999
DVET2	2020	99999999	99999999
DVET3	2020	99999999	99999999
DVET4	2020	99999999	99999999
Finland	2020	99999999	99999999
France	2020	99999999	99999999
Ireland	2020	99999999	99999999
Italy	2020	99999999	99999999
Liechtenstein	2020	99999999	99999999
Luxemburg	2020	99999999	99999999
Netherlands	2020	99999999	99999999
Norway	2020	99999999	99999999
Poland	2020	99999999	99999999
Portugal	2020	99999999	99999999
Slovakia	2020	99999999	99999999
Spain	2020	99999999	99999999
Sweden	2020	99999999	99999999
Switzerland	2020	99999999	99999999
UK	2020	99999999	99999999
Austria	2030	99999999	9591000
Belgium	2030	99999999	0
Czech Republic	2030	99999999	0
DAMP1	2030	99999999	0
DAMP2	2030	99999999	1313012.408
DAMP3	2030	99999999	0
DAMP4	2030	99999999	0
DAMP5	2030	99999999	0
DAMP6	2030	99999999	0
DEnBW1	2030	99999999	0
DEnBW2	2030	99999999	0
Denmark_E	2030	99999999	0
Denmark_W	2030	99999999	17972700
DTPS0	2030	99999999	0
DTPS1	2030	99999999	383257.6759
DTPS2	2030	99999999	75444983.24
DTPS3	2030	99999999	3193813.966
DTPS4	2030	99999999	780710.0805
DTPS5	2030	99999999	0
DTPS6	2030	99999999	0
DVET0	2030	99999999	0
DVET1	2030	99999999	18808015.58
DVET2	2030	99999999	0
DVET3	2030	99999999	19908107.05
DVET4	2030	99999999	0

Table S16.: Maximum installable capacity of Hydrogen storage (continued) [MW]

Region	Year	MaxInstallableConverter	MaxInstallableStorage
Finland	2030	99999999	0
France	2030	99999999	59909000
Ireland	2030	99999999	9591000
Italy	2030	99999999	11981800
Liechtenstein	2030	99999999	0
Luxemburg	2030	99999999	0
Netherlands	2030	99999999	29954500
Norway	2030	99999999	0
Poland	2030	99999999	149786400
Portugal	2030	99999999	14372600
Slovakia	2030	99999999	5990900
Spain	2030	99999999	119831900
Sweden	2030	99999999	0
Switzerland	2030	99999999	3600100
UK	2030	99999999	35945400
Austria	2050	99999999	9591000
Belgium	2050	99999999	0
Czech Republic	2050	99999999	0
DAMP1	2050	99999999	0
DAMP2	2050	99999999	1313012.408
DAMP3	2050	99999999	0
DAMP4	2050	99999999	0
DAMP5	2050	99999999	0
DAMP6	2050	99999999	0
DEnBW1	2050	99999999	0
DEnBW2	2050	99999999	0
Denmark_E	2050	99999999	0
Denmark_W	2050	99999999	17972700
DTPS0	2050	99999999	0
DTPS1	2050	99999999	383257.6759
DTPS2	2050	99999999	75444983.24
DTPS3	2050	99999999	3193813.966
DTPS4	2050	99999999	780710.0805
DTPS5	2050	99999999	0
DTPS6	2050	99999999	0
DVET0	2050	99999999	0
DVET1	2050	99999999	18808015.58
DVET2	2050	99999999	0
DVET3	2050	99999999	19908107.05
DVET4	2050	99999999	0
Finland	2050	99999999	0
France	2050	99999999	59909000
Ireland	2050	99999999	9591000
Italy	2050	99999999	11981800
Luxemburg	2050	99999999	0
Liechtenstein	2050	99999999	29954500
Netherlands	2050	99999999	29954500
Norway	2050	99999999	0
Poland	2050	99999999	149786400
Portugal	2050	99999999	14372600
Slovakia	2050	99999999	5990900
Spain	2050	99999999	119831900
Sweden	2050	99999999	0
Switzerland	2050	99999999	3600100
UK	2050	99999999	35945400

D Technical Parameters

To allow for comparison of literature values, all cost values found in literature were transformed into €₂₀₁₄ under consideration of the yearly averaged US-Dolar to Euro change rate and by assuming a yearly inflation rate of 1,8%.

The parameters are used under the following definitions:

Lifetime: The technological lifetime of the main components.

Availability: Percentage of available capacity in time, if just considering power plant operation limitations, due to e.g. maintenance or reparation work.

Capacity Credit: "By considering an extended time period [...] it is possible to evaluate how much capacity is replaced by variable renewables by looking at the difference between the peak demand and the peak residual demand. [...] The capacity credit is the peak demand less the peak residual demand, expressed as a percentage of the variable renewables installed." [IEA2011].

Storage characteristics: A differentiation between storage and converter technology is done for lifetime and amortisation time definitions. These correspond to the first and second number in S17, respectively. In case of Li-Ion Batteries the same life and amortisation time are assumed but a learning curve is included with values given for 2020, 2030 and 2050. This values can also be found in Table S28

Table S17.: Lifetime [Years]

[NPS ⁺ 12] Database													[HHM11]		[Hun15]	[Unt14]	[MW12]	[Pal13]	Final	
2020													2030							
Conventional Power Plants	CCGT	25	30	30	30	30	30	30	30	30	30	30	30	30	30					
	GT_NGAS	25	30	30	30	30	30	30	30	20	30	30	30	30	30					
	IC	25	20	30	30	30	-	-	-	-	-	-	-	30	30					
	ST_Coal	25	40	40	40	40	40	40	40	40	50	50	30	30	40					
	ST_Lignite	25	40	40	40	40	40	40	40	40	50	50	30	30	40					
Controllable RE	ST_Nuclear	25	60	45	45	45	60	50	60	30	30	50	50	30	50					
	Biomass	25	20	30	30	30	-	-	-	-	-	-	-	25	25					
	CSP	-	25	30	30	30	-	-	-	-	-	-	-	25	25					
	HydroRes	60	-	50	50	50	-	100	-	-	-	-	-	60	60					
	RunOfRiver	60	-	-	-	-	-	-	-	-	-	-	-	60	60					
Fluctuating RE	PV	20	25	25	25	25	-	-	-	-	-	-	25	25	25					
	WindOff	18	20	25	25	25	-	-	-	-	-	-	20	20	23					
	WindOn	18	20	25	25	25	-	-	-	-	-	-	20	20	23					
	HydroStorage	30	-	-	-	-	-	-	-	-	-	-	-	30/15	30/15					
Storage	LlonBattery	15	-	-	-	-	-	-	-	-	-	-	-	21,22,25	21,22,25					
	Pstorage	60	60	-	-	-	-	100	-	-	-	-	-	60/30	60/30					

Table S18.: Amortisation Time [years]

		Final
Conventional Power Plants	CCGT	25
	GT_NGAS	25
	IC	25
	ST_Coal	25
	ST_Lignite	25
	ST_Nuclear	25
Controllable RE	Biomass	25
	CSP	25
	HydroRes	25
Fluctuating RE	RunOfRiver	25
	PV	20
	WindOff	20
	WindOn	20
Storage	HydroStorage	30/15
	LilonBattery	21, 22, 25
	Pstorage	25/25

Table S19.: Availability [%]

	[NPS ⁺ 12]	DLR Database	[Unt14]	[SW07]	[Pal13]	[BPG ⁺ 15]	Final	
Conventional Power Plants	CCGT	96	97.7	84.5	-	100	-	96
	GT_NGAS	94.8	97.7	84.5	-	95	-	94.8
	IC	94.8	97.7	-	-	-	-	94.8
	ST_Coal	89.6	93.5	83.75	-	93	94	90
	ST_Lignite	90.2	94	86.25	-	93	93.5	91
	ST_Nuclear	90	94.5	84.5	-	96	94.5	94
Controllable RE	Biomass	95	88	-	-	-	-	91
	CSP	-	88	-	-	-	-	90
	HydroRes	98	-	90.75	-	-	-	90
Fluctuating RE	RunOffRiver	-	-	-	-	-	-	-
	PV	-	-	-	-	-	-	-
	WindOff	-	-	-	-	-	-	-
	WindOn	-	-	-	-	-	-	-
Storage	HydroStorage	95	-	-	70	-	-	95
	LilonBattery	98	-	-	-	-	-	98
	Pstorage	98	90	95.25	70	-	-	90

Table S20.: Capacity Credit [%]

		[Pal13]		[BPG ⁺ 15]	[Str14]	Final
Conventional Power Plants	CCGT	100	97.7	97.7	90	Availability
	GT_NGAS	0.95	97.7	97.7	90	Availability
	IC	-	-	-	-	Availability
	ST_Coal	0.93	94	94	90	Availability
	ST_Lignite	0.93	93.5	93.5	90	Availability
	ST_Nuclear	0.96	94.5	94.5	90	Availability
Controllable RE	Biomass	-	88	65	80	65
	CSP	-	-	-	90	90
	HydroRes	-	-	-	80	80
Fluctuating RE	RunOfRiver	-	40	25	25-47	30
	PV	0.6	0	0	0	0
	WindOff	0.105	8	1	-	6
	WindOn	0.105	6	1	-	4
Storage	HydroStorage	-	-	-	0	80
	LilonBattery	-	-	-	0	80
	Pstorage	-	80	80	0	80

Table S21.: Investment Costs 1 [€₂₀₁₄/kW]

		[NPS ⁺ 12]			[HHM11]	
		2020	2030	2050	2020	2030
Conventional Power Plants	CCGT	765.31	-	-	1540.07	1199.62
	GT_NGAS	437.32	-	-	770.03	735.67
	IC	437.32	-	-	821.59	785.07
	ST_Coal	1421.29	-	-	1540.07	1472.41
	ST_Lignite	1639.95	-	-	1540.07	1472.41
	ST_Nuclear	5466.49	-	-	3522.61	3476.43
Controllable RE	Biomass	2733.25	-	-	211.57	1913.81
	CSP	1636.67	1461.74	1364.44	4081.08	3508.65
	HydroRes	1606.06	1647.60	1711.01	2025.50	1953.55
Fluctuating RE	RunOfRiver	5280.63	5356.07	5499.29	-	-
	PV	1314.15	1086.74	987.25	1895.55	1440.19
	WindOff	2295.93	1967.94	1421.29	2887.90	2620.48
	WindOn	1126.10	1071.43	983.97	1141.63	1089.00
Storage	HydroStorage	1804.16	1705.76	1640.17	-	-
	LilonBattery	437.32	300.66	218.66	-	-
	Pstorage	710.64	710.64	710.64	-	-

