Supplementary material

Table S1. Tableau of the six selected scenarios and their combinations of descriptor variants (the definitions of all descriptors and their variants can be found in detail in https://elib.uni-stuttgart.de/handle/11682/5710?locale=en)

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•	on market mechanism		more focus on public participation and	· ·	ate/public governance
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	n liberal welfare eleme	-1-	more emphasis on corporatist-statist		liberal welfare elements
		nis	welfare elements		
	ne distribution: and increasing average		income distribution: constant or decreasing inequality and	income distribution: increasing inequality and increasing	income distribution: increasing inequality / continuing weak
	and increasing average		increasing average income	average income	no growth of average income
technology acceptance (energy technologies): decreasing			eptance (energy technologies): Iightly increasing		technology acceptance (energy technologies): decreasing
individual energ	gy consuming behaviou rds non-involvement	r:	individual energy consuming behaviour: trend towards technophily	individual energy consuming trend towards sufficiency	individual energy consuming behavious trend towards non-involvement
	nal development:		educational development:		al development:
strong focus on MIN public attitude towards the energy pu	T/strong limitation on a	eccess e energy transition / NIMBY:	strong focus on MINT/slight limitation on public attitude towards the en	strong focus on MINT/	strong limitation on access public attitude towards the energy
trend towards negative attitude	no tre	nd visible	trend towards pos	sitive attitude	trend towards negative attitude
value orientation and obj	ectives in economic de terialism and performat		value orientation and objectives in trend towards post-materialism		tives in economic development: rialism and performance
media discourse: slight plurality of opinion/ strong trend for t		media discourse: high plurality of opinion/ strong trend for tabloidization	media discourse: high plurality of opinion/ weak trend for tabloidization	media discourse: slight plurality of opinion/ strong trend for tabloidization	media discourse: high plurality of opinion/ strong trend fo tabloidization
	re	duction energy demand - household ap		THE ICT LADIOIUIZATION	reduction energy demand - household
reduction energy demand - PC electric		weak (0.6 % per year) reduction energy demand - PC electric		reduction energy demand - PC	strong (1.3 % per year) reduction energy demand - PC electric
weak (0.8 % per year)		moderate (1.7 % per year)		strong (2.1 % per year)	weak (0.8 % per year)
reduction energy demand - PC reduction	energy demand - PC (0.8 % per year)	reduction energy dema	nd - PC engines (% per year): .55 % per year)	reduction energy deman	d - PC engines (% per year): 8 % per year)
Suong (1.55 % per year) Weak	renovation rate / c	depth - buildings (private):	.55 % per year)	renovation rate / depth - buildings	renovation rate / depth - buildings
	strong	(2 %/yr - 70 %) reduction energy demand - indust	ni.	weak (1 %/yr - 30 %)	strong (2 %/yr - 70 %) reduction energy demand - industry:
		strong (2.3 % per year)			weak (1 % per year)
		reduction energy	demand - commercial sector: (3.4 % per year)		
		expansion district heating:	(V.T /v Per year)		expansion district heating:
investments new vehicle concents and law-	new vehicle sense	strong expansion	investments new vehicle	ente and infractructures:	no change
investments new vehicle concepts and investments small (20% of vehicle market) high (~100	0% of vehicle market)	investments new vehicle concepts moderate (50% of vehicle market)	investments new vehicle conc high (~100% of ve	ehicle market)	investments new vehicle concepts and small (20% of vehicle market)
living trends:			living tren	nds:	living trends: strong increase (60 qm space per head
expansion of rene	(60 qm space per hear wable energies for hear		expansion of renewable energies for heating: expansion of renewable		
strong (4	00 THw per year)		very strong (500 T individual energy demand:	'Hw per year)	weak (250 THw per year)

Details on assessment methods for model-based indicators and overview over indicator targets

The development of the energy demand is to a wide extent constrained by the context scenario (assessment method "CS" in Table S2) and requires only little extra assumptions and modelling. This is in particular true for the final energy productivity of the German economy, the German industry, and small enterprises. In other cases, indicators are pre-constrained by the context scenario. However, a number of other indicators are also rather directly determined by the context, but require extra energy system modelling ("ESM" in Table S2) and/or extra

modelers' assumptions ("MAS") to a larger extent. This includes, e.g., the final energy consumption for space heat of private households, where a simple building stock model is used to translate the context factors "renovation rate of buildings", "renovation depth" of buildings, population development, and development of the average floor space into the energy demand for heating. In the case of the indicator "final energy consumption of the transport sector", the assessment requires modelers' assumptions on, e.g., the split between BEVs/PHEVs on one hand and FCEVs on the other hand. Quantitative values for a last group of indicators cannot easily be traced back to a small number of context descriptors. They are thus regarded as a result of the complex interactions of the energy system model (thus assessment method "ESM" in Table S2).

