Case studies

(update, June 2005)

Final Report of Work Phase 6
of the project

– a research project within the
Altener Program of the European Commission, DG TREN –

Contract No.: Altener contract 4.1030/Z/02-094

Authors:

Mario Ragwitz, Anselm Brakhage – ISI
Lukas Kranzl, Michael Stadler, Claus Huber, Reinhard Haas – EEG
Elena Tsioliaridou – DUTh
Jacky Pett, Pedro Gürtler – ACE
Kaj Joergensen – RISOE
Arkadiusz Figorski, Adam Gula, Elzbieta Gula, Beata Sliz, Artur Wyrwa – AGH

The **Invert** project:

Research project within the Altener Program of the European Commission, DG TREN

Duration: May 2003 – April 2005

Co-ordination: EEG - Energy Economics Group, Institute of Power Systems and Energy Economics, Vienna University of Technology, Austria;

Project partners:

- RISOE - Risoe National Laboratory, Denmark
- ACE – Association for Conservation of Energy, United Kingdom
- AGH – University of Science and Technology, Poland
- CEETA – Centro de Estudos em Economia da Energia, dos Transportes e do Ambiente, Portugal
- DUTh – Demokritos University of Thrace, Greece
- FEWE – Polish Foundation for Energy Efficiency, Poland
- FhG-ISI – Fraunhofer Institute for Systems and Innovation Research, Germany

Contact/Information: web-site: www.invert.at or directly by contacting one of the project partners

Imprint:

Energy Economics Group (EEG), Institute of Power Systems and Energy Economics, Vienna University of Technology.

Gusshausstrasse 25-29 / 373-2, A-1040 Vienna, Austria

Printed in Austria – June 2005

CONTENT

Page

FIGURES VIII

Tables XVII

0 Introduction 1

0.1 The project *Invert* 1

0.2 General remarks 2

0.2.1 Cumulated promotion scheme efficiency (CPSE) and lifetime promotion efficiency (LPSE) 3

0.2.2 Energy price development 5

0.2.3 Payback time 6

1 Germany – Baden Württemberg 7

1.1 Structure of the energy supply 7

1.1.1 Primary Energy Demand and End Energy Consumption 7

1.1.2 Power generation 7

1.1.3 Combined heat and power generation 8

1.1.4 Heating sector 9

1.1.5 Renewables 9

1.2 Promotion schemes 10

1.2.1 Energy Policy 10

1.2.2 Existing promotion schemes 11

1.2.3 Regulations by law 12

1.3 Reference Scenario 12

1.3.1 Essential Assumptions 12

1.3.2 Characteristics of Reference Scenario 13
1.3.3 Total effects of all existing promotion schemes 17
1.3.4 Sensitivity analysis: energy price... 18
1.4 Analysis of hypotheses.. 21
1.4.1 Hypothesis H1: Simultaneous support for RES and conventional heating systems 21
1.4.2 Hypothesis H2: Global versus local optimum 24
1.4.3 Hypothesis H3: Waste of money due to tax exemption of biofuels 26
1.4.4 Hypothesis H4: Heat pumps promotion too low........................ 27
1.4.5 Hypothesis H5: Promotion of heating grids is insufficient.......... 29
1.4.6 Hypothesis H6: Top priority for reducing energy demand 30
1.4.7 Hypothesis H7: Effects of a CO_2 tax.. 32
1.5 References 34

2 Austria – Vienna 36

2.1 Structure of the energy supply.. 36
2.1.1 Primary Energy Demand and End Energy Consumption 36
2.1.2 Heat and power generation 36
2.1.3 Heating sector 37
2.1.4 Renewables... 38
2.2 Promotion schemes in Vienna.. 39
2.3 Reference Scenario... 40
2.3.1 Essential Assumptions 40
2.3.2 Characteristics of Reference Scenario 40
2.3.3 Total effects of all existing promotion schemes 44
2.3.4 Sensitivity analysis: energy price... 45
2.4 Analysis of hypotheses... 48

2.4.1 Hypothesis H1: Restriction of RES&RUE subsidies to buildings without access to district heating is not efficient 49
2.4.2 Hypothesis H2: Subsidy for gas condensing boilers are not justified 54
2.4.3 Hypothesis H3: current tariff structure of district heating does not provide enough incentives for demand side measures 57
2.4.4 Hypothesis H4: Comparison of various level of DSM-subsidies 60
2.4.5 Hypothesis H5: FIT for PV on national level is not sufficient, additional PV subsidy from Vienna is necessary; 62
2.4.6 Scenario: introduction of CO_2-tax 63
2.4.7 Hypothesis H7: Current subsidy for solar thermal systems insufficient 66
2.4.8 Conclusion soft barriers.. 67
2.4.9 Conclusion: Comparison of various measures for further CO_2-reductions.. 67
2.5 References.. 68

3 Poland - Jordanow 70

3.1 The Gminas of Jordanów and Bystra Sidzina........................... 70
3.2 Promotion schemes in Poland.. 72
3.2.1 National Fund for Environmental Protection and Water Management 72
3.2.2 The Voivodeship Fund for Environmental Protection in Krakow 72
3.2.3 Thermal Modernisation Act.. 73
3.2.4 Ekofundusz (EcoFund).. 74
3.2.5 Green Energy Purchase Obligation Ordinance 75
3.2.6 Bank of Environmental Protection 75
3.3 Reference scenario 75
3.3.1 Essential Assumptions 75
3.3.2 Characteristics of reference scenario 76

3.3.3 Sensitivity analysis: energy price 78

3.4 Analysis of Hypotheses for Jordanów 80

3.4.1 Hypothesis 1: Subsidy to conversion from (fossil) fuel to biomass vs subsidies to DSM - aspect of replacement of windows 80

3.4.2 Hypothesis 2: Subsidy to conversion from (fossil) fuel to biomass vs subsidies to DSM – aspect of increase of biomass price 84

3.4.3 Hypothesis 3: Subsidy to conversion from (fossil) fuel to biomass vs subsidies to DSM – aspect of CO_2 tax 86

3.4.4 Hypothesis 4: Pushing small biomass boilers (400,000 project) 90

3.5 Conclusions and recommendations 97

3.6 References 98

4 Greece – Crete 100

4.1 Structure of the energy supply in Crete 100

4.1.1 Primary Energy Demand and End Energy Consumption 100

4.1.2 Power generation 101

4.1.3 Combined heat power generation 102

4.1.4 Heating sector 102

4.1.5 Renewable Energy Sources (RES) 103

4.2 Promotion schemes in Crete 104

4.2.1 Energy Policy 104

4.2.2 Existing promotion schemes 104

4.2.3 Regulations by law 106

4.3 Reference Scenario 106

4.3.1 Essential Assumptions 106

4.3.2 Characteristics of Reference Scenario 107

4.3.3 Total effects of all existing promotion schemes 112

4.3.4 Sensitivity analysis: energy price 113

4.4 Analysis of hypotheses 115

4.4.1 Hypothesis H1: Simultaneous support for wood central and wood single systems ... 115
4.4.2 Hypothesis H2: Support of small scale solar thermal systems 117
4.4.3 Hypothesis H3: DSM measures ... 119
4.4.4 Hypothesis H4: Raise of promotion on biomass (agricultural residues) ... 121
4.4.5 Hypothesis H5: Promotion on Pumped Storage Units (PSU) .. 123
4.4.6 Hypothesis H6: Raise of promotion on solar thermal Power plant ... 125
4.4.7 Hypothesis H7: Higher investment subsidies on Photovoltaic systems ... 127
4.4.8 Hypothesis H8: Higher investment subsidies on small hydro systems ... 127
4.4.9 Hypothesis H9: Higher investment subsidies on wind onshore systems ... 128
4.4.10 Hypothesis H10: Feed in tariffs ... 129
4.4.11 Hypothesis H11: CO_2 tax ... 131
4.5 Conclusions & Recommendations ... 134
4.5.1 Building sector ... 134
4.5.2 Electricity sector ... 135
4.6 References ... 136

5 Denmark ... 137

5.1 Characteristics of the energy sector ... 137
5.1.1 Primary energy demand and end energy consumption ... 137
5.1.2 Heat and power generation ... 137
5.1.3 Dwelling stock and heating ... 138
5.1.4 Renewable energies ... 138
5.2 Promotion schemes in Denmark ... 139
5.2.1 Framework - targets, political agreements etc. ... 139

5.2.2 Financial/economical instruments 140
5.2.3 Regulatory instruments 142
5.2.4 Labelling, auditing, voluntary agreements etc. 142
5.3 Reference Scenario 142
5.4 Analysis of hypotheses 143
5.4.1 General remarks and general conceptual framework of the case studies 143
5.4.2 Hypothesis H1: CO_2 taxation 145
5.4.3 Hypothesis H2: Building RUE promotion subsidies 146
5.4.4 Hypothesis H3: Bio-fuels for transport 147
5.5 Conclusions 148
5.6 References 149

6 UK – Cornwall 151

6.1 Structure of the energy supply 151
6.1.1 Primary Energy Demand and End Energy Consumption 151
6.1.2 Heat and power generation 152
6.1.3 Heating sector 152
6.1.4 Renewables 153
6.2 Promotion schemes 154
6.2.1 Reference Scenario 157
6.3 Hypotheses 162
6.4 Conclusions & Recommendations 162
6.5 References 163

7 French illustration example on solar thermal systems 164

8 Appendix 169

8.1 Append. Germany, Baden Württemberg 169
8.1.1 Basic Data 169
8.1.2 Existing Promotion schemes (Federal and State level) 170
8.1.3 Technology Input Data 175
8.1.4 Building stock 178
8.1.5 Energy price series 179
8.2 App. Vienna 180
8.2.1 Technology input data 180
8.2.2 Building stock 184
8.3 App. Poland 185
8.3.1 Basic Data 185
8.4 App. Crete 191
8.4.1 Basic Data 191
8.4.2 Promotion schemes in Crete 192

FIGURES

Page

Figure 0-1: Promotion efficiency; possible constellations....................................4

Figure 1-1: Primary Energy Demand Baden Württemberg, 2002 7

Figure 1-2: Power generation Baden Württemberg 2000......................................8

Figure 1-3: Heating systems Baden Württemberg 2003 9

Figure 1-4: Gross power generation from renewables in Baden Württemberg 2002 10

Figure 1-5: Use of renewables in Baden Württemberg 2002 10

Figure1-6: Development of heating systems (reference scenario: with existing promotion schemes) 14

Figure1-7: Development of heating systems (without any promotion)..................14

Figure1-8: Development of DHW systems (reference scenario: with existing promotion schemes) 15

Figure1-9: Development of DHW systems (without any promotion) 15

Figure1-10: Development of DSM measures (reference scenario: with existing promotion schemes) 16

Figure1-11: Annual biofuel request 17

Figure1-12: delta transfer costs, delta CO_2 emissions and lifetime promotion efficiency for existing promoltion schemes (reference scenario).........18

Figure 1-13: Sensitivity of CO_2 emissions towards energy price increase...............19

Figure 1-14: Sensitivity of solar thermal uptake towards energy price increase......20

Figure 1-15: Sensitivity of wood heating uptake towards energy price increase 20

Figure 1-16: Sensitivity of final energy demand reduction towards energy price increase..21

Figure1-17: Number of heating systems without promotion for conventional heating systems (H1_1)...22

Figure1-18: Number of heating systems without promotion for RES systems (H1_2) 23

Figure1-19: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_1: without promotion for fossil fuel based heating systems) 23

Figure1-20: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_2: without RES promotion). 24

Figure 1-21: Number of wood heating systems (H2) Cumulated promotion efficiency (H2) 25

Figure1-22: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H2: removal of additional state promotion) 25

Figure 1-23: Biofuel request on tax reduction (H3) 27

Figure 1-24: Number of heat pump systems (H4) 28

Figure1-25: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H4: heat pump subsidy) 28

Figure 1-26: Number of heat distr. heat systems (H5) 30

Figure 1-27: Useful heat energy demand (H6) depending on DSM promotion level31

Figure 1-28: Promotion efficiency depending on promotion level (H6) 32

Figure 1-29: Delta transfer costs, Delta CO_2 emissions and lifetime promotion efficiency (H7) for different CO_2 tax levels 33

Figure 1-30: Additional public income vs. entire transfer costs for heating systems for different CO_2 tax levels 33

Figure 2-1: Final energy demand Vienna, 2002 36

Figure 2-2: District heating generation in Vienna, 2003 37

Figure 2-3: Share of energy carriers on the final energy consumption for heating 38

Figure 2-4: Energy carriers for heating, reference scenario Vienna 41

Figure 2-5: Development of gas heating technologies, reference scenario Vienna 41

Figure 2-6: Energy carriers for DHW, reference scenario Vienna......................... 42

Figure 2-7: Useful and final energy demand for heating, reference scenario Vienna 43

Figure 2-8: Reduction of CO_2-emissions due to insulation and window replacement, reference scenario Vienna 43

Figure 2-9: Change in CO_2-emissions for DSM, heating and DHW, reference scenario Vienna 44

Figure 2-10: Transfer costs for DSM, heating and DHW, reference scenario Vienna 44

Figure 2-11: Promotion scheme efficiency for DSM, heating and DHW, reference scenario Vienna 45

Figure 2-12: Sensitivity of CO_2 reduction towards energy price increase 46

Figure 2-13: Sensitivity of final energy demand reduction towards energy price increase 47

Figure 2-14: Sensitivity of solar thermal uptake towards energy price increase 48

Figure 2-15: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_1: solar thermal subsidy also in the district heating area)) 50

Figure 2-16: Energy carriers for heating, H1-2, Vienna 51

Figure 2-17: Promotion scheme efficiency, H1-2, Vienna 51

Figure 2-18: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_2: biomass subsidy also in the district heating area)) 52

Figure 2-19: Development of gas heating systems, H1-3, Vienna 53

Figure 2-20: Promotion scheme efficiency for heating, H1-3, Vienna 53

Figure 2-21: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_3: gas condensing subsidy also in the district heating area)) 54

Figure 2-22: Energy carriers for heating, H2, Vienna 55

Figure 2-23: Promotion scheme efficiency, H2, Vienna 56

Figure 2-24: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H2: no gas condensing subsidy) 57

Figure 2-25: Energy carriers for heating, H3, Vienna 58

Figure 2-26: Reduction of final energy demand due to change of tariff structure district heating 59

Figure 2-27: Transfer costs and CO_2-emissions, H3, Vienna...... 59

Figure 2-28: Final energy demand heating and DHW, DSM, Vienna 60

Figure 2-29: CO_2-emissions heating and DHW, DSM, Vienna 61

Figure 2-30: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (changing the level of DSM subsidy)...... 61

Figure 2-31: PV electricity generation, Vienna 62

Figure 2-32: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (changing the level of PV subsidy) 63

Figure 2-33: CO_2-reduction due to CO_2-tax, Vienna...... 64

Figure 2-34: Energy carriers for heating, CO_2-tax, Vienna...... 64

Figure 2-35: Transfer costs and public income due to CO_2-tax, Vienna 65

Figure 2-36: Impact of various levels of CO_2-tax on final energy demand, Vienna . 65

Figure 2-37: Impact of various levels of CO_2-tax on CO_2-reduction, Vienna 66

Figure 2-38: Promotion scheme efficiency and CO_2-reduction potential of various measures for CO_2-reduction, Vienna 68

Figure 3-1: Reduction in CO_2 emissions due to DSM 76

Figure 3-2: Number of buildings with new (additional) insulation and windows..... 77

Figure 3-3: Fossil fuels demand in the region...... 77

Figure3-4: Coal and wood demand in the region 78

Figure3-5: Sensitivity of CO_2 reduction towards energy price increase (for reference scenario)...... 79

Figure3-6: Sensitivity of final energy demand towards energy price increase (for reference scenario) ... 79

Figure 3-7: Reduction in CO_2 emissions due to DSM without windows replacement. ... 81

Figure 3-8: Number of buildings with new (additional) insulation and windows ... 82

Figure 3-9: Fossil fuels demand in the region ... 82

Figure 3-10: Coal and wood demand in the region ... 83

Figure3-11: DSM measures including replacement of windows vs. DSM measures with no window replacement with subsidies both to RES and DSM ... 83

Figure3-12: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES ... 84

Figure3-13: Comparison of effectiveness of promotions schemes with and without additional increase of biomass price ... 85

Figure3-14: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 1 % biomass price increase ... 85

Figure3-15: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 2 % biomass price increase ... 86

Figure 3-16: Comparison of effectiveness of promotions schemes with CO_2 tax ... 87

Figure3-17: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 10 €/t CO_2 tax ... 87

Figure3-18: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 20 €/t CO_2 tax ... 88

Figure3-19: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 30 €/t CO_2 tax ... 88

Figure 3-20: Additional public income vs. entire transfer costs for 30 % subsidy to DSM&RES ... 89

Figure 3-21: Fuels demand in the region – scenario with 10€/tCO_2 tax ... 89

Figure 3-22: Fuels demand in the region – scenario with 20€/tCO_2 tax ... 90

Figure 3-23: Fuels demand in the region – scenario with 30€/tCO_2 tax ... 90

Figure3-24: Installation of biomass boilers under the assumption of subsidy levels of 40 % of the investment costs 92

Figure3-25: Installation of biomass boilers under the assumption of subsidy levels of 20 % of the investment costs 93

Figure3-26: Impact of subsidies to straw 2004-2020........ 94

Figure3-27: Impact of subsidies to straw vs. wind 95

Figure3-28: Subsidies to straw – number of coal-to-straw conversions 95

Figure3-29: Subsidies to straw vs wind – delta CO_2 emission 96

Figure3-30: Subsidies to straw vs wind – gradient CO_2 96

Figure 4-1 Distribution of energy consumption per sector........ 100

Figure 4-2 Kind of fuels and the energy form used on the island........ 101

Figure 4-3 Distribution of power energy production per kind of fuel........ 101

Figure 4-4: Final energy demand for Heating (GWh/yr) in residential buildings .. 102

Figure 4-5 Final energy demand for DHW (GWh/yr) in dwellings 103

Figure 4-6 Distribution of RES in electricity production 103

Figure 4-7: Number of heating systems........ 107

Figure 4-8: Overview/Summary - Number of dwellings (DHW)........ 108

Figure 4-9: Overview/Summary - Number of cooling systems 108

Figure 4-10: Overview/Summary – useful energy demand eating 109

Figure 4-11: Single family house (SFH) - Number of buildings with new (or additional) insulation 109

Figure 4-12 Electricity output from RES-E plants [GWh/yr]........ 110

Figure 4-13 Decrease in CO_2-emissions due to RES-E generation (compared to conventional plants) [kton CO_2/yr] (with schemes) 111

Figure 4-14 Sewage gas - Total electricity / heat output from RES-CHP plants [GWh/yr] 111

Figure 4-15: Total decrease in CO_2-emissions (compared to conventional plants) [kton- CO_2/yr] 112

Figure 4-16: Total transfer costs (m€/yr)....112

Figure 4-17: RES-E - Cumulated promotion scheme efficiency [kg CO_2/€]....113

Figure 4-18: RES-CHP - Cumulated promotion scheme efficiency [kg CO_2/€]....113

Figure 4-19: Sensitivity of final energy demand reduction towards energy price increase....114

Figure 4-20: Sensitivity of Delta CO_2 reduction towards energy price increase vs reference scenario....114

Figure 4-21: Number of dwellings with solarthermal systems....115

Figure 4-22: MFH – reference scenario....116

Figure 4-23 MFH – with promotion on wood central....116

Figure 4-24: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_1: with promotion on wood, heating systems)....117

Figure 4-25 Number of dwellings –DHW- with promotion on solar thermal....118

Figure 4-26: Number of dwellings – DHW- reference scenario....118

Figure 4-27: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H2_1: with promotion on solar thermal, heating systems)....118

Figure 4-28 Number of buildings with new (or additional) floor insulation....120

Figure 4-29 Heating+DSM - Cumulated promotion scheme efficiency [kg CO_2/€] – only floor insulation....120

Figure 4-30 Number of buildings with new (or additional) ceiling insulation....120

Figure 4-31 Heating+DSM - Cumulated promotion scheme efficiency [kg CO_2/€] – only ceiling insulation....121

Figure 4-32 Number of buildings with new (or additional) wall insulation....121

Figure 4-33 Heating+DSM - CPSE [kg CO_2/€] – only wall insulation....121

Figure 4-34: Total electricity output (GWh/yr) from RES-E- reference scenario....122

Figure 4-35: Total electricity output (GWh/yr) from RES-E with a higher investment subsidy....122

Figure 4-36: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for electricity sector (H4_1: with promotion on biomass, electricity only) 123

Figure 4-37: Total electricity output (GWh/yr) from RES-E- reference scenario.... 124

Figure 4-38: Total electricity output (GWh/yr) from RES-E- with promotion on PSU 124

Figure 4-39: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for electricity sector (H5_1: with promotion on PSU (hydro), electricity only)........ 124

Figure 4-40: Total electricity output (GWh/yr) from RES-E- reference scenario.... 125

Figure 4-41: Total electricity output (GWh/yr) from RES-E- with higher investment subsidy on solar thermal Power plant 126

Figure 4-42: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for electricity sector (H6_1: with promotion on solar thermal power plants, electricity only) 126

Figure 4-43: Total electricity output (GWh/yr) from Photovoltaic systems 127

Figure 4-44: Total electricity output (GWh/yr) from small hydro systems 128

Figure 4-45: Total electricity output (GWh/yr) from Wind on shore systems 129

Figure 4-46: Total electricity output (GWh/yr) from RES-E plants- with feed in tariffs 0,89 €/ KWh 130

Figure 4-47: Total electricity output (GWh/yr) from RES-E plants- reference scenario........ 130

Figure 4-48 Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for electricity sector (H10_1: higher feed in tariffs)131

Figure 4-49 Delta transfer costs, delta CO_2 emissions and CPSE - RES-E, CO_2 Taxes of 30€/t 132

Figure 4-50 Delta transfer costs, delta CO_2 emissions and CPSE – Heating systems for CO_2 Taxes of 30€/t 132

Figure 4-51 RES-E - Delta transfer costs [m€/yr] depending on the CO_2 tax level 133

Figure 4-52 Heating sector - Delta CO_2 emissions [m€/yr] depending on the CO_2 tax level ... 133

Figure 5-1: Delta CO_2 emissions vs. change in CO_2 tax (H1) ... 145

Figure 5-2: Promotion scheme efficiency vs delta CO_2 emissions (H2) ... 146

Figure 5-3: Bio fuel production (H3) ... 148

Figure 6-1: Final energy consumption by fuel (1997) ... 151

Figure 6-2: Final energy consumption by sector (1997) ... 152

Figure 6-3: RES-E generation capacity; now plus scenario for 2010 ... 153

Figure 6-4: Data refinement to accommodate Warm Front ... 158

Figure 6-5: Warm Front modelling schematic ... 159

Figure 6-6: Switch to mains gas central heating systems ... 161

Figure 7-1: Calibration of willlingness to pay for solar thermal systems in France: Number of dwellings with solar thermal systems in France without willingness to pay in France and estimations by ADEME ... 165

Figure 7-2: Calibration of willlingness to pay for solar thermal systems in France: Number of dwellings with solar thermal systems in France with willingness to pay in France and estimations by ADEME ... 166

Figure 7-3: CO_2-emissions (total emissions for DHW in the reference scenario), CO_2-reductions in the reference and in a maximum scenario (France) ... 167

Figure 7-4: Impact of subsidies and energy price of solar thermal systems in France ... 168

Figure 8-1: Final Energy Consumption Baden Württemberg 2002, on energy carriers ... 169

Figure 8-2: Final Energy Consumption Baden Württemberg 2002, on use ... 170

Figure 8-3: Map, Poland ... 185

Figure 8-4: Heating systems on energy carrier, Crete 2004 ... 198

Figure 8-5: Cooling systems on energy carrier, Crete 2004 ... 198

TABLES

Page

Table 1-1: Aimed Development of RES shares due to Environmental Plan 2000 11

Table 1-2: Soft barriers ... 13

Table 3-1: The cost of energy saving measures for different time intervals (N=12, 15, 20 years) and different rediscount rates (r=0%, r=8%, r=10%, r=12%) ... 80

Table 4-1: Time schedule of RES installations in Crete ... 104

Table 5-1: Typical consumer prices for energy (households) distributed on pre-tax part, energy tax and VAT as of 2002. €-cent/kWh energy content in fuels and €-cent/kWh electricity ... 140

Table 6-1: Other programmes applicable in Cornwall by sector ... 157

Table 6-2: Scottish Power cavity wall insulation promotion scheme ... 160

Table 7-1: Change of promotion scheme for solar thermal systems in France .. 164

Table 8-1: Economic data Baden Württemberg 2002 ... 169

Table 8-2: Promotion Programme EnergieHolz Baden-Württemberg ... 170

Table8-3: Energieeinsparprogramm Altbau (Renovation of old buildings) ... 171

Table 8-4: KfW Programme for CO_2 Reduction ... 172

Table 8-5: KfW CO_2 Building Refurbishment Programme (KfW- CO_2 – Gebäudesanierungs Programm) ... 172

Table 8-6: Programme For Insulation Materials from Renewable Resources ... 173

Table 8-7: Market Incentive Programme For Renewable Energies ... 173

Table 8-8: Demonstration programme for RES and RUE ... 174

Table 8-9: Renewables law (Erneuerbare Energien Gesetz) ... 174

Table 8-10: CHP law (KWK Gesetz) ... 174

Table 8-11: Technology parameters Heating systems, Germany ... 175

Table 8-12: Technology parameters DHW systems, Germany ... 176

Table 8-13: Technology parameters DSM measures, Germany 176
Table 8-14: Technology parameters electricity sector, Germany 177
Table 8-15: Used Feed-in Tariffs, Germany 177
Table 8-16: Bio fuel generation parameters (transport), Baden Württemberg...... 178
Table 8-17: Biomass Potentials Baden Württemberg 178
Table 8-18: Building Stock, Baden Württemberg 178
Table 8-19: Energy price series building sector [€ / MWh], Baden Württemberg. 179
Table 8-20: Heating technology data 180
Table 8-21: DHW technology data 182
Table 8-22: Insulation technology data 182
Table 8-23: Windows technology data 183
Table 8-24: Energy price time series [€/MWh] 183
Table 8-25: Building classes geometry data 184
Table 8-26: Building classes building quality 184
Table 8-27: General Data, Poland 185
Table 8-28: Prognoses of the demand for the primary energy carriers, Poland ... 186
Table 8-29: Electricity generation by type of plant in 2001, Poland (GUS 2002: 30) 187
Table 8-30: Renewable energy technologies implemented in 2001, Poland (GUS 2002b) 187
Table 8-31: The structure of primary energy production in 2001, Poland (GUS 2002:27) 188
Table 8-32: The structure of primary energy consumption in 2001, Poland (GUS 2002:27) 188
Table 8-33: Structure of RES use in 2001 as final energy equivalent in TJ, Poland (GUS 2002b) 188
Table 8-34: The revenue and expenditure of municipality budget per one person per year, Jordanów 189

Table 8-35: The structure of the farms in the region of the case study, Jordanów189

Table 8-36: Building classes in Jordanów: 190

Table 8-37: Production of straw, forest residues and manure, Jordanów 190

Table 8-38: The agriculture production in Jordanów: 191

Table 8-39: Status Quo (2002) 191

Table 8-40: Operational Programme for Competitiveness 192

Table8-41: National Development Law (Law 2601/98) 192

Table 8-42: Law 2773/99 193

Table 8-43: Bulding stock, Crete..194

Table 8-44: Heating systems, Crete 195

Table 8-45: DHW systems, Crete 196

Table 8-46: DHW systems, Crete 197

0 Introduction

0.1 The project In*vert*

Currently, EU-wide significant inefficiencies with regard to the public promotion of different types of energy technologies exist. The major reasons for this fact are:

- money spent is not targeted;
- rebates are too high;
- money is spent without any performance requirement of the technology.

The **objective of this project** is to provide a comprehensive tool and related recommendations for the design of efficient financial support systems for renewable energy sources (RES) and energy efficiency (RUE). These new promotion systems are targeted using a least-cost approach and a rigorous benchmarking system. This ensures that a higher share of RES as well as substantial efficiency improvements are brought about with less public money. Financial support systems for fossil fuels are also considered. In order to identify the optimum solution for a region or a country by means of minimizing public expenses a computer simulation tool is developed.

The **work of this project** will be broken down in the following work phases:

- Review of current financial support systems for energy technologies in EU countries;
- Technology evaluation: analysis of the efficiency, degree of maturity, and likely technological progress of technologies;
- Development of a database of costs and potentials (“Cost curves”) of RES and RUE technologies;
- Stakeholder behavior: analysis of the groups involved (consumers, retailers, politicians) and their behavior related to the type of promotion scheme;
- Development of a computer model to simulate the links between technologies, energy consumption, CO_2 emissions, financial incentives and other energy policies;
- Assembly of case studies for important regions with many subsidies;
- Derivation of action plans for providing efficient promotion schemes on an EU level as well as for single European countries and regions;
- A comprehensive dissemination campaign that completes the project.

The **major result** will be a comprehensive and transparent incentive-based tool for designing efficient promotion schemes for RES and RUE with minimum public costs. It takes into account the typical features of single regions and technologies and ensures that location-tailored support systems are implemented. The main products/deliverables from this work are:

- A computer-based simulation model applicable for EU countries as well as for associate Member States together with energy policy strategies.
- A comprehensive database for technologies (e.g. PV, fuel cells, small CHP, heat pumps, wind turbines, building insulation, biomass boilers).
- A detailed action plan describing how to approach the optimum portfolio of instruments for successful simultaneous implementation of RES and RUE technologies in different EU countries.

A comprehensive dissemination package by Internet, WebPages, CD-ROMs, and workshops in Athens, Copenhagen, Vienna, Paris, Krakow, Brussels and Karlsruhe will ensure a broad dissemination of the results.

0.2 General remarks

In this report a summary of the case studies is presented. For each case study we show a short description of the current energy system and the reference scenario results. Afterwards a number of region specific hypotheses are tested by application of **In*vert*** simulation tool[1]. Detailed basic data for the case studies are given in the annex. The following case studies are described: Baden-Württemberg (Germany), Vienna (Austria), Jordanow (Poland), Crete (Greece) and Denmark. Moreover, illustration examples from UK (Cornwall) and France are presented.

After some general remarks on the definition of the promotion efficiency, the energy price development and the payback time the results on the individual case studies will be presented in the subsequent chapters.

The following authors are mainly responsible for the individual chapters:

Baden-Württemberg (Germany): Mario Ragwitz, Anselm Brakhage – ISI

Vienna (Austria): Lukas Kranzl, Michael Stadler, Claus Huber, Reinhard Haas – EEG

Jordanow (Poland): Arkadiusz Figorski, Adam Gula, Elzbieta Gula, Beata Sliz, Artur Wyrwa – AGH

Crete (Greece): Elena Tsiolaridou – DUTh

Denmark: Kaj Joergensen – RISOE

---

1 For more detailed information on **In*vert*** simulation tool, please visit www.invert.at.

Cornwall (UK): Jacky Pett, Pedro Gürtler – ACE

France: Lukas Kranzl – EEG

The annexes contain the basic input data of the model, main fats on the currently implemented policy schemes in the case study regions, further region specific building and technology data as well as the assumptions on the development of energy prices.

This report is still a draft version because we will include the results of contributions and discussions during the dissemination seminars held in each of the case study regions.

0.2.1 Cumulated promotion scheme efficiency (CPSE) and lifetime promotion efficiency (LPSE)

For the analysis of promotion schemes carried out in this report, the promotion efficiency will be used as one of the key outputs indicating the performance of a certain promotion scheme. The promotion efficiency of a specific policy setting compared to a reference case is defined as

delta CO_2 emissions [kg] / delta of spent public money for promotion [€][2]

In order to facilitate the interpretation of the individual results of the different case studies some general considerations shall be given here.

Both the CO_2 emissions in [kg] as well as the amount of public money spent for the promotion in [€] are based on a specific year n. Therefore the public spending does represent the "budget relevant spending" for any public administration in a year n. This means for example an investment incentive given in the year n will be counted with it's full amount in the year n instead of accounting for the annuities of the amount during the payback time / lifetime of the plant. Therefore the promotion efficiency used in this report should not be directly compared with CO_2 emission reduction costs known from the literature. Typically the values of the promotion efficiency defined above correspond to significantly higher costs of CO_2 emission reduction than one obtains from the ordinary definition of the latter quantity. The definition of the promotion efficiency as given in this report primarily represents the viewpoint of a policy maker who has to fulfill a specific CO_2 emission reduction target until a year n based on limited public budgets until this year n.

2 Therefore both for the emissions as well as for the public money spent the difference to the reference case is calculated. This provides the option of comparing various scenarios with each other and thus calculating the impact of a certain promotion scheme related to a reference scenario (where there is no scheme or another scheme implemented.

It has to be noted that all promotion scheme efficiency values (kg CO_2/Euro) are calculated for the time frame until 2020. CO_2-reductions as well as transfer costs which occur after this time are neglected for calculating these values. Hence, promotion scheme efficiency values reflect the view of a policy maker with a horizon strictly until 2020 and not longer. Thus, a comparison of these values with CO_2-reduction costs of other investigations is not directly feasible. In particular for cases of subsidies granted in the last years of the simulation period we underestimate the promotion scheme efficiency due to neglecting the CO_2-reductions after 2020 but taking into account the whole transaction costs.

So, the **cumulated promotion scheme efficiency (CPSE)** *depicts the short-term-view of a policy maker who does not take into account impacts after the considered time period (e.g. relevant for a certain CO_2-reduction target)*.

However, for further analysis, an additional indicator has been defined: the "**life time promotion scheme efficiency (LPSE)**". This indicator considers all CO_2-reductions and transfer costs occurring during the whole life time of the energy systems, not only during the simulation period. *Thus the LPSE refers to the long-term view of a policy maker taking into account also the impacts after a certain considered time period (e.g. relevant for a certain* CO_2*-reduction target)*.

Furthermore it has to be noted if in the special examination a promotion scheme is implemented or cancelled relating to the compared case (which is normally but not always the reference scenario). Secondly it's important to notice that not total amounts of emissions and costs but their differences ('deltas') to the compared case (reference scenario) will be considered. So we have to differentiate between four cases:

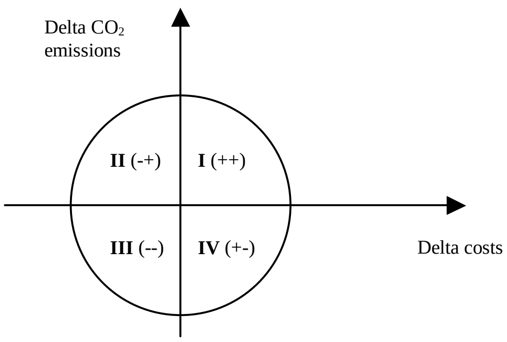


Figure 0-1: Promotion efficiency; possible constellations

***Positive* promotion efficiency**

I) Emissions *and* costs are *increasing*.

Obviously this is the worst case and disqualifying itself.

III) Emissions *and* costs are *decreasing*.

Emissions are reduced while simultaneously money is saved: in this case defects and possibilities of improvements from the reference scenario are indicated. The higher the value of promotion efficiency the more attractive is the analyzed promotion scheme

***Negative* promotion efficiency**

II) *Emissions* are *increasing while costs are decreasing*.

high absolute value: negative effect

low absolute value: positive effect

In case of a high absolute value the increase of emissions is significant whereas only minor amounts of public money are saved. A low absolute value of promotion efficiency relates to the case that a significant amount of public money can be saved by only a minor change of the emission situation.

IV) *Emissions* are *decreasing while costs are increasing*.

This is the expected situation in case of higher CO_2 reduction targets than in the reference scenario: additional money is spent to reduce emissions. The higher the absolute value of promotion efficiency the more attractive is the analyzed promotion scheme.

Finally we would like to mention that in many graphs below delta CO_2 emissions [kt/a], transfer costs [M€/a] and cumulated promotion efficiency [kg CO_2/€] are shown together in the same figure. Because of the very different measuring units two scales had to be used in general: the left sided y-axis always relates to the promotion efficiency, the right y-axis belongs to emissions and costs.

0.2.2 Energy price development

First of all it has to be emphasized that the energy price development has a very crucial influence on the model results as well as on the competitive situation and market penetration of RES and RUE technologies. This already could be observed in the last years while the oil price increased rapidly. That means that the assumptions regarding the fossil energy carrier prices are influencing the results very sensitively, more than the most other parameters.

So, for the reference scenario of each region a sensitivity analysis referring the impact of energy price development on the results has been carried out. However, it should be noted that for the respective reference scenarios a different price development has been assumed. The essential assumptions are listed in the concerning section to the reference scenario of the region.

0.2.3 Payback time

The simulation tool considers all costs and benefits (e.g. due to 'Solar Thermal' systems and 'Insulation' as well as 'Windows') based on a specific 'Payback Time'. The program neglects all economic costs and benefits for the user after the 'Payback Time'. With this **In*vert*** is able to calculate the maximum yearly costs as seen by the consumer. Exactly these costs are the important decision making parameters. This approach corresponds with a risk evaluation of the future. This means the consumers base their decision on a sector specific estimation of the investment bay back.

In*vert* simulation tool provides the possibility to calculate the yearly costs on basis of the lifetime, too. It's very important to pay attention to the difference between 'Payback Time' and 'Lifetime' within the model. The achieved results and their interpretation are heavily dependent on the decision of the used term for the payback time. Different points of view are possible: on one hand a short payback time aiming at fast amortization; on the other hand considering the full lifetime to include later gains (e.g. for solar thermal facilities which do not involve any fuel costs).

1 Germany – Baden Württemberg

1.1 Structure of the energy supply

1.1.1 Primary Energy Demand and End Energy Consumption

The primary energy demand of Baden Württemberg is characterized by the dominance of oil (39 %) and a large nuclear share (26.1 %). Renewables account for 3.2 %. The total primary energy demand is 450 TWh, the final consumption amounts to 286 TWh.

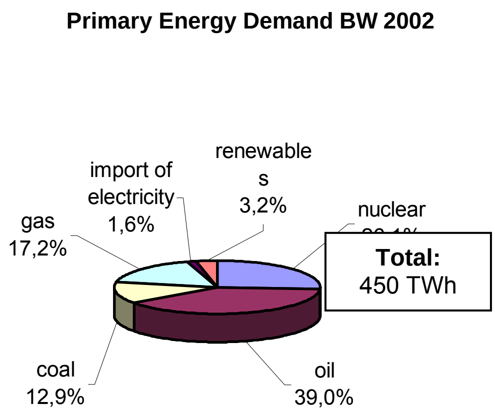


Figure 1-1: Primary Energy Demand Baden Württemberg, 2002

1.1.2 Power generation

The gross electric power consumption in Baden-Württemberg has doubled in the years between 1973 and 1999 and is now 71.3 TWh/a. This increase is much higher than the national average. Between 1973 and 1989 a considerable structural change had taken place. Nuclear energy share enhanced form 7 % to 54 %, therefore the net electricity import dropped from 22 % to 6 % and input of natural gas and oil in electricity generation decreased from 36 % to 7 %. During the following ten years until 1999 the structure of electricity supply retained basically unchanged. 62 % of electricity in Baden-Württemberg are generated without CO_2 emissions, resulting in a relatively low CO_2 intensity of 0.25 kg/kWh_{el} - the German average is 0.56 kg/kWh_{el} – but total CO_2-emisisons of power generation increased due to the growth of consumption.

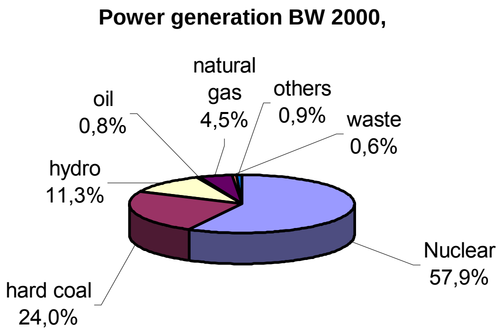


Figure 1-2: Power generation Baden Württemberg 2000

For an improved understanding of the future electricity generation system it is important to differentiate between condensation electricity, combined heat power generation (CHP) and renewable energies (RES). As the share of condensation electricity increased from 80 % to 85 % between 1989 and 1999 CHP decreased from 12.4 % to 9.5 % and RES (without biomass) from 8.2 % auf 6.5 % at the same time. CHP decreased also in absolute terms, RES grew only very modestly. This development is not satisfactory from the point of view of improving efficiency of fossil resources and augmenting the use of RES.

1.1.3 Combined heat and power generation

Electricity from CHP plants presently contributes with a share of 9.5 % to the power generation of Baden Württemberg. This is well below the average of Germany, which is 12 %. The corresponding supply of heat covers about 8 % of the final energy demand for heat.

Traditionally industrial CHP accounts for the largest part followed by the bigger municipal district heating grids in the regions Mannheim-Heidelberg, Stuttgart-Esslingen, Karlsruhe, Pforzheim, Heilbronn und Ulm. Further CHP plants are operating in connection with smaller communal district heating grids. Smaller grids are operated from different operators in approximately 30 communalities. Less than 1 % of the final energy demand is covered by grids, which feed in below 200 GWh per annum.

The situation of building related CHP with cogeneration units from some kW_{el} to some MW_{el} is similar. They are primarily established in public and trade buildings, but they can be also considered for supplying bigger residential buildings especially combined with local heat grids. At present the installed capacity of building integrated cogeneration units in Baden-Württemberg is circa 250 MW_{el} and 460 MW_{th} respectively, corresponding to less than 10% of existing potentials.

1.1.4 Heating sector

The building stock is covering about 2.2 Mio residential buildings and 4.3 Mio dwellings, respectively. Nearly 88 % of the heating energy demand is supplied by central heating systems, dominated by oil and gas heating systems. Currently district heating has a share of only 5.4 % of heating in residential buildings.

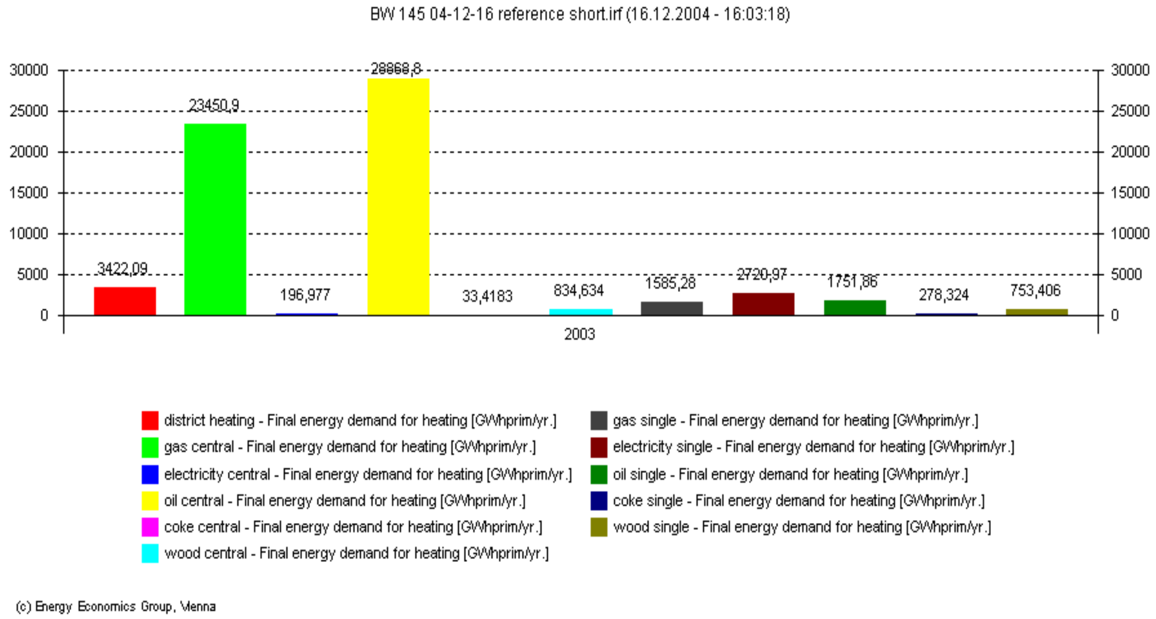


Figure 1-3: Heating systems Baden Württemberg 2003

1.1.5 Renewables

The contribution of renewables to energy supply in Baden-Württemberg is dominated by hydro power and the use of wood. Both renewable sources provide a similar share of the final energy consumption. All other types of RES are still of little quantitative importance. The share of RES in primary energy consumption in 2002 was about 3.2% or 14.3 TWh. The highest absolute increase during the period between 1985 and 2002 came from hydro power and wood; the new RES-technologies such as solar thermal collectors, biogas, wind and photovoltaics naturally showed the highest relative growth rates. Especially in the last years significantly higher growth rates have been observed due to promotion schemes, which have been introduced since 2000. Nearly 250 GWh respectively 30 Mio litre biofuel were used in Baden Württemberg in 2002.

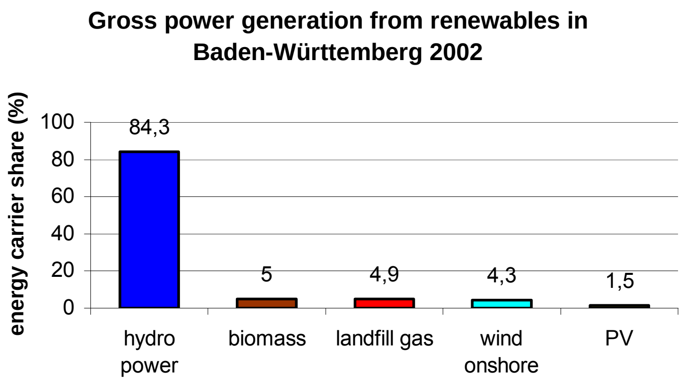


Figure 1-4: Gross power generation from renewables in Baden Württemberg 2002

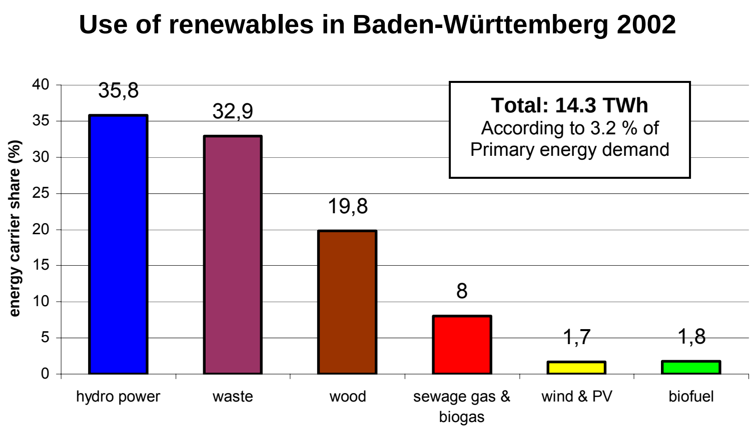


Figure 1-5: Use of renewables in Baden Württemberg 2002

1.2 Promotion schemes

1.2.1 Energy Policy

The State Baden-Württemberg aims at a doubling of the use from renewables till 2010 compared to 1999 (Environmental Plan 2000). This roughly refers to both the share of RES in primary energy consumption as well as in terms of power generation.

Table 1-1: Aimed Development of RES shares due to Environmental Plan 2000

Type of renewables	Electr./heat	2001	Needed expansion until 2010	Generation after expansion in 2010
		GWh/a	GWh/a	GWh/a
Hydro	electr.	4,600	1,100	5,700
Wind	electr.	170	750	920
PV	electr.	32	288	320
Solar thermal	heat	100	1,100	1,200
Biomass	electr.	140	960	1,100
	heat	6,500	4,500	11,000
Biogas	electr.	150	600	750
	heat	50	1,050	1,100
Geotherm.	electr.	0	200	200
	heat	0	400	400
Total electr.	electr.	5,092	3,898	8,990
Total heat	heat	6,650	7,050	13,700
Total	**electr. & heat**	**11,742**	**10,948**	**22,690**

1.2.2 Existing promotion schemes

Baden Württemberg - as well as all other German states - is benefiting from a comprehensive energy policy of the federal government. Several promotion programmes are existing on federal level in order to support energy saving measures as well as the installation of modern systems with high energy efficiency and renewable energies. The most relevant support scheme for the promotion of RES is the Renewable Energies Act (*Eneuerbare Energien Gesetz, EEG*) which guarantees fixed feed in tariffs for all renewable power and CHP generation.

Another instrument specific to enhance the market share of renewables is the *Market incentive programme* consisting of both investment incentives (wood and solar thermal systems) and soft loans.

Of specific relevance for the building sector are the *KfW Programme for CO_2 Reduction* and the *KfW CO_2 Building Refurbishment Programme* both with soft loans and partial debt relieve regarding investments in energy saving measures. The *Programme For*

Insulation Materials from Renewable Resources especially provides subsidies for using insulation materials from Renewable resources.

Additionally to those federal promotion programmes Baden Württemberg is running RES and RUE programmes, which increases the federal subsidies up to 30 % of investment costs for wood heating systems (*Wood for energy use)*. For further details about the existing promotion schemes please see the Annex A2.

1.2.3 Regulations by law

Discussing and analyzing the efficiency of different promotion schemes can not be carried out without considering regulations by law. This concerns existing regulations as well as possible future regulations for reducing energy demand and emissions and/or for the enforced use of RES.

In Germany for example the energy saving act of 2002 regulates obligatory energy saving measures in the building sector - primarily regarding the construction of new buildings but in some aspects also the existing building stock as:

- Houseowners have to switch off heating boilers which have been installed before 1978, until end of 2006 (or latest end of 2008 by fulfilling some additional requirements)
- New boilers have to fulfill new standards
- Pipes for hot water and heat distribution have to fulfill some requirements of insulation until latest 2006
- Ceilings have to been insulated until end of 2006 that they keep a heat thermal coefficient of 0.30 W/m²*K

1.3 Reference Scenario

1.3.1 Essential Assumptions

The Reference Scenario is defined to represent the “business as usual” development based on the existing promotion schemes. It’s basically focusing the building sector. The main assumptions are:

- Moderate rise of fossil energy prices up to 1.5 times of current prices in 2020. Sensitivity analyses regarding the fuel price development will be done in WP 7.
- Wood price constant up to 2008; afterwards a yearly increase of 1.5 %.
- District heating price with a yearly increase of 1.5 %, electricity with a yearly increase of 0.8 %.

- Investment decision for new technologies in building sector based on lifetime; e.g. payback time is set equal with lifetime
- High insulation quality for refurbishment measures
- Refurbishment measures include wall insulation *and* windows replacement

The chosen levels for soft barriers resulted from calibrating the results of simulation runs with reality as well as from experiences and estimation:

Table 1-2: Soft barriers

Technology option	Soft barrier
District heating	- 0.10
Gas central	- 0.10
Wall insulation	- 0.10
Windows replacement	- 0.90
Oil central	+ 0.10
Solar thermal	- 0.27
Wood central	+ 0.03

1.3.2 Characteristics of Reference Scenario

Building Sector

- Moderate growth of district heating (+ 47% up to 2020)
- Significant increase of the growth rates of central wood systems (from about 6,000 heating systems in 2003 up to more than 160,000 heating systems as result of enforced promotion from wood heating systems.
- Strong Increase of central gas systems up to 2012; after it a nearly constant high level of numbers (ca. 1.3 to 1.4 Mio). Continuous decrease of oil systems down to about one third of the current level in 2020 (relating to the level in 2003).
- Central heat pumps will raise up to 80,000 installations in 2020.
- Significant continuous decrease of inefficient single stoves.

Central heating systems

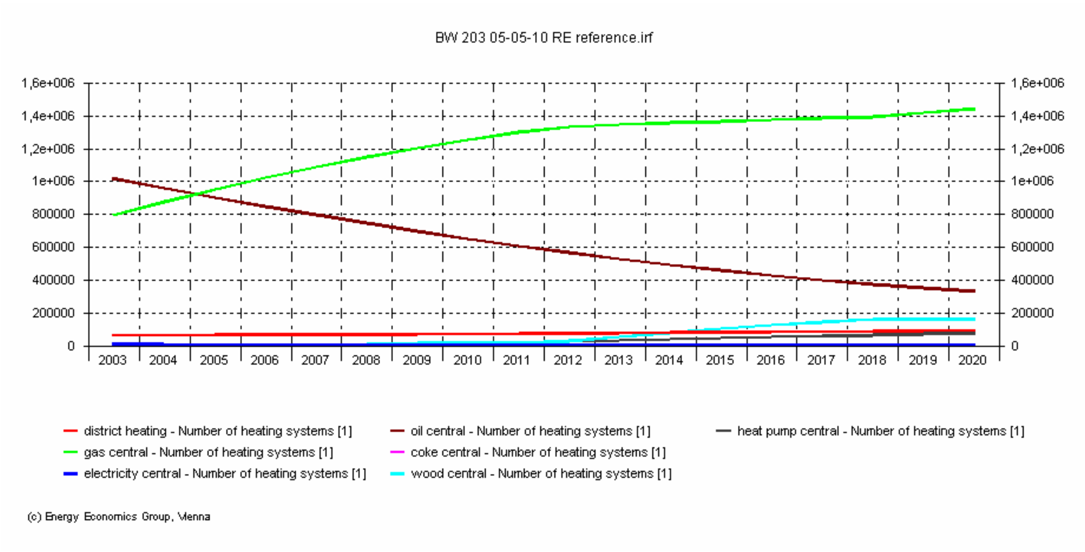


Figure1-6: Development of heating systems (reference scenario: with existing promotion schemes)

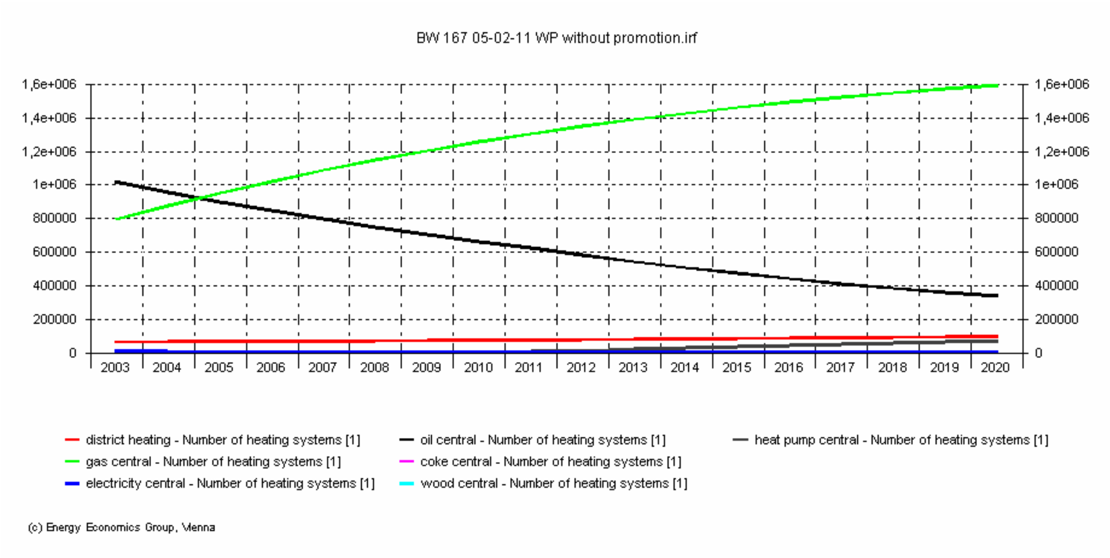


Figure1-7: Development of heating systems (without any promotion)

DHW systems

- New solar thermal facilities will be applied from 2011; after it continuous growing up to 200,000 dwellings in 2020 related to level in 2003 (36,000 dwellings).
- Analogous behavior as heating sector for combined systems (note: electricity includes the growing share of heat pumps).

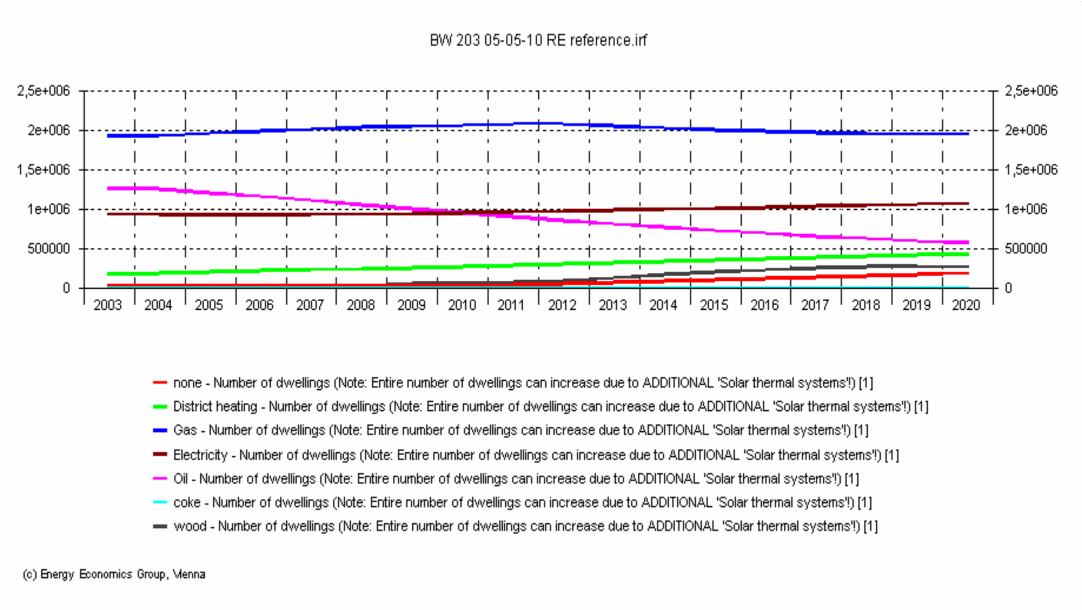


Figure1-8: Development of DHW systems (reference scenario: with existing promotion schemes)

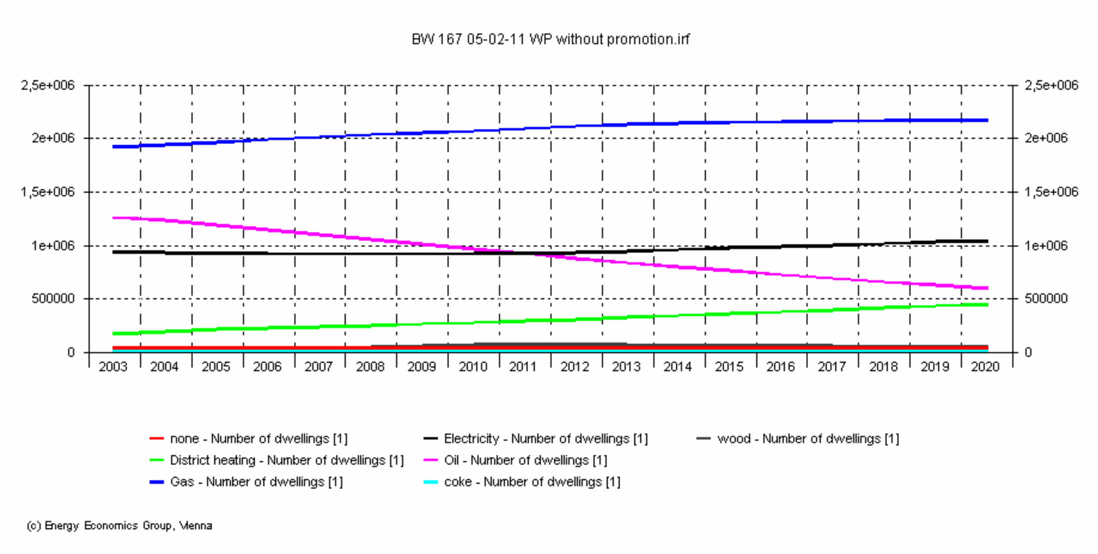


Figure1-9: Development of DHW systems (without any promotion)

DSM measures

- Continuously decrease of heating energy demand from 103 TWh/a in 2003 to 89 TWh/a in 2020 by measures of wall insulation and windows replacement.
- At an average 35,000 dwellings per year will be refurbished (wall insulation *and* windows replacement).

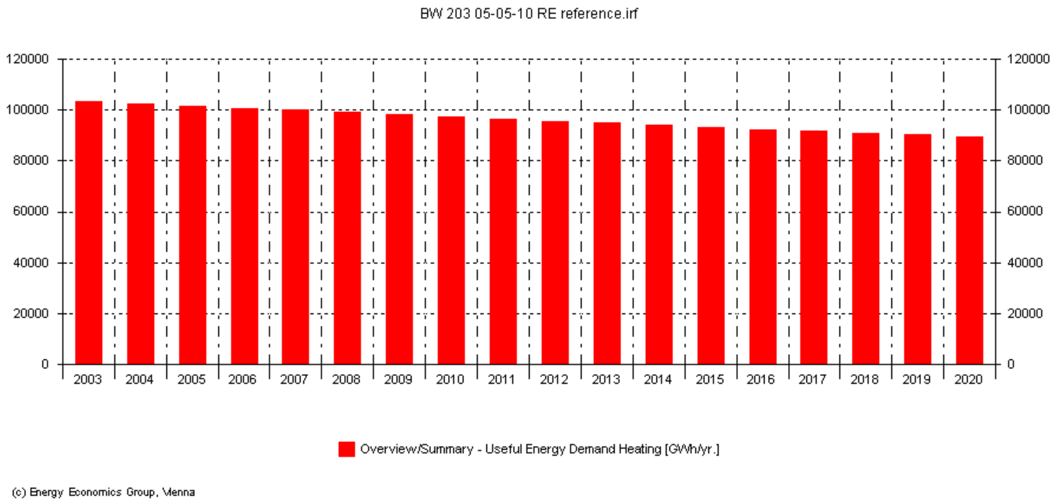


Figure1-10: Development of DSM measures (reference scenario: with existing promotion schemes)

Transport

Tapping 85 % of the full potential of about 100 Mio l / a in 2020 at reference scenario (full tax exemption). Tapping a third of potential already in 2006. The curve of biofuel request of reference scenario in Figure1-11 represents the maximum penetration due to a chosen dynamic parameter of 10 %.

- By applying full fuel tax (that means “without promotion” reaching one third of potential in 2013 and two third of the potential in 2020 (correlated to increase in assumed conventional fuel price: prices increase by the factor 1.5 until 2020, compared to the current prices).

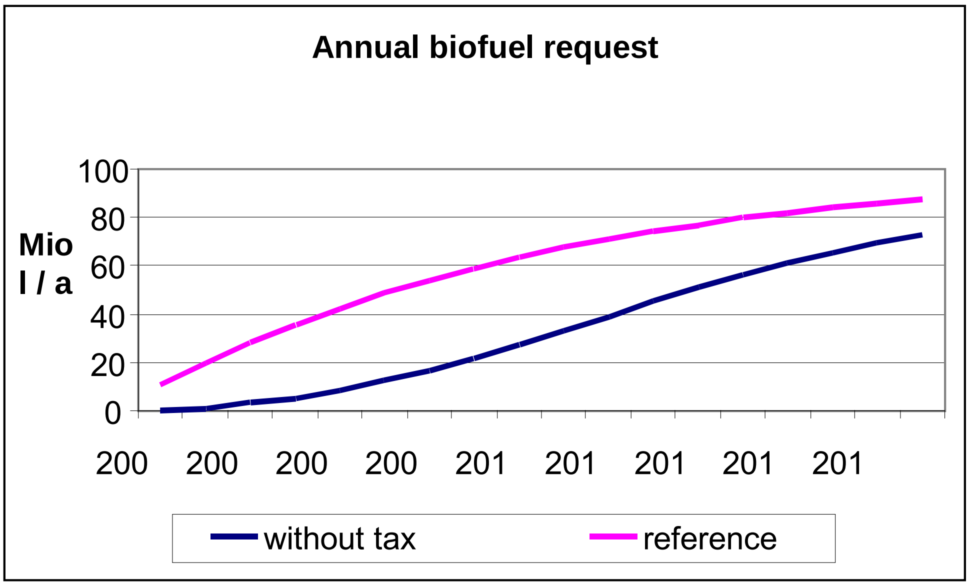


Figure1-11: Annual biofuel request

1.3.3 Total effects of all existing promotion schemes

Essential effects of promotion schemes:

- The existing promotion for RES and RUE in Baden Württemberg leads to cumulated reductions of 36.5 Mt in the time between 2003 and 2020.
- The according promotion costs amount 8.8 bn €.
- The main share – regarding as well the CO_2 reduction as the transfer costs – account for the building sector
- The Lifetime promotion efficiency for building sector is 5.7 kg CO_2 / €, for RES-E 4.7 kg CO_2 / €, for RES-CHP 3.2 kg CO_2 / € and for transport sector 4.7 kg CO_2 / €.