Table S22.: Investment Costs 2 [€₂₀₁₄/kW]

		[Hun15]				[Pal13]
			2020	[Unt14] 2030	2050	
Conventional Power Plants	CCGT	845.40	859.17	859.17	859.17	799.49
	GT_NGAS	400.39	429.59	429.59	429.59	530.07
	IC	-	-	-	-	-
	ST_Coal	1578.08	1610.95	1610.95	1610.95	2266.94
	ST_Lignite	1803.52	2094.24	2094.24	2094.24	2266.94
	ST_Nuclear	3382.78	3390.52	3390.52	3390.52	4252.50
Controllable RE	Biomass	-	-	-	-	-
	CSP	-	-	-	-	-
	HydroRes	-	-	-	-	-
Fluctuating RE	RunOfRiver	-	-	-	-	-
	PV	-	-	-	-	3790.18
	WindOff	-	-	-	-	4762.64
	WindOn	-	-	-	-	1943.32
Storage	HydroStorage	-	-	-	-	-
	LilonBattery	-	-	-	-	-
	Pstorage	-	-	-	-	-

Table S23.: Investment Costs 3 [€₂₀₁₄/kW]

		[BPG ⁺ 15]	Final		
			2020	2030	2050
Conventional Power Plants	CCGT	765.31	850.00	850.00	850.00
	GT_NGAS	355.32	437.32	437.32	437.32
	IC	-	821.59	785.07	750.00
	ST_Coal	1847.68	1500.00	1500.00	1500.00
	ST_Lignite	1639.95	1639.95	1639.95	1639.95
	ST_Nuclear	5466.49	5000.00	5000.00	5000.00
Controllable RE	Biomass	-	2733.25	2733.25	2733.25
	CSP	-	1636.67	1461.74	1364.44
	HydroRes	-	1606.06	1647.60	1711.01
Fluctuating RE	RunOfRiver	-	5280.63	5356.07	5499.29
	PV	-	1314.15	1086.74	987.25
	WindOff	-	2295.93	1967.94	1421.29
	WindOn	-	1126.10	1071.43	983.97
Storage	HydroStorage	-	1804.16	1705.76	1640.17
	LilonBattery	-	437.32	300.66	218.66
	Pstorage	-	710.64	710.64	710.64

Table S24.: Variable Costs [€₂₀₁₄/kWh]

	[NPS ⁺ 12]	[HHM11]	[Hun15]	[MW12]	[Pal13]	[BPG ⁺ 15]	Final
		2020	2030				
Conventional Power Plants	CCGT	0.0003	0.0021	0.0054	0.0022	0.0008	0.0025
	GT_NGAS	0.0003	0.0011	0.0011	0.0023	0.0016	0.0027
	IC	0.0001	0.0011	0.0011	-	-	0.0011
	ST_Coal	0.0001	0.0011	0.0011	0.0045	0.0016	0.0027
	ST_Lignite	0.0001	0.0011	0.0011	0.0049	-	0.0031
Controllable RE	ST_Nuclear	0.0001	0.0129	0.0129	0.0006	0.0032	0.0052
	Biomass	0.0000	0.0097	0.0097	-	-	0.0097
	CSP	0.0000	0.0000	0.0000	-	-	0.0000001
	HydroRes	0.0000	0.0086	0.0086	-	-	0.0000001
	RunOffRiver	0.0000000	-	-	-	-	0.0000001
Fluctuating RE	PV	0.0000001	0.0000000	0.0000000	-	-	0.0000001
	WindOff	0.0000001	0.0000000	0.0000000	-	-	0.0000001
	WindOn	0.0000001	0.0000000	0.0000000	-	-	0.0000001
Storage	HydroStorage	0.0000000	-	-	-	-	0.0000001
	LilonBattery	0.0000000	-	-	-	-	0.0000001
	Pstorage	0.0000000	-	-	-	-	0.0000001

Table S25.: Tear and Wear Costs [€₂₀₁₄/kW]

		[NPS ⁺ 12]	[Hun15]	[BPG ⁺ 15]	Final
Conventional Power Plants	CCGT	0.0005	0.0094	0.0005	0.0017
	GT_NGAS	0.0005	0.0094	0.0005	0.0002
	IC	0.0005	-	-	0.0009
	ST_Coal	0.0016	0.0059	0.0016	0.0024
	ST_Lignite	0.0016	0.0059	0.0016	0.0042
	ST_Nuclear	0.0016	0.0023	0.0016	0.0023
Controllable RE	Biomass	-	-	-	-
	CSP	-	-	-	-
	HydroRes	-	-	-	-
	RunOfRiver	-	-	-	-
Fluctuating RE	PV	-	-	-	-
	WindOff	-	-	-	-
	WindOn	-	-	-	-
	HydroStorage	-	-	-	-
Storage	LilonBattery	-	-	-	-
	Pstorage	-	-	-	-

 Table S26.: Emission factors per fuel [NPS⁺12, WAE12]

Fuel	Emission factor
Biomass	0
Coal	0.3348
Lignite	0.3996
Natural Gas	0.2016
Nuclear	0
Oil	0.2640

Table S27.: Efficiencies by technology and age group

	Lignite	Coal	CCGT	Gas Turbine	IC	Nuclear
1970	0.355	0.387	0.409	0.234	0.457	0.324
1980	0.380	0.407	0.429	0.274	0.457	0.324
1990	0.395	0.417	0.509	0.324	0.457	0.324
2000	0.425	0.467	0.559	0.374	0.457	0.324
2010	0.455	0.495	0.590	0.400	0.457	0.324
2020	0.495	0.540	0.610	0.440	0.457	0.324
2030	0.520	0.550	0.630	0.460	0.457	0.324
2040	0.520	0.550	0.630	0.470	0.457	0.324
2050	0.520	0.550	0.630	0.470	0.457	0.324

Table S28.: Technology Parameters, Storage 1 (based on DLR internal assessment of various sources [AAG⁺12, CCY⁺09, FLLS12, DFF⁺09, JWM07, HEB⁺12, Sau09, MM12, Eur03])

Technology	Year	Invest Storage	Invest Con- verter	AmorTime		LifeTime	
				Storage	Converter	Storage	Converter
HydrogenStorage	2020	0.69	1639.95	30	15	30	15
HydrogenStorage	2030	0.71	1530.62	30	15	30	15
HydrogenStorage	2050	0.77	1311.96	30	15	30	15
LilonBattery	2020	327.99	109.33	21	21	21	21
LilonBattery	2030	245.99	54.66	22	22	22	22
LilonBattery	2050	163.99	54.66	25	25	25	25
PumpedStorage	2020	10.93	579.45	25	25	60	30
PumpedStorage	2030	10.93	546.65	25	25	60	30
PumpedStorage	2050	10.93	491.98	25	25	60	30

Table S29.: Technology Parameters, Storage 2 (based on DLR internal assessment of various sources [AAG⁺12, CCY⁺09, FLS12, DFF⁺09, JWM07, HEB⁺12, Sau09, MM12, Eur03])

Technology	Year	Storage To Converter Ratio	Eta Charge	Eta Dis-charge	Self Dis-charge Rate	Availability	CapCredit
HydrogenStorage	2020	200	0.71	0.60	0.000000	0.95	0.8
HydrogenStorage	2030	200	0.73	0.62	0.000000	0.95	0.8
HydrogenStorage	2050	200	0.75	0.62	0.000000	0.95	0.8
LilonBattery	2020	10	0.93	0.93	0.000071	0.98	0.8
LilonBattery	2030	10	0.94	0.94	0.000071	0.98	0.8
LilonBattery	2050	10	0.97	0.97	0.000011	0.98	0.8
PumpedStorage	2020	7	0.89	0.89	0.000005	0.9	0.8
PumpedStorage	2030	7	0.89	0.89	0.000005	0.9	0.8
PumpedStorage	2050	7	0.91	0.91	0.000005	0.9	0.8

E Variable Factors: Literature Values

To allow for comparison between literature values, all cost values found in literature were transformed into €_{2014} under consideration of the yearly averaged US-Dollar to Euro change rate and by assuming a yearly inflation rate of 1,8%. In case of the demand development, values found in literature referred to relative value changes, or were based on electricity consumption values from years previous to 2014. Therefore, on base of the provided data the relative changes were considered and applied on the available 2014 value. For the evaluation of other parameters, if no values were specifically given for the in this study modeled years, interpolation between given values was done. An overview of the literature and used values is given in the following tables.

Variations consistency

For analysis of the effect of single parameters on the system, only one parameter was varied, whereas the others were assumed to remain as defined in the base scenario trend. After analysing the consistency of the corresponding descriptor-state combinations, some scenarios appeared to be less probable or inconsistent. High fuel prices are only present in the 25 consistent scenarios in relation with a global development into a “Fortress World”, where international order is based on military power. In such case, the agreement on common political measures is very restricted, so that rather low CO₂-allowance prices could be expected. In case of medium fuel prices, low demand is unlikely to be expected, if considering it in combination with the base scenario assumptions. These imply economic and population growth, and high RE-share; and exclude social values development towards consume renouncement. In these cases, the affected parameters should be varied jointly to ensure consistency. However, analysis of the impact of single parameters on the system is pursued. This should, hence, be taken into account by hindsight, if probabilities are assigned to single paths.

