Appendices

Appendix 1: Calculation Methods

The formulas used in the book are shown and explained below. The value added is the sale of products minus the purchase of resources. It shows deliveries of capital, labour and knowledge in an organisation, excluding purchases of materials, energy and hired labour, formally represented as:

$$V_i = (P_{s,i} - P_{r,i}) \cdot Q_i \tag{A.1}$$

Where 'V_i' is value added in monetary terms; 'P_s' is the sales price; 'P_r' is the resource price; 'Q_i' denotes the quantity of resources in terms of mass; for each resource, purchase prices are multiplied by quantities.

Wherein historical changes are analysed, current prices of consumer goods are converted into the constant prices of a year i.e., real prices. Estimates of constant prices 'p_r' are corrections of current prices with the inflation coefficients 'r' in databases. If uncorrected in the databases, the World Bank inflation rates are used for the most part of price estimates, formally represented as:

$$p_r = p_t / \left(\frac{r}{100} + 1 \right) \tag{A.2}$$

The prices corrected for inflation are expressed in the money value of a particular year; for instance, US_{2011} means prices in US Dollars as per the year 2011. Note that when the annual rate of inflation is high, these corrections are laborious and somewhat arbitrary because they refer to the prices of traded goods rather than the prices of consumer goods on the domestic market.

Changes are called 'growth'. Growth 'g_t' is assumed to be an exponential function of time 't' per year, formally represented as:

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$$g_t = {}^{n_{t+1}}\!/_{n_t} - 1 \tag{A.3}$$

The growth rate '*g*' is often an annual average of several years over a period of time. High growth rates generate large changes within a few years, but a low rate spanning a long period of time also causes large changes; for example, twice the volume is generated in 70 years with 1% growth $(1+0.01)^{70}$; in 36 years with 2% growth; and in 24 years with 3% growth. Herewith, low rates are relevant because long-time spans are assessed.

Trends in the growth rate during a period are called accelerators, '*a*', formally represented as:

$$a_t = {}^{g_{t+1}}\!/_{g_t} - 1 \tag{A.4}$$

A trend above 1 implies acceleration of growth; and below 1 a slow-down. Acceleration over a few subsequent decades is an augmenting trend; whereas, the slow-down over a few decades indicates saturation. For instance, augmenting renewable energy is an acceleration of the growth, but a saturating population means slow-down of the growth.

The trends encompass fluctuations, such as booms and slumps of income. Herewith, the standard deviation 's' is used to indicate the scale of fluctuations. This is formally represented as:

$$\mathrm{s} = \sqrt{\left[{}^{1}\!/_{(N-1)}\right] \cdot \sum_{i=1}^{N} (x_1 - \bar{x})^2} \tag{A.5}$$

It is calculated in Excel. A large standard deviation indicates strong fluctuations. Increasing standard deviation spanning a period of time indicates a diverging trend, and a decreasing one shows a converging trend; for example, divergence in CO_2 emissions per capita across countries and convergences in energy consumption. The standard deviation, when compared to the average, is also used as an indication of the validity of conclusions; when the standard deviation is higher than the average, the validity of conclusion is low. For example, it can be a disputable statement with respect to large fluctuations.

Links between observations are correlated; for example, the changes in income when compared to changes in energy consumption. The Pearson correlation is used because it is a reliable and well-known method that is easy to handle in Excel by the interested public. A regression is formally represented as:

$$R^2(x,y) = {}^{\sum (x-\bar{x})\cdot(y-\bar{y})}\!\Big/_{\sqrt{\sum (x-\bar{x})^2 \cdot \sum (y-\bar{y})^2}} \tag{A.6}$$

For example, '*x*', is the annual average growth of income and, '*y*', is the annual average growth of energy consumption during a period. Herewith, a stringent criterium is used because regressions equal to and above 0.8 ($R^2 \geq 0.8$) are considered correlated, and between 0.5 and 0.8 moderately correlated but lower are assumed uncorrelated.

