Integrating policies for renewables and energy efficiency: Comparing results from Germany, Luxembourg and Northern Ireland

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Abstract
The integration and simultaneous consideration of Renewable Energy Sources (RES) and Rational Use of Energy (RUE) heat policies belong to the major challenges for building a sustainable energy system. In this context, the following questions arise:

- How will the take-up of energy efficiency measures in the building stock develop and how will this affect the energy demand for heating?
- How can promotion schemes for demand side measures (DSM) influence the investment in energy efficiency measures in the building stock?
- How can these policies be optimised?
- How do renewable and energy efficient technologies and promotion schemes interact?

This paper provides a comparative analysis of these questions for the cases of Germany, Luxembourg and Northern Ireland. These regions have been the subject of investigations using the Invert simulation tool. Invert is based on detailed bottom-up modelling of the building stock and corresponding heating and domestic hot water systems. The impact of energy price scenarios and promotion schemes can be simulated in a dynamic framework.

The scenarios show that despite different structures in the heating systems, applied energy carriers and the building stock as a whole, in all three investigated regions improvements in the energy efficiency of buildings can be expected until 2020. Due to the current level of energy prices, this is the case even in scenarios without promotion schemes. Without any policies heating energy demand will decrease by about 5-10 % whereas ambitious policies can achieve reductions of 20% and more up to 2020.

In the three investigated regions quite different traditions of RES and RUE policies can be observed. Besides the current energy system, building standards, current state of RES systems and existing potentials this difference in policy culture and tradition turns out to be a major impact parameter for the future design of RES and RUE heat policies.

Introduction
About 40% of EU energy demand is utilised for heating and domestic hot water (EC 2006). This presents a challenge for carbon dioxide (CO_2) reduction to meet climate change commitments, as reduction in this demand through energy conservation measures and user behaviour changes has proved either difficult, costly or both. In the renewables sector, current policies focus on electricity production from renewable sources (RES-E) and transport; the use of renewables for heat production has been confined to a niche that has only begun to be addressed through biomass policies and support for solar thermal technology. In this paper we compare the situation and prospects of RES and RUE heat policies in three different regions: Germany, Luxembourg and Northern Ireland. In each case different projects were undertaken to ascertain appropriate policies for domestic buildings that provided the optimum pay back for the public purse in terms of maximising CO_2

reduction. This was done by applying the Invert simulation tool which was developed as part of an EU ALTENER funded project (Kranzl et al, 2005) along with consideration of the role that stakeholders play in implementing RES & RUE policies (Pett & Guertler, 2005).

The structure of this paper comprises the methodology of the investigations and description of the Invert simulation tool, a description of each case study analysis, and a comparison of the results. The findings are then discussed, taking into account the publication of the EU Energy Policy and Climate Change Programme (EC, 2007a & b), in order to present useful insights into policies to promote take-up of RUE and RES heat in the building stock and improve building energy performance throughout Europe.

Methodology

APPROACH

The core methodological approach of each case study described in this paper consists of four steps. First, we carried out a comprehensive description of the building stock and the related heating and domestic hot water (DHW) systems within the region. This included the distinction between various building categories (e.g. single dwellings) and various construction periods. Each of these building classes are described by representative geometry and building thermal quality (U-values) data. Moreover, the distribution of various heating and DHW systems in each of these building classes was investigated. Second, we analysed the current RES and RUE heat policies in terms of the type of programmes in place, the nature of incentives offered and the level of support. Moreover, political discussions of various policy options were examined. Third was the incorporation of data regarding buildings, heating and DHW systems as well as policies into the Invert simulation tool. We carried out various simulation runs and arranged the results from various scenarios. Finally, we drew conclusions for each of the case studies and compared them with each other.

INVERT SIMULATION TOOL

The section below gives a very short introduction to the Invert simulation tool. For a detailed description of the algorithm see Stadler et al 2007[i].