Table S30.: Final Electricity Consumption Development [TWh]

Source	2014	2020	2030	2050
[ENT15]	3176.80	-	-	-
[Eur11a]	-	-	-	3131.86
	-	-	-	3392.85
[Unt14]	-	3292.27	3494.11	3935.69
	-	-	-	-
	-	-	-	-
[ZLM10]	-	3474.24	3574.79	5254.39
Max	3176.80	3474.24	3574.79	5254.39
Min	3176.80	2954.82	3006.23	2979.95
Base Scenario	3176.80	3127.96	3195.75	3738.10
High	3176.80	3301.10	3385.27	4496.24
Low	3176.80	2954.82	3006.23	2979.95

Table S31.: Final Electricity Consumption Development per European region [TWh]

Region	Year	Base Scenario	High	Low
Austria	2020	75.06	79.21	70.9
Belgium	2020	90.65	95.67	85.64
Czech Republic	2020	67.15	70.87	63.43
Denmark_E	2020	13.45	14.2	12.71
Denmark_W	2020	22.61	23.87	21.36
Finland	2020	90.22	95.22	85.23
France	2020	504.39	532.31	476.48
Ireland	2020	28.38	29.95	26.81
Italy	2020	334.02	352.51	315.54
Liechtenstein	2020	0.22	0.23	0.2
Luxemburg	2020	6.82	7.2	6.45
Netherlands	2020	120.11	126.76	113.47
Norway	2020	135.6	143.11	128.1
Poland	2020	159.11	167.91	150.3
Portugal	2020	52.64	55.55	49.72
Slovakia	2020	28.27	29.83	26.7
Spain	2020	279.22	294.68	263.77
Sweden	2020	146.87	155	138.74
Switzerland	2020	68.23	72.01	64.46
UK	2020	358.07	377.89	338.25
Austria	2030	76.68	81.23	72.14
Belgium	2030	92.62	98.11	87.13
Czech Republic	2030	68.61	72.68	64.54
Denmark_E	2030	13.74	14.56	12.93
Denmark_W	2030	23.1	24.47	21.73
Finland	2030	92.18	97.64	86.71
France	2030	515.33	545.89	484.76
Ireland	2030	28.99	30.71	27.27
Italy	2030	341.26	361.5	321.03
Liechtenstein	2030	0.22	0.23	0.21
Luxemburg	2030	6.97	7.38	6.56
Netherlands	2030	122.72	130	115.44
Norway	2030	138.54	146.76	130.33
Poland	2030	162.55	172.19	152.91
Portugal	2030	53.78	56.97	50.59
Slovakia	2030	28.88	30.59	27.17
Spain	2030	285.27	302.19	268.35
Sweden	2030	150.05	158.95	141.15
Switzerland	2030	69.71	73.85	65.58
UK	2030	365.83	387.52	344.13
Austria	2050	89.7	107.89	71.51
Belgium	2050	108.34	130.31	86.36
Czech Republic	2050	80.25	96.53	63.97
Denmark_E	2050	16.08	19.34	12.82
Denmark_W	2050	27.02	32.51	21.54
Finland	2050	107.82	129.69	85.95
France	2050	602.78	725.03	480.53
Ireland	2050	33.91	40.79	27.03
Italy	2050	399.18	480.14	318.22
Liechtenstein	2050	0.26	0.31	0.21
Luxemburg	2050	8.15	9.81	6.5
Netherlands	2050	143.54	172.66	114.43
Norway	2050	162.05	194.92	129.19
Poland	2050	190.14	228.7	151.58
Portugal	2050	62.91	75.66	50.15
Slovakia	2050	33.78	40.63	26.93
Spain	2050	333.68	401.36	266.01
Sweden	2050	175.51	211.11	139.92
Switzerland	2050	81.54	98.08	65.01
UK	2050	427.91	514.7	341.13

Table S32.: Final Electricity Consumption Development per German region [TWh]

Region	Year	Base Scenario	High	Low
DAMP1	2020	8.89	9.38	8.4
DAMP2	2020	41.78	44.09	39.47
DAMP3	2020	25.78	27.21	24.35
DAMP4	2020	32.18	33.97	30.4
DAMP5	2020	37.71	39.79	35.62
DAMP6	2020	11.64	12.29	11
DEnBW1	2020	15.33	16.17	14.48
DEnBW2	2020	49.26	51.99	46.53
DTPS0	2020	0	0	0
DTPS1	2020	16.15	17.05	15.26
DTPS2	2020	24.6	25.96	23.24
DTPS3	2020	36.43	38.45	34.42
DTPS4	2020	22.78	24.04	21.52
DTPS5	2020	31.78	33.54	30.02
DTPS6	2020	28.05	29.61	26.5
DVET0	2020	0	0	0
DVET1	2020	61.3	64.7	57.91
DVET2	2020	10.85	11.45	10.25
DVET3	2020	46.82	49.42	44.23
DVET4	2020	45.51	48.03	42.99
DAMP1	2030	9.08	9.62	8.54
DAMP2	2030	42.69	45.22	40.16
DAMP3	2030	26.34	27.9	24.78
DAMP4	2030	32.88	34.83	30.93
DAMP5	2030	38.52	40.81	36.24
DAMP6	2030	11.89	12.6	11.19
DEnBW1	2030	15.66	16.59	14.73
DEnBW2	2030	50.33	53.31	47.34
DTPS0	2030	0	0	0
DTPS1	2030	16.5	17.48	15.52
DTPS2	2030	25.13	26.62	23.64
DTPS3	2030	37.22	39.43	35.02
DTPS4	2030	23.28	24.66	21.9
DTPS5	2030	32.47	34.4	30.54
DTPS6	2030	28.66	30.36	26.96
DVET0	2030	0	0	0
DVET1	2030	62.63	66.35	58.92
DVET2	2030	11.08	11.74	10.43
DVET3	2030	47.84	50.68	45
DVET4	2030	46.5	49.25	43.74
DAMP1	2050	10.63	12.78	8.47
DAMP2	2050	49.93	60.06	39.8
DAMP3	2050	30.81	37.06	24.56
DAMP4	2050	38.46	46.26	30.66
DAMP5	2050	45.06	54.2	35.92
DAMP6	2050	13.91	16.73	11.09
DEnBW1	2050	18.31	22.03	14.6
DEnBW2	2050	58.87	70.81	46.93
DTPS0	2050	0	0	0
DTPS1	2050	19.3	23.22	15.39
DTPS2	2050	29.39	35.36	23.43
DTPS3	2050	43.54	52.37	34.71
DTPS4	2050	27.23	32.75	21.7
DTPS5	2050	37.98	45.68	30.28
DTPS6	2050	33.53	40.32	26.73
DVET0	2050	0	0	0
DVET1	2050	73.26	88.12	58.4
DVET2	2050	12.96	15.59	10.33
DVET3	2050	55.96	67.31	44.61
DVET4	2050	54.39	65.42	43.36

Table S33.: Usable areas: Literature Values

Source	Technology	Area Type	[Sch12]	[Hel10]	[Hoo04]	[Ste14]
PV		agricultural land	0.0003	0.10 - 0.35	0.01	0
		grassland	0.0003	0.35	0.01 - 0.05	1
		bare areas	0.3300	0.10 - 0.80	0.05	1
Wind Onshore		sparsely vegetated areas	0.3300	0.80	0.01	1
		bare areas	0.3300	0.10 - 0.80	1.00	1
		sparsely vegetated areas	0.3300	0.80	0.90	1
		grassland	0.0300	0.35	0.50 - 0.80	1
		agricultural areas	0.0300	0.1 - 0.35	0.70	0
		shrub cover	0.0300	0.50	0.50	1
		mosaic (cropland, shrub, tree cover)	0.0300	0.50	0.10 - 0.70	1
		forest	0.0300	0.10	0.10	0
		open ocean (5km distance from coast)	0.16	- (30 GW in Germany)	-	0.75
		bare and sparsely vegetated areas	0.33	- (60 TWh/a in Europe)	-	1
CSP						

Table S34.: Usable Areas: Base Scenario, Minimum and Maximum values

Technology	Area Type	Min	Base Scenario	Max
PV	agricultural and grassland	0.0003	0.0003	0.35
	bare and sparsely vegetated areas	0.01	0.33	0.8
Wind Onshore	agricultural land, grassland, shrubland, mosaic and forest	0.03	0.03	0.8
	bare and sparsely vegetated areas	0.1	0.33	1
Wind offshore	open ocean (5km distance from coast)		0.16	
CSP	bare and sparsely vegetated areas		0.0003	

Table S35.: Coal Prices Development [€₂₀₁₄/MWh]

Source	2014	2020	2030	2050
[Inf15]	6.52	-	-	-
[Hun15]	-	4.23	-0.48	-
[Unt14]	-	14.39	14.82	15.79
[Eur11a]	-	17.59	20.45	17.90
	-	9.80	10.65	10.34
	-	12.84	14.59	14.99
[BCB ⁺ 11]	-	12.17	12.52	-
[NBH ⁺ 14]	-	19.51	23.88	29.85
	-	18.65	21.11	24.30
	-	17.78	18.34	18.75
Max	6.52	19.51	23.88	29.85
Min	6.52	4.23	10.65	10.34
Base Scenario	6.52	11.84	16.94	16.75
High	6.52	19.08	22.49	27.08
Low	6.52	6.89	12.04	11.88

Table S36.: Gas Prices Development [€₂₀₁₄/MWh]

Source	2014	2020	2030	2050
[Inf15]	20.95	-	-	-
[Hun15]	-	37.57	-4.79	-
[Unt14]	-	30.18	32.33	36.62
[Eur11a]	-	38.26	45.43	57.73
	-	19.56	22.78	24.21
	-	27.79	34.28	44.04
[BCB ⁺ 11]	-	29.89	33.63	-
[NBH ⁺ 14]	-	42.98	53.85	64.76
	-	40.79	46.79	52.32
	-	38.59	39.73	39.89
Max	20.95	42.98	53.85	64.76
Min	20.95	19.56	22.78	24.21
Base Scenario	20.95	31.17	36.34	38.39
High	20.95	42.98	52.25	55.06
Low	20.95	21.02	24.44	23.68

Table S37.: Lignite Prices Development [$\text{€}_{2014}/\text{MWh}$]

Source	2014	2020	2030	2050
[Inf15]	3.38	-	-	-
[Hun15]	-	3.87	3.87	-
[Unt14]	-	1.50	1.50	1.50
[Eur11a]	-	-	-	-
	-	-	-	-
	-	-	-	-
[NBH ⁺ 14]	-	19.51	23.88	29.85
	-	18.65	21.11	24.30
	-	17.78	18.34	18.75
Max	3.38	7.08	7.87	11.02
Min	3.38	1.50	1.50	1.50
Base Scenario	3.38	4.78	4.86	5.43
High	3.38	6.99	7.52	10.04
Low	3.38	2.10	2.10	2.10