A mainstream assumption is that higher prices reduce demands. The price elasticities of demand refer to the effects of price changes on demand changes; for instance, the effect of higher prices of energy resources on the consumed volume of energy. The mid-price elasticities are calculated and formally represented as:

$$k = \frac{p_{i+1} - p_i}{(p_{i+1} + p_i)/2} / \frac{q_{i+1} - q_i}{(q_{i+1} + q_i)/2} \tag{A.7}$$

For $p_i = \sum_i^n p_t / n$, also for q_i; $p_{i+1} - p_i$ is price change, $q_{i+1} - q_i$ volume change

In energy, low price elasticity 'e' is usually assumed ($e > -1$), meaning that an increase of the unit price causes less than a unit consumption decrease. The income elasticity is estimated in a similar way for the incomes instead of prices. In energy, income elasticity above +1 is usually assumed; it means that a unit of additional income causes more than a unit of additional consumption.

The energy-efficiencies of conversions usually increase over time, called the effect-increasing technical change. It is expressed in percentage annual change, formally represented as:

$$k_t = k_0 a^t \tag{A.8}$$

Herewith, 'k_t' is the effect due to the change; 'k_0' the initial effect; 'a' the coefficient of the effect-increasing technical change usually assumed due to know-how and scale of activities over time 't', usually in years.

The costs of technologies often decrease over time. This cost-reducing technical change is expressed in a percentage average change of unit cost per year, formally represented as:

$c_t = c_0 a^t$

The unit cost, 'c', also called 'marginal cost', is total cost divided by volume in a year. A popular measurement is the unit costs per double output, formally shown as:

$$c_t = c_0 \left(\frac{o_t}{o_0} \right)^b \tag{A.9}$$

Wherein 'c_t' denotes the unit cost in year t; 'c_0' the unit cost in base year; 'o_t' the output in year t; 'o_0' output in the base year; and 'b' the inclination of the curve that reflects the cost-reducing technical change. The cost reduction is measured by half-time, which is the time needed for the reduction of unit costs by half; it is $c_t/c_0 = 0.5$.

This is much used to estimate the increases in the required scale of the production, given the cost reducing technical change.

In engineering, the effect-increasing change is often used to indicate changes in energy efficiency; and in economics, the cost-reducing changes are used to indicate impacts of technological changes on prices. These two are often combined and called 'technological learning'; whilst the effect-increasing technical change always reduces some costs, the cost changes may not influence the effect when cheaper resources are used without further effect.

The conventional indicator of business performance is profitability. This is estimated with the Net Present Value (NPV). Firstly, the Present value is calculated followed by the Net Present Value:

$$PV_t = \sum_{t=1}^{n} \mathrm{C}/(1 + r/b)^{bt} \tag{A.10}$$

For example, if 1 million USD is invested (also called the outgoing cash flow) 'I' and 1 million USD of income is generated per year during two years (also called the incoming cash flow) 'C' at 10% interest 'r', the NPV is:

1st year $1/(100\%+10\%)^1 = 0.91$
2nd year $1/(100\%+10\%)^2 = 0.83$ million Euro
PV = 1.74
$NPV = PV - I$
NPV is 1.74−1 = + 0.74

Positive NPV indicates potentially profitable investment, negative NPV a loss. When several investments over time are done, they should be discounted much in the same way as the income. If alternative proposals with different timelines are compared, the present value of average annual cash flows are estimated called the 'uniform annual stream' (UAS), 'equivalent annual cost' (EAC), 'present value annuity', or suchlike names. These terms are often used to express annual capital costs of investments. It is calculated as the present value or net present value divided by the annuity factor. The annuity factor A_t is the sum of the discount factors over time, and the uniform annual streams (UAS) is NPV (or PV for nil investment) divided by A_t:

$A_t = \sum_t^n 1/(100\% + r)^t$
$UAS = {}^{NPV}\!/_{A_t}$

Based on the above: $A_t = (100\% + 10\%)^1 + (100\% + 10\%)^2] = 1.1 + 2.21 = 3.31$
UAS = 0.74/3.31 = 0.22 average profit a year.

Appendix 2: Countries Income and Energy

Table A.1 covers: countries' GDP and energy production per capita in the years 1900 and 2000; as well as the annual average growth in ten-year intervals based on the average of the preceding ten years, and correlations between GDP and TWh production in these countries. Highlighted in bold are the net exporters of energy, being larger producers than consumers.