Invert Simulation Tool is a comprehensive computer model supporting the design of energy planning for Renewable Energy Sources (RES) and Rational Use of Energy (RUE). Invert allows the simulation of the existing and new building stock in terms of Demand-Side-Management and the supply side (heating, cooling, domestic hot water systems (DHW), solar thermal), summarized by the term RUE. Furthermore, Renewable Energy Sources, constituting electricity supply (RES-E), heat production (RES-CHP) and bio-fuel production for any desired region can be considered in a bottom-up approach. Due to its flexible design Invert allows comparative and quantitative sensitivity analyses of the interactions between RUE, RES-E, RES-CHP, bio-fuels and greenhouse gas (GHG) reduction for each selected region. In this way the tool allows the simulation of the impact of various promotion schemes (investment subsidies, feed-in tariffs, tax exemptions, subsidy on fuel inputs, CO_2 taxes, soft loans, and additional aside premium) on the penetration of RES and RUE technologies, CO_2-emissions, public expenses, etc.

As already mentioned, Invert is a disaggregated bottom-up model; it allows the definition of any desired building type, specified by a certain thermal quality or any desired single renewable power plant. The main modelling approach in the electricity and bio-fuel part of the model is based on the concept of cost-resource-curves: various parts of RES-E/bio-fuel potentials are assigned to their costs, sorted by costs and compared to the conventional electricity/gasoline or diesel price. In the building related part (heating, cooling, domestic hot water), the algorithm is based on the modelling of the decision making process of various stakeholders regarding a certain heating, cooling or DHW system *option* or for the insulation / window replacement option. A major element is the implementation of various restrictions, like technological, economic or cultural parameters such as comfort aspects of energy systems (for more information see Resch, 2004 and Stadler et al., 2007).

Supply (i.e. heating and DHW systems) and demand (i.e. thermal quality of building envelope) are treated simultaneously in the model.

OUTPUTS AND ANALYSIS

The major Invert simulation tool outputs are:

- Public expenditure (Million Euro/year)
- CO_2 emissions and reductions (kt/year)
- Promotion scheme efficiency (PSE)
- Detailed results from different combinations of options, e.g. insulation and window replacement (GWh/year), mix of energy carriers, final energy demand (GWh/year) and output from RES-E plants (GWh)

Parameters like demographic change etc may be implemented by scenarios for the construction of new buildings and the demolition of existing ones and thus the trend in the total building stock.

A core approach of Invert is to compare the expenditure (due to promotion schemes) in the electricity or building sector with the corresponding reduction of CO_2-emissions. Promotion scheme efficiency (PSE) (Stadler et al., 2005) is used as a significant parameter for the evaluation of different promotion schemes. The PSE estimates the efficiency of a certain strategy compared to a business-as-usual (BAU) scenario by comparing the CO_2-emissions and public expenditure for promoting a certain technology of the reference scenario with the CO_2-emissions and expenditure of the sensitivity scenario. The best solution is an increase in CO_2 emissions reductions accompanied with a decrease in expenditure, however this ideal is rarely discovered. The second best solution is then described as an *efficient promotion scheme*. Efficient promotion schemes are characterised by large decreases in CO_2-emissions and small increases of transfer costs compared to the BAU scenario. The Northern Ireland case study presents the PSE for various scenarios and levels of support for different RES and RUE heat systems.

The expectation is that new promotion policies for RES and RUE will lead to the reduction of CO_2-emissions. At the same time, transfer costs for promotion schemes will increase. Normally, money is spent to reduce emissions. However, PSE is only defined with respect to public expenditure on promotion schemes.