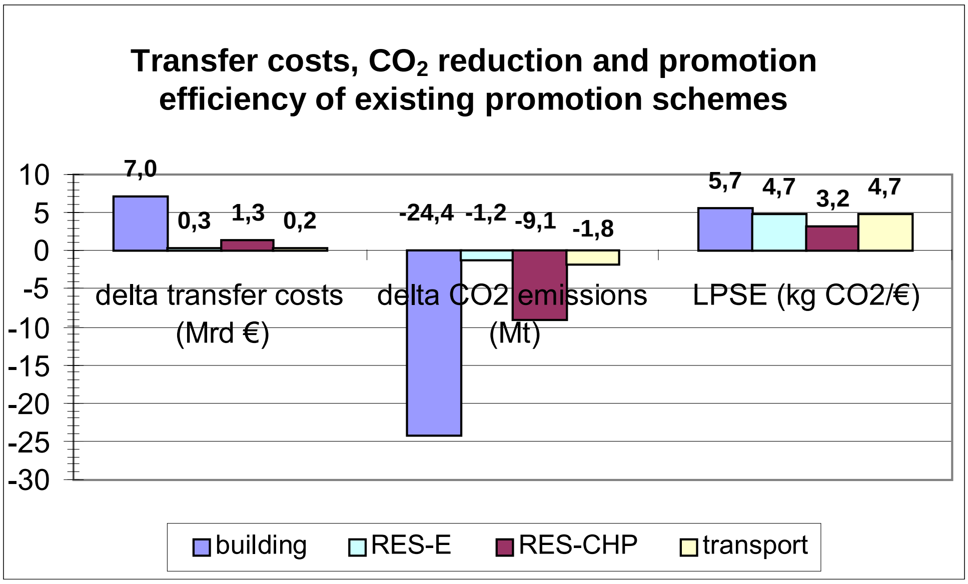


Figure1-12: delta transfer costs, delta CO_2 emissions and lifetime promotion efficiency for existing promoltion schemes (reference scenario) [3]

1.3.4 Sensitivity analysis: energy price

The following part shows the result of a sensitivity analysis carried out with respect to various levels of energy price increase. Four scenarios are calculated with varying levels of price increase for fossil carriers: no increase, 1%, 2.5 % and 4% increase per annum. The 2.5 % level is corresponding to the reference scenario.

As to be expected the energy price increase has a strong impact on the development of CO_2 emissions. While the CO_2 emissions in the heating sector will be reduced only for 11 % from 16.9 Mt/a (2003) to 15.0 Mt/a in 2020 when energy price would be unchanging, the CO_2 reduction by increasing energy prices will be much more higher: 18 % (energy price increase 1 % /a), 32 % (2.5 % /a), and even 52 % (4 % /a) (Figure 1-13).

First of all the reduction is result of the penetration of wood heating systems (Figure 1-15). (It should be noted, that in the case of 4% price increase the resulting wood energy demand would exceed the assumpted potential).

3 The transfer costs in the year n represent the "budget relevant spending" in the year n.

In the case of solarthermal systems the main effect – growing up in 2009 from 35,000 to 200,000 systems in 2020) occurs already in the reference scenario (2.5 % energy price increase) while no increase of solarthermal systems will happen when energy price increase is only 1 %/a or less. An additional increase up to 4 %/a will accelerate the penetration of solarthermal systems (up to 2006) and raise the number in 2020 up to 280,000 (Figure 1-14).

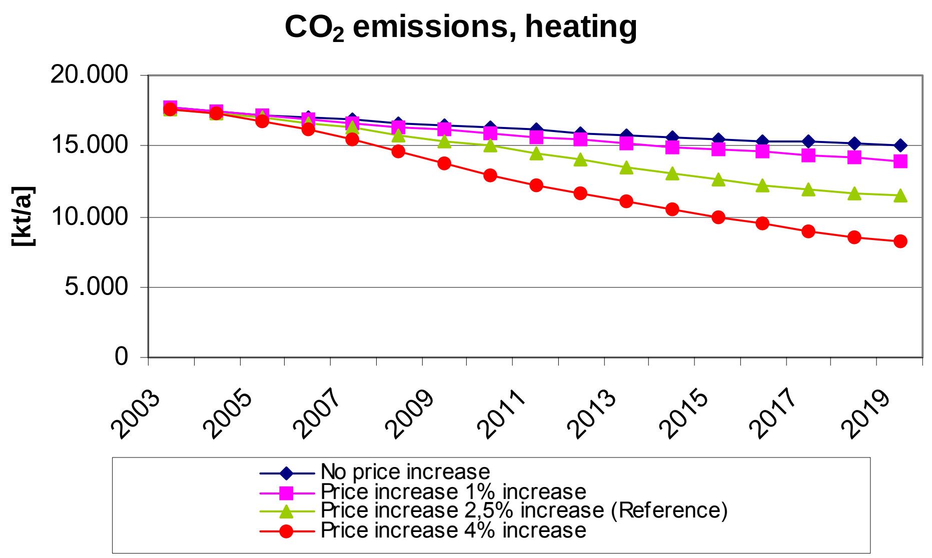


Figure 1-13: Sensitivity of CO_2 emissions towards energy price increase

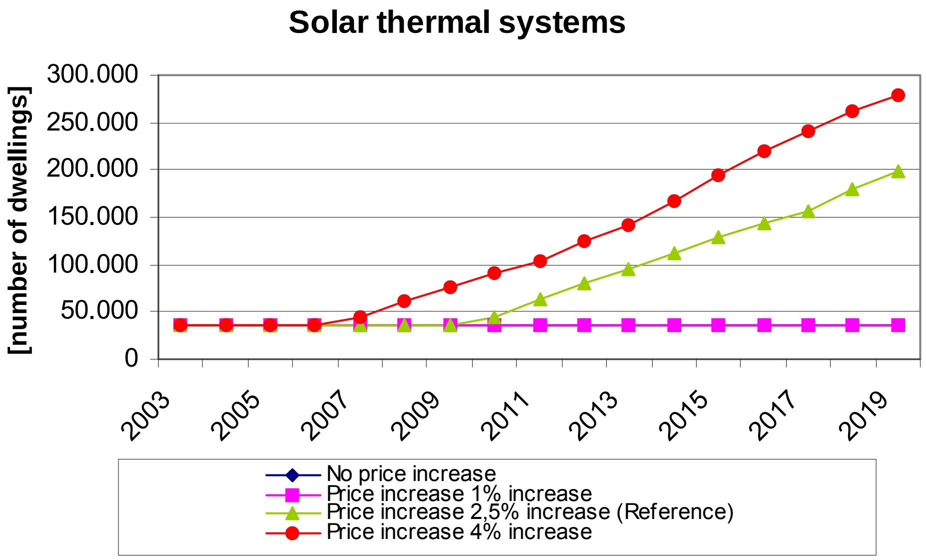


Figure 1-14: Sensitivity of solar thermal uptake towards energy price increase

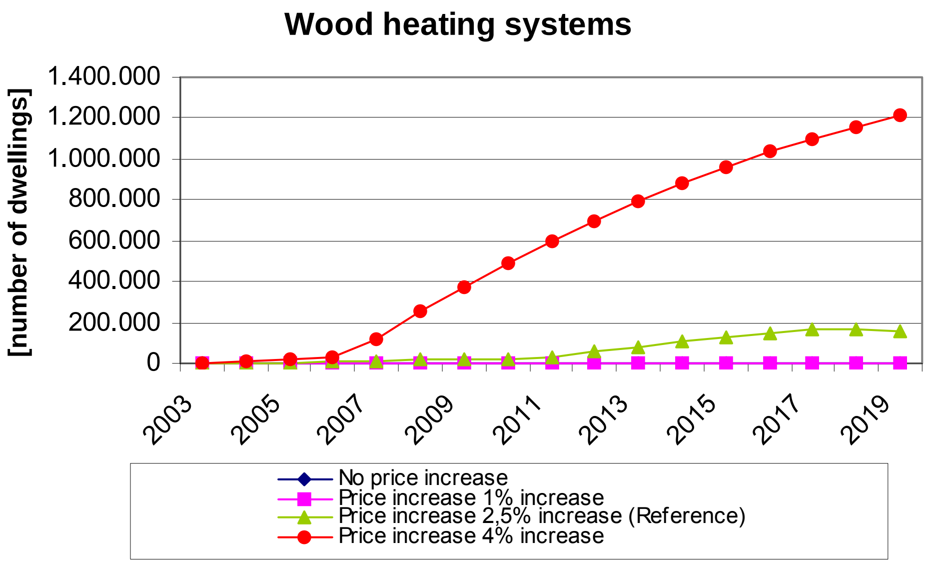


Figure 1-15: Sensitivity of wood heating uptake towards energy price increase

While the impact from energy price increase on the penetration of wood heating and solar thermal systems is rather high, it's comparatively low to DSM measures as shown in Figure 1-16. The reduction of useful energy demand in the heating sector varies only between 11% (no energy price increase) and 15 % (4 %/a price increase). This result reflects the fact that an considerable share of possible DSM measures will be already enforced in the reference scenario.

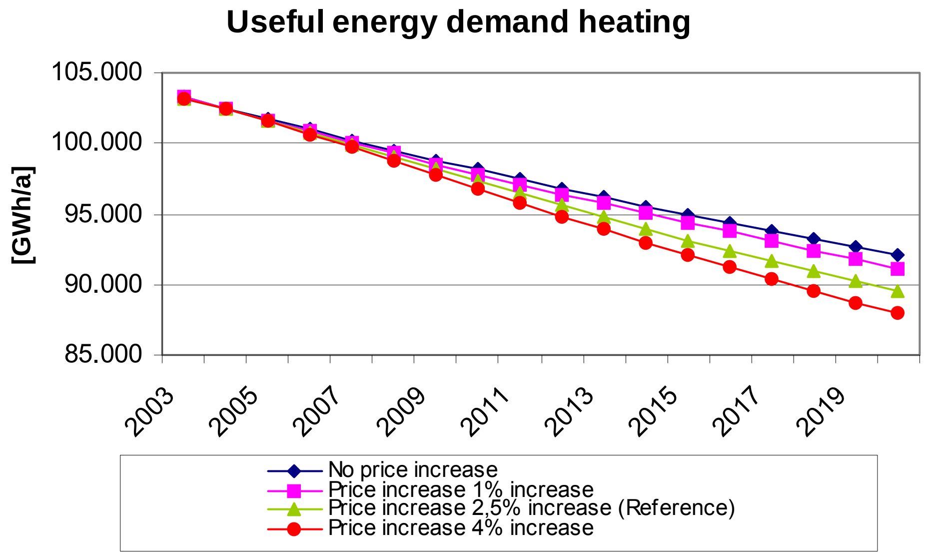


Figure 1-16: Sensitivity of final energy demand reduction towards energy price increase

1.4 Analysis of hypotheses

1.4.1 Hypothesis H1: Simultaneous support for RES and conventional heating systems

Compensations due to *simultaneous support for RES and conventional heating systems* (as condensing and low temperature boilers in KfW CO_2 Programme, KfW Building Refurbishment Programme, Energy Saving Programme) and for renewable sources (i.e. Market Incentive Program) are possible.

Performed variations

- removal of any promotion (soft loans) for conventional systems (H1_1)
- removal of promotion for RES systems (H1_2)

Main results

- Without promotion for conventional systems much less gas heating systems and much more wood heating systems wood be applied (Figure1-17). Please note: the figure is not quite realistic because the biomass potential is exceeded (the model only is noticing but not preventing the limit exceeding). But the qualitative conclusion is unaffected of that.
- The *removal of promotion for conventional heating systems* leads to a strong decrease of CO_2 emissions while only little raising the transfer costs. It shows a high LPSE (ca. 87 kg CO_2/€) (Figure1-19)
- Without RES promotion in the heating sector no wood heating systems would be applied until 2020 (Figure1-18) The *removal of promotion for wood heating systems* leads to a drastic increase of CO_2 emissions with only marginal reductions of transfer costs. With other words: the existing promotion of wood heating systems is offering a high promotion efficiency (Figure1-20).

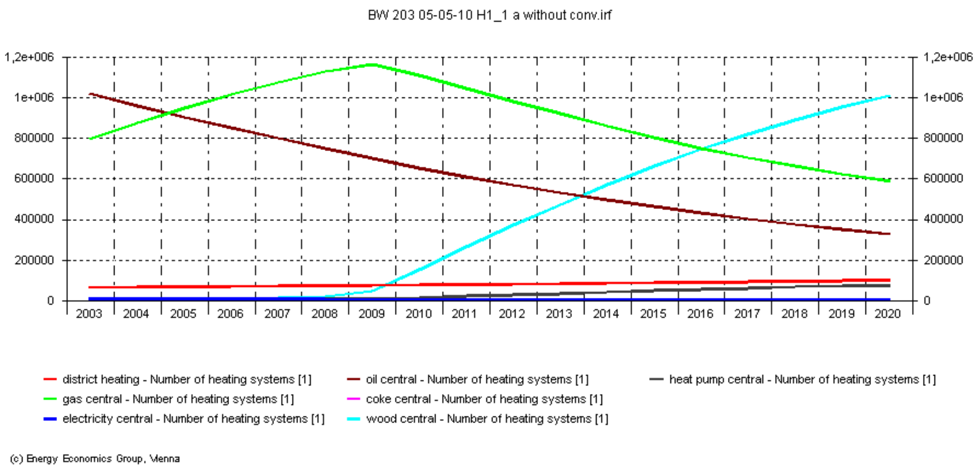


Figure1-17: Number of heating systems without promotion for conventional heating systems (H1_1)

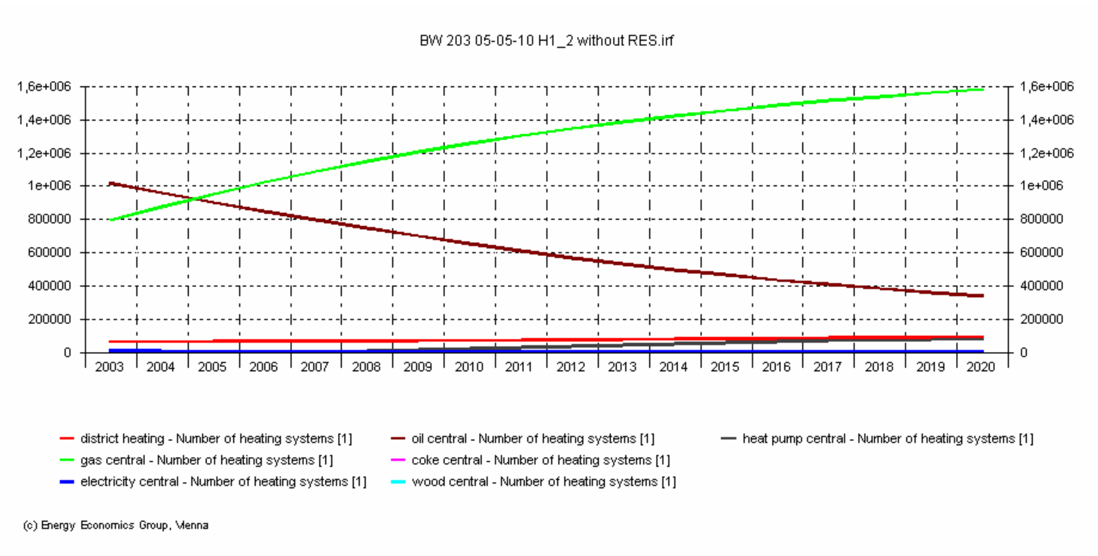


Figure1-18: Number of heating systems without promotion for RES systems (H1_2)

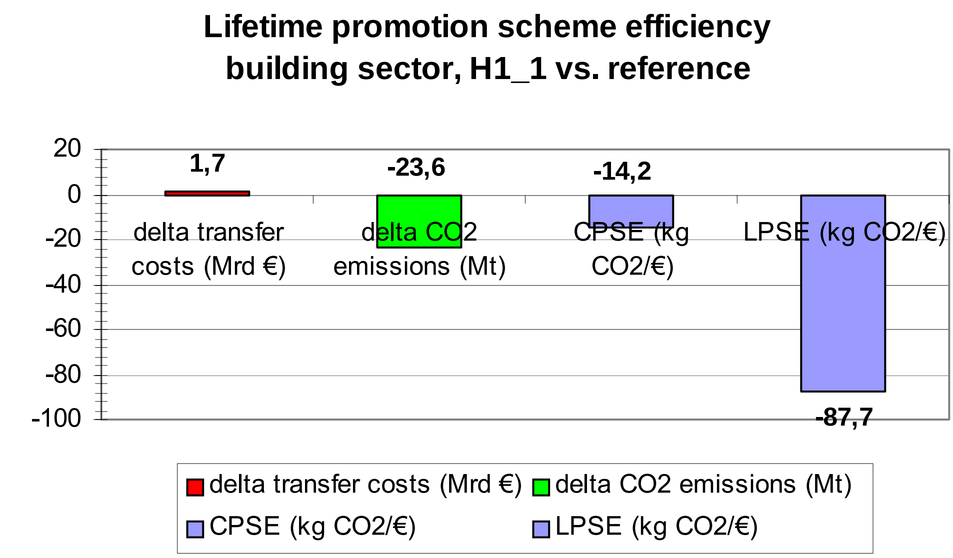


Figure1-19: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_1: without promotion for fossil fuel based heating systems)

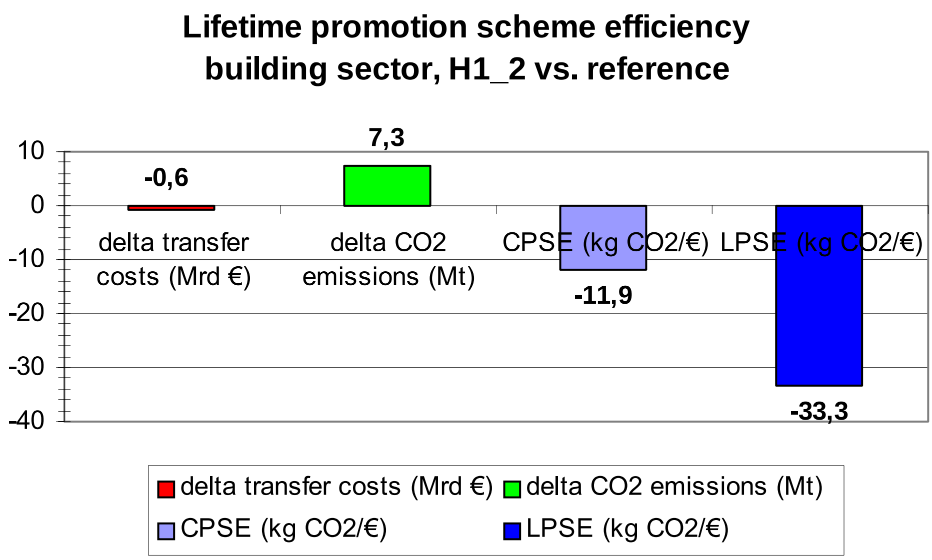


Figure1-20: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_2: without RES promotion)

Conclusion: the simultaneous promotion of conventional heating systems suppresses the enforced use of RES systems !

1.4.2 Hypothesis H2: Global versus local optimum

The maximum cumulating and supplementing limit (between national and regional programmes) may be too high or too low. For example region-specific support will be dominated by national promotion schemes and possibly will miss the intended regional effect or maybe the design of regional promotion schemes could aim at attracting maximum profits of national programmes.

Performed variation

- Reduction of subsidies for wood energy heating systems from 30 % down to 20 % of investment costs according the federal promotion level (e.g. removal of state additional promotion).

Main results

- Significant push for wood systems by subsidies of additional state promotion (Figure 1-21).
- High efficiency for additional state promotion (Figure1-22.

Conclusion: The instrument of additional state promotion for wood heating systems in Baden Württemberg effects the critical incentive for just crossing the threshold of profitability for this specific RES application. So it exemplifies a reasonable specific supplementation to federal promotion policy.

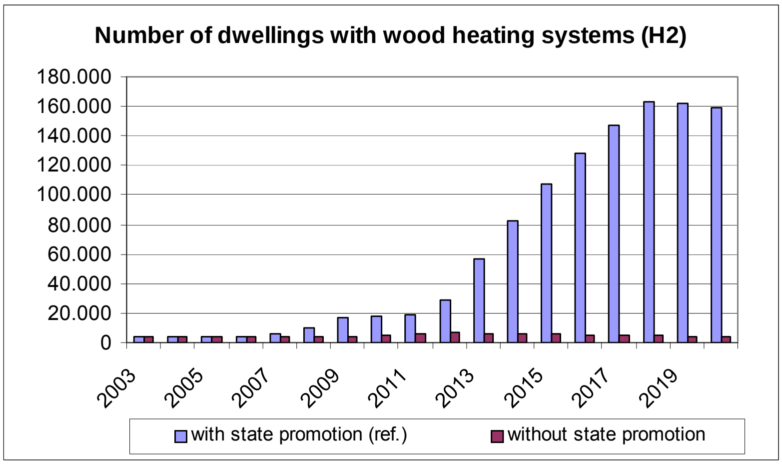


Figure 1-21: Number of wood heating systems (H2) Cumulated promotion efficiency (H2)

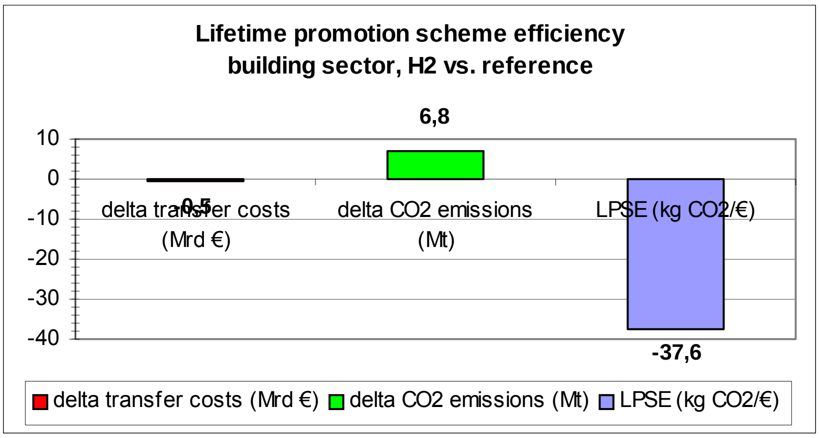


Figure1-22: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H2: removal of additional state promotion)

1.4.3 Hypothesis H3: Waste of money due to tax exemption of biofuels

The current legislation of full tax exemption for biofuels seems to be an unnecessarily generous support for biofuels and thus a waste of public money. A partial tax reduction would be sufficient to induce the profitable use of biofuels. The benefits of the measures in terms of primary energy savings and CO_2 emission savings are not adequately taken into account comparing other sectors of the energy system.

In the reference scenario the maximal share of biofuel is requested (according the assumed dynamic parameters of 10 % p.a.

Performed variations

- Partial tax reduction in stages of 10 %.

Main results

- A partial tax exemption of 70 % for bio fuels would be sufficient to push bio fuel price under the reference diesel price and so to make attractive for drivers (Figure 1-23).
- The difference between 70 % and 100 % tax exemption is wasted money with the only effect of reducing promotion efficiency. The wasted money (the dotted curve in Figure 1-23) amounts cumulated until 2020 ca. 140 M€.

Conclusion: Saved money could be used alternatively to promote the apply of other RES technologies.

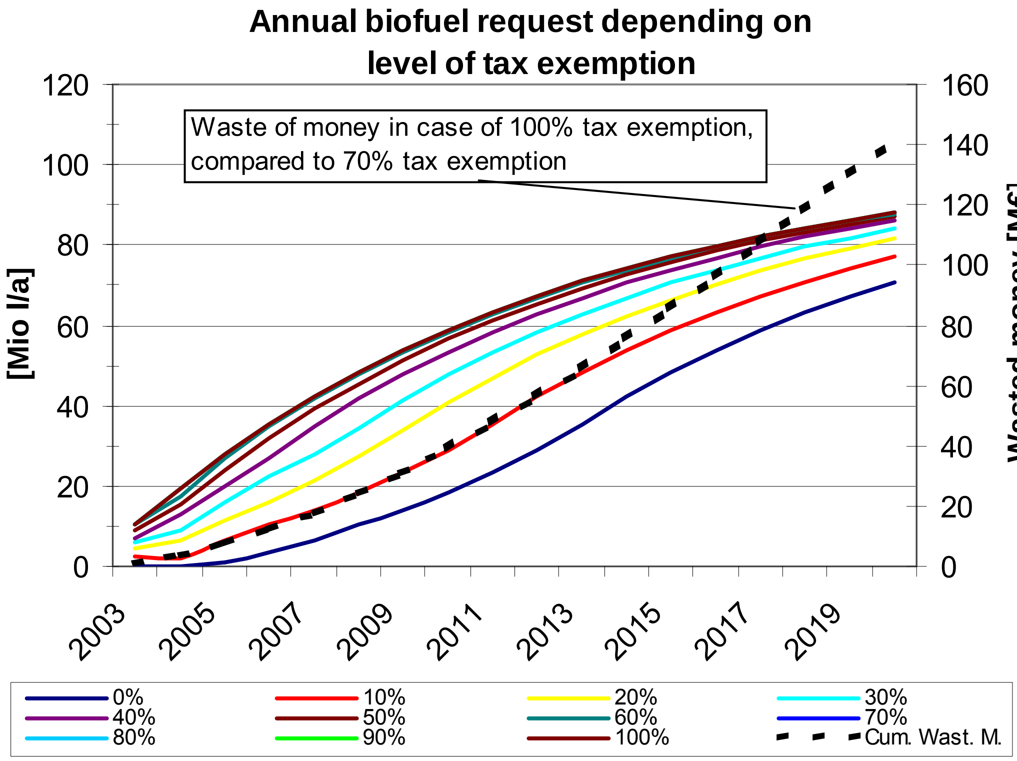


Figure 1-23: Biofuel request on tax reduction (H3)

1.4.4 Hypothesis H4: Heat pumps promotion too low

The market penetration of heat pumps in Germany is rather low compared to other countries as Norway, Sweden or Suisse. It might be reasonable to increase the *promotion of heat pumps* compared to other renewable energies (for example solar thermal collectors) if the evaluation criterion is the CO_2 reduction efficiency. Currently heat pumps are only supported by means of soft loans, but not like active solar thermal installations by subsidies.

Performed variations

- Initiating a 20 % subsidy for heat pump systems

Main results:

- A specific heat pump promotion at first would accelerate the heat market penetration of heat pumps, but in 2020 the number of heat pump systems would not differ very much: 80,000 systems in the case without and 100,000 with specific promotion (
- Figure 1-24).

- An enforced promotion of heat pump systems in combination with the existing promotion schemes amounts a lifetime promotion efficiency of nearly 20 kg/€ (Figure1-25)

Conclusion: An enforced promotion and increased use of heat pumps would be reasonable especially if the additional electricity demand would be covered by RES plants. Thus an enforced heat pump promotion should to be combined with an intensified RES-E promotion.

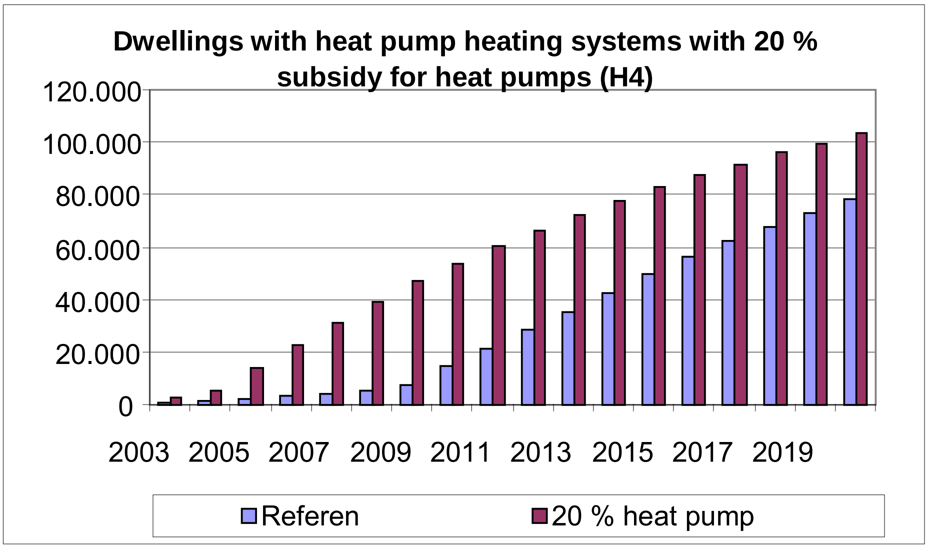


Figure 1-24: Number of heat pump systems (H4)

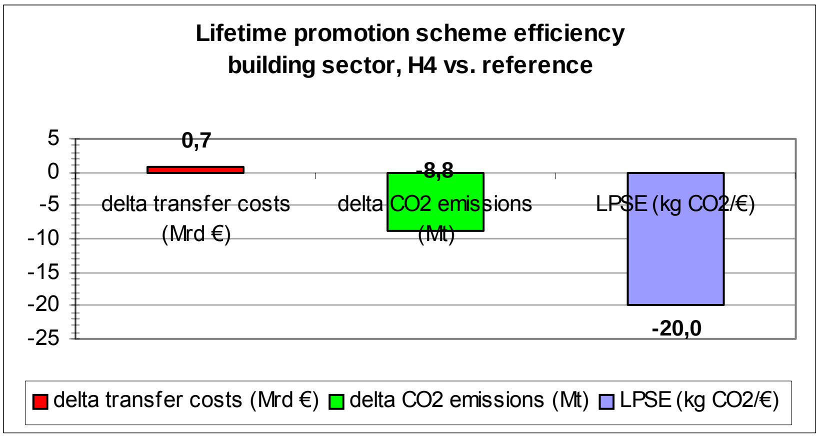


Figure1-25: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H4: heat pump subsidy)

1.4.5 Hypothesis H5: Promotion of heating grids is insufficient

Especially small grids have a key function for the penetration of renewables in the heat sector. It has to be analyzed whether the existing support for heating grids especially in combination with RES-CHP plants is sufficient and if not how to improve it.

Performed variations:

- Decreasing the district heating price by 20 % (for example by price regulations)
- Share of maximal possible additional dwellings with district heating systems raises from 3% (reference) to 4 %.

Main result:

- The lower price for district heating results into a growing number of applied district heating systems (difference to reference scenario grows from 1.7 % in 2003 up to 36 % in 2020) (Figure 1-26)

Conclusion:

The extension of district heating systems in combination with increasing number of CHP facilities sector has to obtain high priority, directly following DSM measures. This imperative notably applies for RES-CHP plants. The available results reinforce this thesis, since the achieved increase of district heating systems by 20 % subsidy is considerable. But the model structure and the input data have to be more differentiated in order to analyze more detailed promotion schemes and to get more substantial results. On one hand the linkage between supply and demand of heat has to be more specialized – for example also including heat demand beyond the residential buildings – , on the other hand it has to be turned more attention to local heating grids, also linking solar thermal facilities.

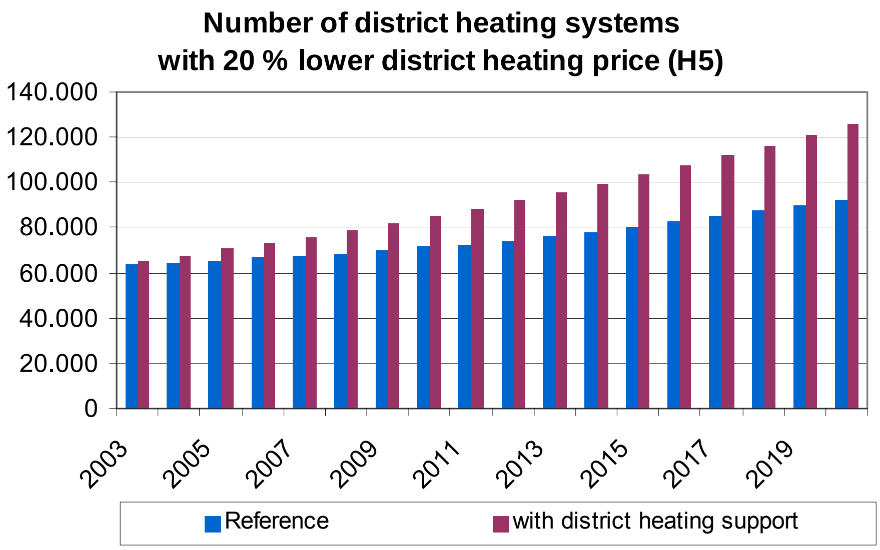


Figure 1-26: Number of heat distr. heat systems (H5)

1.4.6 Hypothesis H6: Top priority for reducing energy demand

Reducing of energy demand has to obtain first priority before all options of increasing the efficiency of energy conversion. Regarding the construction of new buildings this imperative has been taken into account by a strict legislation. But there remains a wide scope of possible measures for existing buildings which is not used enough yet.

It has to be noted that the model is implemented in a manner such that all selected DSM measures get installed by the model if the *total* costs are less than the reduction in heating costs. So, if one of the selected DSM measures (insulation for walls, ceilings and floors and replacement of windows) is not profitable, all measures will not be implemented. Actually windows exchange is much less profitable than insulation. So – for reference scenario and all hypothesis analyses – the introduction of a soft barrier (-0.9) was selected in order to avoid an artificially high restraint for applying DSM measures.

At present the existing promotion includes the grant of soft loans for DSM measures. Furthermore there exists a special Programme for Insulation Materials from Renewable Resources with considerable subsidies. But this promotion scheme is not used as a general promotion scheme in the model because that instrument is not intending primarily the decision for or against an insulation measure but the choice for a specific material. So the model accounts only for soft loans.

Performed variations

- Wall insulation and windows replacement: varying promotion in two steps: down from reference scenario to removal of soft loans and up to introduction of 20 % subsidy.

Main results

- The useful heat energy demand in reference scenario will be reduced by wall insulation and windows exchange measures by 13 % in 2020 against the level today. The removal of the promotion by soft loans would diminish this effect to 10 %; a 20 % subsidy would raise the saving effect to 15,5 % (Figure 1-27.
- Additional DSM promotion leads to a low lifetime promotion efficiency of 2 kg CO_2/€ (
- Figure 1-28). This – at a first view surprising – result is representing the fact that the cost-effective share of refurbishment measures is already applied in reference scenario. The remaining additional measures have much less CO_2 reduction potential because the actual state of the concerning buildings is satisfying a high standard.

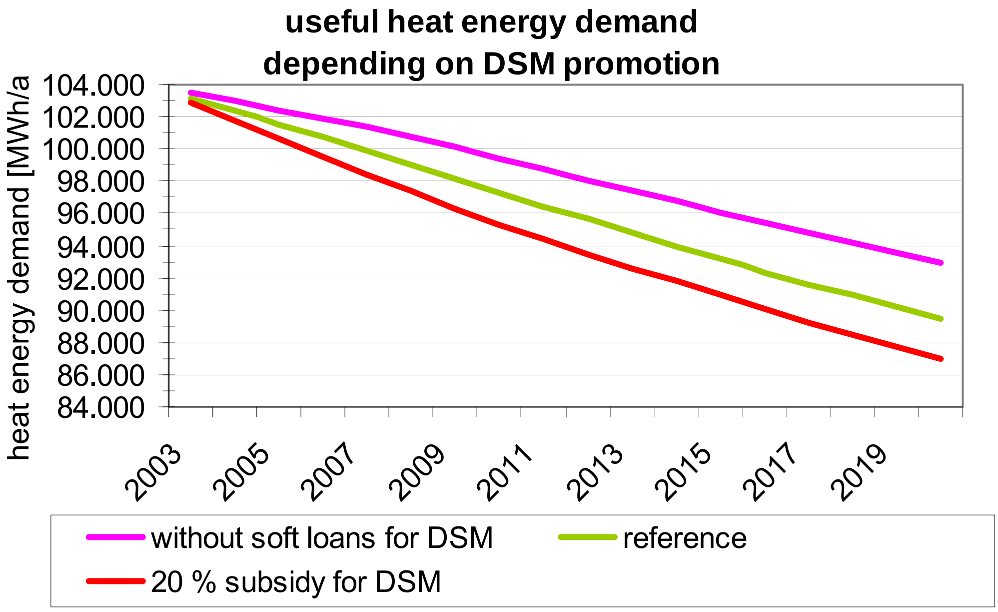


Figure 1-27: Useful heat energy demand (H6) depending on DSM promotion level

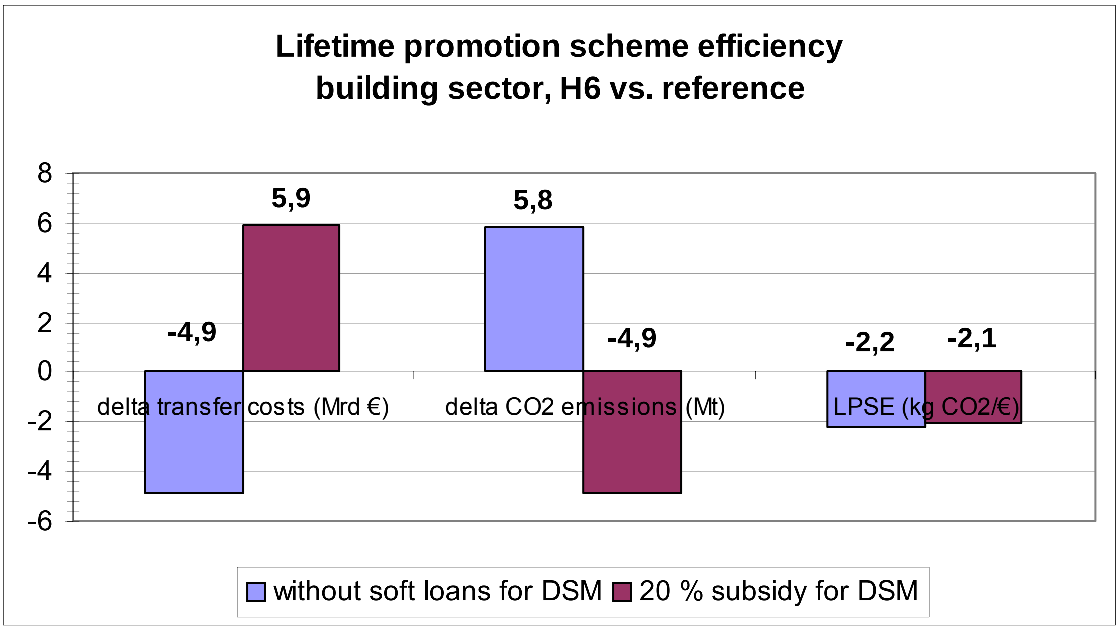


Figure 1-28: Promotion efficiency depending on promotion level (H6)

1.4.7 Hypothesis H7: Effects of a CO_2 tax

Performed variations

- Introduction of CO_2 tax in three steps: 10, 20 and 30 €/t CO_2

Main results:

- In total reducing of CO_2 emissions in heating sector because wood heating systems will mainly substitute gas heating systems.
- A CO_2 tax leads to a lifetime promotion efficiency of 23 kg CO_2/€ (30 € / t CO_2) resp. 28 kg CO_2/€ (10 € / t CO_2) (). (Please note: the exact quantitative data are not realistic because the biomass potential is widely exceeded; the model only is noticing but not preventing the limit exceeding !)

Conclusions:

A CO_2 tax is an effective instrument for building sector. For example for heating systems the additional public income in case of a 30 €/t level is covering the transfer costs (Figure 1-30).

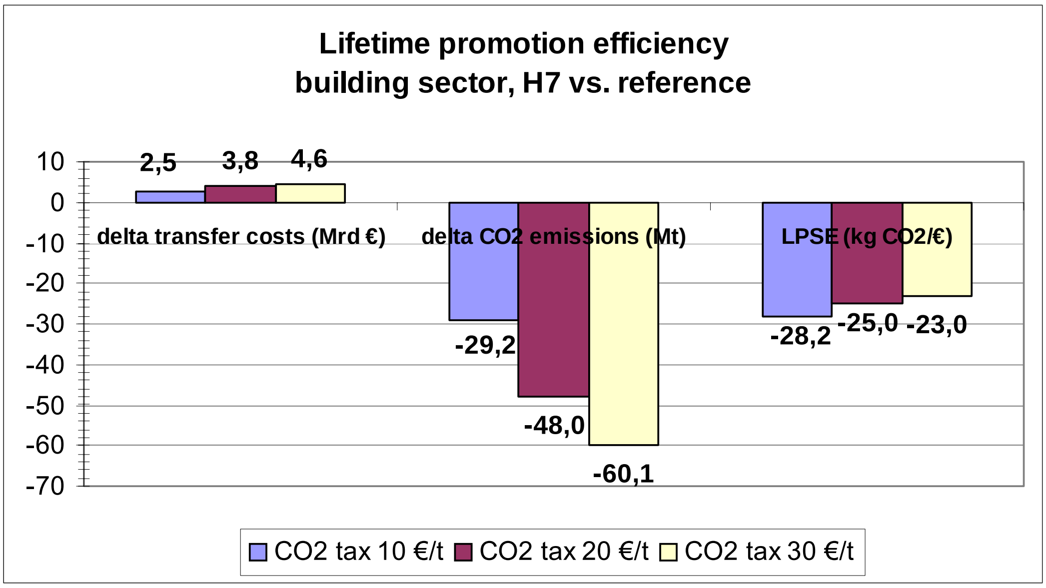


Figure 1-29: Delta transfer costs, Delta CO_2 emissions and lifetime promotion efficiency (H7) for different CO_2 tax levels

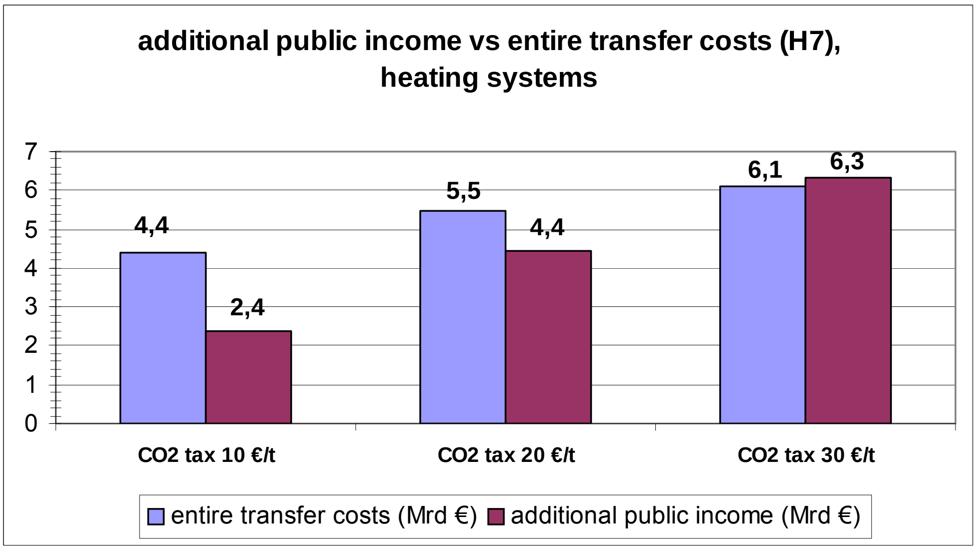


Figure 1-30: Additional public income vs. entire transfer costs for heating systems for different CO_2 tax levels

1.5 References

David, R.; Elsberger, M.; Rouvel, L.: Gebäude und Beheizungsstruktur der Wohngebäude in den alten und neuen Bundesländern: eine Sonderauswertung auf der Grundlage von Daten des Statistischen Bundesamtes Wiesbaden aus der Gebäude- und Wohnungsstichprobe 1993 bzw. der Gebäude- und Wohnungszählung 1995. [2000]. 7 S. + Anhang - Teilprojekt 5, Endenergie: Haushalte. IKARUS, TP 5, Endenergie: Haushalte und Kleinverbraucher

Huber, C.; Faber, T.; Haas, R.; Resch, G.; Green , J.; Ölz, S.; White, S.; Cleijne, H.; Ruijgrok , W.; Morthorst, P.E.; Skytte, K.; Gual, M.; del Rio, P.; Hernández, F.; Tacsir, A. Ragwitz, M.; Schleich, J.; Orasch, W.; Bokemann, M.; Lins, C. (2004) : *Deriving Optimal Promotion Strategies for Increasing the Share of RES-E in a Dynamic European Electricity Market-Final report.* http://www.greenx.at

Informationszentrum Energie (IE), Landesgewerbeamt Baden Württemberg: Energieversorgung Baden-Württemberg 2004. http://www.wirtschaftsinformationen-bw.de/Energie/dl_energiesituation.php

Institut Wohnen und Umwelt GmbH, Darmstadt (IWU): Deutsche Gebäudetypologie – Systematik und Datensätze 2003. www.iwu.de

Kaj Joergensen , Lukas Kranzl, Elena Tsioliaridou, “Rational use of energy and renewable energy sources– a review of current policy strategies and promotion schemes”, INVERT-Altener Program of the European Commission, DG TREN, February 2004

Langniß, Dr. O. u.a.: Evaluierung von Einzelmaßnahmen zur Nutzung erneuerbarer Energien (Marktanreizprogramm) bis August 2004, final report December 2004, (ZSW, ISI).

Nitsch, J.: Situation der erneuerbaren Energien in Deutschland, mögliche Entwicklungen und Schlussfolgerungen für Baden-Württemberg und die Region Südlicher Oberrhein. Vortrag mit Foliensatz 2004.

Nitsch, J.; Bradke, H.; Staiß, F. u.a.: Struktur und Entwicklung der zukünftigen Stromversorgung Baden-Württembergs. DLR 2002.

Staiß, F.: Jahrbuch Erneuerbare Energien 2002/2003

Statistisches Landesamt Baden-Württemberg: Statistische Berichte Baden-Württemberg, Art.-Nr. 3715 02 001: Ergebnisse des Mikrozensus 2002 (2003)

Wirtschaftministerium Baden Württemberg (Hg.): Energiebericht 2001. (2002)

Wirtschaftministerium Baden Württemberg (Hg.): Energiesituation in Baden-Württemberg. 2004. http://www.wirtschaftsinformationen-bw.de/Energie/Downloads/Energiesituation/ESi_BW.pdf

Wirtschaftministerium Baden Württemberg (Hg.): Energiesituation im Haushaltssektor in Baden-Württemberg. 2004. http://www.wirtschaftsinformationen-bw.de/Energie/Downloads/Energiesituation/ESI_Haushalt_BW.pdf

Wirtschaftministerium Baden Württemberg (Hg.): Erneuerbare Energiesituation in Baden-Württemberg. 2004. http://www.wirtschaftsinformationen-bw.de/Energie/Downloads/Energiesituation/EE_BW.pdf

Wirtschaftministerium Baden Württemberg: Förderprogramme im Energiebereich für Wohngebäude in Baden-Württemberg (Bundes- und Landesprogramme). Stand Januar 2005. http://www.wirtschaftsinformationen-bw.de/Energie/Downloads/Foerderprogramme/Foerderbroschuere_Wohngebaeude_1-05.pdf

2 Austria – Vienna

2.1 Structure of the energy supply

2.1.1 Primary Energy Demand and End Energy Consumption

The total final energy consumption in Vienna 2002 amounts to 34 TWh (primary: 41.1 TWh). The high share of oil (40%) is mainly due to the demand in the transport sector. In the heating sector gas (20%) and district heating (15%) are dominating.

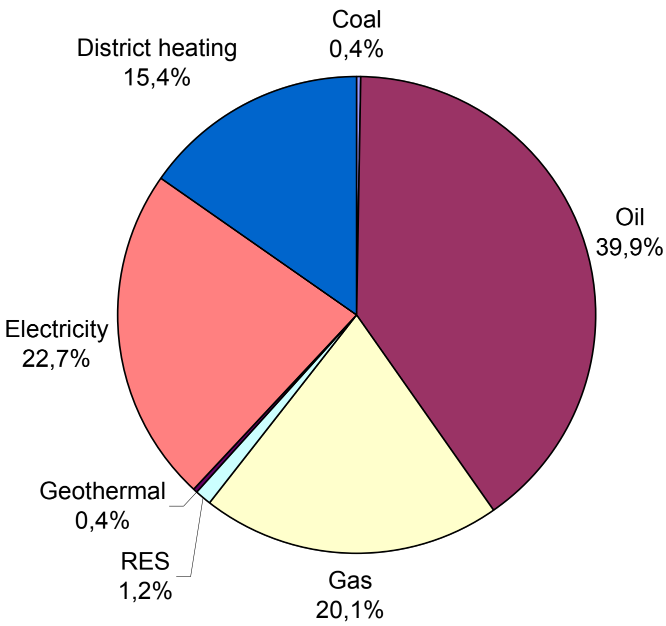


Figure 2-1: Final energy demand Vienna, 2002

34 % of the total final energy consumption is used for transport applications, 33 % in private households, 24% for public and private services and 9 % in the production sector as well as agriculture. 37 % of the total final energy is consumed for heating and domestic hot water purposes.

2.1.2 Heat and power generation

Power generation within the area of Vienna is strongly dominated by three combined heat and power plants (Simmering, Donaustadt, Leopoldau) with a total capacity of 1.5 GW_{el} and 1.1 GW_{th} where the dominating fuel input is natural gas. Electricity generation of these three plants amounts to 5.4 TWh and hence covers 70% of the total electricity consumption in Vienna.

Currently a 65 MW biomass CHP plant is erected near the existing conventional plants Simmering. It is scheduled to put this plant into operation in 2006.

The heat from these CHP plants is fed into the district heating grid of “Wien Energie”. Besides the heat production by CHP there are four waste incineration plants in Vienna amounting to a capacity of 600 kW_{th}. Moreover, there are four peak load heat plants with a capacity of 1 GW_{th}.

Total heat production amounts to around 5.6 TWh. Almost three quarters are generated in CHP plants. The Vienna district heating grid covers around 45% of the total district heating consumption in Austria.

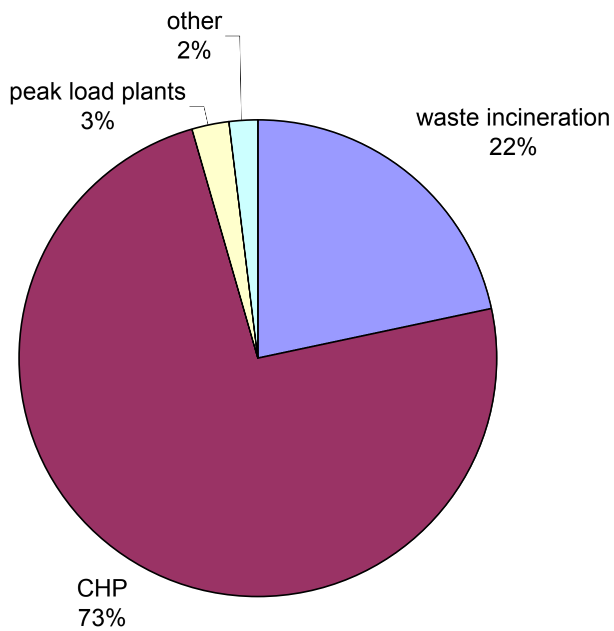


Figure 2-2: District heating generation in Vienna, 2003

2.1.3 Heating sector

The building stock in Vienna covers around 0.8 Mio dwellings. Due to the very urban characteristic, more than 90% of them are multiple dwellings. 42% of the dwellings have central heating systems, 34% heating systems covering one floor. Still there is a share of 23% of all dwellings providing heating with single stoves. However, these systems have been strongly declining in the past two decades.

Gas and district heating are strongly dominating the energy mix for heating in Vienna. Around 58% of the total energy consumption for heating is provided by natural gas, more than a quarter by district heating.

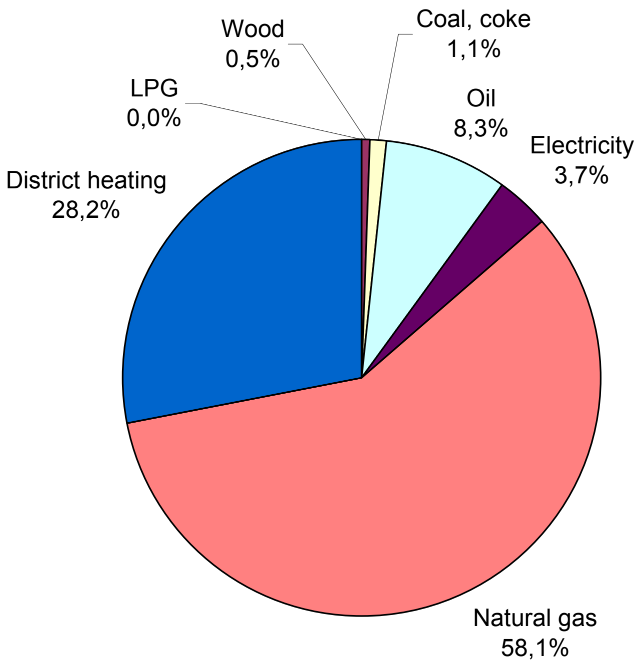


Figure 2-3: Share of energy carriers on the final energy consumption for heating

2.1.4 Renewables

The current generation of electricity from RES in Vienna amounts to around 80 GWh (1% of the total electricity consumption). 40 GWh is provided by landfill gas, 30 GWh by PV and around 8 GWh by wind plants.

Currently a 65 MW biomass CHP plant is erected near the existing conventional plants Simmering. It is scheduled to put this plant into operation in 2006. It is estimated that the plant will generate around 140 GWh_{el} and around 250 GWh_{th}.

Moreover, in 2005 a small hydro power plant generating 24.6 GWh_{el} will be put in operation.

Due to the urban structure, the share of biomass in the heating sector is very low (<1%). The number of solar thermal systems for DHW generation is very low, too. Less than 0.1% of the dwellings are supplied with a solar thermal system.

Currently, there is no production of biofuels within the area of Vienna.

2.2 Promotion schemes in Vienna

A number of national energy policies have an impact on the situation in Vienna. The most important ones are:

- Feed-in-tariffs for RES-E and electricity from CHP: Feed-in-tariffs are determined according to type of technology as well as plant size.
- Energy taxes (e.g. for heating oil, natural gas, electricity, transport fuels)
- Biofuel-quota

On a regional level the municipality of Vienna has adopted a **number** of energy promotion schemes targeting at the reduction of energy demand, the promotion of low-carbon technologies and renewable technologies. The most important ones are:

- Thewosan: This program targets on the improvement of building quality. Depending on the level of building quality which is achieved after refurbishment of the buildings and the amount of energy demand reduction, 30€/m², 45€/m², 60€/m² or 75€/m² are granted.
- Subsidy for biomass heating systems: According to the emission factors grants are given between 20 and 30% of the eligible investment costs. Moreover, costs for maintenance of boilers during the first two years are granted.
- Subsidies for solar thermal systems (30% for DHW systems; 40% for combined systems space heating and DHW).
- Soft loans for window replacement (U-value lower than 1.9, no PVC windows).
- Support for installation of central heating systems and heating systems covering one floor.
- Subsidy for gas-condensing boilers.
- Support for low-energy buildings; requirement of energy efficiency standards for receiving general building construction subsidies.
- Subsidies for connection to district heating.
- Eco-electricity subsidy: Grants are given to PV systems up to 40% of the investment costs.

2.3 Reference Scenario

2.3.1 Essential Assumptions

The Reference Scenario is defined to represent the “business as usual” development based on the existing promotion schemes. The main assumptions are:

- Moderate rise of fossil energy prices by approximately 1% per year (based on WIFO-baseline scenario Austria),
- wood price moderate rise of about 0,2% per year,
- investment decision for new technologies in building sector based on table “stake-holder lifetime”; 10 years for heating and DHW systems, 20 years for solar thermal systems and 25 years for DSM,
- used feed in tariffs are averages from the feed in tariffs distinguished according to various sizes,
- future power generation with biogas or biomass only with CHP,
- medium insulation quality, considering walls, floor, ceiling and windows
- soft barriers for comfort (e.g. wood, coal single stoves), change of heat distribution system from single stove to heating system covering one floor respectively central heating; additional building requirement (e.g. storage availability for wood chips); (especially the soft barriers for central heating systems for the building categories with existing single stoves and heating systems covering one floor turned out to be essential; moreover, biomass heating currently seems very unlikely to become very popular in Vienna and hence has a higher soft barrier),
- support schemes are kept constant until 2020 on the current level.

2.3.2 Characteristics of Reference Scenario

Building Sector

- Moderate growth of district heating.
- Moderate growth of natural gas in the beginning of the simulation period, afterwards slight decrease.
- All other energy carriers decrease (especially oil, electricity, coal).
- Single stove switch mainly to systems covering one floor.
- Wood chips get economic attractive in the last 5 years of the simulation period.

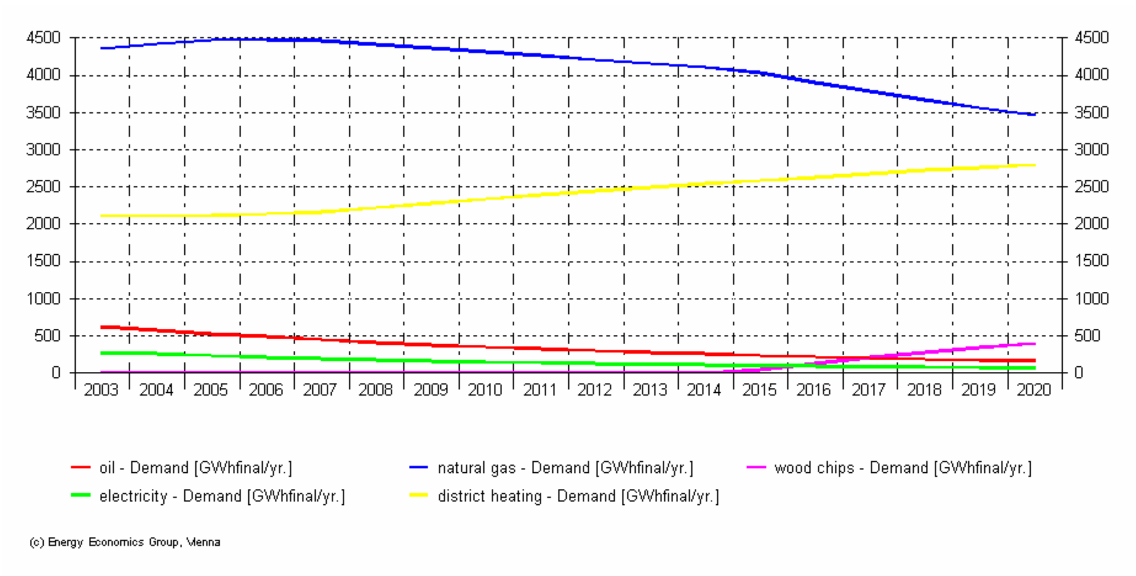


Figure 2-4: Energy carriers for heating, reference scenario Vienna

Figure 2-5 shows that single stoves and heating systems covering one floor are increasingly replaced by central heating systems. Gas condensing systems increase especially in the first decade.

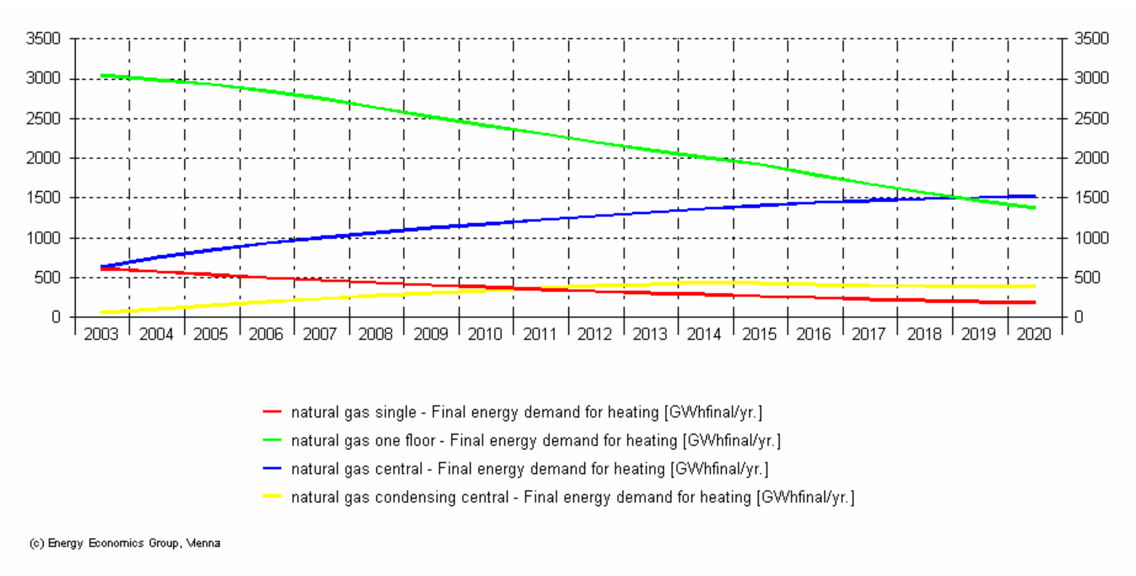


Figure 2-5: Development of gas heating technologies, reference scenario Vienna

DHW systems

- the share of solar thermal systems (indicated as “none” in the figure below) is quite low over the whole simulation period

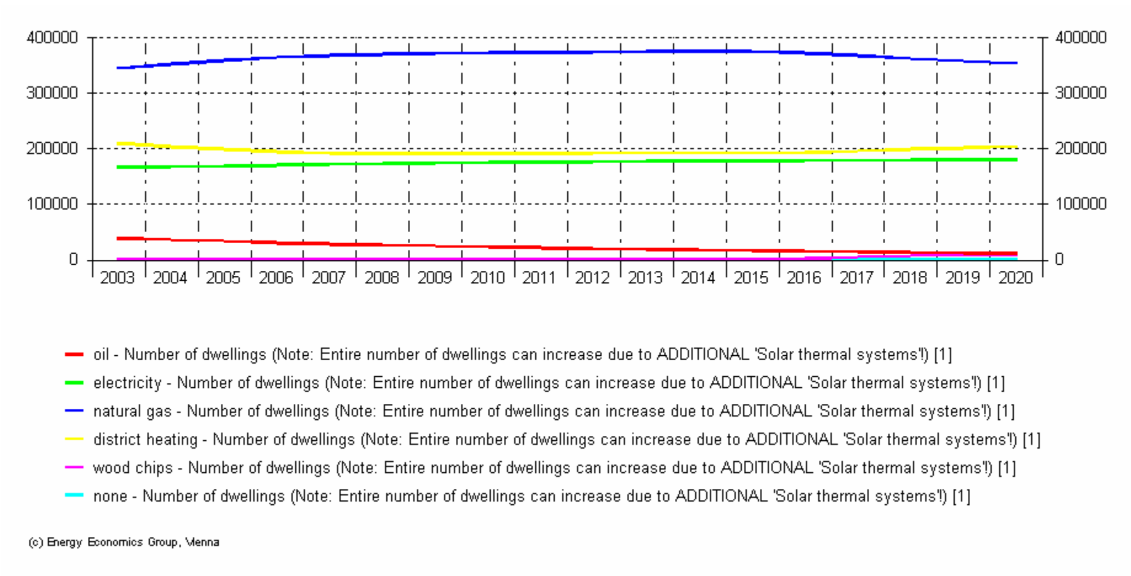


Figure 2-6: Energy carriers for DHW, reference scenario Vienna

DSM measures

- The number of buildings refurbished is relatively low over the whole period. The total useful energy demand reduces by about 10 %.

Useful energy demand decreases by 10%. Building quality is increased for 5000 to 10000 dwellings per year. Due to the change of single stoves to central heating systems, service factors increase. Hence, the final energy demand only decreases by 7%.

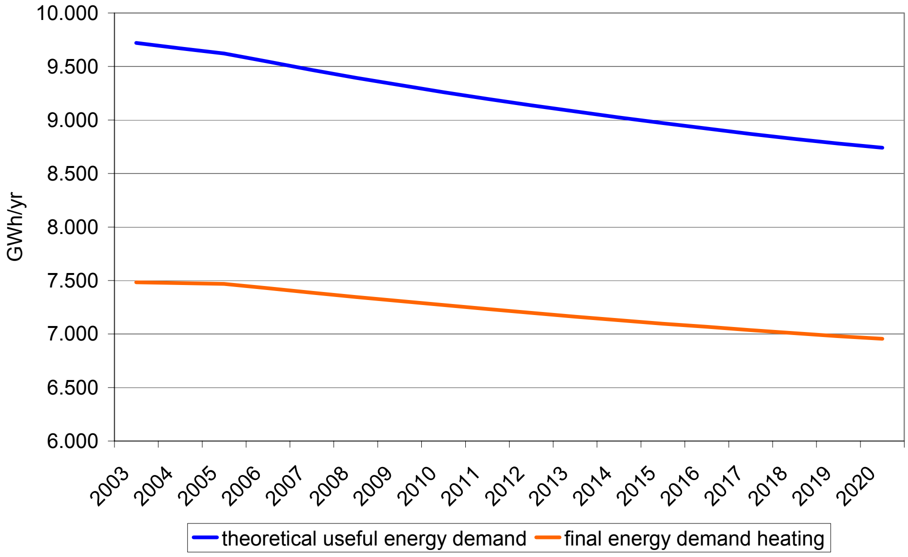


Figure 2-7: Useful and final energy demand for heating, reference scenario Vienna

Reduction of CO_2 emissions due to insulation and window replacement amounts to around 190 kt/ CO_2 per year in 2020.