Table A.1 Countries' income and energy indicators; () means negative number

Data Excluding a Few Extremes in the 1900s	GDP USD/cap in 2000	Energy kWh/Cap in 2000	USD/ kWh in 1900 or Earliest	USD/ kWh in 2000	1900–1950 growth	1960–2000 growth	Correl GDP: TWh
1. Argentina	14,918	28,673	46	0.5	−7%	−3%	0.33
2. Australia	36,001	170,035	0.4	0.2	1%	−3%	(0.07)
3. Austria	35,714	19,109	0.1	1.9	3%	3%	0.87
4. Belgium	33,427	14,192	0.2	2.4	0.4%	4%	0.74
5. Bolivia	2984	17,084	43	0.2	−11%	−4%	0.51
6. Brazil	8316	12,905	35	0.6	−6%	−2%	0.20
7. Bulgaria	8671	14,097	11.1	0.6	−6%	1%	0.37
8. Canada	37,446	174,462	0.4	0.2	−0.5%	−1%	0.09
9. Chile	10,903	6422	1.2	1.7	−1%	1%	0.37
10. China	2460	16,288	10	0.2	−6%	−2%	0.69
11. Colombia	6860	25,115	0.8	0.3	−2%	−1%	0.47
12. Cuba	4882	3888	83	1.3	−4%	−7%	0.15
13. Czech & Slovakia	16,153	29,050	0.4	0.6	−1%	2%	0.69
14. Denmark	35,923	63,797	4.3	0.6	17%	−3%	0.86
15. Germany	33,975	18,114	0.3	1.9	−1%	4%	0.86
16. Egypt	5269	13,824	35	0.4	−7%	−3%	0.59
17. Finland	32,972	25,424	3.1	1.3	−3%	−0.1%	0.29
18. France	31,771	24,628	0.6	1.3	−0.2%	2%	0.64
19. Ghana	2337	1054	1.7	2.2			N.A.
20. Greece	23,138	10,111	71	2.3	−4%	−3%	0.42
21. Hungary	14,757	11,279	0.3	1.3	−0.3%	3%	0.41
22. India	2003	3083	5.1	0.6	−2%	−2%	0.74
23. Indonesia	3472	12,312	3.6	0.3	−3%	−1%	0.70
24. Iran	7573	53,767	2.1	0.1	−6%	−0.04%	(0.04)
25. Iraq	3147	55,066	3.6	0.1	−13%	1%	0.41
26. Ireland	39,152	2902	21	13	−7%	6%	0.94
27. Italy	33,185	6185	27	5.4	−6%	3%	0.63
28. Jamaica	5342	561	100	9.5	−9%	−1%	0.11
29. Japan	33,294	9574	0.8	3.5	−1%	4%	0.94
30. Jordan	3896	662	16	5.9		−5%	(1.00)

(continued)

Table A.1 (continued)

Data Excluding a Few Extremes in the 1900s	GDP USD/cap in 2000	Energy kWh/Cap in 2000	USD/ kWh in 1900 or Earliest	USD/ kWh in 2000	1900–1950 growth	1960–2000 growth	Correl GDP: TWh
31. Korea	22,930	13,491	25	1.7	−7%	2%	0.78
32. Lebanon	11,232	536	36	21	−4%	−0.2%	0.09
33. Mexico	11,338	29,254	2.9	0.4	−3%	−0.2%	(0.55)
34. Morocco	4580	165	34	28	−9%	3%	0.18
35. Myanmar	999	2890	1.1	0.3	6%	−5%	0.25
36. Netherlands	39,923	49,412	5	0.8	−4%	1%	(0.16)
37. New Zealand	25,868	49,389	1.0	0.5	0%	−1%	0.63
38. Norway	54,594	672,999	7.1	0.1	−9%	−3%	0.72
39. Peru	4777	5326	1.2	0.9	−2%	1%	(0.15)
40. Philippines	4187	1301	91	3.2	−3%	−2%	0.89
41. Poland	13,207	20,743	0.2	0.6	−1%	3%	0.71
42. Portugal	21,497	4054	90	5.3	−7%	1%	0.71
43. Romania	7430	15,116	0.9	0.5	−5%	4%	0.02
44. Saudi Arabia	20,129	330,486	3.0	0.1	−20%	1%	0.44
45. South Africa	8478	38,859	0.4	0.2	−0.1%	−1%	0.34
46. CIS	11,532	50,627	1.2	0.2	−2%	−1%	(0.20)
47. Spain	26,424	10,284	3.2	2.6	−2%	2%	0.90
48. Sri Lanka	4391	499	29	8.8		−2%	0.85
49. Sweden	36,374	67,085	7.9	0.5	−4%	−1%	0.46
50. Switzerland	42,752	24,985	1.3	1.7	−1%	1%	0.40
51. Syria	4946	23,334	40	0.2		−11%	0.34
52. Taiwan	31,937	13,080	3.3	2.4	−5%	5%	0.89
53. Thailand	6921	7836	131	0.9		−9%	(0.23)
54. Tunisia	8440	7925	32	1.1		−6%	N.A.
55. Turkey	11,830	4493	5.6	2.6	−3%	2%	0.33
56. United Kingdom	23,696	45,814	0.1	0.5	2%	1%	0.35
57. United States of America	45,887	71,283	0.2	0.6	1%	2%	0.29
58. Uruguay	6269	8929	2.9	0.7	3%	−3%	0.66
59. Venezuela	7927	100,449	5.8	0.1	−12%	3%	0.42
60. Vietnam	2792	29,030	6.8	0.1	−2%	−6%	0.49
61. Yugoslavia	15,524	13,359	3.1	1.2	−3%	1%	0.44
World Total	10,814	27,751	0.4	0.4	−1%	0.5%	0.24