More recently and in particular for the German investigation, new budget neutral promotion schemes have been designed and incorporated into the simulation tool: bonus model and deployment system:

a) Bonus model
Any energy carrier (e.g. biomass) in the building sector can be defined as a receiver of financial support (€/MWh) and this support is financed by so-called 'bonus payer' energy carriers (e.g. fossil fuels). Because of this money transfer from 'bonus payer' to receiver, the 'bonus payers' are restricted in their dynamic development. Depending on the energy consumption in year n and the specified bonus values for receivers (€/MWh) the entire costs of the financial support are calculated. These entire costs have to be paid by the defined 'bonus payers' in year n+1.

b) Deployment system
In this system, there is the obligation to deploy certain technologies (e.g. either biomass or solar thermal systems) in case a heating system is changed or a building is newly constructed. However, investors have the option to pay a penalty in case that they decide for another (e.g. fossil fuel) system.

Description of case studies: Germany, Luxembourg, Northern Ireland

GERMANY

The primary objective of this analysis for Germany was to identify innovative, efficient and budget-neutral policies for promoting RES in the heating sector (Nast et al 2006). The investigation focused on the impact of these schemes on the policies costs and the penetration of RES in the heating sector. Hence, we modelled the building stock and the related heating and DHW systems using the Invert simulation tool. Both the shares of RES as well as the detailed types of heating technologies depend on the development of DSM (primarily insulation and window replacement). Hence, we analysed future scenarios for both the development of building efficiency and RES under various promotion schemes.

The current policies for RES are primarily investment subsidies and soft loans within the framework of the 'market incentive programme'.

The policies for promoting rational use of energy (RUE) in the building sector are partly covered by standards (*Energieeinsparverordnung*) and the KfW building refurbishment programme, which offers subsidies and soft loans. Moreover, the *Bundesländer* have partly established subsidies additionally to federal programmes.

The geographical scope of the investigation was all of Germany. Thus, it is by far the largest region among the three case studies presented in this paper. It covers over 38 m dwellings with a total heat demand of about 780 TWh (ca. 2,800 PJ). The share of RES amounts to about 7 %, the largest share of which is covered by biomass heating systems.

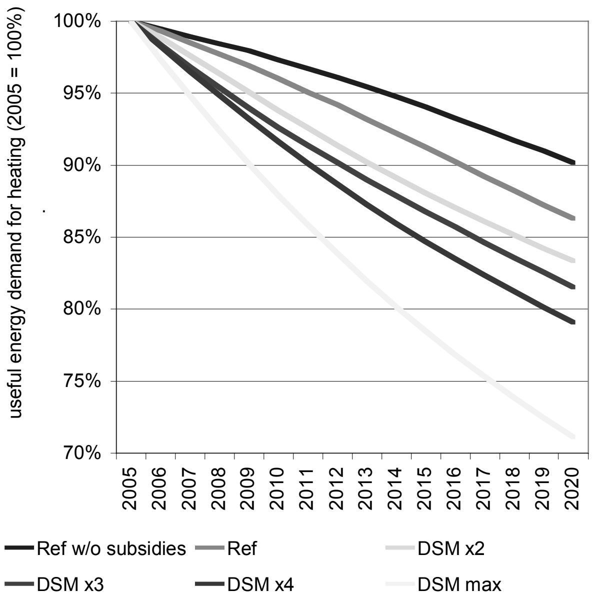

Figure 1. Useful energy demand in various scenarios due to DSM in Germany's building stock

Current state of building stock and heating systems

For modelling the German building stock, we differentiated between nine construction periods according to available statistics (before 1918, 1919-1948, 1949-1957, 1958-1968, 1969-1978, 1979-1983, 1984-1994, 1995-2001, after 2001) and nine building categories (single dwellings, attached houses, small multiple dwellings, large multiple dwellings, sky scrapers, and four types of non-residential buildings).

The development of U-values for single dwellings shows that substantial improvements in building efficiency have occurred over the last decades (see figure 9). However, there is still major potential for building improvements, especially for the buildings constructed before 1980. The values take into account that some parts of the building stock have already been insulated in the past.

The energy carrier mix for heating is strongly dominated by natural gas (47 %) and oil (27 %). District heating covers 13 %, biomass 7 % and electricity 5 % (see figure 10).