Table S38.: Oil Prices Development [$\text{€}_{2014}/\text{MWh}$]

Source	2014	2020	2030	2050
[Inf15]	46.30	-	-	-
[Hun15]	-	56.60	79.59	-
[Unt14]	-	106.32	118.14	124.58
[Eur11a]	-	59.16	66.82	72.64
	-	35.27	40.95	37.55
	-	39.56	47.39	56.75
[BCB ⁺ 11]	-	77.07	83.25	-
[NBH ⁺ 14]	-	106.32	118.14	116.00
	-	62.33	72.69	72.88
	-	35.27	40.95	37.55
Max	46.30	106.32	118.14	116.00
Min	46.30	35.27	40.95	37.55
Base Scenario	46.30	62.33	72.69	76.77
High	46.30	93.13	104.50	110.12
Low	46.30	42.03	48.88	47.35

Table S39.: Interest Rate [%]

Source	2014	2020	2030	2050
[NPS ⁺ 12]	6.00	6.00	6.00	6.00
	-	15.00	15.00	15.00
[Hun15]	-	5.00	5.00	5.00
	-	9.00	9.00	9.00
[Pal13]	-	9.00	9.00	9.00
[SW07]	-	8.00	8.00	8.00
[HHM11]	-	7.00	7.00	7.00
[OEC12]	-	1.88	2.08	1.58
Max	6.00	15.00	15.00	15.00
Min	6.00	1.88	2.08	1.58
Base Scenario	6.00	6.00	6.00	6.00
High	6.00	8.50	11.00	11.00
Low	6.00	4.04	2.08	2.08

Table S40.: CO₂ Allowance Prices Development [€₂₀₁₄/tCO₂]

Source	2014	2020	2030	2050
[EEX15]	6.01	-	-	-
[ZLM10]	-	36.41	32.78	49.02
[Hun15]	-	17.61	53.54	
	-	-	31.65	
[Unt14]	-	26.85	37.59	52.84
[Eur11a]	-	20.03	44.52	55.65
	-	16.69	35.62	56.76
	-	16.69	27.82	260.44
	-	27.82	57.87	294.94
	-	27.82	38.95	317.20
	-	27.82	61.21	300.50
	-	22.26	70.12	345.02
[BCB ⁺ 11]	-	25.29	33.72	37.94
	-	37.94	80.09	101.17
Max	6.01	37.94	80.09	345.02
Min	6.01	16.69	27.82	37.94
Base Scenario	6.01	27.3162865	53.9577885	191.480575
High	6.01	37.9378996	80.0911213	345.02325
Low	6.01	25.1361627	43.7449811	134.567724

F Simulation Results

The results presented here additionally comprise results obtained using a static implementation of the REMix model, which reveal technology lock-in effects when optimising using a myopic approach.

E.1. Static vs Myopic

Table S41.: Net Power Generation [TWh], Storage

Year	Approach	Hydrogen Storage	Pumped Storage	Li-Ion Battery
2020	Static	0.00	23.15	0.13
2030	Static	0.00	23.45	3.20
	Myopic	0.00	23.35	2.61
2050	Static	202.91	29.27	22.48
	Myopic	206.80	30.43	19.77

Table S42.: Net Power Generation [TWh], Conventional Technologies

Year	Approach	Nuclear	Coal	Lignite	CCGT	Gas Turbine	IC
2020	Static	899.78	262.60	543.40	275.09	8.59	0.02
2030	Static	641.81	73.46	494.72	231.62	11.38	0.04
	Myopic	643.60	69.53	522.52	215.73	8.88	0.04
2050	Static	57.56	0.89	0.14	36.98	10.46	0.00
	Myopic	48.32	1.32	6.70	35.04	3.13	0.00

Table S43.: Net Power Generation [TWh], Controllable Renewable Energies

Year	Approach	Biomass	CSP	Hydro Reservoir
2020	Static	1.32	5.95	158.57
2030	Static	1.67	5.90	167.80
	Myopic	1.66	5.91	167.32
2050	Static	23.37	0.00	177.71
	Myopic	23.56	0.00	177.48

Table S44.: Net Power Generation [TWh], Fluctuating Renewable Energies

Year	Approach	Run Of River	Wind Onshore	Wind Offshore	Photovoltaic
2020	Static	338.44	59.94	553.16	51.65
2030	Static	338.45	448.99	638.39	181.45
	Myopic	338.48	438.10	669.08	153.75
2050	Static	322.96	2961.43	302.18	192.45
	Myopic	323.54	2896.37	387.07	187.25

Table generated by Excel2LaTeX from sheet 'TablesLatex'

Table S45.: Total Installed Capacities [GW], Storage

Year	Approach	Hydrogen Storage	Pumped Storage	Li-Ion Battery
2020	Static	0.00	34.01	0.32
2030	Static	0.00	34.01	9.02
	Myopic	0.00	34.01	7.37
2050	Static	131.44	34.01	33.00
	Myopic	133.48	34.01	30.72

Table S46.: Total Installed Capacities [GW], Conventional Technologies

Year	Approach	Nuclear	Coal	Lignite	CCGT	Gas Turbine	IC
2020	Static	120.13	53.02	76.80	159.10	29.78	9.07
2030	Static	83.55	23.53	75.78	114.98	30.30	3.81
	Myopic	83.55	23.53	80.95	114.98	28.28	3.81
2050	Static	9.11	5.93	3.92	12.70	80.77	0.00
	Myopic	7.62	5.93	71.66	12.25	20.75	0.00

Table S47.: Total Installed Capacities [GW], Controllable Renewable Energies

Year	Approach	Biomass	CSP	Hydro Reservoir
2020	Static	24.07	2.20	56.74
2030	Static	24.07	2.20	57.57
	Myopic	24.07	2.20	57.57
2050	Static	24.07	0.00	58.57
	Myopic	24.07	0.00	58.57

Table S48.: Total Installed Capacities [GW], Fluctuating Renewable Energies

Year	Approach	Run Of River	Wind Onshore	Wind Offshore	Photovoltaic
2020	Static	105.78	253.87	14.53	41.93
2030	Static	105.78	280.37	110.12	145.91
	Myopic	105.78	302.23	106.77	123.07
2050	Static	105.78	143.58	798.06	157.07
	Myopic	105.78	187.55	778.78	151.66

Table S49.: Averaged Full Load Hours [h], Storage

Year	Approach	Hydrogen Storage	Pumped Storage	Li-Ion Battery
2020	Static	141.60	716.16	1024.60
2030	Static	30.56	710.35	492.07
	Myopic	106.97	710.11	504.52
2050	Static	1463.21	845.70	688.90
	Myopic	1472.25	876.49	674.30

Table S50.: Averaged Full Load Hours [h], Conventional Technologies

Year	Approach	Nuclear	Coal	Lignite	CCGT	Gas Turbine	IC
2020	Static	7202.67	4633.12	6573.13	1603.90	195.92	7.72
2030	Static	7333.62	2498.50	6770.93	2322.44	210.11	15.52
	Myopic	7364.88	2499.78	6672.36	2255.30	201.91	15.03
2050	Static	6240.44	750.28	663.49	2288.50	103.19	25.56
	Myopic	5916.04	300.38	115.89	2247.03	189.03	16.91

Table S51.: Averaged Full Load Hours [h], Controllable Renewable Energies

Year	Approach	Biomass	CSP	Hydro Reservoir
2020	Static	52.52	1298.48	3139.60
2030	Static	60.46	1074.43	3235.53
	Myopic	59.30	1013.99	3229.15
2050	Static	1143.22	2727.92	3329.64
	Myopic	1149.39	2547.11	3325.56

Table S52.: Averaged Full Load Hours [h], Fluctuating Renewable Energies

Year	Approach	Run Of River	Wind Onshore	Wind Offshore	Photovoltaic
2020	Static	3098.66	2064.52	3105.27	1046.88
2030	Static	3098.37	1994.70	2831.10	1047.40
	Myopic	3097.77	2012.68	3075.22	1047.55
2050	Static	2967.87	1809.99	3372.23	933.30
	Myopic	2970.85	1853.04	3303.80	908.53

Table S53.: Installed Transmission Capacities [GW], From - To Region 1

		Austria		BeNeLux		Denmark_W	
Year	Approach	Germany	Denmark_W	France	Germany	Germany	
2020	Static	4.93	0.70	3.40	1.28	0.73	
2030	Static	16.19	3.16	3.40	20.11	1.60	
	Myopic	17.74	2.77	3.40	20.11	1.51	
2050	Static	22.29	20.74	3.40	35.44	46.73	
	Myopic	23.36	17.71	3.40	37.17	47.51	

Table S54.: Installed Transmission Capacities [GW], From - To Region 2

		France		Iberia	Italy	
Year	Approach	BeNeLux	Germany	France	Austria	France
2020	Static	-	3.20	3.30	0.22	2.58
2030	Static	2.41	11.50	21.62	5.55	17.58
	Myopic	2.41	10.75	21.52	7.45	17.36
2050	Static	26.73	12.94	25.24	10.86	34.18
	Myopic	22.23	13.21	26.42	10.64	34.50

Table S55.: Installed Transmission Capacities [GW], From - To Region 3

		Nordel			PolCzeSlk		
Year	Approach	BeNeLux	Denmark_W	Germany	PolCzeSlk	Austria	Germany
2020	Static	0.70	2.60	4.00	0.60	0.60	2.60
2030	Static	1.40	2.60	4.00	1.67	3.08	7.23
	Myopic	1.40	2.60	4.00	1.20	3.18	7.30
2050	Static	1.40	12.32	5.75	40.21	9.45	8.65
	Myopic	1.40	12.03	4.00	37.88	7.75	9.48