Appendix 3: Success Rates of Innovations in EU (Table A.2)

Table A.2 Rates of successful innovation processes across the EU countries in all sectors (ALL) and in the broadened renewable energy sector (RES+)

Assumed USD_{2010} 0.5 million /R&D project	ALL: all firms				RES+			
		Development performance	Diffusion performance			Development performance	Diffusion performance	
	Number of R&D projects	Patent/R&D projects	Survivor / Birth firms	Success rate of R&D	Number of R&D projects	Patent/R&D projects	Survivor / Birth firms	Success rate of R&D
EU	699,209	8%	10%	1%	9931	18%	74%	13%
Belgium	22,787	6%	44%	2%	356	9%	93%	8%
Bulgaria	715	3%	20%	1%	8	21%	59%	12%
Czech	6940	4%	25%	1%	85	6%	122%	8%
Denmark	19,693	6%	11%	1%	322	53%	−3%	−2%
Germany	203,003	12%	−8%	−1%	1834	39%	68%	27%
Estonia	746	5%	18%	1%	53	3%	−13%	−0%
Ireland	7391	5%	50%	2%	92	11%	116%	13%
Greece	3982	2%	−18%	−0%	10	35%	33%	11%
Spain	35,281	4%	−11%	−0%	295	28%	249%	69%
France	118,989	8%	36%	3%	2626	10%	81%	8%
Croatia	950	N.A.	−8%	N.A.	22	N.A.	40%	N.A.
Italy	53,879	8%	−9%	−1%	982	10%	107%	11%
Cyprus	228	4%	−26%	−1%	N.A.	N.A.	74%	N.A.
Latvia	342	4%	27%	1%	N.A.	N.A.	57%	N.A.
Lithuania	784	3%	21%	1%	15	N.A.	50%	N.A.
Luxembourg	1634	5%	30%	1%	N.A.	N.A.	73%	N.A.
Hungary	3361	6%	−4%	−0%	142	2%	31%	1%
Malta	136	8%	15%	1%	N.A.	N.A.	73%	N.A.
Netherlands	31,850	9%	27%	3%	438	16%	35%	6%
Austria	23,731	8%	2%	0%	304	15%	42%	6%
Poland	8465	5%	11%	1%	174	7%	29%	2%

(continued)

Table A.2 (continued)

Assumed USD_{2010} 0.5 million /R&D project	ALL: all firms				RES+			
		Development performance	Diffusion performance			Development performance	Diffusion performance	
	Number of R&D projects	Patent/R&D projects	Survivor / Birth firms	Success rate of R&D	Number of R&D projects	Patent/R&D projects	Survivor / Birth firms	Success rate of R&D
Portugal	6371	2%	−8%	−0%	12	46%	86%	39%
Romania	1759	3%	33%	1%	66	3%	37%	1%
Slovenia	2088	5%	23%	1%	111	1.5%	76%	1%
Slovakia	1430	3%	27%	1%	41	5%	83%	5%
Finland	17,145	8%	8%	1%	551	7%	64%	4%
Sweden	35,035	7%	29%	2%	363	13%	180%	23%
United Kingdom	90,490	47%	15%	7%	1022	100%	61%	61%

