Tools for the efficient design of RES & RUE promotion schemes: Recommendations derived from the project Invert

Report of Work Phase 7
of the project

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

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CONTENT

1 INTRODUCTION

1.1 The project Invert

The European Union has established a number of targets regarding energy efficiency, Renewable Energy Sources (RES) as well as CO_2-reductions. However, the development in the last years showed that these targets are quite hard to achieve. What is more, these targets often are in contradiction to other policy objectives. On the one hand investigations have been shown that energy taxes or CO_2 taxes could be an efficient instrument to reach the above addressed goals. However, they are hard to implement because of public opposition to such measures. On the other hand, fiscal targets are strongly restricting the possibility for additional means for promoting renewable energy sources and rational use of energy technologies. Hence, these targets require that public money is spent in a most efficient way. However, currently EU-wide significant inefficiencies with regard to the public promotion of different types of energy technologies exist.

The core objective of this project is to provide a tool and recommendations for saving public money through efficient design of promotion schemes for RES and RUE technologies.

The project **Invert** investigated ways and developed a model for identifying such efficient policy options. The deeper understanding of numerous interactions and interdependencies helps designing efficient polices for RES and RUE (Rational Use of Energy) technologies ensuring 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.

The **work of this project** has been 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 (Rational Use of Energy) technologies;
- Stakeholder behaviour: analysis of the groups involved (consumers, retailers, politicians) and their behaviour 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 recommendations for providing efficient promotion schemes for RES and RUE technologies
- A comprehensive dissemination campaign that accompanies the project.

The **major result** of this project is the flexible and transparent incentive-based **Invert** simulation tool. It is a comprehensive model for investigating the efficiency of current policy portfolios and finding ways for achieving higher CO_2-reductions using a minimum of public money. Thus, the tool helps 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 supports the implementation of location-tailored support systems.

Invert investigated the whole range of promotion schemes in the field of renewable energy sources and rational use of energy technologies, i.e. the building part (including heating, domestic hot water and cooling), electricity from renewables and bio-fuels. All these fields are analysed in the previous work packages. However, during the work on the **Invert** simulation tool and the case studies the investigations focused more and more on the sector of existing buildings. In fact, this area turned out to be the most important and innovative part of the tool and the whole project. In particular, modelling the interactions between various policy objectives (e.g. CHP versus thermal building quality), technologies (renewables versus efficiency) and promotion instruments in the field of heating, domestic hot water and cooling are the strengths of **Invert** simulation tool.

1.2 Objectives of this report

The objective of this report is presenting the key recommendations derived in this project. Moreover, a summary of the main outputs of the project are given. This report aims at bringing together the outputs and findings of the previous work-packages. All major results of the project are integrated in this report.

As pointed out above, a core focus of this project is on the building related energy services. Therefore, this report targets in particular on presenting and discussing the results related to the building sector.

Finally, the objective of this report is not only to present the results derived within this project, but also to show the capacity of **Invert** simulation tool. Having completed this report and the project **Invert**, this is not the end of **Invert** simulation tool enhancement. Rather just the phase of establishing and proofing the capability of this tool has terminated by the end of this project, since the tool now will be applied and enhanced in a number follow-up projects and studies, being more and more a useful supporting instrument for the design of efficient promotion schemes towards sustainable energy systems.

1.3 Structure of the report

After this introduction giving a short outline of the project **Invert**, chapter 2 summarizes the state of the art of renewable energy sources in Europe. Historical development and current use of RES in the field of electricity, heat and transport are presented.

Chapter 3 provides an overview about European energy policy objectives as well as currently implemented promotion schemes for RES and RUE technologies.

Chapter 4 explains the main features as well as the basic algorithm of **Invert** simulation tool. The promotion schemes, which are implemented in the model as well as the major outcome parameters of the computer tool are listed and described.

Chapter 5 presents the findings from the stakeholder analysis. It discusses which indicators related to stakeholder design of promotion schemes are correlated with the success of a scheme. In addition, this chapter provides recommendations regarding the engaging of key stakeholders when it comes to implementing a promotion scheme for RES and RUE technologies.

Chapter 6 summarizes the main outcomes and recommendations of the investigations carried out with **Invert** simulation tool. This part includes the key outputs and conclusions from each case study. A methodology for identifying the optimum policy mix is presented and applied to some of the regions investigated. Moreover, the key drivers for the results are identified and interactions between promotion schemes and technologies are discussed.

The last chapter gives a summary and final remarks regarding the design of efficient policy portfolios as well as the application of the tool.

2 RES IN EUROPE: STATE OF THE ART

2.1 Electricity sector

Electricity produced by renewable energy sources (RES-E) in the European Union (EU-25) amounted to 393 TWh in 2003, corresponding to a share of 12.8% of gross electricity consumption. Thereby, EU-15 countries contribute 377.5 TWh, which equals a demand-share of 13.8%, whilst in the new member states RES-E account for 15.6 TWh, corresponding to 4.8% of total demand.

The historical development of RES-E[1] is shown in Figure 2-1 for the European Union (EU-25) for the period 1990 to 2003. As can be seen, hydropower is the dominant source, but 'new' RES-E[2] such as biomass or wind are starting to play a role. The following figures provide some insights on these technologies: Figure 2-2 depicts their historical development, and Figure 2-3 shows a breakdown of their production by country. Wind energy is the RES-E source with the highest yearly growth rates of about 35% in electricity production over the last decade. Especially in EU-15 countries, wind energy is predominant in recent portfolios of 'new' RES-E, whilst biomass dominates in the new member states.

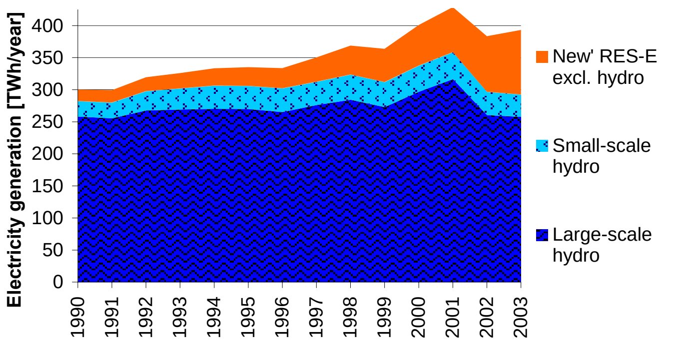

Figure 2-1: Historical development of electricity generation from RES-E (incl. hydro-power) from 1990 to 2003 in the EU-25

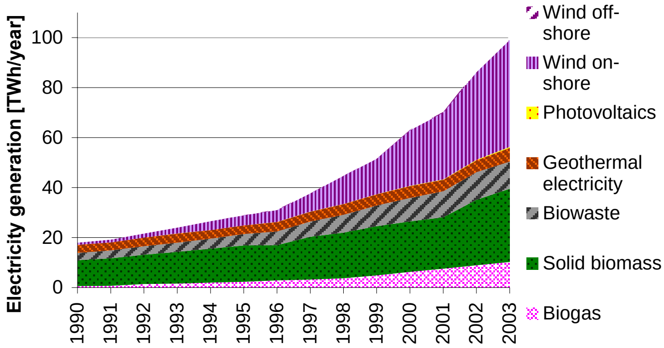

Figure 2-2: Historical development of electricity generation from 'new' RES-E (excl. hydropower) from 1990 to 2003 in the EU-25

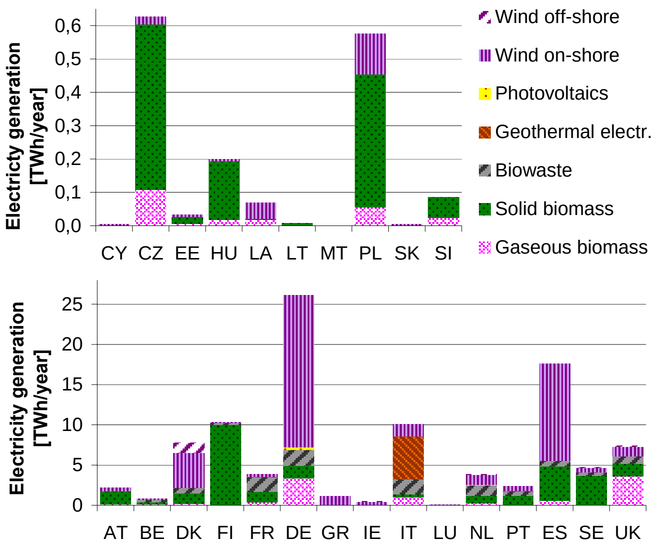

Figure 2-3: Breakdown of electricity generation from 'new' RES-E in 2003 by country

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1 Based on EUROSTAT data, which are only up-to-date until 2003. For many RES, e. g. wind-onshore and PV, more recent data from sector organisations and national statistics have been used. Generally EUROSTAT data were modified where alternative data proved to be more accurate.

2 In general, definitions of RES-E sources are made in accordance with the Directive for the promotion of electricity produced from renewable energy sources in the internal electricity market, 2001/77/EC. The technologies assessed include hydropower (large and small), photovoltaic, solar thermal electricity, wind energy (onshore, offshore), biogas, solid biomass, biodegradable fraction of municipal waste, geothermal electricity, tidal and wave energy.

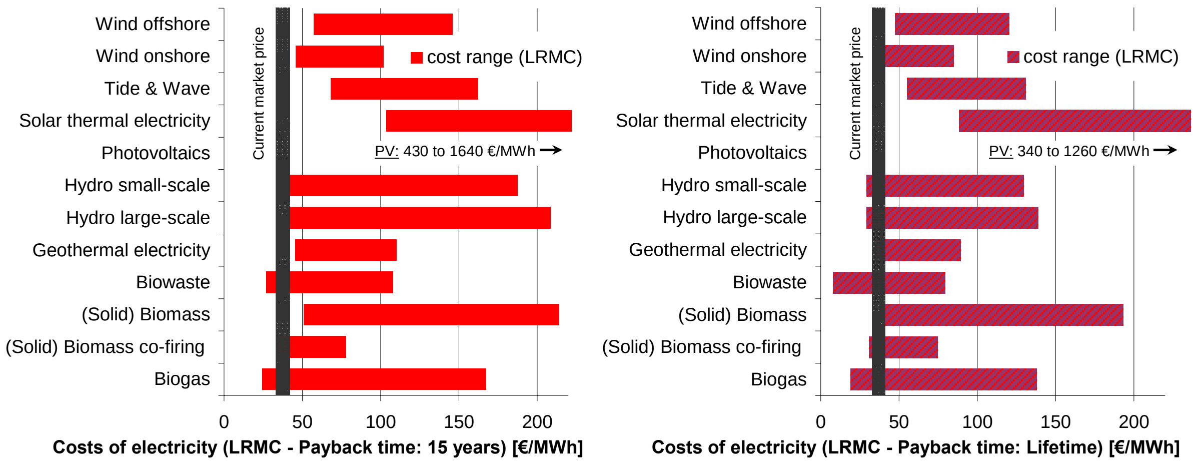

Figure 2-4: Long-term marginal generation costs (for the year 2005) of different RES-E options in EU-25 countries – based on a default payback time of 15 years (left) and by setting payback time equal to lifetime (right).

The capital intensiveness (low fuel and O&M cost) of many RES-E technologies have been an impediment to broad market penetration. Since market introduction, investment costs have decreased substantially for most RES-E technologies. The main drivers for cost reductions have been research & development and economies of scale. Another contributor has been the gradually declining interest rates over the past two decades.

In this context, Figure 2-4 depicts long-run marginal generation costs[3] by RES-E category. Thereby, two different settings are applied with respect to the payback time:[4] On the one hand, a default setting, i.e. a default payback time of 15 years is used for all RES-E options[5] – see Figure 2-4 (left), and on the other hand, the payback is set equal to the technology-specific life time – see Figure 2-4 (right). The broad range of costs for several RES-E represents, on the one hand, resource-specific conditions as of relevance e.g. in the case of photovoltaics or wind energy, which appear between as well as within countries. On the other hand, costs also depend on the technological options available – compare, e.g. co-firing and small-scale CHP plants for biomass.

[3] Long-run marginal costs are relevant for the economic decision whether to build a new plant or not.

[4] For both cases an interest rate of 6.5% is used.

[5] A payback time of 15 years aims to reflect the investor point-of-view in competitive, liberalised markets.

2.2 Heat sector[6]

Heat production from renewable energy sources (RES-H) in the EU-25 amounted to 47.8 Mtoe in 2001, corresponding to a share of 11% of total heat consumption.

It is important to note that the historical data for the RES-H sector at EU-25 member state level and in particular for the new member states are of limited reliability. This is especially valid for non-grid connected wood-heating systems in households because of the decentralised and often non-commercial nature of the activity. In contrast, the data on grid-connected systems, as well as on woodchip and pellet systems, are more reliable due to the fact that relevant fuels or generated heat are traded as commercial products.

Figure 2-5 (next page) illustrates the historic development of RES-H for the EU-15 and the EU-10 from 1990 to 2001. As can be observed therein, heat production is currently dominated by biomass resources, outweighing geothermal and solar thermal heat technologies in both EU-15 and EU-10 countries.

Figure 2-6 (next page) provides more insights on the country-specific situation, depicting a breakdown of RES-H production by country for 2001. Thereby, a further distinction into grid connected and non-grid connected heat production is applied.

[6] Historical data are based on a comprehensive data collection process as undertaken in the recently completed EC-study ‘FORRES 2020’; for details see (Ragwitz et al., 2004).

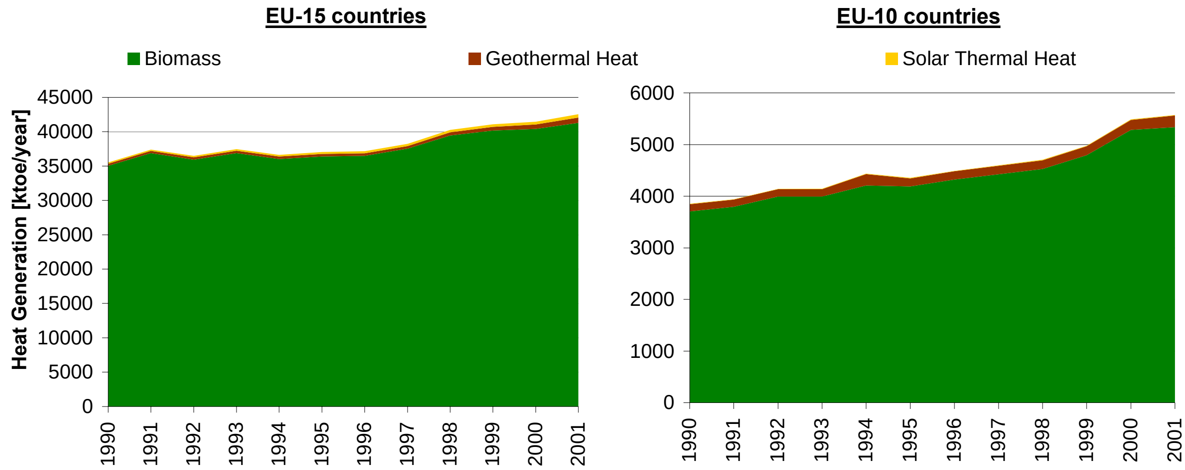

Figure 2-5: RES-H production development from 1990 to 2001 in the EU-15 (left) and the EU-10 (right). Source: 'FORRES 2020'.

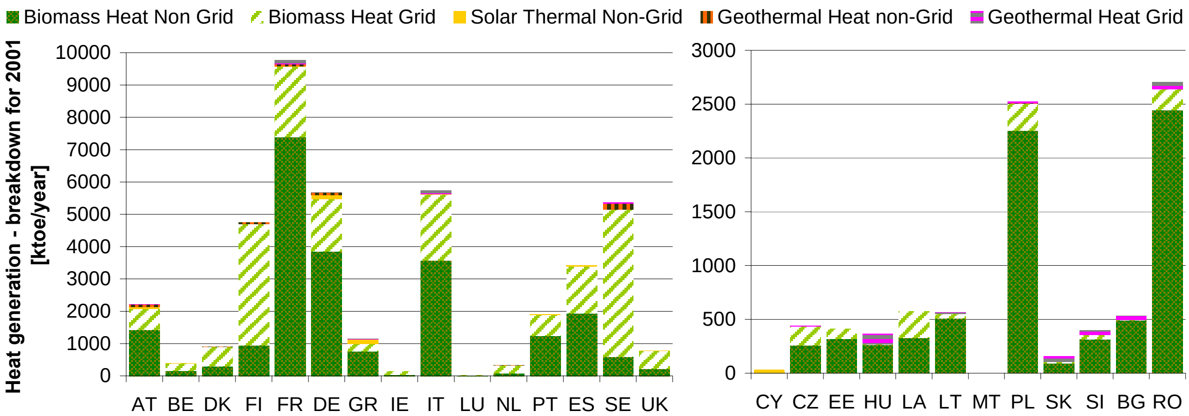

Figure 2-6: RES-H breakdown (2001) from grid and non-grid connected systems in the EU-15 (left) and the EU-10 plus Bulgaria and Romania (right). Source: 'FORRES 2020'

Heat production from non-grid connected biomass systems is predominant in almost all member states except for the Scandinavian countries and the UK, where heat production from biomass in grid connected systems is primary. There is only a minor contribution from solar thermal (1.2%) and geothermal heat production (2.4%), while the overriding share of heat production (96.4%) comes from various biomass sources.

The biomass sector is also the most complex one in terms of feedstock sources and applications. Non-grid systems based on biomass sources comprise traditional wood heat production as well as innovative biomass such as pellets and woodchips, whereas the grid connected systems include district heating and combined heat and power (CHP) plants.

2.3 Transport sector

Biodiesel has the largest share of bio-fuels production in the EU-15, reaching more than 1.2 Mtoe in 2003. During the last decade, biodiesel production increased by about a factor of ten. The growth in bioethanol production has been more modest at about a factor of five compared to 1993 values. Especially Germany, France, Austria, Italy, Sweden and Spain have set the pace for the bio-fuel sector in recent years.

In general, within the new member states the development was less dynamic. A significant increase of bioethanol production was mainly due to developments in Poland, whilst a rapid decline appeared in the biodiesel market after 2000 due to Slovakia's abolishment of the tax reduction scheme.

