List of Figures

Figure 1 : Demand 1999 and the High Efficiency Model. Six Supply scenarios with difference dependence from imports (Imported Fuels). Scenarios 2,4 and 6 assume a decomposition of Japan	erent creased
population of Japan.	Page 2
Figure 2 : Overview of the ERJ Scenarios showing primary energy supply and the share production. Scenarios 2.4 and 6 assume a decreased population of Japan.	e of domestic
Eiguro 2 :	Page 3
The figure 5°. The figures show the dynamics of electricity generation for 2 weeks of the year system always produces enough electricity to cover the demand. If there is low production of windenergy and photovoltaics at the same time, pumped storag guarantee full supply (see days 14, 18, 19 and 271).	rr. The supply- w electricity es get used to
Figure 4 :	Page 4
Final energy demand per sector in Japan in 1999. Source: EDMC.	Page 16
Figure 5 : Final anargy domand in Japan par soctor in 1000	-
Thiar chergy demand in Japan per sector in 1999	Page 17
Figure 6 : Changes in energy intensity of major industries in Japan 1973 – 1998	Page 18
Figure 7 : Final energy demand per industrial sub-sector 1999 and <i>ERJ Demand Model</i>	Page 32
Figure 8 : Residential final energy demand in 1999	Dec. 22
Figure 9 : Final residential energy demand 1999 and <i>ERJ Demand Model</i> in PJ	Page 33
E' 10	Page 36
Commercial energy demand in 1999	Page 36
Figure 11 : Commercial final energy demand comparison	D 20
Figure 12 :	Page 39
Passenger transport 1999	Page 40
Figure 13 : Freight transport 1999	
	Page 40

Figure 14 : The Greenpeace "SMILE" car. The car is based on a series-production vehicl Aerodynamic modifications, weight reduction and the implementation of a hi combustion-engine allowed to half fuel consumption while maintaining the c	le. igh efficient ars power and
performance.	Page 42
Figure 15 : Transport energy reductions 1999 and <i>ERJ Demand Model</i>	Page 13
Figure 16 : Final energy demand, 1999 and the <i>ERJ Demand Model</i>	1 uge +5
Figure 17 : Population projections, Japan 1950 to 2050	Page 44
Figure 18 :	Page 45
Map of Japan	Page 47
The optimisation of installed capacities in the <i>ERJ Supply Model</i>	Page 49
Figure 20 : Structure of the <i>ERJ Model</i>	Page 52
Figure 21 : Kiyomino Solar Settlement (Japan); Source : Hakushin Corporation, Saitama	1 age 52
Figure 22 : Solar radiation in the different regions of <i>ERJ Supply Model</i> Scenario One a	Page 53 as average
values for the year 1999 (in kWh per m ²)	Page 55
Installed area of solar cells in the different regions of Scenario One	Page 56
Figure 24 : The Kyocera Headquarters, which is self sufficient in energy.	Page 57
Figure 25 : High efficiency solar thermal vacuum collector systems; Source : Paradigma, Ritter Energie und Umwelttechnik, Karlsbad, Germany	U
Figure 26 :	Page 58
Figure 27 ·	Page 59
Yearly electricity demand in the residential, commercial and industrial sector regions in the <i>ERJ Supply Model</i>	rs of different
	Page 60

Figure 28 : Installed wind power in the different regions of Scenario One	
instance while power in the unreferit regions of Scenario One	Page 62
Figure 29 : Installed geothermal power plants in the different regions of Scenario One	Page 64
Figure 30 : The use of cogeneration plants in the <i>ERJ Supply Models</i> (storage and solar sy shown)	stems are also
	Page 67
Electrical power of industrial cogeneration in the different regions of Scenari	o One Page 68
Figure 32 : Electrical and thermal power of cogeneration in the residential and commerc the different regions of Japan in Scenario One	ial sectors in
Eisung 22 .	Page 69
The Kramer Junction "SEGS" solar-thermal power plants	Page 70
Figure 34 : Overview of the <i>ERJ Scenarios</i> showing primary energy supply and the shar production	re of domestic
Figure 25 ·	Page 76
Horns Rev in Denmark	D 70
Figure 36 :	Page 79
An ORC power plant; Source :Turboden, Brescia, Italy.	Page 80
Horns Rev in Denmark	
Figure 38 :	Page 82
Domestic energy production in all "Energy-Rich Japan" scenarios. This is the electricity and heat in the installed power plants. Biomass is set to zero. Susta produced biomass holds enormous potential, but the amount available was un time of publication of this study.	production of ainably hknown at the
	Page 85
Figure 41 : Parabolic reflectors producing electricity used for hydrogen production	Page 87
Figure 42 : Schematic diagram of the MAN hydrogen bus	-
Eisung 42	Page 89
The 12 regions of the ERJ Electrical System Model	
	Page 93