The different assessment methods in Table S2 cannot always be clearly distinguished—their boundaries are fluid. However, it illustrates well that some sustainability indicators are more directly constrained by the context scenario than other indicators, which require more modelling and/or other input from the modelers' side.

Table S2. Details of assessment methods and target values for the 16 model-based indicators.

Indicator	Assessment Method	Target Value 2050
Energy-related emissions of particulate matter (TSP)	EF	45.6 kt
Energy-related emissions of Cadmium	EF	2.0 t
Energy-related greenhouse gas emissions	EF	207 Mt CO2eq
Energy-related emissions of acid forming gases	EF	690 kt SO2eq
Final energy productivity of the German economy (GDP per FEC)	CS	743 €/GJ
Final energy productivity of the German industry (GVA per FEC)	CS	621 €/GJ
Final energy productivity of small enterprises (GHD) (GVA per FEC)	CS	3251 €/GJ
Final energy consumption in the transport sector	CS+MAS	1521 PJ
Final energy consumption of private households per capita	CS+ESS	17.6 GJ/cap
Installed capacity of renewable energy power plants	CS+MAS+ESM	169 GW
Number of electric vehicles	CS+MAS+ESM	22 Mio
Share of imported energy to primary energy consumption	ESM	43%
Share of renewable energy on gross final energy consumption	ESM	60%
Area under cultivation of energy crops	ESM	1.6 Mio h
Use of primary energy	ESM	7190 PJ
Modal split in the transport sector	MAS	20%

Results (frequency distribution) of non-model-based indicators for all consistent scenarios as a data basis for the definition of targets for those indicators

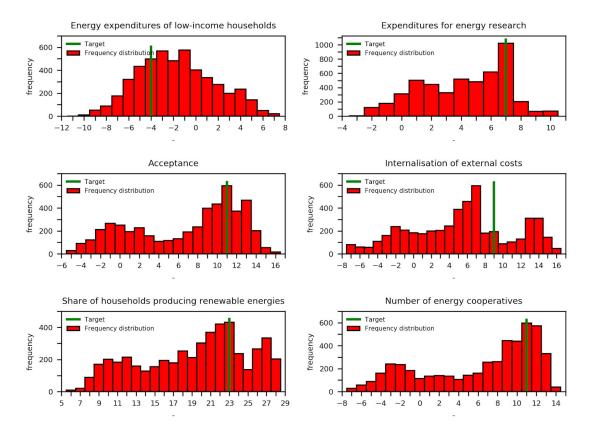


Figure S1. Frequency distribution of the values of all six non-model-based indicators among all consistent scenarios.

Figure S1 shows the frequency distribution of the results for the non-model-based indicators for all consistent scenarios. The green line indicates the target value defined as the 25% or 75% percentile, respectively (see Section 2.5 and Table S3). As explained in the main text, for each non-model-based indicator, a target value was chosen corresponding to the 25% percentile for those indicators where a decrease in the absolute indicator value is desired, and to the 75% percentile for those indicators where an increase in the indicator value is desired. Table S3 gives an overview over non-model-based indicators and the resulting target values.

Table S3. Definition of target-values for non-model-based indicators.

Indicator	Target Percentil e	Target Value
Monthly energy expenditures of households with a monthly net income < 1300€	25%	-4
Federal expenditures for energy research	75%	7
Acceptance of renewable energies in the neighbourhood	75%	11
Degree of internalization of energy-related external costs	75%	9
Share of households producing renewable electricity	75%	23
Number of energy cooperatives engaged in renewable energy plants	75%	11

Additional results for model-based indicators

Table S4. Overview of model-based indicator results: Absolute values (top) and normalized values (bottom). A green color in the bottom table indicates normalized indicator values > 1 (scenario exceeds target), orange cells indicate that the indicator development 2015-2050 is going in the desired direction, but the target is not reached. The red cells indicate where the development between 2015 and 2050 is going in the opposite direction (relative to the target).