Table S56.: Installed Transmission Capacities [GW], From - To Region 4

		Switzerland			UK_IE			
Year	Approach	Austria	France	Germany	Italy	BeNeLux	France	Nordel
2020	Static	0.47	3.20		1.81	2.00	3.00	1.40
2030	Static	0.47	5.56	6.26	2.81	4.11	11.53	2.33
	Myopic	0.47	5.65	6.24	2.81	4.77	12.04	2.44
2050	Static	0.47	8.39	8.04	2.81	46.00	48.00	8.35
	Myopic	0.48	8.39	8.04	2.81	46.41	56.04	8.14

Table S57.: Total Installed Capacities per Region [GW], Storage

Year	Approach	Region	Hydrogen Storage	Li-Ion Battery	Pumped Storage
2020	Static	Austria	0.00	0.00	33.53
		BeNeLux	0.00	0.00	13.30
		Denmark_W	0.00	0.37	-
		France	0.00	0.00	49.72
		Germany	0.00	0.00	69.51
		Iberia	0.00	0.00	69.33
		Italy	0.00	0.00	65.76
		Nordel	0.00	0.08	15.97
		PolCzeSlk	0.00	0.57	38.50
		Switzerland	0.00	0.00	15.33
		UK_IE	0.00	1.78	3.21
2030	Myopic	Austria	0.00	0.00	33.53
		BeNeLux	0.00	0.20	13.30
		Denmark_W	0.00	7.79	-
		France	0.00	0.00	49.72
		Germany	0.00	0.00	69.51
		Iberia	0.00	0.00	69.33
		Italy	0.00	0.00	65.76
		Nordel	0.00	3.84	15.97
		PolCzeSlk	0.00	0.68	38.50
		Switzerland	0.00	0.00	15.33
		UK_IE	0.00	70.73	3.21
	Static	Austria	0.00	0.00	33.53
		BeNeLux	0.00	0.33	13.30
		Denmark_W	0.00	9.31	-
		France	0.00	0.00	49.72
		Germany	0.00	0.12	69.51
		Iberia	0.00	0.00	69.33
		Italy	0.00	0.00	65.76
		Nordel	-	11.36	15.97
		PolCzeSlk	0.00	0.29	38.50
		Switzerland	0.00	0.00	15.33
		UK_IE	0.00	86.16	3.21
2050	Myopic	Austria	0.06	0.33	33.53
		BeNeLux	35.70	3.13	13.30
		Denmark_W	253.58	7.88	-
		France	31.43	0.40	49.72
		Germany	115.15	16.20	69.51
		Iberia	23.82	131.38	69.33
		Italy	0.49	107.74	65.76
		Nordel	-	18.30	15.97
		PolCzeSlk	54.48	10.91	38.50
		Switzerland	0.04	2.59	15.33
		UK_IE	682.95	69.04	3.21
	Static	Austria	0.00	0.00	33.53
		BeNeLux	29.54	2.51	13.30
		Denmark_W	272.05	1.32	-
		France	43.98	0.97	49.72
		Germany	124.74	34.35	69.51
		Iberia	19.17	156.68	69.33
		Italy	0.00	110.51	65.76
		Nordel	-	28.91	15.97
		PolCzeSlk	53.17	43.33	38.50
		Switzerland	0.00	1.27	15.33
		UK_IE	681.98	10.53	3.21

Table S58.: Total Installed Capacities per Region [GW], Conventional Technologies

Year	Approach	Region	Nuclear	Coal	Lignite	CCGT	Gas Turbine	IC
2020	Static	Austria	0.00	13.31	1.87	48.24	3.31	0.46
		BeNeLux	63.04	34.95	38.92	185.67	24.15	6.68
		Denmark_W	0.00	17.68	0.32	12.16	1.68	8.79
		France	724.70	20.78	14.77	63.20	45.43	8.36
		Germany	93.96	220.00	261.42	164.07	37.90	9.86
		Iberia	79.91	70.97	24.83	354.19	34.01	37.09
		Italy	-	66.43	149.87	492.98	53.96	7.77
		Nordel	139.92	29.43	73.74	32.97	88.29	3.92
		PolCzeSlk	66.15	71.35	228.63	23.67	17.65	2.56
		Switzerland	29.26	0.00	0.00	2.23	1.24	0.15
2030	Myopic	UK_IE	124.45	38.29	30.96	370.68	38.04	14.10
		Austria	0.00	0.51	18.76	38.63	0.00	0.31
		BeNeLux	0.00	23.06	101.82	112.93	20.84	3.14
		Denmark_W	0.00	9.43	1.38	0.69	1.76	3.02
		France	590.49	0.14	0.00	59.50	24.27	1.87
		Germany	-	91.65	275.99	126.22	35.37	4.76
		Iberia	79.91	15.28	14.17	329.04	15.85	13.47
		Italy	-	63.73	149.87	392.69	14.60	4.41
		Nordel	80.38	6.16	73.74	21.08	109.11	0.60
		PolCzeSlk	66.33	48.42	188.27	23.50	17.71	2.06
	Static	Switzerland	14.03	0.00	2.46	1.86	0.02	0.02
		UK_IE	88.04	0.47	51.58	206.74	90.87	8.24
		Austria	0.00	0.51	22.47	38.58	0.00	0.31
		BeNeLux	16.55	23.06	100.91	115.21	18.66	3.14
		Denmark_W	0.00	9.43	1.14	0.70	3.58	3.02
		France	590.49	0.14	0.00	59.50	24.27	1.87
		Germany	-	91.65	260.25	134.52	38.56	4.76
		Iberia	79.91	15.28	2.86	329.04	15.85	13.47
		Italy	-	63.73	105.20	392.69	14.60	4.41
		Nordel	80.38	6.16	22.14	24.22	127.47	0.60
		PolCzeSlk	89.44	48.42	142.50	42.70	15.60	2.06
		Switzerland	14.03	0.00	3.36	1.86	0.02	0.02
		UK_IE	88.04	0.47	47.12	206.21	92.84	8.24
	Myopic	Austria	0.00	0.00	18.76	5.50	0.96	0.00
		BeNeLux	0.01	8.80	101.83	8.20	24.15	0.00
		Denmark_W	0.01	0.00	1.38	0.69	1.78	0.00
		France	19.16	0.00	0.00	24.86	85.48	0.00
		Germany	-	55.32	201.31	65.79	41.51	0.00
		Iberia	48.03	0.00	11.32	35.04	4.27	0.00
		Italy	-	0.00	149.87	143.69	80.37	0.00
		Nordel	0.00	0.00	73.74	3.57	32.32	0.00
		PolCzeSlk	32.32	1.10	163.64	42.68	14.80	0.00
		Switzerland	-	0.00	2.46	1.34	2.85	0.00
	Static	UK_IE	0.00	0.00	51.58	7.59	90.43	0.00
		Austria	0.00	0.00	0.00	6.21	36.45	0.00
		BeNeLux	0.00	8.80	0.00	7.91	37.37	0.00
		Denmark_W	0.00	0.00	0.00	0.00	0.00	0.00
		France	27.32	0.00	0.00	26.82	286.98	0.00
		Germany	-	55.31	32.15	77.74	137.75	0.00
		Iberia	57.87	0.00	0.00	34.99	3.84	0.00
		Italy	-	0.00	0.00	146.22	256.65	0.00
		Nordel	0.00	0.00	0.00	0.00	2.27	0.00
		PolCzeSlk	30.08	1.09	10.92	51.30	156.31	0.00
		Switzerland	-	0.00	0.00	1.45	13.14	0.00
		UK_IE	0.00	0.00	0.00	0.00	36.33	0.00

Table S59.: Total Installed Capacities per Region [GW], Controllable Renewables

Year	Approach	Region	Biomass	CSP	Hydro Reservoir
2020	Static	Austria	6.76	-	56.40
		BeNeLux	27.50	-	-
		Denmark_W	4.94	-	-
		France	12.75	0.14	135.49
		Germany	38.33	-	3.85
		Iberia	13.85	24.02	170.93
		Italy	22.21	0.00	25.85
		Nordel	79.88	-	114.24
		PolCzeSlk	8.03	-	10.81
		Switzerland	4.85	-	105.01
		UK_IE	45.65	-	1.62
2030	Myopic	Austria	6.76	-	60.50
		BeNeLux	27.50	-	-
		Denmark_W	4.94	-	-
		France	12.75	0.14	135.49
		Germany	38.33	-	3.85
		Iberia	13.85	24.02	170.93
		Italy	22.21	0.00	25.85
		Nordel	79.88	-	114.24
		PolCzeSlk	8.03	-	10.81
		Switzerland	4.85	-	110.00
		UK_IE	45.65	-	1.62
	Static	Austria	6.76	-	60.50
		BeNeLux	27.50	-	-
		Denmark_W	4.94	-	-
		France	12.75	0.14	135.49
		Germany	38.33	-	3.85
		Iberia	13.85	24.02	170.93
		Italy	22.21	0.00	25.85
		Nordel	79.88	-	114.24
		PolCzeSlk	8.03	-	10.81
		Switzerland	4.85	-	110.00
		UK_IE	45.65	-	1.62
2050	Myopic	Austria	6.76	-	60.50
		BeNeLux	27.50	-	-
		Denmark_W	4.94	-	-
		France	12.75	0.01	135.49
		Germany	38.33	-	3.85
		Iberia	13.85	0.02	170.93
		Italy	22.21	0.02	36.85
		Nordel	79.88	-	114.24
		PolCzeSlk	8.03	-	10.81
		Switzerland	4.85	-	110.00
		UK_IE	45.65	-	1.62
	Static	Austria	6.76	-	60.50
		BeNeLux	27.50	-	-
		Denmark_W	4.94	-	-
		France	12.75	0.00	135.49
		Germany	38.33	-	3.85
		Iberia	13.85	0.00	170.93
		Italy	22.21	0.00	36.85
		Nordel	79.88	-	114.24
		PolCzeSlk	8.03	-	10.81
		Switzerland	4.85	-	110.00
		UK_IE	45.65	-	1.62