3 EU ENERGY POLICY OBJECTIVES AND PROMOTION INSTRUMENTS FOR RES & RUE

3.1 EU Energy Policy objectives

Within the last decade the European Union has established a number of policy objectives and directives targeting on energy efficiency and the increased use of renewable energy sources. The most important are:

- GREEN PAPER on Energy Efficiency or Doing More With Less", Brussels, 10.6.2005, COM(2005) 265 final. The major objective of the paper is, *"With today's energy-efficient technology, it is possible to save around 20% of our energy consumption by an increase in energy efficiency on a cost-effective basis. In order to realize this cost-effective savings potential by 2020, the estimated average annual increase of 0.6% in gross energy consumption has to be changed into an average annual decrease of 0.9 % by 2020. This would mean savings of up to 60 billion € per year, an amount roughly equal to a quarter of the EU yearly expenditure on energy imports. This money will be invested in the European economy in a manner that will have a positive impact on jobs and growth. The current consumption trends in the EU are upwards, but the measures proposed in this Green Paper would bring back energy consumption of EUR 25 to its 1990 level if the trend in European GDP turns out as forecasted. An energy saving of around 380 Mtoe, the current consumption of Germany and Finland put together."*
- *"Directive of the European Parliament and of the Council" on energy end-use efficiency and energy services which are to increase the efficiency of providing energy services*" for end users significantly (COM(2003) 739 final
- Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the "promotion of the use of bio-fuels or other renewable fuels for transport".
- increase the energy efficiency and achieve potential savings in the building sector as stated in the *"Directive of the European Parliament and of the Council" on the energy performance of buildings" (16 December 2002)*
- Contribution to the Directive of the European Parliament of the Council on the "promotion of cogeneration based on a useful heat demand in the internal energy market", Com (2002) 415 final.
- reaching the goal of generating 22.1% of electricity from renewable energy sources (RES-E) in the EU by 2010, as proposed in *"Directive of the European Parliament and of the Council on the promotion of electricity from renewable energy sources in the internal electricity market "* September 2001, or the indicative target of doubling the share of renewable energy sources from 6 % to 12 % in the energy balance in the EU by 2010 given by the White Paper *"Energy for the Future: Renewable Source of Energy"*, 1997.
- Contribution to the "Lisbon strategy for growth and employment" to find the right balance between economic, social, and environmental objectives.

3.2 Instruments for the Promotion of RES & RUE in Europe

A wide range of promotion schemes exist in the field of RES & RUE technologies. Table 3.1 gives an overview about the types of instruments. It is able to classify them to financial and non-financial (always push and pull) schemes. Moreover, a distinction according to the phase where the instrument is applied can be done: pre-investment, investment and post-investment. The report of WP1 "Review of current policy strategies and promotion schemes" documents all these instruments in the European Union.

Table 3.2, Table 3.3 and Table 3.4 indicate the main instruments existing in the field of electricity, heat and bio-fuels.

It turns out that for each of the considered sectors electricity, heat and transport there are quite typical kind of policies in EU-15 and the selected accession countries according to this typology though of course there are also many country-specific specialities.

Energy taxes as a financial post-investment push approach have a strong impact on both RUE and – because of broad exemptions for renewables – also for RES. Therefore, this instrument cannot be classified clearly to one kind of technology. All considered countries have at least some kind of energy taxes. The most important ones are taxes on transportation fuels, heating oil and electricity with quite high variations among countries.

With respect to RUE the non-financial strategies are the dominating ones. In the field of electricity the main focus is on labelling and in the field of heat on regulatory schemes (building regulations). As it can be expected, building regulations depend to a large extent on the climate conditions in the countries. Promotion schemes for the RUE in the area of transport are not analysed in this project.

Compared to RUE in general there is much more focus on financial incentives when it comes to RES. In the field of electricity generation from RES post-investment schemes - first of all feed-in-tariffs - strongly dominate and are partly combined with subsidies. Some countries have implemented quotas based on tradable green certificates. In the field of heat generation from RES strong emphasis is given to investment subsidies which are often a combined with tax incentive schemes – especially reduction of VAT and income tax. Promotion schemes in the field of transport are heavily dominated by post-investment tax incentives, basically tax exemptions for bio-fuels and relatively high taxation of fossil fuels.

Table 3.1 Matrix summarising the main dimensions of promotion schemes existing in the European Union in the field of RES & RUE technologies

	Financial		**Non-financial**	
	Push	**Pull**	**Push**	**Pull**
Pre-investment/ implementation	energy taxes	support of R&D, manufacturing, demos	Prohibition, mandates, quotas, building codes, standards	voluntary agreements, labelling, grid access regulation
Investment/ implementation	energy taxes	investment grants, financing or tax relief		
Post-investment/ implementation	energy taxes	feed-in tariffs, energy tax, Quota obligation (TGC)		
Indirect schemes	(energy tax)			education, campaigns, project framework conditions

Table 3.2 Current promotion strategies for RES-Electricity in EU-15 and selected new member states

Country	Major strategy	RES-E TECHNOLOGIES CONSIDERED: Large Hydro	Small Hydro	'New' RES (Wind on- & offshore, PV, Solar thermal electricity, Biomass, Biogas, Landfill gas, Sewage gas, Geothermal)	Municipal Solid Waste
Austria	**FITs**	No	Renewable Energy Act 2003. (Ökostromgesetz). FITs guaranteed for 13 years for plants which get all permissions between 1st of January 2003 and 31st of December 2004 and, hence, start operation by the end of 2006. Investment subsidies mainly on regional level.		No
Belgium	**TGC + guaranteed electricity purchase**	No	Federal: The Royal Decree of 10 July 2002 (operational from 1st of July 2003) sets minimum prices for RES-E. Except for offshore wind it will be implemented by the regional authorities: Wallonia: Quota obligation (based on TGCs) on electricity suppliers– increasing from 3% in 2003 up to 12% in 2010. Flanders: Quota obligation (based on TGCs) on electricity suppliers– increasing from 3% (no MSW) in 2004 up to 6% in 2010. Brussels region: No support scheme yet implemented.		
Czech Republic	**FITs + investment subsidies**		Governmental program (subsidies), State environmental fund subsidies, specific program for feed in tariffs, tax on nuclear electricity, the Energy Act (obligation to purchase RES-E)		
Denmark – current	**FITs**	No	Act on Payment for Green Electricity (Act 478): Fix settlement prices instead of former high FITs. Valid for 10 years. Tendering plans for offshore wind.		No
Denmark – proposed	**TGC**	No	Quota obligation based on TGC – planned for 2004-2005		No
Finland	**Tax Exemption**	No	Tax refund: 0.44€c/kWh (plant <1MW), Mix of tax refund and investment subsidies: From January 2003: Tax refund of 0.73 €c/kWh for Wind and of 0.44€c/kWh for other RES-E. Investment subsidies up to 40% for Wind and up to 30 % for other RES-E, Exemption on Energy Tax for renewable energy, Green Labels		No
France	**FITs**	No	FITs for RES-E plant < 12 MW guaranteed for 15 years (20 years PV and Hydro). Tenders for plant >12 MW. FITs in more detail: Biomass: 4.9€c/kWh, Biogas: 4.6€c/kWh, Geothermal: 7.62€c/kWh, PV 15.25-30.50 €c/kWh; Landfill gas: 4.50-5.72€c/kWh; Wind: 3.05-8.38 €c/kWh; Hydro: 5.49-6.10 €c/kWh. Investment subsidies for PV, Biomass and Biogas (Biomass and Biogas PBEDL 2000-2006).		FIT: 2.58-4.42 €c/kWh
Germany	**FITs**	No	German Renewable Energy Act: FITs guaranteed for 20 years. In more detail, FITs for new installations in 2003 are: Hydro: 6.65- 7.67 €c/kWh; Wind: 6-8.9€c/kWh; Biomass: 5,8-10 €c/kWh, Landfill gas, Sewage gas and mine Biogas: 6.65-7.67€c/KWh; solar PV and Solar thermal electricity: 45.7€c/kWh; Geothermal: 7.16-8.95€c/kWh		No
Greece	**FITs + investment subsidies**	No	FITs guaranteed for 10 years (at a level of 70-90% of the consumer electricity price) and a mix of other instruments: a) Law 2601/98: Up to 40% investment subsidies combined with tax measures; b) CSF III: Up to 50% investment subsidies depending on RES type		No
Hungary	**FITs + investment subsidies**		Technological Development Fund (R&D), Energy Saving Program and Action Plan (Subsidies), Environmental Protection Plan (Subsidies), Biomass Usage for energy production, Electricity Act (Feed in tariffs)		
Ireland	**Tender + Taxes**		Tendering scheme – currently AER VI with technology bands and price caps for small Wind (<3MW), large Wind (>3MW), small Hydro (<5MWp), Biomass, Biomass CHP and Biogas. In addition, tax relief for investments in RES-E, CO_2 Tax, Waste Management (Regulation), House of Tomorrow: increase energy efficiency according to PV		No
Italy	**TGC**	Quota obligation (based on TGCs) on electricity suppliers: 2% target, increasing annually; TGC issued for all (new) RES-E (inc. large Hydro and MSW) – with rolling redemption; unclear penalty enforcement and market distortions. Investment subsidies for PV (Italian Roof Top program).			
Luxembourg	**FITs**	No	No	FITs guaranteed for 10 years (PV 20 years) and investment subsidies for Wind, PV, Biomass and small Hydro. FITs for Wind, Biomass and small Hydro: 2.5€c/kWh, for PV: 50€c/kWh.	No
Poland	**Quota/ green certificates**	No	Ecofund (Subsidies), National Fund for Environmental Protection and Water Management – grants and soft loans, Bank of Environmental Protection – soft loans, , Green Power Purchase obligation (Ordinance of the Ministry of Economy), absence of investment plans in nuclear power plants until 2020 (new energy strategy assumes construction of nuclear plants after 2020), pollution fees for NOx. SOx,, CO2, State Committee for Scientific Research provides some small research grants		
Portugal	**FITs + investment subsidies**	Yes	FITs (Decree law 339-C/2001 and Decree law 168/99) and about 40% investment subsidies, (MAPE within PRIME Programme) for Wind, PV, Biomass, Small Hydro and Wave. FITs in 2003: Wind: 8.0€c/kWh-8.9€c/kWh; Wave: 24.6€c/kWh; PV:31€c/kWh-53€c/kWh, Small Hydro: 7.6€c/kWh. R & D Programs, MAPE Grants and Soft loans, VAT reduction, The Energy excise Duty (ISP)		No
Slovenia	**FITs + investment subsidies**		Ordinance on rules for definition of prices and purchase of electricity (feed-in tariffs), Environment Ministry Fund (subsidy, bidding), Efficient Use of Energy (soft loans)		
Spain	**FITs**	Depend-ing on the plant size	FITs (Royal Decree 2818/1998): RES-E producer have the right to opt for a fixed price or for a premium tariff. Both are adjusted annually by the government according to the variation in the average electricity sale price. In more detail (only premium, valid for plant < 50 MW): Wind: 2.7€c/kWh; PV: 18-36€c/kWh, Small Hydro: 2.9€c/kWh, Biomass: 2.5-3.3€c/kWh. Moreover, soft loans and tax incentives (according to "Plan de Fomento de las Energías Renovables") and investment subsidies on a regional level		FIT: 1.7 €c/kWh
Sweden	**TGC**	No	Quota obligation (based on TGC) on consumers: Increasing from 7.4% in 2003 up to 16.9% in 2010. For Wind Investment subsidies of 15% and additional FITs ("Environmental Bonus") in size of 1.9€c/kWh are available. Favourable Taxation for RES		No
Netherlands	**FITs + tax exemption**		Mixed strategy: green pricing, tax exemptions and FITs. The tax exemption for green electricity amounts 2.9€c/kWh and FITs range from 2.9€c/kWh for mixed Biomass and waste streams to 6.8€c/kWh for Wind, PV, Tidal, Wave and Small Hydro, Regulation Energy Tax (REB)		No
United Kingdom	**TGC**	No	Quota obligation (based on TGCs) for all RES-E: Increasing from 3% in 2003 up to 10.4% by 2010 – penalty set at 3.51£/kWh. Optional to the TGC-system, eligible RES-E are exempted from the Climate Change Levy certified by Levy Exemption Certificates (LEC's), which cannot be separately traded from physical electricity. The current levy rate is 0.43 £/kWh. Investment grants in the frame of different programs (e.g. Clear Skies Scheme, DTI´s Offshore Wind Capital Grant Scheme, the Energy Crops Scheme, Major PV Demonstration Program and the Scottish Community Renewable Initiative)		No

Table 3.3 Current promotion strategies for RES-Heat in EU-15 and selected new member states

Country	Major strategy	Description of promotion schemes
Austria	**Investment subsidies**	The Research programs for Industry, the Fund of Scientific Research, soft loans in the frame of support of residential buildings, "Kommunalkredit-Program" (investment subsidies), subsidies on provincial level
Belgium	**Tax Exemption+ investment subsidies**	Investment subsidies schemes for RES in Walloon Region in the private sector, UREBA: Investment subsidies schemes for RES in Walloon Region in the public sector, Company tax reduction for investment (company tax code,1992), Valued added tax (V.A.T)- tax investment
Czech Republic	**Tax exemption**	State environmental fund subsidies, specific program for aimed at developing renewable energy production (tax incentive), energy taxes, government program for the support of Energy Savings and the Utilization of RES
Denmark	**Regulation + investment subsidies**	Act on Utilisation of Renewable energies (Investment subsidies), Solar heating obligation in new buildings
Finland	**Tax Exemption+ investment subsidies**	Investment subsidies (State Decision 29/99), Exemption on Energy Tax for renewable energy
France	**Tax Exemption+ investment subsidies**	Solar thermal Program Helios 2000-2006 Biomass Introduction Program PBEDL 2000-2006, Tax incentives
Germany	**investment subsidies + Tax Exemption**	German Renewable Energy Act: FITs guaranteed for 20 years. Support Program Resources (R&D), ERP and DtA Environment and Energy Efficiency Program (investment subsidies and soft loans), German Market incentive program, income tax exemption for pure liquid and solid fuels
Greece	**Investment subsidies+ Regulation**	Law 2601/98: Up to 40% investment subsidies combined with tax measures, CSF III: Up to 50% investment subsidies depending on RES type, Regulation for Rational Use of Energy in Buildings (RRUEB), Legislation for boilers and burners
Hungary	**Investment subsidies**	Technological Development Fund (R&D), Energy Saving Program and Action Plan (Subsidies), Environmental Protection Plan (Subsidies), Biomass Usage for energy production, Energy Loan program (Soft loans)
Ireland	**Regulation+ energy tax**	Waste Management (Regulation), CO_2 Tax, House of Tomorrow: increase energy efficiency according to Solar Thermal
Italy	**Tax incentives**	CO_2 Tax (energy tax), Lower VAT rates for Solar heat systems
Luxembourg	**Investment subsidies**	Investment subsidy: Rebate Solar thermal, Investment Subsidies for Biomass, Subsidies for dissemination
Poland	**Grants and soft loans for solar collectors and fuel conversion to biomass quota/green certificates**	Ecofund (Subsidies), National Fund for Environmental Protection and Water Management – grants and soft loans, Bank of Environmental Protection – soft loans, Green Power Purchase obligation (Ordinance of the Ministry of Economy), absence of investment plans in nuclear power plants until 2020 (new energy strategy assumes construction of nuclear plants after 2020), pollution fees for NOx. SOx,, CO2, State Committee for Scientific Research provides some small research grants, Thermal Modernisation Act (Fund) supporting heat savings and fuel conversion,
Portugal	**Investment subsidies + Tax Exemption**	R & D Programs, MAPE Grants and soft Loans, VAT reduction, The Energy excise Duty (ISP), the governmental program "Agua Quente Solar"
Slovenia	**Investment subsidies**	Environment Ministry Fund (subsidy, bidding), Efficient Use of Energy (soft loans), The environmental development fund of the Republic Slovenia
Spain	**Investment subsidies + Tax Exemption**	Incentives for active solar thermal under the Plan de Formento de las Energias renovables (investment subsidies), Soft loans and tax incentives (according to "Plan de Fomento de las Energías Renovables") and investment subsidies on a regional level
Sweden	**TGC+ investment subsidies**	Favourable Taxation for RES, Subsidies for small-scale producers, investment grants, environmental bonus, Quota obligation (based on TGCs)
Netherlands	**Tax exemption+ subsidies**	Mixed strategy: green pricing, tax exemptions and subsidies. Subsidy Energy Program (DEN), Tax deduction for RE investments (EIA), Energy Subsidy Regulation (ERP), CO_2 Reduction Plan, Regulation Energy Tax
United Kingdom	**Investment subsidies+ campaigns**	Investment grants in the frame of different programs (e.g. Clear Skies Scheme, DTI´s. EST Save energy campaign, Planning Policy Guidance, Government fund to promote biomass energy crps

Table 3.4 Current promotion strategies for bio-fuels in EU-15 and selected new member states

	Major strategy	RES-T TECHNOLOGIES CONSIDERED
Austria	**Tax exemption**	Research programs for Industry, tax reduction for pure liquid bio-fuels, taxes on fossil transport fuels
Belgium	**Tax exemption**	Company tax reduction for investment (company tax code,1992), Valued added tax (VAT) -tax exemption, taxes on fossil transport fuels
Czech Republic	**Tax exemption**	Energy taxes, excemption from excise tax for biodiesel fuel, government program for the support of Energy Savings and the Utilization of RES, taxes on fossil transport fuels
Denmark	**Tax exemption**	Taxes on fossil transport fuels
Finland	**Tax exemption**	Investment subsidies (State Decision 29/99), Exemption on Energy Tax for renewable energy, taxes on fossil transport fuels
France	**Tax exemption**	Taxes on fossil transport fuels
Germany	**Tax exemption**	Support Program Resources (R&D), Support for biogenic fuels and lubricants, tax exemption for pure liquid and solid bio-fuels , taxes on fossil transport fuels
Greece	**Tax exemption**	Tax incentives: Law 2364/95, Promotion Campaigns for Energy Efficiency, taxes on fossil transport fuels
Hungary	**Tax exemption**	Taxes on fossil transport fuel, Technological Development Fund (R&D), taxes on fossil transport fuels
Ireland	**Tax exemption**	Taxes on fossil transport fuels
Italy	**Tax exemption**	CO_2 Tax (energy tax), Tax Exemption for Bio-fuels, taxes on fossil transport fuels
Luxembourg	**Tax exemption**	Taxes on fossil transport fuels
Poland	**Tax exemption**	Ecofund (Subsidies), National Fund for Environmental Protection and Water Management, Bank of Environmental Protection, Energy Taxes, Green Power Purchase obligation (Ministry of Economy), State Committee for Scientific Research – only research grants, taxes on fossil transport fuels
Portugal	**Tax exemption**	Vehicle Acquisition tax reduction, taxes on fossil transport fuels
Slovenia	**Tax exemption**	Taxes on fossil transport fuels
Spain	**Tax exemption**	Direct tax Provision for environmentally Friendly Investments, National Tax Exemptions for bio-fuels, taxes on fossil transport fuels
Sweden	**Tax exemption**	Tax Reduction for bio-fuels, taxes on fossil transport fuels
Netherlands	**Tax exemption**	Subsidy Energy Program (DEN), Tax deduction for RE investments (EIA), taxes on fossil transport fuels
United Kingdom	**Tax exemption**	Fuel Duty, EST Transport Initiative: Powershift, cleanup and Bestpractice, taxes on fossil transport fuels

4 Invert SIMULATION TOOL: FORMAL FRAMEWORK AND IMPLEMENTATION

Invert is a free available comprehensive dynamic bottom-up simulation tool[7] to evaluate the effects of different promotion schemes (investment subsidies, feed-in tariffs, tax exemptions, subsidy on fuel input, CO_2 taxes, soft loans, and additional set aside premium) on the energy carrier mix, CO_2 reductions and costs for society due to promoting certain strategies. Furthermore, Invert allows in a very easy way to simulate different scenarios (price scenarios, thermal building insulation scenarios, different consumer behaviours, etc.) and the according impact on future trends of renewable as well as conventional energy carriers.