Model-based indicators	unit				Value		
Model-based indicators	unit	Target	Inertia	Market	Change	NH3	NH8
model results (absolute values)							
Energy-related emissions of particulate matter (TSP)	kt	29,6	45,7	39,6	34,8	35,0	29,0
Energy-related emissions of cadmium	t	0,77	1,88	1,14	1,03	0,99	1,14
Share of imported energy to primary energy use	%	48%	79%	59%	43%	39%	55%
Final energy consumption of private households per capita	GJ/cap/a	17,6	16,0	17,4	16,1	26,9	17,6
Share of renewable energy on gross final energy consumption	%	65%	33%	51%	74%	80%	56%
Area under cultivation of energy crops	Mio. ha	3,7	3,1	2,2	2,1	2,1	1,9
Use of primary energy	PJ/a	7.274	11.057	8.498	9.078	8.502	7.876
Specific Final Energy Consumption for Space Heat of Households (Temperature Adjusted)	MJ/m2	145	146	146	144	362	146
Final energy consumption in the transport sector	PJ/a	1.411	2.039	1.962	1.565	1.268	1.901
Modal split in the transport sector (share of milage by public transport - trains, trams, busses)	%	23%	21%	21%	26%	24%	21%
Number of electric vehicles	Mio	53,1	11,7	30,9	47,2	52,1	11,7
Final energy productivity of the German economy (GDP per FEC)	€/GJ	851	630	853	891	770	776
Final energy productivity of the German industry (GVA per FEC)	€/GJ	598	344	589	582	591	603
Final energy productivity of small enterprises (GHD) (GVA per FEC)	€/GJ	4.705	5.435	4.554	4.465	4.599	4.742
Energy-related greenhouse gas emissions	Mt CO2eq/a	160	582	243	166	141	227
Energy-related emissions of acid forming gases	kt SO2eq	414	952	726	449	395	683
Installed capacity of renewable energy power plants (w/o import, w/o biogenic waste)	GW	187	118	170	346	318	175
normalised values							
Energy-related emissions of particulate matter (TSP)	%	201%	103%	140%	169%	168%	205%
Energy-related emissions of cadmium	%	161%	90%	138%	145%	147%	137%
Share of imported energy to primary energy use	%	83%	-28%	44%	102%	118%	58%
Final energy consumption of private households per capita	%	107%	122%	109%	121%	21%	107%
Share of renewable energy on gross final energy consumption	%	91%	31%	65%	110%	121%	75%
Area under cultivation of energy crops	%	-254%	-142%	6%	11%	19%	56%
Use of primary energy	%	95%	32%	75%	65%	75%	85%
Specific Final Energy Consumption for Space Heat of Households (Temperature Adjusted)	%	130%	129%	129%	130%	42%	129%
Final energy consumption in the transport sector	%	109%	51%	58%	95%	122%	64%
Number of electric vehicles	%	352%	77%	205%	313%	346%	77%
Final energy productivity of the German economy (GDP per FEC)	%	124%	73%	124%	133%	105%	106%
Final energy productivity of the German industry (GVA per FEC)	%	84%	18%	82%	80%	83%	86%
Final energy productivity of small enterprises (GHD) (GVA per FEC)	%	156%	190%	149%	145%	151%	158%
Energy-related greenhouse gas emissions	%	107%	26%	91%	106%	110%	94%
Energy-related emissions of acid forming gases	%	217%	60%	126%	207%	223%	139%
Installed capacity of renewable energy power plants (w/o import, w/o biogenic waste)	%	125%	29%	102%	351%	311%	109%

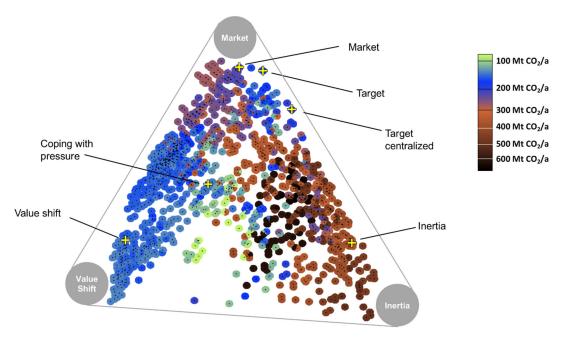


Figure S2. Localizations of the selected scenarios on Pregger et al.'s "landscape of societies".