Development of energy demand and the role of efficiency measures

For the simulation of a reference scenario we kept the current policies constant until 2020 and assumed a moderate price increase. The results of the reference scenario show that current energy prices combined with the policies currently in place lead to a reduction in useful energy demand of about 14 % by 2020. By increasing the current subsidies, higher energy reductions could be achieved (20 % until 2020). However, these reductions would require substantially greater efforts: Figure 1 shows scenarios of multiplying the current DSM subsidies by two, three and four. DSM-max represents the theoretical case of 100 % investment subsidy for DSM in order to estimate the maximum achievable scenario given certain maximum market penetration rates (renovation rates of buildings). Still, the maximum heating energy reduction from DSM in Germany's building sector is nearly 30 % until 2020. However, this potential is hard to achieve, because parts of this potential are quite

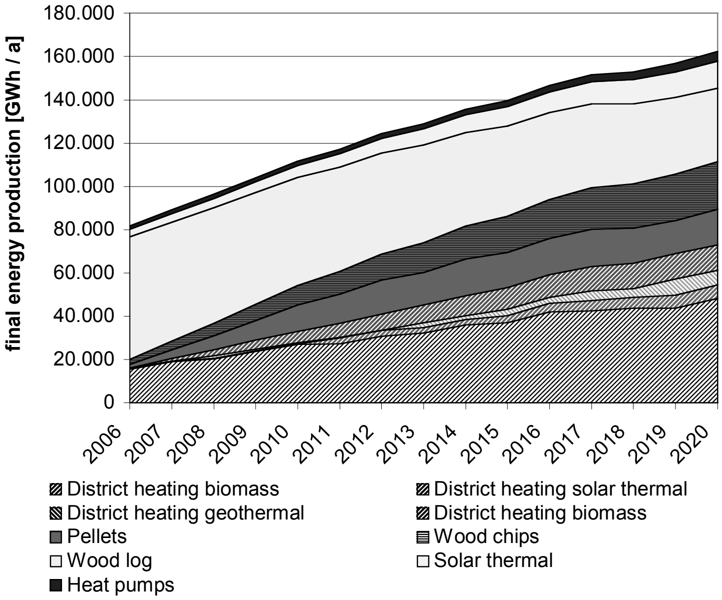

Figure 2. RES heat development in Germany under the 'Bonus' Promotion scheme

costly to realise. The number of buildings with new insulation varies between below 1 % (reference scenario), 1.8 % (DSM x4-scenario) and almost 3 % (DSM-max) per year on average over the simulation period (2005-2020).

Figure 2[1] shows the uptake of RES heat in a budget neutral promotion scheme, called 'bonus system' (see above and Nast et al 2006). Operators of renewable energy systems receive a bonus payment per kWh which has to be paid by operators of fossil fuel systems. Thus, in a way similar to the feed-in-tariff-scheme, this system does not require public expenditure. The figure shows that the share of RES could be substantially increased, although the share of currently dominating wood log boilers is assumed to decline.

Outlook and current policy discussions

Current discussions about new policies in the heating sector strongly focus on an increase of RES. Innovative budget-neutral policy instruments are at the core of this discussion. Three main schemes are subject to investigation: Installation obligation (consumers are obliged to provide a certain share of their heating demand by renewables or otherwise have to pay a penalty, called deployment system in the Invert simulation tool, see above), quota obligation (fuel suppliers have to ensure of a certain share of renewables in their sales volume) and the aforementioned bonus system. The strong benefit of budget-neutral instruments like obligations, quota or bonus systems are that they are not dependent on short-term political considerations and availability of public budget. Thus, they potentially can provide a stable and prosperous environment for RES in the medium to long-term.

The interaction with efficiency improvements in the building stock is not yet targeted by these schemes. However, this will be the subject of investigation in a subsequent project.