Invert is applicable on the existing building stock (for heating, cooling, Domestic Hot Water Systems (DHW), solar thermal), Rational Use of Energy (RUE), as well as Renewable Energy Sources according electricity supply (RES-E) and heat production (RES-CHP) and for bio-fuel production on any region. Due to the flexible design, Invert allows comparative and quantitative sensitivity analyses of the interactions between RUE, RES-E, RES-CHP, and Bio-Fuels as well as Greenhouse Gas (GHG) -reduction for each selected region.

Invert can be applied to a broad range of region types. Within the case study investigations of this project[8], quite different regions were investigated: Small and large, rural and urban, southern and northern regions ranging from small communities to whole nations.

4.1 Modelling decision making process in Invert

Invert models the decisions making process of the stakeholders taking into account market restrictions (e.g. RES-E market barriers, learning curves, consumer behaviour). Hence, Invert is a disaggregated bottom-up model summing up the decisions of a number of different individuals. However, two different approaches - depending on the sector - are used in Invert.

For the building sector (including DSM, heating, cooling, DHW, solar thermal) an option approach is used. In contrast to the option approach, in the RES-E, RES-CHP and bio-fuel sector a dynamic cost curve approach is used. These two different approaches are roughly described in Figure 4-2and Figure 4-1:

.

The option-based approach considers that consumers and investors in the building sector (i.e. decision makers in the field of heating, cooling and domestic hot water systems as well as insulation and window replacement) are faced with a variety of various options, e.g. when it comes to the replacement of the heating system. As shown in Figure 4-2 each of these options is assigned to annual costs of providing the required energy service (e.g. indoor climate) by this technology. The algorithm calculates the costs for each option in each building type depending on the specific characteristics of this building type[9]. It is assumed that the consumers in average decide for the cheapest option (recognized by the consumer). However, it is very important to note that within this option-based approach Invert allows modelling the cheapest option seen by the stakeholder via so-called Soft Barriers. The decision making process of the consumer is influenced by a variety of different technical and non-technical aspects (e.g. comfort, social barriers, education). All these

[7] For download, please visit www.invert.at.

[8] For more information according the case studies, see part 6.1 of this report or the report of WP 6 “Case studies”.

[9] A building type represents the most disaggregated level when it comes to the description of the building stock: The whole building stock within the investigated region is separated into building categories (e.g. multiple vs. single dwellings) and construction periods (e.g. before 1918, 1919-1930, etc.). The specific combination of a certain building class with a certain heating, cooling or domestic hot water system is called “building type”. Based on this description, Invert simulates the decision making process upon which heating, cooling or domestic hot water system is chosen or whether demand side measures (insulation, window replacement) is carried out.

aspects together are modelled depending on the technology and the type of consumer behaviour.

These soft barriers allow increasing or decreasing the monetary costs of a technology

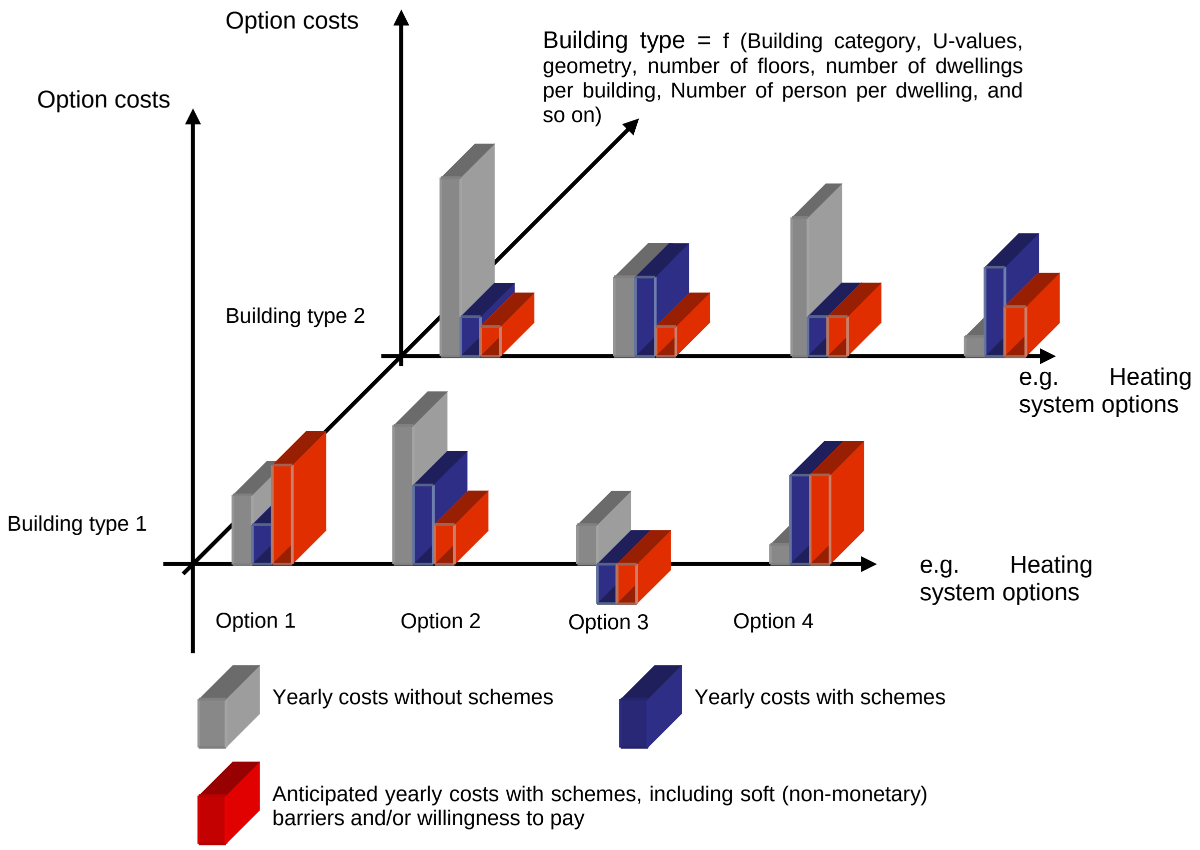

Figure 4-2: Option based approach in the building sector

(on basis of the lifetime/individual payback time) depending on the estimated consumers preferences and behaviour (=soft barrier factor). This results in the fact that Invert enables the combination of monetary decisions and consumers' behaviour.

In the RES-E, RES-CHP and bio-fuel part of Invert certain types of potentials are assigned to their costs (short term/long term marginal costs). This results in a cost-resource curve. Each part of these potentials with the same costs is called a "band" of this curve. The database includes all these potentials as well as the required data for calculating costs within each band. The algorithm of the Invert simulation tool gathers and sorts all bands for the electricity/heat as well as bio-fuel production in a least cost order. Each 'band' is characterised by a certain set of parameters. For example wind: All wind farms/plants with the same full loud hour can be gathered and treaded as one unique 'band' if it is assumed that the investment costs (as well as O&M costs) within a 'band' in average are the same.. Of course, there are different costs for each plant in a 'band'. In other words, in reality we would obtain a continuous cost curve.

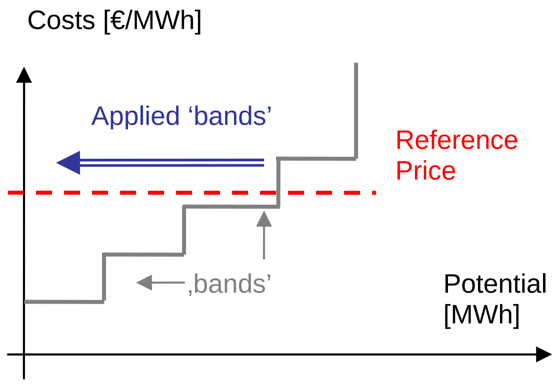

Figure 4-1: Cost curve approach used in the RES-E, RES-CHP and bio-fuel part of Invert

However, for the modelling in Invert we use a stepped discrete function as an approximation. It is assumed that all RES-E/CHP or bio-fuel bands are installed or used when the costs for the electricity/heat or bio-fuel production is lower than the electricity or bio-fuel reference price used in the model.

4.2 Implemented promotion schemes

Promotion schemes are the major scenario input which can be specified by the user of the tool in order to investigate the impact of these instruments on CO_2-emissions, transfer costs, technology mix etc. The algorithm of the tool takes into account these schemes when calculating the costs seen by a consumer or investor of implementing a certain technology. Thus, the promotion scheme settings influence the decision making process of consumers and investors by decreasing (e.g. by subsidies) or increasing (e.g. by a tax) the costs of a certain technology.

Table 4-1: Promotion Schemes implemented in Invert simulation tool (part one)

Sector	Sub sector	CO_2 tax	Invest-ment subsidy	Soft Loan	Feed in tariff
Building	Heating	√	√	√	x
	DHW (including solar thermal)	√	√	√	x
	Cooling	√	√	√	x
	DSM	x	√	√	x
	District heating	√	√	√	x
Electricity	RES-E	√	√	x	√
	RES-CHP	√	√	x	√
	District heating	√	√	x	√
Bio-fuel	Bio-fuels	√	x	x	x

Table 4-2: Promotion Schemes implemented in Invert simulation tool (part two)

Sector	Sub sector	Tax exemption	Subsidy on fuel input	Additional aside premium
Electricity	RES-E	√	√	x
	RES-CHP	√	√	x
	District Heating	√	√	x
Bio-fuel	Bio-fuel	√	x	√

Table 4-1 and Table 4-2 show the promotion schemes implemented within Invert simulation tool.

At the electricity part, the promotion schemes are separated to RES-E and RES-CHP. Invert considers in this part only promotion schemes for renewables. In principle, promotion schemes for conventional energy carriers can be considered only in the building part (heating, cooling, DHW).

The two major promotion schemes in the building sector (Investment Subsidy and Soft Loans) can be applied on each defined (by the user) building category (e.g. single family households, multifamily households) and defined technology for heating, cooling, DHW, solar thermal systems. Furthermore, it is possible to assign a certain Demand-Side (DS) strategy for each defined building category and building part (walls, ceiling, floor, and windows).

Figure 4-3 shows how promotion schemes can be specified in the Invert simulation tool. The figure shows exemplary the investment subsidies in the building part, which includes heating, cooling, domestic hot water, windows and insulation. A certain technology (which can be defined flexibly by the user) can be selected and assigned to a certain value of investment subsidy. These values can be specified for each building category separately. So, each defined (by the user) building category (e.g. single family dwelling old) can be combined with a defined heating, cooling, DHW technology and linked with a certain promotion scheme (e.g. investment subsidy in the building sector).

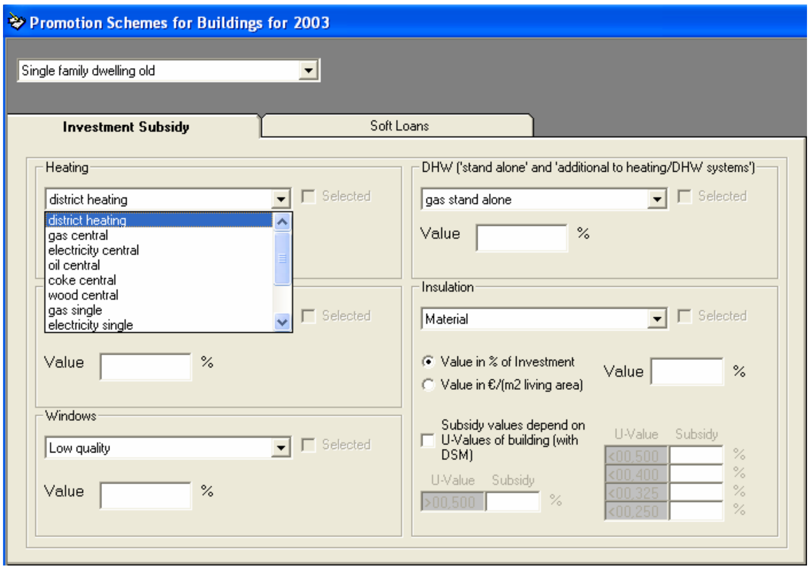

Figure 4-3: Promotion scheme window for buildings

4.3 Comparing the efficiency of promotion schemes

One of the basic ideas within **Invert** is to compare promotion schemes and strategies for the reduction of CO_2-emissions in the different sectors building, electricity and transport. Therefore, **Invert** allows comparing portfolios of promotion schemes against to each other. The core question for this comparison is: *"How efficient is a certain mix of promotion schemes in reducing CO_2-emissions?"*

When we want to evaluate the impact of changing the promotion schemes for RES & RUE technologies, we will probably find out that this change will result both in a change of CO_2-emissions as well as of transfer costs. Assuming that we can achieve a CO_2-reduction compared to the reference scenario, we consider those schemes more efficient that can reach this reduction with a lower amount of public money (transfer costs) than others can.[10] Hence, we are searching for instruments that result in high CO_2-reductions requiring low public money (transfer costs). For evaluating this aspect within **Invert** simulation tool the "Promotion scheme efficiency" (PSE) was defined to investigate the described issue. The PSE estimates the efficiency of a certain strategy compared to a reference scenario by comparing the CO_2 emissions and transfer costs (public budget relevant spendings for promoting a certain technology) of the reference scenario with the CO_2 emissions and transfer costs of the sensitivity scenario. The most efficient promotion schemes are indicated by high decreases in CO_2 emissions and low increases (or even decreases) of transfer costs compared to the reference scenario.

$$PSE = \frac{\sum_{i=1}^{n} \Delta CO_2 Emissions_{\ i}}{\sum_{i=1}^{n} \Delta TransferCosts_{\ i}}$$

The formula above shows that the changes in CO_2-emissions and transfer costs are summed up for all years (i).

Policy maker with a short-term view could argue that for reaching a certain CO_2-target in a certain time frame, CO_2-emissions and transfer costs occurring after this time frame are of no relevance. Only the achievable CO_2-reductions in this period as well as the budget relevant spending within this period should be considered. In this case "n" in the formula above is the end of the simulation period. **Invert** calculates this value as "Cumulated promotion scheme efficiency" (CPSE). It has to be noted that this value systematically overestimates the costs for reducing CO_2-emissions and has a bias against subsidies in favour of continuous payments like soft loans or feed-in-tariffs. This is because CO_2-reductions of plants subsidised at the end of the simulation period are not taken into account fully, whereas transfer costs are fully considered.

On the other hand a policy maker with a long-term view would argue that of course also CO_2-emissions and transfer costs occurring after the simulation period have to be considered. In this case "n" in the formula above is the end of the life time of applied technologies. **Invert** calculates this value as "Life time promotion scheme efficiency" (LPSE). These values reflect much better the actual CO_2-abatement costs, as they are

[10] Part 6.3 of this report describes how this concept can be used to derive optimum portfolios of promotion schemes in order to achieve a certain level of CO_2-reductions. For that purpose, we have to consider the concept of the "efficiency" in combination with the "effectiveness" of a certain promotion scheme: the total amount of achievable CO_2-reductions.

known from literature. The results presented in this report refer mainly to this concept of LPSE.[11]

4.4 Outputs of Invert simulation tool

The results achievable with **Invert** can be displayed on an aggregated as well as disaggregated level. All outputs according technologies, energy carriers, RES-E/CHP as well as bio-fuel technologies are displayable on a disaggregated level.

All outputs necessary for the estimation of the promotion scheme efficiency in the different (sub)-sectors (building, electricity, bio-fuel, heating, cooling, etc.) are displayable on an aggregated level (CO_2 emissions and transfer costs).

The following shows the main outputs of the **Invert** simulation tool.