Table A.3 Carbon intensity, carbon performance and carbon efficiency in the EU

	Carbon intensity in tonne CO_2 per capita		Carbon performance in €$_{2010}$ per kg		Carbon efficiency in kg CO_2 / kWh	
	2018	Growth 2008–2018	2018	Growth 2008–2018	2018	Growth 2008–2018
EU28	5.5	−1.9%			0.15	−1.1%
Belgium	6.8	−2.3%	10.7	−1.4%	0.12	−1.0%
Bulgaria	5.8	−2.4%			0.18	−1.8%
Czechia	8.1	−1.3%	5.3	−3.5%	0.17	−1.4%
Denmark	11.8	−2.0%	7.1	−2.9%	0.33	−1.0%
Germany	7.5	−2.7%	9.0	−2.2%	0.17	−0.6%
Estonia	13.0	−1.5%	2.5	−1.6%	0.24	−1.0%
Ireland	8.9	0.8%			0.25	4.2%
Greece	5.5	2.7%	5.3	−0.5%	0.21	−1.3%
Spain	4.6	−3.6%			0.14	−1.5%
France	3.4	−2.3%			0.08	−1.3%
Croatia	3.1	−2.3%			0.13	−2.0%
Italy	4.2	−2.8%			0.14	−2.2%
Cyprus	6.9	−3.8%			0.20	−1.3%
Latvia	4.0	−3.1%	5.8	−0.5%	0.14	−1.1%
Lithuania	5.0	0.5%			0.15	3.2%
Luxembourg	12.6	2.2%	21.5	−4.9%	0.15	0.8%
Hungary	3.8	−1.7%	7.0	−2.8%	0.12	−1.5%
Malta	7.4	−1.3%			0.36	2.2%
Netherlands	8.5	−0.7%			0.16	−0.1%
Austria	5.5	−1.1%			0.12	−1.0%
Poland	7.8	−1.7%			0.24	−0.8%
Portugal	4.2	0.1%			0.15	−0.9%
Romania	3.2	−1.2%			0.16	−2.4%
Slovenia	6.2	−3.2%			0.16	0.0%
Slovakia	5.5	−1.7%			0.15	−0.7%
Finland	8.0	−1.5%	8.8	−3.2%	0.11	−1.7%
Sweden	3.8	−2.2%	21.5	−.26%	0.07	−1.9%
Un. Kingdom	4.6	−2.5%			0.01	0.7%

Appendix 4: Checklist Possible Benefits

Possible benefits of energy services with renewable resources in the literature

	Producers' attributes	Consumers' attributes
Individual	• Resource diversification Local resources can be identified and utilized (NREL, 1997; Resch et al., 2008; EPA, 2011) Financial risks in resource purchase can be spread (Awerbuch, 2004; Adamec et al., 2011) • Management Congestion on grid can be relieved with flexible production (EPA, 2011; Richter, 2012; Eyer & Corey, 2010; Castillo & Gayme, 2014; Burger & Luke, 2016) Attention for stability of voltage is invoked (Eyer & Corey 2010; Adamec, 2011; EPA, 2011; Richter, 2012; Castillo & Gayme, 2014) Back up and reserves can expand to reduce power losses (Schiermeier et al., 2008; EPA, 2011; Richter, 2012; Castillo & Gayme, 2014; Siao, 2014; Bronski et al., 2015) Lower peak costs when production is more flexible (Eyer & Corey, 2010; EPA, 2011; Richter, 2012; Busch & McCormick, 2014; Neubauer & Simpson, 2015) • Marketing Price volatility is mitigated when renewables are add-on (Awerbuch, 2004; Adamec et al., 2011; EPA, 2011) Certification of the sustainability performance can reduce regulation (Schiermeier et al., 2008; Richter, 2012) Branding of renewable energy enables new tariffs (Adamec et al., 2011) Flat rate fee due to renewables add-on is easier to manage (Schleicher-Tappeser, 2012) Diverse renewable energy justifies the dynamic pricing (Schleicher-Tappeser, 2012; Eid et al., 2016) • Change of current Distributed systems foster cheaper supply of direct current (Pepermans et al., 2003) Cheaper low voltage infrastructure is possible (Levin & Thomas, 2016)	• Prices Monopoly price of suppliers are mitigated (Pepermans et al., 2003; Schleicher-Tappeser, 2012; Eid et al., 2016) Peaks in supplies can be stored in appliances (Adamec et al., 2011; Neubauer & Simpson, 2015) Pricing can be based on local nodes rather than generic (Schleicher-Tappeser, 2012) Charges on the decreasing demands can be avoided (Richter, 2012) • Volume Electricity from waste heat can be generated (Pepermans et al., 2003; Rismanchi, 2017) Incentive to reduce peaks are easier to introduce (Tuballa & Abundo, 2016) Appliance can be integrated into a system (Adamec et al., 2011; Tuballa & Abundo, 2016) Consumption of energy can be better monitored (Adamec et al., 2011) Individual and collective autonomy increase (NREL, 1997; Pepermans et al., 2003; Richter, 2012; Siao, 2014; Eid et al., 2016)