Table S60.: Total Installed Capacities per Region [GW], Fluctuating Renewables

Year	Approach	Region	Run Of River	Wind Onshore	Wind Offshore	Photovoltaic
2020	Static	Austria	42.57	37.56	-	0.09
		BeNeLux	2.77	103.84	53.65	1.16
		Denmark_W	0.11	66.67	4.81	0.04
		France	175.81	348.58	0.00	12.81
		Germany	43.55	600.51	46.78	42.88
		Iberia	180.08	573.58	0.08	334.54
		Italy	169.95	254.89	0.00	66.93
		Nordel	423.74	133.13	6.16	0.04
		PolCzeSlk	34.17	106.42	0.55	4.64
		Switzerland	35.80	0.74	-	14.19
		UK_IE	55.08	500.99	49.90	20.09
2030	Myopic	Austria	42.57	33.79	-	6.51
		BeNeLux	2.77	103.84	160.77	0.74
		Denmark_W	0.11	74.98	30.22	0.02
		France	175.81	793.36	0.00	12.47
		Germany	43.55	651.17	460.63	32.89
		Iberia	180.08	454.74	0.00	883.11
		Italy	169.95	190.10	0.00	392.10
		Nordel	423.74	118.33	246.86	0.04
		PolCzeSlk	34.17	418.24	0.00	3.42
		Switzerland	35.80	0.00	-	15.23
		UK_IE	55.08	592.33	156.19	20.07
	Static	Austria	42.57	33.10	-	7.47
		BeNeLux	2.77	103.84	134.49	0.74
		Denmark_W	0.11	74.98	35.96	0.02
		France	175.81	822.80	0.00	12.47
		Germany	43.55	651.17	449.33	32.89
		Iberia	180.08	399.83	0.00	948.88
		Italy	169.95	78.45	0.00	520.94
		Nordel	423.74	60.91	315.39	0.04
		PolCzeSlk	34.17	403.34	0.00	3.42
		Switzerland	35.80	0.00	-	15.91
		UK_IE	55.08	592.33	160.53	20.07
2050	Myopic	Austria	42.57	9.35	-	93.32
		BeNeLux	2.77	48.97	362.90	0.01
		Denmark_W	0.11	74.98	947.88	0.01
		France	175.81	580.77	1028.97	11.70
		Germany	43.55	147.09	820.01	117.31
		Iberia	180.08	72.95	552.13	1062.76
		Italy	169.95	423.01	4.56	544.66
		Nordel	423.74	33.91	1572.35	0.01
		PolCzeSlk	34.17	346.42	36.37	5.57
		Switzerland	35.80	0.09	-	23.86
		UK_IE	55.08	592.33	2586.91	0.01
	Static	Austria	42.57	4.08	-	93.29
		BeNeLux	2.77	51.05	358.61	0.00
		Denmark_W	0.11	74.98	983.59	0.00
		France	175.81	364.84	1216.23	0.00
		Germany	43.55	32.06	845.90	129.11
		Iberia	180.08	137.15	510.87	1062.76
		Italy	169.95	432.09	4.55	549.13
		Nordel	423.74	0.00	1685.42	0.00
		PolCzeSlk	34.17	36.34	171.86	0.45
		Switzerland	35.80	0.08	-	23.42
		UK_IE	55.08	592.33	2450.33	0.00

Table S61.: Net Power Generation per Region [TWh], Conventional Technologies

Year	Approach	Region	Hydrogen Storage	Pumped Storage	Li-Ion Battery
2020	Static	Austria	-	0.28	0.00
		BeNeLux	0.00	0.94	0.00
		Denmark_W	0.00	-	0.00
		France	0.00	4.58	0.00
		Germany	0.00	6.28	0.00
		Iberia	-	2.61	0.00
		Italy	-	3.05	0.00
		Nordel	0.00	2.02	0.00
		PolCzeSlk	0.00	3.07	0.02
		Switzerland	-	0.01	0.00
		UK_IE	0.00	0.32	0.11
2030	Myopic	Austria	0.00	1.43	0.00
		BeNeLux	0.00	1.03	0.00
		Denmark_W	0.00	-	0.39
		France	0.00	3.03	0.00
		Germany	0.00	4.73	0.00
		Iberia	0.00	5.07	0.00
		Italy	0.00	3.33	0.00
		Nordel	-	1.25	0.00
		PolCzeSlk	0.00	2.60	0.02
		Switzerland	0.00	0.61	0.00
		UK_IE	0.00	0.28	2.20
	Static	Austria	0.00	1.37	0.00
		BeNeLux	0.00	0.99	0.00
		Denmark_W	0.00	-	0.38
		France	0.00	2.99	0.00
		Germany	0.00	4.66	0.00
		Iberia	0.00	5.42	0.00
		Italy	0.00	3.11	0.00
		Nordel	-	1.40	0.08
		PolCzeSlk	0.00	2.64	0.00
		Switzerland	0.00	0.61	0.00
		UK_IE	0.00	0.26	2.74
2050	Myopic	Austria	0.00	2.60	0.00
		BeNeLux	4.58	0.98	0.00
		Denmark_W	49.72	-	0.29
		France	7.06	3.67	0.00
		Germany	18.66	5.48	0.00
		Iberia	4.21	5.80	8.99
		Italy	0.00	5.62	8.30
		Nordel	-	1.29	0.54
		PolCzeSlk	9.54	3.49	0.36
		Switzerland	0.00	1.29	0.00
		UK_IE	113.04	0.22	1.29
	Static	Austria	0.00	2.60	0.00
		BeNeLux	2.88	0.96	0.00
		Denmark_W	50.57	-	0.00
		France	7.59	3.46	0.00
		Germany	18.22	5.39	0.54
		Iberia	3.36	5.57	10.90
		Italy	0.00	5.38	8.69
		Nordel	-	1.21	0.62
		PolCzeSlk	8.95	3.25	1.71
		Switzerland	0.00	1.24	0.01
		UK_IE	111.34	0.22	0.00

Table S62.: Net Power Generation per Region [TWh], Conventional Technologies

Year	Approach	Region	Nuclear	Coal	Lignite	CCGT	Gas Turbine	IC
2020	Static	Austria	-	5.19	0.00	12.51	0.00	-
		BeNeLux	44.98	19.42	26.03	43.62	0.16	0.00
		Denmark_W	0.00	5.89	0.00	1.42	0.05	0.00
		France	483.13	1.28	3.62	1.26	0.00	-
		Germany	66.95	102.04	164.49	37.04	1.23	0.00
		Iberia	55.47	37.42	8.54	34.76	0.00	-
		Italy	-	40.97	124.49	66.33	0.00	-
		Nordel	99.06	8.08	46.85	6.09	6.47	0.00
		PolCzeSlk	47.23	25.37	154.16	2.80	0.43	0.01
		Switzerland	20.89	0.00	0.00	0.00	0.00	-
		UK_IE	82.08	16.95	15.22	69.26	0.24	0.00
2030	Myopic	Austria	0.00	0.08	17.61	7.92	0.00	0.00
		BeNeLux	0.00	6.37	77.04	26.80	0.16	0.01
		Denmark_W	0.00	1.38	0.00	0.00	0.00	0.01
		France	416.83	0.01	0.00	6.85	0.12	0.00
		Germany	-	30.85	136.41	24.04	0.28	0.01
		Iberia	55.84	1.40	1.42	39.33	0.02	0.00
		Italy	-	16.95	117.18	52.54	0.02	0.00
		Nordel	55.45	0.97	42.02	3.07	6.14	0.00
		PolCzeSlk	46.36	11.43	106.51	3.73	0.31	0.00
		Switzerland	10.01	0.00	0.00	0.38	0.00	0.00
	Static	UK_IE	59.11	0.10	24.34	51.06	1.83	0.01
		Austria	0.00	0.07	22.81	7.56	0.00	0.00
		BeNeLux	0.00	6.34	85.65	26.46	0.15	0.01
		Denmark_W	0.00	1.41	0.00	0.00	0.00	0.01
		France	416.25	0.01	0.00	6.28	0.15	0.00
		Germany	-	31.07	147.00	23.78	0.28	0.01
		Iberia	55.51	1.25	1.43	40.56	0.02	0.00
		Italy	-	20.41	81.87	68.32	0.04	0.00
		Nordel	54.51	1.08	14.27	3.44	8.63	0.00
		PolCzeSlk	46.36	11.72	107.21	3.79	0.29	0.00
2050	Myopic	Switzerland	10.01	0.00	2.06	0.37	0.00	0.00
		UK_IE	59.17	0.10	32.41	51.05	1.81	0.01
		Austria	0.00	0.00	0.47	0.00	0.00	0.00
		BeNeLux	0.00	0.14	1.11	0.00	0.00	0.00
		Denmark_W	0.00	0.00	0.00	0.00	0.00	0.00
		France	0.00	0.00	0.00	0.00	0.00	0.00
		Germany	-	1.15	1.46	0.00	0.00	0.00
		Iberia	35.64	0.00	0.00	0.00	0.00	0.00
		Italy	-	0.00	1.88	35.02	2.21	0.00
		Nordel	0.00	0.00	0.26	0.00	0.22	0.00
	Static	PolCzeSlk	12.68	0.03	1.32	0.02	0.06	0.00
		Switzerland	-	0.00	0.00	0.00	0.11	0.00
		UK_IE	0.00	0.00	0.19	0.00	0.52	0.00
		Austria	-	0.00	0.00	0.00	0.42	0.00
		BeNeLux	0.00	0.07	0.00	0.00	0.00	0.00
		Denmark_W	0.00	0.00	0.00	0.00	0.00	0.00
		France	0.00	0.00	0.00	0.00	2.18	0.00
		Germany	-	0.79	0.10	0.00	1.12	0.00
		Iberia	44.96	0.00	0.00	0.00	0.00	0.00
		Italy	-	0.00	0.00	36.98	4.55	0.00
		Nordel	0.00	0.00	0.00	0.00	0.00	0.00
		PolCzeSlk	12.60	0.03	0.04	0.00	2.10	0.00
		Switzerland	-	0.00	0.00	0.00	0.09	0.00
		UK_IE	0.00	0.00	0.00	0.00	0.00	0.00

Table S63.: Net Power Generation per Region [TWh], Controllable Renewable Energies