1. Figure 2 includes RES heat energy systems and no fossile energy. This is the reason for a positive slope in Figure 2 compared with the negative slope in Figure 1 for the total heating energy demand.

LUXEMBOURG

In the case of Luxembourg, we investigated the potential of a broader penetration of RES and RUE in the residential heating and DHW sector of Luxembourg. The objective was to develop scenarios for stronger implementation of RES and RUE technologies and the corresponding CO_2-reduction and to derive suggestions and recommendations for future policy development.

Promotion schemes in Luxembourg presently are based on investment subsidies. For RES-heat systems relatively high investment subsidies in the range of 30%-50% are in place. However, it has to be taken into account that the taxation of energy and especially of fossil fuels is substantially lower than in neighbouring countries. Thus, the promotion schemes' level of incentive for RES and RUE technologies has to be higher in order to ensure cost efficiency compared with competing fossil energy systems.

With respect to the renovation of buildings, the government of Luxembourg has established promotion schemes which are quite attractive from an economic point of view. For RES and RUE measures in the residential heating sector, an investment subsidy of 1,500 Euro per annually reduced ton of CO_2 is granted. This scheme offers high flexibility because the reduction in CO_2 emissions can be achieved by various technologies and systems. Moreover, the incentive is quite attractive. Nevertheless, the experience with this scheme showed that the up-take of this subsidy was quite low. Obviously, calculating the CO_2 reduction turned out to be a high barrier and not sufficiently transparent. Thus, the success of this scheme was below expectations. With respect to new buildings, up to 140 €/m² and 77 €/m² are granted for the construction of passive houses and low-energy houses respectively.

In Luxembourg there are about 170,000 dwellings and a residential heating demand of about 3.6 TWh (ca. 13 PJ). We divided the building stock into eight age-bands according to official statistics (before 1919, 1920-1945, 1946-1955, 1956-1970, 1971-1980, 1981-1990, 1991-1995, after 1995) and four build-

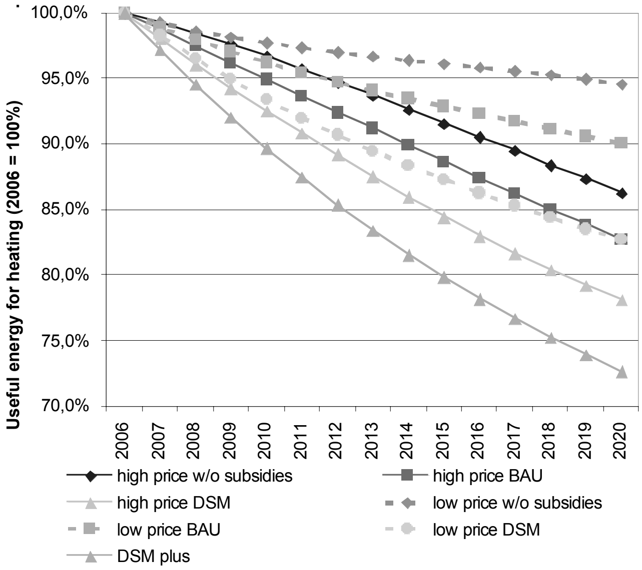

Figure 3. Useful energy demand for heating in various scenarios (depending on price level and level of support)

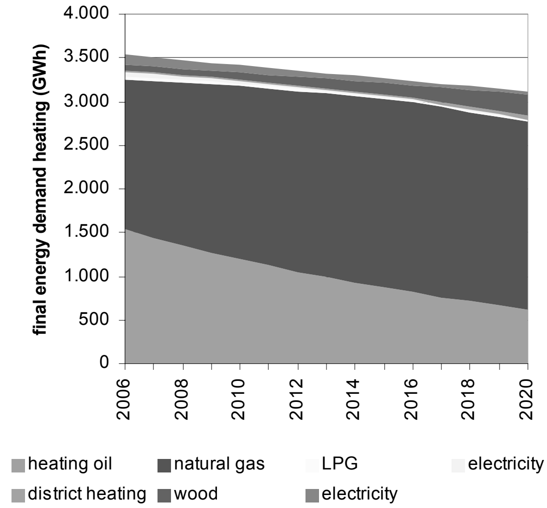

Figure 4. Final energy demand for heating, Luxembourg scenario high price, business as usual

ing types (single dwellings, double dwellings, small multiple dwellings and large multiple dwellings).