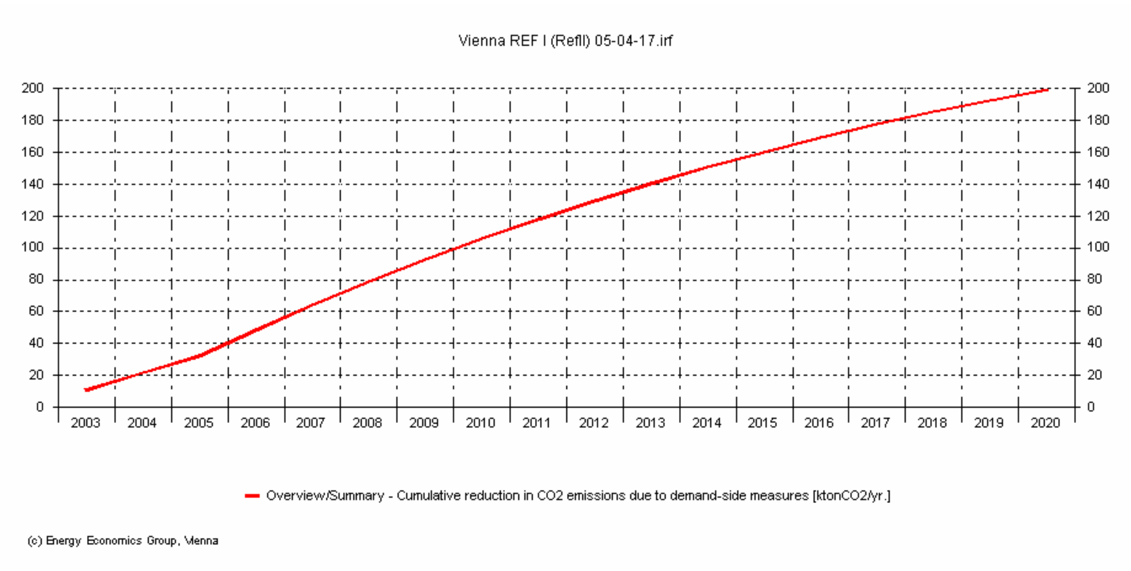


Figure 2-8: Reduction of CO_2-emissions due to insulation and window replacement, reference scenario Vienna

2.3.3 Total effects of all existing promotion schemes

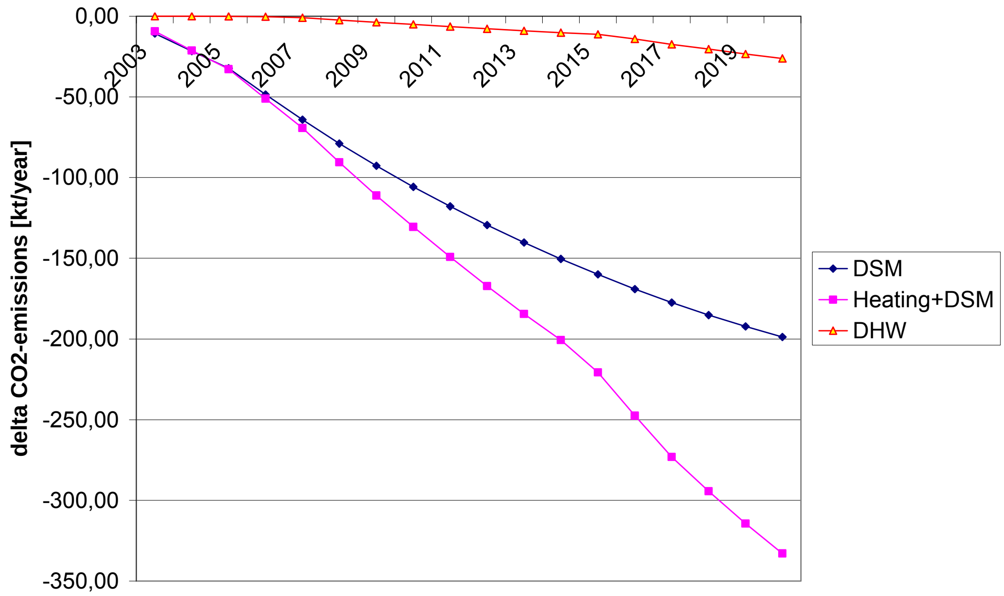


Figure 2-9: Change in CO_2-emissions for DSM, heating and DHW, reference scenario Vienna

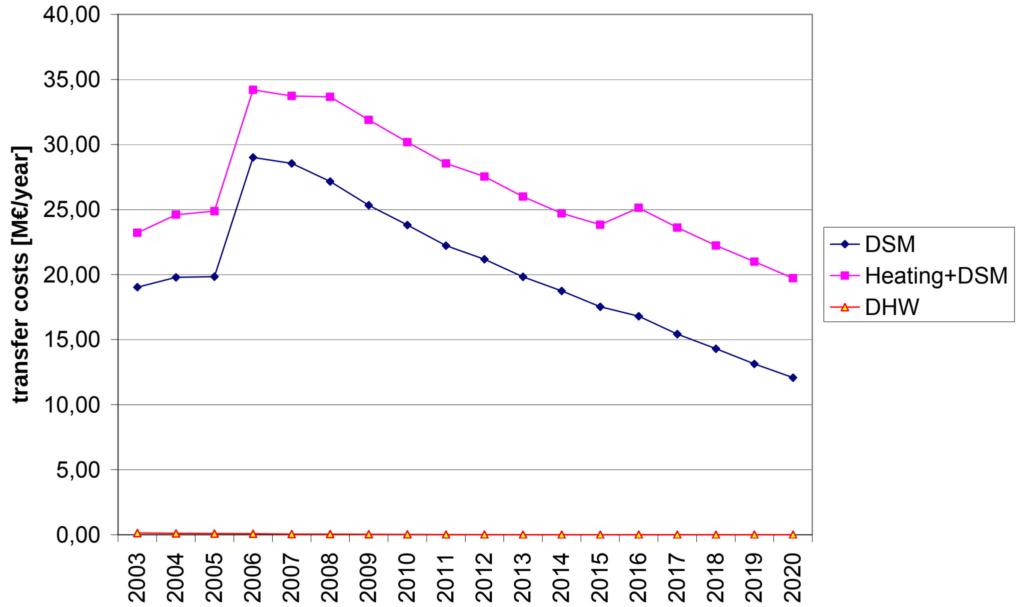


Figure 2-10: Transfer costs for DSM, heating and DHW, reference scenario Vienna

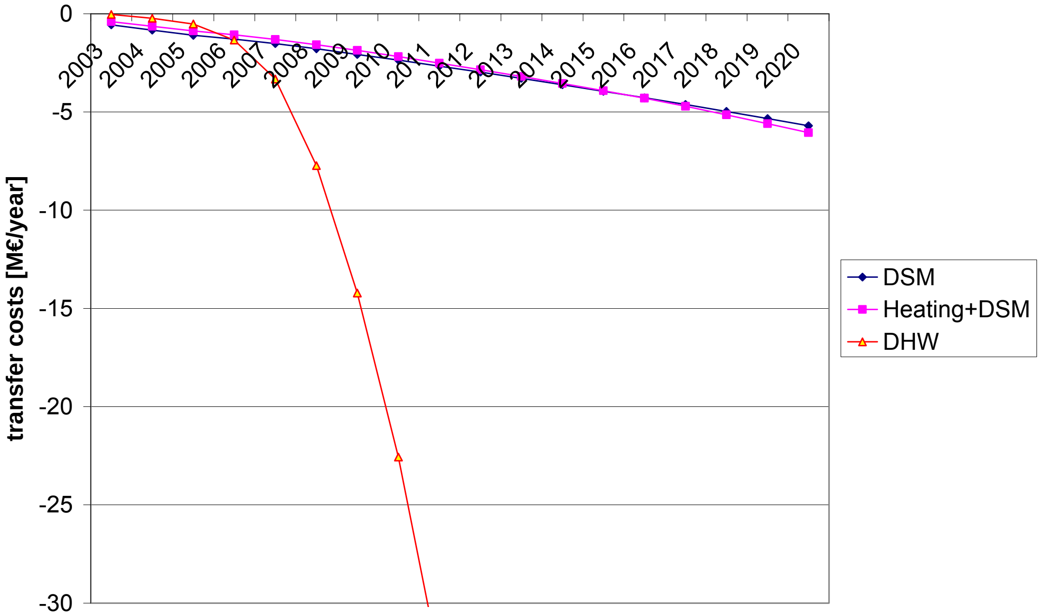


Figure 2-11: Promotion scheme efficiency for DSM, heating and DHW, reference scenario Vienna[4]

Regarding promotion scheme efficiency of current promotion schemes, it turns out, that DHW has clearly the highest efficiency. However, due to the insufficient level of subsidies (see hypotheses), its relevance is very low. The promotion scheme efficiency of insulation is generally in the same range as for heating.

2.3.4 Sensitivity analysis: energy price

The following part shows the result of a sensitivity analysis carried out with respect to various levels of energy price increase. Three scenarios are calculated with varying levels of price increase for all energy carriers: 1%, 2%, 4%.

[4] As the promotion efficiency is based on the "budget relevant spending" in the year n instead of the actual costs, the promotion efficiency is not directly comparable to the CO_2 emission reduction costs known from other literature sources. The values for the promotion scheme efficiency represent the short-term view of a policy maker.
For the anaylsis carried out in work-package 7 (Recommendations and action plan) of this project another indicator has been defined considering also the long-term view. Please take a look on the report of that work package (www.invert.at).

The price increase in all scenarios leads to a higher incentive for insulation and window replacement which results in a reduction of final energy demand. However, in the case of CO_2-emissions there are two overlapping impacts: On the one hand, increased DSM leads to a reduction of emissions, on the other hand, the relation of price between natural gas and district heating changes which leads to a lower penetration of district heating in the scenarios 1% and 2% compared to the reference scenario.[5] Moreover, the increase of all energy prices (i.e. also wood chips) leads to a lower penetration of biomass in the 1% and 2% scenario. The outcome is that in the 1% scenario CO_2-emissions are higher than in the reference scenario, in the 2% scenario they are in the same range and in the 4% scenario they are lower.

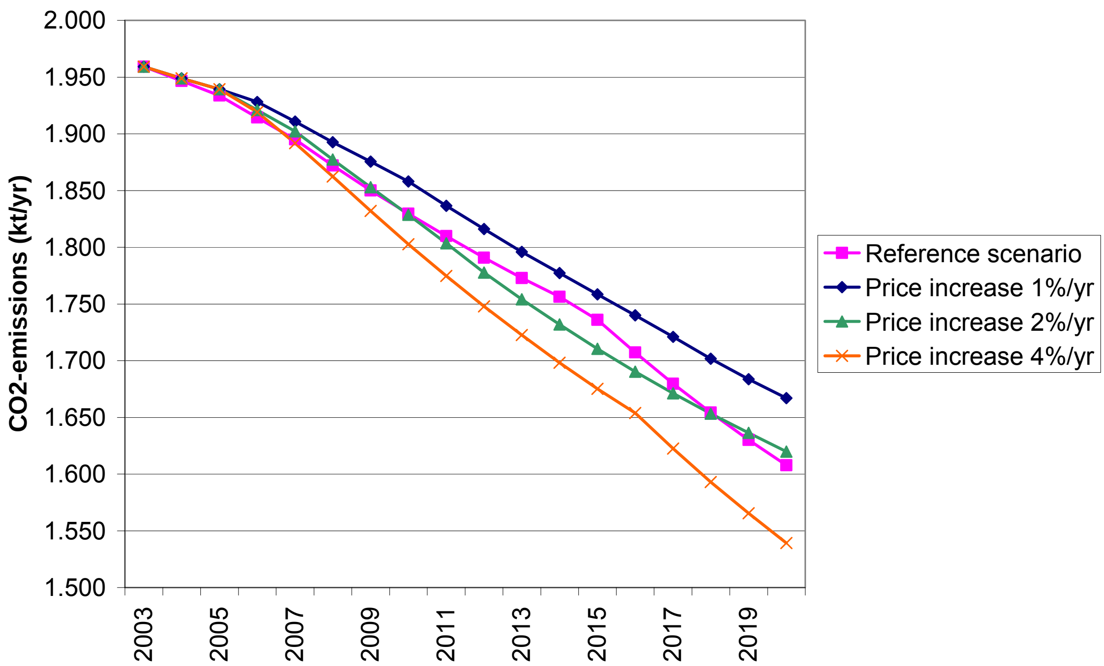


Figure 2-12: Sensitivity of CO_2 reduction towards energy price increase

5 The energy price forecast resemble very much in the 1% and in the reference scenario. However, the price increase in the reference scenario is not the same for all energy carriers and thus differences appear.

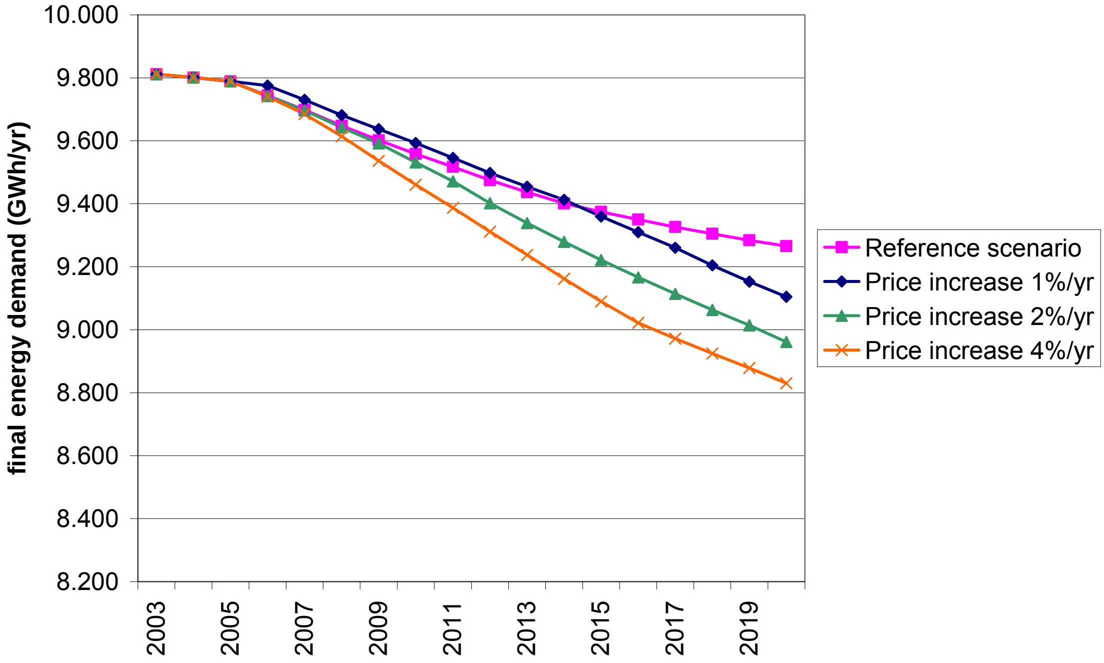


Figure 2-13: Sensitivity of final energy demand reduction towards energy price increase

It can be seen that the energy price has a very high impact on solar thermal systems. In the 4% scenario a very sharp increase of solar thermal systems takes place from 2016 on.

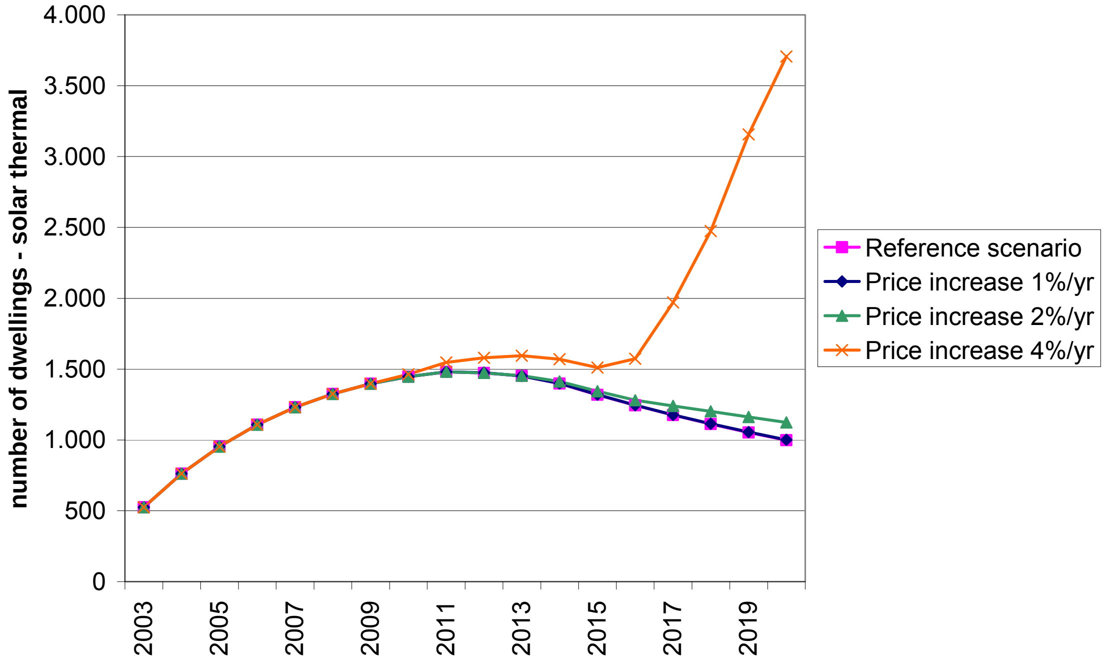


Figure 2-14: Sensitivity of solar thermal uptake towards energy price increase

The promotion scheme efficiency of the existing schemes (compared to a scenario without schemes) is lower in the scenarios with a higher price increase. This is due to the fact that DSM measures would occur in any case with higher energy prices and the impact of the schemes is lower due to a higher free-rider effect.

2.4 Analysis of hypotheses

General remarks

Due to the structure of Vienna as an almost completely urban area, the relative low potentials for RES (especially biomass and biofuels) as well as the focus of current promotion schemes on the building part, the case study of Vienna is restricted to the building part.

2.4.1 Hypothesis H1: Restriction of RES&RUE subsidies to buildings without access to district heating is not efficient

In Vienna, subsidies for some technologies are restricted to buildings which are not situated in the district heating supply area. This is especially the case for solar thermal systems, biomass and gas condensing boilers. The following hypotheses investigate the impact of extending theses subsidies also to buildings which have optional access to district heating.

2.4.1.1 Hypothesis H1-1: Restriction of solar thermal subsidy to buildings without access to district heating is not efficient

Performed variations

- Solar thermal subsidy (30%) available for all buildings, not only those without access to district heating

Main results

- There is no significant increase of solar thermal systems. The reason is, that the existing promotion scheme for solar thermal systems in general is not sufficient to provide a significant positive incentive. Hence, the impact of extending this insufficient scheme on the district heating supply area is negligible.
- Hence, the measure has nearly no impact on CO_2 emissions and transfer costs as well.

The impact of general higher promotion schemes for solar thermal systems is investigated in Hypotheses H-7.

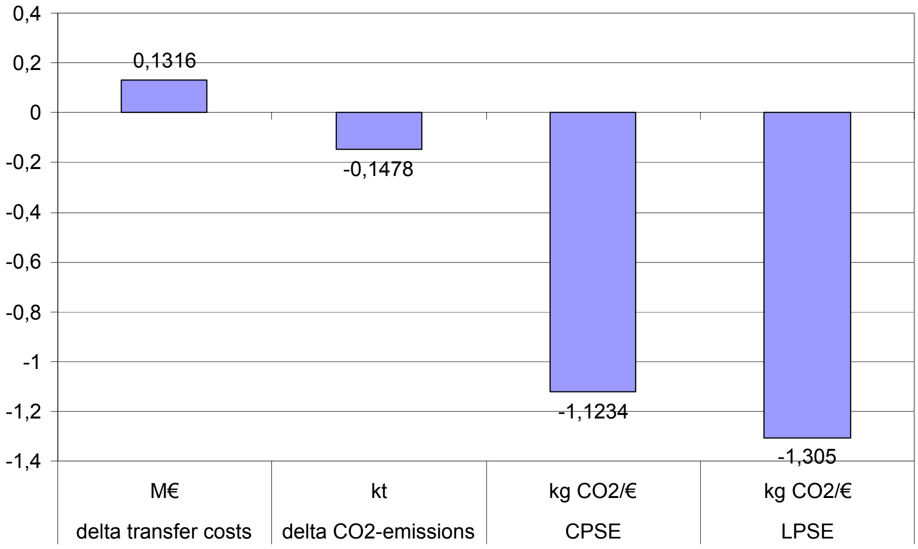


Figure 2-15: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_1: solar thermal subsidy also in the district heating area))

2.4.1.2 Hypothesis H1-2: biomass subsidy for buildings situated within the the district heating supply area

Performed variation:

- Access to biomass subsidy also in areas where district heating is available.

Main results:

- The overall development of various energy carriers strongly resembles the reference scenario. However, the increase of biomass systems at the end of the simulation period is stronger than in the reference scenario, which is due to the systems installed within the district heating supply area: Around 400 GWh are provided by biomass systems in this scenario in 2020, compared to around 320 GWh in the reference scenario. It turns out that the biomass systems primarily reduce the switching of other systems to district heating.
- Due to the lower CO_2-emission factor of biomass compared to district heating, this leads to a reduction of around 5.5 kt CO_2 in 2020.
- Transfer costs are more than 1 M€/yr in the last three years of the simulation period. This results in a promotion scheme efficiency of around –3 (CPSE), -36 (LPSE) respectively.

Hence, one could conclude that extending the promotion schemes for biomass systems to the district heating supply area is reasonable. Of course there are also other parameters to be taken into consideration: fuel transport, emissions (CO, NO_x, VOC), etc. This result thus can as well be seen as a conclusion for the extension of the district heating grid: It could be more effective to promote small biomass heating grids as well as biomass heating systems for big multiple dwellings in the outskirts of Vienna than promoting a strong and expensive grid extension in these areas. Biomass systems here could as well be regarded as micrograds (which in fact has not been investigated within this project in detail).

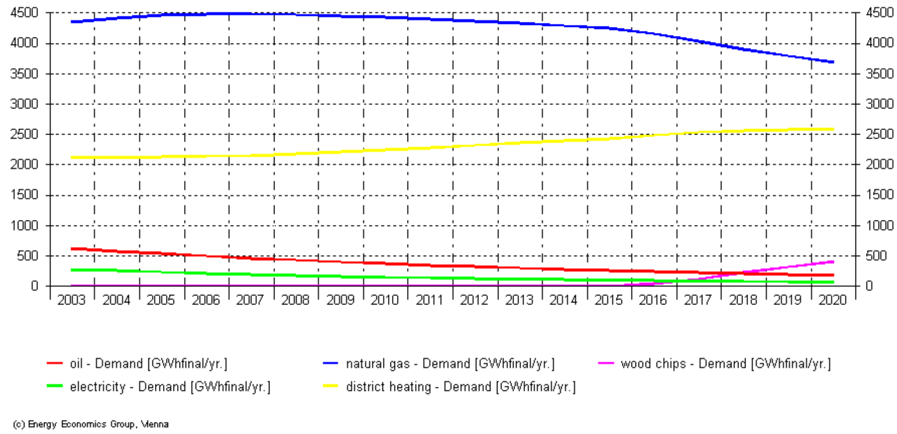


Figure 2-16: Energy carriers for heating, H1-2, Vienna

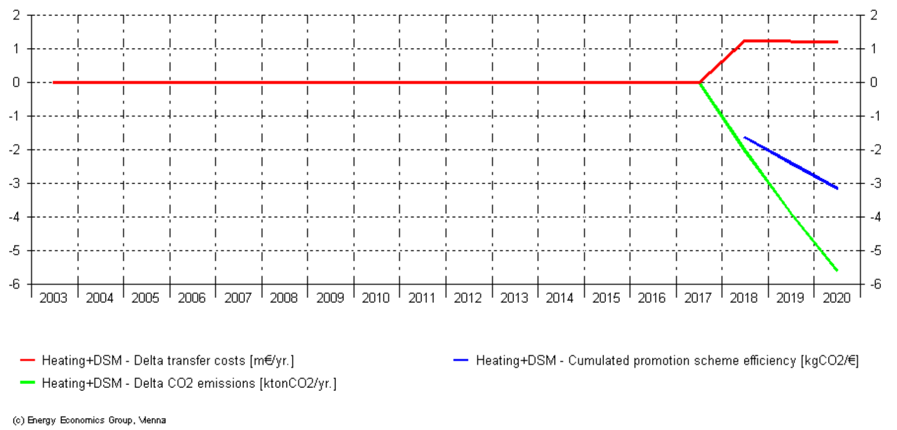


Figure 2-17: Promotion scheme efficiency, H1-2, Vienna[6]

[6] As the promotion efficiency is based on the "budget relevant spending" in the year n instead of the actual costs, the promotion efficiency is not directly comparable to the CO_2 emission reduction costs known from other literature sources. The values for the promotion scheme efficiency represent the short-term view of a policy maker.
For the anaylsis carried out in work-package 7 (Recommendations and action plan) of this

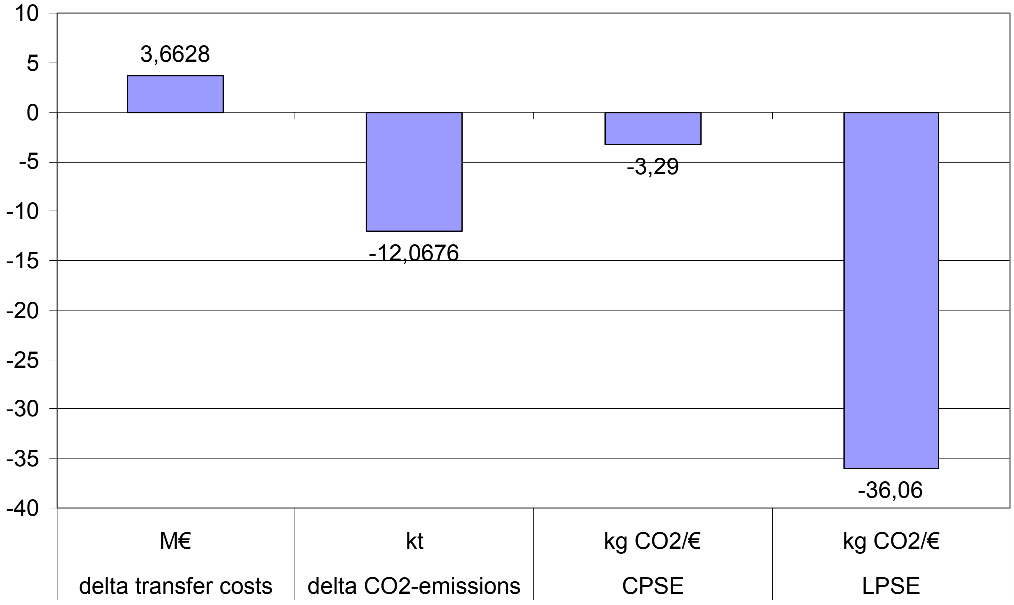


Figure 2-18: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_2: biomass subsidy also in the district heating area))

2.4.1.3 Hypothesis H1-3: gas condensing boilers for buildings with availability of district heating would be reasonable

Performed variation:

- Access to gas condensing boilers subsidy also in areas with access to district heating.

Main results:

- The measure leads to a higher penetration of gas condensing boilers. 510 GWh of heat are provided by gas condensing boilers in 2020 compared to 410 GWh in the reference scenario.
- However, the impact on CO_2-emissions is dubious. In the first years (until 2007) gas condensing boilers primarily replace conventional gas systems (compared with the reference scenario). This leads to a reduction of about 2,000 t CO_2 per year in 2007.

---

project another indicator has been defined considering also the long-term view. Please take a look on the report of that work package (www.invert.at).

In the following years (2007-2011) gas condensing boilers primarily replace district heating (compared to the reference scenario) which leads to an increase of annual CO_2-emissions of nearly 4,000 t/yr in 2011. The impact in the last period (2011-2020) is quite low, which is similar to the reference scenario: Natural gas systems are getting less attractive.

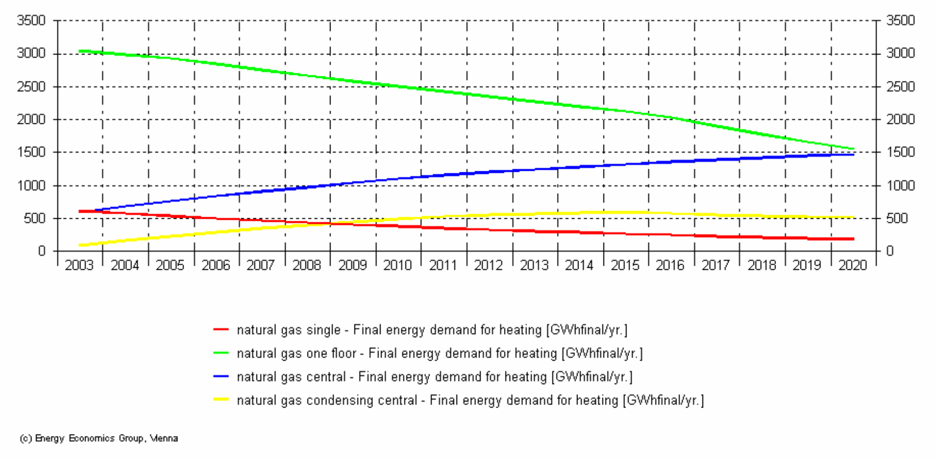


Figure 2-19: Development of gas heating systems, H1-3, Vienna

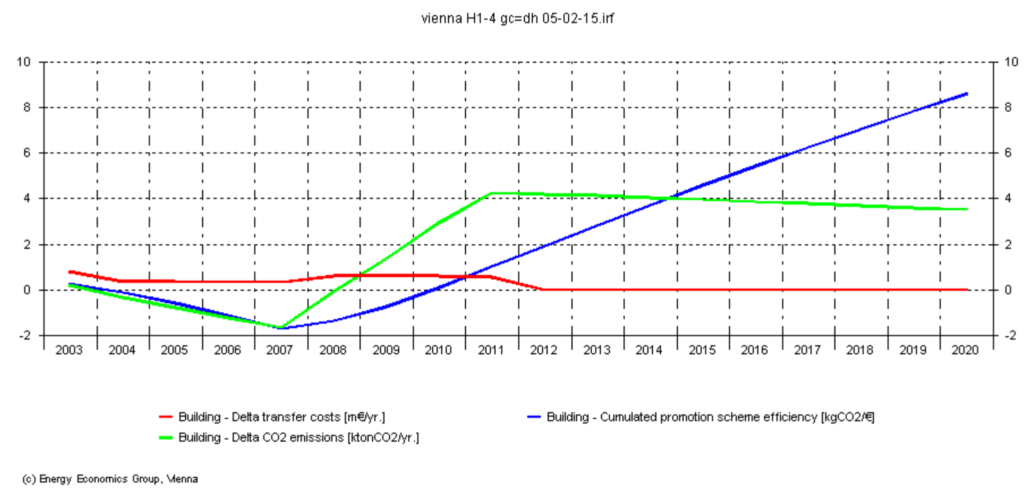


Figure 2-20: Promotion scheme efficiency for heating, H1-3, Vienna[7]

[7] As the promotion efficiency is based on the "budget relevant spending" in the year n instead of the actual costs, the promotion efficiency is not directly comparable to the CO_2 emission reduction costs known from other literature sources. The values for the promotion scheme efficiency represent the short-term view of a policy maker.
For the anaylsis carried out in work-package 7 (Recommendations and action plan) of this project another indicator has been defined considering also the long-term view. Please take a look on the report of that work package (www.invert.at).

The following figure shows the change in transfer costs, CO_2-emissions, CPSE and LPSE in the whole simulation period for this hypothesis.

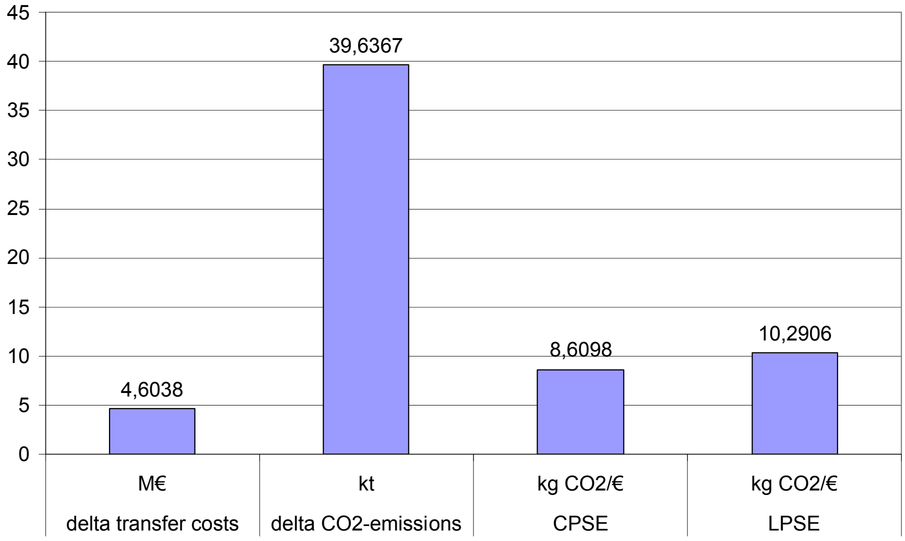


Figure 2-21: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_3: gas condensing subsidy also in the district heating area))

2.4.2 Hypothesis H2: Subsidy for gas condensing boilers are not justified

Performed variations

- Removal of all existing subsidies for gas condensing boilers

Main results

- Without subsidies almost no gas condensing boilers would be installed.
- In the first decade of the simulation period the removal of subsidies for gas condensing boilers results in a higher share of conventional gas central systems. This leads to higher CO_2-emissions. Hence, one could conclude that the subsidies for gas condensing boilers lead to a substantial CO_2 reduction (of about 10 kt per year in the year 2013). (-8kg/€ in 2013)
- However, in the last years of the simulation period, the removal of subsidies for gas condensing boilers lead to an earlier introduction of wood chips than in the reference

scenario. In this period the existence of these subsidies hinders the competitiveness of wood chip heating systems.

The promotion scheme efficiency has to be interpreted very carefully, because a change of the quadrants takes place during the simulation period. The “net” cumulated promotion scheme efficiency of removing the subsidy for gas condensing boilers in the second period is around -14 kg CO_2/€ (in the period 2014-2020). (It has to be noted that also in the reference scenario no new gas condensing central systems would be installed after 2015). (see footnote 7)

It has to be concluded that the simultaneous promotion of gas condensing and biomass boilers leads to inefficiency because two competing systems are promoted at the same time. However, due to the fact that the impact of biomass promotion is low in the first period of the simulation anyway, this loss of efficiency in this period is very low, too.

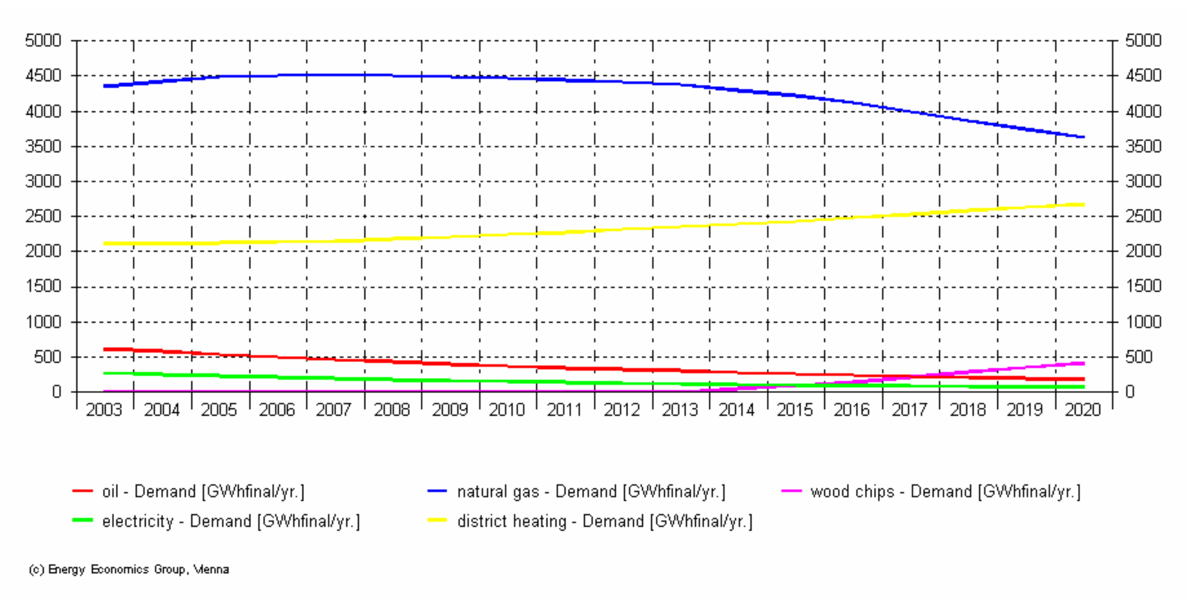


Figure 2-22: Energy carriers for heating, H2, Vienna

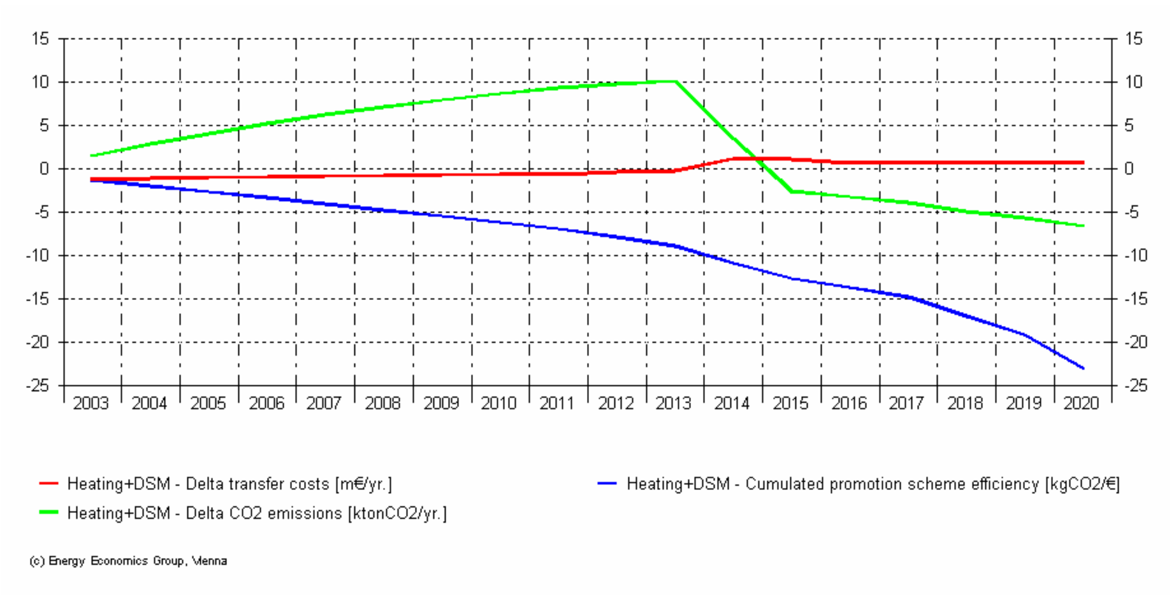


Figure 2-23: Promotion scheme efficiency, H2, Vienna

The following figure shows the change in transfer costs, CO_2-emissions, CPSE and LPSE in the whole simulation period for this hypothesis. In a cumulated view, there is a reduction of CO_2-emissions. However, as pointed out above, the impact in the second period (after 2013) is negative. The CPSE and LPSE indicators in fact are a mixture of these two periods. For the CPSE the impact of reducing subsidies for gas condensing boilers prevails over the impact of fostering biomass. This results in a higher value of CPSE which means that compared to the gain of public budget high additional CO_2-emissions have to be accepted. The LPSE takes into account the additional CO_2-reductions after 2020, too. This results in a higher weight for the impact in the second period of the simulation: The reduction of CO_2-emissions resulting in higher transfer costs.

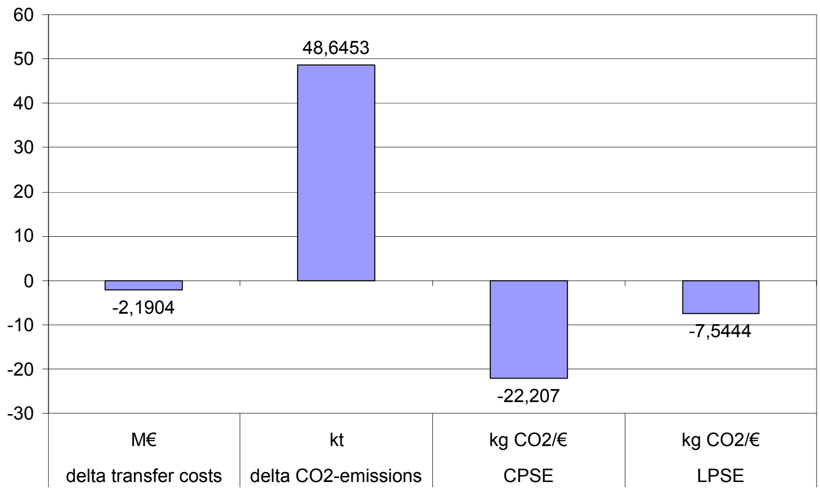


Figure 2-24: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H2: no gas condensing subsidy)

2.4.3 Hypothesis H3: current tariff structure of district heating does not provide enough incentives for demand side measures

Currently, a high flat rate for district heating exists in Vienna. For buildings with a higher building quality (ca. 60 kWh/m²/yr) the share of variable costs is only about one third of the total annual costs of the heating system. [8]

Performed variations

- Reduction of the flat rate district heating price by 2/3
- Increase the energy price of district heating to an amount that the average consumer is faced with the same total costs for district heating.

Main results

- The change in tariff structure leads to a higher reduction of useful energy demand (total reduction: around 15% instead of 10% in the reference scenario)
- While in the first decade the change in the tariff structure leads to a competitive advantage of district heating vs. gas and oil, this changes in the second decade. How-

8 Fernwärme Wien, the district heating company of Vienna recently has introduced a special district heating tariff for low-energy buildings. The flat rate is reduced by 14% for buildings with a final energy demand of less than 50 kWh/m²/yr.

ever, in 2017, the number of dwellings supplied with district heating is the same as in the reference scenario. Before it's higher, afterwards it's lower. Hence, from the CO_2 reduction in the year 2017 we can get the net-impact of changing the tariff structure: 4 kt.

- The higher incentive for insulation and window replacement leads to higher transfer costs (DSM promotion schemes are the same as in the reference scenario!). This leads to relatively high transfer costs resulting in a low promotion scheme efficiency of around -0.6 $kgCO_2$/€.

The results of this hypothesis-testing show, that the tariff structure has a high impact on the economic efficiency of insulation and window replacement. However, the impact on CO_2-emissions is not very high due to the low CO_2-emission factor of district heating in Vienna.

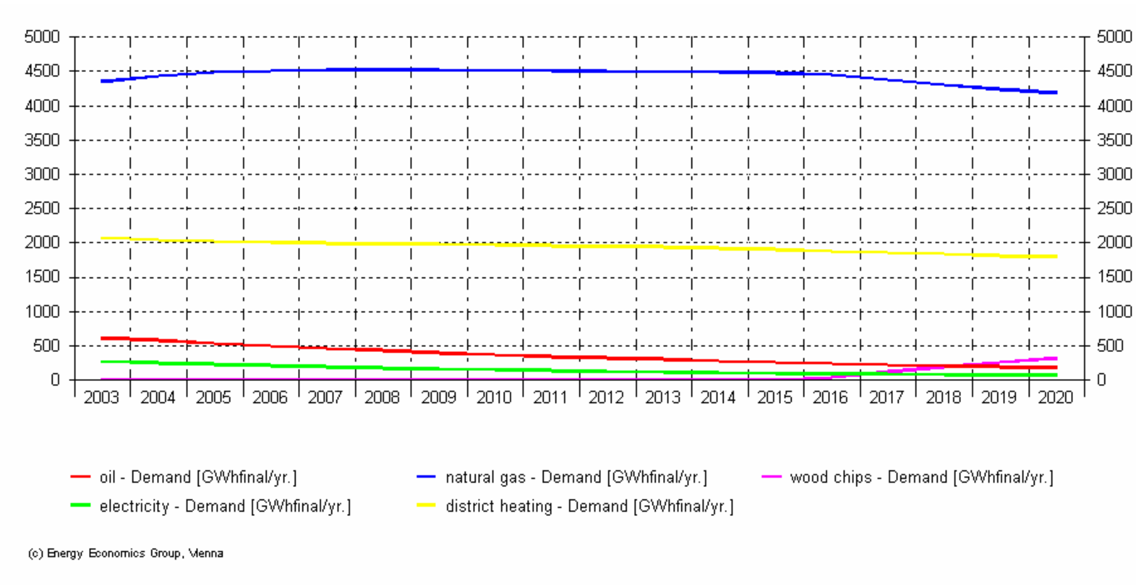


Figure 2-25: Energy carriers for heating, H3, Vienna

The following figure shows the reduction of total final energy demand for heating and domestic hot water due to the change in the tariff structure of district heating: DSM becomes attractive for buildings with district heating, too.

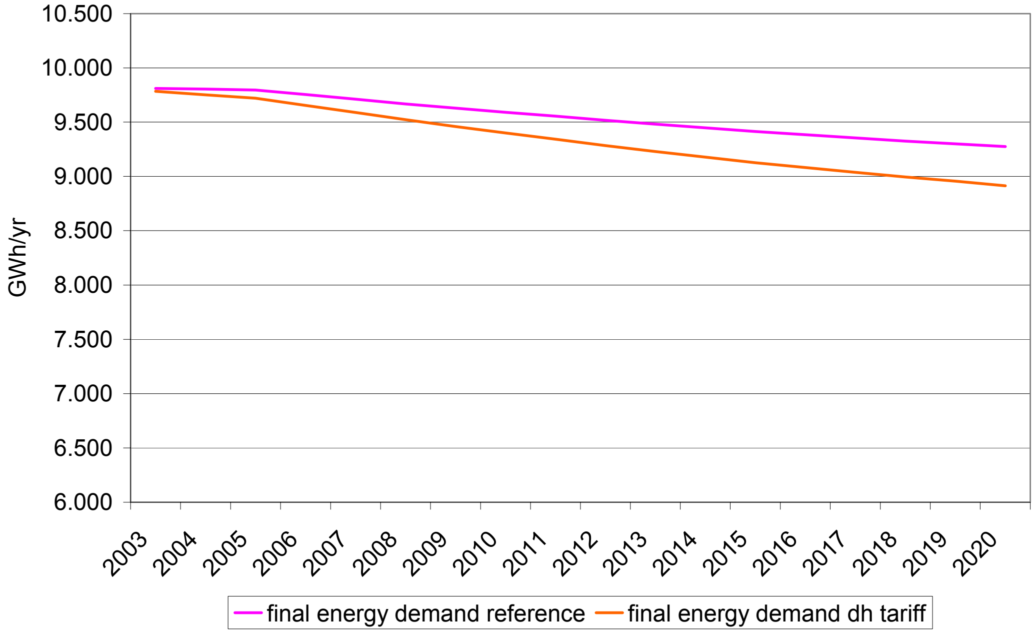


Figure 2-26: Reduction of final energy demand due to change of tariff structure district heating

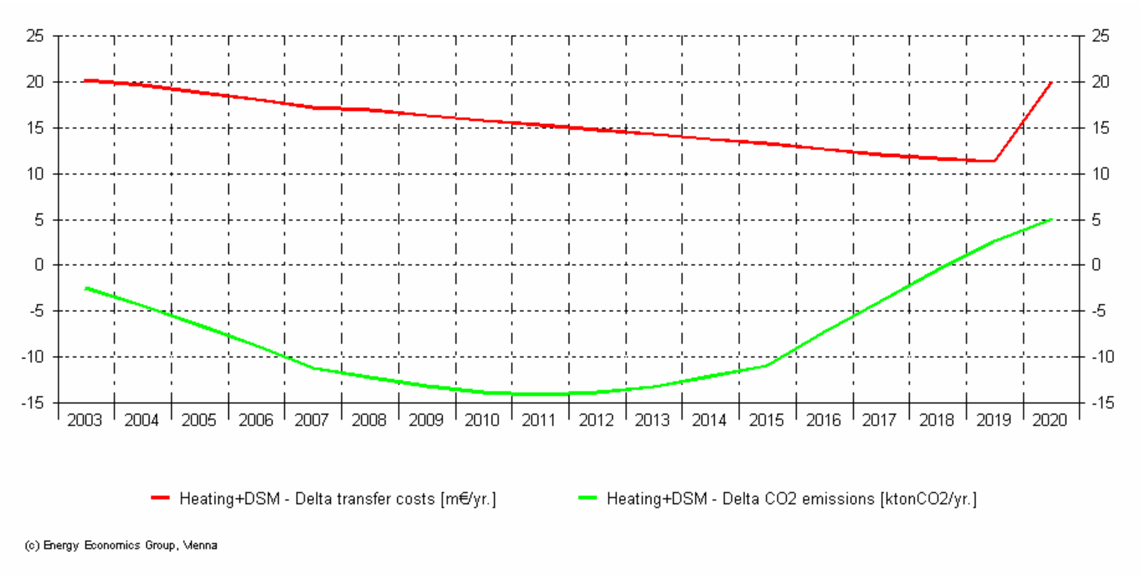


Figure 2-27: Transfer costs and CO_2-emissions, H3, Vienna

2.4.4 Hypothesis H4: Comparison of various level of DSM-subsidies

Performed variation:

- Varying the level of DSM subsidies by +/- 10€/m²

Main results:

- CO_2-emissions would increase by 840 kt in case of a reduction of DSM subsidy and would rise by 890 kt in case of an increase. This would lead to total transfer costs in the range of -230M€ (decrease of subsidy) and 550M€ (increase of subsidy) (cumulated until 2020). The figures below show the impact of increasing vs. decreasing DSM subsidies on he reduction of final energy demand and CO_2-emissions.
- The promotion scheme efficiency (LPSE) varies between –10 kg/€ and –4 kg/€ when varying the level of subsidy by +/- 10€/m².
- As for most promotion schemes, the promotion scheme efficiency is getting lower with higher grants, because this implies the promotion of expensive, inefficient applications. Hence, the optimum level of subsidy depends on the promotion scheme efficiency of alternative schemes. (compare with: district heating, biomass, heat pump, solar thermal).

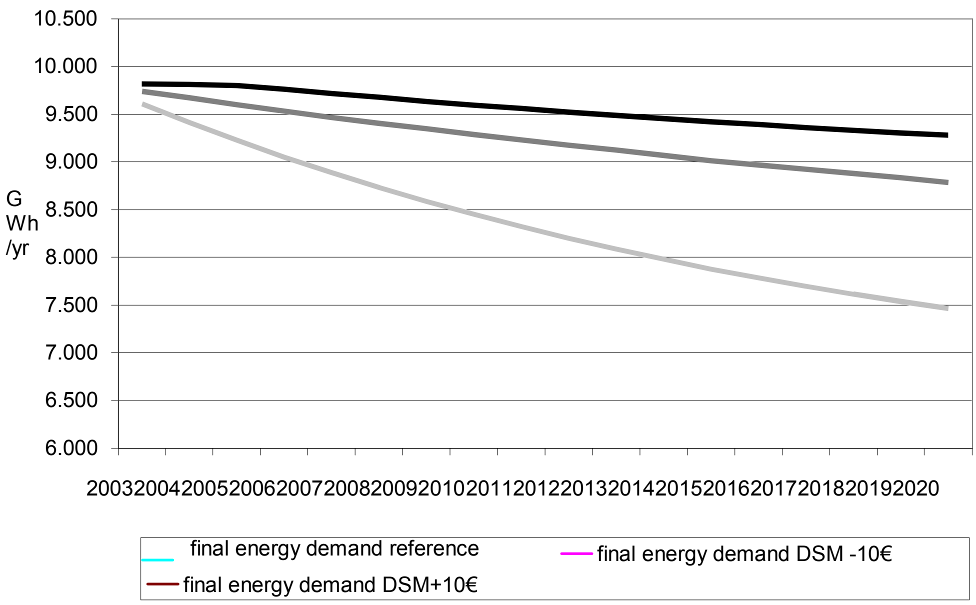


Figure 2-28: Final energy demand heating and DHW, DSM, Vienna

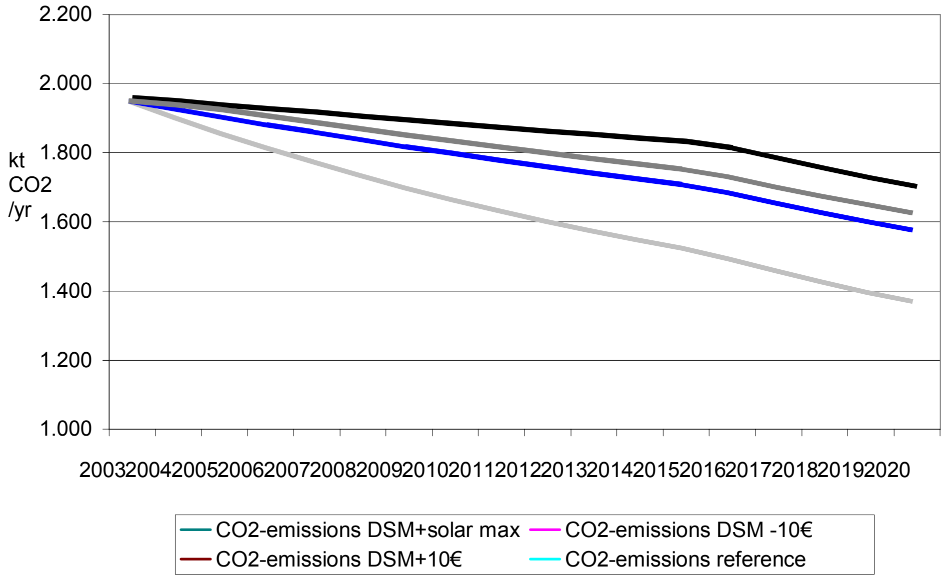


Figure 2-29: CO_2-emissions heating and DHW, DSM, Vienna

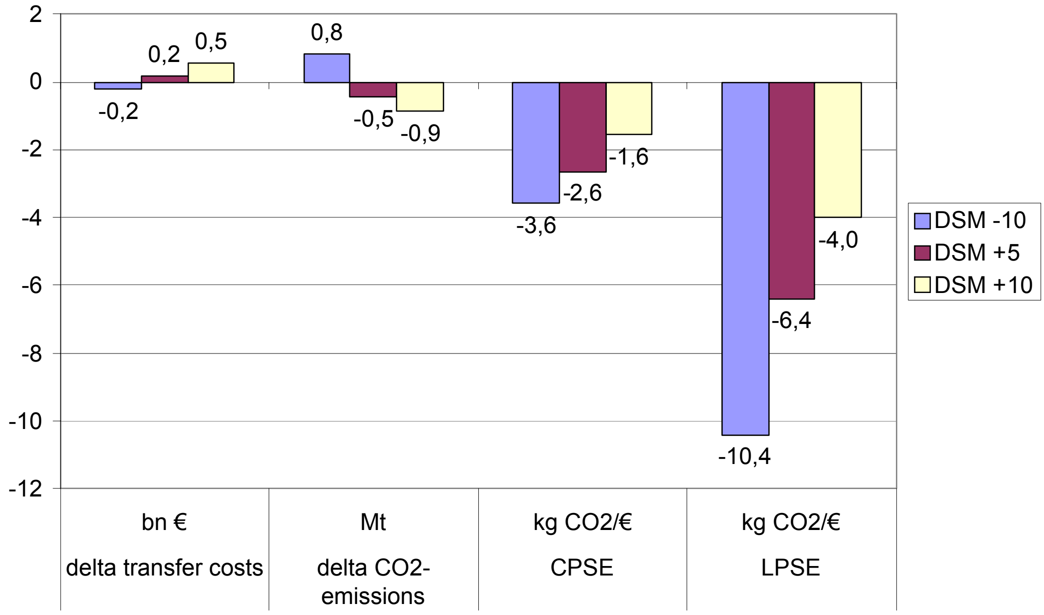


Figure 2-30: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (changing the level of DSM subsidy)

In a maximum DSM Scenario CO_2-emissions could be reduced by 4 Mt (cumulated 2020). For this scenario it was assumed that all buildings getting refurbished replace their windows and insulate walls, ceiling and floor. It turns out that in the +10€/m² scenario around 22% of this potential would be achieved.

2.4.5 Hypothesis H5: FIT for PV on national level is not sufficient, additional PV subsidy from Vienna is necessary;

Performed variations:

- Variation of the level of regional PV subsidy between 0 and 40% (Currently up to 40% are granted.)

Main results:

- Only the FIT would not be enough to guarantee general economic competitiveness of PV systems in Vienna. New PV installations would not be economic efficient.

As is shown below, subsidising PV systems additionally leads to substantially higher electricity generation.

However, “local” promotion scheme efficiency, which considers only the regional subsidy, not the national FIT, is rather low with about –0.6 kg/€ for all level of subsidies. The total promotion scheme efficiency (including FIT) would still be much lower than the “local” one.

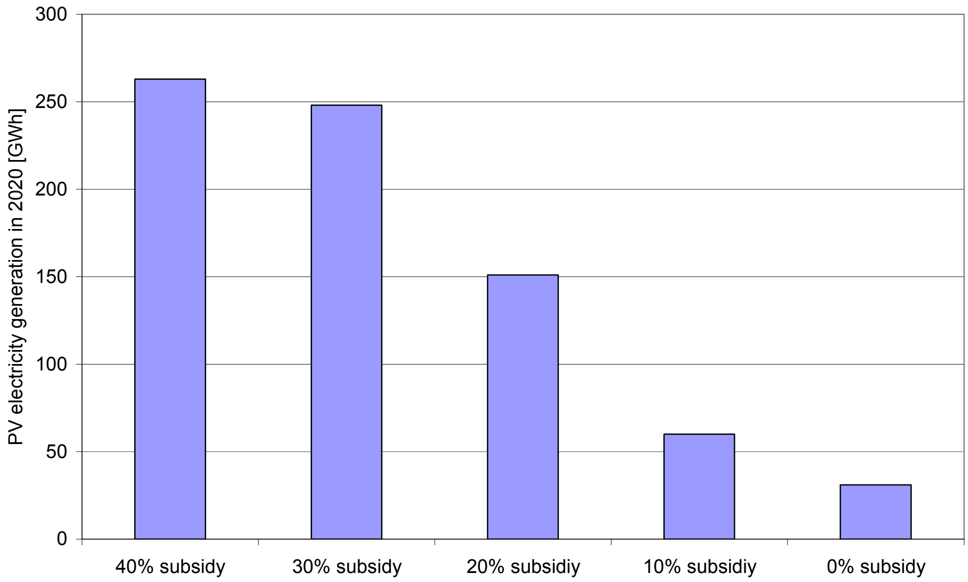


Figure 2-31: PV electricity generation, Vienna

Due to the strong learning rate that is expected for PV systems a cost-depending decrease of the subsidy would be efficient. This can be seen from the fact that the difference between the impact of 30% and 40% subsidy scheme is quite low, because in the second decade 30% subsidy turns out to be enough for all of the PV potential bands in Vienna.

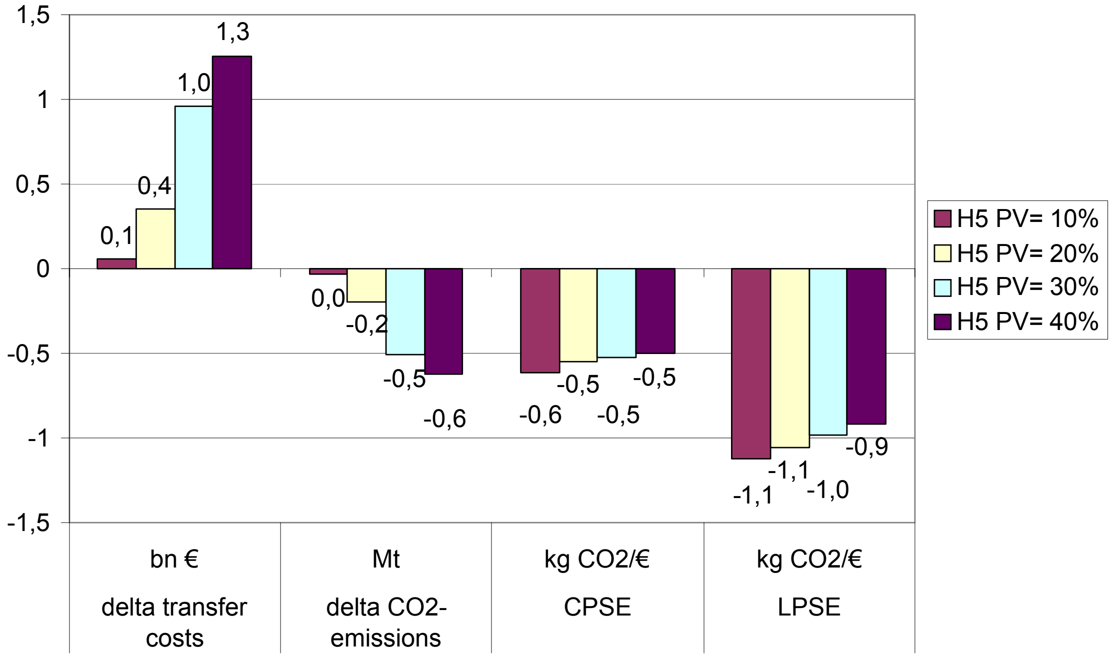


Figure 2-32: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (changing the level of PV subsidy)

2.4.6 Scenario: introduction of CO_2-tax

Performed variation:

- Introduction of a CO_2-tax amounting 3€/ton in the building part. (Results for 5€, 10€, 20€ and 30€ are shown at the end of this part.)

Main results:

- The CO_2-tax leads to a decrease of 25 kt per year. (446 kt cumulated until 2020. It advances the introduction of biomass heating systems by approximately 2 years.
- At the beginning of the simulation the public income due to the CO_2-tax amounts to 4.3 M€ which declines to 3.3 M€ in 2020, due to the lower CO_2-emissions. Within

the first 10 years of the simulation the transfer costs due to subsidies in the building part could be financed by these tax income by almost 100%.

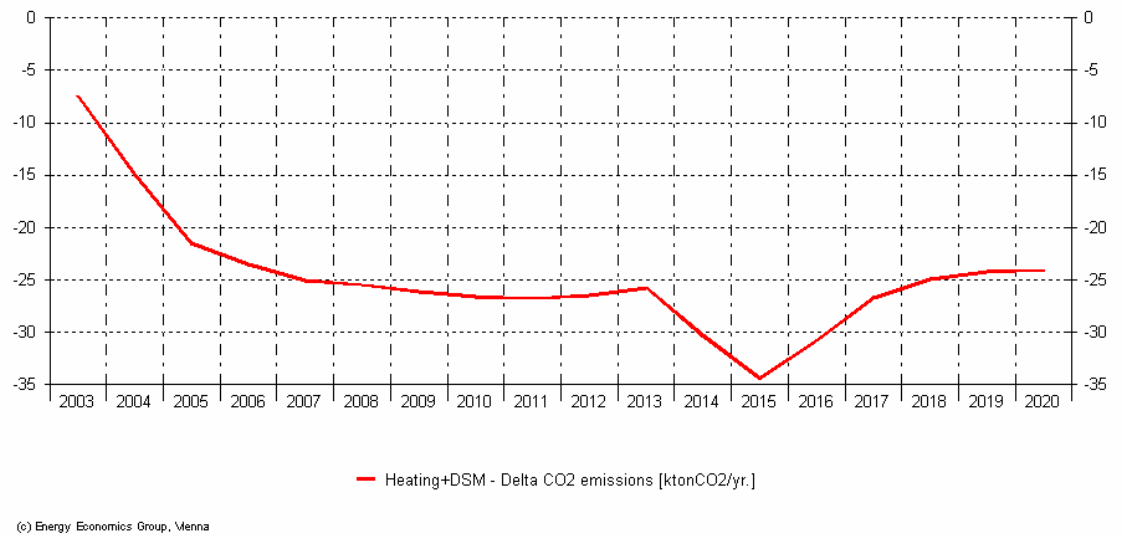


Figure 2-33: CO_2-reduction due to CO_2-tax, Vienna

The steep decrease of CO_2-reduction in 2014 -2015 is due to the earlier introduction of biomass heating systems compared to the reference scenario. This effect is leviated afterwards because from 2016 onwards biomass systems would have been installed anyway (i.e. in the reference scenario).