(continued)

	Producers' attributes	Consumers' attributes
Collective	• Mitigation of impacts External effects on environment are reduced NREL, 1997; Schiermeier et al., 2008; EPA, 2011; Eller & Gauntlett, 2017) Import dependency is reduced (Resch et al., 2008; Eller & Gauntlett, 2017) • Local stakeholders Local constructors' capabilities are developed (NREL, 1997) Local business in electricity storage is generated (Schiermeier et al., 2008; EPA, 2011; Eller & Gauntlett, 2017) Polluted land and wasteland can be used (Busch & McCormick, 2014) Wasted energy can be recovered (EPA, 2011; Rismanchi, 2017) Use of renewable resources can be optimised (Rismanchi, 2017) Large-scale, costly investment can be deferred (Adamec et al., 2011; EPA, 2011; Bronski et al., 2015; Burger & Luke, 2016) Energy consumption in the remote areas is enhances (Eller & Gauntlett, 2017)	• Economy Larger local income in generated (Richter, 2012; Busch & McCormick, 2014) More local jobs are created (NREL, 1997; Busch & McCormick, 2014) Higher and more stable tax income is generated (NREL, 1997; Busch & McCormick, 2014) Better regional image attracts business (Richter, 2012; Busch & McCormick, 2014) Diversification enables price stability (Busch & McCormick, 2014) Diversification reduces investment peaks (Busch & McCormick, 2014 • Social interest Cumulative benefits are generated (Adamec et al., 2011) Isolated consumers can be better served (Akinyele & Rayudu, 2014) Social capabilities increase (Busch & McCormick, 2014) Services can be tuned to demands in communities (Tuballa & Abundo, 2016)