Figure 44 : Analysis of annual demand in Tohoku East showing daily fluctuations	Page 04
Figure 45 : Examples of hourly demand curves	rage 94
Figure 46 :	Page 94
Three wind turbine power curves	Page 96
Figure 47 : The maximum power output of hydropower plants in Kanto.	Daga 00
Figure 48 :	rage 99
Energy supply and demand over one week in January in gigawatts. The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower	nd and the
Figure 40 ·	Page 104
Energy supply and demand in Hokkaido West over one week in January in C figure shows the energy supply by different technologies, the total demand a of electrical surplus in hydrogen or pumped hydropower	bigawatts.The nd the storage
Figure 50 ·	Page 105
Energy supply and demand in Kanto over one week in January in Gigawatts, shows the energy supply by different technologies, the total demand and the electrical surplus in hydrogen or pumped hydropower	. The figure storage of
	Page 106
Figure 51 : Energy supply and demand in Chugoku over one week in January in Gigawatts. The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower	
Elemen 50	Page 107
Duration of overproduction of electricity in Japan	
Figure 53 :	Page 110
Projected Japanese final energy demand according to the standard (1999) and Demand Model	d the ERJ
Figure 54 :	Page 112
Domestic energy production in all "Energy-Rich Japan" scenarios	Page 114
Figure 55 : ERJ supply and demand in GigaWatts, showing the first week in January and September in Scenario One	l third week in
Eisure 56	Page 115
Power output of several wind turbines computed for different spatial resoluti ISUSI	ons. Source:
	Page 135

Figure 57 : Daily load curves for households in Japan in summer. Source: ISEP	
Figure 58 :	Page 139
Daily load curves for industry in Japan in summer. Source: ISEP	Page 139
Figure 59 : Daily load curves for commerce and service sector in Japan in summer. Sou	rce: ISEP Page 140
Figure 60 : Annual load curves of various energy-consumption sectors on an absolute ar scale. Source: ISEP	nd a normalized
Figure 61 ·	Page 140
Comparison of a season change with and without adjustment. Source: ISUS	I Page 143
Figure 62 : Effects of random fluctuations on the curves. Source: ISUSI	Page 144
Figure 63 : The input dialog of a consumer module. The total consumption, the weekend variation are entered here. The annual load curve is also entered on this page curves are entered on the 'Daily envelopes' page. Source: ISUSI	l factor, and the The daily load
Figure 64 : Dialog of the import-export manager. The lengths and numbers of lines com subregions can be entered here. The import-export manager calculates an en distribution matrix with the minimum transmission losses from this information ISUSI	Page 145 necting the nergy tion. Source:
Figure 65 : Dialog for a photovoltaic module. Various surfaces with differing alignment connected to the same weather station, can be entered here. In addition, the r information on the position of the module and its efficiency. More than one inclination and declination ("Inclination" and "Adjustment") with solar arra sizes can be set. The setting "Radiation input is diffuse/direct" means that the meteorological data are available divided into diffuse and direct radiation, in "Calculate radiation from global", where these data must be computed from irradiance. The "number of the weatherstation" identifies the set of meteoro pertaining to the module. Source: ISUSI	Page 147 s, that are all nodule requires angle of ys of different ne n contrast to the global logical data Page 150
Figure 66 : Typical output curves of wind turbines Source: ISUSI	
	Page 151