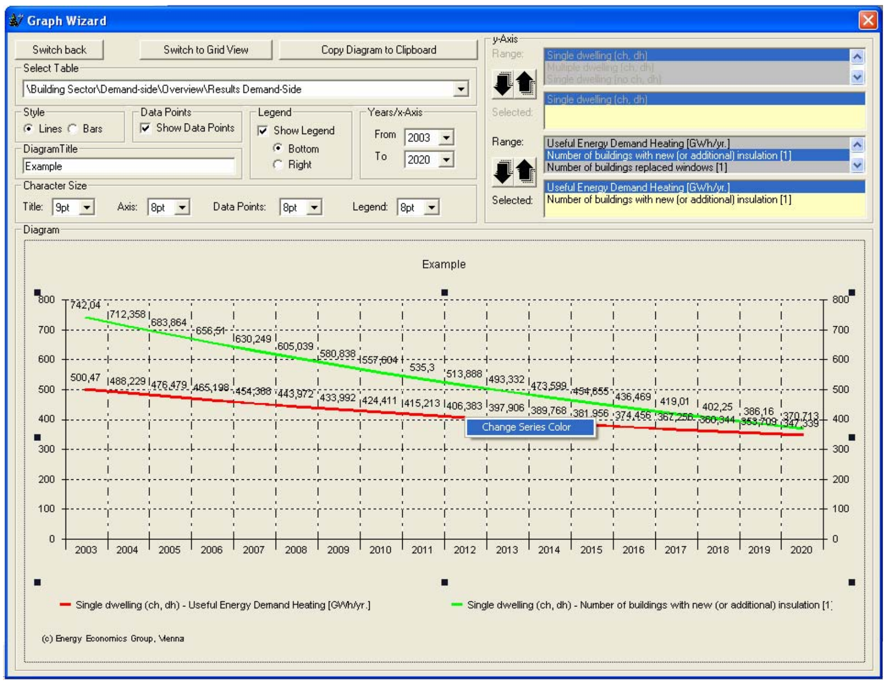

Figure 4-4: Individual generation of graphs in **Invert**

General Outputs (for Heating, Cooling, DHW, DSM, RES-E/CHP, Bio-Fuel):

- Public transfer costs for promoting RES & RUE technologies (Mio Euro/year)
- CO_2-emissions (total and reductions due to promotion schemes) (kt/year))

Heating, Cooling and DHW:

- Energy demand reductions due to insulation and window replacement (DSM) for various building types (GWh/year)
- Mix of energy carriers for heating, domestic hot water and cooling systems (numbers of systems (1); numbers of buildings (1);
- final energy demand (GWh/year);...)
- District heating related outputs

Electricity/District Heating:

- Output from RES-E plants (GWh)
- Installed capacity of RES-E plants (MWel)
- Heat output from RES-CHP plants (GWh)
- Installed capacity of RES-CHP plants (MWel)
- Heat output from conventional Heat /CHP plants (GWh)

Bio-fuels:

- Total production of various types of bio-fuels (l)
- Entire agricultural surface needed for the bio-fuel production (ha)

A useful feature in **Invert** is the ‘Graph Wizard’, which allows preparing graphs individually (see also Figure 4-4). All in the Portfolio file represented tables can be shown and prepared for graphical documentation and copied to Microsoft Word or any other application.

[11] See part 6.1 of this report.

4.5 Invert: flexible, self explaining, user friendly

Invert simulation tool is available for free. This has major impacts on the characteristics of the tool: Invert has been designed in a way to be very flexible and self explaining with a user friendly handling. The flexibility is achieved by a open database system allowing to create or adjust own datasets. All data required for the simulation is available and can be viewed. Figure 4-5 shows the database tree view of Invert. By clicking on any table within the tree the related data can be viewed or modified.

The model incorporates many hints assisting the user. At crucial steps, the user gets additional information at the bottom of the program. Furthermore, a comprehensive help file exists with explanations of the used formulas and algorithm. Due to the possibility to create or adjust own database and simulation files, there is a validation tool checking the input data. Moreover, there is a simulation error information system giving hints and support in case of any simulation error. Invert has been designed for users who are slightly trained in energy economics and modelling. It is not necessary to be an expert in energy modelling.

The model will be further enhanced after the end of this project, too. Therefore, a 'Live Update Tool' exists to update Invert automatically via the Internet. Furthermore, the program allows importing outdated Invert database files automatically in the new required format.

Invert simulation tool supports all Microsoft standards like copy and paste from and to Excel or any other application.

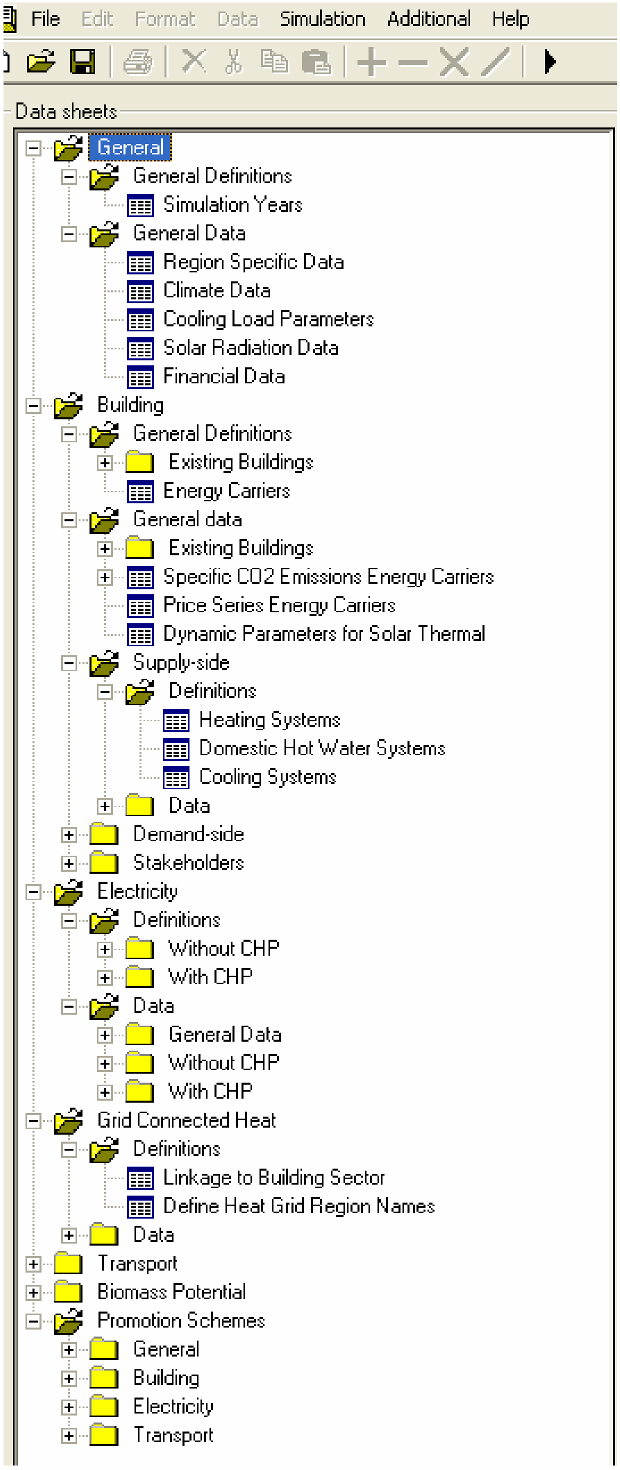

Figure 4-5: Tree view of an Invert database

5 STAKEHOLDER BEHAVIOUR

The target of the analysis of stakeholder behaviour within the project **In*vert*** were:

- Benchmarks for successful policies together with a set of logical combinations for success.
- Evaluation of less successful policies with learning points for future developments.
- Discussion of the impacts of different policy factors on target group behaviour.

A wide range of policies (promotion schemes or programmes) were reviewed by the partners. As the objectives of the schemes varied, the determination of scheme success was limited to the degree to which the objectives were met, and the degree to which the budget was met, over- or under-spent. This rating of scheme success was core to the rest of the analysis or stakeholder behaviour, its relationship with the promotions scheme and their design (combinations for success), and the factors within schemes that had an impact on target group behaviour.

Extensive analysis was undertaken to determine significant links between various factors and stakeholder behaviour or scheme success. The overall aim was to identify features of programme design and stakeholder interaction so as to propose risk factors acting on the project's potential which could be linked with the computer model. The process by which this was carried out is described in detail in the report on WP4. In this chapter the main findings are summarised, then some opportunities for integrating these findings with scheme design are investigated in order to provide recommendations for the future.

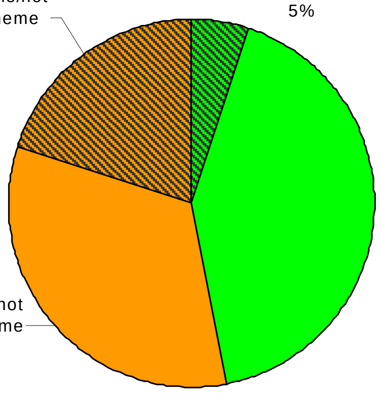

Figure 5-1: Relationship between scheme success and stakeholder behaviour in carrying out the expected role

One of the first hypotheses tested was whether stakeholder behaviour was correlated with programme success. This was only weakly correlated, at 0.37, and this did not change substantially when omitting those programmes with a known financial reason for lack of success. However, as shown in Figure 5-1 the majority of stakeholders carried out their expected roles (75%), and of the 25% who did not (cross-hatched in the diagram), 80% of these were in schemes that were not completely successful. The weak correlation is sufficient due to the non-linear nature of the rating system used. This meant that a decision was needed as to whether to identify factors leading to stakeholder engagement with the scheme (the original concept) or to focus on the likely issues relating to success of the programme. It was this latter approach that was taken.

5.1 Indicators correlated with scheme success

The approach taken enabled a large number of sub-indicators to be identified that had a correlation with stakeholder behaviour and/or scheme success. Further analysis of these indicators, including tests for significance, enabled the following points to be proposed as high risk issues for programme design:

- The type of organisation that initiated the programme
- The role this organisation plays in design or managing or funding the programme
- The type of organisation required to certify, inspect, licence or give any specific approvals for the scheme to be taken up (this does not include normal audit type approvals)
- Whether end-users are likely to rely on third parties (i.e. not the originator or managing agent/promoter of

the programme) to influence their decision to participate in the scheme

- The type of marketing planned for the programme
- The way the technologies are to be introduced
- Whether intermediate stakeholders (i.e. not the policy owner, designer, manager or funder) are involved in the design of the scheme e.g. through consultation process

These points are explained below in more detail, to clarify what is meant and to caution against reading too much into the brief outline.

5.1.1 The type of organisation that initiated the programme

The analysis showed that where programmes were initiated by organisations other than government (or a government agency acting for the government), there was a lower rate of success. This lower rate included programmes initiated by local or regional government. This may be influenced by the relatively small number of programmes surveyed initiated by regional government, but one might suggest that the political landscape changes more quickly and may be more dependent on personality in some local administrations than in national ones. Consequently the first issue in the design of programmes is whether the stakeholder initiating the programme has the political will, power or ability to see the programme through.

5.1.2 The role this organisation plays in designing, managing or funding the programme

There were significant differences between the success of schemes where the originator set up and designed only; set up and managed it, or set up and funded it (with management by a third party). The most successful combination was a government body setting up the scheme and handing it to a third party to run. However where a government body was responsible only for funding a scheme, there was a high risk of lack of success. This has face validity in the risk of withdrawal of funding without other penalty for an organisation not otherwise involved. Equally the more successful option has government concentrating on the initiation and general support with the third party managing agent accountable for the smooth running of the programme.

5.1.3 The type of organisation required to certify, inspect, licence or give any specific approvals

A large number of schemes required an inspection or third party approval of some type. Examples include:

- Verification of installation of measures before a grant is paid
- Inspection and approval of building standards
- Licensing or planning consent for renewable energy plant

It did not seem to make a difference whether the type of organisation involved was a government, non-governmental or commercial organisation. The existence of this requirement was shown to be a weak spot in the design of the schemes. The most successful way round appeared to be where the inspection was contracted to a commercial organisation; there was a business benefit for this work to be done. The least successful appeared to be when the task was allocated to a government or local government department. Two issues seemed to be common: lack of resources for or interest in carrying out the additional work and lack of consultation over how such inspection or licensing would work in practice. The most outstanding example of this was the national energy department failing to achieve licences for renewable installations in specific areas as these needed environmental impact assessments from the environment department.

5.1.4 Whether end-users rely on third parties to influence their decision

Limitations on data did not enable the validation of this against the type of marketing planned (next point), but the issues are probably connected. The risk is that end-users trust advisers who do not believe that the change being promotes is good, or where it is not in their own interest to persuade the end-user to take up the scheme. One respondent in the survey had to class stakeholders as ‘positive architects’ and ‘negative architects’ to classify stakeholder behaviour effectively. The former understood the issue (sustainable housing) and believed it was in everyone’s best interest for the end-user to take up the scheme (in this case a subsidy). The latter we assume feel that the extra work is not worth the effort, the subsidy not worth change, and consequently tend to dissuade potential end-users from taking up the scheme.

Where there was a positive information flow that enabled clearer understanding especially of the technical issues, it offset this reliance on those acting in their own self-interest, or just out of touch with modern science and building practice. It should be pointed out that programmes involving architecture professionals were generally well supported by their professional body, but this is a design feature for a programme.

5.1.5 The type of marketing planned for the programme

Linked with the above, where marketing was included and directed by the scheme owner to the end user, it increased the chance of success. The suggestion is that it is well focused and professionally handled. Other approaches, except for marketing by both owner and agent for the scheme, had a neutral effect. Strangely, marketing that was carried out both by the scheme owner and the agent was associated with a lower chance of success; the two logical alternative explanations are firstly, the different marketing messages confused the end-user, or else the programme itself was sufficiently difficult to put across or unpopular that it required heavy marketing. The problem here is the need for additional marketing for a risky programme rather than the risk relating the marketing itself.

5.1.6 The way the technologies are to be introduced

Using the word technology to cover not just technical innovation but also the knowledge and skills to introduce them we found that for early stage programmes, including R&D was a positive factor in success, as was the availability of reference sites for other stages. The factor most linked with success however, was the inclusion of a demonstration programme, and the more proactive this was, the more likely it was to be successful. Other combinations that did not include demonstration were highly likely to risk low achievement of objectives.

5.1.7 Whether intermediate stakeholders are involved in scheme design

For most of the countries surveyed, only the policy owner and managing agent were involved in the scheme design. The countries most likely to carry out extensive consultation amongst our seven were Denmark and UK. This design feature was added once it was realised that using the indicators above produced a good to very good correlation (0.5 to 0.78) with scheme success in a wide variety of sub-set analyses, but was woefully inadequate (0.1) for Denmark and UK in the activity culture category 3, compared with the other countries in activity culture category 2 where correlation was 0.73. This was the difference between countries that applied the view “State leads but provision of resources etc. from other sources” (category 2) and “Partnerships with organisations needed to achieve progress” (category 3). The correlation with scheme success was boosted (to 0.26) by including a weighting factor for whether intermediate stakeholders had been consulted. This is still not good, but there are clearly further issues to be investigated here which are beyond the scope of the available data.

5.2 Engaging key stakeholders with promotion schemes for RES & RUE

Are these indicators sufficient to design programmes that will engage stakeholders for successful outcomes?

As there is a difference in the ‘risk indicators’ when applied to different cultural groups, it suggests the indicators alone are not sufficient. Our model, drawn from a number of behavioural theories and augmented by the findings of this project as shown in Figure 5-2, shows the specific programme or policy factors that operate on the contributing elements of stakeholder behaviour, and further identifies the type of organisation and role it plays in the programme, but this does not show the cultural differences other than that they exist. Is this awareness of their existence sufficient? In all programme design there must be judgement exercised as to the issues to be addressed, the cost-effectiveness of measures, what levels of uptake to expect . . . in fact, all the questions that must be answered in the design of a programme.

What is needed is for a framework that enables the scheme designer, in the situation of their own culture, to determine how much risk attaches to a specific situation, when they have detailed knowledge of the actors.

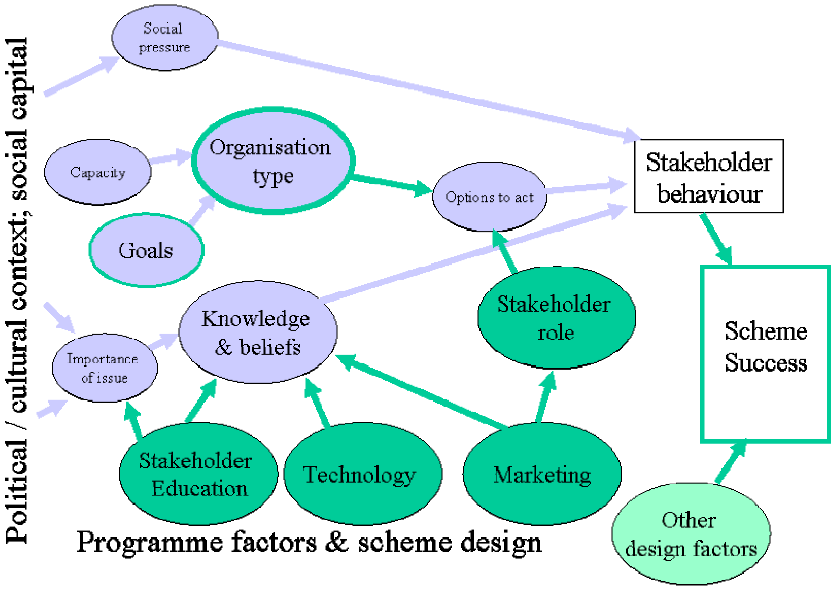

Figure 5-2: Model of stakeholder behaviour responding to scheme design

One way of thinking about this is to consider a process for designing a programme and to identify the stages at which stakeholder engagement is necessary, desirable, or appropriate. This approach is similar to that of a value chain (see for example, Kasanen 2001)[12].

In Figure 5-3, the left hand column depicts the typical stages of the design of a programme, including a loop from the testing phase back to redesign of the programme (it could arguably go to stage 3 or earlier). At each stage consideration should be given to the role that stakeholder engagement might play. The strength of the arrows connecting the stakeholder role on the right with the programme design on the left show the importance of this engagement.

The role of the stakeholder in Stage one is often overlooked; problem definition is implicit at this stage from the viewpoint of the programme owner, often a government body. Often though, different stakeholders have entirely different views as to what the problem may be - so input into framing the problem, from which the aims are derived, might be quite important. This will inevitably lead to some form of politicisation though, which can be thought of as a risk. However, it is important to address the risk at this stage, as it can save a great deal of time later (and discovery of lack of stakeholder support) if it turns out that stakeholders hold very different views from the initiators, or even mutually opposing views to each other.

Stage two is particularly important for the involvement of stakeholders involved in the supply side of the scheme (not necessarily energy supply side). Stage three, likewise, should address the demand side stakeholder s. How acceptable is this programme to them? Involvement in Stage four assists in resolving rollout/logistics and funding issues with stakeholders, and both four and five are important for involvement of those actually directed to deliver the programme, or its constituent parts.

As a precursor to implementation many programmes include a trial, pilot, or scenario testing phase. This experimentation is very valuable, and may lead to feedback loops to primarily 4 and 5 (one would hope) but maybe a lot further back depending on outcomes!

Seven really depends on the deliverables; it maybe that the programme can only be delivered through stakeholders, and stakeholder involvement is not indicated here as a separate issue. It may be may be difficult to get stakeholders to take part in stages eight and nine, monitoring and evaluation, unless it is actually their business role to carry out these tasks. Getting a commitment early on for these stages from those stakeholders affected might help.

This approach, involving stakeholders throughout the design of a programme is not uncommon in the UK and Denmark, as shown by best practice guidance such as that published by the Council for the Protection of Rural England (CPRE 1990)[13].