Appendix 5: Carbon Intensity, Performance, Efficiency

Table 1 Carbon intensity, carbon performance and carbon efficiency in the EU

	Carbon intensity in tonne CO_2 per capita		Carbon performance in €$_{2010}$ per kg		Carbon efficiency in kg CO_2 / kWh	
	2018	Growth 2008-2018	2018	Growth 2008-2018	2018	Growth 2008-2018
EU28	5.5	-1.9%			0.15	-1.1%
Belgium	6.8	-2.3%	10.7	-1.4%	0.12	-1.0%
Bulgaria	5.8	-2.4%			0.18	-1.8%
Czechia	8.1	-1.3%	5.3	-3.5%	0.17	-1.4%
Denmark	11.8	-2.0%	7.1	-2.9%	0.33	-1.0%
Germany	7.5	-2.7%	9.0	-2.2%	0.17	-0.6%
Estonia	13.0	-1.5%	2.5	-1.6%	0.24	-1.0%
Ireland	8.9	0.8%			0.25	4.2%
Greece	5.5	2.7%	5.3	-0.5%	0.21	-1.3%
Spain	4.6	-3.6%			0.14	-1.5%
France	3.4	-2.3%			0.08	-1.3%
Croatia	3.1	-2.3%			0.13	-2.0%
Italy	4.2	-2.8%			0.14	-2.2%
Cyprus	6.9	-3.8%			0.20	-1.3%
Latvia	4.0	-3.1%	5.8	-0.5%	0.14	-1.1%
Lithuania	5.0	0.5%			0.15	3.2%
Luxembourg	12.6	2.2%	21.5	-4.9%	0.15	0.8%
Hungary	3.8	-1.7%	7.0	-2.8%	0.12	-1.5%
Malta	7.4	-1.3%			0.36	2.2%
Netherlands	8.5	-0.7%			0.16	-0.1%
Austria	5.5	-1.1%			0.12	-1.0%
Poland	7.8	-1.7%			0.24	-0.8%
Portugal	4.2	0.1%			0.15	-0.9%
Romania	3.2	-1.2%			0.16	-2.4%
Slovenia	6.2	-3.2%			0.16	0.0%
Slovakia	5.5	-1.7%			0.15	-0.7%
Finland	8.0	-1.5%	8.8	-3.2%	0.11	-1.7%
Sweden	3.8	-2.2%	21.5	-.26%	0.07	-1.9%
Un. Kingdom	4.6	-2.5%			0.01	0.7%

Table A.3 shows the carbon intensity, carbon performance, and carbon efficiency in the EU28 member countries. Totals in 2018 and annual average growth during 2008–2018 are shown.

Appendix 6: Inputs and Outputs of Hydrogen Production

Data for the Hydrogen Production

Impacts of hydrogen for coal substitution on CO_2 emission reduction and costs in USD_{2019} are estimated. Tables show energy and emission coefficients, input-output data, substitution, emission reduction and cost of four technologies:

1. Steam Methane Reforming with Water Gas Shift (SMR + WGS), about 97% of global production
2. Steam Methane Reforming with Water Gas Shift and Carbon Capture and Storage (SMR + WGS + CCS)
3. Methane Pyrolysis (MP) in the pilot stage
4. Electrolysis of water (EL), about 3% of global production (up to kWh 50–55 per kg H_2) (Tables A.4, A.5, A.6 and A.7).

Table A.4 Assumed coefficients for the estimates

per kg H_2	kWh/kg	CO_2 kg/kWh	CO_2 kg/kg
Hydrogen	33	0	0
Natural gas	14	0.2	2.6
Coal (bisemous)	7	0.3	2.3

Table A.5 Shows input–output data based on the Wikipedia

kWh, kg, TWh, million tonnes	SMR +WGS	SMR+WHG – CCS	Methane Pyrolysis	Electrolysis
Inputs				
Heat kWh	5.7	5.7	5.2	0
Electra kWh	0	0	0	39.4
Methane kg	2.2	2.9	4.4	0
Water kg	4.9	3.3	0	9.1
Outputs				
H_2 kg	1	1	1	1
CO_2 kg	6.0	1.5	0	0
CO_2 storage kg	0	3.6	0	0
O_2 kg	0	0	0	8.0
Carbon kg	0	0	3.3	0
Energy kWh				
In	36	45	65	39
Out	33	33	33	33
Out-In	−2	−12	−32	−6

Table A.6 CO_2 emission reduction due to those substitutions in kg/kg H_2

Coal reduction	11.7	11.7	11.7	11.7
Net CO_2 reduction	5.7	10.2	11.7	11.7
CO_2 equivalent oil	8.5	8.5	8.5	8.5
Net CO_2 reduction	2.5	7.0	8.5	8.5
CO_2 equivalent gas	7	7	7	7
Net CO_2 reduction	1.0	5.5	7.0	7.0

Table A.7 Costs and emission reduction (all costs in USD_{2019})

Electra	0.2	0.2	0.2	1.5
Power gas	0.4	0.4	0.7	0
CCS	0.0	0.5	0	0
Total	0.6	1.1	0.9	1.5
Cost-effectiveness estimates				
CO_2 reduction for coal	49%	87%	100%	100%
Cost-effect USD_{2019}/tonne	103	106	80	128
CO_2 reduction for gas	14%	78%	100%	100%
Cost-effect USD_{2019}/tonne	606	198	135	215

Appendix 7: Indicators of the Valorisation

Table A.8 shows the purchasing power per capita in 2015, and its growth based on the World Bank data. The countries with more accessible energy due to income growth and declining disparities are shown bold. Income disparities within countries are shown with Gini coefficients in the years of the earliest estimate in the database and in 2015. Gini coefficients indicate division of income in ten equal income classes indexed from 0 to 1; 0 being no income difference and 1 the maximum difference in two categories: extremely poor and rich. Although the Gini coefficients are criticised because not cover all countries and wealth groups, do not consider the division between wages and capital, do not specify the highest few percent of income which covers a large part of all income; yet, they are widely used.