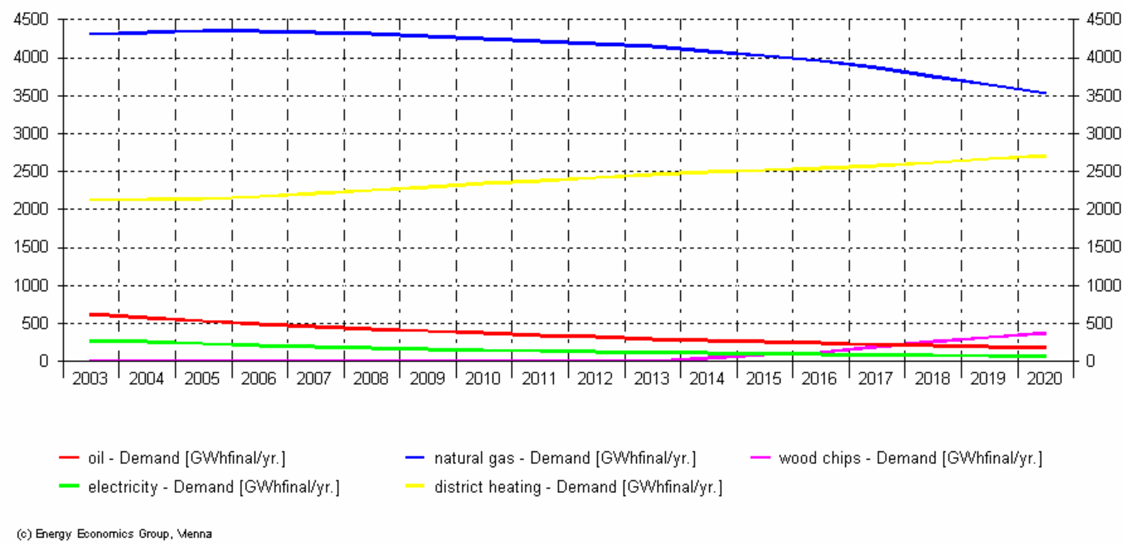


Figure 2-34: Energy carriers for heating, CO_2-tax, Vienna

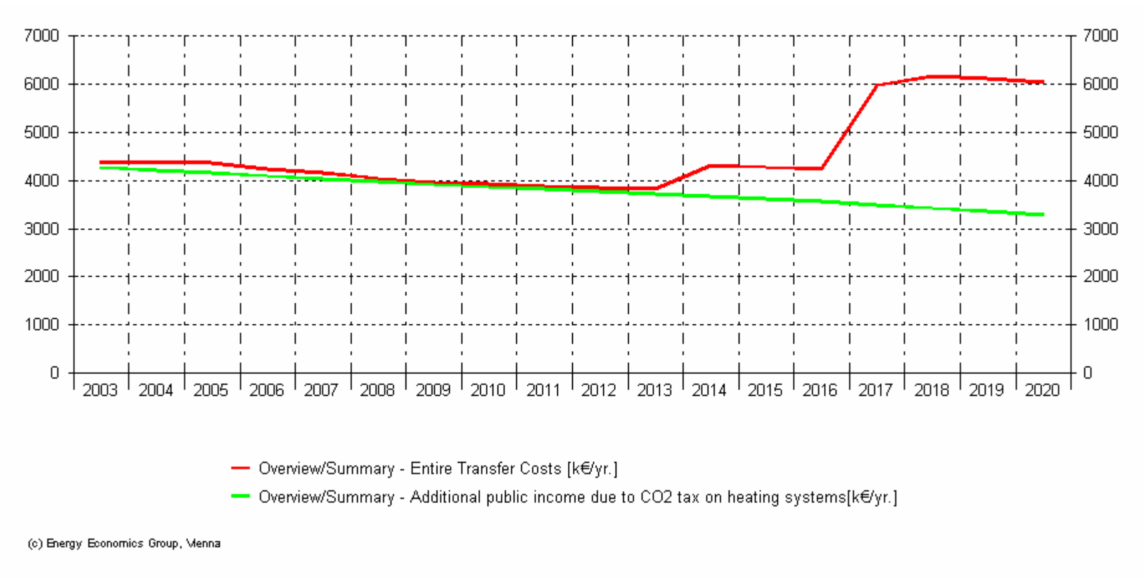


Figure 2-35: Transfer costs and public income due to CO_2-tax, Vienna

The following figure shows the impact of raising the CO_2-tax to 10, 20 and 30€/t, respectively.

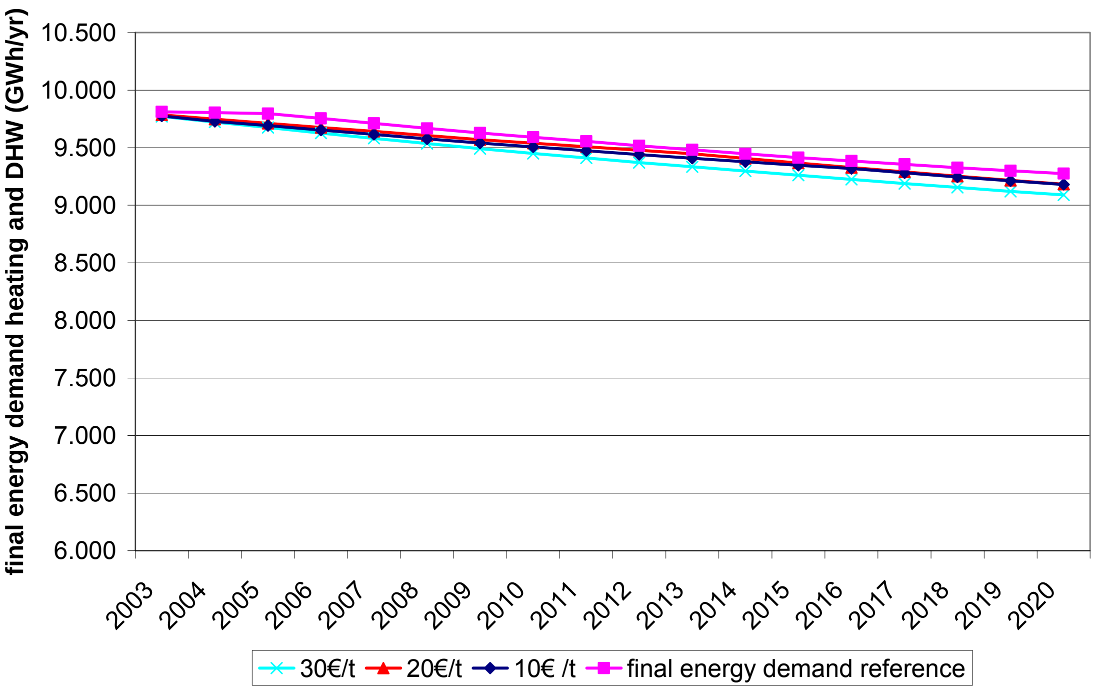


Figure 2-36: Impact of various levels of CO_2-tax on final energy demand, Vienna

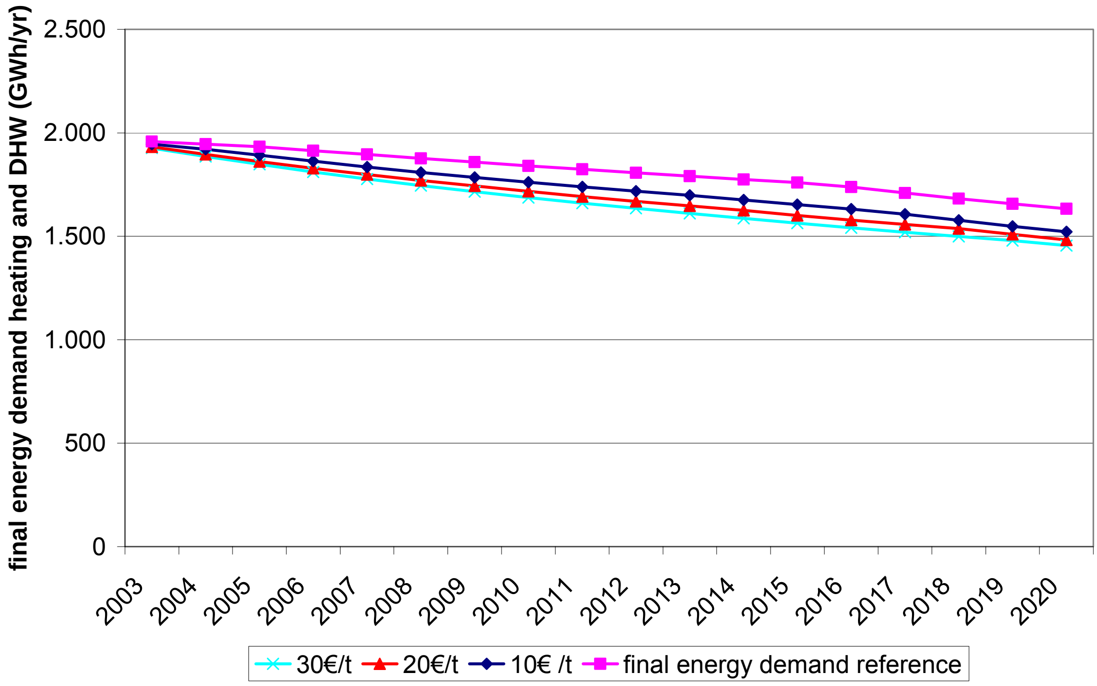


Figure 2-37: Impact of various levels of CO_2-tax on CO_2-reduction, Vienna

2.4.7 Hypothesis H7: Current subsidy for solar thermal systems insufficient

Performed variation:

- Raising subsidies for solar thermal systems to 50% (but only outside the district heating area)

Main results:

- The total impact still is rather low at a level of 50% subsidy: In the maximum about 1,900 dwellings are supplied by solar thermal systems. Total transfer costs are less than 300,000 Euro per year, CO_2 reduction is in the maximum about 500 t CO_2/year.
- The promotion scheme efficiency (CPSE) is about –5 kg CO_2/€ in the year 2020.

However, the technical potential for CO_2-reduction by solar thermal collectors is quite high: Until 2020 over 100 kt CO_2/yr could be reduced. But it needs quite high level of subsidies to ensure economic attractiveness.

2.4.8 Conclusion soft barriers

The analysis of this case study has shown that soft barriers have a very high impact on the decision of various heating systems and investing in DSM measures. This is especially the case for:

- Installation of biomass heating systems
- Change of single stoves and one floor systems to central heating systems
- DSM in buildings erected before 1919. Due to the building requirements and protection of historical monuments, insulation turns out to be quite difficult or not feasible. Calculating an additional scenario taking into account these problems, it turns out that cumulated CO_2-emissions until 2020 are 500 kt (3%) higher than in the reference scenario.

With respect to these barriers additional research would be necessary. Especially in the building part it turns out that economic efficiency is just one among other important aspects influencing the decision making process.

2.4.9 Conclusion: Comparison of various measures for further CO_2-reductions

As it was pointed out above, for achieving higher CO_2-reductions than in the reference scenario various different measures are possible. In the following, some of them are compared to each other: [9]

- Extending the existing biomass subsidy to the district heating supply area. As has been pointed out above (H1) this leads to a promotion scheme efficiency of about -3 kg/€ (CPSE).
- Extending the existing subsidy for gas condensing boilers to the district heating supply area does not lead to a CO_2 reduction and hence has to be rejected.
- Increasing the solar thermal subsidy to 50% leads to a promotion scheme efficiency of about 3 kg/€ (CPSE). However, the CO_2-reduction potential is quite low.
- Increasing the subsidy for insulation by 10€/m² leads to a promotion scheme efficiency of - 2.8 kg/€ (CPSE). The CO_2 reduction potential is much higher than for the other options: 900 kt (ca. 4 %) could be saved until 2020. This means that despite of

[9] As the promotion efficiency is based on the "budget relevant spending" in the year n instead of the actual costs, the promotion efficiency is not directly comparable to the CO_2 emission reduction costs known from other literature sources. The values for the promotion scheme efficiency represent the short-term view of a policy maker.
For the anaylsis carried out in work-package 7 (Recommendations and action plan) of this project another indicator has been defined considering also the long-term view. Please take a look on the report of that work package (www.invert.at).

the lower promotion scheme efficiency compared to other options, DSM subsidy is a crucial issue for achieving higher CO_2-reductions.

- A high promotion scheme efficiency could be achieved by raising subsidy for district heating which would lead to a higher rate of connected buildings to the existing district heating grid (not assuming a stronger extension of the grid!). Promotion scheme efficiency would be around - 38 kg/€ (CPSE). The achieved CO_2-reduction potential of this measure would be 230 kt (cumulated until 2020).
- Raising biomass subsidy by 10% would result in a promotion scheme efficiency of - 32 kg/€ (CPSE).. The crucial question for the actual CO_2-reduction potential that could be achieved certainly is the question of acceptability and fuel transport. However, due to this high level of promotion scheme efficiency, biomass should be considered as relevant option in the outskirts of Vienna.

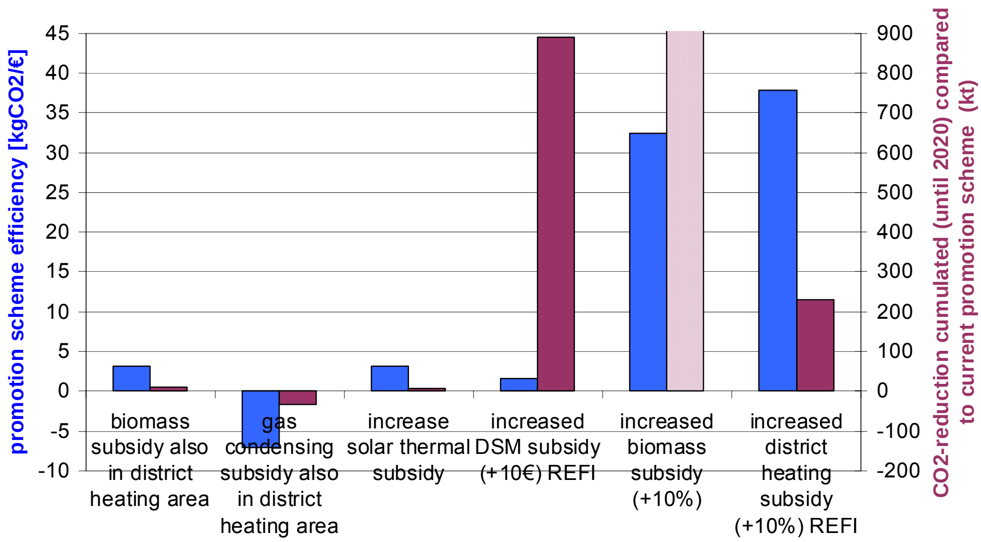


Figure 2-38: Promotion scheme efficiency and CO_2-reduction potential of various measures for CO_2-reduction, Vienna

Additional aspects of comparing promotion schemes by various indicators are investigated in the report of WP7 (recommendations and action plan) of this project.

2.5 References

Haas, R., Auer H., Biermayr P.: The impact of consumer behaviour on residential energy demand for space heating. Energy and Buildings 27 (1998) pp 195-205, Vienna 1997

Kratena, K., Schleicher, S.: Energieszenarien bis 2020. Im Auftrag von BMWA und BMLFUW. – Wien 2001.

Statistik Austria: Häuser- und Wohnungszählung 1991. – Wien 1993

Statistik Austria: Wohnungen 2002. Ergebnisse der Wohnungserhebung im Mikrozensus September 2002 – Wien 2003

Wiener Stadtwerke: Geschäftsbericht der Wiener Stadtwerke 2003. – Wien 2004.

3 Poland - Jordanow

3.1 The Gminas of Jordanów and Bystra Sidzina

The main argument for selecting the gminas of Jordanów and Bystra Sidzina is that it is very typical and representative for the Polish conditions. There are five hundred similar cities in Poland (Cities with population up to 10 thousand citizens constitute the 50% of cities in Poland). It should be also noted that considering the common historical, economic and political experience, cities of the comparable size in new member states have many similarities as far as the problems that ***In**vert* is to address. Therefore, the sample of cities that may find ***In**vert* useful based on Jordanów model is more than 4000.

Concerning the size of the gminas and having in mind that the size of regions selected for ***In**vert* covers a very wide range, it may be very beneficial for achieving the Project goals to increase the flexibility of ***In**vert* model.

The county of Sucha Beskidzka lies in the southwest extreme of the Malopolska voivodeship. Malopolska (literally, Little Poland) is a historical and ethnographic region in southeastern Poland. Geographically, it encompasses the basin of the upper and partly middle Vistula with most of the Polish Carpathians, the Sandomierz Basin, the Oswiecim Basin and the Malopolska Upland.

Forest area is as big as 432,000 hectares; this figure gives the average forestation ratio for the Malopolska province of 28.5%, close to the national average. The degree of forestation in the Carpathian part of the province is high and exceeds 40%. The region is also distinguished by the species and production-related variety of forests – from poor lowland woods, through rich highland and mountain forests, to high mountain woods. Approx. 210,000 hectares have been formally classified as protected forests, what makes almost 50% of all forests, i.e. more by 10% of forest area that the national average for protected forests. Water- and soil-protecting forests are predominant. The share of “mass recreation” forests (situated close to cities) is also substantial.

In our study we are concentrating on areas that, on one side, are typical for this region and have significant renewable energy potential, on the other.

The Subcarpatian mountains in Southern Poland are abundant with forests and there has been a long tradition of timber logging and wood processing in small, usually family owned, timber-mills and wood processing workshops.

The county of Sucha Beskidzka covers an area of 685.7 km^2 with a population of over 80,000. It is made up of 9 gminas comprising 3 towns and 34 villages. The area is mountainous consisting of large sections of the Zywiec Beskids (High Beskids), the Makow Beskids (Middle Beskids), and the Small Beskids. The Slovak border runs along the Babia Gora ridge. The Skawa - a right-bank tributary of the Vistula - is the largest river. Its waters are joined by many mountain streams, creeks and rivulets. 50% of the Podbabiogorze region is wooded, the forests being the greatest natural wealth of the region.

On the territory of five communes (gmina): Maków Podhalański, Bystra-Sidzina, Zawoja, the town of Jordanów, and the village of Jordanów, alone - of a total area not exceeding 20x8 kilometres - there exist and operate about one thousand small wood-processing enterprises. The specific feature is that those facilities are both small and scattered. The amount of wood-waste they produce is usually more than enough to meet their own energy needs; they usually produce more wood waste than they need even in winter. At the same time, most of the buildings in the area are heated using coal, usually of rather low quality, burned in inefficient old stoves or boilers. This is the heritage of the cheap coal era of the past decades. In summer the wood processing enterprises or workshops, scattered in the region, have significant surplus of wood residues, the disposal of which poses a serious problem for them. Consequently, a large fraction of this valuable environmentally friendly fuel is disposed off in unauthorised places (rivers, road sides or ponds) causing serious environmental pollution. Part of the wood-waste is uselessly burned (also in summer) only for the sake of getting rid of the production residues, which for the facility owners mean no more than cumbersome waste.

However, the situation is very dynamic. In the few recent weeks a problem already surfaced in media. Namely, the introduction of mandatory quota for green electricity is creating a huge demand for wood biomass for co-firing with coal in power stations. The large power stations to fulfil quota obligation (7.5% green electricity in 2010) contract the huge amount of wood with no restriction to the cost of fuel and transport. At the same time, The State Forests Administration does not agree to increase the limit of wood felling. This already now creates shortage of this biomass and drives its price up. There is an outcry of paper, plywood and furniture industry that they will close their factories in Poland. Poland started buying wood from Slovakia now.

Our case study will concentrate on the city and gmina of Jordanów and Bystra Sidzina. The gminas covers an area of 194 km^2, with the population of 21,664.

Jordanów is situated in the valley of the Skawa River, on the verge of three mountain ranges: Beskid Wyspowy, Beskid Średni and Beskid Żywiecki. The area of Jordanów is 21.03 square km, 35% out of which constitute forests, mainly coniferous ones. The population of the city is 5000 inhabitants. It is a commercial, educational and cultural centre, as well an industrial and service focal point for the neighbouring villages. The city is active in environmental protection: since 2000 Jordanów is member of the Polish Network “Energie Cites”. It has undertaken actions to promote renewable energy sources and energy efficiency in buildings as well as actions to develop technical and social infrastructure. Apart from that, the City puts significant effort on sewage treatment and waste collection. The representatives of the city administration participated in 2001 in training courses organised under the European Programme TEMPUS (IB_JEP 14326 “Courses on Sustainable Energy for Local Administrators”). One of the results has been selection of Jordanów as participant of the GEF project “Integrated Approach to Wood Waste Use for Space Heating in Poland” developed by the AGH University of Science and Technology and the Polish Foundation for Energy Efficiency, Centre in Kraków.

3.2 Promotion schemes in Poland

3.2.1 National Fund for Environmental Protection and Water Management

Through subsidies and preferential loans the National Fund supports initiatives that serve the improvement of the state of our nature. Special attention is given to ecological activities adapting Poland to the European Union Standards and fuel conversion from coal to gas and biomass. The National Fund is the largest institution financing environmental protection projects in Poland. The mission of the Fund is to provide financial support for undertakings of a national or interregional scale.

Calls for proposals are announced. First, applications have to be submitted, then based on established criteria selection is performed. The main criterion is cost of CO_2 reduction.

3.2.2 The Voivodeship Fund for Environmental Protection in Krakow

WFOŚiGW supports (soft loan) up to 10 000 000 PLN (and up to 80% of investment cost for public bodies and 70% for other investors) for one task, but not more than 20 000 000 PLN for more than one investment for the same investor. The interest rates vary from 0.5 to 0.8 rediscount rate of draft (but not less than 4 and 5.5% respectively).

In the case of grants the maximum support is 2 000 000 PLN, but not more than 40% of investment cost.

If ecological effect is achieved and 60% of the loan is paid back, the loans may be written off:

- up to 40% for water protection, waste disposal,
- up to 20% for installation of technologies less harmful to environment (for private persons and enterprises),
- up to 35% for other investments.

3.2.3 Thermal Modernisation Act

In December 1998 the Polish parliament approved TMA supporting heat saving investments in buildings. The goals set forth were:

- Decreasing losses in district heat transmission pipes and in buildings (space heating and hot water).
- Replacement of old coal boilers by more efficient ones or conversion from coal to gas, oil or biomass.

The mechanism is based on regular commercial bank loans with the abolishment of 25% of the loan once the investment has been completed. The 25% difference is covered by a special Thermal Modernisation Fund fed mainly by the State budget. Minimum 20% of own contribution is required. The assumption is that the loan is paid back from energy savings. Therefore, energy audits are required to prove that sufficient savings are achievable. The audits are further verified by authorised energy auditors. These procedures, no doubt, create additional transaction costs, which depend on the size of the object, ranging typically between 5 and 20 % of the investment total for large (housing block) and small (single family) building respectively. Apart from the cost barrier for small customers, the first few years have revealed several essential drawbacks of the Act. Notably:

a) Short payback time ceiling of max. 7 years which could seldom be met when confronted with the minimum 25 % savings required.

b) Condition that 75 % of the loan has to be paid back before the 25 % premium is granted.

c) Lack of eligibility of such buildings as hotels etc.

d) Lack of good and effective promotion of the TMF.

e) Too complicated procedure requiring energy audit and additional costs.

f) 25 % premium is not granted for investors with own financial resources, they have to take a loan to obtain grant.

Consequently, only very few applications were submitted. To remove these barriers the Act was modified in 2001:

- The lower bound for heat savings by envelope improvements was set at 15%, provided that the heating system in the building had been modernised between 1985 and 2001.
- Otherwise the 25% saving requirement still applies, however, the savings may now be achieved jointly by heating system modernisation and envelope retrofits.
- For buildings, where only the heating system is improved the minimum savings are now 10 %.
- Abolishment of 25 % of the loan once the investment has been completed.

Unfortunately, if only envelope improvements are made the 25 % ceiling still applies which in practice excludes the low cost measures with short PBT. On the other hand, the low limit of only 10 % for system improvements alone improvements favours boiler and/or controls (re)installation, which by their nature are rather expensive. This should be changed, if the energy saving potential (especially the short term one) is to be better exploited and other benefits (job creation or improved thermal comfort) achieved.

NOTE: The total potential of thermal modernisation measures in Poland amounts at 40 billion PLN. According to TMA, out of this amount 80% (32 billion PLN) can be credited, out of which 25% (8 billion PLN) can be financed from TMF as a premium.

According to Bank Gospodarstwa Krajowego (the Bank gives credits and is responsible for verification of energy audits and loan applications) 30 M PLN were spent as a premium on thermal modernisation within TMA scheme in 2003 (the same as in 2002), what amounts to 0.3% of the potential.

3.2.4 Ekofundusz (EcoFund)

Grants

Grants for replicable projects:

Solar collectors (vacuum tube or flat-plate solar collectors only): 600 PLN/m2, not less than 50000 PLN. 6 M PLN available per year.

Wind turbines: 700 000 PLN/MW, 35 M PLN available per year.

Rape oil: 200 PLN/t esters, not more than 10% of cost of installation. 10 M PLN/year available.

Requirement: production of esters: 10 000t/y

Energy plantations: 1000 PLN/ha, 50-500 ha. 10 M PLN available per year. Letter of intent is required from future recipient (local heat plant or fuel supplier).

3.2.5 Green Energy Purchase Obligation Ordinance

The first ordinance to the Energy Act concerning RES purchase obligation came into effect on December 15th 2000. The Ordinance set the green energy fraction at 2.4 in 2001, which would be gradually increased up to 7.5% in 2010.

3.2.6 Bank of Environmental Protection

Preferential credits for:

- Reduction of emission from public transport: up to 70% of investment cost (max. 2 000 000 PLN). The interest rate is 0.4 of rediscount rate of draft (but not less than 3%)
- Purchase and installation of equipment for environmental protection: up to 100% with interest rate sets individually from 1%.
- Renewable energy sources: up to 80% of investment cost (max. 3 000 000 PLN). The interest rate is 0.5 of rediscount rate of draft
- Thermal renovation: up to 80% of investment cost. Interest rate is set individually. 25% of the credit is written off once project has been completed
- Modernisation of lighting: up to 100% with interest rate sets individually

3.3 Reference scenario

3.3.1 Essential Assumptions

As seen from the above information, the use of promotion schemes in Poland is practically negligible as compared with the existing potentials, both in RES and RUE. Therefore, it is reasonable to use a “no-promotion” scheme as a baseline scenario. This applies, in particular, to Jordanów, where hardly any RUE/RES investment supported by the aforementioned promotion schemes could be identified. The same applies to the most of the similar municipalities in Poland.

The medium option has been chosen for DSM with all measures checked and soft barrier of – 0.6.

The soft barrier for gas is used (0.9), because no grid gas is available in the investigated area except few limited districts. Additionally soft barrier for biomass is implemented (entrance to the market barrier, logistic barrier).

3.3.2 Characteristics of reference scenario

Figure 3-1 shows the baseline incremental CO_2 reductions (green) and the cumulative reductions (red) over 20 years.

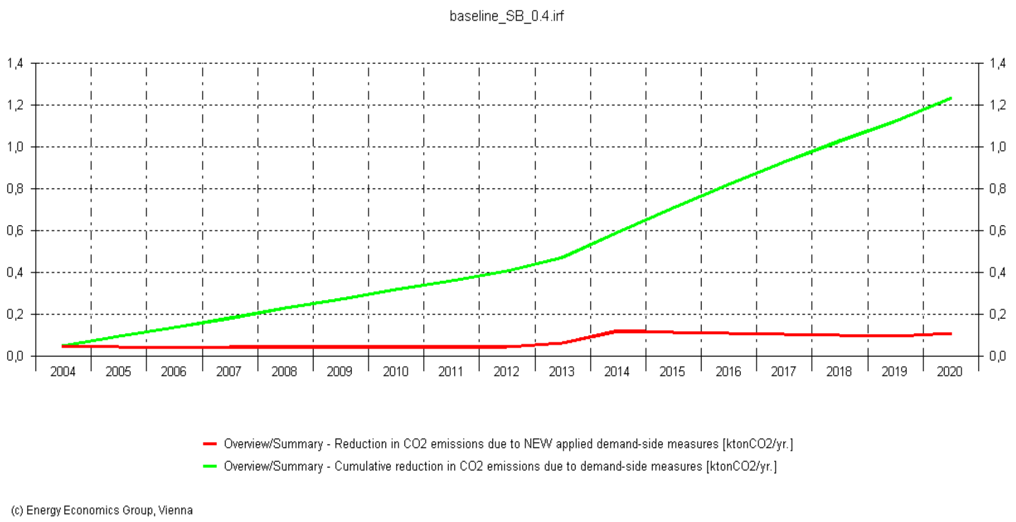


Figure 3-1: Reduction in CO_2 emissions due to DSM

The steeper increase in year 2013 reflects the accumulated fuel price increase over time, which is also seen in Figure 3-2, which shows the number of buildings retrofitted per year. The total number of retrofitted buildings over 20 years amount to 84.

Figure 3-3 shows the demand for fossil fuels including electricity, which is coal derived in Poland.

Figure3-4 presents the fuels dominating in Jordanów: hard coal and wood, in form of log wood and wood chips, separately.

The results of Figure 3-3 are rather obvious and reflect the price impact.

The curves in Figure3-4 show that the demand for coal and wood is rather stable: coal slightly decreases, the demand for log wood is increasing (2GWh over the time).

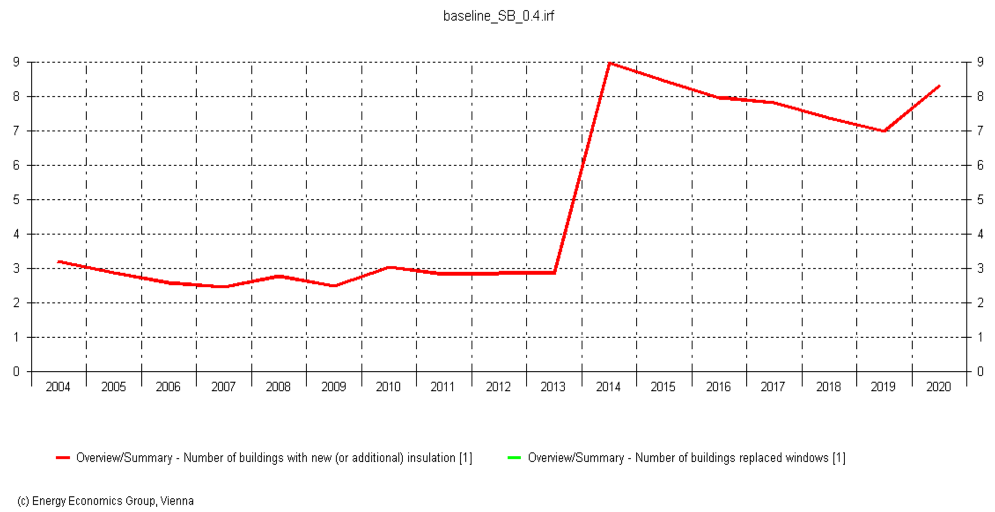


Figure 3-2: Number of buildings with new (additional) insulation and windows

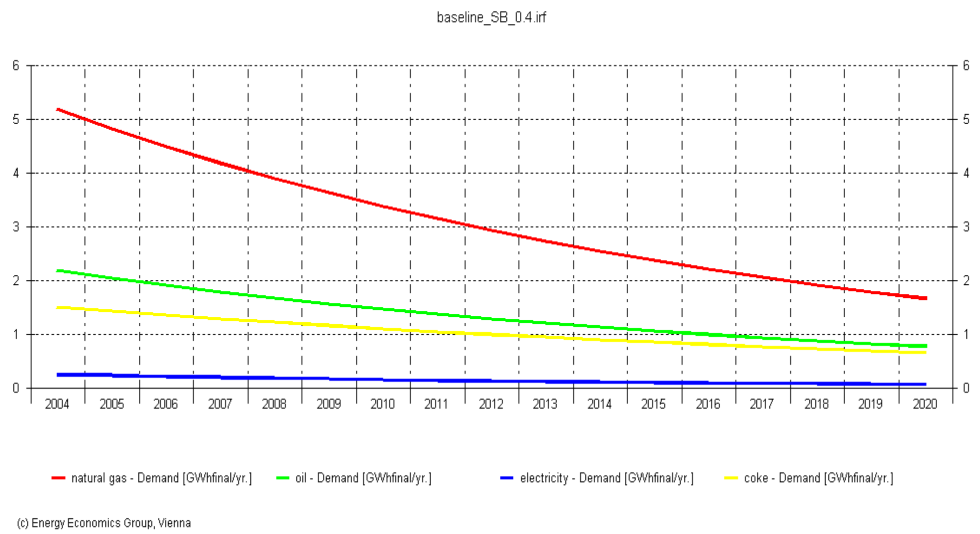


Figure 3-3: Fossil fuels demand in the region

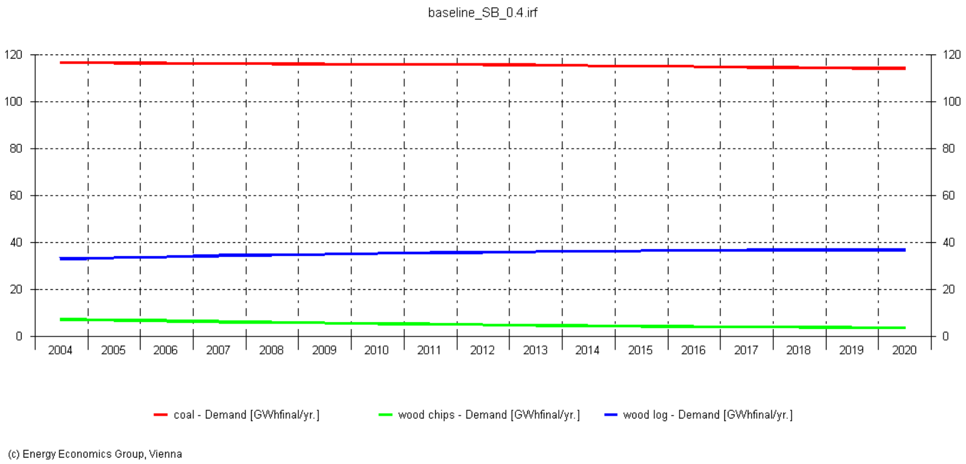


Figure3-4: Coal and wood demand in the region

3.3.3 Sensitivity analysis: energy price

Figure3-5 shows the very impact of energy price increase. The curves of reference scenario (no increase) and of a price increase of 1 %/a don't differ essentially. In both cases the CO_2 emissions will be reduced from about 47 kt/a (2003) to about 45 kt/a in 2020. But a 2 %/a energy price increase the CO_2 emissions leads to distinct reduction of more than 20 %, and a 4%/a increase even leads to a reduction of more than a half.

Relating to the development of the final energy demand the energy price impact is not as strong as relating to the CO_2 emissions (Figure3-6). In the case of 4%/a price increase the final energy demand will be reduced for 13 % from 166 GWh/a (2003) to 144 GWh/a in 2020. A 2%/a increase leads to a reduction of 8 %, a 1%/a increase to 6 % reduction while the reference scenario leads to 5 % reduction.

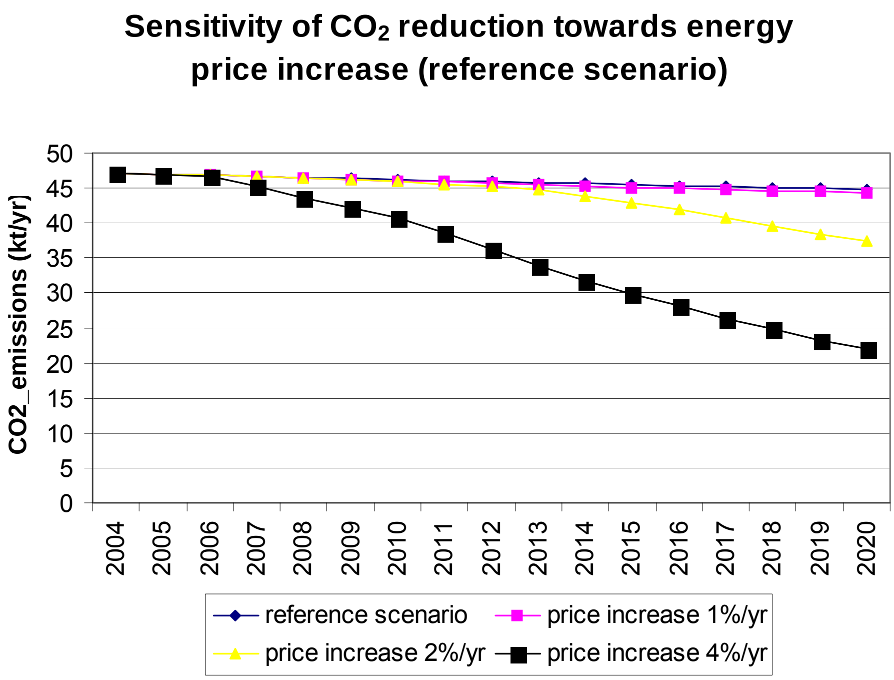


Figure3-5: Sensitivity of CO_2 reduction towards energy price increase (for reference scenario)

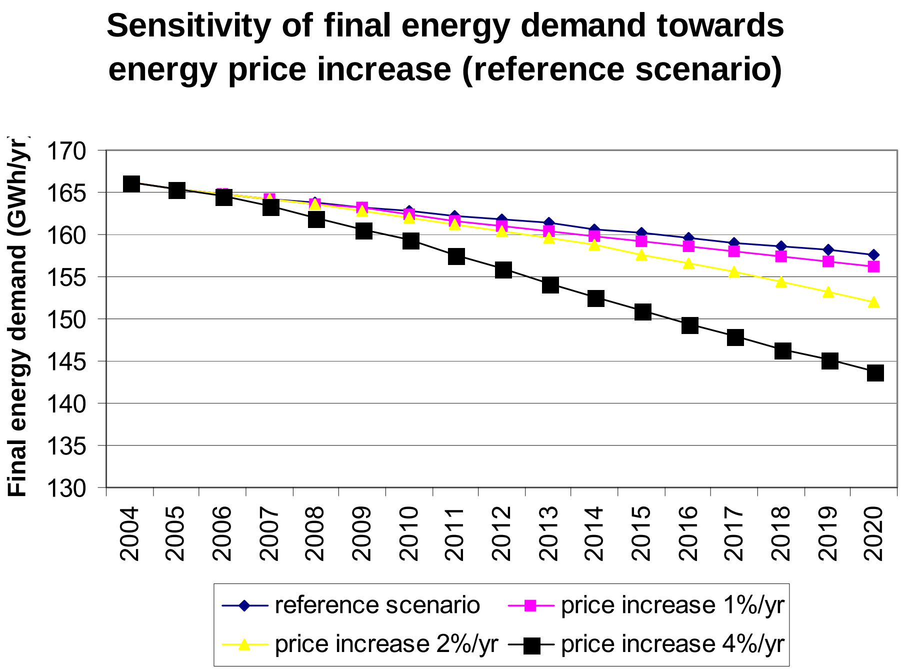


Figure3-6: Sensitivity of final energy demand towards energy price increase (for reference scenario)

3.4 Analysis of Hypotheses for Jordanów

The structure of the hypotheses suggested below is such that they can be tested first for the concrete input data we have already collected for Jordanów and then extrapolated to the whole country or to the particular regions (voivodships), using more-or-less hypothetical (still plausible) input data.

3.4.1 Hypothesis 1: Subsidy to conversion from (fossil) fuel to biomass vs subsidies to DSM - aspect of replacement of windows

One of the most disputed questions in Poland, as far as thermal retrofits of buildings are concerned, is installation of new windows replacing the old ones, which very often are in bad condition. Cost effectiveness, indoor air quality and energy saving impacts are widely disputed. Taken separately, window exchange is very expensive, as seen in Table 12, with payback times reaching more than 20 years. Moreover, typical new windows in Polish market are excessively airtight, which with no forced ventilation in most of Polish residential and office buildings, leads to serious indoor CO_2 and moisture problems. Related health hazards are a big concern. Paradoxically, typical windows in Poland secure sufficient ventilation levels and, typically, require inexpensive measures to reduce excessive air leakages. The latter approach developed by FEWE Krakow under a USAID project in 1997-2000 showed that such an approach would bring substantial energy savings at low cost, at the same time creating new local jobs for unskilled workers. At the same time application of such draught reduction measures, when executed professionally does not create the air quality problems mentioned above. Despite of those observations the replacement of old windows is commonplace in Poland, which is partly due the marketing power of new window manufacturers, dealers and installers.

Table 3-1: The cost of energy saving measures for different time intervals (N=12, 15, 20 years) and different rediscount rates (r=0%, r=8%, r=10%, r=12%)

The cost of saving of 1 GJ [PLN/GJ]		Walls	Attic	Cellar	Windows	Doors
Calculations by Konrad Dybek, Master Thesis, 2002	N=20 y, r=8%	28,0	16,6	18,9	74,2	48,2
	N=15 y, r=10%	36,2	21,4	24,4	95,8	62,2
	N=12 y, r=12%	44,4	26,3	30,0	117,6	76,3
	N=15 y, r=0%	18,3	10,9	12,4	48,6	31,5

Calculations by FEWE	N=20 y, r=8%	12,7	21,0	10,2	104 [a]	-----
	N=12 y, r=12%	20,2	33,3	16,1	164,8 [a]	-----

a – windows with triple glasses

We have attempted to test this hypothesis in a more complex environment, with inclusion of other thermal improvements, i.e., insulation of building envelope elements, which is possible with the use of ***Invert***.

In Hypothesis with DSM without windows replacement, the baseline scenario includes no windows replacement too. The obtained results for baseline scenario are presented below.

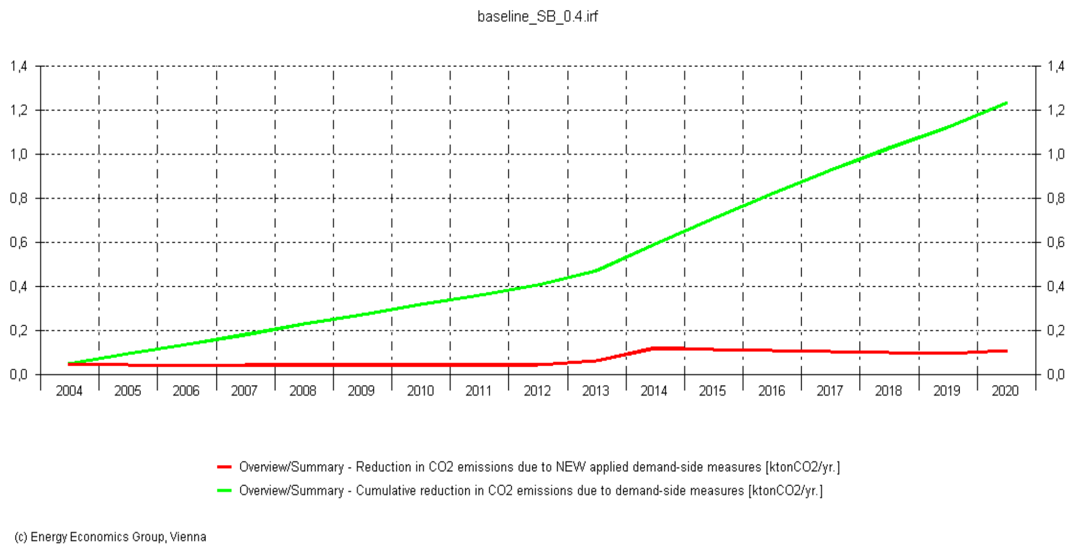


Figure 3-7: Reduction in CO_2 emissions due to DSM without windows replacement.

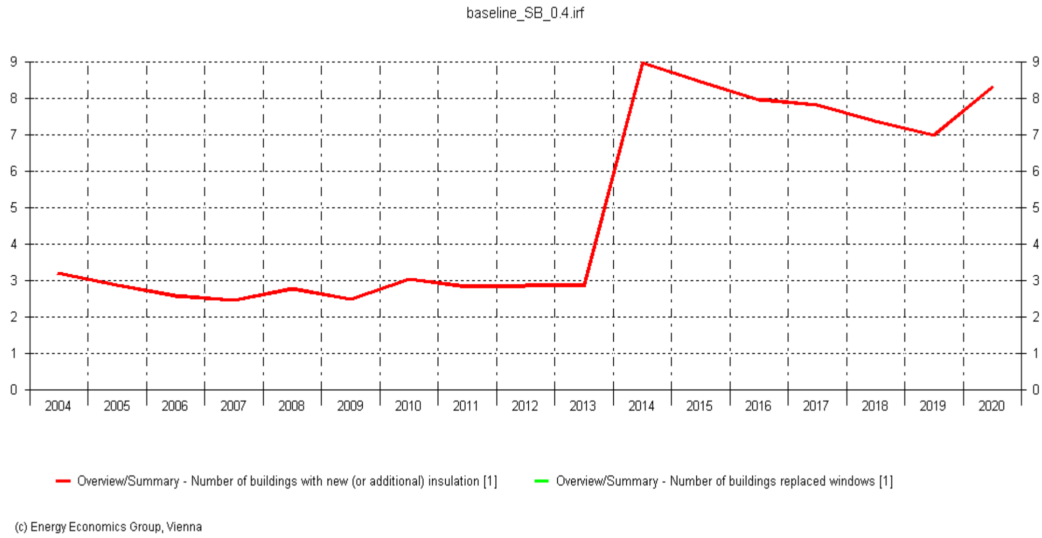


Figure 3-8: Number of buildings with new (additional) insulation and windows

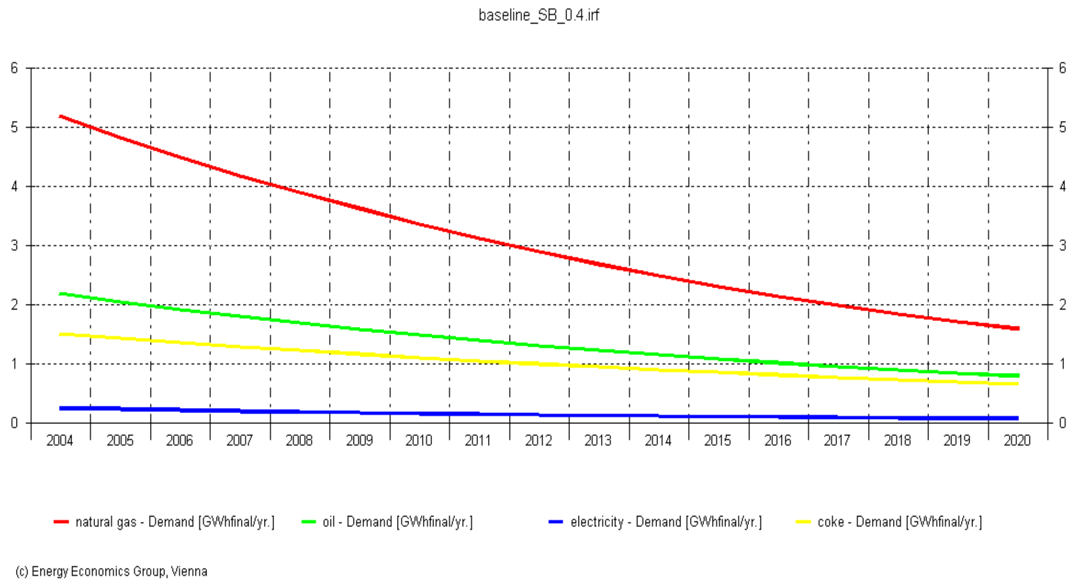


Figure 3-9: Fossil fuels demand in the region

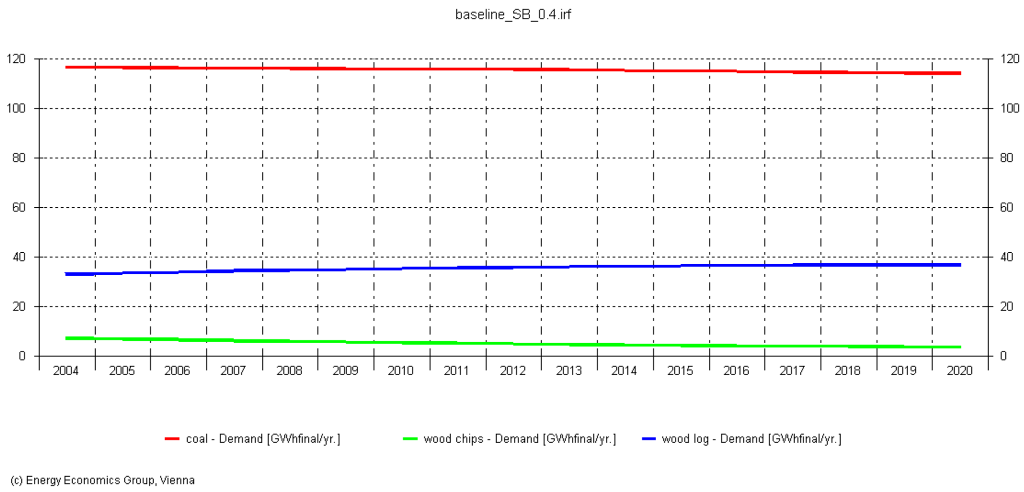


Figure 3-10: Coal and wood demand in the region

With the assumed input parameters the most effective promotion scheme is about 30% subsidies to RES&DSM measures. The DSM measures, with and without windows replacement, play only marginal role in additional (comparing to baseline scenario) CO_2 reduction (Figure3-11, and especially for the case of 30% subsidy for RES&DSM in Figure3-12).

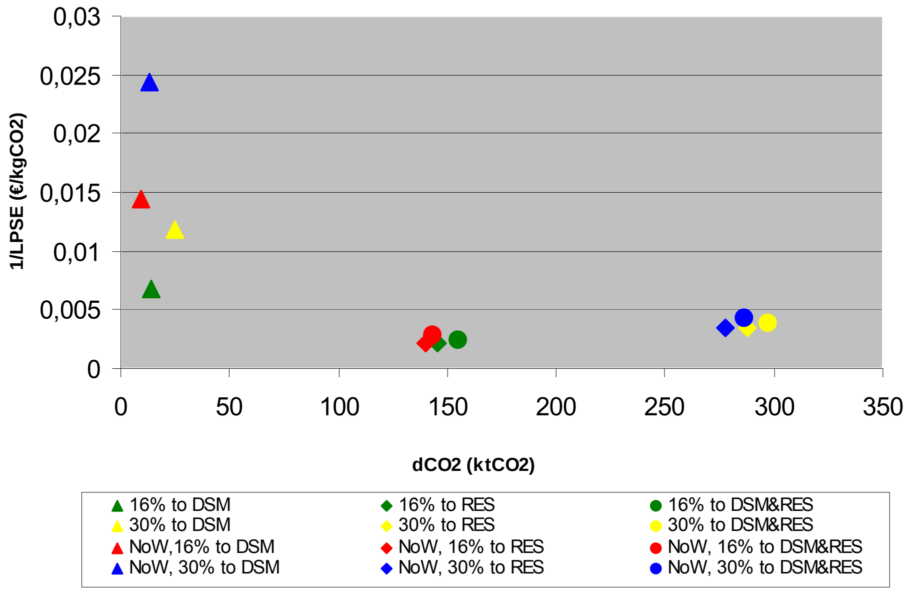


Figure3-11: DSM measures including replacement of windows vs. DSM measures with no window replacement with subsidies both to RES and DSM

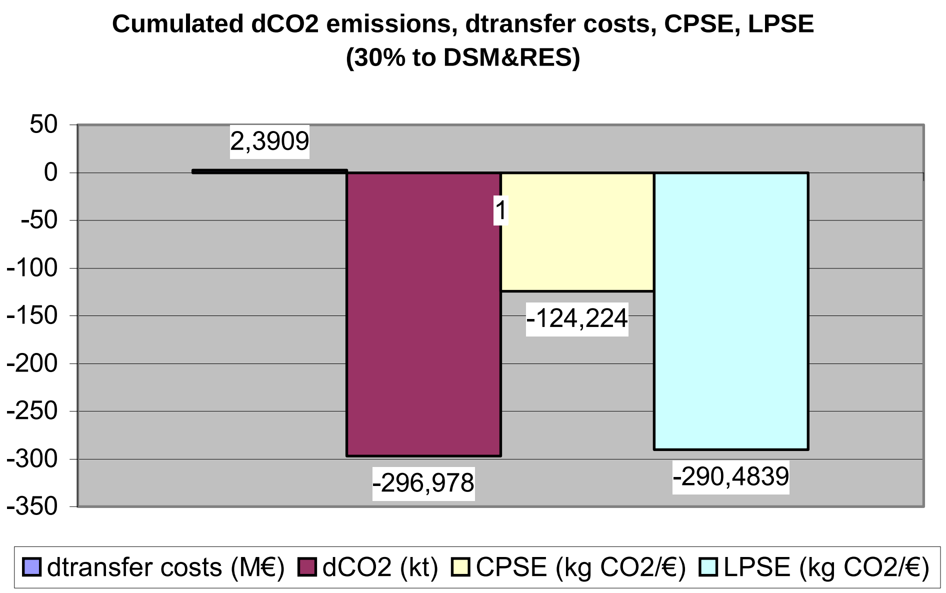


Figure3-12: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES

3.4.2 Hypothesis 2: Subsidy to conversion from (fossil) fuel to biomass vs subsidies to DSM – aspect of increase of biomass price

The impact of additional increase of biomass price was investigated.

The level of subsidy to the total investment cost was varied (16%, 30%) for both options separately and RES&DSM at the same time.

It is interesting to note that the model shows that subsidies to RES are more effective than to the corresponding subsidies to DSM. The best results were achieved while using subsidies both to RES & DSM. In Jordanów region the most effective subsidies are at the level of 30% of total investment costs.

The results are presented in Figure3-13 and especially for the case of 30% subsidy for RES&DSM in Figure3-14 and Figure3-15

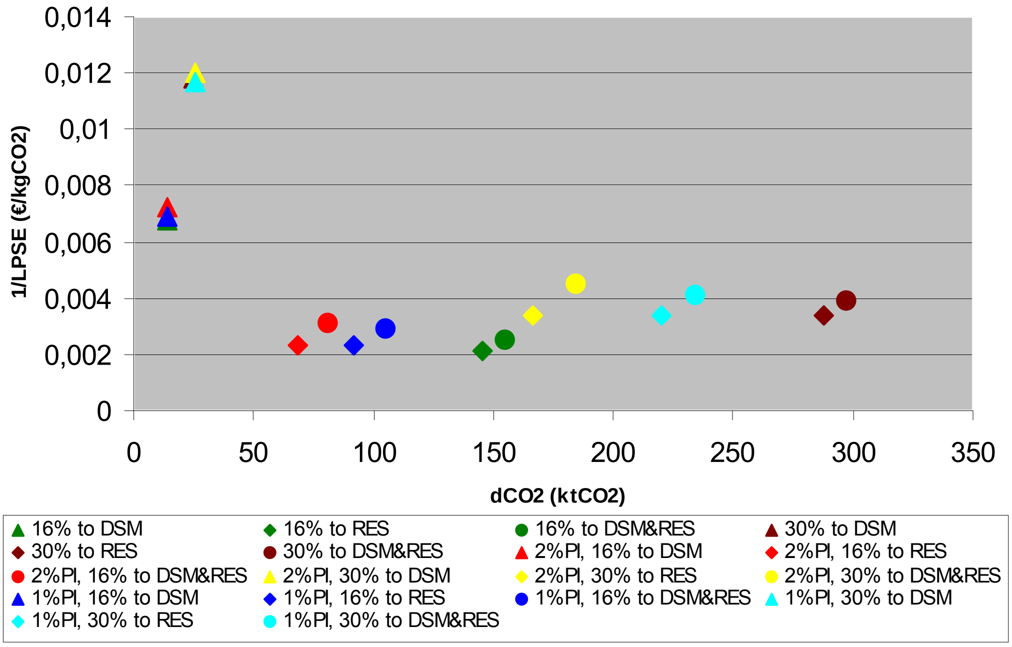


Figure3-13: Comparison of effectiveness of promotions schemes with and without additional increase of biomass price

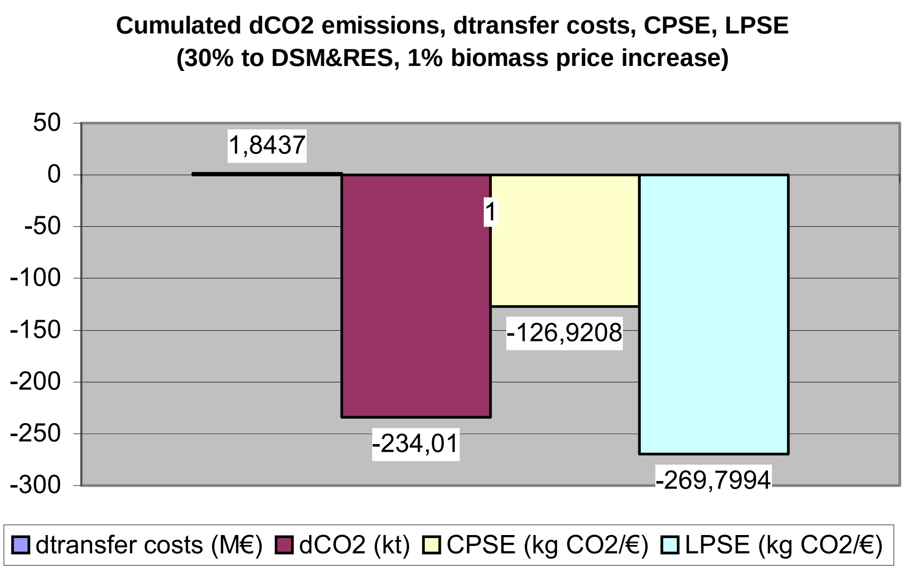


Figure3-14: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 1 % biomass price increase

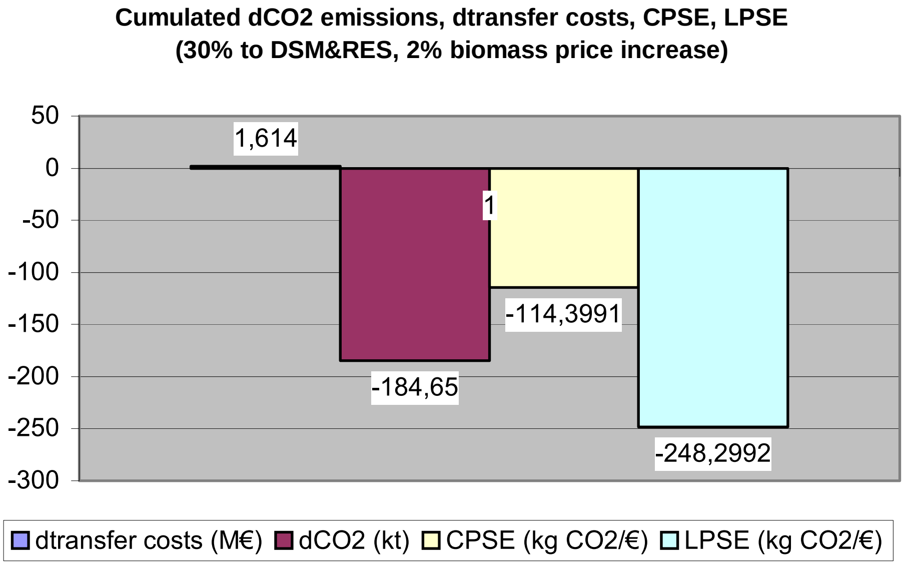


Figure3-15: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 2 % biomass price increase

3.4.3 Hypothesis 3: Subsidy to conversion from (fossil) fuel to biomass vs subsidies to DSM – aspect of CO_2 tax

The level of subsidy to the total investment cost was varied (16%, 30%) for both options separately and RES&DSM at the same time. The impact of introduction of CO_2 tax (10, 20 and 30€/tCO_2) was investigated.

It is interesting to note that the model shows that subsidies to DSM are more effective than to the corresponding subsidies to RES. The best results were achieved while using subsidies both to RES and DSM. In Jordanów region the most effective subsidies are at the level of 30% of total investment costs. The results are presented in Figure 3-16 and especially for the case of 30% subsidy for RES&DSM in Figure3-17 until Figure3-19.

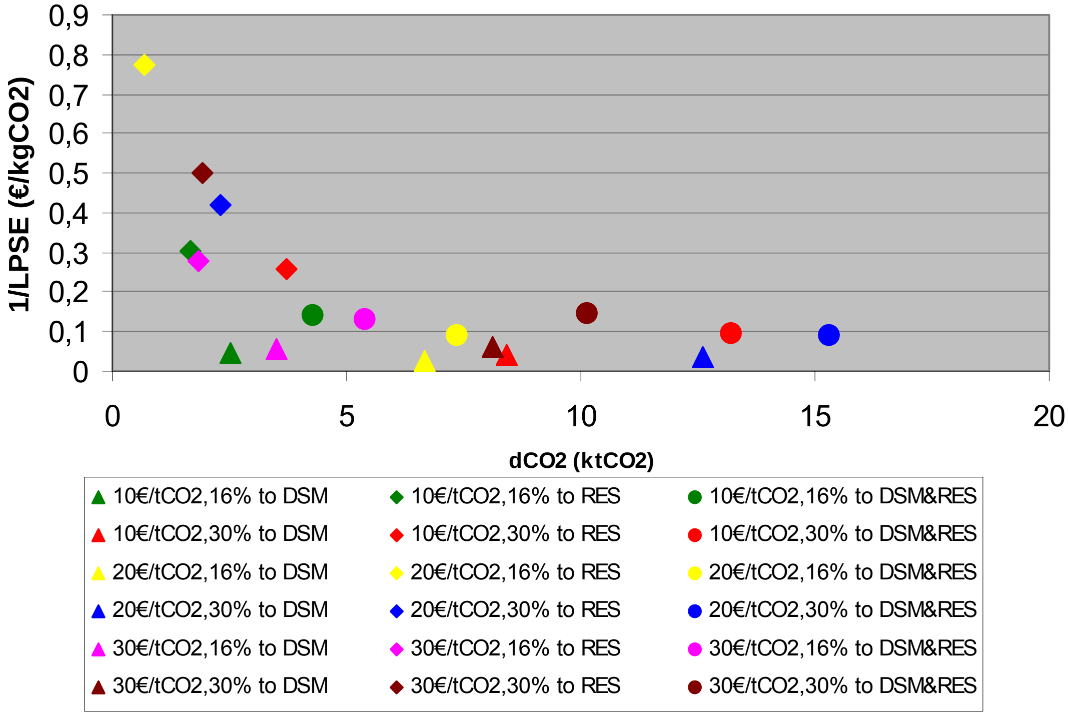


Figure 3-16: Comparison of effectiveness of promotions schemes with CO_2 tax

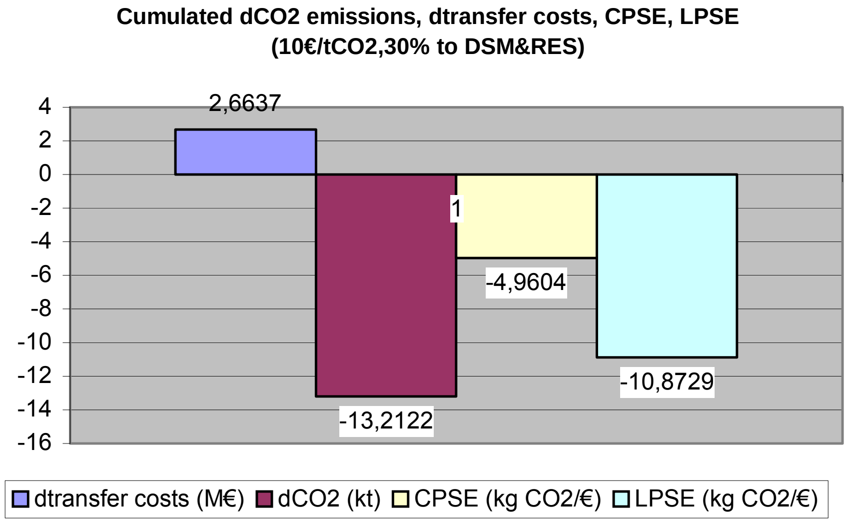


Figure3-17: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 10 €/t CO_2 tax

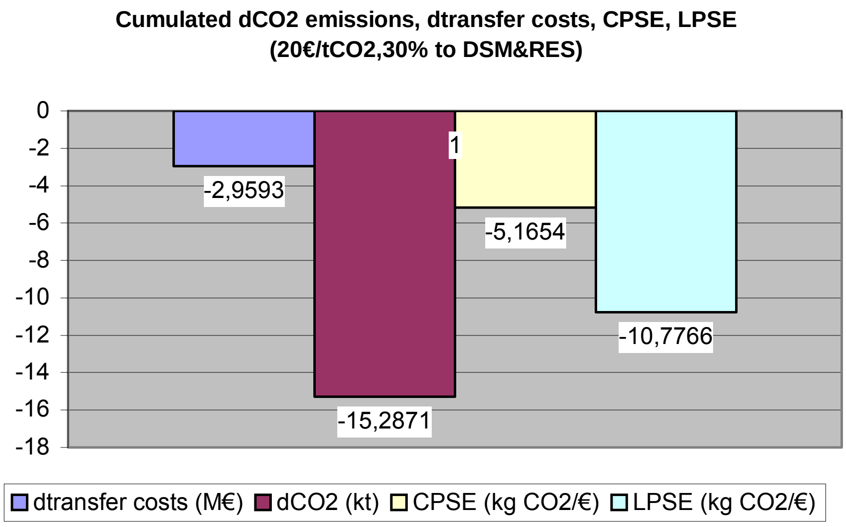


Figure3-18: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 20 €/t CO_2 tax

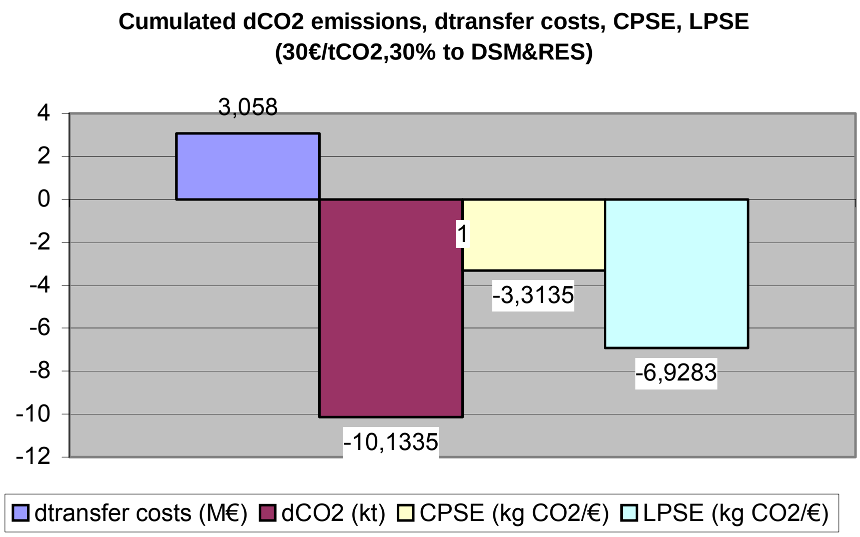


Figure3-19: Cumulated delta CO_2 emissions, delta transfer costs, CPSE and LPSE for 30 % subsidy to DSM&RES and 30 €/t CO_2 tax

It's important to emphasize that in all cases – even for high subsidies as shown in Figure 3-20 – the cumulated additional public income is much higher than the entire transfer costs.