Year	Approach	Region	Biomass	CSP	Hydro Reservoir
2020	Static	Austria	-	-	20.75
		BeNeLux	0.01	-	-
		Denmark_W	0.02	-	-
		France	-	0.03	31.25
		Germany	0.27	-	1.75
		Iberia	-	5.92	22.91
		Italy	-	0.00	5.77
		Nordel	0.91	-	45.62
		PolCzeSlk	0.03	-	2.28
		Switzerland	-	-	27.78
		UK_IE	0.09	-	0.46
2030	Myopic	Austria	0.05	-	24.86
		BeNeLux	0.16	-	-
		Denmark_W	0.03	-	-
		France	0.03	0.03	31.25
		Germany	0.30	-	1.75
		Iberia	0.00	5.88	22.93
		Italy	0.02	0.00	5.77
		Nordel	0.75	-	44.99
		PolCzeSlk	0.08	-	2.28
		Switzerland	0.02	-	33.03
		UK_IE	0.22	-	0.46
	Static	Austria	0.04	-	24.98
		BeNeLux	0.17	-	-
		Denmark_W	0.03	-	-
		France	0.03	0.03	31.25
		Germany	0.31	-	1.75
		Iberia	0.01	5.86	22.93
		Italy	0.02	0.00	5.77
		Nordel	0.73	-	45.45
		PolCzeSlk	0.08	-	2.28
		Switzerland	0.02	-	32.92
		UK_IE	0.22	-	0.46
2050	Myopic	Austria	0.88	-	27.81
		BeNeLux	2.90	-	-
		Denmark_W	0.49	-	-
		France	1.32	0.00	31.07
		Germany	4.66	-	1.74
		Iberia	1.12	0.00	22.81
		Italy	2.82	0.00	8.19
		Nordel	5.81	-	45.59
		PolCzeSlk	1.28	-	2.25
		Switzerland	0.54	-	37.57
		UK_IE	1.74	-	0.44
	Static	Austria	0.88	-	27.99
		BeNeLux	2.90	-	-
		Denmark_W	0.49	-	-
		France	1.32	0.00	31.05
		Germany	4.73	-	1.74
		Iberia	1.10	0.00	22.81
		Italy	2.80	0.00	8.19
		Nordel	5.67	-	45.57
		PolCzeSlk	1.24	-	2.25
		Switzerland	0.55	-	37.67
		UK_IE	1.69	-	0.44

Table S64.: Net Power Generation per Region [TWh], Fluctuating Renewable Energies

Year	Approach	Region	Run Of River	Wind Onshore	Wind Offshore	Photovoltaic
2020	Static	Austria	15.65	-	5.10	0.01
		BeNeLux	0.76	21.11	24.26	0.10
		Denmark_W	0.03	1.83	19.46	0.00
		France	40.53	0.00	65.31	1.23
		Germany	20.41	15.79	128.04	3.82
		Iberia	26.62	0.02	80.22	39.70
		Italy	37.95	0.00	34.83	3.24
		Nordel	164.11	1.96	23.14	0.00
		PolCzeSlk	7.29	0.16	18.75	0.43
		Switzerland	9.47	-	0.08	1.50
		UK_IE	15.62	19.07	153.98	1.60
2030	Myopic	Austria	15.65	-	5.21	0.01
		BeNeLux	0.76	60.53	24.21	0.07
		Denmark_W	0.03	14.50	19.42	0.00
		France	40.53	0.00	134.70	1.20
		Germany	20.32	215.41	127.64	2.92
		Iberia	26.71	0.00	62.20	107.64
		Italy	37.95	0.00	26.12	38.38
		Nordel	164.10	78.28	19.14	0.00
		PolCzeSlk	7.28	0.00	83.19	0.32
		Switzerland	9.47	-	0.00	1.61
		UK_IE	15.67	69.37	167.25	1.60
	Static	Austria	15.65	-	5.21	0.01
		BeNeLux	0.76	55.27	24.21	0.07
		Denmark_W	0.03	15.24	19.42	0.00
		France	40.53	0.00	145.90	1.20
		Germany	20.34	205.16	127.70	2.93
		Iberia	26.70	0.00	51.49	118.33
		Italy	37.95	0.00	9.11	55.39
		Nordel	164.06	110.41	5.79	0.00
		PolCzeSlk	7.28	0.00	82.30	0.32
		Switzerland	9.47	-	0.00	1.61
		UK_IE	15.69	62.90	167.26	1.60
2050	Myopic	Austria	15.60	-	1.69	12.15
		BeNeLux	0.70	132.36	5.06	0.00
		Denmark_W	0.02	402.97	17.01	0.00
		France	40.08	374.11	83.73	0.00
		Germany	20.27	296.32	17.38	0.00
		Iberia	26.36	138.73	0.00	117.36
		Italy	37.91	0.00	52.75	55.36
		Nordel	152.30	540.98	4.53	0.00
		PolCzeSlk	7.22	0.00	66.74	0.00
		Switzerland	9.41	-	0.00	2.37
		UK_IE	13.66	1010.91	138.18	0.00
	Static	Austria	15.60	-	0.00	12.15
		BeNeLux	0.69	113.94	10.61	0.00
		Denmark_W	0.02	419.12	16.98	0.00
		France	40.00	416.98	58.97	0.00
		Germany	20.26	296.29	0.00	4.76
		Iberia	26.37	126.09	12.35	117.37
		Italy	37.90	0.00	52.74	55.36
		Nordel	151.80	576.72	0.00	0.00
		PolCzeSlk	7.22	44.29	11.36	0.43
		Switzerland	9.41	-	0.00	2.37
		UK_IE	13.68	968.00	139.16	0.00

F.2. Sensitivity Study with Static Approach

Table S65.: Total Installed Capacities [GW], Storage

Year	Scenario	Hydrogen Storage	Pumped Storage	Li-Ion Battery
2020	Base	0.00	34.01	0.32
	CO2PricesHigh	0.00	34.01	0.34
	CO2PricesLow	0.00	34.01	0.09
	DemandHigh	0.00	34.01	0.30
	DemandLow	0.00	34.01	0.00
	FuelPricesHigh	0.00	34.01	0.27
	FuelPricesLow	0.00	34.01	0.33
	InterestRateHigh	0.00	34.01	0.37
	InterestRateLow	0.00	34.01	0.27
	UsableAreaHigh	0.00	34.01	0.40
	UsableAreaLow	0.00	34.01	0.11
2030	Base	0.00	34.01	9.02
	CO2PricesHigh	0.00	34.01	11.22
	CO2PricesLow	0.00	34.01	6.44
	DemandHigh	0.00	34.01	9.19
	DemandLow	0.00	34.01	8.69
	FuelPricesHigh	0.00	34.01	12.06
	FuelPricesLow	0.00	34.01	9.56
	InterestRateHigh	0.00	34.01	10.01
	InterestRateLow	0.00	34.01	9.72
	UsableAreaHigh	0.00	34.01	13.30
	UsableAreaLow	0.00	34.01	8.36
2050	Base	131.44	34.01	33.00
	CO2PricesHigh	153.54	34.01	34.13
	CO2PricesLow	80.73	34.01	30.80
	DemandHigh	159.03	34.01	49.76
	DemandLow	96.09	34.01	26.15
	FuelPricesHigh	157.63	34.01	34.18
	FuelPricesLow	2.46	34.01	33.17
	InterestRateHigh	48.89	34.01	31.09
	InterestRateLow	135.95	34.01	30.81
	UsableAreaHigh	133.08	34.01	58.24
	UsableAreaLow	125.80	34.01	29.06

Table S66.: Total Installed Capacities [GW], Conventional Technologies

Year	Scenario	Nuclear	Coal	Lignite	CCGT	Gas Turbine	IC
2020	Base	120.13	53.02	76.80	159.10	29.78	9.07
	CO2PricesHigh	120.13	53.02	51.50	159.10	33.18	9.07
	CO2PricesLow	120.13	53.02	80.16	159.10	29.53	9.07
	DemandHigh	120.13	53.02	95.45	159.10	31.51	9.07
	DemandLow	120.13	53.02	61.68	159.10	28.09	9.07
	FuelPricesHigh	120.13	53.02	123.90	159.10	26.58	9.07
	FuelPricesLow	120.13	53.02	36.83	159.10	47.39	9.07
	InterestRateHigh	120.13	53.02	53.04	159.10	32.31	9.07
	InterestRateLow	120.13	53.02	91.22	159.10	28.32	9.07
	UsableAreaHigh	120.13	53.02	75.89	159.10	29.91	9.07
	UsableAreaLow	120.13	53.02	78.87	159.10	29.06	9.07
2030	Base	83.55	23.53	75.78	114.98	30.30	3.81
	CO2PricesHigh	83.55	23.53	13.20	135.20	43.45	3.81
	CO2PricesLow	83.55	23.53	122.00	114.98	16.81	3.81
	DemandHigh	83.55	23.53	90.89	114.98	40.22	3.81
	DemandLow	83.55	23.53	60.28	114.98	22.01	3.81
	FuelPricesHigh	115.42	23.53	32.33	114.98	16.94	3.81
	FuelPricesLow	83.55	23.53	13.20	170.78	50.18	3.81
	InterestRateHigh	83.55	23.53	72.32	119.41	52.53	3.81
	InterestRateLow	91.50	23.53	73.01	114.98	15.55	3.81
	UsableAreaHigh	83.55	23.53	79.21	114.98	31.33	3.81
	UsableAreaLow	83.55	23.53	75.72	114.98	32.13	3.81
2050	Base	9.11	5.93	3.92	12.70	80.77	0.00
	CO2PricesHigh	9.48	5.93	3.92	0.00	67.83	0.00
	CO2PricesLow	3.77	5.93	3.92	64.63	98.33	0.00
	DemandHigh	13.47	5.93	3.92	20.87	108.49	0.00
	DemandLow	5.31	5.93	3.92	6.74	57.59	0.00
	FuelPricesHigh	9.36	5.93	3.92	0.00	63.49	0.00
	FuelPricesLow	2.02	5.93	3.92	136.52	136.17	0.00
	InterestRateHigh	2.02	5.93	3.92	85.86	121.70	0.00
	InterestRateLow	48.00	5.93	3.92	0.00	67.10	0.00
	UsableAreaHigh	2.69	5.93	3.92	13.07	76.14	0.00
	UsableAreaLow	10.04	5.93	3.92	12.26	89.47	0.00