Impact assessments for indicator "Acceptance of Renewable Energies in the Neighborhood"

This table shows the impacts of all descriptor variants (2 to 4 per descriptor) on the indicator "Acceptance of Renewable Energies in the Neighborhood". The impacts were rated by the expert panel using an integer scale -3 (strongly restricting) to +3 (strongly promoting).

Table S5. Descriptor impacts on the indicator "Acceptance of Renewable Energies in the neighborhood" for different variants of the descriptors used in the scenarios.

Acceptance of Renewable Energies in the Neighborhood					
Global development					
General	Market Forces	Policy Reform	Fortress World	Eco-Communalism	
	0	1	2	2	
Global development					
rice for fossil fuels	Low prices	Moderate growth of prices	Strong growth of prices		
	0	1	2		
J integration	EU Renaissance	Nobody Cares	EU under threat		
	0	0	0		
opulation development	Strongly decreasing	Moderately decreasing	Relatively high population		
	0	0	0		
DP growth	Weak development	Moderate development	Strong development		
	0	0	0		
	Low unemployment / pro-	High unemployment / pro-			
abour market development	worker flexibility	employer flexibility	Division of labour market		
about market development	0	0	0		
ertiarisation of the economy	Weak tertiarisation	Strong tertiarisation			
er dansation of the economy	0	0			
novation capabilities	Decreasing	Constant	Increasing		
	0	0	1		
				1	
		European Germany - focus	-1.1.1		
ransnational trade flows	European Germany	on services	Global Germany	Renationalization	
	0	0	0	0	
ternational power line	Trend national capacity	Trend European power grid	Trend trans-European		
tegration	autarky	/ European autarky	optimization		
	1	0	0		
		•			

Infrastructure expansion of				
power lines	Appropriate expansion	Delayed expansion	Strongly delayed expansion	
power mies	0	0	0	1
				J
Renewable electricity expansion	Weak expansion	Moderate expansion	Strong expansion	_
	0	0	1	
Centralized/decentralized power	-		Conversion to decentralized	
generation and -storage	the central system 0	Hybrid structure 0	system architecture 1]
	Market in charge of security	Providers in charge of	State in charge of security of	
Electricity market regulations	of supply	security of supply	supply	1
	0	0	0	
Energy policy stability	Decreasing policy stability	Constant policy stability	Increasing policy stability	_
	-1	0	1	
Energy policy instruments	Regulatory instruments	Technology-specific economic instruments	Technology-unspecific economic instruments	
Energy policy instruments	0	0	0]
Governance in the field of				
infrastructure expansion	Coordinated expansion	Uncoordinated expansion		
illi asti ucture expansion	0	0	x	
Planning law / public		Focus legitimacy and	Dominance of group	
infrastructure planning	Focus acceleration 0	acceptance 0	interests 0	Compromise 0
	0	0	0	0
		Citizen's participation and		
Political design model	State control	transparency	Market mechanisms	No significant shift
	-1	1	-1	0
		Conservative-corporatist	Social democratic welfare	
Social welfare state design	Liberal welfare state	welfare state	state	7
	0	0	0	
Private income development	Increasing inequality / low income growth	Const decr. inequality /	Increasing inequality / high income growth	Const decr. inequality / high income growth
	0	0	0	0
Acceptance of energy	Dogressins	Constant	Cliabelly in	Strongly is seed in
technologies	Decreasing -2	Constant	Slightly increasing 1	Strongly increasing 3
		·		
Energy consumption behaviour	Trend towards being	Trend towards being	Trend towards being	
(individual)	unconcerned	economical	technology-focused	Trend towards sustainability
	0	0	0	0
	Focus MINT / low access	Focus MINT / strong access	Focus general education /	
Education development	barriers	barriers	low access barriers	
	1	0	-1	
			1	