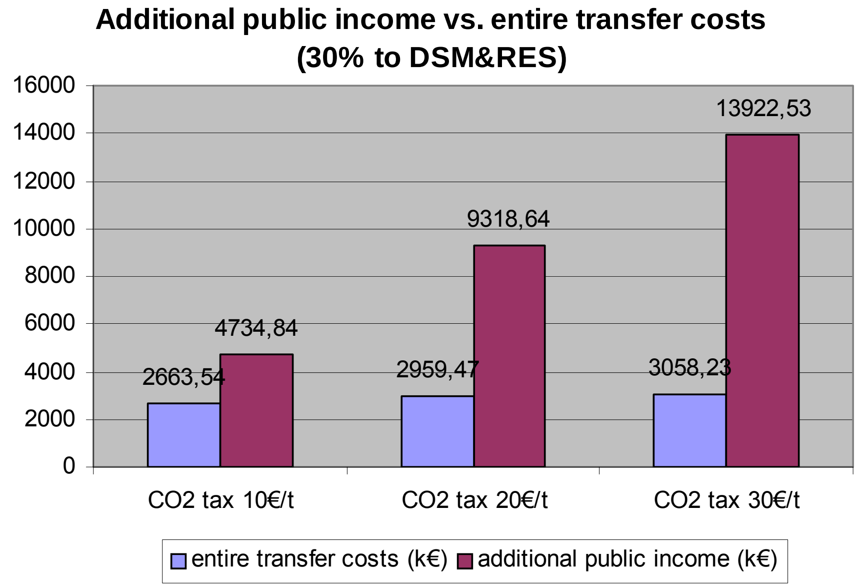


Figure 3-20: Additional public income vs. entire transfer costs for 30 % subsidy to DSM&RES

The result is that in the CO_2 tax case the DSM-only option is more favoured compared to the RES-only. Due to the CO_2 tax the number of coal-to-wood conversion in baseline scenario is very high as shown in Figure 3-21 until Figure 3-23. As a result, the impact of subsidies to RES investment is much lower than in previous hypothesis.

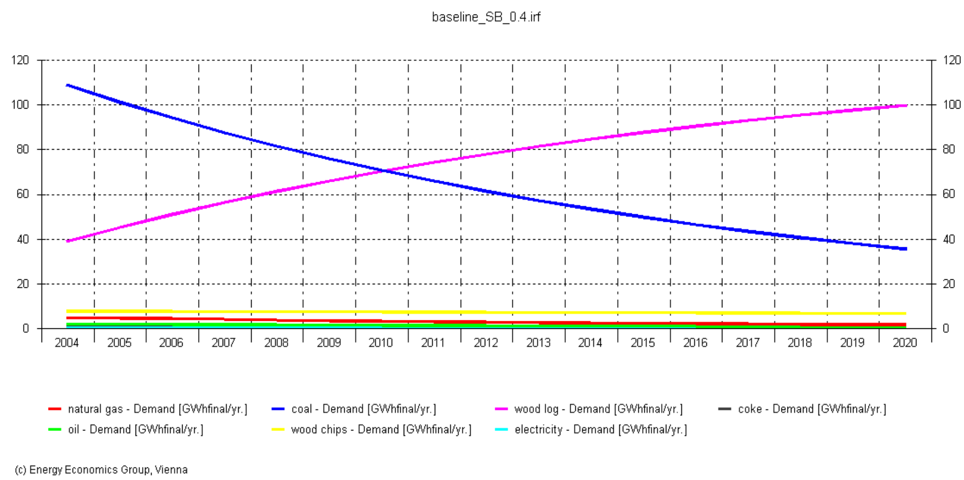


Figure 3-21: Fuels demand in the region – scenario with 10€/tCO_2 tax

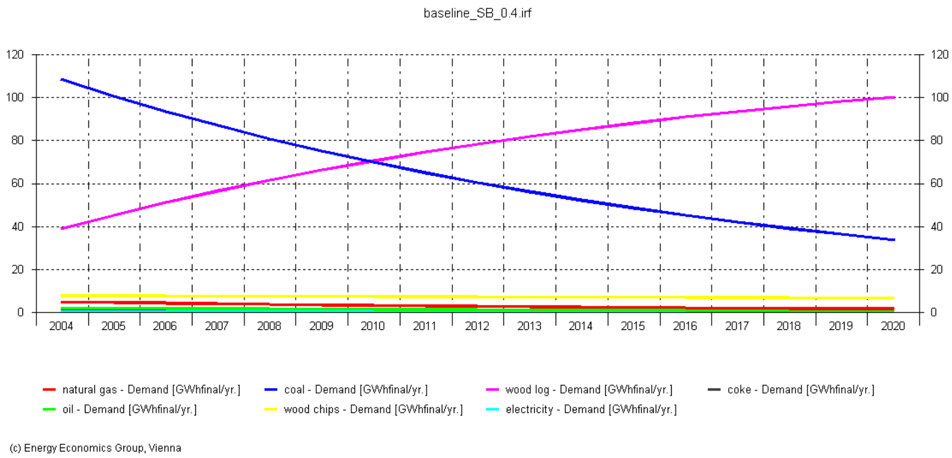


Figure 3-22: Fuels demand in the region – scenario with 20€/tCO_2 tax

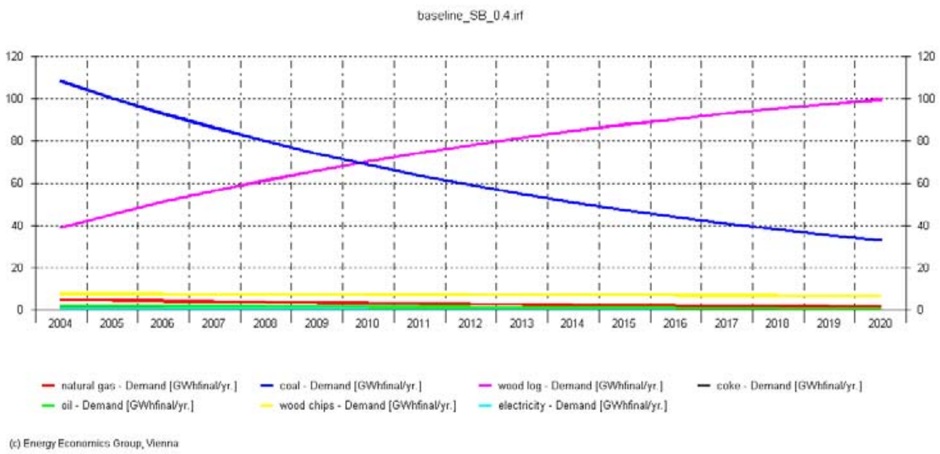


Figure 3-23: Fuels demand in the region – scenario with 30€/tCO_2 tax

3.4.4 Hypothesis 4: Pushing small biomass boilers (400,000 project)

In recent analyses of the barriers which hamper the development of the energy use of biomass in the new member states emphasis is often put on the investment cost which is too high for individual households, especially rural, to install a new biomass boiler [1-4].

The agricultural sector in Poland is dominated by small and medium-sized farms. There are about 1 900 000 small farms with the arable land area ranging between 1 and 10 ha [5]. The potential of biomass that can be used for energy purposes produced by the Polish farming sector is significant. The estimated amount of straw alone that can be used as fuel (apart from bedding and feeding animals) is about 11 Mt [6]. It has been estimated that about 400 000 farms could convert their heating systems from low quality coal, they use at present, to biomass produced locally, mostly self-produced.

Relatively inexpensive and simple biomass boilers, most appropriate to meet the farmers' needs, are produced in Poland and are accessible on the Polish market [7]. They are suited to use bale straw, but also log wood or different forms of wood waste. However, despite of the overall cost-effectiveness of switching from coal to local biomass, the volume of biomass boiler investments is next to negligible, against the potential market of several hundred thousand boilers. Several barriers hindering the development of this market can be mentioned: lack of information lack of easily accessible demonstration, lack of local experts who would promote biomass in the local energy plans. However, the main barrier for the coal to biomass conversion is the investment cost [8].

In an attempt to overcome this barrier, a project was suggested, aimed at decreasing the investment costs by combining the financial support schemes (subsidies) with the effect of scale to be achieved by bundling a number of small project into one package. The first pilot project has been implemented [9] in the commune of Trzcianne in north-eastern Poland where 41 individual boilers were installed in a single project organised by the local mayor. The bundling was aimed mainly at minimising the transaction costs related to acquisition, energy audits and professional advice, engineering design etc, which otherwise are internalised in the cost of the investment, either on part of the dealer or installer, or both, and constitute a large fraction of the investment total. Additionally, the project included training of a local installer who would also assess the heat demand and give technology advice as well as provide maintenance services in the future. On the other hand, financial support was organised by the mayor assisted by an external advisor. This approach further decreased the transaction costs for the individual farmers.

The project has shown that, as a result of packaging of small projects into a bigger one, the level of the subsidy needed to overcome the investment cost barrier can be decreased. The success of the project has made some other municipalities interested in using the same the approach and to consideration of launching a nation-wide or regional (voivodship or county) programme of conversion of small capacity individual heating systems in the rural areas form coal to locally available biomass. The programme would include the promotion scheme to support such investments in form of subsidies. At present, such a scheme does not exist on the national or regional level. However, prior to launching such programme, the effect of subsidies should be first estimated in terms of the number of installations they would generate and the environmental impact in terms of carbon dioxide emissions reduction.

In the present paper we present results of calculations using the computer model ***Invert*** [10] to assess the effect of subsidies on the dynamics of conversion from coal to straw.

Figure3-24 and Figure3-25 below show the dynamics of the installation of biomass boilers under the assumption of two different subsidy levels, 40 % and 20% of the investment costs, respectively.

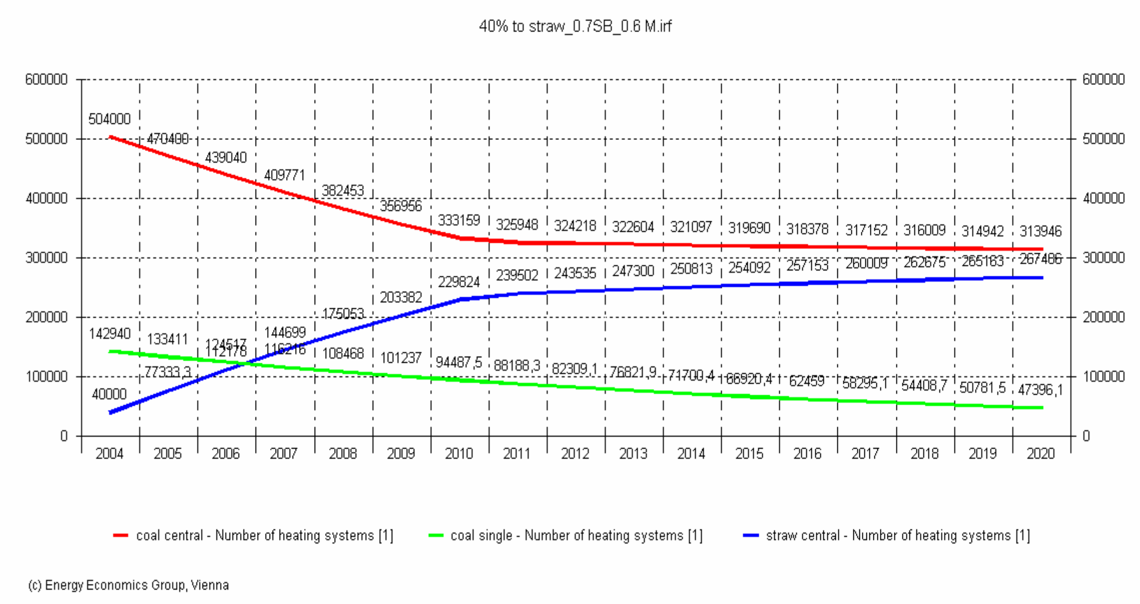


Figure3-24: Installation of biomass boilers under the assumption of subsidy levels of 40 % of the investment costs

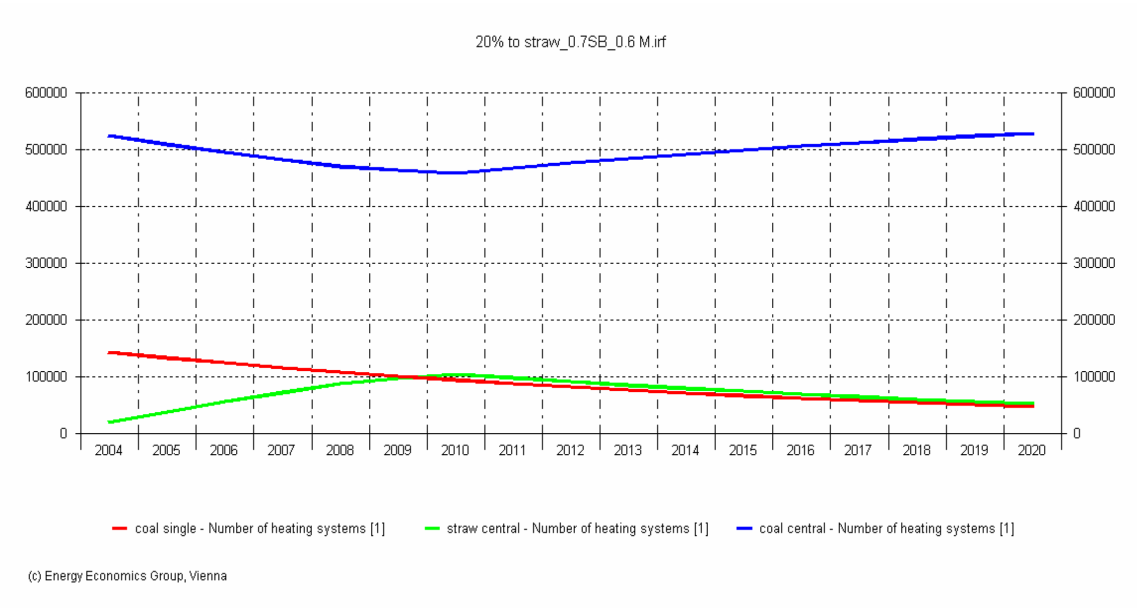


Figure3-25: Installation of biomass boilers under the assumption of subsidy levels of 20 % of the investment costs

The other assumptions used were:

- Only single family residential buildings are taken into account.
- The fuel used before conversion is coal and after conversion it is straw.
- The baseline was assumed to be a negligible level of conversions (zero in the calculations).
- A moderate increase of the price of coal, 27 % between 2004 and 2020, and a significant increase of 73% of the price of straw have been assumed.
- The distribution of boiler capacities was based on thermal evaluation of a sample of ca 2500 single family buildings in the communes of Jordanow, Bystra-Sidzina and Osielec in southern Poland (boilers ranging between 20-50 kW)

The figures illustrate the competition of replacement of the individual coal stoves ("coal single") used for heating of separate rooms with boilers heating the whole building ("central" coal or straw). As is seen, at the level of 20%, conversions to biomass win over the coal central only in the first 10 years, yielding afterwards to "coal central". The effect is due to an interplay between the lower investment cost for the coal boilers and the straw burning ones, vs the price of fuel. At 40%, the trend continues until 2020, when the number of "straw central" reaches ca. 270 thousand boilers.

Figure3-26 and Figure3-27 below shows CO_2 reduction (d CO_2) and lifetime promotion scheme efficiency (LPSE) for different subsidies ranging between 20 and 40 % and for hypotheses assuming further increase of straw price and introduction CO_2 tax.

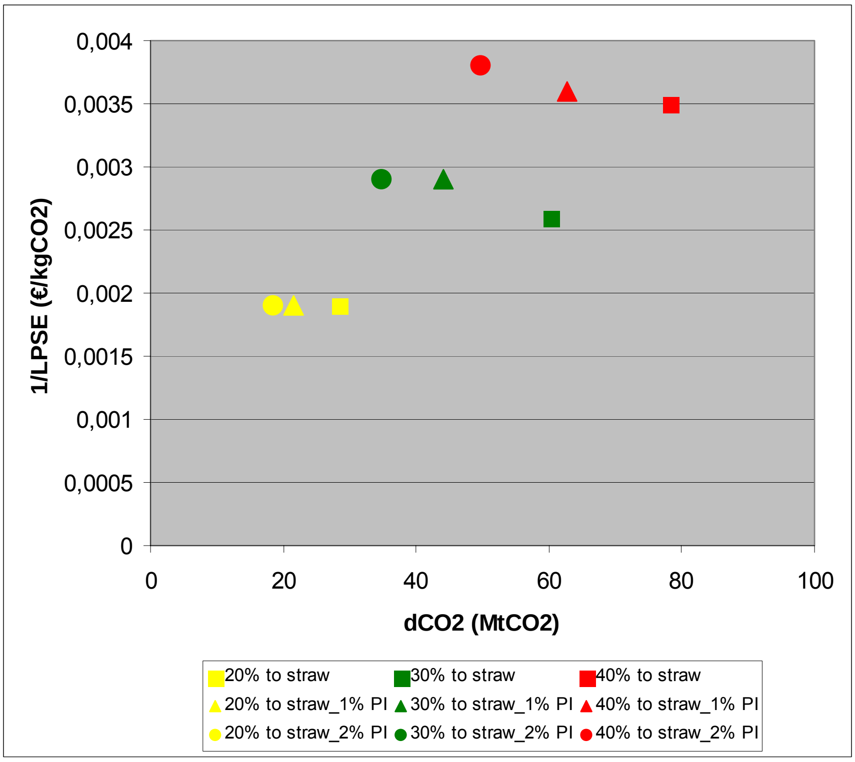


Figure3-26: Impact of subsidies to straw 2004-2020

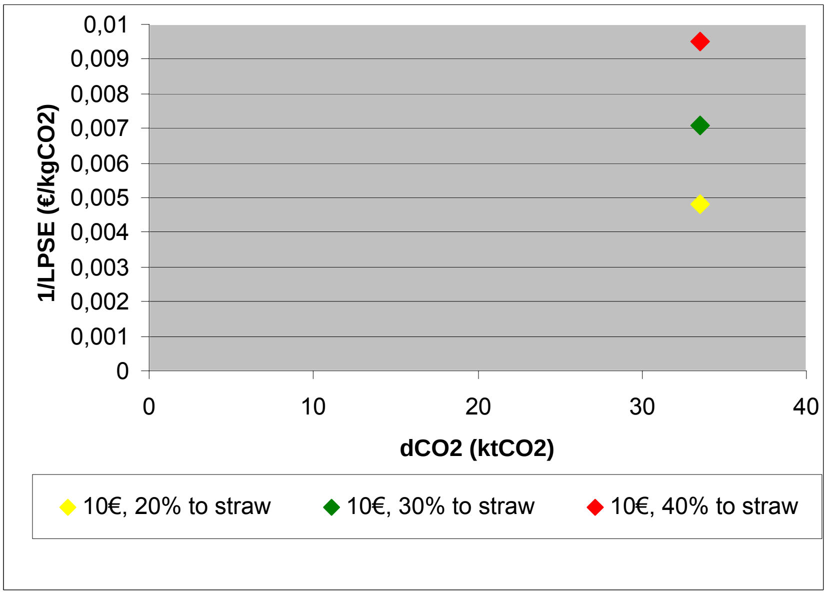


Figure3-27: Impact of subsidies to straw vs. wind

Figure below shows an impact of straw price increase and CO_2 tax on number of coal-to-straw conversions at different subsidies ranging between 20 and 40%.

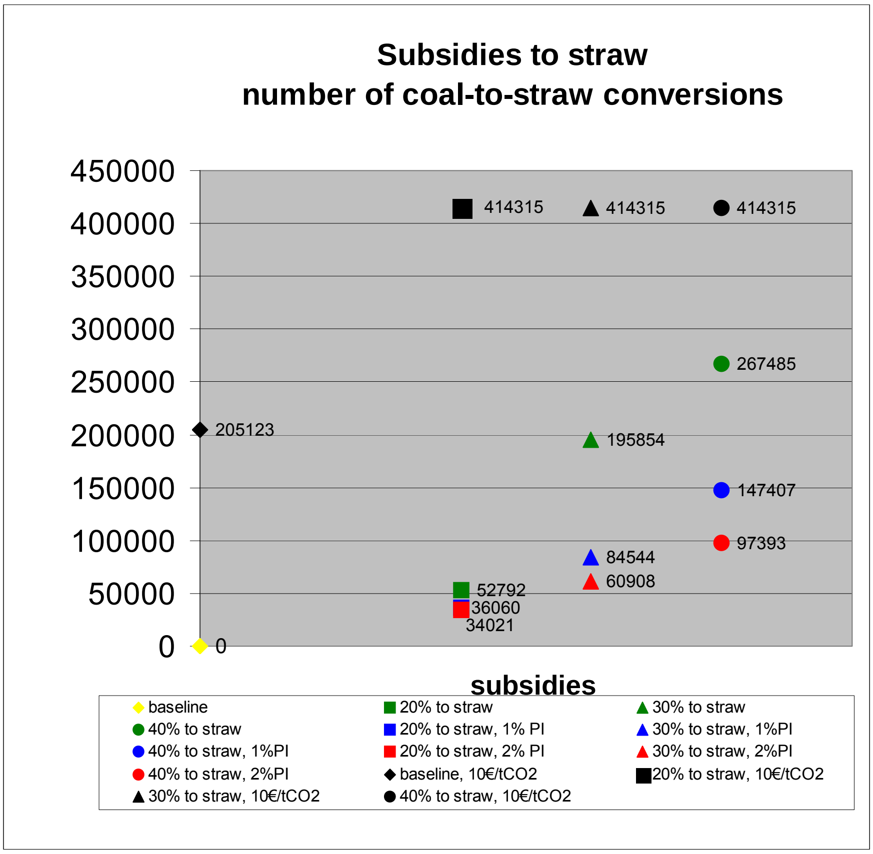


Figure3-28: Subsidies to straw – number of coal-to-straw conversions

The above figure shows that combining CO_2 tax with subsidies would be very interesting solution for promotion of use of straw for energy purposes.

The figures below show the comparison of the results of simulations for straw with the corresponding results for wind energy. A simple calculation for the first year shows that the same amount of subsidies (transfer cost) used for wind energy give lower CO_2 reduction and a lower gradient.

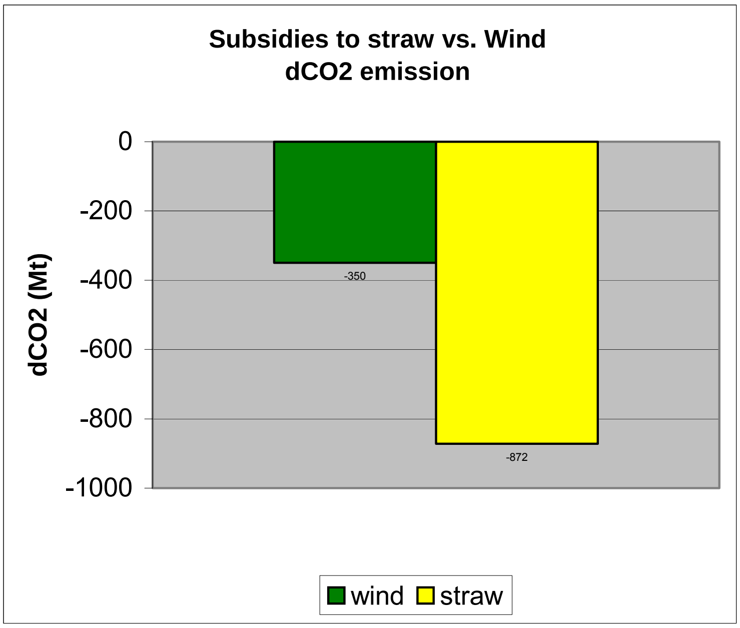


Figure3-29: Subsidies to straw vs wind – delta CO_2 emission

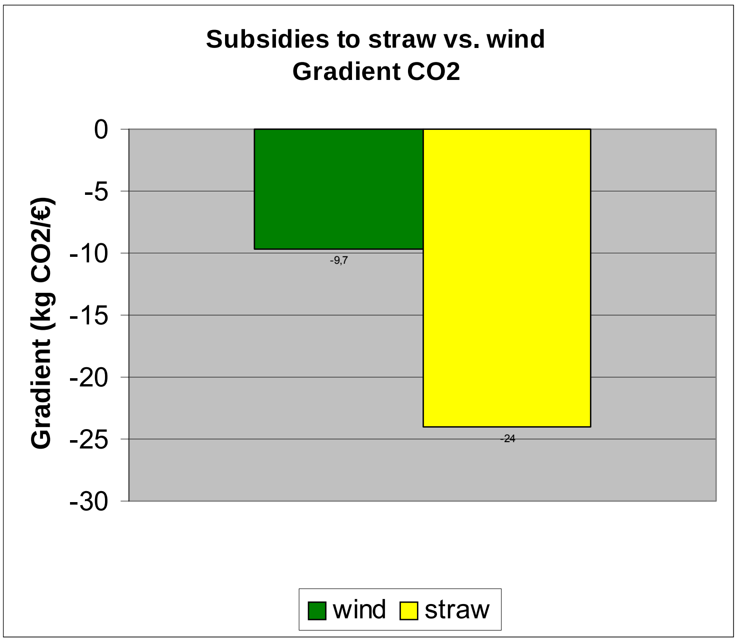


Figure3-30: Subsidies to straw vs wind – gradient CO_2

The above results show that the conversion of individual coal boilers to biomass (here to straw) offers an interesting CO_2 emission reduction option. Apart from the aforementioned advantages the programme based on "packaging" small biomass projects into bigger ones would:

- make it feasible to monitor the reduction of carbon dioxide, based on the biomass use in each municipality participating in the Project. Once tracking of emission reductions have become possible one may consider inclusion of them in the national balance, which could be a basis for rewarding the municipalities e.g., to offset the costs of monitoring. Alternatively, it could provide a basis for JI ventures.
- improve the local air quality by decreasing local emissions resulting from burning low-quality coal, and often burning waste containing plastics or rubber materials.
- create new local jobs (boiler installation and maintenance, often also biomass harvesting in dedicated energy plantations). At the national level new jobs would be created in boiler manufacturing and related industries.

3.5 Conclusions and recommendations

The first conclusion, which follows from the simulations, is that DSM with window exchange is not cost-effective in terms of energy saved. This conclusion is well confirmed by field experience and other independent analyses (in particular by USAID project in Poland). The recommendation, which follows, is that public money should not be used for window exchange on grounds of environmental benefits, as it can be more effectively used in other DSM investments. In fact, subsidies to window exchange in Poland have been practically abandoned as it brings rather comfort and aesthetic benefits than cost-effective energy reductions.

Having these observations in mind, one can consider this conclusion to be a test for the model.

The second conclusion is that at low RES technology price supporting DSM measures is more cost-effective than RES or combined RES/DSM measures. The model enables one to estimate the optimal level of subsidies, which in this case is around 20% with the assumed parameters. This, at the same time, is an important guideline for decision makers in the determination of level subsidies.

The third conclusion concerns higher cost of RES technology. In this case, rather obviously, subsidies to RES become more effective. The quantitative result is that only at the subsidy level of 20% the motivation to invest in RES becomes sufficient, which constitutes an important guideline for decision makers. In particular, the recommendation is that the public money should be preferably spent for RES subsidies in public buildings such as schools, where constrain are such that inexpensive and simple RES technologies are not acceptable.

A very important conclusion valid for all three hypotheses concerns the maximisation of CO_2 emission reduction. By the very nature, the biomass potential in a given area is a limited resource. The question is then what maximum CO_2 reduction can be obtained with this predetermined resource. In other words, the target is here, the global environmental benefit that can be maximised locally. The simulations show that in all three hypotheses the maximum effect is achieved when, both RES and DSM are subsidised at the same time, contrary to the previous practice of considering separately projects addressing RES and DSM. It should be pointed out that this ***Invert*** modelling result constitutes *a posteriori* justification of the approach first proposed in 1999 to combine RES and DSM in a single project. This approach was a basis of the GEF grant for the project “Integrated approach to wood-waste use for space heating in Poland” proposed for a pilot implementation in the Jordanów area.

3.6 References

Filipowicz et al, Monitoring of selected parameters of building and energy audit, Rynek Instalacyjny 12/2003, pp. 75-79

Mijakowski M., Indoor air humidity in naturally ventilated dwellings, Instal 1/2003, pp. 18-22

National Census 2002, GUS, Kraków 2003

Statistical Yearbook 2003, GUS, Warsaw 2004

[1] Denisiuk, W., “Straw Heating Technologies”, presented at the V International Slovak Biomass Forum, Bratislava, Feb. 21-22, 2005

[2] Cahn, M., “Are European Cities Going towards Greener”, ibid

[3] Gula, A., et al., “Project Examples in Poland”, ibid

[4] Deli,K., L. Deli, “Project Examples in Hungary”, ibid

[5] Polish Statistical Yearbook, 2003

[6] Gradziuk,P., A.Grzybek, K.Kowalczyk, „Sloma Energetyczne Paliwo", Ed. Akademia Rolnicza w Lublinie, Polbiom, IBMER, Warszawa 2001

[7] see.eg. http//www.metalerg.pl

[8] Teliga,K., et al. „Biomass for Energy in a Country in Economic Transition, Polish Experience. Barriers vs Support, presented at.World Renerwable Energy Congress VIII, Denver, Co, Aug.29-Sep.3, 2004

[9] see article in monthly "Czysta Energia" (Clean Energy), no 3/2005

[10] see website, www.invert.at

4 Greece – Crete

4.1 Structure of the energy supply in Crete

4.1.1 Primary Energy Demand and End Energy Consumption

Located in the South-East Mediterranean, Crete is one of 13 regions of Greece and the largest island of this country. It covers an area of 8,336 km^2 and has a population of 601,131 resident inhabitants (2001). Crete is divided into four prefectures (Heraklion, Chania, Rethymnon and Lassithi). The economic sectors contribute to Crete's GDP as follows: Primary sector 19%, Secondary sector 18%, tertiary sector 63%.The distribution of energy consumption per sector is shown in Figure 4-1.

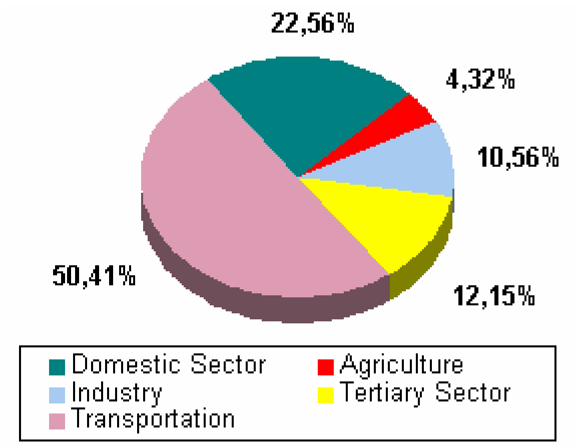


Figure 4-1 Distribution of energy consumption per sector

Total energy consumption in Crete accounts for 29,700 TJ (2000). The primary energy demand of Crete is characterized by the dominance of oil, diesel and a number of wind plants, installed on the island. Crete is not interconnected to the mainland; the kind of fuels and the energy form, which are used, are shown in Figure 4-2. Furthermore, it should be pointed that 12 % of the whole energy consumption of the island is provided by the use of biomass (mainly olive oil kernel). This energy is used for thermal energy in oil mills, greenhouses, hotels etc.

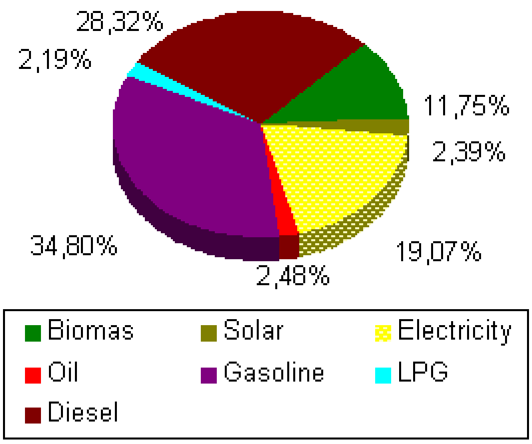


Figure 4-2 Kind of fuels and the energy form used on the island

4.1.2 Power generation

Total electricity demand in Crete reaches 2,138.9 GWh (2000). Two electric power generation, which belong to the Public Power Corporation (PPC) are in operation in Crete, covering a great share of electricity demand of the island. The first one is situated in the Prefecture of Heraklion (Linoperamata) with total installed power of 197.15 MW and the second one is located in the prefecture of Chania with total installed power of 236.8 MW. The conventional installed power for electricity production is 514.4 MW and the RES installed power is 70 MW (see Chapter 2.4). The distribution of power energy production per kind of fuel is shown in Figure 4-3.

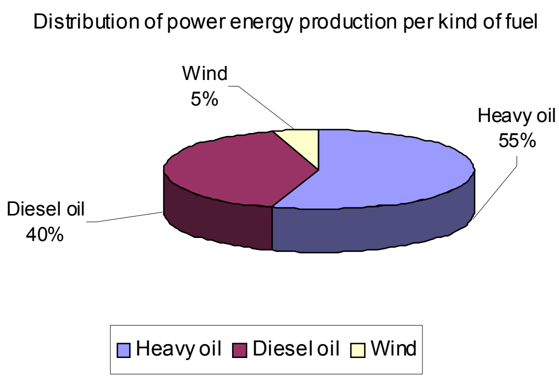


Figure 4-3 Distribution of power energy production per kind of fuel

4.1.3 Combined heat power generation

Electricity from CHP plants presently contributes with a small share the power generation of Crete. There are two sewage Cogeneration Units on the island, used in the waste water treatment plants in Heraklion and Chania. The total electricity potential of these plants is 2 GWh per year.

4.1.4 Heating sector

The building stock is covering about 287,000 residential buildings and respectively 474,000 dwellings. Nearly 30% of the heating energy demand is supplied by central heating systems, using oil as fuel input. Figure 4-4 shows the final energy demand for heating according to each heating system used in Crete. Single heating systems (oil, wood, gas and electricity) have a share of 70% of heating in residential buildings. Electricity stand alone systems, used to provide DHW are installed in more than half (58%) of the dwellings. Solar thermal collectors are also widely used as additional to electricity and cover 38% of the total energy demand for DHW. Final energy demand for DHW is covered in Crete by oil combined systems and electricity (

Figure 4-5). Finally, in the cooling sector, energy needed for cooling is provided mainly by split air-conditioning (AC) units.

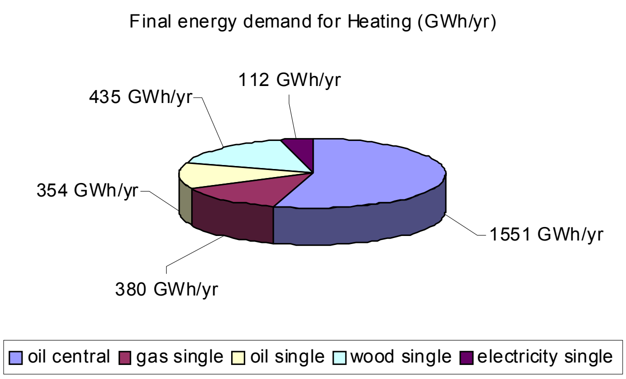


Figure 4-4: Final energy demand for Heating (GWh/yr) in residential buildings

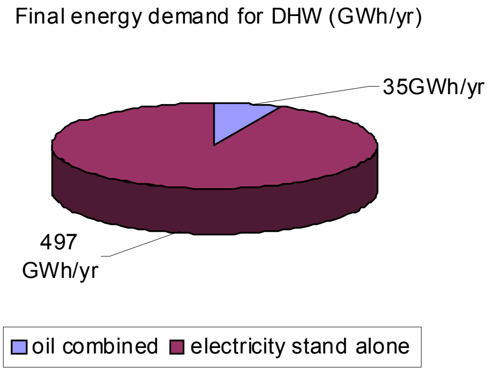


Figure 4-5 Final energy demand for DHW (GWh/yr) in dwellings

4.1.5 Renewable Energy Sources (RES)

Crete is an island with great RES potential. RES electricity production covers almost 10% of the total electricity demand (Figure 4-6). In East and central part of the island there are many wind parks of total capacity 108 MW, while many new wind parks are under construction. In the west part of Crete, two small hydro stations are in operation, with a total installed capacity of 0.76 MW. Photovoltaic systems, although quite expensive yet, are installed in different parts of the island covering a small share of the electricity demand (0.67 MW). Solar thermal collectors, used for domestic hot water (DHW) are widely used. More than 80,000 m^2 (133 m^2/1000 persons) are installed in housed and hotels and cover 3% of the total energy demand of the island. Electricity potential of 360 GWh per year is also estimated for Biomass products, such as agricultural residues. Moreover, there is an innovative pilot thermal system for electricity production, with estimated potential of 112 GWh per year.

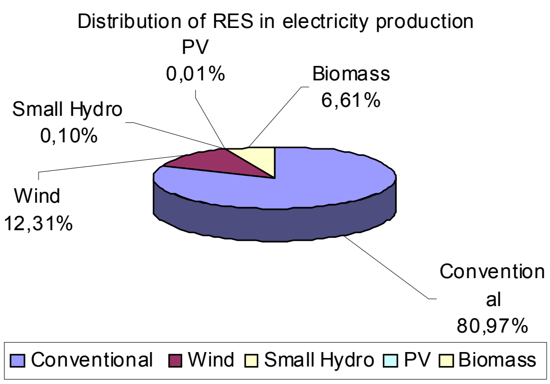


Figure 4-6 Distribution of RES in electricity production

4.2 Promotion schemes in Crete

4.2.1 Energy Policy

The Regional Energy Agency of Crete, in cooperation the Ministry of Development and Public Power Corporation have adopted an integrated energy policy and programming, which gives emphasis to the promotion of RES and Rational Use of Energy (RUE). Additionally, the National Technical University of Athens have formulated the "Implementation Plan for RES in Crete", which is based on available RES potential of the island (Table 4-1).

Table 4-1: Time schedule of RES installations in Crete

	Wind (MW)	Biomass (MW)	Hydro (MW)	PV (MW)	PSU (MW)	Solal Thermal Collectors (1000m^2)
2000	89.3	20	0.6	0.2	-	87.5
2001	115.2	20	1.01	0.3	-	125
2002	124.8	20	1.56	0.8	-	175
2003	134.8	40	2.15	1.4	-	225
2004	140.5	40	3.99	1.7	-	287.5
2005	200	40	6	2	125	362.5
2010	250	60	6	4	125	500

4.2.2 Existing promotion schemes

4.2.2.1 National Operational Programme for Competitiveness

The Measure 2.1 of Subprogramme 2 of the National Operational Programme for Competitiveness (OPC) / CSF III (2000-2006) is devoted entirely to providing State support (grants) to private investments in:

a) renewables,

b) rational use of energy, and

c) small-scale (<50 MW_e) cogeneration.

The total budget of Measure 2.1, for the 2000-2006 period of CSF III, is 1.07 billion Euros, of which 35.6% or 382 million Euros is the public subsidy available to

RES/RUE/CHP investments. About two-thirds of the total available subsidy (~ 260 million Euros) is foreseen to be awarded specifically to RES investment projects.

4.2.2.2 National Development Law

This is a financial instrument-umbrella, covering all private investments in Greece, in all sectors of economic activity. It has a strong regional character, in that the level of public support depends strongly on the particular geographic region, in which the given private investment is planned to materialize. Regions with high unemployment rates and low incomes per capita receive the highest investment subsidies from the State.

Investments in RES installations (both electricity- and heat-producing ones) have a special status under Law 2601/98, similar to the one bestowed to other selected categories of investments, such as investments in high technology, environmental protection, etc. More specifically, the main provisions of Law 2601/98 concerning public support of RES investments.

4.2.2.3 Basic law governing RES electricity - Law 2773/1999

The basic law governing RES electricity is Law 2773 of 1999, on the liberalization of the domestic electricity market, and, specifically, its Chapter 10, Articles 35-41. This law has incorporated the majority of provisions of the earlier Law 2244 of 1994, which, unlike Law 2773, was devoted entirely to RES electricity matters. At present, there is no Greek law dealing specifically with heat production from RES.

Law 2773/99 instituted a new license, the so-called electricity generation license, which is now the first license required to be obtained by any electricity-producing station, conventional or RES-based, in a long planning / licensing procedure that also includes presiding permit, land-use permit, approval of environmental terms and conditions, installation license, operation license, etc.

Law 2941 of 2001 supplemented Law 2773/99 with certain important provisions about renewables, including: a) the definition of the general terms and conditions, under which it is allowed to install RES stations in forests and forestry lands, and b) the characterization of all RES projects as projects of public utility status, which gives them the same rights and privileges in land expropriation procedures as those given to public works, independently of the legal status of the RES project owner (being private or public).

4.2.3 Regulations by law

4.2.3.1 Regulation for Rational and Efficient Use of Energy

In 1995, the Greek Ministry of Environment, Urban Planning and Public Works prepared an Action Plan, entitled "Energy 2001", aiming at promoting the use of RES, as well as the application of energy-efficiency technologies, in the building sector. The Action Plan was prepared in order to define specific measures for the reduction of greenhouse gas emissions in buildings, in accordance with the "National Action Plan for the Abatement of CO_2 and Other Greenhouse Gases". Following official adoption of the Action Plan by the Greek Government, "Energy 2001" was further reinforced by the enactment of Ministerial Decree (MD) 21475/98, which incorporated the provisions of Council Directive 93/76/EC (SAVE Directive) for the stabilisation of CO_2 emissions and the efficient use of energy in buildings.

Article 4 of the MD 21475/98 provides for the future issuing of a Regulation for the Rational and Efficient Use of Energy (RREUE), which will be in compliance with the Greek General Building Code and will replace the existing Regulation on the thermal insulation of buildings. The drafting of the Regulation has been assigned by the Ministry of Environment, Urban Planning and Public Works to the Centre for Renewable Energy Sources (CRES), and it has been carried out in accordance with the provisions and specifications set out by MD 21475/98.

4.3 Reference Scenario

4.3.1 Essential Assumptions

The Reference Scenario is defined to represent the "business as usual" development based on the existing promotion schemes. The main assumptions are:

- Fossil energy prices rises up to 1.5 times of current prices in 2020
- Investment decision for new technologies in building sector based on payback time; e.g. payback time differs from lifetime
- Used feed in tariffs refer to not interconnected islands (Crete) and stand for the electricity price paid to independent producers (0.079 €/ KWh)
- There is no potential or future energy policy for district heating in Crete
- Simulation for transport is not included, since there is no use of biofuels on the island

4.3.2 Characteristics of Reference Scenario

4.3.2.1 Building Sector

Heating systems

It has to be mentioned that for the time being no promotion schemes (investment subsidies or soft loans) exist with respect to building sector (heating, DHW, cooling systems and DSM measures).

- Significant increase of the growth rates of central oil systems (from about 96,000 heating systems in 2004 up to more than 223,000 heating systems in 2020
- Continuous decrease of single gas, oil and wood systems down to about one third in 2020 (relating to the level in 2004)
- Continuous decrease of single electricity systems up to 2020
- No use of wood central heating systems

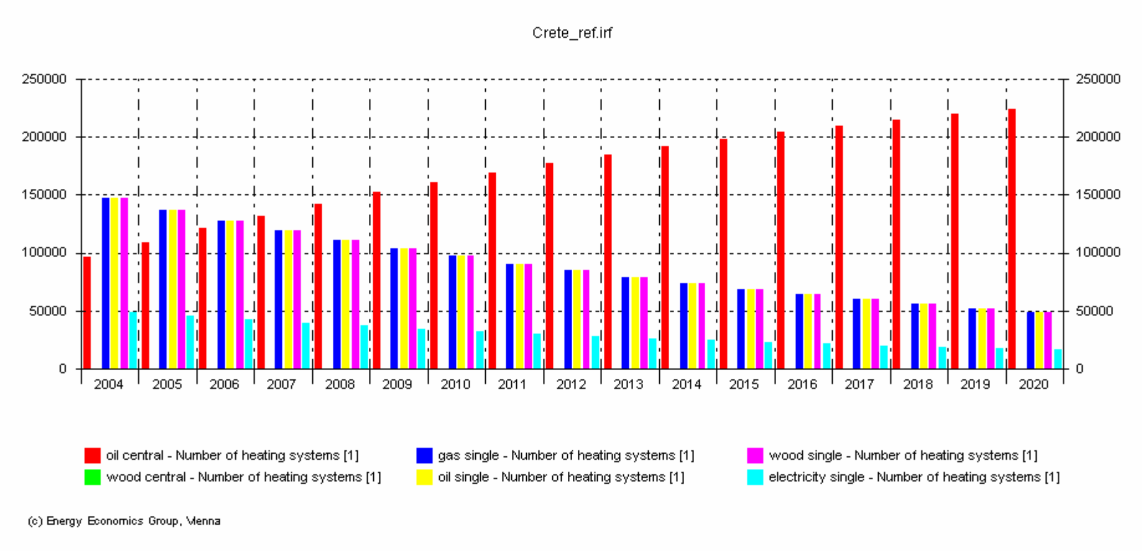


Figure 4-7: Number of heating systems

DHW systems

- Very slow decrease of electricity stand alone DHW systems –(6%)
- Moderate increase of solar thermal systems (17%)
- Continues increase of DHW systems, combined with heating systems (68%) (analogous behaviour as heating sector for combined systems)

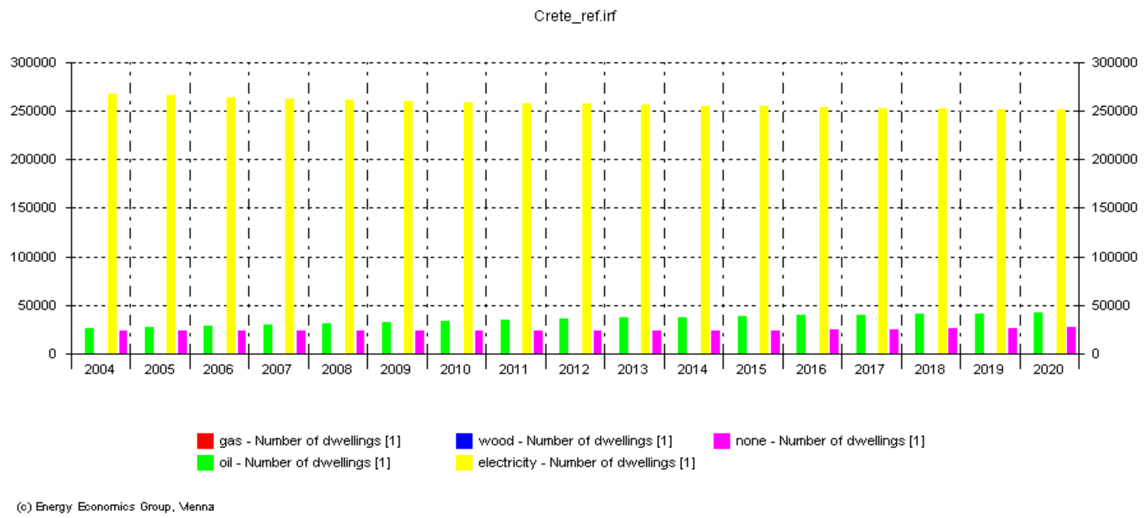


Figure 4-8: Overview/Summary - Number of dwellings (DHW)

Cooling systems

- Continuous decrease of split AC units from 580,000 cooling systems in 2004 to 200,000 systems in 2020
- At the same time, oil cooling systems rise up to ten times by 2020

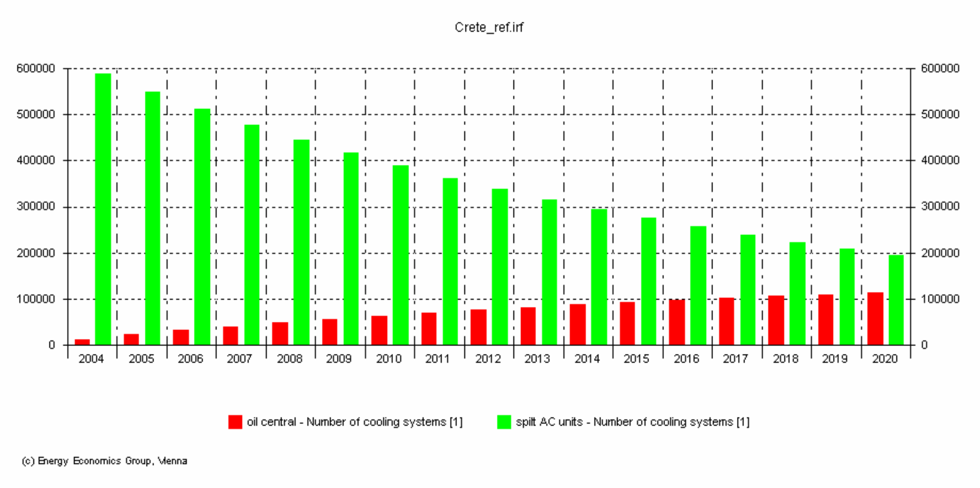


Figure 4-9: Overview/Summary - Number of cooling systems

DSM measures

- Insignificance decrease of heating energy demand from 2004 to 2020

- Very few buildings, and only SFH will be provided with new wall insulation

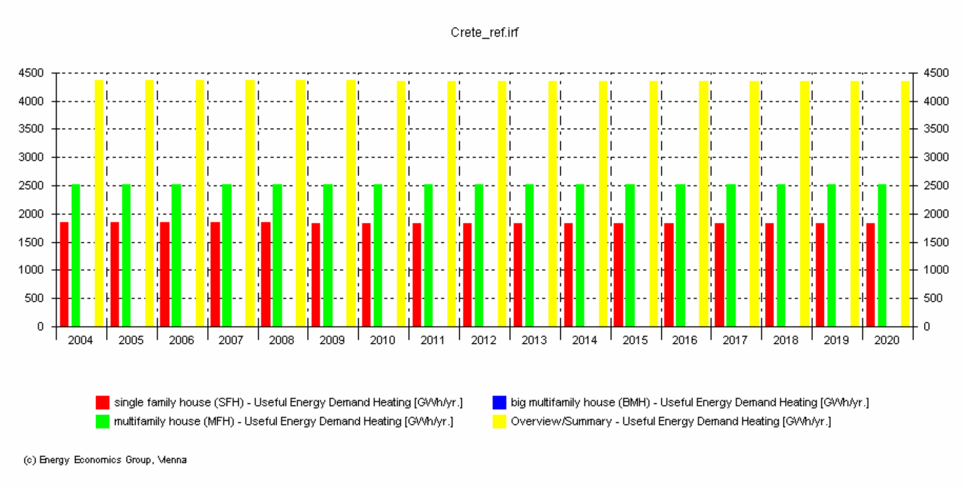


Figure 4-10: Overview/Summary – useful energy demand eating

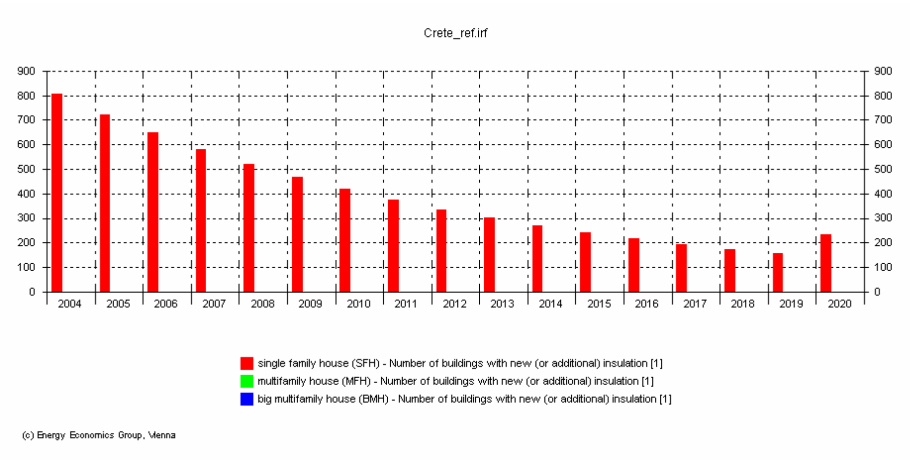


Figure 4-11: Single family house (SFH) - Number of buildings with new (or additional) insulation

4.3.2.2 RES power generation

RES-E- electricity output

- Significant increase of wind onshore electricity production (from about 336 GWh/yr in 2004 to 781 GWh/yr in 2012; stable energy production till 2020.
- New small hydro plants are installed every year up to 2012 and account for more than 22 GWh/yr till 2020
- Very small and continuous contribute of PV systems, providing 0.17 GWh/yr

- Biomass will be applied from 2016, producing up to 360 GWh/yr (the whole electricity potential)
- Solar thermal power plant not in use till 2009 (22.4 GWh/yr) up to 2020

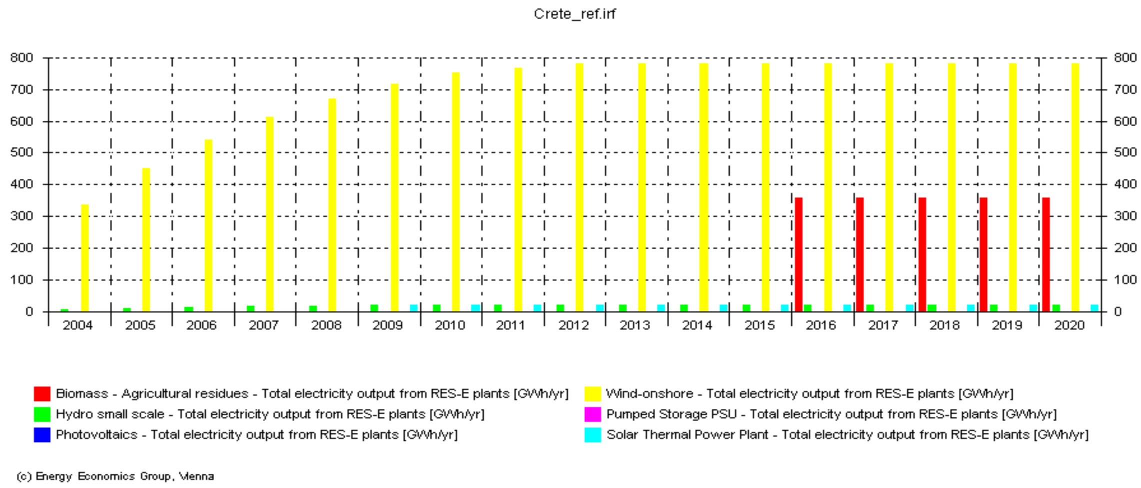


Figure 4-12 Electricity output from RES-E plants [GWh/yr]

With the existing promotion schemes, total electricity output from RES-E plants in Crete will rise up to 1180 GWh/yr by 2020 (204 GWh/yr produced by RES in 2002). Without promotion there would be no increase of power generation from RES plants (in comparison to the present situation) besides a small amount by wind parks and hydro small plants. Total electricity production by RES would not reach more than 212 GWh/yr.

- CO_2 emissions reduce every year due to new RES plants, installed on the island (significant reduce after the installation of biomass plant in 2016)

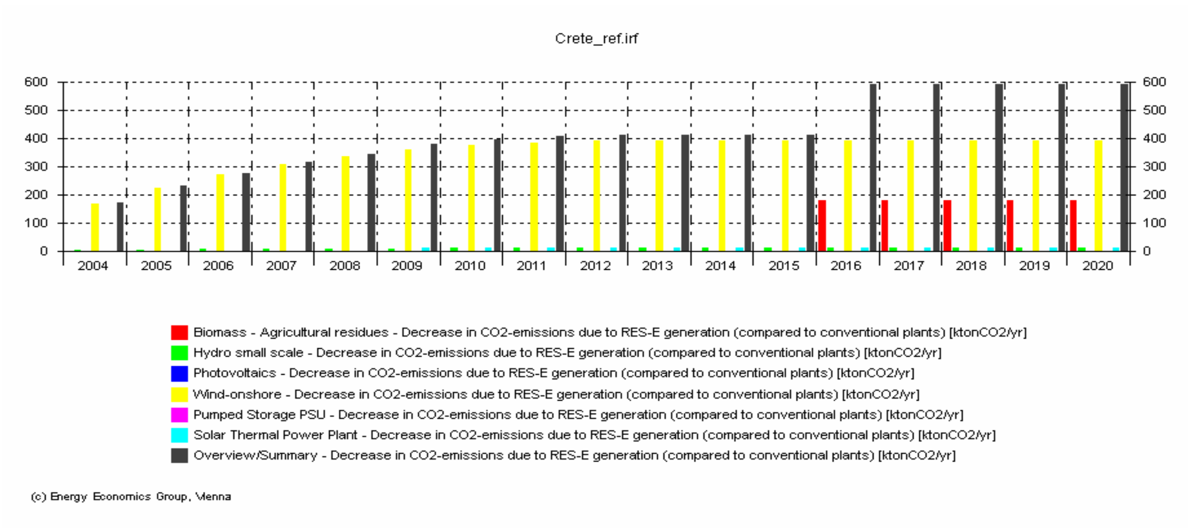


Figure 4-13 Decrease in CO_2-emissions due to RES-E generation (compared to conventional plants) [kton CO_2/yr] (with schemes)

- The only CHP plant on the island (using sewage gas as input fuel) operates since 1996 and continually contributes to RES share of Crete with 2 GWh/yr electricity and 0.5 GWh/y heat output up to 2020
- Stable CO_2 emission reduction every year, due to the operation of RES – CHP plant

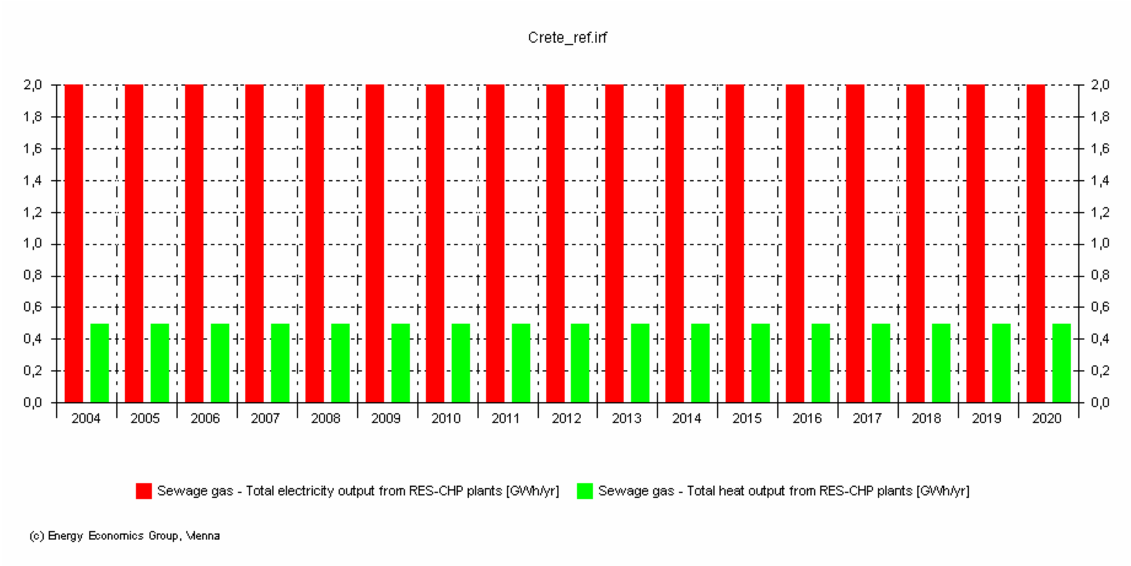


Figure 4-14 Sewage gas - Total electricity / heat output from RES-CHP plants [GWh/yr]

4.3.3 Total effects of all existing promotion schemes

Essential effects of promotion schemes:

- The existing promotion for RES and RUE in Crete leads to cumulated reductions of 422 CO_2 kton in the time between 2004 and 2020 (Figure 4-15).
- The according promotion costs amount 730 m€ (cumulated 2004-2020) (
- Figure 4-16).
- The main share – regarding as well the CO_2 reduction as the transfer costs – account for the electricity sector (without CHP), since there is no promotion for the building sector
- The average cumulated promotion efficiency in 2020 is about 9.7 kg CO_2 / € (Figure 4-17) for RES-E plants, 12.6 kg CO_2 / € (
- Figure 4-18) for RES-CHP plants and 9.7 kg CO_2 / € as overall (electricity production from RES-CHP is small compared to RES-E).