Table A.9 shows the energy indicators in 2015, and the average growth in the period from 1990 to 2015; the growth rates during 1990–2005 and 2005–2015 are also estimated, and discussed below; they are not presented in this table. The indicators are: energy performance, energy and electricity consumption, shares of renewable energy and modern renewable energy in energy consumption.

Table A.8 Incomes per capita: annual average growth and disparities

	GDP-PPP		Gini coefficients	
Bold: growing accessibility	USD per capita	Growth 1990–2015	Earliest found	2015
World	15,694	**4.4%**	N.A.	N.A.
USA	56,469	**3.5%**	38	41
Japan	40,607	**3.0%**	32	–
EU	38,447	**3.9%**	N.A.	N.A.
Russia	24,692	**5.5%**	48	**38**
Mexico	16,983	**4.6%**	50	**46**
Brazil	15,617	**3.8%**	61	**51**
China	14,450	**11.5%**	43	**42**
Indonesia	11,040	**5.5%**	40	–
Philippines	7320	**4.2%**	N.A.	N.A.
India	6127	**7.0%**	35	–
Nigeria	6038	**4.9%**	45	**43**
Pakistan	5000	**3.8%**	33	34
Bangladesh	3336	**5.7%**	28	32
Ethiopia	1633	**5.6%**	45	**39**

Table A.9 Indicators for assessing valorisation of energy consumption: energy performance, energy and electricity consumption, share of all renewable energy and modern renewable energy in 2015 and annual average growth

	Energy performance		Energy consumption		Electricity consumption		Share renewables in consumption		Share modern renewables in consumption	
	USD/ kWh	Growth	kWh/ cap	Growth	kWh/ capita	Growth	Share	Growth of share	Share	Growth of share
Growth is annual average during 1990–2015	2015	1990–2015	2015	1990–2015	2015	1990–2015	2015	1990– 2015	2015	1990– 2015
World	0.7	1.6%	21,642	0.5%	3052	1.1%	14%	0.2%	1.5%	5.2%
USA	0.2	0.2%	79,107	−0.4%	12,833	0.9%	7%	1.1%	1.4%	2.8%
Japan	0.9	1.0%	39,359	−0.2%	7864	0.8%	6%	2.5%	1.5%	3.2%
EU	0.9	1.7%	36,205	−0.4%	5968	1.0%	14%	4.6%	2.9%	11.7%
Russia	0.4	1.4%	57,278	−0.7%	6588	0.7%	3%	0.2%	0.0%	12.1%
Mexico	0.9	1.1%	17,974	0.3%	2231	2.4%	8%	−1.3%	2.2%	−1.5%
Brazil	0.9	−0.3%	16,606	1.7%	2506	0.5%	41%	−0.6%	0.9%	18.3%
China	0.5	4.7%	25,218	4.3%	4047	4.2%	9%	−3.8%	1.6%	31.6%
Indonesia	1.0	1.5%	10,176	1.9%	823	4.8%	33%	−1.3%	7.7%	5.5%
Philippines	1.1	1.9%	6061	0.5%	749	2.5%	59%	−1.9%	18.4%	0.4%
India	0.7	2.3%	7550	2.5%	859	2.2%	25%	−2.4%	0.6%	24.0%
Nigeria	0.6	2.1%	8898	0.4%	144	1.9%	80%	0.1%	0.0%	0.0%
Pakistan	0.8	0.86%	5781	0.89%	488	1.4%	38%	−0.9%	0.1%	0.0%
Bangladesh	1.1	0.9%	2738	2.7%	326	5.1%	25%	−3.1%	0.0%	0.0%
Ethiopia	0.3	3.3%	5850	0.2%	86	5.3%	94%	−0.1%	0.0%	−3.1%

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