[12] Kasanen, Pirkko 2001 " Value chains and energy efficiency measures" In *Further than ever from Kyoto? Rethinking energy efficiency can get us there*. Proceedings of Summer Study 2001, eceee, Stockholm

[13] CPRE 1990, "Environmental Statements: Getting them right" CPRE, London England.

What may be needed is a more generic approach that enables the programme designer to test the likely acceptability of a particular approach to the key stakeholders (particularly those who would be affected by the scheme, or who would be asked to adopt the output from it).

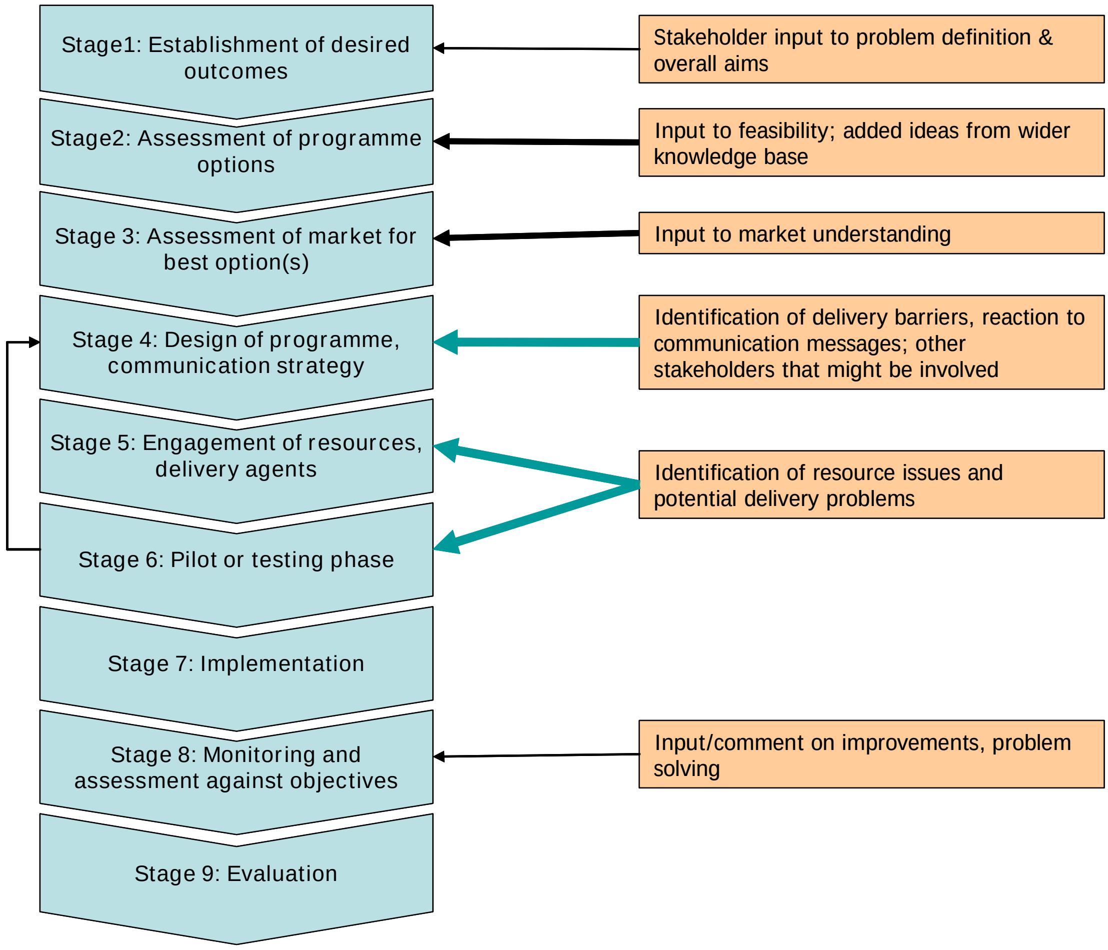

Figure 5-3: Value chain for programme design and delivery with stakeholder engagement points

At this stage, however, it is possible to consider the key risk areas discovered by **Invert** and ask whether there are points at which these risks can be alleviated. The programme designer familiar with techniques such as control point analysis would carry out this assessment during the course of implementing the technique. It simply asks at each stage in the programme design "What could go wrong", " When will I know" and "How can I prevent it or fix the problem". Awareness of the stakeholder risk can ensure that these points are assessed at the appropriate points.

Without such a formalised approach however, the key risk areas could be assessed using the staged approach above, as shown in Table 5-1:

The table shows that for most instances, the key risks should be considered at most stages. However they can be placed very specifically in the stages of designing a programme as shown in Figure 5-4.

At stage 1, the scheme designer needs to know that, from the **Invert** research, it is not necessary for the initiator to be involved in the implementation or actual monitoring of the programme, but the initiator may need to be involved in the rest of the stages if the programme is to meet its objectives. If the initiator is also organising, managing or funding the programme, the involvement throughout becomes much stronger.

The organisation required to provide inspections or certifications in stage 7 can be involved as early as possible in the design process to enable any key issues such as lead times or capacity to be addressed. At the very least they must be involved at stage 5. Understanding the thought processes of third party advisers, and building in their suggestions, is likely to reduce the risk that they bring to the scheme, and they too should be involved by stage 5. It seems likely that marketing need not be considered until the assessment of the market for the options, but awareness of the type of technology and the crucial nature of provide access to demonstrations suggests this should be included from stage 2, and therefore stakeholders with knowledge of technology introduction need to be included. Finally the intermediate stakeholders, those who have an interest but not necessarily a responsibility, are the ones who are really the beneficiaries of this value chain approach, as they are the ones whose input is identified throughout the process as shown in Figure 5-3.

Table 5-1: Stages of the scheme design and consideration of key risk elements

Risk element / involvement stage of design	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
The type of organisation that initiated the programme	✓	✓	✓	✓	✓	✓			✓
The role this organisation plays in design or managing or funding the programme	✓	✓	✓	✓	✓	✓	✓	✓	✓
The type of organisation required to certify, inspect, licence or give any specific approvals for the scheme	✓	✓	✓	✓	✓	✓	✓	✓	✓
Whether end-users are likely to rely on third parties to influence their decision to participate in the scheme	✓	✓	✓	✓	✓	✓	✓	✓	✓
The type of marketing planned for the programme			✓	✓	✓	✓	✓	✓	✓
The way the technologies are to be introduced	✓	✓	✓	✓	✓	✓	✓	✓	✓
Whether intermediate stakeholders (i.e. not the policy owner, designer, manager or funder) are involved in the design of the scheme e.g. through consultation process	✓	✓	✓	✓	✓	✓		✓	✓

5.3 Conclusions and recommendations relating to stakeholder engagement

The conclusions from this work are that there are quantifiable risks associated with engaging certain types of stakeholder or not during the design of the promotion scheme, and that the design elements of the scheme can be directly related to the success of stakeholder engagement with the scheme.

It is clear that using a formal programme design methodology, these risk elements are more likely to be identified, especially where the culture of engaging stakeholders is already adopted in a country. However, the actual type of engagement, and the tools with which to engage them, may be more highly developed in some countries than others. Further work is needed, for example for countries such as Denmark and UK where stakeholder consultation is more regularly practised, to identify whether new strategies are needed to ensure that the technologies are acceptable to the stakeholders or the methods for public participation or marketing are more likely to achieve take up of the technology being proposed in the promotion scheme. Indeed the issue may be more to do with partnership working and the implications therein of shred financial risk, than just the issue of stakeholder engagement.

The applicability of existing strategies to other cultures is also worth examining. It should not be assumed that the strategies developed over many years in one culture are ready to be transferred to another, where the base assumptions about key life issues may be very different.

The formal requirements of the work phase are delivered as follows:

- *Benchmarks for successful policies together with a set of logical combinations for success*:
    - o successful policies are initiated by organisations with the authority and commitment to seeing the scheme through

- successful policies consider the stakeholders that have an inspection or licensing role at an early stage
- successful policies tend to be well designed and to have considered risks

- *Evaluation of less successful policies with learning points for future developments*
  - Less successful policies tend to have a higher rate of stakeholders who do not carry out their expected roles, or not early enough in the project
  - Less successful policies tend not to pay sufficient detail to informing the end user of the benefits of the policy, whether through marketing, demonstration or education

- *Discussion of the impacts of different policy factors on target group behaviour*
  - Key target groups are most affected by advisers knowledgeable about the RES or RUE measure being promoted; informing these advisers is important
  - Appropriate marketing, education and demonstration opportunities are key to engaging the target groups attention and positive response

In summary, then, the recommendations are:

- Scheme design takes a formal, methodological approach to risk assessment and incorporates stakeholder risk elements
- Where stakeholder engagement is regularly practiced, further work is needed to establish more closely the relationship between scheme design and programme success. In particular the differences in approaches when partnership working is required needs analysis.
- Further work is undertaken to establish whether it is possible to identify what makes one technology (including both RUE & RES measures and the means by which they are introduced) more acceptable to end-user and affected stakeholders

Further work is undertaken to determine whether there are strategies for improving stakeholder, particularly end-user perceptions of new technologies in order to reduce the risk of rejection.

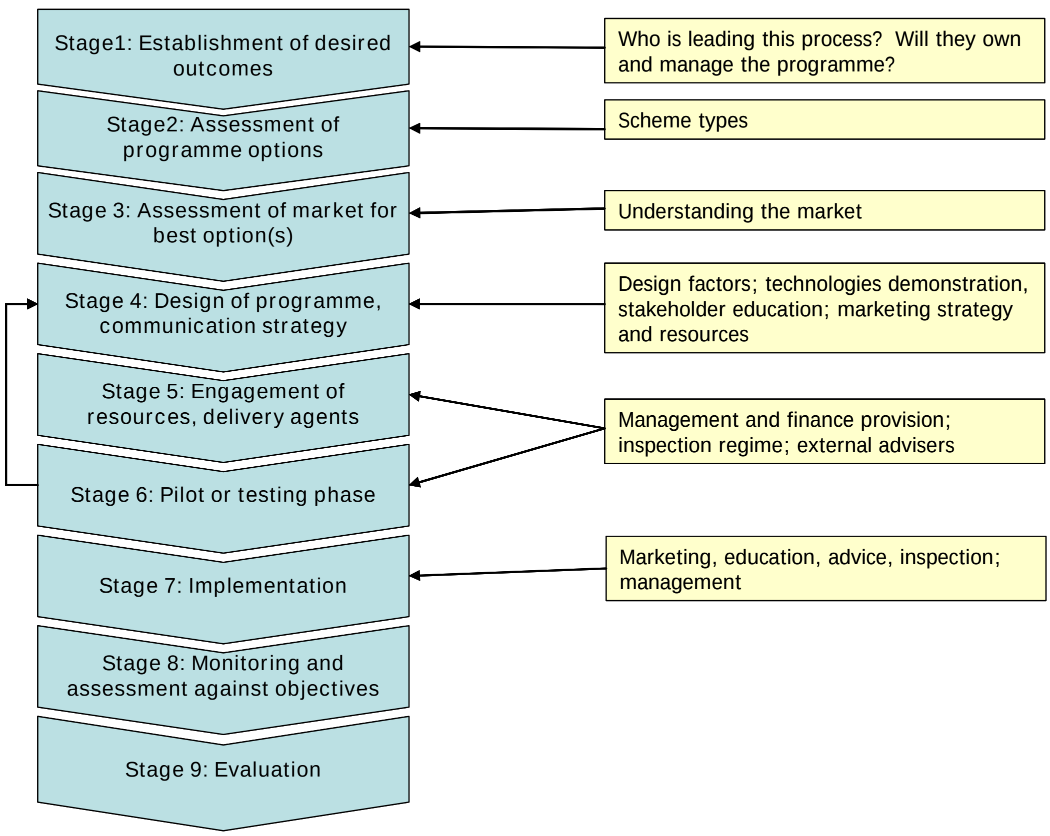

Figure 5-4: Areas of risk in developing a promotion scheme: key issues for stakeholder involvement

6 EFFICIENT PROMOTION OF RES & RUE: FINDINGS FROM REGIONAL INVESTIGATIONS

6.1 Survey of case studies

This part of the report presents the key outputs and recommendations of the case studies carried out in Baden-Württemberg (Germany), Vienna (Austria), Jordanow (Poland), Crete (Greece) and Denmark.[14]

6.1.1 Germany - Baden Württemberg

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

Simultaneous support for RES and conventional heating systems

In Baden-Württemberg a substantial bundle of RES and RUE promotion schemes exists. Some building refurbishment programmes are also including support for modern heating systems as condensing and low temperature based on conventional energy carriers.

It turned out that simultaneous promotion of conventional heating systems suppresses the enforced use of RES systems: a removal of promotion for conventional systems would results into considerable CO_2 reduction at a high promotion efficiency because significantly less gas heating systems and much more wood heating systems would be applied (Figure 6-1).

Additional state promotion

Another analysis concerns possible conflicts between national and regional programmes ('global versus local optimum'). On federal level a 20% subsidy for wood heating systems is provided in Germany; in Baden-Württemberg a cumulating option with state promotion programmes up to 30% is possible. It turnes out, that the instrument of additional state promotion for wood heating systems in Baden Württemberg gives the critical incentive for just crossing the threshold of profitability for this specific RES application combined with a high promotion efficiency. This example therefore demonstrates the possible benefit of local governments when supplementing a federal promotion policy.

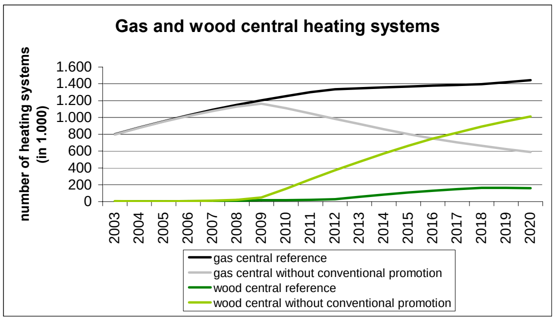

Figure 6-1: wood and gas heating systems for reference scenario and without conventional promotion[15]

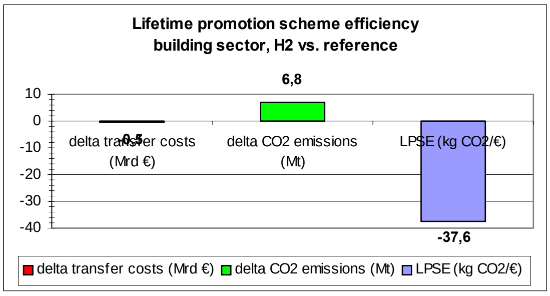

Figure 6-2: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (removal of additional state promotion)

Tax exemption for bio-fuels

Germany provides a complete tax exemption for bio-fuels. The current legislation of full tax exemption for bio-fuels seems to be an unnecessarily generous support for bio-fuels and thus a waste of public money. A partial tax exemption of 70% for bio-fuels for transport would be sufficient to push bio-fuel price under the reference diesel price and therefore to create the corresponding market. The difference between 70% and 100% tax exemption is wasted money with the only effect

[14] For more detailed information, data and tested hypotheses please see the report of WP6 "case studies".

[15] Please note that the pictures of the German case study are shown with German comma settings.

of reducing the promotion efficiency. The wasted money (the dotted curve in Figure 6-3) amounts cumulated to ca. 140 M€ until 2020.

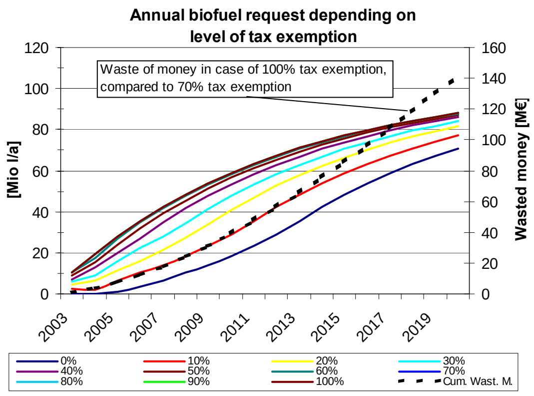

Figure 6-3: Annual bio-fuel request depending on level of tax exemption

Sensitivity analysis: energy price

The following example 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 energy sources: no increase, 1%, 2.5 % and 4% increase per annum. The 2.5 % level is corresponding to the reference scenario.

In the case of solar thermal systems the main effect – an increase from 35,000 in 2009 to 200,000 systems in 2020 – occurs already in the reference scenario (2.5 % energy price increase) while no increase of solar thermal 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 solar thermal systems (up to 2006) and raise the number in 2020 up to 280,000 (Figure 6-4).

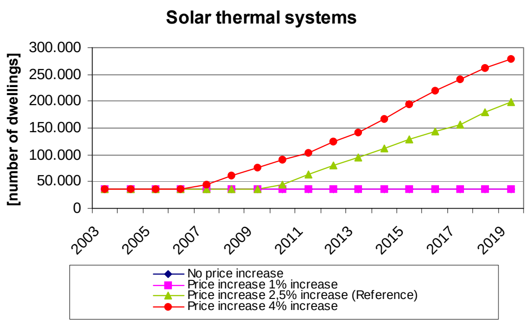

Figure 6-4: Number of solarthermal systems depending on energy price increase

While the impact of energy price increase on the penetration of solar thermal (or also wood heating) systems is rather high, it is comparatively low with regard to DSM measures as shown in Figure 6-5. 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 a considerable share of possible DSM measures will be already enforced in the reference scenario.

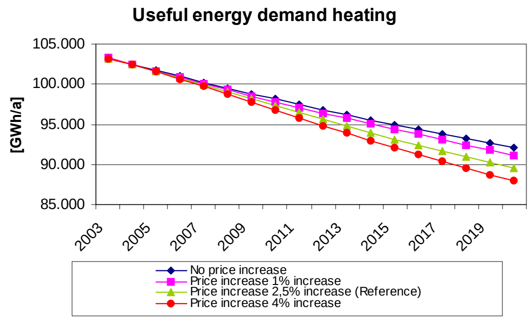

Figure 6-5: Useful energy demand for heating depending on energy price increase

6.1.2 Austria - Vienna

Due to the urban structure of Vienna, the relatively low potentials for RES (especially biomass and bio-fuels) as well as the focus of current promotion schemes on the building part, the case study of Vienna is restricted to the building part.

Varying the level of DSM subsidies:

Increasing the investment grant for insulation by 10€/m² leads to rather high CO_2 reductions (Figure 6-7).