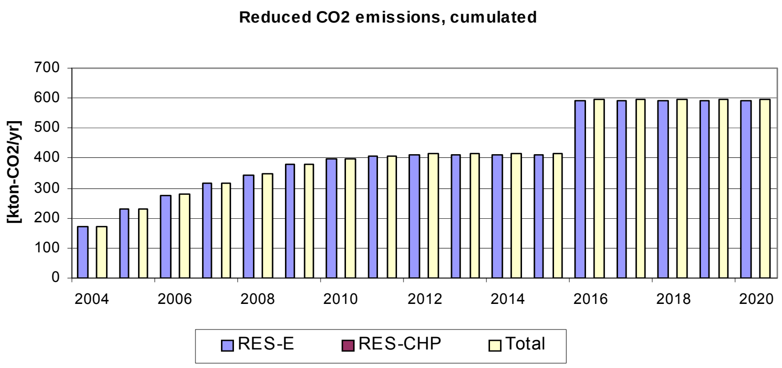


Figure 4-15: Total decrease in CO_2-emissions (compared to conventional plants) [kton- CO_2/yr]

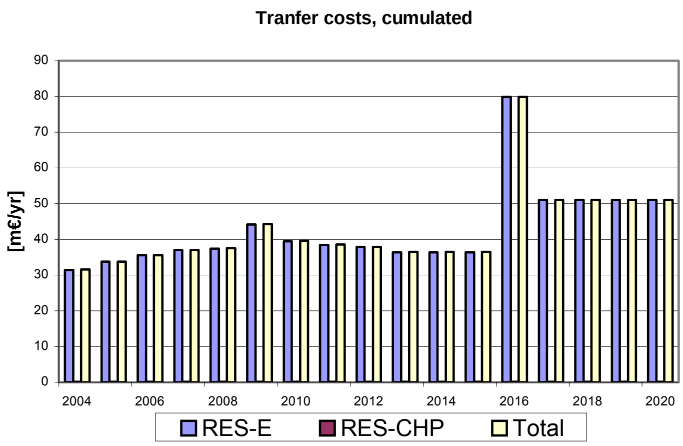


Figure 4-16: Total transfer costs (m€/yr)

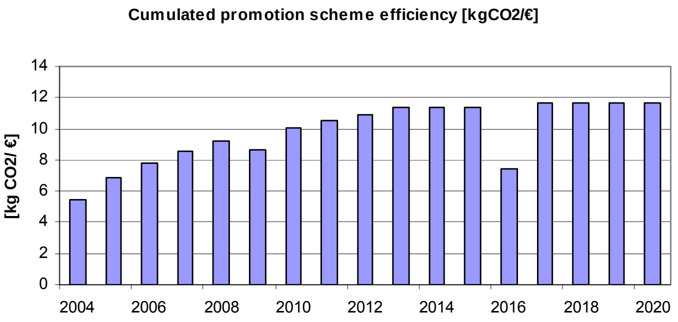


Figure 4-17: RES-E - Cumulated promotion scheme efficiency [kg CO_2/€]

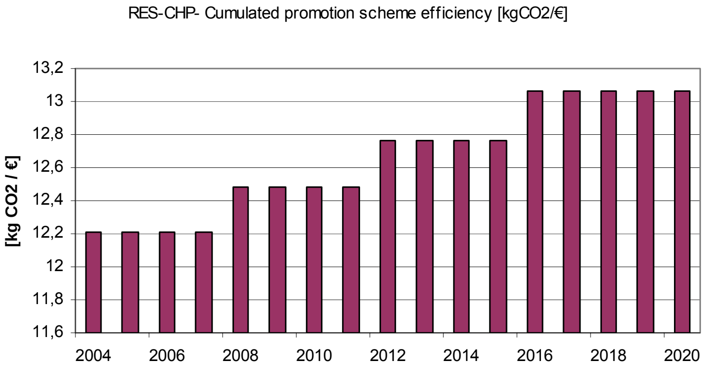


Figure 4-18: RES-CHP - Cumulated promotion scheme efficiency [kg CO_2/€]

4.3.4 Sensitivity analysis: energy price

The price increase in all scenarios leads to a higher incentive for insulation and window replacement which results in a reduction of final energy demand.

However in CO_2 emissions, price increase has different effects. In Reference scenario, CO_2 emissions increase every year. This is due to the fact that currently there are no investment subsidies or soft loans for heating, DHW, cooling in Building sector or for DSM.

When increasing the price by 1% or 2%, CO2 emissions which are higher than in the reference scenario. The increase of all energy prices by 4% leads to a further installation of solar thermal systems, and consequently in a reduction in CO2 emissions.

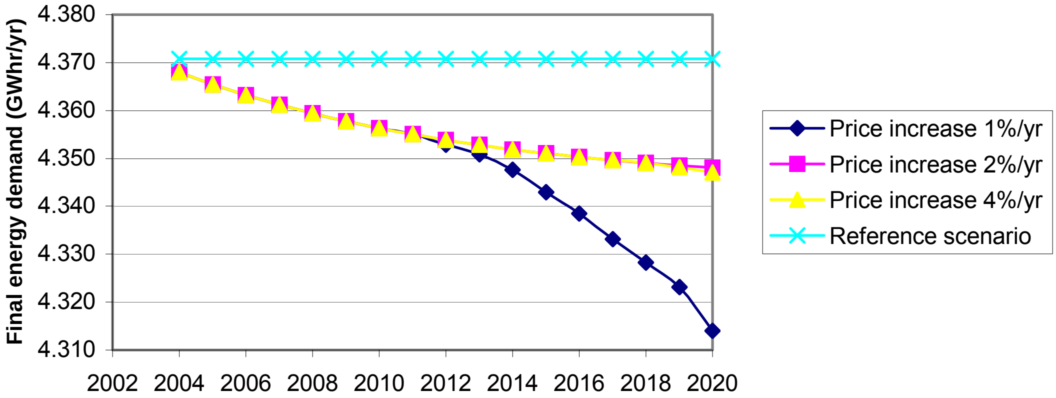


Figure 4-19: Sensitivity of final energy demand reduction towards energy price increase

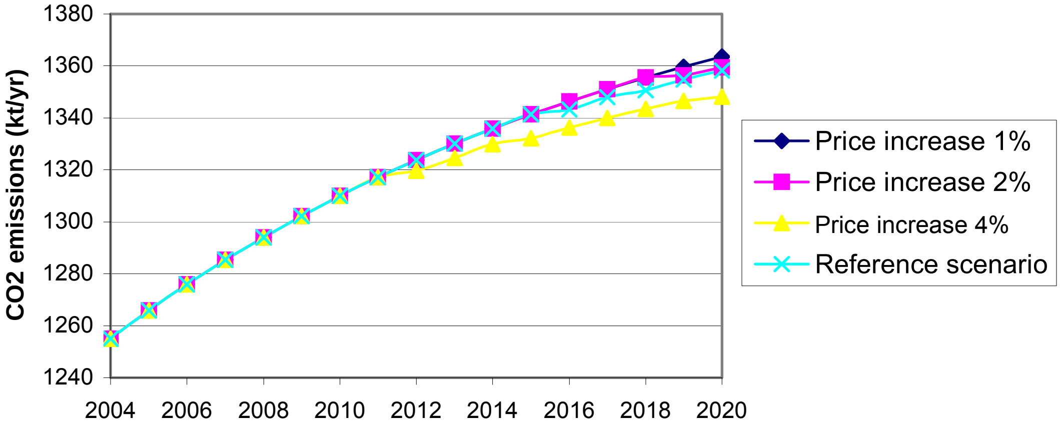


Figure 4-20: Sensitivity of Delta CO_2 reduction towards energy price increase vs reference scenario

With respect to solar thermal systems, the number of solar thermal dwellings is lower than the one in reference scenario for price increase of 1% or 2%, but higher for price increase of 4%.

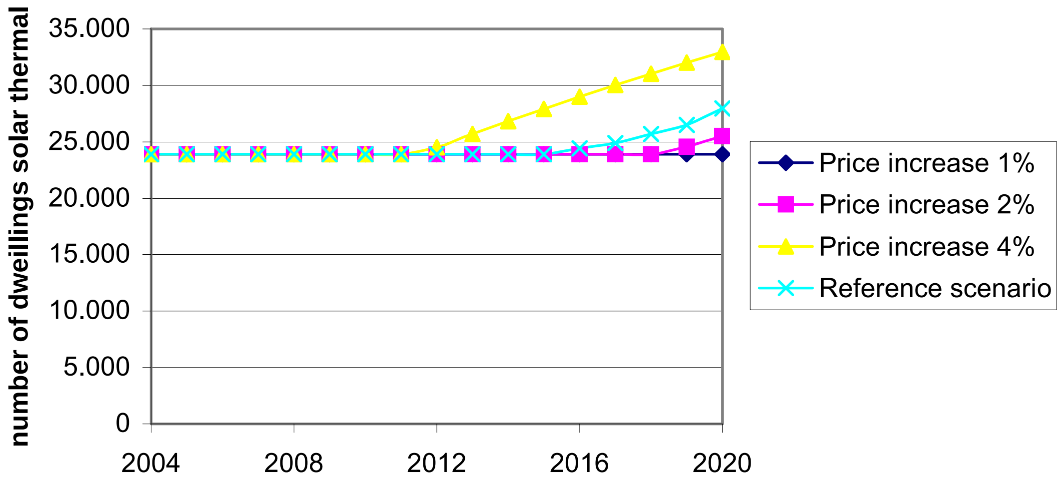


Figure 4-21: Number of dwellings with solarthermal systems

4.4 Analysis of hypotheses

4.4.1 Hypothesis H1: Simultaneous support for wood central and wood single systems

With the existing promotion policy, buildings in Crete will not install any wood central systems (in MFH or BMH). Furthermore, wood single systems will continuously decrease (in SFH)

Performed variations

- Investment subsidies for wood central systems in heating sector in MFH and BMH (HYP_1_1)
- Investment subsidies for wood single systems in heating sector in SFH (HYP_1_2)

Main results

- With an investment subsidy of 40%, wood central systems will be installed after 2017 in MFH. New systems will contribute to a further decrease of CO_2 emissions. CPSE is ca. 4 kg CO_2/€ in 2020 but LPSE is 47 kg CO_2/€ (Figure 4-24)
- The same investment subsidy for wood single systems in SFH, will have no impact on the continues decrease of the installation of these systems

Conclusion: the simultaneous promotion of wood central systems, in MFH and BMH makes them profitable from 2018 to 2020.

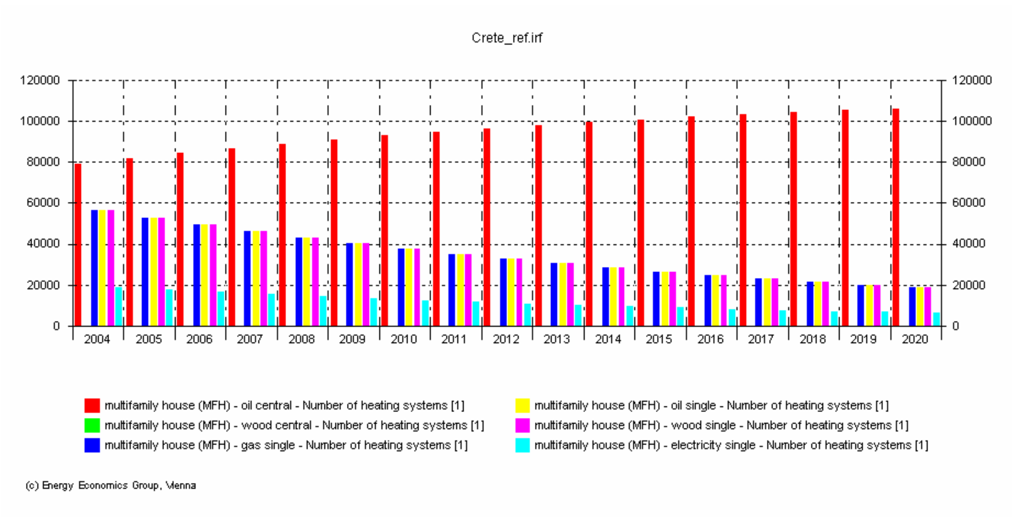


Figure 4-22: MFH – reference scenario

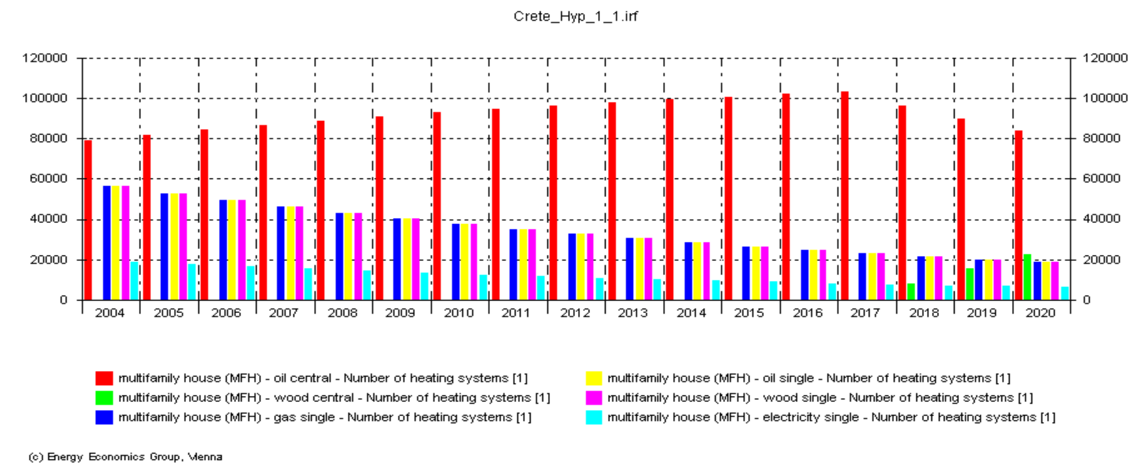


Figure 4-23 MFH – with promotion on wood central

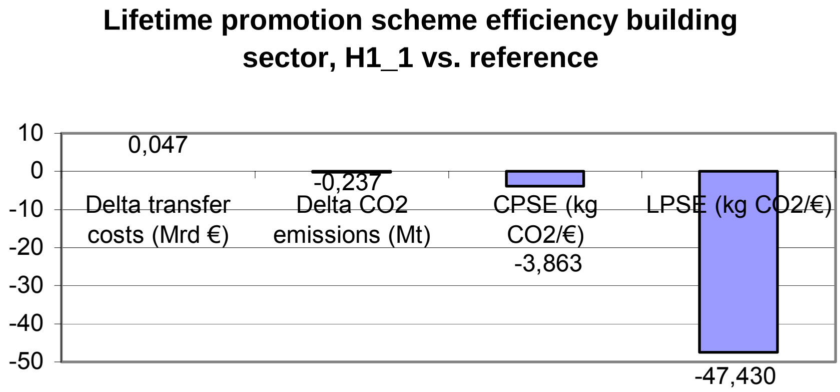


Figure 4-24: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H1_1: with promotion on wood, heating systems)

4.4.2 Hypothesis H2: Support of small scale solar thermal systems

More than 80,000 m^2 (133 m^2/1000 persons) are installed in houses and hotels on the island and cover 3% of the total energy demand of Crete. However, there is no subsidy for small scale solar thermal systems

Performed variation

- Investment subsidy of 40% on solar thermal systems for DHW in SFH, MFH and BMH

Main results

- significant rise of solar thermal systems by 25% till 2020 (Figure 4-25 and Figure 4-26)
- CPSE is ca. 84 kg CO_2/€ in 2020, and LPSE is ca. 90 kg CO_2/€ (Figure 4-27)

Conclusion: The instrument of additional state promotion for solar thermal systems will increase the use of solar energy for producing DHW, mainly on MFH.

Figure 4-25 Number of dwellings –DHW- with promotion on solar thermal

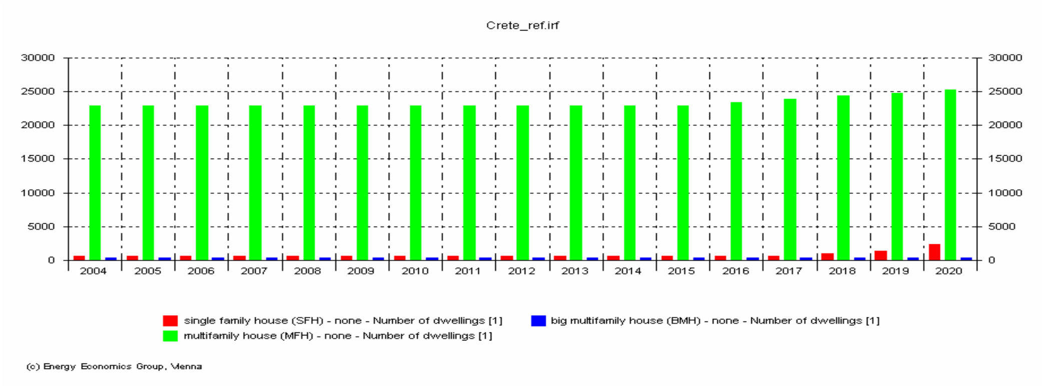


Figure 4-26: Number of dwellings – DHW- reference scenario

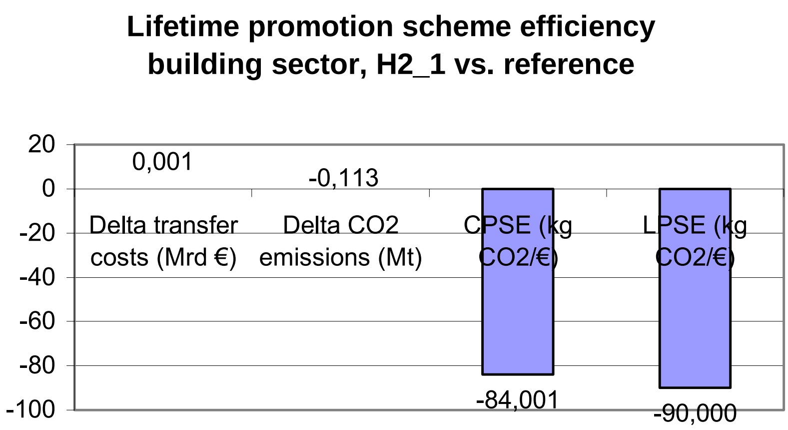


Figure 4-27: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (H2_1: with promotion on solar thermal, heating systems)

4.4.3 Hypothesis H3: DSM measures

It has to be noted that the model is working in that kind that all selected DSM measures get installed by the model if the *entire* costs are less than the reduction in heating costs. So, if one of the selected DSM measures (insulation for walls, ceilings and floors and replacement of windows) isn't profitable, all measures won't get in use. Actually windows exchange is much less profitable than insulation. At reference scenario, there is no energy policy for new wall insulation or windows.

Sensitivity analysis to selected DSM measures

The effect of promotion schemes in DSM was determined if instead of only two DSM measures all four measures in reference scenario would be selected (separately). On this way we obtain an idea of potential effects and efficiency by an enforced DSM promotion.

Performed variations

- Wall insulation: investment subsidy of 40% for new wall insulation in SFH, MFH and BMF (HYP_3_1)
- Wall insulation: investment subsidy of 40% for new floor insulation in SFH, MFH and BMF (HYP_3_2)
- Wall insulation: investment subsidy of 40% for new ceiling insulation in SFH, MFH and BMF (HYP_3_3)
- Wall insulation: investment subsidy of 40% for new windows in SFH, MFH and BMF (HYP_3_4)

Main results

- The use of investment subsidies has a stronger impact on floor and ceiling insulation only. Changes in insulation are not observed, however in BMH.
- Investment subsidies for new windows are not profitable (no changes)
- The cumulated CO_2 reduction in the case of new insulation is rather low: It is ca. 1.4 kg CO_2/€ (with 40 % subsidies) in case of floor and ceiling insulation (Figure 4-28 and Figure 4-30) and less than 1 kg CO_2/€ in case of wall insulation.

Conclusion: Very low cumulated promotion scheme efficiency in H3 shows that the analyzed promotion schemes for DSM are less attractive than the reference scenario. Insulation measures need further investigation, in order to save heat energy or reduce heat energy demand in buildings

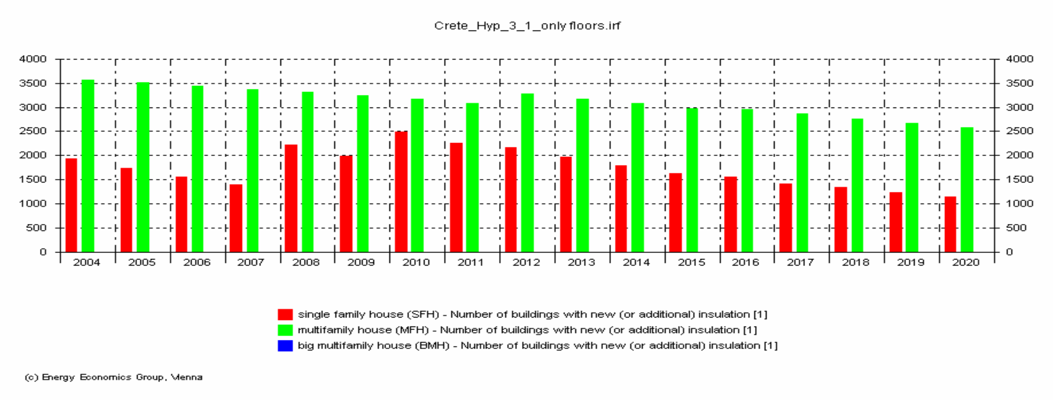


Figure 4-28 Number of buildings with new (or additional) floor insulation

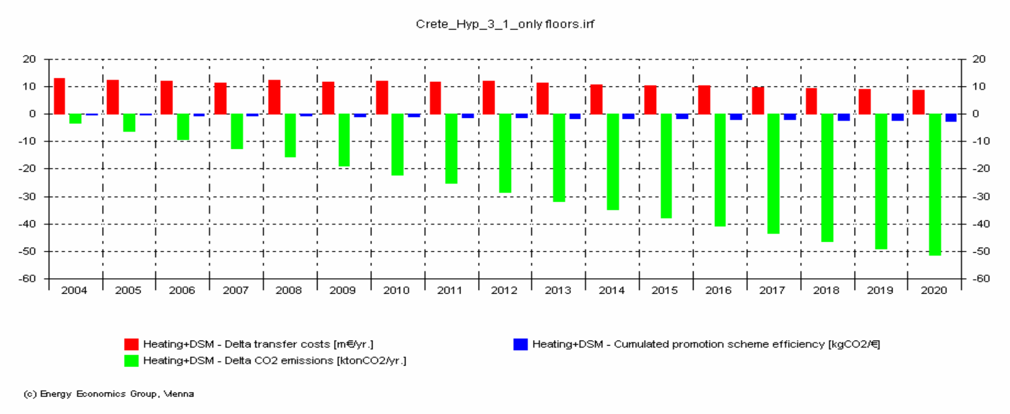


Figure 4-29 Heating+DSM - Cumulated promotion scheme efficiency [kg CO_2/€] – only floor insulation

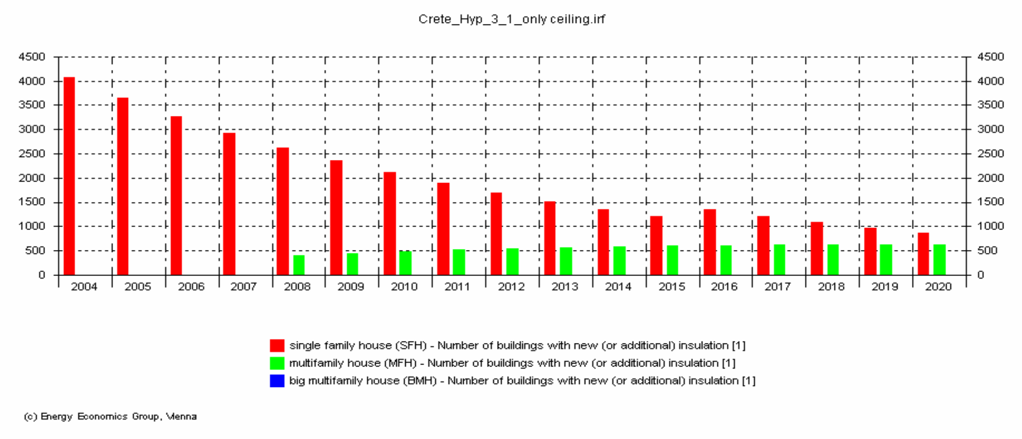


Figure 4-30 Number of buildings with new (or additional) ceiling insulation

Figure 4-31 Heating+DSM - Cumulated promotion scheme efficiency [kg CO_2/€] – only ceiling insulation

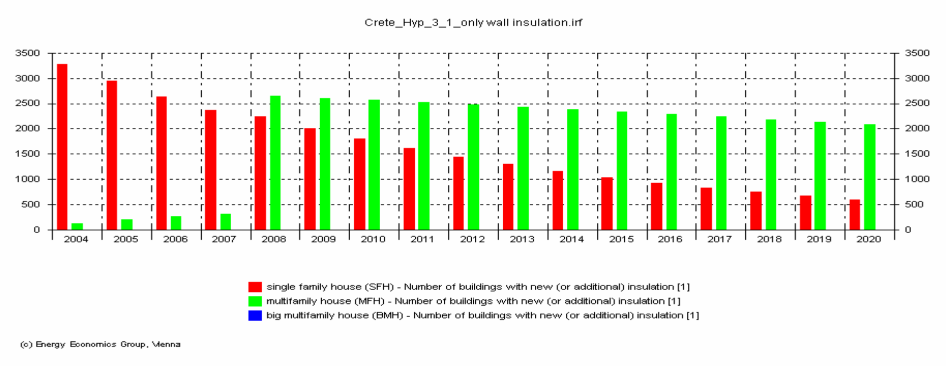


Figure 4-32 Number of buildings with new (or additional) wall insulation

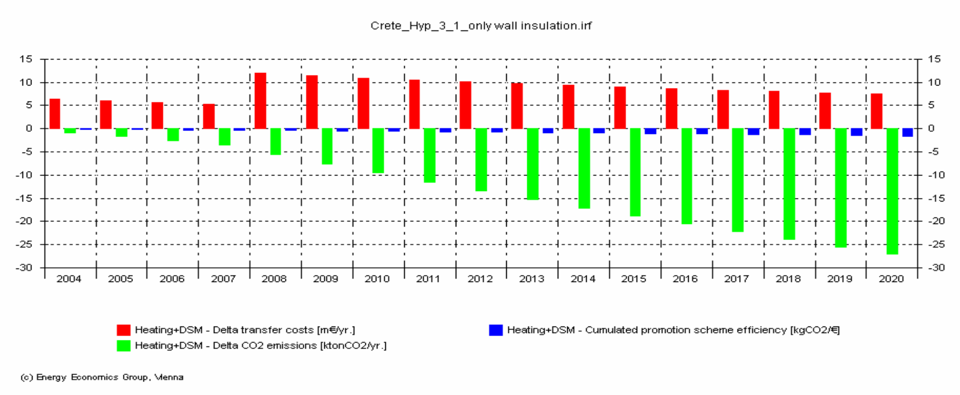


Figure 4-33 Heating+DSM - CPSE [kg CO_2/€] – only wall insulation

4.4.4 Hypothesis H4: Raise of promotion on biomass (agricultural residues)

Electricity production from biomass in Crete has not been developed yet. However, there is a great electricity potential, using agricultural residues as input fuel. For the time being investments on biomass get a subsidy of 40%. **Invert** shows that no biomass plant installation will take place before 2016.

Performed variations

- Raising the subsidy by 20 % for biomass (60% investment subsidy in total)

Main result:

- Electricity production from biomass comes in force in 2004 (Figure 4-34 and Figure 4-35). Biomass plants continuously provide 360 GWh/yr (the whole electricity potential)
- Furthermore, transfer costs are high only for one year. They reduce after 2004.
- CPSE is ca. 7.3 kg CO_2/€ in 2020, LPSE is ca. 10 kg CO_2/€ (Figure 4-36)

Conclusion: A higher investment subsidy on biomass could double the electricity production from RES in 2004 (from 336 GWh/yr to 706 GWh/yr) with low transfer costs.

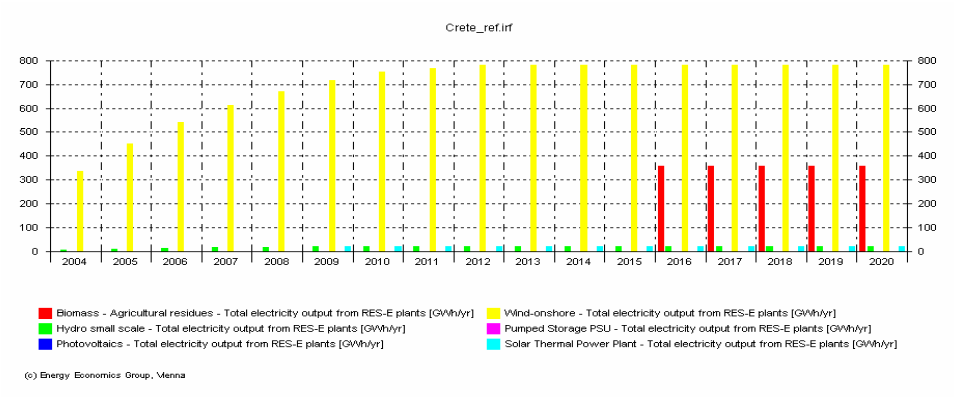


Figure 4-34: Total electricity output (GWh/yr) from RES-E- reference scenario

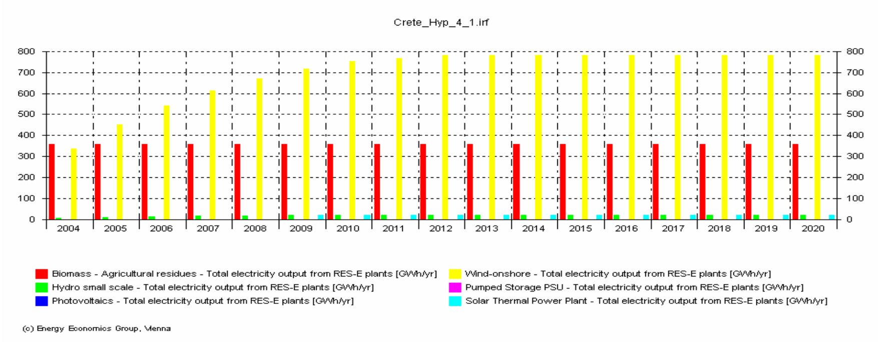


Figure 4-35: Total electricity output (GWh/yr) from RES-E with a higher investment subsidy

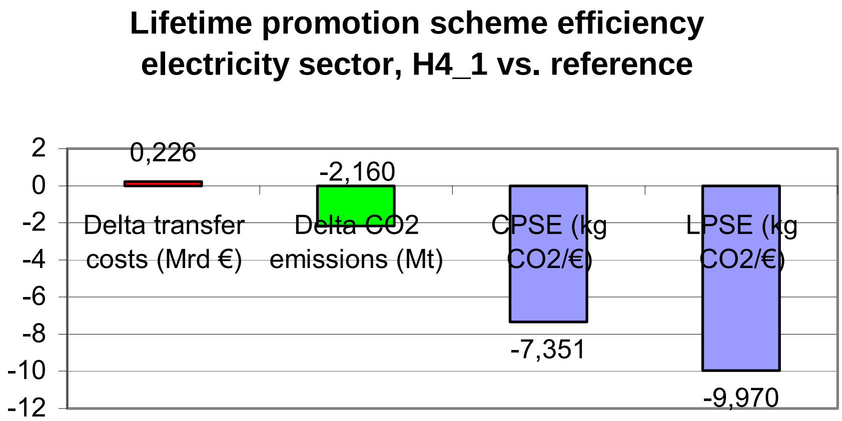


Figure 4-36: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for electricity sector (H4_1: with promotion on biomass, electricity only)

4.4.5 Hypothesis H5: Promotion on Pumped Storage Units (PSU)

The installation of PSU is vital for Crete's electrical system. PSU can transform the intermittent RES variable energy production into a uniform production at pre- determined hours. Pumped storage systems are not expected to operate before 2005 due to technical difficulties. Without promotion PSU will not come in force till 2020 (Figure 4-37).

Performed variations:

- Investment subsidy of 40% for PSU.

Main results:

- PSU are installed in 2004 and provide 83 GWh/yr (Figure 4-38)
- CPSE is ca. 5.2 kg CO_2/€ in 2020, LPSE is ca. 8.9 kg CO_2/€ (Figure 4-39)

Conclusion: Investment subsidy of 40% on PSU will cause early installation of the systems, raising the total electricity production on the island.

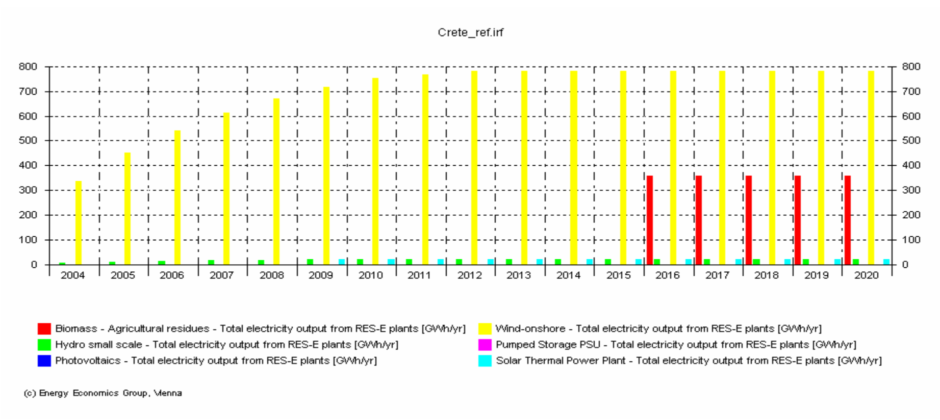


Figure 4-37: Total electricity output (GWh/yr) from RES-E- reference scenario

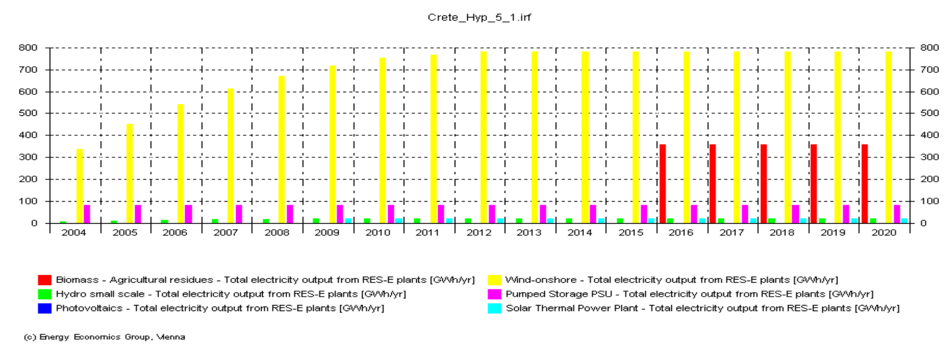


Figure 4-38: Total electricity output (GWh/yr) from RES-E- with promotion on PSU

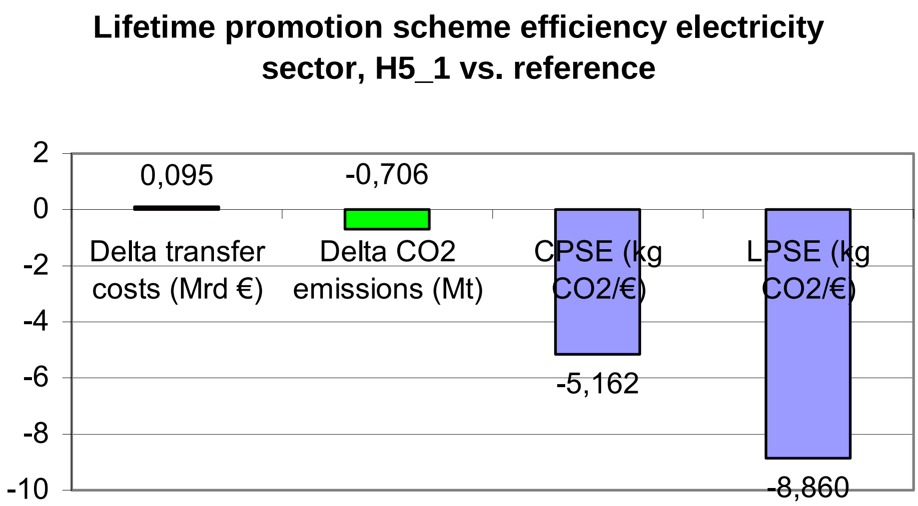


Figure 4-39: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for electricity sector (H5_1: with promotion on PSU (hydro), electricity only)

4.4.6 Hypothesis H6: Raise of promotion on solar thermal Power plant

According to the case study based on **Invert** simulation tool, solar thermal Power plant will operate after 2009. The existing promotion policy provides 30% investment subsidy on new installations.

Performed variations

- Raising the investment subsidy of Solar Thermal Power Plant by 20%

Main results

- Power plants will be applied in 2004, and electricity production reaches 22.4 GWh/yr till 2020 (Figure 4-40 and Figure 4-41)
- CPSE is ca. 4.8 kg CO_2/€ in 2020, LPSE is ca. 5.4 kg CO_2/€ (Figure 4-42)

Conclusion: Earlier installation of solar thermal Power plant will rise electricity production from 2004 up to 2020 and contribute in CO_2 emissions decrease (Figure 4-42).

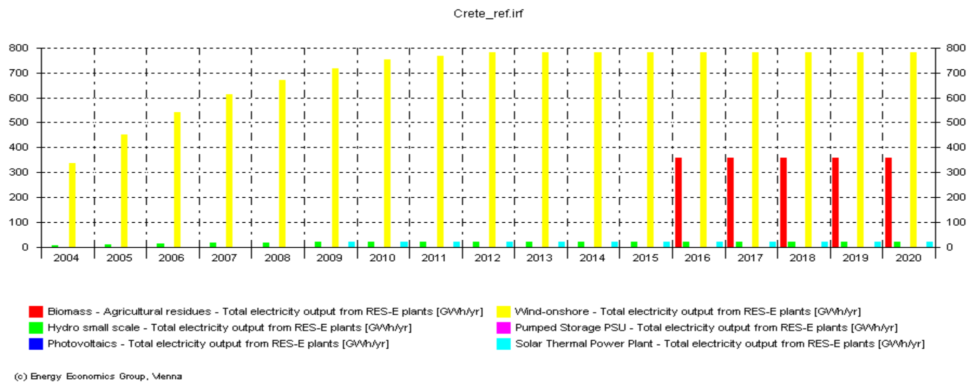


Figure 4-40: Total electricity output (GWh/yr) from RES-E- reference scenario

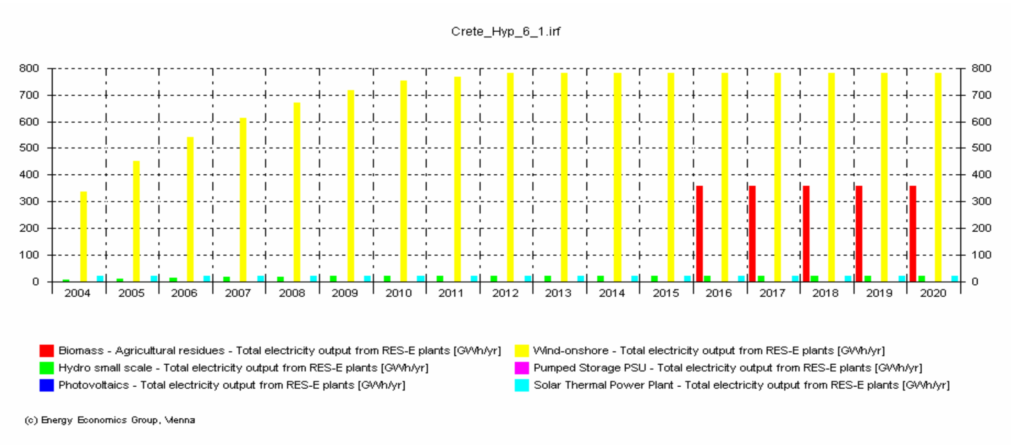


Figure 4-41: Total electricity output (GWh/yr) from RES-E- with higher investment subsidy on solar thermal Power plant

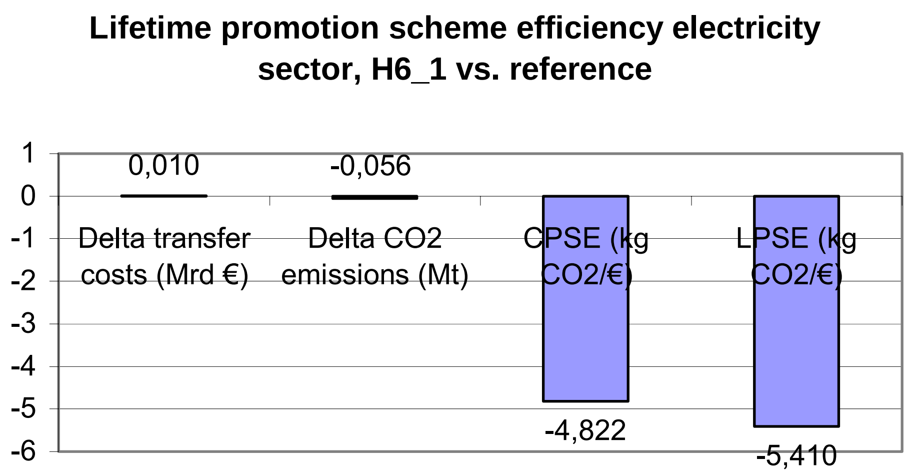


Figure 4-42: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for electricity sector (H6_1: with promotion on solar thermal power plants, electricity only)

4.4.7 Hypothesis H7: Higher investment subsidies on Photovoltaic systems

Existing promotion schemes on PV applications (40%investment subsidy) show a continuous electricity production of 0.17 GWh/yr from 2004 up to 2020.

Performed variations

- Raising the investment subsidy of PV applications by 20%

Main results

- No impact on the installation of new PV systems.

Conclusion: Photovoltaic systems are still expensive and maybe yet not that profitable.

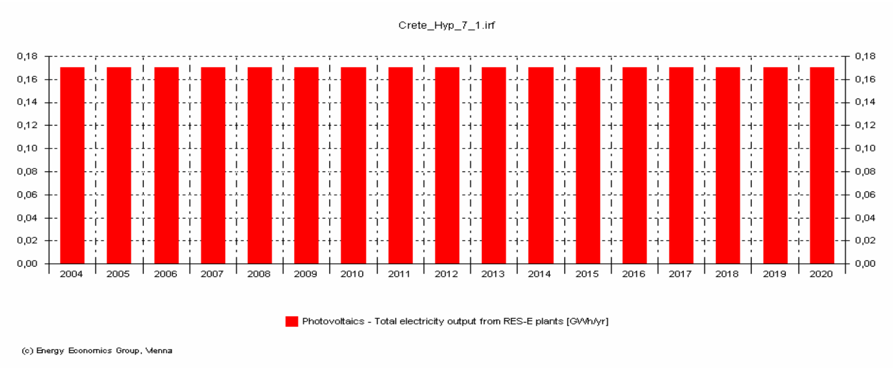


Figure 4-43: Total electricity output (GWh/yr) from Photovoltaic systems

4.4.8 Hypothesis H8: Higher investment subsidies on small hydro systems

Electricity production of small hydro stations rise from 2004 to 2012, and is stable from 2012 up to 2020. With an existing promotion scheme of 40% of investment subsidy, **In*vert*** simulation tool shows an increase in electricity from 6.5 GWh/yr in 2004 to 22.6 GWh/yr to 2012.

Performed variations

- Raising the investment subsidy of small hydro systems by 20%

Main results

- There is no further development of new hydro systems.

Conclusion: The existing promotion policy contributes to the best development of small hydro systems in Crete.

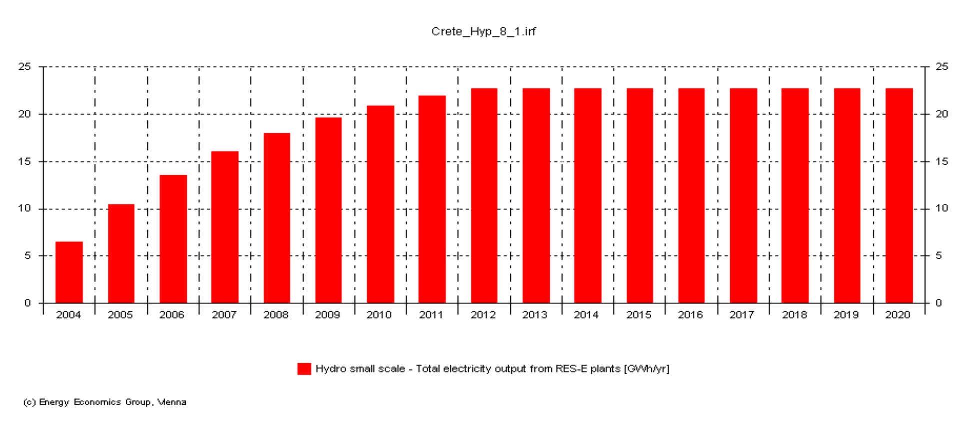


Figure 4-44: Total electricity output (GWh/yr) from small hydro systems

4.4.9 Hypothesis H9: Higher investment subsidies on wind on-shore systems

Wind energy in Crete has a great share in electricity production of RES. 12.7% of the total electricity demand of the island is covered by wind parks, installed mainly on the east part of Crete. The existing promotion policy (30% investment subsidy) leads to new installation of wind onshore systems. Electricity production from wind applications rises from about 336 GWh/yr to 781 GWh/yr till 2012.

Performed variations

- Raising the investment subsidy of wind onshore systems by 20%

Main results

- There is no further development of wind applications.

Conclusion: The existing promotion policy contributes to the best development of wind energy systems in Crete, because the whole potential can be achieved having implemented the current promotion scheme.

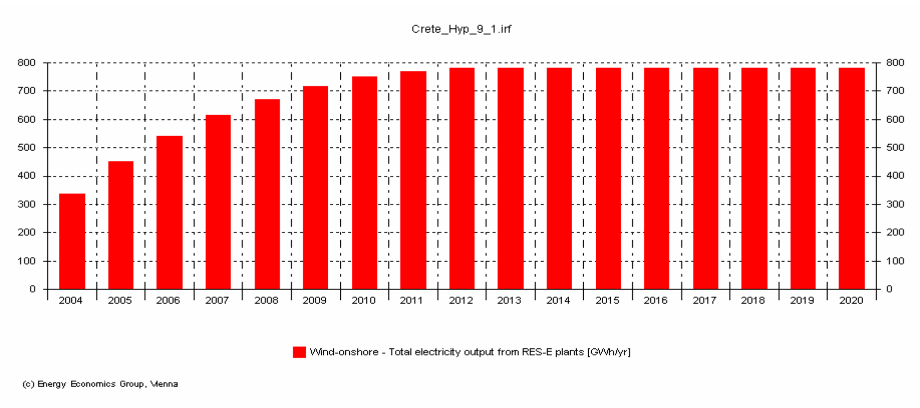


Figure 4-45: Total electricity output (GWh/yr) from Wind on shore systems

4.4.10 Hypothesis H10: Feed in tariffs

Crete's energy system is not interconnected to mainland. Feed in tariffs for not interconnected islands are 0.079 €/ KWh or 79 €/MWh and refer to independent producers. This is the price that PPC pays to producers in order to purchase electricity produced by RES.

Performed variations

- Raising the feed in tariffs by 10 €-cents/ KWh

Main results

- Biomass, pumped storage systems and solar thermal power plants come in force from the first year of simulation runs (2004) (Figure 4-46 and Figure 4-47)
- CO_2 emissions reduce about 230 kt/yr till 2017 and about 40 kton/yr from 2018 to 2020
- Transfer costs continuously reduce and are below zero in 2016
- CPSE is ca. 5.8 kg CO_2/€ in 2020, LPSE is ca. 6.9 kg CO_2/€ (Figure 4-48)

Conclusion: Raising the price of feed in tariffs could contribute to further development and new installations of RES plants in Crete.

Higher investment subsidies and/ or a further increase of feed in tariffs for sewage gas (CHP –plants) will not change the amount of electricity or heat produced by CHP plants.

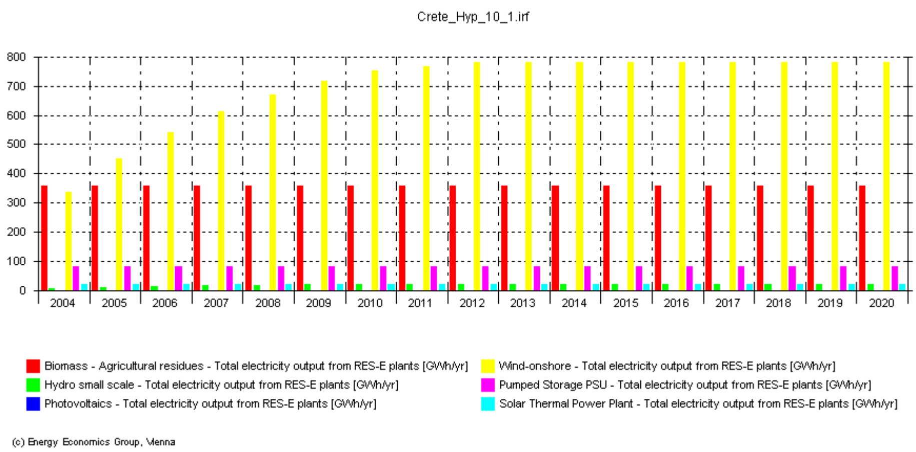


Figure 4-46: Total electricity output (GWh/yr) from RES-E plants- with feed in tariffs 0,89 €/ KWh

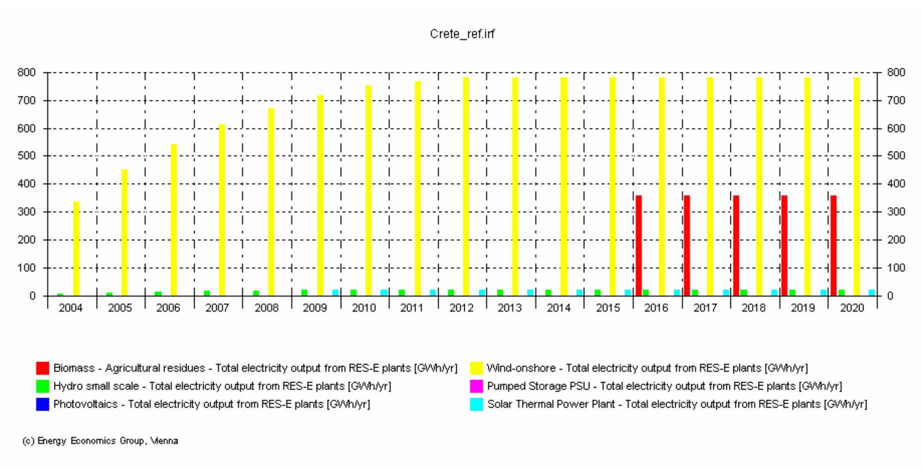


Figure 4-47: Total electricity output (GWh/yr) from RES-E plants- reference scenario

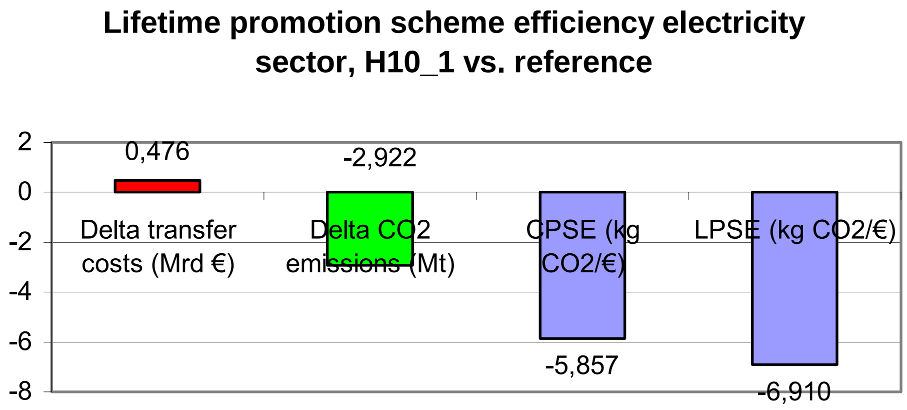


Figure 4-48 Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for electricity sector (H10_1: higher feed in tariffs)

4.4.11 Hypothesis H11: CO_2 tax

Performed variations

- Introduction of CO_2 tax in three steps: 10, 20 and 30 €/t CO_2

Main results:

- in electricity sector there are delta transfer costs but no delta CO_2 emissions, as shown in Figure 4-49 for the example of a CO_2 tax of 30 €/t.
- in the building sector there are only CO_2 reductions but no transfer costs, as shown in Figure 4-49 for the example of a CO_2 tax of 30 €/t.
- Already a CO_2 tax of 10 €/t would effect a notable CO_2 reduction of 2.9 Mt/a in heating sector. A triplication of the tax level up to 30 €/t would increase the CO_2 reduction "only" with the factor 1.5 up to 4.2 Mt/a (Figure 4-52).
- A CO_2 tax of 10 €/t would save transfer costs of 70 M€/a in RES-E sector. A triplication of the tax level up to 30 €/t would effect a triplication of saved money (Figure 4-51).

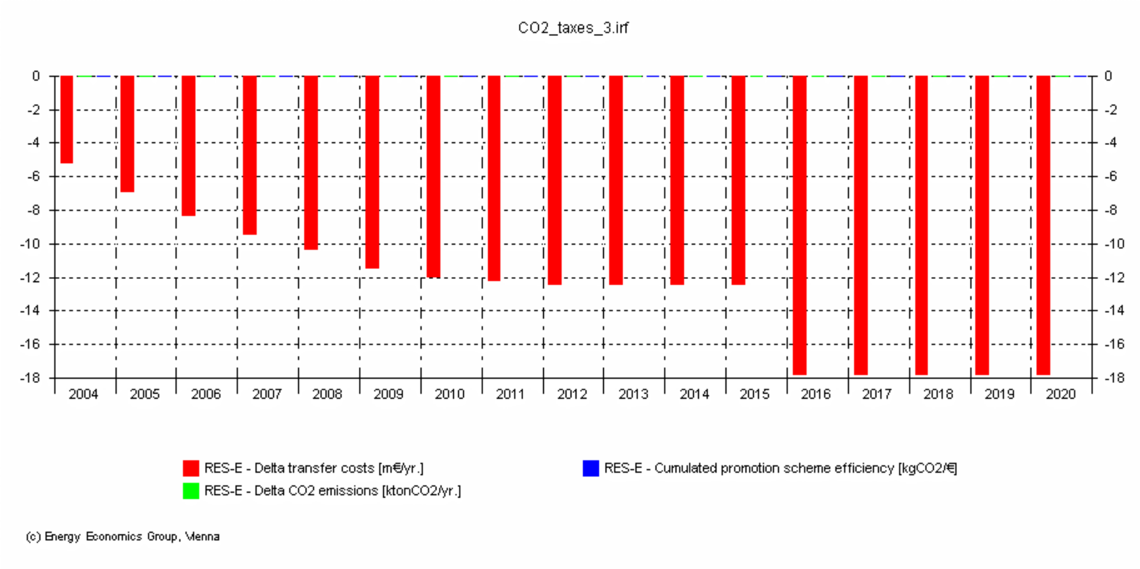


Figure 4-49 Delta transfer costs, delta CO_2 emissions and CPSE - RES-E, CO_2 Taxes of 30€/t

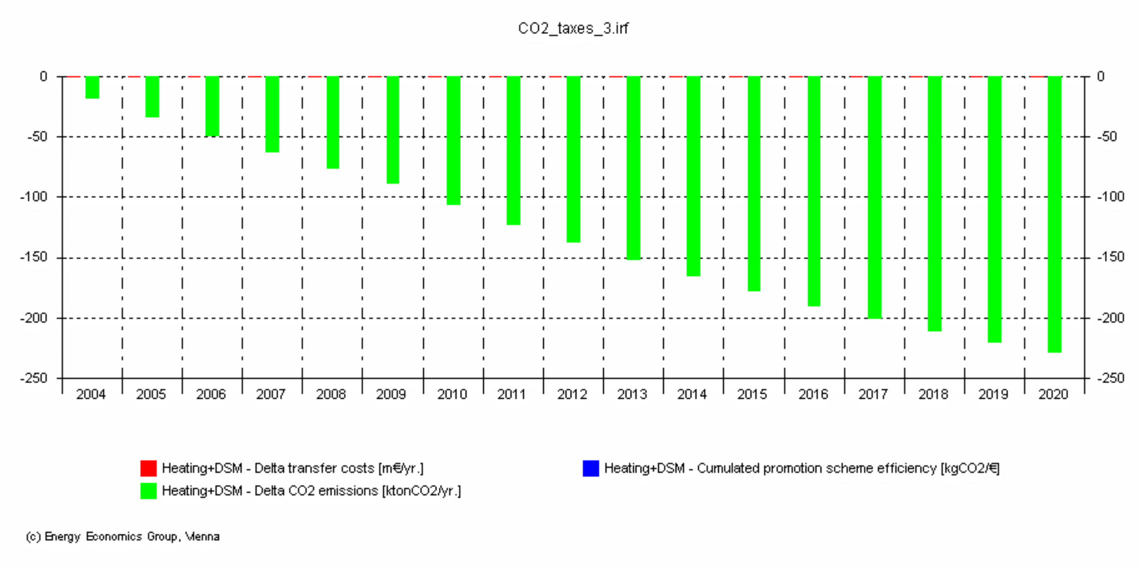


Figure 4-50 Delta transfer costs, delta CO_2 emissions and CPSE – Heating systems for CO_2 Taxes of 30€/t

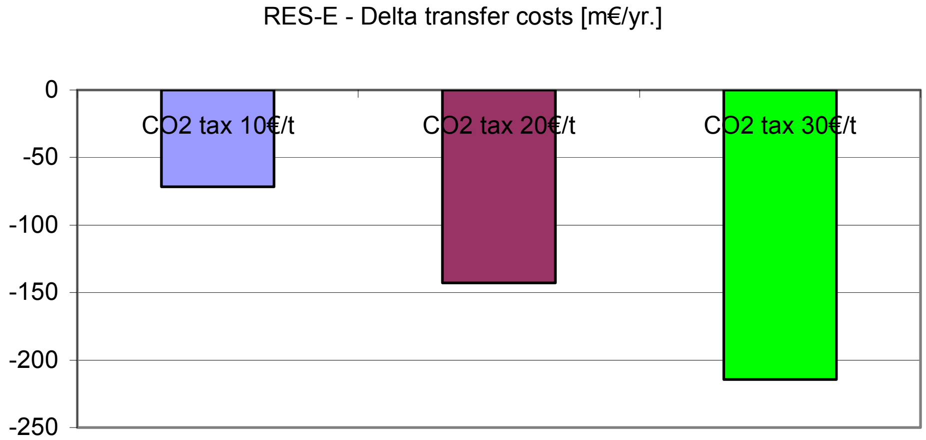


Figure 4-51 RES-E - Delta transfer costs [m€/yr] depending on the CO_2 tax level

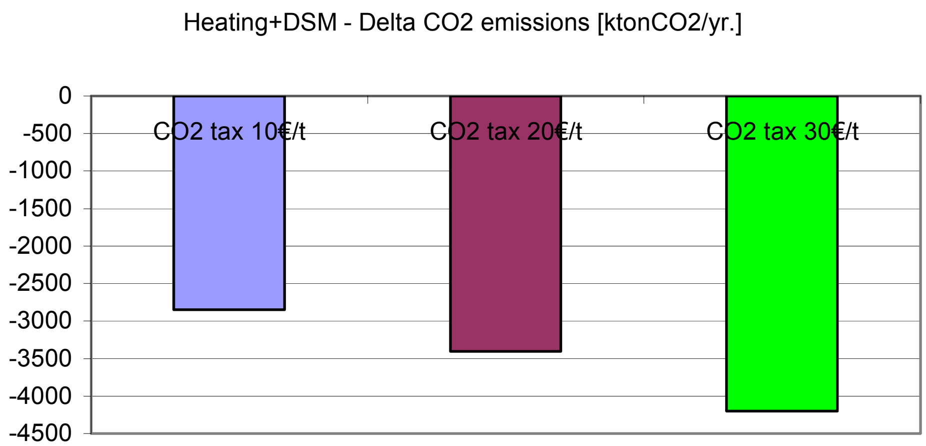


Figure 4-52 Heating sector - Delta CO_2 emissions [m€/yr] depending on the CO_2 tax level

4.5 Conclusions & Recommendations

4.5.1 Building sector

Heating systems

With respect to heating systems the only RES systems that can be installed in Crete are wood central and wood single systems (solid biomass). The simultaneous promotion of 40% investment subsidy for wood central systems (HYP_1_1) makes them profitable in MFH and BMH from 2018 to 2020. However, no earlier installation is suggested by the simulation tool. On the other hand, wood single heating systems (HYP_1_2) seem to decrease every year, despite the promotion policy of 40% investment subsidy. Cumulated promotion efficiency is ca**. 4 kg CO_2/€** in 2020.

DHW systems

In DHW sector, the instrument of additional state promotion for solar thermal systems will increase the use of solar energy for producing DHW, mainly in MFH. The number of solar thermal systems installed in dwellings will rise by 25% till 2020 (Figure 4-28 and Figure 4-29). Cumulated promotion efficiency is ca. **84 kg CO_2/€** to 2020 (Figure 4-30)

DSM measures

Regarding DSM measures, very low cumulated promotion scheme efficiency in H3 (**1.4 kg CO_2/€** in case of floor and ceiling insulation and less than **1 kg CO_2/€** in case of wall insulation) shows that the analyzed promotion schemes for DSM are less attractive than the reference scenario. Insulation measures need further investigation, in order to save heat energy or reduce heat energy demand in buildings.

Cooling systems

In cooling sector, there is no option of covering cooling demand by RES, for the time being. Split AC units and oil combined systems are in operation in the buildings of the island. Simulation runs indicate a continuous decrease of the use of AC split systems and, at the same time an increase of oil combined systems. Nevertheless, oil systems are combined with the ones in heating sector and it is therefore difficult to investigate with **In*vert*** simulation tool (**In*vert*** combines oil systems in heating only with oil systems in DHW)

4.5.2 Electricity sector

RES-E- electricity output

A stronger promotion policy on biomass (plus 20% of investment subsidies) could double the electricity production from RES in 2004 (from 336 GWh/yr to 706 GWh/yr) with low transfer costs. Furthermore, transfer costs are high only for one year and they reduce after 2004. Cumulated promotion efficiency is ca. **7.3 kg CO_2/€** from 2004 to 2020 (Figure 4-46)

Pumped storage systems are not expected to operate before 2005 due to technical difficulties. Without promotion PSU will not come in force till 2020 (according to **In*vert***) (Figure 5.18). Investment subsidy of 40% on PSU will cause early installation of the systems, raising the total electricity production on the island. PSU are installed in 2004 and provide 83 GWh/yr (Figure 5.19). Cumulated promotion efficiency is ca. **5.2 kg CO_2/€** from 2004 to 2020 (Figure 4-38)

The existing promotion policy provides 30% investment subsidy on new installations. Raising the investment subsidy of Solar Thermal Power Plant by 20% indicates earlier installation of Power plants. Electricity production will increase from 2004 up to 2020 and contribute in CO_2 emissions decrease. Cumulated promotion efficiency is ca. **4.8 kg CO_2/€** from 2004 to 2020 (Figure 4-37)

Photovoltaic systems are still expensive and maybe yet not that profitable. Existing investment subsidy (40%) as well as suggested subsidy (60%) will lead only to partly use of the electrical potential on the island (0,17 GWh/yr from 2004 up to 2020). Consequently, a more expensive energy policy is not suggested by **In*vert***.

As far as small hydro stations and wind onshore plants are concerned, the existing promotion policy contributes to the best development of them in Crete. Nevertheless, the whole electricity potential for small hydro and wind energy systems is not achieved till 2020.

Raising feed in tariffs could contribute to further development and new installations of RES plants in Crete. However, the application of this instrument will only lead to further and earlier installation of biomass, PSU and solar thermal power plants. Transfer costs continuously reduce and are below zero in 2016. Cumulated promotion efficiency is ca. **5.8 kg CO_2/€** from 2004 to 2020 (Figure 4-48)

RES-CHP- electricity / heat output

The only CHP plant on the island (using sewage gas as input fuel) operates since 1996 and continually contributes to RES share of Crete with 2 GWh/yr electricity and 0,5 GWh/yr heat output from 2004 up to 2020 (result of simulations runs) (Figure 4-11).

Higher promotion in investment subsidies and/ or a further increase of feed in tariffs for sewage gas (CHP –plants) will not change the amount of electricity or heat produced by CHP plants.

4.6 References

"Implementation Plan for Large Scale Deployment of Renewable Energy Sources in Crete-Greece", National Technical University of Athens (NTUA), Renewable Energy Sources Unit (RENES) and Regional Energy Agency of Crete.

Centre for Rewable Energy Sources, website www.cres.gr

Invert project, Altener Program of the European Commission, www.invert.at

Kaj Joergensen , Lukas Kranzl, Elena Tsioliaridou, "Rational use of energy and renewable energy sources– a review of current policy strategies and promotion schemes", INVERT-Altener Program of the European Commission, DG TREN, February 2004

Lukas Kranzl, Elena Tsioliaridou, Claus Huber, "Technology evaluation", INVERT-Altener Program of the European Commission, DG TREN, March 2004

M.Kteniadis, N.Zografakis, "Energy management in public buildingd of European islands, The case of Crete-Greece"

Michael Stadler, Lukas Kranzl, Claus Huber, "The Invert simulation tool, user manual", Altener Program of the European Commission, DG TREN, January 2005

Nikolaos Zografakis, "Island of Crete: In the forefront of renewable energy sources implementation among European and Mediterranean islands"

Power Public Corporation (PPC), website www.dei.gr

Regulation Authority of Energy, website www.rae.gr

5 Denmark

The Danish case study covers Denmark as a whole as there is not a tradition for regional energy policies, including the provision of promotional instruments, in Denmark.

5.1 Characteristics of the energy sector

5.1.1 Primary energy demand and end energy consumption

The total primary energy consumption was 240 TWh in 2003. A combination of RUE and RES initiatives – particularly the former – is responsible for having kept both primary energy consumption and CO_2-emissions roughly constant since the over some 30 years in spite of the strong growth of the economy during the period. During the same period final energy demand has increased by some 10%.