Pagure 71 : Dialog for a geothermal power plant. Input of rated capacity and the thermal a efficiencies. Source: ISUSI gure 72 : Dialog for a pumped-storage power plant. The input parameters are the maxim level at the start of the simulation run, and the efficiency. In addition, the maxim	
gure 71 : Dialog for a geothermal power plant. Input of rated capacity and the thermal a efficiencies. Source: ISUSI gure 72 : Dialog for a pumped-storage power plant. The input parameters are the maxim level at the start of the simulation run, and the efficiency. In addition, the maxim	Page 156
Pagure 72 : Dialog for a pumped-storage power plant. The input parameters are the maxim level at the start of the simulation run, and the efficiency. In addition, the maxim	and electrical
Dialog for a pumped-storage power plant. The input parameters are the maxim	Page 157
and available capacities can be specified. The momentary level is an output pa Source: ISUSI	num level, the mum storable arameter.
P	Page 157
gure 73 : Representation of a selection of the results of SimRen within the simulation er Source: ISUSI	nvironment.
Pa	Page 159
Test of photovoltaic module: Comparison of simulated with measured values. Spangardt (1999).	Source:
P	Page 160
gure 75 : Energy supply of Japan in the 3rd week of the year. Source: ERJ.	
P	Page 166

Figure 68 : Dialog for CHP plant in the household and industrial sectors. The times of day and target temperatures for daytime and nighttime heating can be entered here, for example ("Day heating begins ... and ends ...", "Starting temperature", "Target temperature"), as well as the thermal and electrical efficiency. What rated capacity per square metre is installed is entered in "thermal power rating per qm". This value, multiplied by the "Covered qm", gives the total rated capacity of the CHP plant module. The field "Minimum minutes of operation" can be used to specify the shortest time the installation will run after being switched on, in order to avoid constant switching on and off. This block does not require any information on the set of meteorological data, since the temperatures are passed on to the CHP plant module from a separate meteorological data module. Source: ISUSI

Typical dialog for a group of wind turbines. The number of wind turbines, the height of their hubs, and the roughness of the surroundings can be entered. Some information from the adjacent weather station is also required. Thus each wind turbine can have its own set of meteorological data assigned to it, which is given in the field "Number of the weatherstation". Source: ISUSI

Figure 67 :

efficiencies can be specified. Nothing more is needed to calculate the output. Source: ISUSI

Figure 70 : Dial

Figure 69 :

Figure

Dial

Figure

Dial

Figure

Repr Sour

Figure

Test

Figure

Page 152

Page 154

Page 155

Dialog for CHP plants in industry. Here, the rated capacity and thermal and electrical

effici

Figure 76 : Energy supply of the Hokkaido West region of the Japanese energy model i of the year. Source: ERJ.	n the 3rd week
	Page 167
Energy supply of the Kanto region of the Japanese energy model in the 3rd year. Source: ERJ.	week of the
Figure 78 ·	Page 168
Energy supply of the Chugoku region of the Japanese energy model in the 3 year. Source: ERJ.	3rd week of the
Figure 70 ·	Page 169
Energy supply of Japan in the 35th week of the year. Source: ERJ.	Page 170
Figure 80 :	
Energy supply of a model region, including coal-fired and gas-fired power p ERJ.	plants. Source:
	Page 171
Figure 81 : Energy supply of a model region, including coal and gas power. Source: EF	RJ. Page 172
Figure 82 :	1
The figure shows the energy supply by different technologies, the total dem storage of electrical surplus in hydrogen or pumped hydropower in Week 1.	and and the . Source: ERJ. Page 177
Figure 83 : The figure shows the energy supply by different technologies, the total dem storage of electrical surplus in hydrogen or pumped hydropower in Week 2.	and and the Source: ERJ. Page 178
Figure 84 : The figure shows the energy supply by different technologies, the total dem storage of electrical surplus in hydrogen or pumped hydropower in Week 3.	and and the Source: ERJ. Page 179
Figure 85 : The figure shows the energy supply by different technologies, the total dem storage of electrical surplus in hydrogen or pumped hydropower in Week 4.	and and the Source: ERJ.
Figure 86 : The figure shows the energy supply by different technologies, the total dem	and and the
storage of electrical surplus in hydrogen or pumped hydropower in Week 5	. Source: ERJ. Page 181
Figure 87 : The figure shows the energy supply by different technologies, the total dem storage of electrical surplus in hydrogen or pumped hydropower in Week 6	and and the Source: ERJ. Page 182
Figure 88 : The figure shows the energy supply by different technologies, the total dem storage of electrical surplus in hydrogen or pumped hydropower in Week 7.	and and the Source: ERJ. Page 183

Figure 89 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 8. Source: ERJ. Page 184 Figure 90 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 9. Source: ERJ. Page 185 Figure 91 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 10. Source: ERJ. Page 186 Figure 92 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 11. Source: ERJ. Page 187 Figure 93 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 12. Source: ERJ. Page 188 Figure 94 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 13. Source: ERJ. Page 189 Figure 95 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 14. Source: ERJ. Page 190 Figure 96 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 15. Source: ERJ. Page 191 Figure 97 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 16. Source: ERJ. Page 192 Figure 98 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 17. Source: ERJ. Page 193 Figure 99 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 18. Source: ERJ. Page 194 Figure 100 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 19. Source: ERJ.