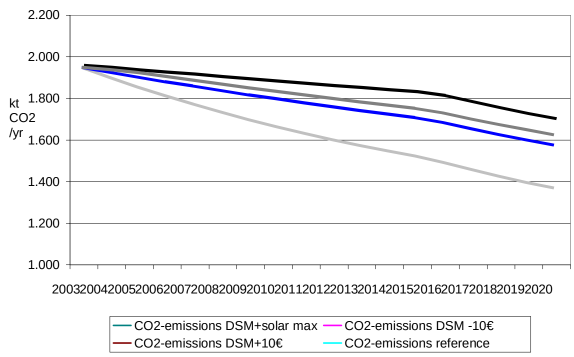

Figure 6-6: CO_2 emissions heating and DHW, DSM, Vienna, depending on DSM subsidy level

The promotion scheme efficiency (LPSE) varies between –10 kg/€ and –4 kg/€ when varying the level of subsidy by –10, +5, +10 €/m² (Figure 6-7). As for most promotion schemes, the promotion scheme efficiency is getting lower with higher grants, because this implies the promotion of expensive, less efficient applications.

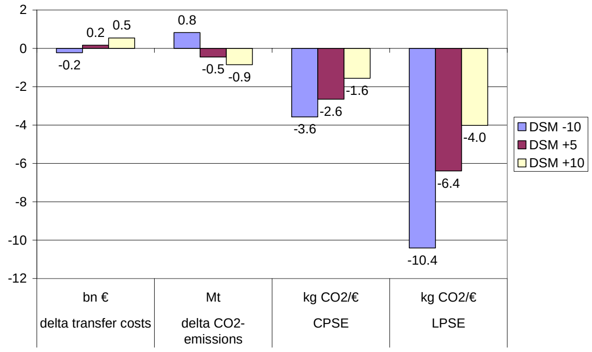

Figure 6-7: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (changing the level of DSM subsidy)

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

<u>Removal of all existing subsidies for gas condensing boilers:</u>

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.

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.

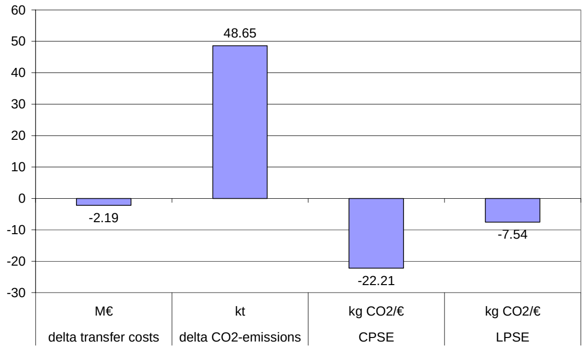

Figure 6-8: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency (LPSE) for building sector (removal of gas condensing boiler promotion)

<u>Extending of subsidies in district heat supply areas</u>

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. Therefore, some hypotheses investigate the impact of extending these subsidies also to buildings, which have optional access to district heating, with following results:

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.

Extending the existing biomass subsidy to the district heating supply area leads to a promotion scheme efficiency of about -3 kg/€ (CPSE).

Extending solar thermal subsidies to district heating areas does not result into a 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.

6.1.3 Poland – Jordanow

Promotion of small biomass boilers for rural areas

In recent analyses of the barriers, which hamper the development of biomass energy in the new member states emphasis is often put on the investment cost, which is too high for individual households, especially in rural areas, to install a new biomass boiler. The agricultural sector in Poland is dominated by small and medium-sized farms. 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. However, the main barrier for the coal to biomass conversion is the level of investment costs. In an attempt to overcome this barrier, a project has been suggested, aiming at decreasing the investment costs by combining the financial support schemes (subsidies) with using economy of scale effects to be achieved by bundling a number of small projects into one package.

The **Invert** model was used to assess the effect of subsidies on the dynamics of conversion from coal to straw.

Figure 6-9 shows CO_2 reduction and efficiency for different subsidies ranging between 20 and 40% and for hypotheses assuming further increase of straw price,

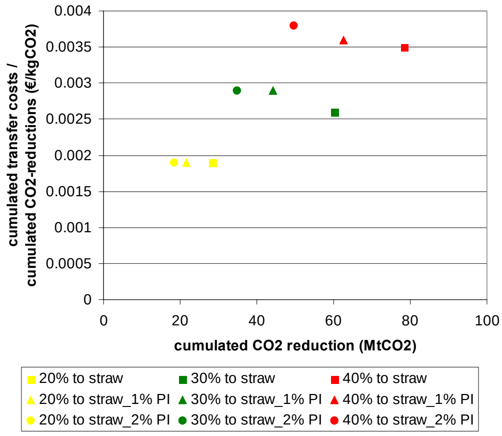

Figure 6-9: Impact of subsidies to straw 2004-2020

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.
- 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.

RES vs DSM subsidies (case study for Jordanow)

The combination of subsidies to conversion from (fossil) fuel to biomass and subsidies to DSM was investigated with underlying different aspects: a) with and without replacement of windows, b) increase of biomass price, c) CO_2 tax with strongly hypothetical values: 10, 20 and 30 EUR per tonne (with the present level of 0,04 EUR).
A very important conclusion valid for all investigations 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 achieved 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.

In the case of investigated impact of CO_2 tax, it is important to emphasize that in all cases – even for high subsidies as shown in Figure 6-10 – the cumulated additional public income is much higher than the entire transfer costs.

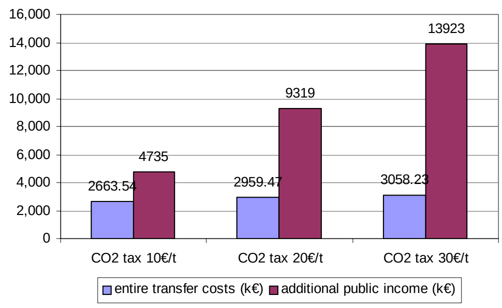

Figure 6-10: Additional public income vs. entire transfer costs for 30 % subsidy to DSM&RES

6.1.4 Greece – Crete

Crete offers a very specific situation because of island site, high solar radiation and low population density.

RES-E subsidies

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) apart from minor capacity increase of wind power and small scale hydro. Total electricity production by RES would not reach more than 212 GWh/yr

A stronger promotion policy on biomass (plus 20% investment grants) could double the electricity production from RES until 2010 with low transfer costs. Cumulated promotion efficiency is ca. 7.3 kg CO_2/€ from 2004 to 2020

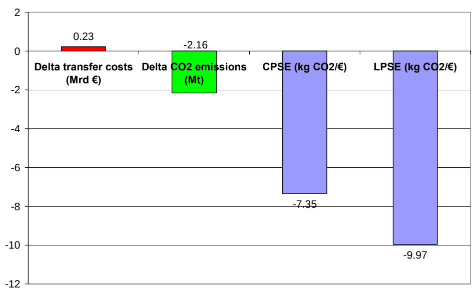

Figure 6-11: delta transfer costs, delta CO2 emissions, CPSE and LPSE RES-E sector

Feed in tariffs

Crete's energy system is not interconnected to mainland. Feed in tariffs for not interconnected islands are 0.079 €/ KWh and refer to independent producers.

The impact of raising of feed in tariffs by 10 €-cents/ KWh was investigated. Main results

- Biomass, pumped storage systems and solar thermal power plants come in force from the first year of simulation runs (2004)

- CO_2 emissions reduce by about 230 kt/yr until 2017 and about 40 kt/yr from 2018 to 2020

- CPSE is ca. 5.8 kg CO_2/€ in 2020, LPSE is ca. 6.9 kg CO_2/€ (Figure 6-12)

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

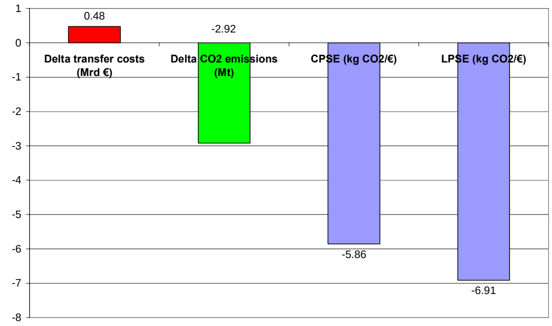

Figure 6-12: Cumulated delta CO_2 emissions, delta transfer costs and promotion efficiency for electricity sector (higher FIT)

DHW systems

An area of more than 80,000 m^2 solar thermal systems (133 m^2/1000 persons) is installed in houses and hotels on the island and covers 3% of the total energy demand of Crete. However, there is no subsidy for small scale solar thermal systems, and therefore it is interesting to investigate the impact of introduction of subsidies on a possible more extensive penetration of solar thermal systems. A specific state promotion (40% investment grants) for solar thermal systems would increase the use of solar energy for domestic hot water, mainly in multi family houses, with high promotion efficiency. The number of solar thermal systems installed in dwellings will rise by 25% until 2020 (Figure 6-13).

Figure 6-13: Number of dwellings – DHW in reference case (above) and with promotion on solar thermal (below)

6.1.5 Denmark

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

CO_2 tax in building sector

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

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.

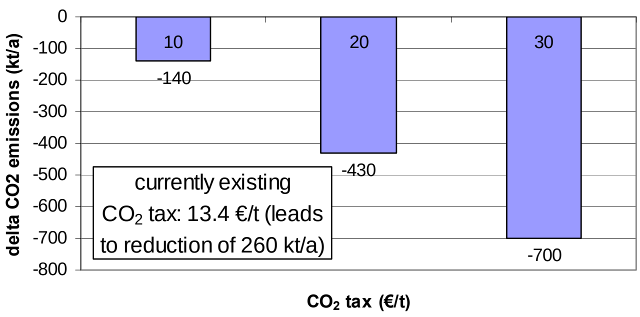

Figure 6-14: Reduction of CO_2-emissions depending on CO_2 tax level

The graph in Figure 6-14 shows the calculated change in CO_2-emissions (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.

Generally, great 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.

RUE promotion through 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.

Generally, the changes in CO_2-emissions in conjunction with these types of promotion schemes are limited according to the modelling results - even in the combined scenario of insulation and window replacements. As shown previously in this chapter, even a modest increase of the CO_2-tax will have a much higher impact than any of the six options covered in the above graph.

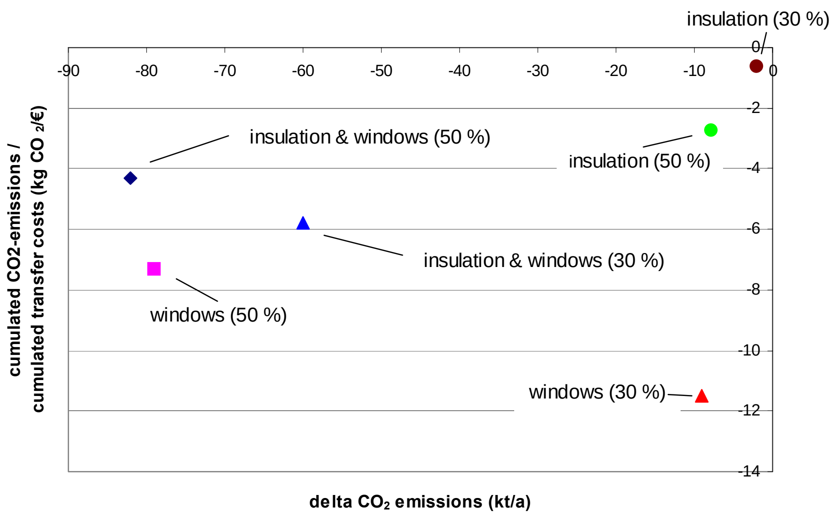

Figure 6-15: Promotion scheme efficiency vs delta CO_2 emissions

6.2 Deriving the optimum policy mix

One of the basic ideas of **Invert** is the comparison of promotion schemes: *How efficient are various instruments when it comes to promoting renewable and energy efficient technologies and reducing CO_2-emissions?*

How many tonnes of CO_2 can be saved by spending a certain amount of money for promoting RES and RUE technologies?

As pointed out above,[16] a key output of **Invert** simulation tool is the promotion scheme efficiency: the ratio of the change in CO_2-emissions and the change in transfer costs compared to a reference scenario. Looking at the results gained from the case studies, we can find out that there is quite a big variety of the efficiency for various measures.[17] However, it turns out that the measures with the highest efficiency often are those resulting in the lowest CO_2 reduction. This goes along with the intuitive presumption that the required amounts of public budget for reducing higher amounts of CO_2-emissions increases on a progressive scale. When it comes to evaluating and comparing of promotion schemes it is necessary to consider both the efficiency (kg CO_2 saved per €) and the effectiveness (kg CO_2 saved) of an instrument in an integrated manner.

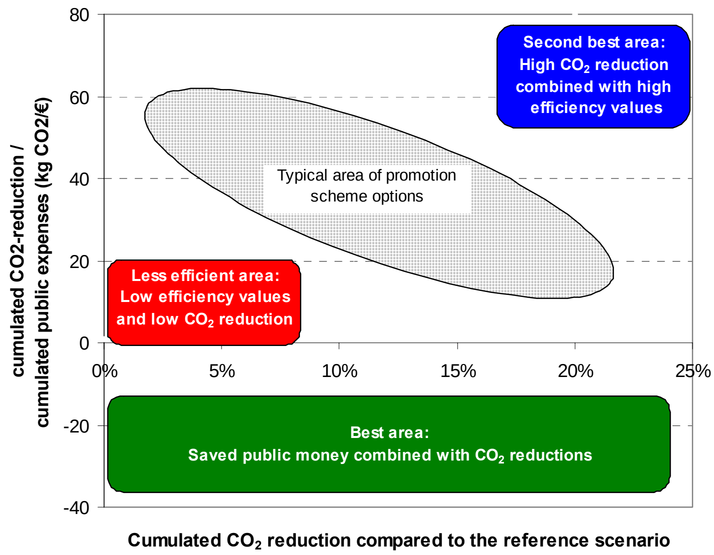

Figure 6-16: Efficiency-CO_2 graph – basic principle

Figure 6-16 shows the basic principle of an efficiency-CO_2-graph integrating these two important aspects for evaluating promotion schemes: efficiency and effectiveness. It can be seen that there is one area where CO_2-reductions can be achieved with negative costs (on the bottom of the figure). Measures in this area typically refer to the abolishment of counterproductive subsidies for fossil energy technologies. Besides, from these measures of course it would be most favourable to find instruments resulting in a very high reduction of CO_2-emissions at very high efficiency levels. This refers to the area on the top and the right hand side of the figure. However as it is well known, cheap CO_2-reduction potentials are limited and so the typical area of promotion scheme options are in the middle of the graph: Increasing the level of a scheme typically increases the CO_2-reduction but decreases the efficiency. Measures (and mix of measures) situated in the left bottom part can be regarded as not efficient, because the same amount of CO_2 could be saved with a higher efficiency, i.e. with a lower amount of public budget.

So, single promotion schemes can be compared to each other with respect to the efficiency and achievable CO_2-reductions by using this graph. Figure 6-17 shows exemplary results for some technologies in an urban region[18]: The efficiency and the potentials are quite different: Scheme for supply systems (in this case biomass and district heating) in general show higher efficiencies, but lower CO_2-reduction potentials than DSM options.

However, when it comes to promotion scheme design, the whole policy mix consisting of various measures for various technologies has to be considered. The options for the policy makers usually consist of a large number of combinations of different levels of promotion for different technologies. In Figure 6-18 the case of increasing the level of a certain promotion scheme coming from the current policy mix has been considered for two typical cases.

[16] See part 4.3 of this report.

[17] See part 6.1 and 6.3 of this report as well as the report of WP6 “case studies”.

[18] These results refer to the case study Vienna. More information is included in the report of WP6 “Case studies”.

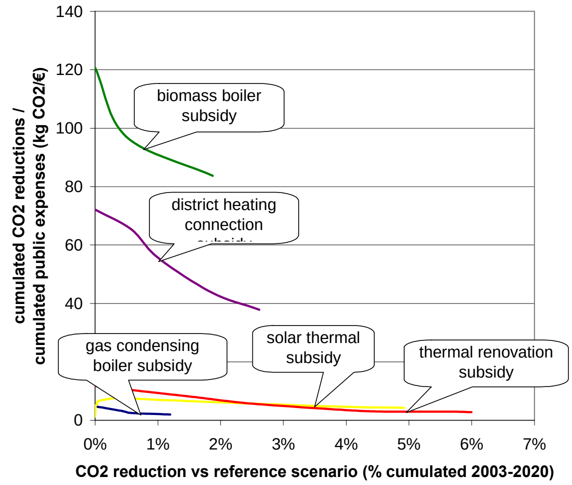

Figure 6-17: Efficiency-CO_2 graph – single promotion schemes

In both cases, the promotion scheme efficiency of the currently implemented policy mix is 15 kgCO_2/€.

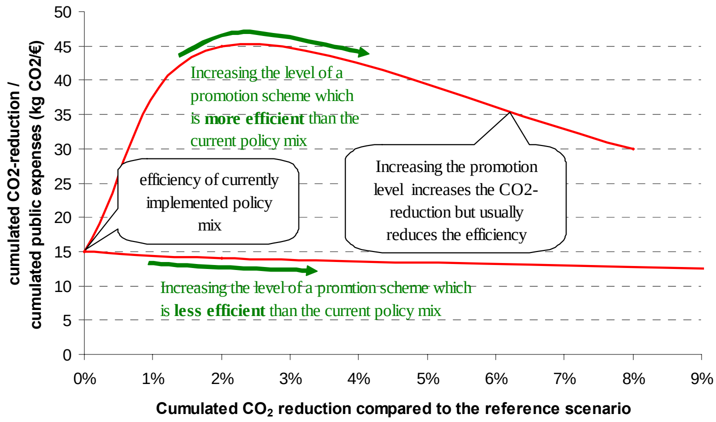

Figure 6-18: Efficiency-CO2 graph – typical characteristics

In the upper curve, the promotion scheme efficiency at the beginning strongly rises by increasing the level of incentive for efficient promotion scheme or rather technology compared to the efficiency of the current policy mix. Therefore, total efficiency of the whole promotion mix rises. The same amount of CO_2-reduction could be achieved with a smaller amount of public money compared to the case of extending the current policy mix for all technologies in the same magnitude. Or in other words, the additional reduction of CO_2-emissions does not lead to an increase of specific CO_2-abatement costs. Hence, this technology currently is under-represented.