Table S67.: Total Installed Capacities [GW], Controllable Renewables

Year	Scenario	Biomass	CSP	Hydro Reservoir
2020	Base	24.07	2.20	56.74
	CO2PricesHigh	24.07	2.20	56.74
	CO2PricesLow	24.07	2.20	56.74
	DemandHigh	24.07	2.20	56.74
	DemandLow	24.07	2.20	56.74
	FuelPricesHigh	24.07	2.20	56.74
	FuelPricesLow	24.07	2.20	56.74
	InterestRateHigh	24.07	2.20	56.74
	InterestRateLow	24.07	2.20	56.74
	UsableAreaHigh	24.07	2.20	56.74
	UsableAreaLow	24.07	2.20	56.74
2030	Base	24.07	2.20	57.57
	CO2PricesHigh	24.07	2.20	57.57
	CO2PricesLow	24.07	2.20	57.57
	DemandHigh	24.07	2.20	57.57
	DemandLow	24.07	2.20	57.57
	FuelPricesHigh	24.07	2.20	57.57
	FuelPricesLow	24.07	2.20	57.57
	InterestRateHigh	24.07	2.20	57.57
	InterestRateLow	24.07	2.20	57.57
	UsableAreaHigh	24.07	2.20	57.57
	UsableAreaLow	24.07	2.20	57.57
2050	Base	24.07	0.00	58.57
	CO2PricesHigh	24.07	0.00	58.57
	CO2PricesLow	24.07	0.00	58.57
	DemandHigh	24.07	0.00	58.57
	DemandLow	24.07	0.00	58.57
	FuelPricesHigh	24.07	0.00	58.57
	FuelPricesLow	24.07	0.00	58.57
	InterestRateHigh	24.07	0.00	58.57
	InterestRateLow	24.07	0.00	58.57
	UsableAreaHigh	24.07	0.00	58.57
	UsableAreaLow	24.07	0.00	58.57

Table S68.: Total Installed Capacities [GW], Fluctuating Renewables

Year	Scenario	Run Of River	Wind Onshore	Wind Offshore	Photovoltaic
2020	Base	105.78	253.87	14.53	41.93
	CO2PricesHigh	105.78	256.74	14.53	41.31
	CO2PricesLow	105.78	250.52	14.53	43.98
	DemandHigh	105.78	257.87	14.55	39.35
	DemandLow	105.78	246.66	14.42	45.76
	FuelPricesHigh	105.78	240.32	14.53	60.33
	FuelPricesLow	105.78	243.41	14.53	35.02
	InterestRateHigh	105.78	259.97	14.53	26.46
	InterestRateLow	105.78	223.92	14.53	79.50
	UsableAreaHigh	105.78	267.59	7.57	41.96
	UsableAreaLow	105.78	226.04	23.71	41.80
	Base	105.78	280.37	110.12	145.91
2030	CO2PricesHigh	105.78	334.64	163.92	145.91
	CO2PricesLow	105.78	242.31	51.79	139.34
	DemandHigh	105.78	307.07	119.07	145.86
	DemandLow	105.78	256.67	99.92	145.83
	FuelPricesHigh	105.78	316.86	167.07	151.46
	FuelPricesLow	105.78	244.70	48.03	145.91
	InterestRateHigh	105.78	250.73	53.68	124.54
	InterestRateLow	105.78	320.98	120.01	148.42
	UsableAreaHigh	105.78	389.20	32.77	158.30
	UsableAreaLow	105.78	277.24	129.33	111.36
2050	Base	105.78	143.58	798.06	157.07
	CO2PricesHigh	105.78	143.67	812.41	156.62
	CO2PricesLow	105.78	145.69	739.28	151.66
	DemandHigh	105.78	201.09	975.86	214.74
	DemandLow	105.78	144.67	572.66	145.07
	FuelPricesHigh	105.78	142.98	813.07	156.62
	FuelPricesLow	105.78	153.18	593.43	145.52
	InterestRateHigh	105.78	125.77	707.55	139.80
	InterestRateLow	105.78	117.47	731.76	156.62
	UsableAreaHigh	105.78	266.88	672.79	274.53
	UsableAreaLow	105.78	140.02	810.49	159.92

F.3. Sensitivity Study with Myopic Approach

Table S69.: Total Installed Capacities [GW], Storage

Year	Scenario	Hydrogen Storage	Pumped Storage	Li-Ion Battery
2030	Base	0.00	34.01	7.37
	CO2PricesHigh	0.00	34.01	8.76
	CO2PricesLow	0.00	34.01	6.38
	DemandHigh	0.00	34.01	7.16
	DemandLow	0.00	34.01	6.73
	FuelPricesHigh	0.00	34.01	0.27
	FuelPricesLow	0.00	34.01	8.59
	InterestRateHigh	0.00	34.01	9.52
	InterestRateLow	0.00	34.01	8.52
	UsableAreaHigh	0.00	34.01	12.51
	UsableAreaLow	0.00	34.01	7.45
2050	Base	133.48	34.01	30.72
	CO2PricesHigh	152.11	34.01	31.99
	CO2PricesLow	71.01	34.01	28.82
	DemandHigh	159.70	34.01	49.39
	DemandLow	94.87	34.01	24.47
	FuelPricesHigh	140.27	34.01	26.04
	FuelPricesLow	2.05	34.01	33.09
	InterestRateHigh	46.91	34.01	31.50
	InterestRateLow	137.83	34.01	31.65
	UsableAreaHigh	130.98	34.01	52.77
	UsableAreaLow	128.48	34.01	27.47

Table S70.: Total Installed Capacities [GW], Conventional Technologies

Year	Scenario	Nuclear	Coal	Lignite	CCGT	Gas Turbine	IC
2030	Base	83.55	23.53	80.95	114.98	28.28	3.81
	CO2PricesHigh	83.55	23.53	40.48	117.28	41.21	3.81
	CO2PricesLow	83.55	23.53	124.04	114.98	17.16	3.81
	DemandHigh	83.55	23.53	98.22	114.98	36.94	3.81
	DemandLow	83.55	23.53	64.91	114.98	22.18	3.81
	FuelPricesHigh	83.55	23.53	112.88	114.98	12.52	3.81
	FuelPricesLow	83.55	23.53	25.81	159.16	51.40	3.81
	InterestRateHigh	83.55	23.53	76.60	116.61	50.60	3.81
	InterestRateLow	83.72	23.53	87.07	114.98	14.26	3.81
	UsableAreaHigh	83.55	23.53	84.63	114.98	26.57	3.81
	UsableAreaLow	83.55	23.53	82.44	114.98	29.28	3.81
2050	Base	7.62	5.93	71.66	12.25	20.75	0.00
	CO2PricesHigh	7.70	5.93	31.19	2.30	46.34	0.00
	CO2PricesLow	3.32	5.93	114.76	44.58	29.14	0.00
	DemandHigh	12.53	5.93	88.93	20.56	31.86	0.00
	DemandLow	4.19	5.93	55.62	7.83	11.85	0.00
	FuelPricesHigh	7.95	5.94	103.60	0.02	0.04	0.02
	FuelPricesLow	2.02	5.93	16.52	138.33	123.28	0.00
	InterestRateHigh	2.02	5.93	67.31	87.22	65.47	0.00
	InterestRateLow	41.52	5.94	77.80	0.04	6.41	0.03
	UsableAreaHigh	2.02	5.93	75.34	14.92	14.96	0.00
	UsableAreaLow	8.62	5.93	73.15	10.90	28.81	0.00

Table S71.: Total Installed Capacities [GW], Controllable Renewables

Year	Scenario	Biomass	CSP	Hydro Reservoir
2030	Base	24.07	2.20	57.57
	CO2PricesHigh	24.07	2.20	57.57
	CO2PricesLow	24.07	2.20	57.57
	DemandHigh	24.07	2.20	57.57
	DemandLow	24.07	2.20	57.57
	FuelPricesHigh	24.07	2.20	57.57
	FuelPricesLow	24.07	2.20	57.57
	InterestRateHigh	24.07	2.20	57.57
	InterestRateLow	24.07	2.20	57.57
	UsableAreaHigh	24.07	2.20	57.57
	UsableAreaLow	24.07	2.20	57.57
2050	Base	24.07	0.00	58.57
	CO2PricesHigh	24.07	0.00	58.57
	CO2PricesLow	24.07	0.00	58.57
	DemandHigh	24.07	0.00	58.57
	DemandLow	24.07	0.00	58.57
	FuelPricesHigh	24.07	0.02	58.57
	FuelPricesLow	24.07	0.00	58.57
	InterestRateHigh	24.07	0.00	58.57
	InterestRateLow	24.07	0.04	58.57
	UsableAreaHigh	24.07	0.00	58.57
	UsableAreaLow	24.07	0.00	58.57

Table S72.: Total Installed Capacities [GW], Fluctuating Renewables

Year	Scenario	Run Of River	Wind Onshore	Wind Offshore	Photovoltaic
2030	Base	105.78	302.23	106.77	123.07
	CO2PricesHigh	105.78	358.84	155.12	123.86
	CO2PricesLow	105.78	258.18	50.07	125.13
	DemandHigh	105.78	315.94	116.41	137.04
	DemandLow	105.78	287.28	97.33	110.05
	FuelPricesHigh	105.78	335.64	157.58	143.22
	FuelPricesLow	105.78	268.98	48.55	116.09
	InterestRateHigh	105.78	273.07	50.07	107.40
	InterestRateLow	105.78	331.41	116.64	147.53
	UsableAreaHigh	105.78	413.52	32.22	124.70
	UsableAreaLow	105.78	285.77	123.90	108.51
2050	Base	105.78	187.55	778.78	151.66
	CO2PricesHigh	105.78	243.63	760.26	151.66
	CO2PricesLow	105.78	150.38	737.43	151.66
	DemandHigh	105.78	221.94	964.99	216.15
	DemandLow	105.78	187.53	549.85	144.35
	FuelPricesHigh	105.78	243.25	751.41	168.91
	FuelPricesLow	105.78	164.05	592.15	144.34
	InterestRateHigh	105.78	146.48	693.62	142.21
	InterestRateLow	105.78	249.20	671.68	151.74
	UsableAreaHigh	105.78	336.70	634.76	270.01
	UsableAreaLow	105.78	199.17	777.15	166.53

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