In contrast, transport energy demand has grown substantially during the period - by almost 40% over the last quarter of a century. Consequently transport's share of the total energy demand has increased too over the period, from 24% of the final energy demand in 1980 to 31% currently, and this trend is envisaged to continue in the business-as-usual projection to 34% in the year 2020.

The principal energy sources as of 2003 are: oil (42%), natural gas (25%), coal (20%), and RES (14%).

Denmark is net-exporter of oil and natural gas.

5.1.2 Heat and power generation

The electricity supplied to the domestic market in Denmark was 35 TWh in 2003. The actual generation by the Danish power supply system varies considerably from year to year due to variations in the exchange with the European power system (Scandinavia and Germany). In recent years, this exchange has mostly resulted in an overall net export of power to the surrounding countries.

The split of the power generation on different types of power sources are roughly a third from central power stations, a quarter from decentralised and industrial power generation and 15-20% from wind power. The split on fuels of the domestic power generation are (2003): coal 54%, natural gas (22%), oil (4%), wind 15%, biomass and waste the remainder.

There is no nuclear power in Denmark based on a decision by the Danish Parliament in 1985.

About 60% of the heating demand is covered by district heating (2003) while 15% are individual natural gas and 18% individual oil heating, 6% electric heating, 3% individual solid fuels (mainly wood and straw), and 0.4% heat pumps. Large-scale CHP plants account for roughly two thirds of the district heating with the remainder being covered by smaller-scale (decentralised) CHP plants. Only about 5% is heat generation without power production.

5.1.3 Dwelling stock and heating

There are roughly 2.5 million dwellings (roughly 0.5 per capita) in about 1.5 million residential buildings in Denmark.

Main building classes in the residential sector: single dwellings or single-family houses (36% of dwellings as of 2003), multiple dwellings (39% of dwellings), and terrace houses (13%).

The following construction periods are used to classify the dwelling stock: pre-1930 (26% of dwellings), 1931-50 (15%), 1951-60 (9%), 1961-1972 (23%), 1973-78(10%), 1979-97 (16%), and 1998-2003 (2%). In other words roughly a quarter of the present dwelling stock has been erected after 1973 when energy requirements were tightened considerably in the wake of the first oil crisis. The share of single dwellings has been constantly on the increase in recent decades.

The insulation standard of the Danish building stock is relatively high. During the last 30 years increases of energy requirements of the building regulations have been a significant factor in the achievement of Danish energy targets.

Indeed the development of the insulation standard has not been governed by energy saving considerations but also by the contribution of a well-insulated building shell to a high level of indoor comfort. For instance, about half the glazing areas were double glazed by 1970, i.e. well before oil crisis in the 1970’s.

About 85% of the dwelling stock has central heating base predominantly on district heating, individual natural gas or individual oil heating. Of the remaining electric heated stoves is the predominant option, albeit with a declining share, not least due to subsidising schemes of transfer to central heating in district heating areas.

Regarding DHW-systems, the great majority has systems combined with the central heating systems. About 20% of the dwelling stock has separate DHW systems, notably in the form of electric water heater (about two thirds of the separate systems) and gas water heaters (one third).

5.1.4 Renewable energies

The main renewable energy sources in Denmark have been: wind energy, biomass combustion (for heating and to a smaller extent CHP), biogas (for CHP) and solar heating (notably for DHW supply).

Modern wind power was introduced in the late 1970's, expanding rapidly in the start of the 1980s not least as a result of the introduction of feed-in tariffs and various remedies to improve the quality of wind power projects. Today about 15-20% of the Danish electricity generation is based on wind.

Besides wind biomass is the most important renewable energy source. Historically, biomass heating and cogeneration have been the most significant options in this context. The most significant biomass heating projects have been in the form of individual straw or wood heating based on central heating. Also wood and straw have been used for district heating - mostly in the form of heating only but to a smaller extent in cogeneration projects, too.

Biogas projects based on anaerobic digestion of manure, mostly located on farms, has been common since the 70's, though with limited fractions of the overall power generation. Over the last 10-15 years a form of centralised biogas cogeneration projects based on biomass resources from a range of sources, including both manure from farms and biodegradable industrial and municipal waste has developed. These projects mostly have supplied heat to small district heating schemes.

Municipal waste is considered a CO_2-neutral fuel in the official Danish energy planning and hence is counted as renewable energy. It is combusted in conjunction with district heating, primarily in heat generating plants but a few examples of CHP based on waste combustion exist, too.

There is virtually no hydropower, except through power imports due to a lack of potentials

5.2 Promotion schemes in Denmark

5.2.1 Framework - targets, political agreements etc.

Currently (primo 2005) the Danish government is working on a new energy strategy towards the year 2025. Generally, this work is used as basis for the case study, particularly with respect to the Reference Scenario.

Political agreements are a significant factor in the forming of energy policy in Denmark. The most recent, of 29 March 2004, addresses among other things promotion of wind energy and decentralised CHP and concerning the future development of the energy infrastructure. Past political agreements for instance have mandated power utilities to utilise certain minimum amounts of renewables.

5.2.2 Financial/economical instruments

Historically, energy and environmental taxes, including carbon taxes, have played key role in Denmark for decades - and continue to do so.

In Denmark *energy taxes* are levied on the primary energy consumption of gasoline, diesel oil, heating oil, coal and natural gas. In addition, there is a tax on electricity covering electricity for the public grid as well as for own consumption. These are shown in the table below. On top of the energy tax, there is a VAT-rate of 25% added to the prices, including tax.

Table 5-1: Typical consumer prices for energy (households) distributed on pre-tax part, energy tax and VAT as of 2002. €-cent/kWh energy content in fuels and €-cent/kWh electricity.

	Pre-tax	Energy or electricity taxes	VAT	Total
Gasoline	3.8	6.0	2.4	12.2
Diesel oil	4.0	3.6	1.9	9.5
Heating oil	3.5	2.8	1.6	7.9
Coal	0.8	0.2	0.2	1.2
Natural gas	7.8	2.5	2.6	2.8
Electricity	7.5	8.8	4.1	20.4

Generally companies can reclaim energy and electricity taxes, except for gasoline and diesel oil consumption for transportation applications. In terms of revenue, the gasoline and diesel consumption accounts roughly for between a third and half of the total energy taxes. Roughly a quarter is electricity taxes.

In 1998 a carbon tax scheme for energy products was introduced. Generally, the carbon tax is around DKK 100 (13-14 €) per tonne CO_2. Electricity and CHP generators are exempted from CO_2 tax (instead their electricity generation are subject to the above-mentioned electricity tax).

The scheme has relatively complicated rules for businesses' possibilities to reclaim the carbon tax. Together these possibilities mean that typically businesses will pay up to 90% of the carbon tax. The revenue from it has been used for RD&D activities promoting CO_2-reductions.

Feed-in tariffs played a crucial role in the strong growth of windpower I Denmark from the early 1980s onwards and still are a significant instrument in conjunction with promotion of RES-E.

Feed-in tariffs for different power generation categories:

- Wind turbines not built by power utilities to meet mandates
- Mandated wind turbines built by power utilities
- Household wind turbines (<25 kW and grid-connected through own installation)
- Biogas cogeneration plants
- Scrapping certificates to support the replacement of existing wind turbine capacity

In addition, there is a tax alleviation scheme for personal income generated from wind-electricity.

There are few direct *subsidy* schemes for RUE or RES in force in Denmark. In recent years several schemes have been terminated or reduced substantially – e.g. grants for RES investments and for pensioners' insulation investments.

There is still a subsidy scheme for energy R&D but reduced by three quarters and with no secured means for RUE or RES. In addition, R&D subsidies may be obtained after application through the PSO (Public Service Obligation) scheme funded by a levy on electricity. The PSO scheme is confined to technologies relevant to the electricity system, notably on the supply side.

The so-called Electricity Savings Trust (also financed by a levy on electricity) can provide subsides targeted both at the R&DD level and at the user level – focusing on energy efficiency of electric appliance (including gas cookers), lighting etc. The EST is focusing on selecting priority fields to maximise the benefit and it uses a great part of its means for subsidising the conversion of electric space heating to more energy efficient heating systems.

Subsidies in the form of direct grants, while of little significance today, have played an important role in conjunction with both RES and RUE in the past. Subsidy levels have generally been relatively low (rarely above 30%).

5.2.3 Regulatory instruments

Building regulations have had energy requirements since the 1970s and these have been adjusted several times since then.

New building regulations - BR 2005 - are to be implemented in a near future. These among other things are to adapt the Danish building regulations to the requirements of the EU Building Directive.

Furthermore mandates especially directed towards the energy utilities have been significant parts of the political agreements mentioned above. Typically these mandates have instructed power utilities to establish certain amounts of power generation based on wind and biomass.

5.2.4 Labelling, auditing, voluntary agreements etc.

Energy labelling and auditing of buildings and appliances have been widely used since 1980s to a great extent serving as model for EU directives. Labelling of buildings covers single-family houses and other dwellings as well as larger buildings (including offices)

Voluntary agreements also have played an important role, e.g. for household appliances. For instance, there is currently a voluntary agreement between the Danish Energy Authority on one side and representatives from the glazing industry in Denmark on the other concerning replacement of windows. The objective of this agreement is to phase out conventional thermo glazed windows in conjunction with the window replacement, substituting them by advanced types with much lower U-values.

5.3 Reference Scenario

The Reference Scenario is a business-as-usual development based on the baseline development of the most recent energy strategy work carried out by the Danish Energy Authority. Hence the Reference Scenario is based on the projections of energy prices, energy consumption etc. used by the DEA in conjunction with the above mentioned energy strategy work. Oil prices are envisaged to follow the developments according to the central prognosis of the IEA's World Energy Outlook 2004 - in line with the assumptions of the baseline of the energy strategy work of the Danish Energy Authority. This means that a relatively low oil prices is expected compared to recent levels (primo 2005).

Biomass prices are assumed to remain constant in fixed prices.

According to the Reference Scenario, the domestic electricity consumption is envisaged to increase by 28% until 2020 and the same applies to transport energy demand.

In the Reference Scenario existing promotion schemes, including schemes that are passed but are yet to be put into force, are presumed to be retained in their present form.

Energy and environmental taxes are assumed to remain at the current level unless changes have been decided.

Feed-in tariffs are maintained in the same form as the present, including any changes decided - e.g. in conjunction with political agreements - but not yet implemented.

Building regulations are presumed to develop in line with the content of the new building regulations (BR 2005). However, given that the model focuses on the existing building stock building regulations are of limited impact, except to the extent they regulate rehabilitation work and the like.

5.4 Analysis of hypotheses

5.4.1 General remarks and general conceptual framework of the case studies

The conceptual framework of the analysis of the hypothesis - in the form of the Reference Scenario - has crucial impact the results in different manners. Some of the most significant factors are summarised in the following.

The hypotheses are intended to throw light on key problems in energy policy. The Danish case study is conceived on the background of the key issues described in the following.

Comparisons of different types of promotional instruments.

Overall it is presumed that the choice of instruments are not necessarily based on a comprehensive assessment of all options but involves pre-selection based on preferences of various kinds, for instance

- Market driven vs. public sector invention strategies.
- Push vs. pull instruments
- Soft vs. hard instruments
- Positive vs. negative instruments
- Instruments perceived as “cheap” or “expensive”

There is not in itself any wrong in preferring certain types of instruments to others in spite of their strict costs and benefits but the risk is that these preferences substitute more comprehensive assessments of instruments.

Assessment of trade-offs/conflicts between RUE and RES measures particularly with a view to projects based on district heating.

There are different aspects of the problem. First, RUE, RES and/or district heating may compete about subsidies. Secondly, if subsidies are applied in different sectors, this reduces the effect of each item - which should be taken into account in conjunction with calculations. Thirdly, RES investments may discourage RUE investments (in vice versa) for consumer economic reasons. In particular, this can be the case in conjunction with district heating projects where tariff structures play an important role.

Potential RUE measures maybe overlooked due to obstacles in conjunction with supply side heating investments into renewable energy.

Conflicts between RES and RUE investments may be aggravated in conjunction with district heating projects (particularly cogeneration projects) because fixed costs usually constitute a greater share and because tariff structures may be a powerful tool to ensure that these investments are covered. Hence they may at the same undermine the promotion of RUE measures. As a general principle - not always applied in practice - heating tariffs and tariff structures are expected to reflect costs whereas from an RUE viewpoint the fixed fraction of the tariffs should be as small as possible (ideally zero).

Different applications of biomass resources.

The total biomass resources that may be generated on the collected Danish land are in the range of the total Danish primary energy use at present but in practice the resources are naturally much lower. Hence, it is important to choose the best options referring to aspects such as applications (transport, individual heating, district heating, CHP) and energy conversion paths and energy carriers. Also it will in many connections be useful to be able to assess the utilisation against non-energy applications.

At the same time the resources have a very “elastic boundaries” (registration uncertainties, trade off with other utilisations, criteria for exploitation of biomass resource).

So far the official Danish policy in this field has been to reserve the biomass resources to be utilised for energy for stationary energy applications, namely CHP. Hence, Denmark is pursuing a zero-target for transport applications in a European context based on the assessment that CO_2 reductions achieved in the transport sector by means of bio fuels are much more costly than those of biomass CHP projects. The available biomass resources for energy applications are based on an assessment carried out by the Danish Energy Authority.

In practice, it is not possible to cover all of these aspects in the case study, partly due to limitations to input and outputs from the model. Thus the following practical approach is applied to illustrate the above issues as much as possible.

5.4.2 Hypothesis H1: CO_2 taxation

This hypothesis explores the introduction of a CO_2-tax in Denmark of €10, €20 and €30 per tonne - in addition to the existing CO_2-tax. The tax is to be implemented in the building sector. In addition the impact of removing the existing CO_2 tax (corresponding to an additional CO_2-tax of -€13.4/tonne) in the building sector has be assessed.

Given that there are no transfer costs, it is not possible in this connection to calculate promotion scheme efficiencies. Indeed, the tax creates an additional public sector income that may be used for subsidies, e.g. towards insulation or window replacement. This is not included in the analysis, though.

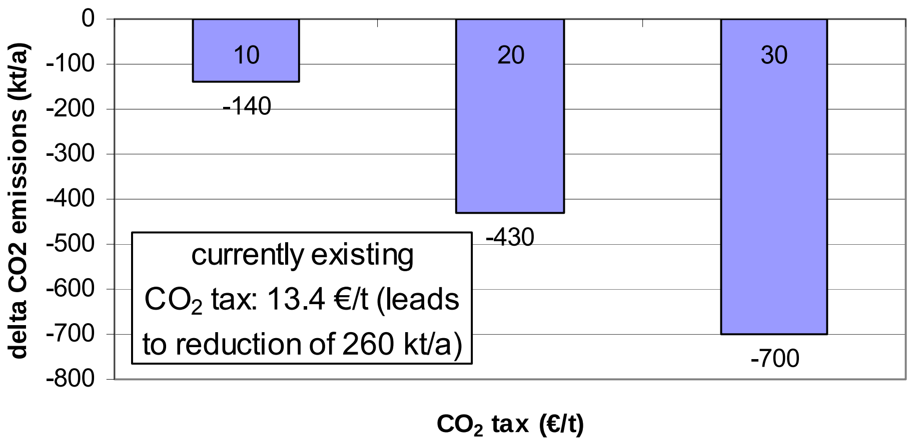


Figure 5-1: Delta CO_2 emissions vs. change in CO_2 tax (H1)

The graph shows the calculated change in CO_2-emissions in (in 1000 tonnes CO_2 per year) against the change in CO_2-tax - in both cases focusing on the building sector. As can be seen, there is in the model calculations a strong correlation between changes in CO_2-tax and emissions.

5.4.3 Hypothesis H2: Building RUE promotion subsidies

This hypothesis explores the effect of promoting RUE measures in the existing building (dwelling) stock by means of direct subsidies.

The focus is on better insulation and window replacement in buildings - both individually and together. Two levels of subsidies are analysed, namely 30% and 50% of costs. For insulation only material costs are subsidised. For window replacements all window standards are assumed to be eligible for subsidies.

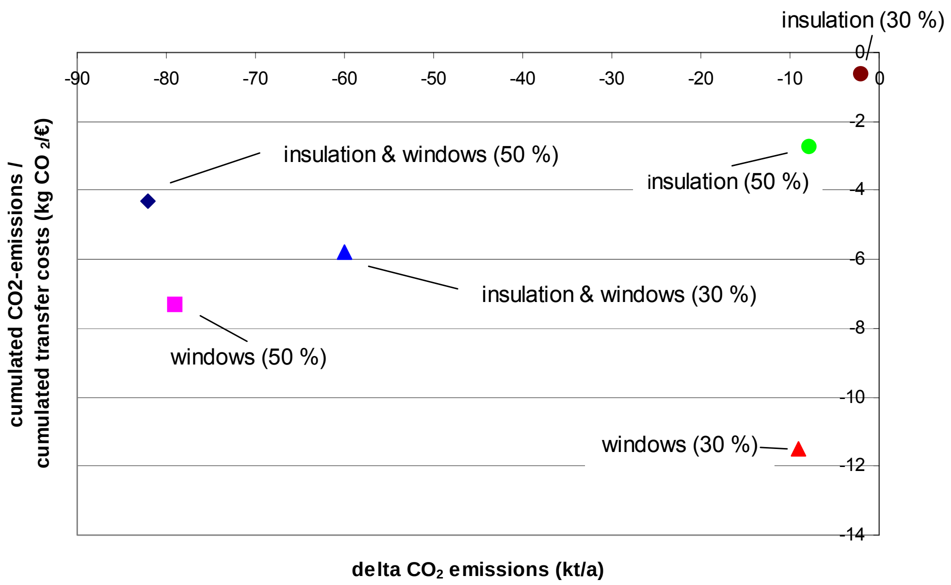


Figure 5-2: Promotion scheme efficiency vs delta CO_2 emissions (H2)

The graph shows the calculated cumulated promotion scheme efficiency (kg CO_2/€) against the change in the estimated annual CO_2-emissions in buildings for the six investigated options with respect to subsidising of insulation/window replacement. It can be seen that all options have negative promotion scheme efficiencies - i.e. will improve the conditions in comparison with the reference scenario. Looking separately at insulation and window replacement, it is clear in this analysis that window replacement has considerably better promotion scheme efficiencies than subsidies towards insulation. Furthermore for given level of subsidies (30% and 50%), the estimated change in the annual CO_2-emissions is highest for window replacements. If both insulation material and window replacement costs are eligible for subsidies, the change in CO_2-emissions, unsurprisingly, increases and the promotion scheme efficiencies end up in between insulation and window replacement individually.

Generally, the changes in CO_2-emissions in conjunction with these types of promotion schemes are limited, even in the combined scenario of insulation and window replacements. As shown previously in this chapter, even a modest increase if the CO_2-tax will have a much higher impact than any of the six options covered in the above graph.

If the promotional scheme containing 30% subsidies towards both insulation and window replacement is combined with a CO_2-tax of 20 €/tonne CO_2 in the building sector, the CO_2-reduction is multiplied by roughly 8.5. Since the costs related to this only increase marginally, the cumulated promotional scheme efficiency is roughly seven-doubled to this change. This extent of this improvement probably to a large extent reflects the fact that the impact of a CO_2 is much higher than that of the subsidies.

It should be emphasised that these findings rely strongly on the assumptions both in designing the scenario as such and with respect to the reference scenario.

5.4.4 Hypothesis H3: Bio-fuels for transport

This hypothesis investigates the effect of using part of the biomass resources for bio fuels for the transportation sector. These two bio fuels are covered: rape seed oil (replacing/supplementing diesel) and ethanol (replacing/supplementing gasoline). Furthermore, different subsidising principles are investigated, namely in the form of subsidies based on hectare land and litre fuel respectively. Obviously in practice, a combination of the two principles is a very likely approach.

In each case subsidies are designed cover 50% of the hectare or fuel conversion costs respectively. Up to 100000 hectares are assumed to be reserved for each of the two fuel options.

However, it has not been possible to carry through the analysis of this hypothesis. This is due to an operational error, which means that promotional schemes do not have an impact on the outcome of the modelling. Thus the bio fuel production in the modelling is primarily determined by the framework constituted by the land set aside for the bio fuels.

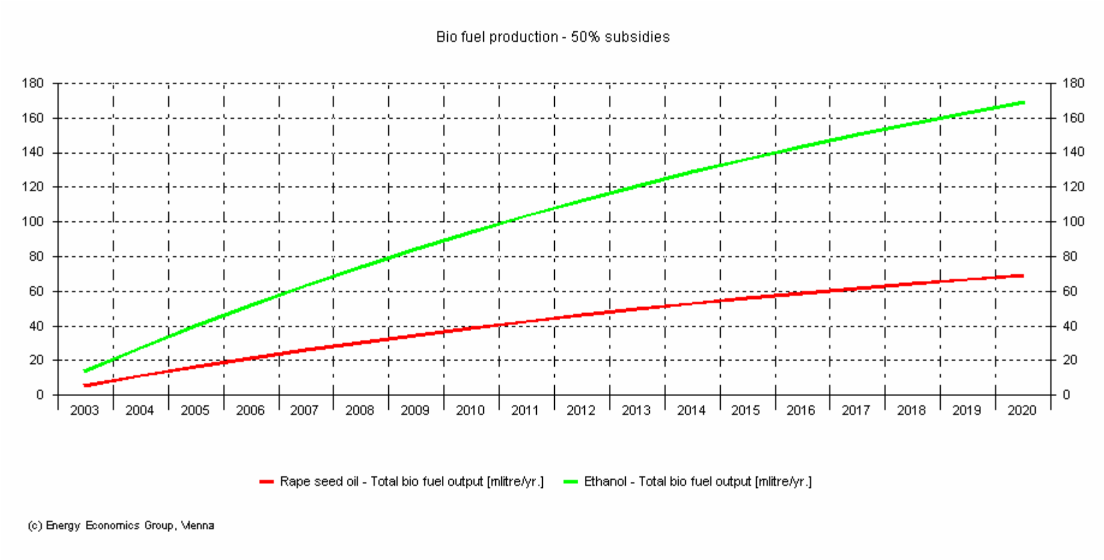


Figure 5-3: Bio fuel production (H3)

Under these circumstances, the graph shown here illustrates the calculated bio fuel output over time. In addition to the operational error, the model contains an internal simplification relating to the division of bio fuels on rape seed oil and ethanol - namely that this is not based on costs.

5.5 Conclusions

When assessing the estimated impacts, on cost and benefit side, of the hypotheses investigated above it should be kept in mind that they are compared to a reference scenario and this in itself results in significant CO_2 reductions. Consequently, the marginal reductions in conjunction with the hypotheses are much smaller. At the same time, the promotion efficiencies generally become poorer in this connection.

Generally, much greater impacts can be achieved by means of a CO_2- tax in the building sector. Moreover this as an income-generating instrument instead of one linked to additional expenses. In this context the main limits are defined by the political opportunities for increased taxes - at least to the extent the assumptions of the model can be assumed to be applying.

Indeed, the combination of subsidies and CO_2-tax appear to be very beneficial - both for the total CO_2-reductions and for the cumulated promotional scheme efficiency.

5.6 References

Bach, Peter, Danish Energy Authority, personal communication, June 2004

Central Statistics Office: Data on the building stock

Danish District Heating Association: ”Fjernvarmepriserne i Danmark - resultatet af prisundersøgelsen 2004” (in Danish). Kolding, 2004.

Danish Energy Authority: “Teknologidata for el- og varmeproduktionsanlæg” (in Danish). Copenhagen 1995.

Danish Energy Authority: “Danmarks vedvarende energiressourcer”. Copenhagen 1996.

Danish Energy Authority: “Energistatistik 2003” (in Danish). Copenhagen 2004.

Danish Energy Authority: “Langsigtet energistrategi frem mod 2025” (in Danish). Copenhagen 2004.

Danish Energy Authority: “Perspektiver for samfundsøkonomiske produktionsomkostninger for el- og varmeproduktionsteknologier år 2025” (draft, in Danish). Copenhagen, October 2004.

Danish Energy Authority: “Vejledning i samfundsøkonomiske analyser på energiområdet + Appendix: Beregningsforudsætninger for samfundsøkonomiske beregninger på energiområdet” (draft, in Danish). Copenhagen 2004.

Danish Energy Authority: “Handlingsplan for en fornyet energispareindsats” (draft, in Danish). Copenhagen 2004.

Danish Energy Authority: “Handlingsplan for en fornyet indsats - energibesparelser og marked. Faglig baggrundsrapport” (draft, in Danish). Copenhagen 2004.

Danish Energy Authority, Elkraft System & Eltra: “Technology data for electricity and heat generating plants”, Copenhagen March 2004

Elkraft System: “Scenarieberegninger - klimavirkemidler og forsyningssikkerhed” (in Danish). Ballerup, 2003.

Gylling, Morten: “Energiafgrødeprogrammet. Hovedrapport. Rapport 131” (in Danish, English summary”. Danish Research Institute of Food Economics, Frederiksberg 2001.

Gylling, Morten et al: “Langsigtede biomasseressourcer til energiformål. Rapport 125” (in Danish, English summary). Danish Research Institute of Food Economics, Frederiksberg 2001.

Joergensen, Kaj et al: “Rational use of energy and renewable energy sources - a review of current policy strategies and promotion schemes. Report of Work Phase 1 of the INVERT project”. INVERT-Altener Programme of the European Commission, DG TREN, Brussels 2004.

Kranzl, Lukas et al: “Technology evaluation. Internal report of Work Phase 2 of the INVERT project”. INVERT-Altener Programme of the European Commission, DG TREN, Brussels 2004.

Monefeldt Tommerup, Henrik: “Energibesparelser I eksisterende og nye boliger. Rapport Byg-DTU R-080” (in Danish). Department of Civil Engineering, Technical University of Denamrk, Lyngby, 2004.

Schipper, Lee et al: “Energy Use in Denmark: an international perspective”, International Energy Studies Group, Lawrence Berkeley Laboratory, Berkeley 1992.

Vries, H. J. de et al: “Renewable electricity policies in Europe - country fact sheets 2003”. ECN, Amsterdam, 2003.

Wittchen, Kim B.: “Vurdering af potentialet for varmebesparelser I eksisterende bygninger. Dokumentation 057” (in Danish). Danish Building and Urban Research, Hoersholm, 2004

6 UK – Cornwall

The English county of Cornwall was selected by the UK partners to test the **In*vert*** model and identify its strengths and limitations. This report does not comprise a full case study analysis, as it was found that the approach to RUE programmes in the UK is different from those in the other countries studied. This may be related to the differences found in work package 4, the stakeholder behaviour analysis, where Denmark and UK showed significantly different results from the rest of the countries studied. In this case study overview, we attempt to demonstrate where the **In*vert*** model works and where it does not, with suggestions for how it could be made more applicable to UK policy structure.

6.1 Structure of the energy supply

6.1.1 Primary Energy Demand and End Energy Consumption

Final energy consumption in Cornwall is currently estimated to be 13TWh. The last assembled data for final energy consumption by fuel was in 1997, shown in Figure 6-1.

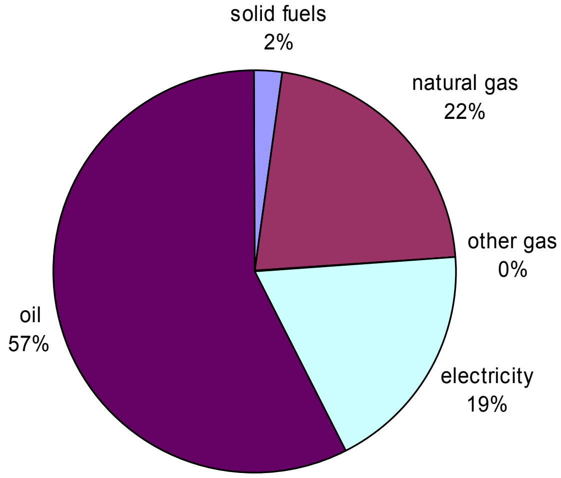


Figure 6-1: Final energy consumption by fuel (1997)

Solid fuels include coal, coke and breeze and a very small proportion of biomass fuels. Other gas, already a tiny proportion (0.0007%), includes coke oven and renewable gas (especially landfill gas). Electricity contains a higher than UK average of RES, described in section **6.1.4**.

Energy consumption by sector for the same year in Figure 6-2 shows the transport sector (road, air, rail and water) as the largest. This is followed by the domestic sector, commercial (public administration, commerce and agriculture) and industrial (construction, minerals and ‘other’ industrial).

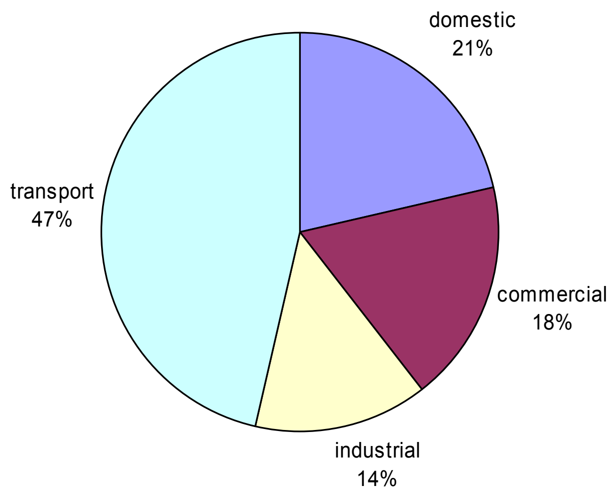


Figure 6-2: Final energy consumption by sector (1997)

Cornwall's annual energy bill has been estimated at £579 million – about 9% of GDP – of which 98% leaves the local economy.

6.1.2 Heat and power generation

The vast majority of power plant is not in Cornwall. Electricity is mainly grid-sourced and originates from gas-fired, coal-fired and nuclear plant in other parts of the UK; approximately 1000MW installed capacity caters for Cornwall's electricity needs.

There is no grid-connected heat supply in Cornwall. A large minerals refinery operates two CHP plants with a combined capacity of 11.25MW_e, and the regional water company has two plants with 395kW_e. Both companies use the energy supplied by these plants on site.

6.1.3 Heating sector

In the UK, grid-supplied natural gas is the main source of heat, particularly in the domestic sector. The main feature of the heating sector in Cornwall is that the majority of dwellings in Cornwall (55%) are not connected to the natural gas network. In England overall, only 15% of dwellings do not have a mains natural gas supply. Natural gas is nevertheless the main heating fuel in Cornwall, but the next most common fuels for domestic heating are electricity, followed by oil, solid fuels and LPG. These fuels imply higher than average heating costs and CO_2 emissions. Eighteen per cent of Cornish homes do not have central heating systems, only slightly higher than the English average (14%). Cornwall also has a high proportion (38%) of solid wall dwellings (i.e. no cavity), which increases building energy demand and heating costs and also means that wall insulation of non-multi-family solid wall buildings is usually cost-ineffective.

The structure of the heating sector places Cornish households at a higher than normal risk of fuel poverty. A fuel poor household is one which needs to spend more than 10% of its disposable income to heat its home to an adequate standard of warmth: 21°C in the living room and 18 °C in other occupied rooms. The number of households at risk of fuel poverty in Cornwall is 45,489, or 24.4%. This is roughly the English average, but Cornwall has some concentrated areas of at-risk households which are amongst the highest in England.

Heat from renewable sources is currently a small sector in Cornwall. Duchy College supplies some of its heat from 10 ha of Miscanthus, and approximately 50 buildings, mostly in the social housing or public sector, use ground source heat pumps.

6.1.4 Renewables

The current installed RES-E generation capacity is 49.3MW, as detailed in Figure 6-3. Renewables account for 5% of the region's electricity requirements, and 2.5% of the total UK installed capacity. The UK has a target of 10% electricity supplied by renewables by 2010: Figure 6-3 also illustrates a feasible scenario for the additional capacity required to meet this target for Cornwall, which the region has also set itself.

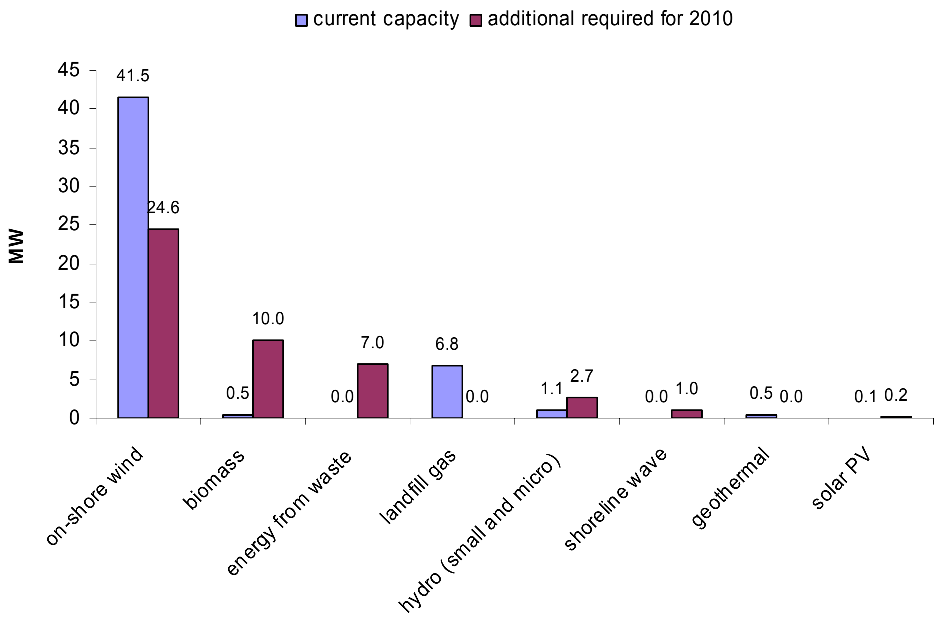


Figure 6-3: RES-E generation capacity; now plus scenario for 2010

RES in Cornwall is clearly dominated by on-shore wind in the mid-term, for which there is an estimated additional potential of 188-500MW accessible economic resource. Cornwall being a relatively rural region compared to other parts of the UK, there is considerable biomass potential in the longer term, not only for electricity, but also for heating and as transport fuel. The latter should be a significant consideration in light of the size of the transport sector in Cornwall (see section 6.1.4).

Taking RES-H and RES-T into account in addition to RES-E, Cornwall is aiming for a total installed renewables capacity of 234MW (93.8 of which is to be RES-E) by 2010, generating 675GWh of electricity and providing 609 GWh of heat and transport fuel.

In the longer term, Cornwall's sizeable marine resources mean that shoreline and offshore wave, tidal barrage, tidal stream and offshore wind energy will be tapped. Cornwall being the sunniest region of the UK also should imply that solar PV and solar thermal (no data available) will grow in importance. As tourism forms a significant proportion of Cornwall's GDP, the main challenge to realising RES potential lies in developing RES with in harmony with the landscape.

6.2 Promotion schemes

The Cornwall Sustainable Energy Partnership (CSEP) has produced an Energy Strategy for Cornwall. It advocates an integrated RES and RUE which also aims to stimulate the local economy and employment, and it deliberately seeks to exploit synergies between sustainable energy deployment and economic and social considerations. Informed by national objectives and targets, the quantitative targets for the region according to its strategy are:

- **Overall**
    - 20% CO_2 emissions reduction on 1990 levels (60% by 2050)
- **Buildings (domestic)**
    - Ensure take-up of RUE measures in deprived areas reaches 6500 (2003-2006)
    - Save 223 kt CO_2 by 2010
- Buildings (commercial)
    - Save 223 kt CO_2 by 2010
- **RES-E**
    - 93-108MW of renewable electricity capacity in Cornwall by 2010
- Biomass/Transport
    - 609 GWh of heat/fuel by 2010

The sectors in bold type are the ones considered in this case study.

By most accounts Cornwall's renewable and sustainable energy practices are advanced. An analysis carried out by the European Commission's Bacchus Guidelines project identified Cornwall as being the best example of successful integration of energy projects into local development strategies of all of their case study regions. Furthermore, CSEP was adopted as a model for the London Energy Partnership. The establishment and scope of interest of the CSEP justifies the assertion that in Cornwall, RES and RUE are a ‘political focus’ for the region. However, other than access to structural funds for RES projects, Cornwall relies on central government programmes for funding RES and RUE implementation; there are no specific regional schemes in place. The most important schemes – indispensable for the construction of the reference scenario – are listed by sector below:

Buildings sector (domestic)

- *Warm Front*: Direct grant aiming to alleviate fuel poverty by supporting demand-side measures for low-income households. Specifically, it provides:
    - Grants up to £1,500 for packages of insulation e.g. loft and/or cavity wall insulation and draught proofing and heating improvements for owner-occupier householders in receipt of certain benefits.
    - Grants up to £2,500 (Warm Front Plus) for owner-occupier householders over 60 in receipt of certain benefits to provide similar packages which also allow for full heating systems where appropriate.
- *Energy Efficiency Commitment*: Administered by the energy regulator as a statutory requirement for gas and electricity suppliers to provide their customers with RUE measures:
    - Defra[10] (formally) sets suppliers’ energy efficiency target (energy saved in terms of TWh as a result of demand-side energy efficiency improvements), energy suppliers are allowed to spend defined amount of money per customer to aid them in meeting their targets by setting up schemes to promote domestic energy efficiency measures to their customers (e.g. marketing, installer accreditation, bulk discounts).
    - To address fuel poverty, there is a requirement for suppliers to achieve a certain proportion (which has increased over time) of take-up of measures in low-income households (known as ‘Priority Group’).

RES-E sector

- *Renewables Obligation*: A quota system with elements of a feed-in tariff, administered by the energy regulator to increase installed RES-E capacity:

[10] Department of Environment, Food and Rural Affairs

- Introduced in April 2002, the Renewables Obligation requires all licensed electricity suppliers in England and Wales to supply a specific proportion of their electricity from RES, and provides a number of paths to compliance.
- Individual suppliers are responsible for demonstrating that compliance to the energy regulator through a system of Renewables Obligation Certificates (ROCs).
- ROCs are freely tradable – suppliers who exceed the Obligation can sell them to those who do not achieve it.
- Alternatively, suppliers unable to fulfil the Obligation can buy their way out at a cost (currently) of £47.18 per MWh. This implies that fulfilment of the Renewables Obligation is subject to the cost not being excessive as defined by Ofgem. Payments are recycled to those who do comply ('feed-in tariff' component).
- In order to provide a stable and long-term market for RES, the Obligation will remain in place until 2027. Yearly targets have been set up to the 2010/2011 period.

- *Capital Grants Programme Offshore Wind*: Partial subsidy by the Department of Trade and Industry (lower of 40% of eligible project costs or £10m) of offshore wind farm development (min. 20MW output) with stated aim of stimulating early development of a significant number of offshore wind farms in order to reduce future costs of the technology. Total remaining budget is £40m.

Transport sector[11]

- *Energy Crops Scheme*: Defra-funded direct, fixed grant programme directed at the private sector with stated primary aim of rural development, as well as contribution toward environmental and social objectives:
    - £ 29 m available from 2000 to 2006 toward establishment grants of: £1,600 or £1,000 per hectare, depending on land type, for establishing short rotation coppice (SRC) of either willow or poplar and £920 per hectare for establishing miscanthus.
    - Crops must be grown for electricity, heat or co-generation (see footnote) within a "reasonable" radius of the growing land.

[11] There are other more important programmes, but none of them pertain to biofuels for transport. The scheme listed is not for the transport sector, but could be modelled as if it was. The transport sector has the lowest priority for simulation out of the three sectors.

Table 6-1: Other programmes applicable in Cornwall by sector

Buildings (domestic)	Buildings (commercial)	RES-CHP	Transport
▪ Clear Skies Programme ▪ Major PV Demonstration Programme ▪ Innovations Programme ▪ Reduced VAT for DSM measures ▪ Building Regulations	▪ Climate Change Levy ▪ Lightswitch ▪ Major PV Demonstration Programme ▪ Action Energy ▪ Enhanced Capital Allowances ▪ Building Regulations	▪ Bio-energy programme ▪ Community Energy	▪ Fuel Duty ▪ PowerShift ▪ CleanUp

Table 6-1 lists the other important programmes and schemes applicable in Cornwall for all relevant sectors.

The integration of at least some of these schemes into the Cornwall case study is desirable, but is a second priority compared to the selection of significant programmes outlined for the chosen sectors above.

6.2.1 Reference Scenario

The Reference Scenario is defined to represent the "business as usual" development based on the selected existing promotion schemes. The selection of promotion schemes above, which is absolutely necessary for the construction of an adequate reference scenario, pose specific, currently insurmountable, problems for implementation in the ***Invert*** simulation tool. Sectors and associated schemes are discussed in the subsection below.

6.2.1.1 Modelling difficulties and essential assumptions

Buildings sector (domestic)

Warm Front as a subsidy does not apply for all households and is not linked to specific RUE measures. Adequate modelling of Warm Front in the reference scenario would thus require two substantial refinements; one to the data and one to the INVERT model itself. Each is explained in turn.

The refinement to the data requires the creation of a number of subdivisions of the various buildings sector (domestic) categories in order to separate out the households that are eligible for Warm Front grants. There are two types of grant; one for owner-occupiers in receipt of certain social benefit payments and one for those amongst this group that are over 60 years of age. Data on each building type needs to be subdivided as illustrated by example in Figure 6-4. At the end of the process, two new building types – “Warm Front eligible (under 60)” and “Warm Front eligible (over 60) – can be created for each existing building type. This will ensure that promotion scheme parameters can be applied to the eligible households in the **Invert** simulation tool.

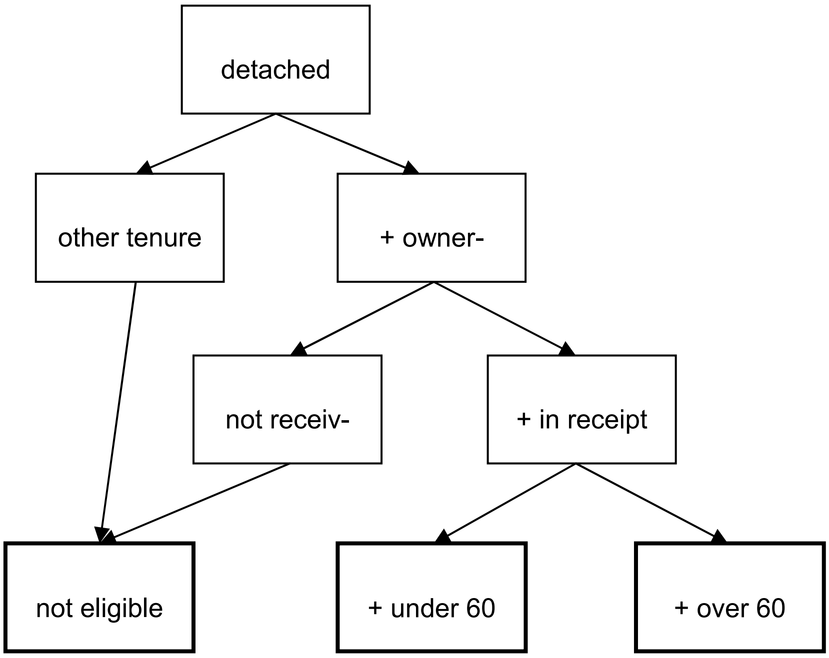


Figure 6-4: Data refinement to accommodate Warm Front

Parameters for promotion schemes applicable to the eligible groups then need to be applied. Warm Front pays up to a lump sum maximum of £ 1,500 (group A) or £ 2,500 (group B) that can be spent on all measures defined as cost-effective under the scheme. The second necessary refinement is to the simulation tool itself. The grant will pay for insulation and heating measures on the principle of ‘insulation first, heating second’. The grant will not pay for insulation of a solid (i.e. non-cavity) wall dwelling, but will pay for a new, better heating system in this case. It will pay for loft insulation to 250 mm if there is none, but will currently not pay for an increase if the loft insulation is at the standard installed in a major insulation programme in the 1980s (100 mm). The **Invert** simulation tool would need to make ‘intelligent’ decisions on the technologies installed, choosing the most cost-effective insulation and heating measures subject to the parameters just described. The main conceptual difference to the current state of the simulation tool is the introduction of a promotion scheme that simultaneously supports two separately modelled measures. The problem of solid wall dwellings can easily be overcome via the use of application barriers for insulation of the relevant building types. A process for take-up of a Warm Front grant is proposed in Figure 6-5.

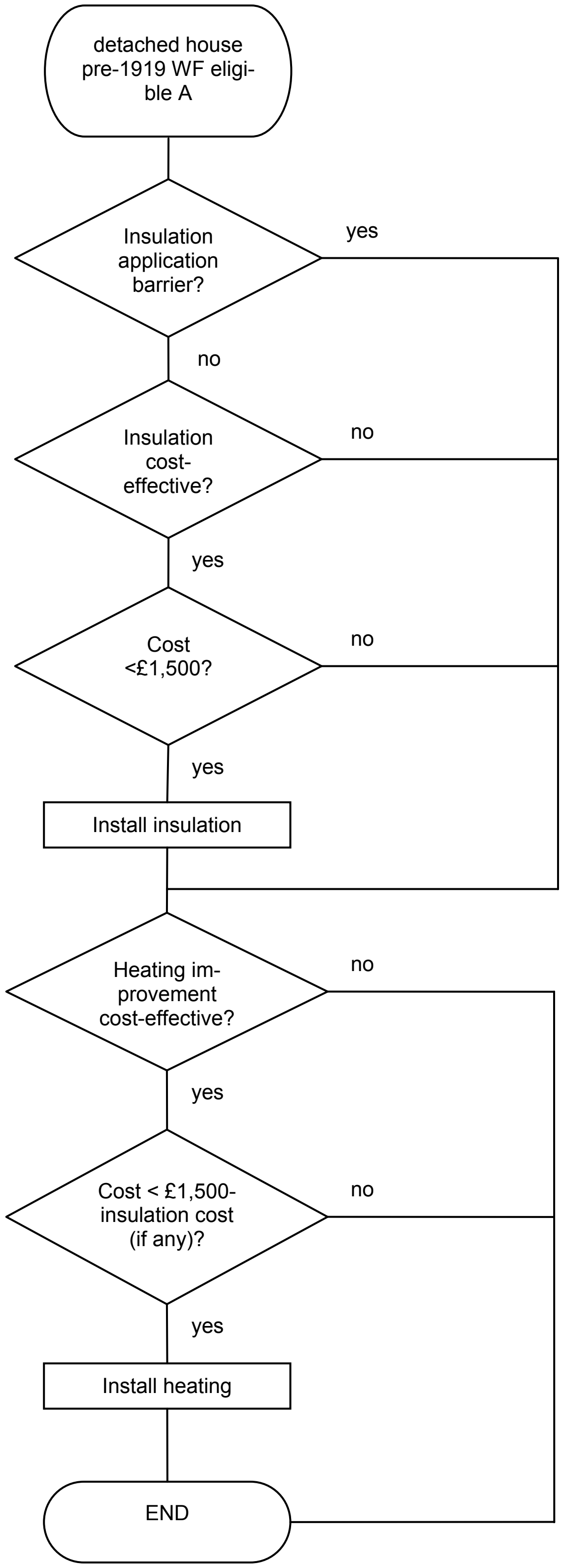


Figure 6-5: Warm Front modelling schematic

The other crucial promotion scheme in the domestic buildings sector is the *Energy Efficiency Commitment* (EEC). There are 17 EEC schemes in Cornwall, targeting two groups of end-users: priority and non-priority. Non-priority households are usually eligible for discounts on insulation and heating measures, and priority households (i.e. those receiving certain social benefits) are eligible either for greater discounts within the same schemes or can receive measure for free. Table 6-2 contains a typical example of an EEC scheme for cavity wall insulation available in Cornwall.

Table 6-2: Scottish Power cavity wall insulation promotion scheme

	Typical price (without a grant)	Standard offer	Senior citizens	Customers in receipt of benefit
Gas heated homes	£380	£125	£99	free
Electrically heated homes	£380	£50	£50	free

The “senior citizens” group and “customers in receipt of benefit” group are sufficiently similarly defined compared with the corresponding groups in the Warm Front scheme, but it would be necessary to define additional building types similar to the Warm Front eligible groups but applied to the non-owner occupiers; EEC schemes are open to everyone. What is also necessary is the ability to simultaneously implement multiple promotion schemes for the same technologies in the simulation tool. The main line of investigation for Cornwall in particular but in the UK in general would be to assess the relative or combined effectiveness of different EEC schemes and the relative or combined effectiveness of EEC schemes and Warm Front grants. This would further require that the outputs of the **Invert** simulation tool can display transaction costs and CO_2 savings not only by technology, but also by promotion scheme. This is because individual promotion schemes would no longer be synonymous with individual technologies.

An additional necessary refinement to the model would be the input of the annual rate of connection to the natural gas network, with automatic removal of application barriers for mains gas technologies in the corresponding proportion of relevant building types. The need for such a feature stems from the fact that without any promotion scheme, most Cornish households will switch to mains gas heating systems, an option available only to a small proportion of those who do not have mains gas heating yet – see Figure 6-6 [12].

---

[12] As stated before 55% of Cornwall’s dwellings (approximately 110,000) are not connected to mains gas.

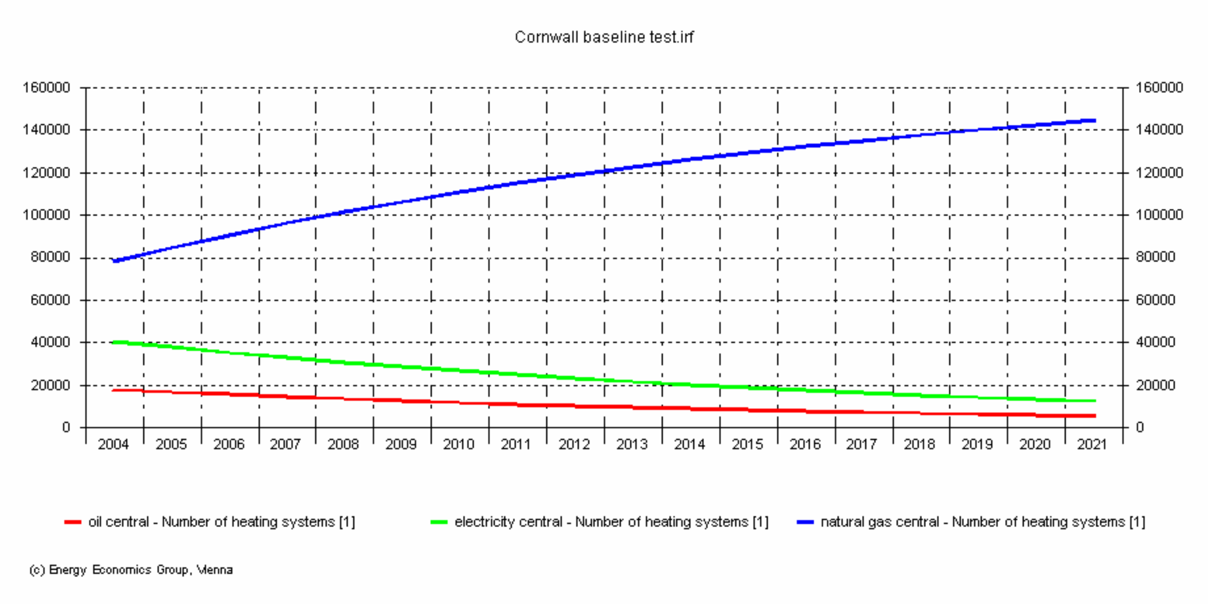


Figure 6-6: Switch to mains gas central heating systems

RES-E sector

There are two crucial promotion schemes available to the RES-E sector in Cornwall, the *Renewables Obligation* and the *Offshore Wind Capital Grants Programme*. The Capital Grants Programme can be implemented in the simulation tool but cannot be seen in isolation from the Renewables Obligation (RO). Despite having a 'feed-in tariff' component[13], the RO is fundamentally a quota scheme, and it has been decided not to implement quota schemes in the ***Invert*** model. However, in the case of the UK/Cornwall, the RO is by far the most important determinant of the RES-E market; it is in fact the only significant determinant. Without the RO as the underlying statutory driver, the Capital Grants Programme would not provide sufficient incentive to invest in RES-E plant.

Transport sector

The Energy Crops scheme can be implemented into the model. However, it would not strictly form part of a reference scenario for transport because the scheme does not subsidise the growth of energy crops for transport – though obviously the scenario if it did can easily be investigated. Cornwall is one of the most rural regions in the UK, making the investigation of energy crops important, but data on biomass potentials is extremely poor.

---

[13] As stated before: Electricity suppliers who do not fulfil their quota obligations must pay a fee of (currently) £47.18 per MWh of unfulfilled quota. This money recycled to fully compliant suppliers, lowering the cost of their RES-E production.

6.3 Hypotheses

In light of the difficulties in constructing a reference scenario, it is meaningless to attempt to model hypotheses that demonstrate the value of the model to the UK and Cornwall policy agenda. The difficulties could be overcome, in which case the most interesting hypotheses to test against the reference scenario and lines of investigation would be:

Buildings (domestic) sector

- Effectiveness and efficiency of outcomes of EEC schemes if they are coordinated, consolidated and streamlined.
- Extension of Warm Front to incorporate the private-rented sector.
- Increasing investment in the extension of the gas network.

RES-E sector

- Comparing the effects of feed-in tariffs for the Cornwall-relevant RES-E technologies with the effect of the Renewables Obligation.
- Showing how subsidies for on-shore and offshore wind installations affect the distribution of electricity supply.
- Testing the promotion of wind and tidal energy technologies.

Transport sector

- Considering the much higher than UK average energy consumption of the transport sector in Cornwall and the rural nature of the region, comparing the effects on transaction cost and CO_2 emissions of the Energy Crops scheme as it is (i.e. only for RES-E, RES-H and RES-CHP) with applying it to the transport sector.

6.4 Conclusions & Recommendations

At its current stage of development, the **In*vert*** simulation tool is of greater relevance to the UK in terms of academic enquiry rather than policy making. There are some very important hypotheses to test for Cornwall, but first the **In*vert*** model and simulation tool need to be adapted to fit the UK policy and promotion scheme context. It would be desirable to liaise with the appropriate academic institution, with EEG peer-reviewing the adaptations to the model and simulation tool to create a 'UK Edition' of the software which may have application in other countries and regions also.

6.5 References

All Cornish energy data and references to regional targets and objectives are from:

Cornwall County Council: State of the Cornish Environment: 2002 Baseline Edition. – Truro, Cornwall 2002

Cornwall Sustainable Energy Partnership: Action Today for a Sustainable Tomorrow: The Energy Strategy for Cornwall. – Camborne, Cornwall 2004

Renewable Energy Office for Cornwall: Renewable Energy: a strategy for Cornwall 2002-2010. – Redruth, Cornwall 2002

7 French illustration example on solar thermal systems

This chapter provides a short summary of the illustration example carried out for France on solar thermal systems. Actually, for France no case study had been scheduled within this project. However, together with ADEME it has been decided to carry out this example in order to illustrate Invert simulation tool for French conditions. The main objective of this example is to investigate the impact of various incentives for solar thermal systems for domestic hot water in France.

Currently, there is only a low penetration of solar thermal systems: In the year 2002 6.000 units had been installed. At the beginning of 2005 a change of the promotion scheme for solar thermal systems took place: A complicated subsidy scheme was transferred into a tax incentive scheme resulting in the same level of financial incentive.

Table 7-1: Change of promotion scheme for solar thermal systems in France

before 01-01-2005			since 01-01-2005		
ADEME	2 - 3 m2	690 €	Fiscal administration	tax credit	40%
	3 - 5 m2	920 €			
	5 - 7 m2	1 150 €			
Fiscal administration	tax credit	15%			
Local administration	0 - 100% of ADEME subsidy		Local administration	subsidy	

"The change has no economic impact for private owners"

calculation based on a 4m2 DHW in an existing building

investment cost = 4 009 € (2 954 € material costs)

ADEME		700 €			
Region		700 €	Region		700 €
Tax credit		366 €	Tax credit		975 €
	Sum =	1 688 €		Sum =	1 675 €

In order to take into account the varying levels of solar radiation in France, four regions have been defined. Within each of them a similar range of solar radiation is assumed:

- Paris/Strasbourg
- Tours/Macon
- Bordeaux

- Montpellier/Perpignan/Nice

For these four regions ADEME provided data for solar radiation and number of current DHW systems (according to energy carrier and combined/stand alone systems) and energy prices. Cost data for DHW and solar thermal systems have been checked with the **Invert** data base and adjusted to the French conditions. Based on the current energy prices three price scenarios have been defined: A low price scenario, a moderate price increase (1.4%/yr) and a high price scenario (4%/yr).

From empirical evidence it is known that there exists at least for a certain share of consumers and investors a high willingness to pay. According to the figures of the last years as well as the estimation of ADEME regarding the future uptake of solar thermal systems factors for the willingness to pay (negative soft barriers) have been estimated for the reference (low price) scenario. The following figures show the values for the soft barriers as well as the impact of them (number of dwellings with solar thermal systems in the reference scenario with and without willingness to pay). [14]

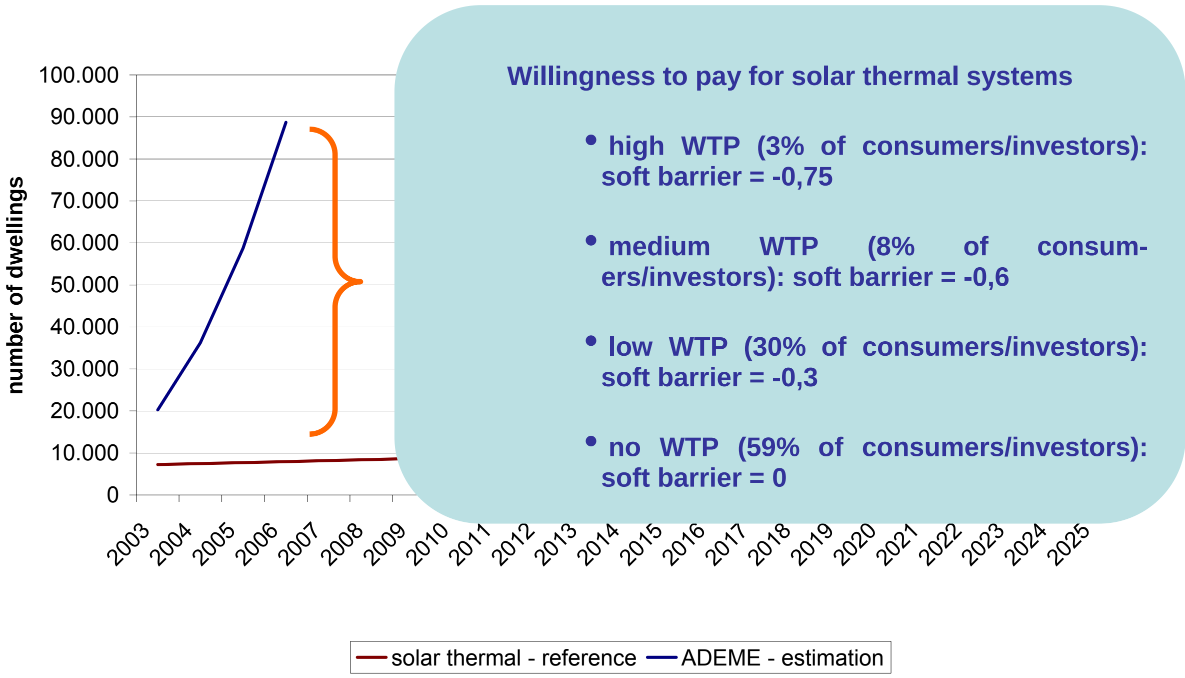


Figure 7-1: Calibration of willlingness to pay for solar thermal systems in France: Number of dwellings with solar thermal systems in France without willingness to pay in France and estimations by ADEME

[14] It should be noted that the calculations are based on the assumption that only systems with a central heating system in the building are considered for switching to solar thermal. This assumption may be necessary to reconsider for some parts of France. However, this was not possible within this analysis.

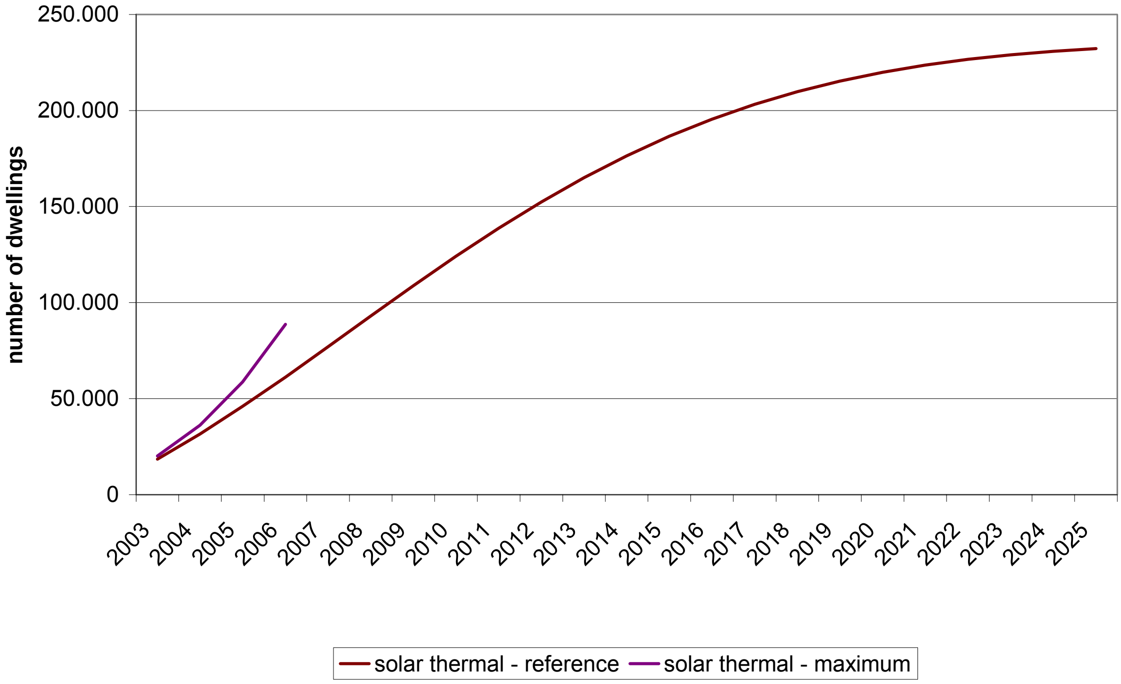


Figure 7-2: Calibration of willlingness to pay for solar thermal systems in France: Number of dwellings with solar thermal systems in France with willingness to pay in France and estimations by ADEME

The following figure shows the impact of solar thermal systems on related CO_2-emissions and CO_2-reductions. It can be seen that the share of CO_2-reductions by solar thermal systems is very low in the reference scenario. However, in a maximum-solar scenario (100% investment subsidy) substantial reductions could be achieved.

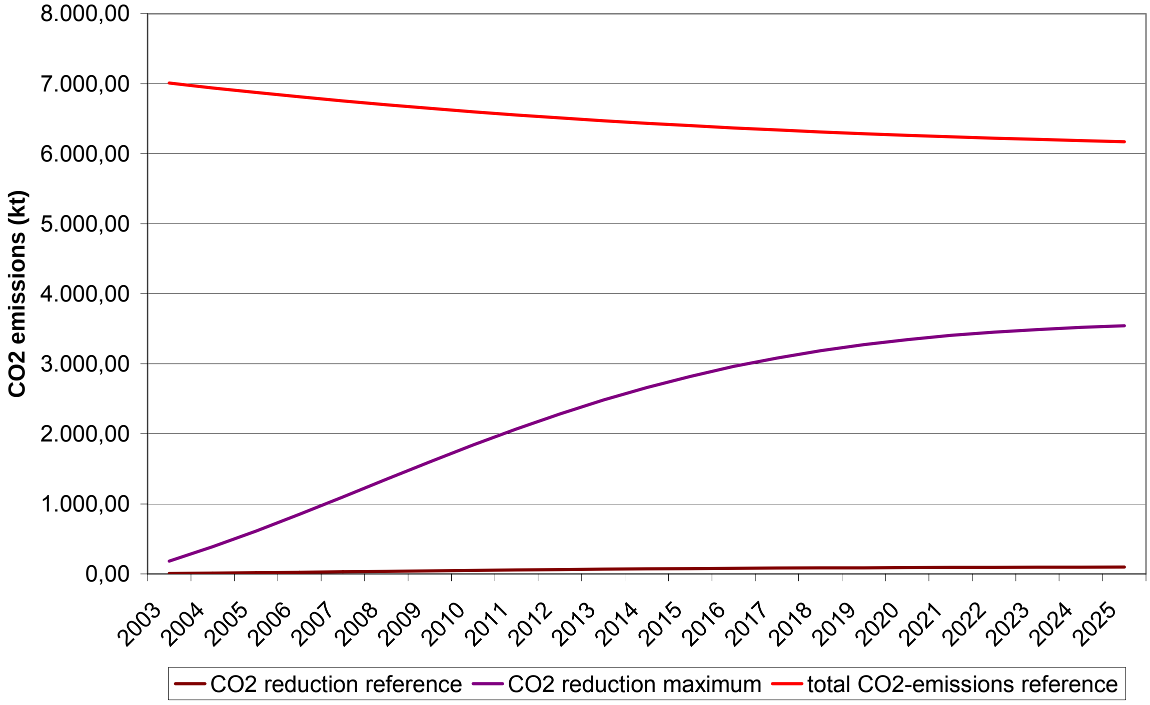


Figure 7-3: CO_2-emissions (total emissions for DHW in the reference scenario), CO_2-reductions in the reference and in a maximum scenario (France)

As can be seen from the figure below, the impact of the energy price is very high: In the high price scenario more than 50% of the maximum can be achieved until 2020. Moreover, an increase of the current investment subsidies by 20% can induce a substantial growth.