However, it turns out that the efficiency declines again with higher values of promotion. This has two major reasons: First, the scheme now addresses more expensive CO_2-reduction potentials. This results in higher costs and thus a lower efficiency. Second, for an increasing number of people, those high promotion level represent over-subsidisation. The lower curve in the figure shows the case of a promotion scheme, which can reduce CO_2-emissions, but not with a higher efficiency than in the current policy mix. This curve represents an extension of the currently existing policy.

Combining a number of different policy options, we can create a set of such curves. This set corresponds to the variety of policy options resulting in different levels of CO_2-emissions with different levels of efficiency. The envelope of this set represents the optimum policy mix for a certain CO_2-reduction target.[19] Of course, the policy maker may conclude that with respect to other policy goals it may be reasonable to decide for a portfolio that is not exactly on the envelope curve, but a little bit lower. However, in this case the envelope may be a guide for the specific policy strategy selection.

Summing up, the optimum policy mix strongly depends on the amount of CO_2-reduction, which shall be achieved.

Moreover, the curve indicates whether the current mix of policy instruments is the most efficient one in terms of saved CO_2-emissions per Euro of public budget spent[20]: If a point on the envelope exists with a higher value of CO2-reduction per Euro compared to the current policy mix, an efficiency improvement takes place.

The following part shows some results of this curve for case studies carried out within the project **Invert**.

[19] It has to be noted that the exact shape of the envelope-curve depends on the number and type of combinations, which are carried out for deriving the set of curves. Therefore, the concept relies on the assumption that the most efficient combinations are included within the simulation runs.

[20] Of course, it has to be noted that there are always additional other policy goals (e.g. energy saving, employment, welfare, …)

6.3 Comparative analysis of regions

This chapter provides exemplary results from the efficiency-CO_2-curves described above.

In all investigated cases, the promotion scheme efficiency[21] shows a quite large range. In the Western and Southern regions[22], the values go from 5 to 60 kg CO_2/€. In Poland the promotion scheme efficiency lie in a range of about 5-650 kg CO_2/€. Besides the lower purchasing power parity, the following reasons can be identified for these substantially higher efficiency values in Poland:

- the current dominant position of coal in the heating sector with high specific CO_2-emissions;
- low current state of promotion schemes: even very attractive policy options are not tapped in the current policy mix;
- lower costs for biomass heating technologies compared to Western European countries
- high biomass potentials.

The impacts of these factors are more detailed explained in the chapter 6.4.

Regarding the promotion of different technologies, in the building part, for all investigated regions a clear ranking of measures with respect to efficiency-values could be identified:

(i) If possible, removing counterproductive schemes for fossil fuels is the most efficient measure: CO2-emissions can be reduced by simultaneously saving public money.

(ii) Schemes for supply side measures are the second option in the "efficiency ranking".

(iii) DSM (insulation and window replacement) is generally the option with the least value of the efficiency. Among the demand side measures window replacement is the one with the least cost efficiency. Nevertheless, due to aesthetical and comfort reasons window replacement is one of the most applied measures.

However, in order to achieve ambitious levels of CO_2-reductions it is indispensable to focus also on those measures with lower efficiency values. Particularly in regions where biomass potentials are rare or other high barriers exist (like in urban regions), there is no way to achieve ambitious CO_2-targets without DSM.

Figure 6-19 shows that combining a certain supply side scheme (e.g. subsidy for biomass boiler) with increasing levels of DSM subsidy leads to higher CO_2-reductions. However, there is no way to avoid lower efficiency values. The amount of efficiency-reductions as well as reduced CO_2-emissions of course depend on region specific conditions (climate, building stock, current heating systems …).

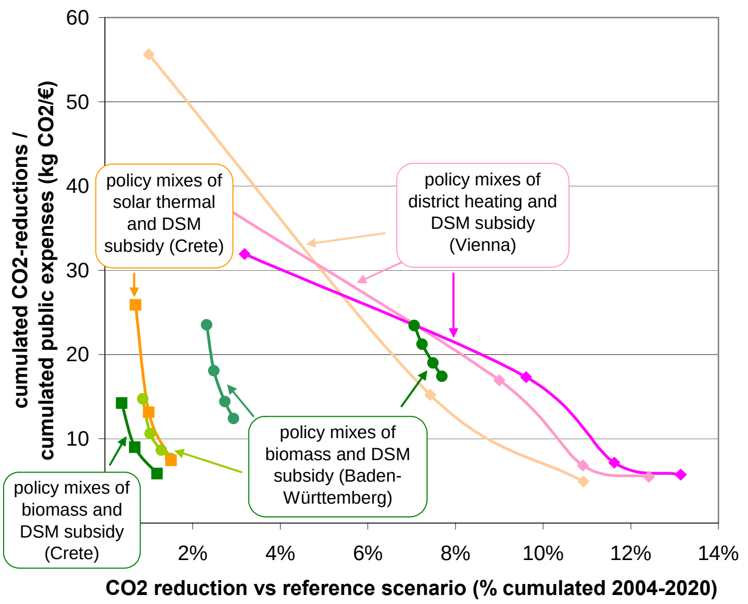

Figure 6-19: Combining RES & RUE promotion schemes in the building sector

Figure 6-20 to Figure 6-23 present the main combinations of various promotion schemes in the heating and domestic hot water sectors in the investigated regions. The envelope of each set of curves represents the most efficient policy mix for a certain CO_2-target. The envelope curves show quite different shapes in the different regions. These differences are due to the region specific characteristics:

[21] The values presented in this chapter refer to the lifetime promotion scheme efficiency, as described in chapter 4.3.

[22] Baden-Württemberg, Crete, Vienna, Denmark

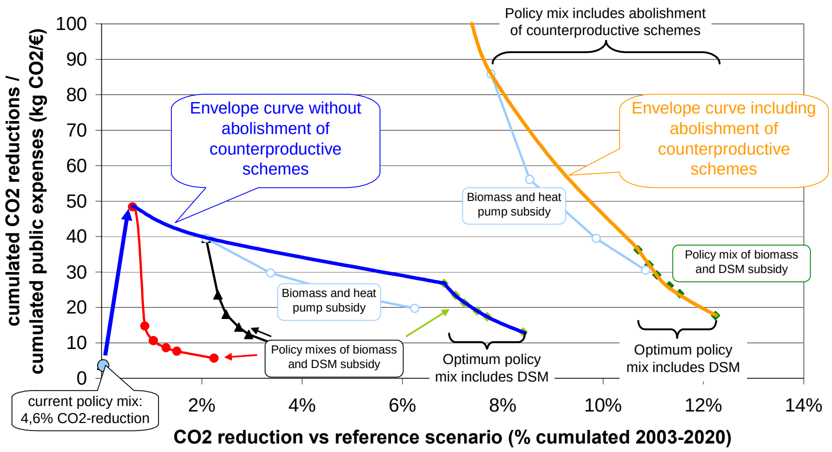

Figure 6-20: Efficiency-CO_2-graph (building sector) Baden-Württemberg (Germany)

<u>Baden-Württemberg</u>:

The efficiency-CO_2 graph shows that an increase in the biomass subsidy would be the measure with both the highest CO_2-reduction potential and attractive efficiency values. In the bottom left part of Figure 6-20, various policy mixes of biomass, DSM and heat pump subsidies are depicted.[23] A maximum of nearly 7% CO_2-reduction could be achieved by biomass subsidies. For higher reductions, less

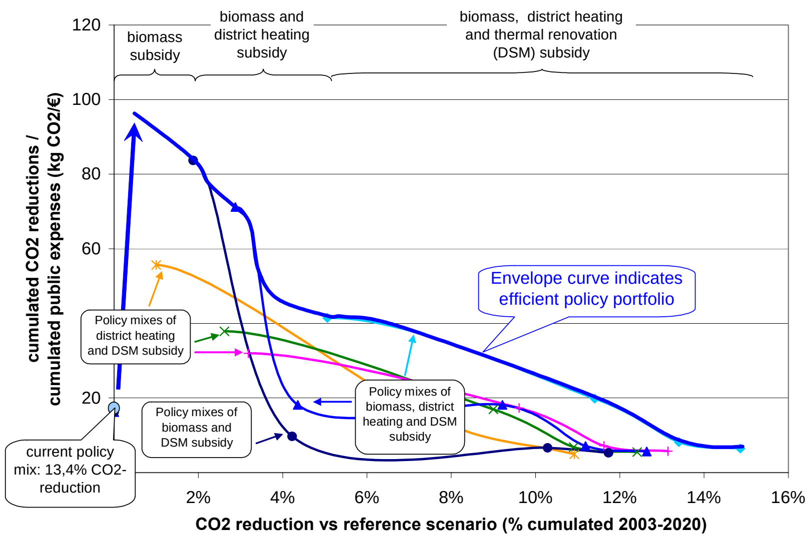

Figure 6-21: Efficiency-CO_2-graph (building sector) Vienna (Austria)

efficient options like DSM, heat pumps and solar thermal collectors have to be added to the policy portfolio.

However, if the abolishment or reduction of conventional promotion schemes (i.e. subsidies for efficient fossil boilers) is also considered, higher CO_2-reductions with much higher efficiency (i.e. lower costs) could be achieved. More than 4% of the CO_2-emissions could be reduced even at negative costs. Hence the abolishment of counterproductive schemes for fossil heating systems should have the highest priority.

The envelope curve shows that 12% of CO_2-emissions cumulated until 2020[24] could be saved additionally until 2020 by increasing the efficiency at the same time from currently 4kg CO_2/€ to nearly 18 kg CO_2/€.

<u>Vienna</u>:

The highest potential for CO_2-reduction in Vienna's building sector is an increase of the subsidies for thermal renovation. Almost 10% of total 15% CO_2-emissions which could be saved additionally until 2020 is due to demand side measures. However, this policy is not the one with the highest efficiency (kgCO_2/€). Promotion schemes for biomass and connection to district heating show much higher efficiency values. Of course, for biomass heating systems typically high barriers exist in urban areas. However, if those barriers could be overcome (e.g. by increasing the subsidy in the outskirts where no district heating is available), biomass would be the most efficient option for CO_2-reduction in the building sector of Vienna, see Figure 6-21. District heating is the second efficient supply-side measure. However, in order to

[23] Some policy mixes (e.g. solar thermal promotion) have been skipped in order to keep the figure clear.

[24] Please note that all figures in this part of the report refer to the sum of cumulated CO_2-emissions 2003-2020. Hence, a reduction of 12% CO_2 cumulated until 2020" means that in the beginning of the simulation period the annual reduction is below 12%, but in the end clearly higher than the average value of 12%.

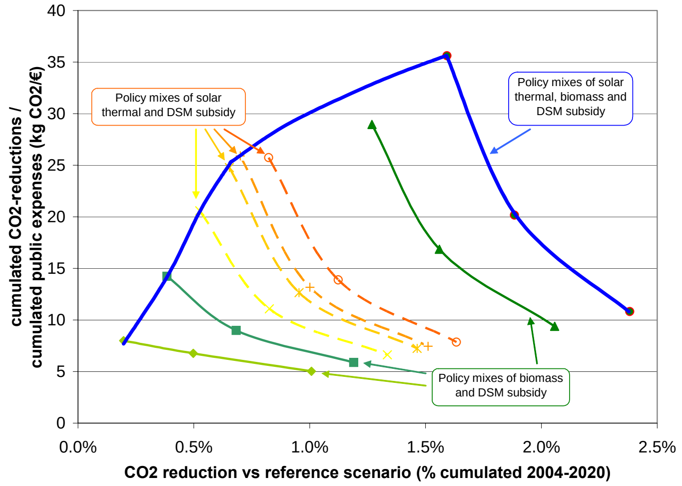

Figure 6-22: Efficiency-CO_2-graph (building sector) Crete (Greece)

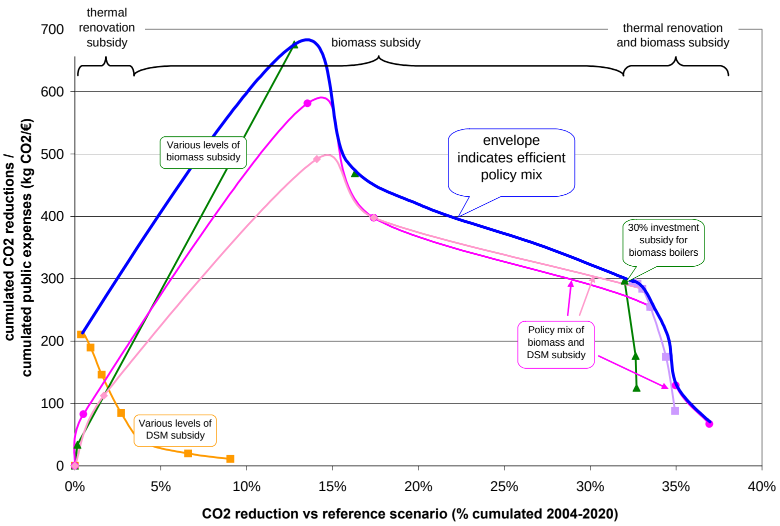

Figure 6-23: Efficiency-CO_2-graph (building sector) Jordanow (Poland)

achieve an ambitious target of additional CO_2-reduction beyond 5% additionally, the currently existing subsidy for insulation would have to be increased, even though this results in a loss of efficiency (i.e. higher costs). In contrary to the Baden-Württemberg, the CO_2-reduction potential of thermal renovation clearly exceeds the potential of supply side measures.

The envelope curve reveals, that the implementation of the optimum policy mix could lead to an increase of CO_2-reduction of additional 12% without any loss of efficiency (i.e. without higher specific CO_2-abatement costs) compared to the current policy mix.

Crete:

Due to the geographic situation, Crete is a region where the promotion of solar thermal system would be a quite attractive option. Nevertheless, currently there are no promotion schemes for these systems. Making use of the biomass potentials of Crete for heating purposes would be attractive, too. However, as Figure 6-22 shows even by combining solar thermal, wood and DSM promotion, only less than 1.5% of the CO_2-emissions in the building sector could be saved. Of course, this is because a considerable amount of energy is required for cooling purposes.[25] Hence, the share of heating energy demand on the total energy demand in the building sector is smaller than in northern regions. The specific form of the curves of supply side options with positive gradient is discussed below in this chapter.

Jordanow (Poland):

The analysis of the city of Jordanow in Poland shows that a subsidy for biomass heating boilers represents the option with the highest efficiency as well as and the highest CO2-reduction potential. More than 30% of the CO2-emissions in the building sector could be reduced by this measure. It should be mentioned that an investment subsidy higher than 30% would be inefficient, leading to waste of money. The reason is that: the PSE-curve has a very steep decline at this point. Figure 6-23 shows that the efficiency (LPSE) loss (i.e. the difference) between the pure biomass and the curve representing the biomass and DSM policy mix) is not very high. This should be taken into account when it comes to the policy design, considering the possibility of future stronger price increase for biomass.[26]

[25] Technologies like insulation, window replacement and various cooling technologies have been included in the analysis. However, passive cooling, solar cooling etc have been neglected.

[26] Other price scenarios have been calculated in the case study investigations, but are not presented in this graph.

Combining biomass and DSM subsidy would result into a total CO_2-reduction of more than 35% with an efficiency value of about 100 kg CO_2/€. Figure 6-23 shows a clear maximum of the promotion scheme efficiency of DSM at around 12% CO_2-reduction.

Comparing the shapes of the curves in the different case study regions, it turns out that in some regions and for some technologies efficiency increases when raising the level of promotion.[27] This is in contradiction with the typical presumption that the cheap potentials are achieved first. However, in the building sector policy makers cannot be sure about this. Assume, with 30% investment subsidy for solar thermal collectors these systems are mainly attractive for those building owners with biomass heating systems. But with 40% investment subsidy solar collectors may become attractive also for building owners with oil heating system. Of course, CO2-savings are much higher in the second case. This is one reason for increasing efficiency values. The other reason is that low levels of subsidies may induce a higher share of free-riders: Mainly those people invest in the technology, who would have done it in any case. Therefore, grants have no real impact. Higher incentives induce investments in other target groups and thus reduce the free-rider effect.

Figure 6-24 shows the case of solar thermal subsidies combined with subsidies for thermal renovation in Crete. Increasing the latter ones leads to a lower efficiency (kg CO_2/€), increasing the former ones leads to a higher efficiency until the 50% investment subsidy is reached. Hence, the maximum efficiency of solar thermal subsidy is achieved not at low levels of promotion, but at 50% investment grant.

6.4 Key drivers for results

Deriving conclusions from the investigations carried out in this project of course is connected with the question about the key drivers influencing the results. The case study investigations were accompanied by comprehensive sensitivity analyses. Furthermore, from the comparison among the different regions, the most important and most influencing parameters were identified. Three basic categories of key drivers have been identified:

(i) physical,

(ii) economic

(iii) social conditions.

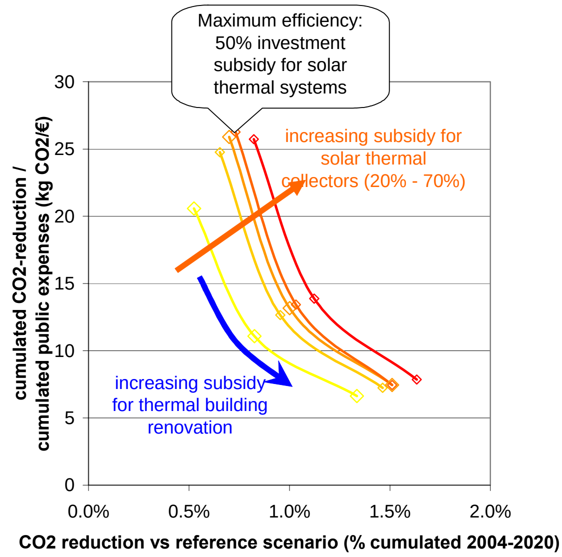

Figure 6-24: Increasing levels of the promotion scheme efficiency with increasing levels of promotion

Physical conditions:

Three essential parameters have to be mentioned in the area of physical conditions and constraints, namely:

(i) RES potentials,

(ii) climate conditions

(iii) existing energy systems.

The existing potentials for RES available within a region are one of the most obvious constraints; though, depending on the size of the region, imports of biomass can be considered, if this is compatible with the policy targets. Of course, besides of the existing potentials also the potentials that are already achieved restrict the future policy options. Of course, like in the case of wind, solar thermal and PV potentials also depend on climate conditions in the considered region. Beside this impact, climate conditions have an important impact on heating as well as cooling demand. Thus, energy and CO_2 saving options by demand side measures like insulation and window replacement depend strongly on these

[27] In particular, this is the case in Crete (e.g. in the case of subsidies for solar thermal collectors) and Baden-Württemberg (biomass boilers).

parameters. As could be seen from the Greek case study, the options for reducing the heating energy demand only contribute to a very limited extent to reducing the energy demand whereas regarding the options for reducing cooling demand still high barriers exist.