Page 195

Figure 101 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 20. Source: ERJ. Page 196 Figure 102 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 21. Source: ERJ. Page 197 Figure 103 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 22. Source: ERJ. Page 198 Figure 104 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 23. Source: ERJ. Page 199 Figure 105 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 24. Source: ERJ. Page 200 Figure 106 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 25. Source: ERJ. Page 201 Figure 107 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 26. Source: ERJ. Page 202 Figure 108 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 27. Source: ERJ. Page 203 Figure 109 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 28. Source: ERJ. Page 204 Figure 110 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 29. Source: ERJ. Page 205 Figure 111 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 30. Source: ERJ. Page 206 Figure 112 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 31. Source: ERJ.

Page 207

Figure 113 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 32. Source: ERJ. Page 208 Figure 114 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 33. Source: ERJ. Page 209 Figure 115 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 34. Source: ERJ. Page 210 Figure 116 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 35. Source: ERJ. Page 211 Figure 117 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 36. Source: ERJ. Page 212 Figure 118 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 37. Source: ERJ. Page 213 Figure 119 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 38. Source: ERJ. Page 214 Figure 120 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 39. Source: ERJ. Page 215 Figure 121 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 40. Source: ERJ. Page 216 Figure 122 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 41. Source: ERJ. Page 217 Figure 123 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 42. Source: ERJ. Page 218 Figure 124 : The figure shows the energy supply by different technologies, the total demand and the storage of electrical surplus in hydrogen or pumped hydropower in Week 43. Source: ERJ. Page 219

Figure 125 :	
The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower in Week 44	and and the . Source: ERJ. Page 220
Figure 126 :	
The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower in Week 45	and and the . Source: ERJ. Page 221
Figure 127 :	
The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower in Week 46	and and the . Source: ERJ. Page 222
Figure 128 :	
The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower in Week 47	and and the . Source: ERJ. Page 223
Figure 129 :	
The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower in Week 48	and and the . Source: ERJ. Page 224
Figure 130 :	
The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower in Week 49	and and the . Source: ERJ. Page 225
Figure 131 :	-
The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower in Week 50	and and the . Source: ERJ. Page 226
Figure 132 :	
The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower in Week 51	and and the . Source: ERJ. Page 227
Figure 133 :	
The figure shows the energy supply by different technologies, the total dema storage of electrical surplus in hydrogen or pumped hydropower in Week 52	and and the . Source: ERJ. Page 228
Figure 134 :	1 450 220
Percentage of nominal output of Hydropower in Hokkaido East.	
	Page 229
Figure 135 :	C
Percentage of nominal output of Hydropower in Hokkaido West.	
	Page 230
Figure 136 :	
Percentage of nominal output of Hydropower in Tohoku East.	D 001
Eigung 127	Page 231
Figure 15/ : Percentage of nominal output of Hydronower in Toboky West	
r creentage or nominal output or rryuropower in ronoku west.	

Figure 138 : Percentage of nominal output of Hydropower in Kanto.	
	Page 233
Figure 139 : Percentage of nominal output of Hydropower in Chubu.	Page 234
Figure 140 : Percentage of nominal output of Hydropower in Hokuriku.	Daga 225
Figure 141 : Percentage of nominal output of Hydropower in Kansai.	rage 255
Figure 142 :	Page 236
Percentage of nominal output of Hydropower in Shikiku.	Page 237
Figure 143 : Percentage of nominal output of Hydropower in Chugoku	U
Eisere 144	Page 238
Pigure 144 : Percentage of nominal output of Hydropower in Kyushu South.	Page 230
Figure 145 :	1 age 237
Percentage of nominal output of Hydropower in Kyushu North.	Page 240