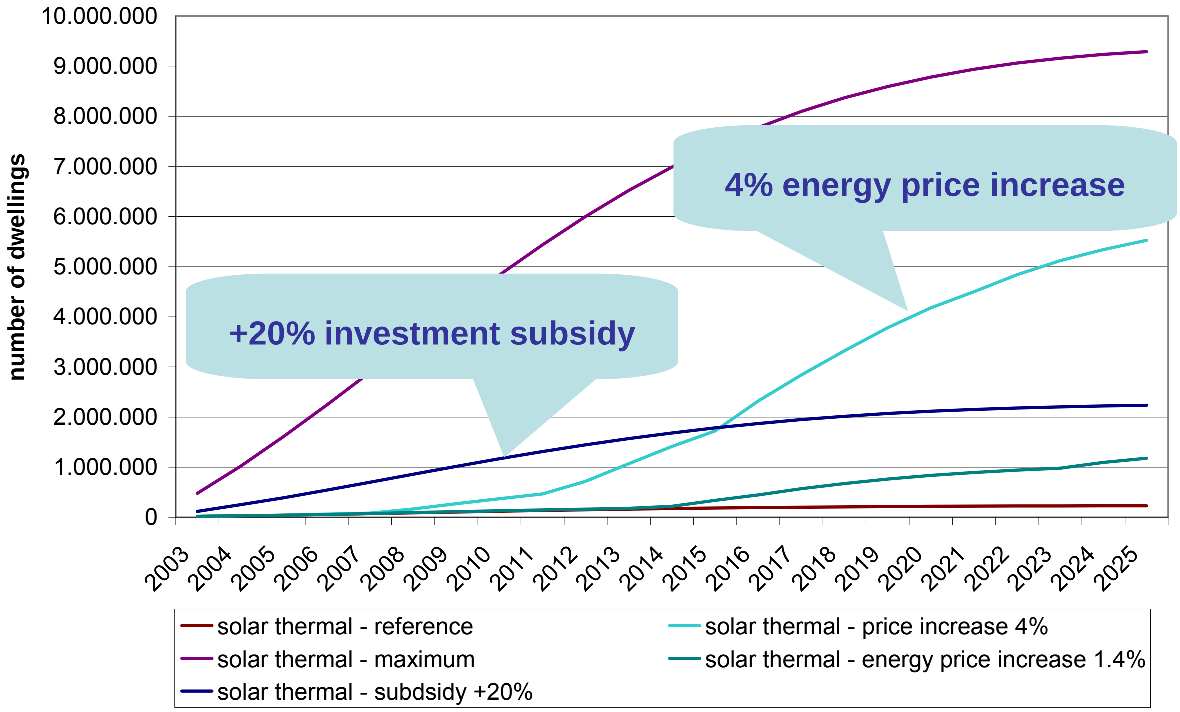


Figure 7-4: Impact of subsidies and energy price of solar thermal systems in France

8 Appendix

8.1 Append. Germany, Baden Württemberg

8.1.1 Basic Data

Table 8-1: Economic data Baden Württemberg 2002

	total		**specific per capita**	
Area	35.751	km²	3.405	m² / head
Population	10,7	Mio		
Households	4,8	Mio	0,448	
Car stock	7,0	Mio	0,657	
GDP *)	287,4	Mrd € / a	27,1	k€ / head
Primary energy consumption	450	TWh / a	42,1	MWh/a*head
Endenergy consumption	310	TWh / a	29,0	MWh/a*head
Gross power generation	70	TWh / a	6,6	MWh/a*head
Energy determined CO_2 emissions	80,4	Mt	7,5	t / a*head
Energy intensity	1.566	kWh PE / k€		

*) gross domestic product

(Informationszentrum Energie: Energieversorgung in BW 2004)

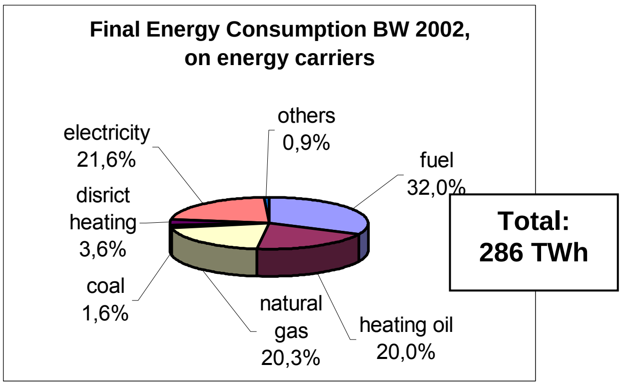


Figure 8-1: Final Energy Consumption Baden Württemberg 2002, on energy carriers

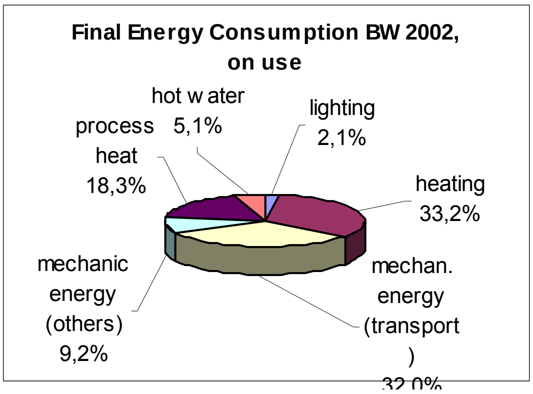


Figure 8-2: Final Energy Consumption Baden Württemberg 2002, on use

8.1.2 Existing Promotion schemes (Federal and State level)

Table 8-2: Promotion Programme EnergieHolz Baden-Württemberg

Issue	Description
Renewable energy source	Wood
Description of the instrument	Investment subsidy
Target of the instrument	Support of innovative biomass technologies
Stage of policy implementation	Implemented since 2003
Operational period of the instrument.	Open
Specification of the instrument	Up to 20% investment subsidy for very innovative wood chip installations Up to 15% investment subsidy for innovative solutions in the fields of fuel logistics and pellet applications *Subsidies can be cumulated with other programmes up to 30 %* of *investment costs*
Key factors	Both the wood industry as well as the power plant operator can apply

Table8-3: Energieeinsparprogramm Altbau (Renovation of old buildings)

Issue	Description
Renewable energy source	RES & RUE
Description of the instrument	Soft loans
Target of the instrument	Increase the interest in energy efficiency improvements in old buildings and use od renewables
Stage of policy implementation	Implemented since 2003
Operational period of the instrument.	Open
Specification of the instrument	For buildings built before 1984 Soft loans (- 1% *) up to 15.000 € per dwelling a) Measures for improvement of heating insulation b) Measures for using of renewable energies and for reduction of heat energy demand (installation and modernization of heat pumps, solar thermal, biomass, heat recovery, heat exchanger) *- Installation of condensed and low temperature boilers only in combination with one of the measures above* *- Can be supplemented for residual investment cost by KfW Programme for CO_2 reduction* *- Can be combined with communal promotion schemes*
Key factors	Companies, private

*) related to the end user credit interest rate of State Bank; which is at present about 4 %

Table 8-4: KfW Programme for CO_2 Reduction

Issue	Description
Renewable energy source	RES & RUE
Description of the instrument	Lower interests on loans
Target of the instrument	Investments in RES and RUE
Stage of policy implementation	Implemented before 2003
Operational period of the instrument.	Open
Specification of the instrument	*Interest rate 3,2 % nom. (10 a) to 3,85 % nom. (30 a)* *First 2 (10 a) to 5 (30 a) years without paying back* a) heat insulation (exterior walls, ceiling, floor, windows) b) Modern heating facilities (condensing boiler, low temperature boiler) c) Using renewable energy facilities (solar thermal, heat pumps, biomass, geothermal...) d) Energy saving house 60 (< 60 kWh/m²) *Can be cumulated*
Key factors	House owner, privates

Table 8-5: KfW CO_2 Building Refurbishment Programme (KfW- CO_2 – Gebäudesanierungs Programm)

Issue	Description
Renewable energy source	RES and RUE
Description of the instrument	Lower interests on loans
Target of the instrument	Investments in RES and RUE
Stage of policy implementation	Implemented before 2003
Operational period of the instrument.	Open
Specification of the instrument	Only for buildings built before 1979 Various packages combining several measures as - Heat insulation - Windows exchange - Exchange & modernisation of heating plants (condesing boiler) - heat pumps - Fuel switch *Interest rate: 2,00 (20 a) – 2,30 (30 a) % nom.* *Maximum: 80 – 250 €/m² living area; (level depends on specific measure)* - Energy saving houses 40 and passive houses *Interest rate: 3,00 (20 a) – 3,30 (30 a) % nom.partly debt remission to 20 %.* *Up to 100 % of investment costs;* *First 3 (20 a) to 5 (30 a) years without paying back* *Can be cumulated*
Key factors	House owner, privates

Table 8-6: Programme For Insulation Materials from Renewable Resources

Issue	Description
Renewable energy source	RUE
Description of the instrument	Subsidy
Target of the instrument	Increase the interest in energy efficiency improvements in old buildings materials
Stage of policy implementation	Implemented before 2003
Operational period of the instrument.	Open
Specification of the instrument	- List of about 20 eligible materials - Two categories (certification by FNR, Fachagentur nachwachsende Rohstoffe) *Subsidy* **category I:** 35,00 €/m³ (ca. 44 %) **category II:** 25,00 €/m³ (ca. 32 %) *Cumulation with KfW CO_2 Building Refurbishment Programme possible*
Key factors	House owner

Table 8-7: Market Incentive Programme For Renewable Energies

Issue	Description
Renewable energy source	Very innovative technologies; demonstration projects
Description of the instrument	Investment subsidy
Target of the instrument	Support of sales of RES technologies
Stage of policy implementation	Implemented before 2003
Operational period of the instrument.	Apllications have to be made before 15.10.2006
Specification of the instrument	a) *Subsidies* - Solar thermal facilities (can not be cumulated): < 200 m²: 110 €/m² > 200 m²: 60 €/m² - Biomass (automatic loading & firing): < 100 kW: 60 €/kW - Wood chips: < 100 kW: 50 €/kW - Photovoltaics in schools: 3.000 €/facility b) 3,65 % nom. Interest rate *& partly debt remission & partly debt remission* - Biomass > 100 kW: 60 €/kW (Max. 275.000 €) - Biomass CHP < 250 kW_{el}: 250 € / kW_{el} - Biogas CHP < 70 kW: 15.000 € per plant - Geothermal: 103 €/kW_{th} (Max. 1.000.000 €) c) 3,65 % nom. Interest rate - Biogas CHP > 70 kW cumulation possible except for solar thermal facilities *for b) and c)* *Up to 100 % of investment costs;* *First 3 (20 a) years without paying back*
Key factors	Privates, Companies

Table 8-8: Demonstration programme for RES and RUE

Issue	Description
Renewable energy source	Very innovative technologies; demonstration projects
Description of the instrument	Investment subsidy
Target of the instrument	Support of innovative technologies
Stage of policy implementation	Implemented before 2003
Operational period of the instrument.	Open
Specification of the instrument	investments in new technologies, which are commercially used for the first time; demonstration projects up to 40% investment subsidy
Key factors	

Table 8-9: Renewables law (Erneuerbare Energien Gesetz)

Issue	Description
Renewable energy source	RES
Description of the instrument	Feed in tariffs
Target of the instrument	Improvement of competitiveness of renewables for power generation
Stage of policy implementation	Adopted in 2000; amended in 2004
Operational period of the instrument.	open
Specification of the instrument	Tariff depends on kind of RES, size of facility, year of construction; (s. also A 3.2)
	Partly decreasing rates for facilities which will be begin operation in future times
Key factors	

Table 8-10: CHP law (KWK Gesetz)

Issue	Description
Renewable energy source	RES & RUE
Description of the instrument	Supplement for supply with current of CHP plants
Target of the instrument	maintaining, modernization und extension of CHP plants
Stage of policy implementation	Since 2002; Amended 2004
Operational period of the instrument.	Open
Specification of the instrument	Additional fee for power generation by CHP plants; level of refund depends on age resp. time of beginning operation and size of facility; additional boni for example for using innovative technologies
Key factors	

8.1.3 Technology Input Data

Table 8-11: Technology parameters Heating systems, Germany

Name	Heating technology	"new" tech-nology for the future?	Heat power [kW]	Efficiency [1]	Investment and instal-lation costs [€]	O+M costs [€/year]	Lifetime [yr.]
dh1	district heating	False	10	0,96	0	0	50
dh2	district heating	False	20	0,96	0	0	50
gc1	gas central	False	10	0,82	0	0	15
gc2	gas central	False	20	0,82	0	0	15
ec1	electricity central	False	10	0,92	0	0	15
ec2	electricity central	False	20	0,92	0	0	15
oc1	oil central	False	10	0,78	0	0	15
oc2	oil central	False	20	0,78	0	0	15
cc1	coke central	False	10	0,72	0	0	15
cc2	coke central	False	20	0,72	0	0	15
wc1	Wood central	False	10	0,71	0	0	15
wc2	Wood central	False	20	0,71	0	0	15
gs1	gas single	False	10	0,7	0	0	15
gs2	gas single	False	20	0,7	0	0	15
es1	electricity single	False	10	0,92	0	0	15
es2	electricity single	False	20	0,92	0	0	15
os1	oil single	False	10	0,7	0	0	15
os2	oil single	False	20	0,7	0	0	15
cs1	coke single	False	10	0,65	0	0	15
cs2	coke single	False	20	0,65	0	0	15
ws1	Wood single	False	10	0,65	0	0	15
ws2	Wood single	False	20	0,65	0	0	15
n dh c 1	district heating	true	10	0,96	0	305	20
n dh c 2	district heating	true	20	0,96	0	610	20
n gas c 1	gas central	true	16,49	0,88	3.222	100	20
n gas c 2	gas central	true	23,8	0,88	3.311	100	20
n gas c 3	gas central	true	32,16	0,88	3.493	100	20
n gas c 4	gas central	true	300	0,88	50.000	1.000	20
n oil c 1	oil central	true	10	0,85	4.500	100	20
n oil c 2	oil central	true	15	0,85	4.511	100	20
n oil c 3	oil central	true	36	0,85	4.789	150	20
n oil c 4	oil central	true	300	0,85	55.000	1.000	20
n co c 1	coke central	true	15	0,75	6.154	116	20
n co c 2	coke central	true	20	0,75	6.621	116	20
n co c 3	coke central	true	25	0,75	7.088	145	20
n co c 4	coke central	true	30	0,75	7.554	175	20
n co c 5	coke central	true	35	0,75	8.021	204	20
n co c 6	coke central	true	40	0,75	8.488	233	20
n wl c 1	Wood central	true	15	0,75	6.154	116	20
n wl c 2	Wood central	true	20	0,75	6.621	116	20
n wl c 3	Wood central	true	25	0,75	7.088	145	20
n wl c 4	Wood central	true	30	0,75	7.554	175	20
n wl c 5	Wood central	true	35	0,75	8.021	204	20
n wl c 6	Wood central	true	40	0,75	8.488	233	20
n el s 1	elect. single	true	2	0,96	327	0	20
n el s 2	elect. single	true	6	0,96	980	0	20
n hp c 1	heat pump centr.	true	15	2,8	9.085	100	15
n hp c 2	heat pump centr.	true	20	2,8	11.000	100	15

Table 8-12: Technology parameters DHW systems, Germany

Name	Stand-alone / additional DHW technology	"new" technology for the future?	DHW power [kW] (resp. for solarth.: surface [m²])	Efficiency	Investment and installation costs [€]	O+M costs [€/year]	Lifetime [yr]
g1	gas stand alone	False	5	0,72	0	0	15
g2	gas stand alone	False	10	0,72	0	0	15
e1	electricity stand alone	False	5	0,92	0	0	15
e2	electricity stand alone	False	10	0,92	0	0	15
h1	heat pump stand alone	False	5	2,8	0	0	15
h2	heat pump stand alone	False	10	2,8	0	0	15
s1	solar thermal	False	5	0,3	0	0	15
s2	solar thermal	False	10	0,3	0	0	15
n e s 1	electricity stand alone	true	3	0,625	790	13	15
n e s 2	electricity stand alone	true	6	0,673	813	13	15
n e s 3	electricity stand alone	true	9	0,632	873	13	15
n sth 1	solar thermal	true	5	0,33	4.600	70	20
n sth2	solar thermal	true	15	0,33	9.000	170	20
n sth 3	solar thermal	true	50	0,33	27.500	400	20
n sth 4	solar thermal	True	200	0,33	81.800	1.200	20
n sth 5	solar thermal	True	1.300	0,33	440.000	8.500	20

Table 8-13: Technology parameters DSM measures, Germany

Insulation Material	Lambda [W/m*K]	Specific investment costs material [€/m³]	Specific installation costs facade [€/m²]	Specific installation costs basement [€/m²]	Specific installation costs ceiling [€/m²]	Lifetime [yr.]
Material	0,038	45	25	9	9	30

Windows	U-value [W/m²*K]	G-Value [%]	Specific investment costs material [€/m²]	Specific installation costs [€/m²]	Lifetime [yr.]
Low quality	2,6	0,65	250	60	20
Medium quality	1,3	0,55	400	65	20
High quality	0,75	0,45	750	90	20

Table 8-14: Technology parameters electricity sector, Germany

Band name	Technology	Electricity Potential [GWh/yr.]	Load hours electricity [h]	Load hours heat [h]	Efficiency electricity [1]	Efficiency heat [1]	O+M costs [€/(kW.yr)]	Investment costs [€/kW]
With CHP								
C-N-BG-1	Biogas	30	2.830	1.840	0,39	0,39	120	2.700
C-N-BG-2	Biogas	130	4.800	3.120	0,39	0,48	120	2.700
C-N-BG-3	Biogas	190	4.800	3.120	0,43	0,44	130	3.400
C-N-BG-4	Biogas	220	8.100	6.480	0,39	0,48	130	3.400
C-N-BG-5	Biogas	340	8.100	6.480	0,42	0,45	140	4.400
C-N-BG-6	Biogas	215	8.100	6.480	0,44	0,44	140	4.400
C-N-BM-1	Biomass	200	6.000	1.500	0,1	0,7	336	7.158
C-N-BM-2	Biomass	300	6.000	1.500	0,1	0,75	215	5.113
C-N-BM-3	Biomass	500	6.000	1.800	0,1	0,75	178	4.346
C-N-BM-4	Biomass	1.500	6.000	3.500	0,15	0,7	119	2.899
C-N-BM-5	Biomass	400	6.000	1.600	0,31	0,57	407	4.934
C-N-BM-6	Biomass	100	6.000	1.500	0,38	0,5	160	2.127
C-N-BM-7	Biomass	500	6.000	1.800	0,36	0,56	440	2.199
C-N-BM-8	Biomass	300	6.000	1.500	0,47	0,45	481	4.806
C-N-BM-9	Biomass	2.200	6.000	3.500	0,47	0,45	481	4.806
C-N-BM-10	Biomass	1.000	6.000	3.000	0,47	0,45	481	4.806
C-N-SG-1	Sewage gas	5	2.830	1.840	0,39	0,39	125	2.400
C-N-SG-2	Sewage gas	20	4.800	3.120	0,39	0,48	125	2.400
C-N-SG-3	Sewage gas	30	4.800	3.120	0,43	0,44	155	3.150
C-N-SG-4	Sewage gas	36	8.100	6.480	0,39	0,48	155	3.150
C-N-SG-5	Sewage gas	54	8.100	6.480	0,42	0,45	175	3.500
C-N-SG-6	Sewage gas	35	8.100	6.480	0,44	0,44	175	3.500
C-N-LG-1	Landfill gas	5	2.830	1.840	0,39	0,39	55	1.400
C-N-LG-2	Landfill gas	22	4.800	3.120	0,39	0,48	55	1.400
C-N-LG-3	Landfill gas	32	4.800	3.120	0,43	0,44	65	1.650
C-N-LG-4	Landfill gas	39	8.100	6.480	0,39	0,48	65	1.650
C-N-LG-5	Landfill gas	60	8.100	6.480	0,42	0,45	85	1.950
C-N-LG-6	Landfill gas	38	8.100	6.480	0,44	0,44	85	1.950
Without CHP								
E-N-HY-LS-1	Hydro large scale	360	5.500	0	1	0	45	5.624
E-N-HY-LS-2	Hydro large scale	1.100	5.500	0	1	0	36	3.579
E-N-HY-SS-1	Hydro small scale	70	5.000	0	1	0	55	6.136
E-N-HY-SS-2	Hydro small scale	200	5.000	0	1	0	45	4.090
E-N-SO-PV-1	PV	800	800	0	1	0	22	4.060
E-N-WI-ON-1	Wind-onshore	990	1.580	0	1	0	66	1.099
E-N-WI-ON-2	Wind-onshore	230	2.335	0	1	0	66	1.099

Table 8-15: Used Feed-in Tariffs, Germany

	€/MWh
Hydro large	66,5
Hydro small	96,7
PV	470
Wind-onshore	80
Biogas	150
Biomass	160
Sewage gas	75
Landfill gas	75

Note: The real detailed tariff structure had to be simplified in order to adapt it to the model structure. The effects of this simplification should be negligible.

Table 8-16: Bio fuel generation parameters (transport), Baden Württemberg

	Bio fuel potential [ha]	Yield factor [litre/ha]	Feedstock costs [€/ha]	Conversion costs [€/litre]
Rape oil	90	1.150	500 - 800	0,122

Table 8-17: Biomass Potentials Baden Württemberg

Expected available potential	[GWh/a]
Biogas	3.850
Landfill gas	825
Sewage gas	825
Solid Biomass	15.000

8.1.4 Building stock

Table 8-18: Building Stock, Baden Württemberg

(Mikrozensus 2002, Statistisches Landesamt BW)

building period	Total	SFH	TEH	MFH	BMH	SSC
before 1918, half-timbered	85.750	45.176	0	40.574	0	0
before 1918	440.250	156.270	93.815	149.949	40.216	0
1919-1948	427.000	97.588	181.359	91.770	56.284	0
1949-1957	609.793	123.021	254.059	125.051	107.663	0
1958-1968	838.203	150.359	310.516	152.840	131.588	92.900
1969-1978	762.003	136.690	282.288	138.946	119.625	84.455
1979-1983	346.875	65.728	183.506	42.172	55.470	0
1984-1994	558.925	101.678	287.713	73.430	96.104	0
1995-2001	253.680	41.557	121.931	39.274	50.919	0
since 2002	32.520	5.327	15.631	5.035	6.527	0
Total	4.355.000	923.393	1.730.817	859.040	664.395	177.355

8.1.5 Energy price series

Table 8-19: Energy price series building sector [€ / MWh], Baden Württemberg

Year	District heating	Gas	Electricity	Oil	coke	wood
2003	33,0	46,0	170,0	34,0	50,0	35,0
2004	33,5	47,2	171,4	34,9	51,3	35,0
2005	34,0	48,3	172,7	35,7	52,5	35,0
2006	34,5	49,5	174,1	36,6	53,8	35,0
2007	35,0	50,8	175,4	37,5	55,2	35,0
2008	35,6	52,0	176,8	38,5	56,6	35,5
2009	36,1	53,3	178,2	39,4	58,0	36,1
2010	36,6	54,7	179,5	40,4	59,4	36,6
2011	37,2	56,0	180,9	41,4	60,9	37,1
2012	37,7	57,4	182,2	42,5	62,4	37,7
2013	38,3	58,9	183,6	43,5	64,0	38,3
2014	38,9	60,4	185,0	44,6	65,6	39,2
2015	39,5	61,9	186,3	45,7	67,2	40,4
2016	40,0	63,4	187,7	46,9	68,9	41,6
2017	40,6	65,0	189,0	48,0	70,6	42,9
2018	41,3	66,6	190,4	49,2	72,4	44,2
2019	41,9	68,3	191,8	50,5	74,2	45,7
2020	42,5	70,0	193,1	51,7	76,1	47,3

8.2 App. Vienna

8.2.1 Technology input data

Table 8-20: Heating technology data

Heating technology	Use technology for the future ("new" technology)	Heat power [kW]	Efficiency [1]	Investment and installation costs [€]	O+M costs [€/year]	Lifetime [yr.]	'Average Standard' Payback time [yr.]
LPG single	False	10	0,7	0	0	15	10
LPG single	False	20	0,7	0	0	15	10
wood single	False	10	0,61	0	0	15	10
wood single	False	20	0,61	0	0	15	10
coal, coke, briquettes single	False	10	0,58	0	0	15	10
coal, coke, briquettes single	False	20	0,58	0	0	15	10
oil single	False	10	0,7	0	0	15	10
oil single	False	20	0,7	0	0	15	10
electricity single	False	10	0,94	0	0	15	10
electricity single	False	20	0,94	0	0	15	10
natural gas single	False	10	0,7	0	0	15	10
natural gas single	False	20	0,7	0	0	15	10
LPG one floor	False	10	0,77	0	0	15	10
LPG one floor	False	20	0,77	0	0	15	10
wood one floor	False	10	0,68	0	0	15	10
wood one floor	False	20	0,68	0	0	15	10
coal, coke, briquettes one floor	False	10	0,62	0	0	15	10
coal, coke, briquettes one floor	False	20	0,62	0	0	15	10
oil one floor	False	10	0,75	0	0	15	10
oil one floor	False	20	0,75	0	0	15	10
electricity one floor	False	10	0,94	0	0	15	10
electricity one floor	False	20	0,94	0	0	15	10
natural gas one floor	False	10	0,78	0	0	15	10
natural gas one floor	False	20	0,78	0	0	15	10
LPG central	False	10	0,77	0	0	15	10
LPG central	False	20	0,77	0	0	15	10
wood log central	False	10	0,68	0	0	15	10
wood log central	False	20	0,68	0	0	15	10
coal, coke, briquettes central	False	10	0,62	0	0	15	10
coal, coke, briquettes central	False	20	0,62	0	0	15	10
oil central	False	10	0,76	0	0	15	10
oil central	False	20	0,76	0	0	15	10
electricity central	False	10	0,94	0	0	15	10
electricity central	False	20	0,94	0	0	15	10
natural gas central	False	10	0,78	0	0	15	10
natural gas central	False	20	0,78	0	0	15	10
district heating central	False	10	0,95	0	0	100	10
district heating central	False	20	0,95	0	0	100	10
pellets central (manual)	true	10	0,8	8.400,00	116	20	10
pellets central (manual)	true	15	0,8	8.800,00	116	20	10
pellets central (manual)	true	20	0,8	8.900,00	116	20	10
pellets central (manual)	true	25	0,8	9.600,00	145	20	10

pellets central (manual)	true	30	0,8	9.900,00	175	20	10
pellets central (automatic)	true	10	0,8	10.100,00	58	20	10
pellets central (automatic)	true	15	0,8	10.500,00	87	20	10
pellets central (automatic)	true	20	0,8	10.600,00	116	20	10
pellets central (automatic)	true	25	0,8	11.300,00	145	20	10
pellets central (automatic)	true	30	0,8	11.600,00	175	20	10
wood chips central	true	15	0,82	15.000,00	145	20	10
wood chips central	true	25	0,82	15.500,00	145	20	10
wood chips central	true	30	0,82	16.000,00	175	20	10
wood chips central	true	40	0,82	16.500,00	233	20	10
wood chips central	true	50	0,82	17.000,00	291	20	10
wood chips central	true	60	0,82	18.000,00	349	20	10
wood chips central	true	80	0,82	19.500,00	465	20	10
wood chips central	true	100	0,82	22.000,00	582	20	10
wood log central	true	15	0,75	6.154,00	116	20	10
wood log central	true	20	0,75	6.621,00	116	20	10
wood log central	true	25	0,75	7.088,00	145	20	10
wood log central	true	30	0,75	7.554,00	175	20	10
wood log central	true	35	0,75	8.021,00	204	20	10
wood log central	true	40	0,75	8.488,00	233	20	10
coal, coke, briquettes central	true	15	0,75	6.154,00	116	20	10
coal, coke, briquettes central	true	20	0,75	6.621,00	116	20	10
coal, coke, briquettes central	true	25	0,75	7.088,00	145	20	10
coal, coke, briquettes central	true	30	0,75	7.554,00	175	20	10
coal, coke, briquettes central	true	35	0,75	8.021,00	204	20	10
coal, coke, briquettes central	true	40	0,75	8.488,00	233	20	10
oil central	true	10	0,85	4.500,00	100	20	10
oil central	true	15	0,85	4.511,00	100	20	10
oil central	true	36	0,85	4.789,00	150	20	10
oil central	true	300	0,85	50.000,00	1.000,00	20	10
natural gas central	true	16,5	0,88	3.222,00	168	20	10
natural gas central	true	23,8	0,88	3.311,00	168	20	10
natural gas central	true	32,16	0,88	3.493,00	168	20	10
natural gas central	true	300	0,88	50.000,00	1.200,00	20	10
LPG central	true	14	0,77	3.866,00	100	20	10
LPG central	true	18	0,77	4.014,00	100	20	10
heat pump central	true	15	2,8	9.085,00	100	20	10
heat pump central	true	20	2,8	11.000,00	100	20	10
district heating central	True	4	0,96	2.000,00	427,224	100	10
district heating central	True	6	0,96	2.000,00	427,224	100	10
district heating central	true	10	0,96	2.000,00	610,32	100	10
district heating central	true	20	0,96	2.000,00	1.220,64	100	10
electricity single	true	2	0,96	327	0	20	10
electricity single	true	6	0,96	980	0	20	10
pellets single	true	6	0,8	3.222,00	60	15	10
pellets single	true	12	0,8	3.400,00	60	15	10
LPG single	true	4	0,9	841	50	15	10
LPG single	true	8	0,9	950	50	15	10
natural gas one floor	True	5	0,78	2.500,00	168	15	10
natural gas one floor	True	15	0,78	2.500,00	168	15	10
natural gas one floor	True	20	0,78	2.800,00	168	15	10
natural gas one floor	True	30	0,78	3.000,00	175	15	10
wood single	True	5	0,61	500	0	15	10

wood single	True	10	0,61	500	0	15	10
wood single	True	15	0,61	800	0	15	10
coal, coke, briquettes single	True	5	0,58	500	0	15	10
coal, coke, briquettes single	True	10	0,58	500	0	15	10
coal, coke, briquettes single	True	20	0,58	800	0	15	10
oil single	True	5	0,7	500	0	15	10
oil single	True	10	0,7	500	0	15	10
oil single	True	15	0,7	800	0	15	10
natural gas condensing central	true	10	0,99	5.500,00	168	20	10
natural gas condensing central	true	15	0,99	5.500,00	168	20	10
natural gas condensing central	true	20	0,99	5.800,00	168	20	10
natural gas condensing central	true	30	0,99	6.200,00	168	20	10
natural gas condensing central	true	100	0,99	18.000,00	430	20	10

Table 8-21: DHW technology data

Stand-alone/additional DHW technology	Use technology for the future ("new" technology)	DHW power [kW] or surface (only for Solar Thermal systems) [m2]	Efficiency [1]	Investment and installation costs [€]	O+M costs [€/year]	Lifetime [yr]	'Average Standard' Payback time [yr.]
natural gas stand alone	False	5	0,72	0	0	10	10
natural gas stand alone	False	15	0,72	0	0	10	10
electricity stand alone	False	5	0,92	0	0	10	10
electricity stand alone	False	15	0,92	0	0	10	10
solar thermal	False	5	0,3	0	0	10	10
solar thermal	False	10	0,3	0	0	10	10
electricity stand alone	true	3	0,625	790	13	15	5
electricity stand alone	true	6	0,673	813	13	15	5
electricity stand alone	true	9	0,632	873	13	15	5
solar thermal	true	5	0,33	4.600,00	70	20	10
solar thermal	true	15	0,33	9.000,00	170	20	10
solar thermal	true	50	0,33	27.500,00	400	20	10
solar thermal	true	200	0,33	81.800,00	1.200,00	20	10
solar thermal	true	1.300,00	0,33	440.000,00	8.500,00	20	10
heat pump stand alone	False	5	2,8	0	0	10	10
heat pump stand alone	False	10	2,8	0	0	10	10

Table 8-22: Insulation technology data

Lambda [W/mK]	Specific investment costs material [€/m3]	Specific installation costs facade [€/m2]	Specific installation costs basement [€/m2]	Specific installation costs ceiling [€/m2]	Lifetime [yr.]	'Average Standard' Payback time [yr.]
0,038	45	25	9	9	30	10

Table 8-23: Windows technology data

Technology	U-value [W/m2K]	G-Value [%]	Specific investment costs material [€/m2]	Specific installation costs [€/m2]	Lifetime [yr.]	'Average Standard' Payback time [yr.]
Low quality	2,6	0,65	250	60	30	10
Medium quality	1,3	0,55	400	65	30	10
High quality	0,75	0,45	750	90	30	10

Table 8-24: Energy price time series [€/MWh]

Year	LPG	wood log	coal, coke, briquettes	oil	electricity	natural gas	district heating	pellets	wood chips
2003	83,5	30,1	38,8	40,9	142,1	39,5	31,2	42,8	28,6
2004	81,0	30,2	39,0	39,6	141,3	39,8	30,8	43,0	28,7
2005	79,3	30,2	39,0	38,8	141,4	40,1	30,6	43,0	28,7
2006	78,4	30,3	39,1	38,4	145,1	40,3	30,5	43,1	28,8
2007	77,8	30,3	39,2	38,1	148,7	40,4	30,5	43,2	28,8
2008	77,5	30,3	39,2	38,0	152,3	40,6	30,5	43,2	28,8
2009	77,4	30,4	39,2	37,9	155,9	40,7	30,5	43,3	28,9
2010	77,4	30,4	39,3	37,9	156,1	40,8	30,5	43,3	28,9
2011	77,8	30,5	39,3	38,1	156,3	41,0	30,7	43,4	29,0
2012	78,4	30,5	39,4	38,4	156,9	41,3	30,9	43,5	29,0
2013	79,1	30,6	39,5	38,7	157,5	41,6	31,1	43,6	29,1
2014	80,0	30,6	39,6	39,1	158,1	41,9	31,4	43,6	29,1
2015	80,8	30,7	39,7	39,6	158,8	42,2	31,7	43,7	29,2
2016	81,8	30,8	39,8	40,0	159,4	42,5	32,0	43,9	29,3
2017	82,8	30,9	39,9	40,5	160,0	42,9	32,4	44,0	29,4
2018	83,9	31,0	40,0	41,1	160,7	43,2	32,7	44,1	29,5
2019	85,0	31,1	40,1	41,6	161,3	43,6	33,1	44,3	29,5
2020	85,7	31,1	40,2	42,0	162,0	43,9	33,3	44,3	29,6

Source: WIFO: Energie-Szenarien 2020.

8.2.2 Building stock

The following tables show the data for the building classes used in the case study Vienna. Moreover, a distinction of these classes has been made according to their situation within or outside the district heating supply area as well as the existence of a central heating system.

Table 8-25: Building classes geometry data

Construction period	Building category	Number of dwellings per building	Number of persons per dwelling	Room height [m]	Number of floors	Length of building [m]	Width of building [m]
before 1919	single dwelling	1,3	2,6	3,0	1,2	17,2	8,6
1919-1944	single dwelling	1,1	2,6	2,8	1,2	13,6	6,8
1945-1960	single dwelling	1,1	2,5	2,6	1,2	13,7	6,9
1961-1970	single dwelling	1,1	2,5	2,6	1,2	15,1	7,5
1971-1980	single dwelling	1,1	2,5	2,6	1,2	15,9	7,9
1981-1990	single dwelling	1,0	2,5	2,6	1,2	15,5	7,8
after 1990	single dwelling	1,0	2,8	2,6	1,2	15,5	7,8
before 1919	multiple dwelling	14,5	2,6	3,3	4,0	29,0	9,7
1919-1944	multiple dwelling	14,2	2,5	2,8	4,6	24,0	8,0
1945-1960	multiple dwelling	13,5	2,5	2,6	5,0	23,4	7,8
1961-1970	multiple dwelling	14,2	2,5	2,6	5,4	24,8	8,3
1971-1980	multiple dwelling	17,7	2,5	2,6	5,4	29,7	9,9
1981-1990	multiple dwelling	15,8	2,8	2,6	5,3	29,1	9,7
after 1990	multiple dwelling	15,8	2,9	2,6	5,3	29,1	9,7

Table 8-26: Building classes building quality

Construction period	Building category	U-value ceiling [W/m2K]	U-value exterior walls [W/m2K]	U-value windows [W/m2K]	U-value doors [W/m2K]	U-value floor [W/m2K]	Seam loss windows [W/m2K]	Seam loss doors [W/m2K]
before 1919	single dwelling	1,10	1,10	3,10	2,50	1,55	1,60	1,40
1919-1944	single dwelling	1,25	1,20	3,15	2,20	1,40	1,30	1,20
1945-1960	single dwelling	1,35	1,35	3,40	2,00	1,30	1,10	1,00
1961-1970	single dwelling	1,20	1,25	3,00	1,80	1,10	1,00	0,90
1971-1980	single dwelling	0,70	1,10	2,30	1,70	0,90	0,80	0,70
1981-1990	single dwelling	0,30	0,65	2,00	1,60	0,63	0,40	0,40
after 1990	single dwelling	0,25	0,65	1,80	1,80	0,60	0,70	0,60
before 1919	multiple dwelling	1,10	1,10	3,10	2,50	1,55	1,30	1,20
1919-1944	multiple dwelling	1,25	1,20	3,15	2,20	1,40	1,10	1,00
1945-1960	multiple dwelling	1,20	1,35	3,40	2,00	1,30	1,00	0,90
1961-1970	multiple dwelling	1,20	1,25	3,00	1,80	1,10	0,80	0,70
1971-1980	multiple dwelling	0,70	1,10	2,30	1,70	0,90	0,80	0,70
1981-1990	multiple dwelling	0,30	0,65	2,00	1,60	0,63	0,70	0,60
after 1990	multiple dwelling	0,25	0,65	1,80	1,80	0,60	0,60	0,50

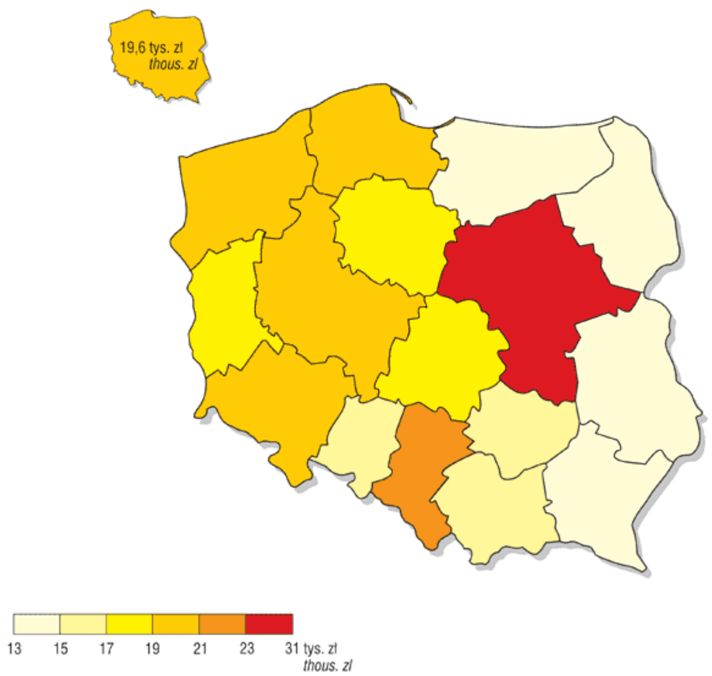
8.3 App. Poland

8.3.1 Basic Data

Table 8-27: General Data, Poland

Area	312 685 km^2
Population	38.2 mil.
Density of population	122 persons/km^2
Electricity generation	150.8 TWh
Electricity generation per capita	3.06 MWh

PRODUKT KRAJOWY BRUTTO NA 1 MIESZKAŃCA WEDŁUG WOJEWÓDZTW[a] W 2001 R. (ceny bieżące)
GROSS DOMESTIC PRODUCT PER CAPITA BY VOIVODSHIP[a] IN 2001 (current prices)



a Grupowanie metodą jednostek lokalnych rodzaju działalności; bez uwzględnienia zmian podanych w nocie na str. 432; patrz uwagi ogólne do Rocznika, ust. 14 na str. 15.

a Grouping by local kind-of-activity unit method; without taking into consideration of changes given in note on page 433; see general notes to the Yearbook, item 14 on page 22.

Figure 8-3: Map, Poland

Table 8-28: Prognoses of the demand for the primary energy carriers, Poland

Prognoses of the demand for the Primary Energy (PE) carriers. ("Assumptions of the energy policy for Poland until 2020, February 2000).

Scenario	Specification	Unit	1997	2005	2010	2015	2020
SURVIVAL	Hard coal*	mln ton		92,9	87,9	86,0	83,5
	Brown coal	mln ton		66,8	67,2	66,1	65,6
	Crude oil*	mln ton		20,4	20,2	20,8	21,1
	Natural gas	mld m^3		16,4	19,7	22,9	26,0
	Nuclear energy	Mtoe***		0,0	0,0	0,0	0,0
	Renewable energy**	Mtoe***		5,3	5,5	5,7	5,9
	Country-scale demand	Mtoe***		106,2	110,7	110,7	112,2
REFERENCE	Hard coal*	mln ton	104,5	91,3	84,3	83,9	81,9
	Brown coal	mln ton	65,4	66,8	67,4	66,2	65,6
	Crude oil*	mln ton	18,6	20,2	20,4	21,4	22,3
	Natural gas	mld m^3	12,0	17,9	22,0	25,0	29,3
	Nuclear energy	Mtoe***	0,0	0,0	0,0	0,0	0,0
	Renewable energy**	Mtoe***	5,5	5,5	6,0	6,5	7,1
	Country-scale demand	Mtoe***	107,3	106,4	109,1	112,4	116,2
PROGRESS-PLUS	Hard coal*	mln ton		85,5	84,6	84,5	82,4
	Brown coal	mln ton		66,4	67,2	66,2	65,6
	Crude oil*	mln ton		22,2	23,5	25,3	27,9
	Natural gas	mld m^3		15,7	18,4	22,1	27,6
	Nuclear energy	Mtoe***		0,0	0,0	0,0	0,0
	Renewable energy**	Mtoe***		5,8	6,3	6,9	7,7
	Country-scale demand	Mtoe***		103,7	109,7	114,7	121,3

* together with import-export balance of derivative carriers
** hydro energy, wind, solar, geothermal energy, biomass (together with non-commercial), rape seed oil, ethanol, energy from wastes
*** 1 toe = 41.868 GJ; toe – one tone of equivalent fuel

In January 2005, new "Assumptions of the Energy Policy for Poland until 2025" was adopted by the Sejm, lower house of the Polish Parliament. In this document, the nuclear energy is considered since 2020.

Table 8-29: Electricity generation by type of plant in 2001, Poland (GUS 2002: 30)

	2001
Hard and brown coal	96.26%
Hydro	1.54%
Nuclear	0.00%
Oil	1.34%
Gas	0.49%
Other	0.36%
PRODUCTION	145.6 TWh
Import	4.3 TWh
Domestic consumption	124.7 TWh
Export	11.1 TWh

Table 8-30: Renewable energy technologies implemented in 2001, Poland (GUS 2002b)

Renewable energy resource	Specification	No. of units	Power installed MWt	Energy Production	
				Electricity GWh/a	Thermal TJ/a
	TOTAL	114,321	7,197.1	2,619.4	105,333.6
Biomass [e)]	CHP systems in pulp & paper and furniture industry	3	330.0	449.1	5,298.5
	Wood industrial and DHP (only heat) (>500kW) [a)]	150	600.0	-	9,633.6
	Straw district heating plants (>500kW) [a)]	35	50.0	-	802.8
	Wood small-scale heat plants (<500kW) [a)]	110,000	5,500.0	-	88,308.0
	Straw small-scale heat plants (<500kW) [a)]	150	45.0	-	722.5
	Biogas CHP- and DH-systems [b)]	29	38.9	72.5	250
	Landfill gas CHP- and DH-systems [b)]	17	15.9	59.0	102.0
Solar systems	Solar panels [c)]	3,143	11.5	-	27.9
	Photovoltaic panels [b)]	170	0.15	-	-
Geothermal	Geothermal DHP	4	29.4 [d)]	-	138.9 [d)]
	Others not specified [f)]	-	21.3		49.4
Wind	Wind – single turbines and farms	40	27.9	13.6	-
Hydro	Hydro PP [g)]	12	345.2	1,394.0	-
	Small hydro PP [h)]	568	181.8	631.2	-

[a)] estimated data [b)] data from 2000 [c)] including solar thermal water and air [d)] only geothermal (peak capacities not included) [e)] liquid bio-fuels not included [f)] other RET units: balneology, swimming pools, drying units, greenhouse heating, animal breeding, etc; heat pumps not included [g)] hydropower plants and pumping-storage power plants > 5 $Mw_{el.}$ [h)] small hydro power plants < 5 $Mw_{el.}$

Table 8-31: The structure of primary energy production in 2001, Poland (GUS 2002:27)

	PJ	%
TOTAL	3357.4	100
Hard coal	2478.9	73.83
Lignite	510.9	15.22
Crude oil	32.6	0.97
Natural gas	146.3	4.36
Other	187.7	5.62

Table 8-32: The structure of primary energy consumption in 2001, Poland (GUS 2002:27)

	PJ	%
TOTAL	3925.2	100
Hard coal	1933.1	49.25
Lignite	510.8	13.01
Crude oil	770.2	19.62
Natural gas	471.4	12.00
Other	239.7	6.12

Table 8-33: Structure of RES use in 2001 as final energy equivalent in TJ, Poland (GUS 2002b)

	Biomass			Geothermal	Solar systems	Wind	Hydro	Total
	Solid	Biogas	Biofuels					
Total generated energy [TJ]	106,4	0,8	1,0	0,2	0,3	0,5	7,2	115,8
Share in total RES use [%]	91.84	0.71	0.93	0.16	0.02	0.04	6.30	100.0

Tables below shows the main data on the case study region. We have to admit that the ***Invert*** model requires a large amount of data, which in Poland is not yet gathered or available.

The data required in relation to the Building Sector is detailed; buildings should be divided into various categories in accordance to the period in which they were built (various lambda coefficients), their dimensions – length, width, height, number of floors, the type of usage, their geographical orientation, and also the type of energy carrier used to produce heat and hot water as well as few others.

Collecting such data in Polish conditions is difficult. The data is not available in annual statistics or through the official administration of individual Municipalities. For the purposes of the

Polish case study we ourselves prepared a database concerning the Building Sector in relevant Municipalities, using the following information:

1. Public census in 2002
2. Annual statistics in 2003
3. Interviews with officials of individual municipalities
4. Individual surveys
5. Surveys of buildings on the basis of 1:500 scale plans
6. Energy audit of around 50 public service buildings

Buildings were divided into two categories in accordance with their purpose: domestic buildings and also public service buildings, and within these categories followed division by period and size of building, as demanded by the model. Such a division is conditional on the fact that existing promotion schemes in Poland are first of all available for public service buildings.

One should underline, that in every division all buildings had to be standardized according to their size. Such a procedure might be weighed down by a certain error, because in rural areas large number of buildings were built by private owners and modified in the course of building such, that buildings in a given period might differ in size between each other.

In Polish conditions only the so called housing settlements – agglomerated housing blocks build up in 'great slabs' in the 1970's to 1990's and managed by Housing Associations can provide the data demanded by the model, however it is not aggregated but in the form of building plans from which it is possible to extract dimensions, number of flats, etc.

Table 8-34: The revenue and expenditure of municipality budget per one person per year, Jordanów

	Revenue	Expenditure
	Of municipality budget per capita in PLN (1 EUR =4,2 PLN)	
City of Jordanów	1.6160	1.715
Municipality of Jordanów	1.279	1.219
Municipality of Bystra-Sidzina	1.289	1.277

Table 8-35: The structure of the farms in the region of the case study, Jordanów

Specification	Number of farms
The farms below 1 ha of agriculture land	1.197

The farms between 1 ha and 5 ha	2.519
The farms between 5 ha and 10 ha	224
The farms exceeding 10 ha of agriculture land	16
TOTAL	3.956

Table 8-36: Building classes in Jordanów:

Defining existing buildings (building class)					
Building class	Number of buildings	Construction period	Building category	Number of dwellings per building	Number of persons per dwelling
wooden single family house (SFH-w)					
Type _SFH-w_A existing	38	before 1918	single family dwelling	1,2	3,69
Type _SFH-w_B existing	307	1919-1945	single family dwelling	1,19	3,72
Type _SFH-w_C existing	40	1946-1950	single family dwelling	1,23	3,68
Type _SFH-w_D existing	35	1951-1960	single family dwelling	1,23	3,63
Type _SFH-w_H existing	28	1991-2003	single family dwelling	1,2	3,30
single family house (SFH)					
Type _SFH_A existing	51	before 1918	single family dwelling	1,2	3,30
Type _SFH_B existing	130	1919-1945	single family dwelling	1,19	3,78
Type _SFH_C existing	45	1946-1950	single family dwelling	1,23	3,69
Type _SFH_D existing	405	1951-1960	single family dwelling	1,23	3,73
Type _SFH_E existing	578	1961-1970	single family dwelling	1,23	4,10
Type _SFH_F existing	743	1971-1980	single family dwelling	1,6	3,68
Type _SFH_G existing	875	1980-1990	single family dwelling	1,7	3,72
Type _SFH_H existing	665	1991-2003	single family dwelling	1,2	3,60
multifamily house (MFH)					
Type _MFH_F existing	9	1971-1980	multifamily house	18	3,30
Type _MFH_G existing	6	1980-1990	multifamily house	37	3,26
schools (sch)					
Type _SCH_A existing	1	before 1918	schools	1	47
Type _SCH_B existing	2	1919-1945	schools	1	600
Type _SCH_E existing	8	1961-1970	schools	1	2337
Type _SCH_G existing	2	1981-1990	schools	1	480
Type _SCH_H existing	1	1991-2003	schools	1	250
public houses (PH)					
Type _PH_A existing	2	before 1918	public buildings	1	60
Type _PH_B existing	4	1919-1945	public buildings	1	260
Type _PH_E existing	6	1961-1970	public buildings	1	120
Type _PH_F existing	10	1971-1980	public buildings	1	171
Type _PH_G existing	2	1980-1990	public buildings	1	40

Table 8-37: Production of straw, forest residues and manure, Jordanów

Potential [t/a]	Heating value		Technical potential [GJ/a]
5813	14 GJ/t	straw [a]	81.382
5163	10,3 GJ/t	forest residue [b]	53.179
7011	20 MJ/m^3	manure [c]	31.218

a) the straw potential is used for bedding and fodder for cattle, horses and pigs. The required potential for such purposes is even higher and amounts 9832 t.
b) the wood log and wood chips potential used in the model is higher because takes into account also the wood waste from enterprises processing wood mainly from out of the region
c) the manure is used mainly as fertilizer.

Table 8-38: The agriculture production in Jordanów:

: Specification	Average yield for specific crops [dt/ha]	Area [ha]	Production per year [t/y]
Wheat	30,9	785	2425,65
Rye	26,2	112	293,44
Barley	31,5	242	762,30
Oats	24,4	669	1632,36
Triticale	27,2	120	326,40
Cereals mixed	28,9	111	320,79
Rape	19,7	83	163,51
Meadow hey	38,0	3690	14022,00
Potatoes	184,0	786	14462,40
Corn	24,0	754	1809,60

8.4 App. Crete

8.4.1 Basic Data

Table 8-39: Status Quo (2002)

	total	
Area	8.336	km²
Population	601.131	Inhabitants
Number of buildings	287.268	
Number of dwellings	474.204	
Total energy consumption	29.700	TJ /a
Total electricity demand	2.140	GWh / a
Total calculated heat demand	2.832	GWh / a
Total calculated DHW demand	532	GWh / a
Total calculated cooling demand	492	GWh / a

8.4.2 Promotion schemes in Crete

Table 8-40: Operational Programme for Competitiveness

Issue	Description
Renewable energy source	All (Biomass, biogas, geothermal, hydropower, solar energy, wind energy)
Description of the instrument	Investment subsidy
Target of the instrument	Support of development through the use of RES, RUE and Small CHP (<50 MW_e) technologies for covering the local energy needs
Stage of policy implementation	Implemented since 2001
Operational period of the instrument.	Open
Specification of the instrument	Public subsidy on the total eligible RES/RUE/Small CHP investment cost: – Wind parks, conventional solar thermal units: 30% – Small hydro, biomass, geothermal, high-tech solar thermal units, passive solar: 40% – Photovoltaic systems: 50% – RUE: 40% – Small CHP: 35%
Key factors	Grants are awarded to RES/RUE/CHP projects by OPC following rounds of public calls for RES investment proposals and subsequent competitive evaluation of the submitted proposals (per round).

Table8-41: National Development Law (Law 2601/98)

Issue	Description
Renewable energy source	All
Description of the instrument	Various alternatives available (see below)
Target of the instrument	Increase private investments in Greece
Stage of policy implementation	Implemented since 2003 (currently under revision)
Operational period of the instrument.	Open
Specification of the instrument	• 40% public subsidy on the total eligible RES investment cost + 40% subsidy on the interest of loans obtained for the purpose of financing the RES investment • Alternatively, 40% subsidy on the loan interest + 100% tax deduction on the RES investment cost
Key factors	This is a financial instrument-umbrella, covering all private investments in Greece, in all sectors of economic activity. It has a strong regional character, in that the level of public support depends strongly on the particular geographic region, in which the given private investment is planned to be materialised. Note: • Level of subsidy (40%) is independent of the RES technology and the geographical region of the country • Required own capital : 40% (min) of the total investment cost

Issue	Description
	• Minimum investment cost required : 176,000 Euro • Maximum subsidy granted : 14.7 million Euro • Maximum investment cost subsidized : 36.7 million Euro

Table 8-42: Law 2773/99

Issue	Description
Renewable energy source	All
Description of the instrument	Feed-in tariffs
Target of the instrument	Increase private investments in Greece
Stage of policy implementation	Implemented since 2003 (currently under revision)
Operational period of the instrument.	Open
Specification of the instrument	• Feed in tariffs (not interconnected inslands): -7,9 €cents/kWh, for independent producers -6,2 €cents/kWh for auto producers surplus
Key factors	• A capacity restriction of the total power installed: -50 MW for biomass, biogas, geothermal, solar energy and wind energy -10 MW for hydropower

Simulation Input Data and Parameters for the case study

Building stock in Crete

Table 8-43: Bulding stock, Crete

BUILDING CLASS	NUMBER OF BUILDINGS	CONSTRUCTION PERIOD	BUILDING CATEGORY
single family house (SFH)			
Type _SFH_B existing	23.970	before 1919	single family dwelling
Type _SFH_C existing	43.317	1919-1945	single family dwelling
Type _SFH_D existing	49.428	1946-1960	single family dwelling
Type _SFH_E existing	13.612	1961-1970	single family dwelling
Type _SFH_F existing	12.312	1971-1980	single family dwelling
Type _SFH_G existing	7.230	1981-1985	single family dwelling
Type _SFH_H existing	6.525	1986-1990	single family dwelling
Type _SFH_I existing	5.400	1991-1995	single family dwelling
Type _SFH_J existing	3.971	1996-2000	single family dwelling
Type _SFH_K existing	1.824	since 2001	single family dwelling
multifamily house (MFH)			
Type _MFH_B existing	0	before 1919	multifamily house
Type _MFH_C existing	0	1919-1945	multifamily house
Type _MFH_D existing	0	1946-1960	multifamily house
Type _MFH_E existing	31.994	1961-1970	multifamily house
Type _MFH_F existing	28.937	1971-1980	multifamily house
Type _MFH_G existing	16.992	1981-1985	multifamily house
Type _MFH_H existing	15.336	1986-1990	multifamily house
Type _MFH_I existing	12.692	1991-1995	multifamily house
Type _MFH_J existing	9.335	1996-2000	multifamily house
Type _MFH_K existing	4.287	since 2001	multifamily house
big multifamily house (BMH)			
Type _BMH_B existing	0	before 1919	big multifamily house
Type _BMH_C existing	0	1919-1945	big multifamily house
Type _BMH_D existing	0	1946-1960	big multifamily house
Type _BMH_E existing	0	1961-1970	big multifamily house
Type _BMH_F existing	0	1971-1980	big multifamily house
Type _BMH_G existing	13	1981-1985	big multifamily house
Type _BMH_H existing	45	1986-1990	big multifamily house
Type _BMH_I existing	27	1991-1995	big multifamily house
Type _BMH_J existing	21	1996-2000	big multifamily house

Type _BMH_K existing	0	since 2001	
Total number of build-ings	**287.268**		

Heating systems in Crete

Table 8-44: Heating systems, Crete

BUILDING TYPES (HEATING)	NUMBER OF BUILDINGS	TYPE OF HEATING SYSTEM	ENERGY CARRIER HEATING SYSTEM
central heating			
oil			
before 1919	0	centr. heat.	oil
1919-1945	0	centr. heat.	oil
1946-1960	0	centr. heat.	oil
1961-1970	3.199	centr. heat.	oil
1971-1980	14.468	centr. heat.	oil
1981-1985	17.005	centr. heat.	oil
1986-1990	15.381	centr. heat.	oil
1991-1995	13.259	centr. heat.	oil
1996-2000	13.327	centr. heat.	oil
since 2001	6.111	centr. heat.	oil
Single stove			
gas			
before 1919	7.191	single stove	gas
1919-1945	12.995	single stove	gas
1946-1960	14.828	single stove	gas
1961-1970	12.722	single stove	gas
1971-1980	8.034	single stove	gas
1981-1985	2.169	single stove	gas
1986-1990	1.958	single stove	gas
1991-1995	1.458	single stove	gas
1996-2000	0	single stove	gas
since 2001	0		
electricity			
before 1919	2.396	single stove	electricity
1919-1945	4.332	single stove	electricity
1946-1960	4.943	single stove	electricity
1961-1970	4.240	single stove	electricity
1971-1980	2.678	single stove	electricity
1981-1985	723	single stove	electricity
1986-1990	651	single stove	electricity
1991-1995	486	single stove	electricity
1996-2000	0	single stove	electricity

since 2001	0	single stove	
oil			
before 1919	7.191	single stove	oil
1919-1945	12.995	single stove	oil
1946-1960	14.828	single stove	oil
1961-1970	12.722	single stove	oil
1971-1980	8.035	single stove	oil
1981-1985	2.169	single stove	oil
1986-1990	1.958	single stove	oil
1991-1995	1.458	single stove	oil
1996-2000	0	single stove	oil
since 2001	0	single stove	
wood			
before 1919	7.191	single stove	wood
1919-1945	12.995	single stove	wood
1946-1960	14.828	single stove	wood
1961-1970	12.724	single stove	wood
1971-1980	8.035	single stove	wood
1981-1985	2.169	single stove	wood
1986-1990	1.958	single stove	wood
1991-1995	1.458	single stove	wood
1996-2000	0	single stove	wood
since 2001	0		

DHW systems in Crete

Table 8-45: DHW systems, Crete

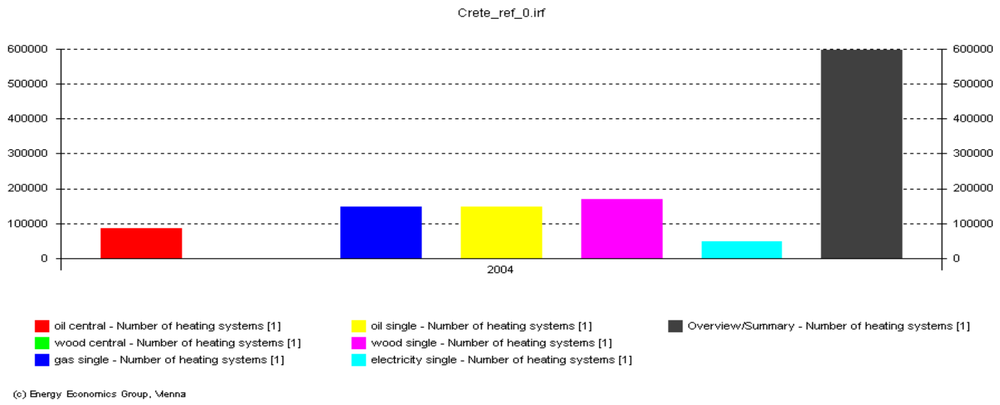
BUILDING TYPES (DHW)	NUMBER OF DWELLINGS	TYPE OF DHW SYSTEM)	ENERGY CARRIER
	combined systems		
oil	23.857	combined with heating system	oil
wood	0	combined with heating system	wood
	separated systems		
electricity	269.226	seperated from heating system	electricity
solar	181.121	seperated from heating system	renewable energy
Total number of dwellings	**474.204**		

Cooling systems in Crete

Table 8-46: DHW systems, Crete

BUILDING TYPES (HEATING)	NUMBER OF BUILDINGS	TYPE OF COOLING SYSTEM	ENERGY CARRIER COOLING SYSTEM
Central cooling			
1996-2000	652	centr. Cooling	oil
since 2001	1.276	centr. Cooling	oil
Split AC units			
before 1919	12.382	single units	electricity
1919-1945	21.990	single units	electricity
1946-1960	24.657	single units	electricity
1961-1970	27.364	single units	electricity
1971-1980	24.749	single units	electricity
1981-1985	14.546	single units	electricity
1986-1990	13.162	single units	electricity
1991-1995	10.882	single units	electricity
1996-2000	7.991	single units	electricity
since 2001	3.667	single units	electricity

Heating systems in 2004



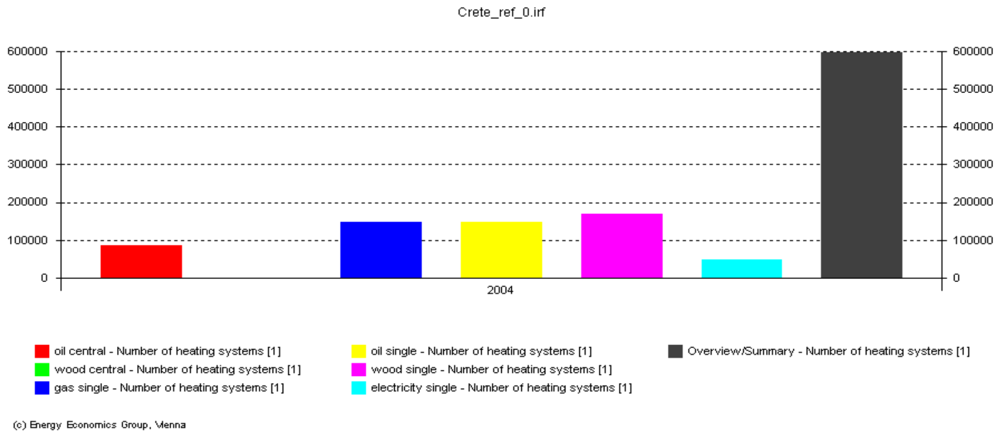


Figure 8-4: Heating systems on energy carrier, Crete 2004

Cooling systems in 2004

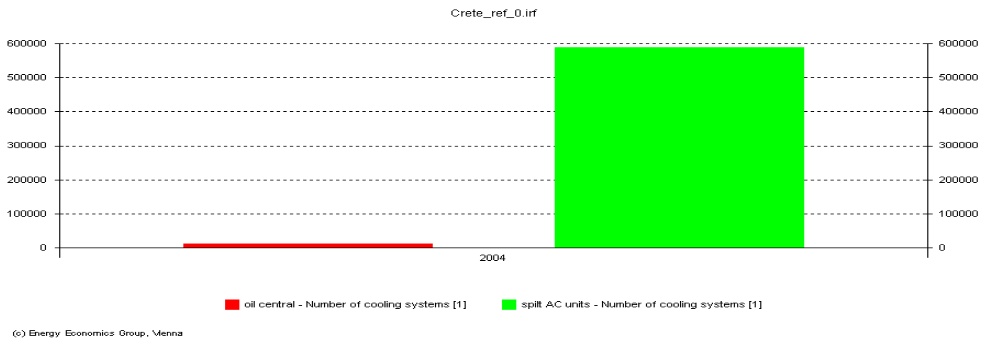


Figure 8-5: Cooling systems on energy carrier, Crete 2004