Existing energy systems are one of the most important and at the same time very inert side-condition. This part comprises the following issues:

- Electricity and district heating generation units determine specific emission factors as well as costs.
- The current mix of heating, domestic hot water and cooling devices impacts the CO_2-saving potentials by changing the energy carriers, introducing more efficient technologies like condensing boilers or thermal building renovation.
- The current state and thermal quality of the building stock (U-values, specific heating and cooling demand) of course has a high impact on the achievable energy and CO_2 savings due to insulation and window replacement.

Economic conditions:

The most considerable parameters are:

(i) absolute energy price development,

(ii) cost structure among energy carrier and technologies

(iii) currently implemented promotion schemes

The future trend of energy prices is one of the most essential parameters implementing DSM strategies as well as for the development of the energy carrier mix, in particular in the building sector. This means that this development has quite important effects on the optimum design of promotion schemes. Policy instruments that may be efficient for low energy prices may become inefficient in case of higher energy prices. Calculations from the case studies have shown that the promotion scheme efficiency for DSM declines between 25% and 85% assuming that the promotion scheme level remains constant and the energy price increases.[28] Partly, this is due to higher share of free-riders for which DSM would be cost efficient also without subsidies.

[28]See case study investigations for Jordanow (Poland) and Vienna (Austria).

The energy price development as it has been described here, mainly refers to the absolute level of energy costs for consumers. However, the relationship of costs between various energy carriers and CO_2 abatement options also varies strongly between various regions among Europe. This of course impacts the choice of the policy makers regarding the optimum policy mix. E.g. comparing the investment costs for wind plants and biomass heating in boilers between Western European countries and Poland, it turns out that the investment costs for wind turbines are nearly the same, but the costs of biomass boilers in Poland are about 65% and up to 80% cheaper than Western European products. This fact of course strongly influences the efficiency relationship between various policy options.

In addition to the energy prices and cost structure, the existing promotion schemes show a high impact on the options for further CO_2-reductions. E.g. the case of the Polish investigation shows that because current promotion of RES in the building sector is quite neglectable, both high CO_2-saving potentials and high efficiencies (i.e. low CO_2-abatement costs) can be tapped at the same time. Thus, the higher the CO_2-reductions achieved by current promotion schemes, the more difficult it is to achieve even higher efficiencies by adding more promotion schemes; and the higher the efficiency of current promotion schemes are, the more difficult it is to raise the efficiency even further.

Social conditions:

Many social side-conditions have to be considered as key drivers for the results. These include:

(i) acceptability issues (e.g. biomass in urban regions, comfort requirements, etc),

(ii) barriers like information lacks,

(iii) the way stakeholders cooperate or do not

Moreover, the individual interest rate as well as payback time assumed implicitly by various types of investors or consumers influences particularly the decision upon high investments and thus has to be regarded carefully also as a region specific parameter.

6.5 Interaction of promotion schemes and policy objectives

Besides of the tension between fiscal and energy policy targets, there is also a number of interactions between the energy policy targets

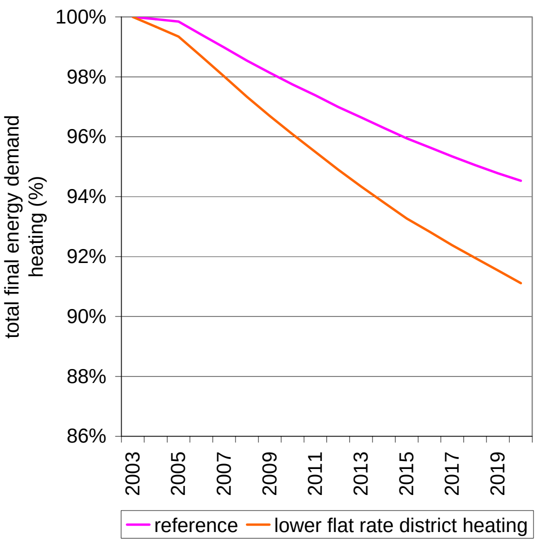

Figure 6-25: Impact of tariff structure on DSM activities

themselves. For example, energy efficiency targets, building directive, bio-fuel directive and CHP directive[29] are influencing each other. The simultaneous investigation of supply and

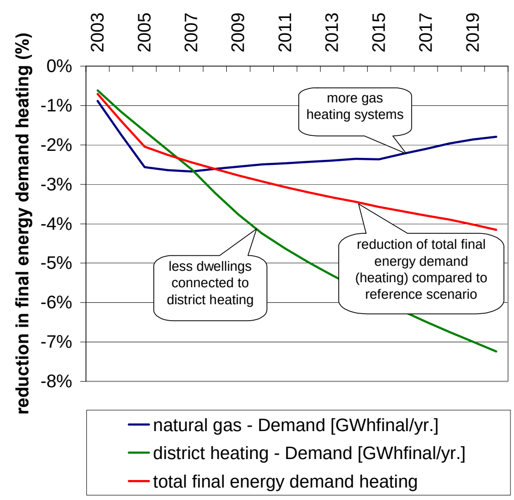

Figure 6-26: Impact of DSM promotion on energy carrier mix

demand side measures as well as the building, electricity and bio-fuel sector with Invert simulation tool allows getting a deeper understanding of these interactions. . In the following outlines, examples of interactions and dependencies between RES and RUE technologies are discussed.

The crucial parameter that drives investments in demand side measures is the reduced costs of energy. The cost reduction is influenced by the decline of heating energy demand and energy price. Hence, of course the incentive for demand side measures depends on the level of the energy price. More precise it is the variable part of the energy price that influences the results. The variable part of the energy price differs strongly between energy systems, even stronger than the total energy costs of different energy carriers. Particularly for the grid connected energy carriers, like district heating, natural gas and electricity, the share of the variable energy price additionally depends on the flat rate that is charged by the utility. This leads to a quite big variety. In the cases investigated in this project, we compared the variable share of the energy price in the building sector (heating, domestic hot water, cooling). The lowest values and the highest values of the variable energy price vary by the more than the factor 5, even though the total energy costs (including flat rate, O&M costs, investment costs) are much closer. The energy carriers with the lowest values of variable energy prices in general are[30] biomass fuels and district heating. Consumers and investors with a heating system based on biomass or district heating thus have the lowest incentive for insulation and window replacement. However, these energy systems are exactly those addressed by a number of promotion schemes and are one of the main targets of energy policy.

Figure 6-25 illustrates the connection of the share of the variable energy price on DSM activities. The figure shows an example where a system with a currently high flat rate and low variable energy price has been changed to a system with a very low flat rate and a correspondingly higher variable energy price. It turns out that only by introducing this measure the total final energy demand for heating within this region could be reduced by more than 2%.

In addition, also insulation and window replacement are a target of energy policy. These measures simultaneously have an impact on the energy carrier mix. Figure 6-26

[29] See chapter 3.1

[30] This refers to the investigated case study regions.

shows the effect of an increased subsidy for DSM (insulation and window replacement)[31]. Due to the increased DSM promotion, the total final energy demand for heating reduces by 4% until 2020 compared to the reference scenario (based on the current promotion schemes). However, this reduction is not the same for all energy carriers. The reduction of district heating is more than 7% and the reduction of gas heating systems is less than 2%. However, the reason for this deviation is not, that mainly buildings connected to district heating are refurbished. On the contrary, mainly buildings with gas heating systems become refurbished. The essential point is that the increased DSM subsidy leads to more DSM activities. For those decision makers who once have decided for such a DSM investment (partly due to the subsidies), district heating is not as cost efficient any more as it would have been the case without refurbishment. Due to the high flat rate and the low share of variable energy price this heating system is now (with insulation) more unattractive than it has been before. This leads to a decrease of district heating in the energy carrier mix.

Summing up, increasing DSM promotion simultaneously can have an impact on the energy carrier mix and thus may have an undesirable side effect by compensating other promotion schemes. Understanding such interactions can substantially improve the options for an optimum design of promotion schemes.

6.6 The free-rider-effect and over-subsidisation

One of the major challenges in designing promotion schemes is to investigate, quantify and reduce or even avoid the free rider effect: How many people would invest in RES & RUE technologies in any event, i.e. even without any promotion scheme? How is it possible to direct promotion schemes to those target groups who would not invest without the scheme?

Invert simulation tool calculates the change in CO_2-emissions and transfer costs in the building sector – and hence the efficiency of promotion schemes (kg CO_2/€)[32] - by comparing different scenarios. E.g. the outcomes of a scenario with subsidies for solar thermal collectors are compared to a scenario without these subsidies.[33] Hence, the results of the second scenario (without solar thermal subsidies) include those plants and related CO_2-savings that maybe would be achieved without any policy intervention. When comparing the results of the first scenario (with subsidies) with the second (without subsidies) we get the net-effect of the subsidy: How many plants would be erected *due* to the policy, or in other words, how many plants would not be erected in case there is no subsidy?

Thus, the results regarding the efficiency and CO_2-reductions take account of the free-rider effect. Policy makers are able to identify the pure net-impact of a certain policy instrument or policy mix by using **Invert**.

A case of free rider effect can be observed in Figure 6-23. In the bottom left hand corner of the figure we can see three points (one on the curve “various levels of biomass subsidy”, two others on the curves “policy mix of biomass and DSM subsidy”). These three points represent low levels of investment subsidy (5%) for biomass boilers (with various levels of DSM subsidy). Probably our presumption would be as follows: Those low levels of incentive will not lead to very high CO_2-reductions (which is true). On the other hand it would show high promotion scheme efficiency levels (which is wrong), because of the very low amount of money applied for each boiler. The reason why the second part of our presumption is wrong is the free rider effect. That low amount of incentives reaches only a very small new target group of consumers and investors. However, all those who would invest in biomass boilers in any case of course receive this money although they do not contribute to CO_2-reductions (compared to the reference scenario!). Hence, compared to the reference scenario, for those people considerable amounts of costs occur but no CO_2-reductions. This free rider effect causes efficiency values which are by more than the factor 6 lower than they could be by increasing the level of subsidy. Let us consider doubling the level of subsidy (from 5% to 10%). The points in the range of 12-14% CO_2-savings in

[31] This example refers to the case study carried out for the city of Vienna.

[32] See part 4.3 of this report.

[33] This first scenario in **Invert** simulation tool is called reference scenario. The reference scenarios mentioned in chapter 6.3 assume the current policy mix to remain constant until 2020.

Figure 6-23 represent this doubling of subsidies. The figure shows that this drastically increases the promotion scheme efficiency. The share of free riders can be reduced strongly. Of course, those people who would have invested in any case (i.e. without subsidy) now receive the double amount of money than before, but the share of people who invest *due* to the scheme is much higher now. This clearly leads to higher efficiency values. Thus, those points still include some free riders but the share is much lower than before.

However, it turns out that the efficiency declines again with additionally increasing values of promotion. This has two major reasons: First, the scheme now addresses more expensive CO_2-reduction potentials. This results in higher costs and thus a lower efficiency. Second, the amount of money (and thus efficiency loss) due to over-subsidisation increases: The number of people rises, who would have reduced CO2-emissions also with a smaller incentive. Therefore, it is important to find promotion structures, which are incentive compatible, i.e. consumers and investors who are willing to invest already by receiving low grants should not be able to claim a higher support. Such incentive compatible constraints are an important instrument for increasing the efficiency of a promotion scheme. One of those measures is the step-design of financial incentives. This is applied e.g. in the form of stepped feed-in-tariffs for various full-load-hours in the case of wind plants. Another example are stepped schemes for thermal building renovation[34]: Different levels of subsidy are granted for different levels of achieved heating energy demand reductions or thermal building standards.

Step-designs provide enough incentives for ambitious projects and those consumers and investors who would not decide for an RES or RUE technology in case of a lower promotion level. However, this policy design reduces the loss due to over-subsidisation because those consumers and investors, who invest also with a lower inventive, are excluded from high-level subsidies.

[34] E.g. as currently implemented in Vienna. See report of WP6 “case studies”.

7 CONCLUSIONS AND FINAL REMARKS

Reaching the targets regarding energy efficiency, renewable energy sources and CO_2-reductions in the EU is a core challenge in the frame of current European energy policies. A broad range of technologies and related promotion instruments forms the current portfolio and those of future policy options, but which policy mix is most efficient and most effective?

In particular in the view of the buildings directive and the energy service directive ***Invert*** simulation tool provides a comprehensive tool for deriving efficient policy solutions.

The investigations of this project showed that CO_2-taxes[35]could represent a very effective instrument.[36] Due to the direct internalisation of external costs, inefficiencies with respect to subsidy schemes can be reduced. Of course, the concept of promotion scheme efficiency in terms of saved CO_2-emissions per public expenses (kgCO_2/€) as it has been applied in this project is not applicable here. The impacts on the economy rather have to be investigated by macroeconomic models. As far as CO_2-taxes realised in a manner neutral to the total public budget, their realisation is more a matter of political volition and power. In fact, energy taxations in political reality is not always easy to realise.

As long as CO_2-taxes or other forms of energy carrier taxes are not implemented in a level high enough fostering RES & RUE technologies, other incentives have to be set if the ambitious targets shall be achieved. The analysis within ***Invert*** as well as other projects[37] showed no clear priority for a certain type of instrument like soft loans, subsidies or feed-in-tariffs. Rather it is a matter of the right design of each instrument.

One of the core messages of this project is that for a comprehensive analysis and optimisation of policy instruments two aspects have to be taken into consideration: efficiency and effectiveness. The efficiency of a promotion scheme indicates how much of a target (e.g. CO_2-reduction) can be achieved by using a certain amount of public money in terms of kgCO_2/€. The effectiveness measures how much this instrument can contribute to reaching a certain target in absolute terms (e.g. kg CO_2-reduction). Both aspects have to be considered at the same time. Taking into account only one of these aspects isolated, may lead to fallacy. In this report, CO_2-efficiency graphs are presented,[38] combing these two aspects. They clearly show that the optimum policy mix is a matter of the target: Which level of CO_2-reduction should be achieved until a certain year? What additional targets should be met (energy security, energy saving, reduction of other emissions …)?

Finding an optimum of efficiency and effectiveness requires taking into account a lot of interconnected circumstances and side conditions. The following lists and briefly describes the most important of them:

- Interactions of technologies and policies
  Technologies and policies show multiple interdependencies. They influence each other and thus can help increasing the efficiency and effectiveness of the policy mix or in contrary can hinder each other. The most important interactions investigated in this project are the following:
  First, in the building sector supply and demand side measures are influencing each other, in particular due to different levels of energy prices for different energy carriers. Hence, a change in the policy for DSM usually simultaneously causes an impact on the energy carrier mix.
  Second, the improvement in the thermal building quality will reduce the total heating demand in particular that part supplied by district heating. This leads to a decline of options for cogeneration plants.
  Third, potentials (in particular biomass potentials) are restricted. Thus, a competing situation between various sectors may occur affecting efficient policy portfolios.

[35] Or taxes on the consumption of various energy carriers;

[36] See the results of the case study investigations presented in the report of WP6 „Case studies“.

[37] Action plan of the project Green-X: Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market.

[38] See part 6.2 and 6.3 of this report.

- Promotion of competing (fossil) systems
  The simultaneous promotion of competing systems can lead to substantial loss of efficiency (i.e. public money). The case study investigation shows that identifying and removing counterproductive schemes for fossil technologies (like for gas condensing boilers) can lead to both substantial CO_2-reductions and savings of public money at the same time.

- Incentive compatibility
  The incentive compatible design of promotion schemes is one of the basic requirements for efficient policies. It has to be considered that each public intervention can lead to side-effects. E.g. subsidies granted as a percentage of investment costs show the tendency to decrease the incentive for cost reductions, subsidies granted per kW of installed power may lead to over dimensioning e.g. of heating boilers. Thus, schemes should be based on parameters leading to incentives that support the target of the policy and hence are incentive compatible. E.g. subsidies for insulation granted in €/m² living area, depending on the achieved energy savings and building quality show less negative bias than investment subsidies granted as a fixed percentage of investment costs.

- New technologies
  For new technologies, which have not yet reached the maturity to enter the market, the efficiency criteria may not be applied. In the case of new technologies, efficiency turns out to be of minor importance as long as they have not reached effectiveness. The reason is that the loss of public money is very low even in case of high promotion because the absolute number of those plants is still very low. However, as soon as the technology becomes mature and the promotion scheme becomes effective, the efficiency criteria should be applied.

- Dynamic paths of scheme modification
  Potentials, energy prices, cost structures, available technologies and social conditions have a high impact on the efficiency and effectiveness of promotion schemes for RES & RUE. However, all these parameters are subject to a continuous process of change and development. Hence, the dynamic modification of schemes is indispensable for a maximum achievement of objectives.

- Stakeholder engagement
  Whenever it comes to the evaluation and designing of promotion schemes, individual behaviour and decision making of people must be considered. They interact with many other different stakeholders in a certain political and cultural context. The stakeholder analysis carried out within the project **Invert** showed that there are quantifiable risks associated with engaging certain types of stakeholders or not during the design of the promotion scheme. The design elements can be directly related to the success of stakeholder engagement with the scheme. Hence, it is clearly recommended to incorporate a formal, methodological approach to risk assessment in the scheme design and to incorporate stakeholder risk elements.

- Reducing the free-rider effect
  A key element for setting up efficient promotion schemes is reducing the free-rider effect. This is possible by differentiation among consumer types, technologies (and efficiency levels of technologies) as well as efficiency levels of demand side measures and must be linked to incentive compatible support schemes.

Invert simulation tool within this project has been proofed to be a very useful and attractive model supporting the understanding of the issues outlined above. However, there is still a number of important additional issues to be analysed: a more detailed understanding and modelling of decision making processes, including additional (including non-financial) promotion schemes, refinement of cooling related technologies, adaptation to other regions including the combination of various regions etc.
A number of follow-up projects are currently under discussion applying **Invert** simulation tool for the investigation of policy options and the optimum design of future energy policies, especially in the building sector. These new studies will help to further enhance the tool and develop new insights in particular with respect to the decision making structure of consumers and investors. All the findings gained in this project as well as the upcoming projects will provide us with a deeper perception of our energy system – thus providing the basis for making it a sustainable one.

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