The analysis of the building quality of various construction periods shows a steep decline of U-values in 1995 (and for exterior walls in 1980) which hints at the large potential for energy saving measures in this field. The values take into account that some parts of the building stock already have been insulated in the past.

Currently, the heating and DHW energy consumption is based almost fully on oil (46 %) and natural gas (46 %). Only a small part is covered by electricity (4 %), biomass (2 %), district heating (1 %) and LPG (1 %).

Scenarios up to 2020

In the case of Luxembourg, we investigated the impact of a low energy price versus high energy price scenario. (low: slight decrease of oil price, moderate increase of gas price (19 %), moderate increase of electricity (9 %) and biomass prices (3 %); high: increase of oil (40 %), gas (68 %), electricity (44 %), and biomass prices (43 %) up to the year 2020).

Figure 3 shows the effect of promotion schemes in the field of DSM (insulation and window replacement) on the useful energy demand for heating. For each of the price scenarios it shows the impact of the actual policy (BAU), a more ambitious policy (DSM[ii]), a maximum DSM-scenario (DSM plus: 100 % subsidy for insulation and window replacement) and no support at all (w/o subsidies). It is obvious that the energy price has a strong impact on the uptake of energy efficiency measures: In the period from 2006 to 2020 the average annual share of buildings with new insulation in the low price scenario varies in the range below 0.3 % (w/o subsidies), 0.7 % (BAU) up to 1.3 % (ambitious DSM policy) of the whole building stock, whereas in the high price scenario these shares range from 0.9 % (w/o subsidies), 1.3 % (BAU) and 1.8 % (ambitious DSM policy).

Due to this high dependency on energy prices, it becomes apparent that the price increase of fossil fuels over the last few years has led to a quite strong incentive for DSM, which actually is even stronger than that of the corresponding promotion schemes. Thus, even the 'without subsidies – low price' scenario leads to a fall in heating energy demand, due to the currently relatively high prices of fossil fuels and so providing enough incentive for DSM at least in those buildings with the lowest thermal standards.

The energy carrier mix in all scenarios shows a shift from oil to gas and just a very moderate increase of biomass systems, which is due to the urban structure and limited biomass potentials within the area of Luxembourg (see Figure 4).

Outlook and current policy discussions

In accordance with the Energy Performance of Buildings Directive (EPBD), Luxembourg implemented the energy certificate for buildings. Of course, the target of the energy certificate is to foster energy efficiency measures in the building stock. Thus, the responsible authorities are currently thinking of ways to link promotion schemes for RES and RUE to the building certificate. This could be achieved by linking the level of economic incentive to the number of certified efficiency classes that can be skipped by implementing a certain measure. However, this would imply an energy certificate as a precondition for receiving the subsidy, which could turn out to pose a significant barrier to uptake. Therefore, a second option for the linkage of energy certificate and RUE and RES heat support could be a bonus system. This system would consider investment subsidies for various RUE and RES heat measures (e.g. insulation, solar thermal systems, pellet boilers) and an additional bonus for the number of energy classes (defined in the energy certificate) that are skipped by the specific measures, in this way also offering an incentive for early certification.

NORTHERN IRELAND

The Invert simulation tool was applied to the region in 2006 during research on the delivery of energy demand reduction in Northern Ireland. The geographical situation of Northern Ireland (NI) distinguishes its energy policy from the rest of the UK as it does not benefit from direct links to North Sea oil and gas supplies. It has not benefited from the 'dash for gas'

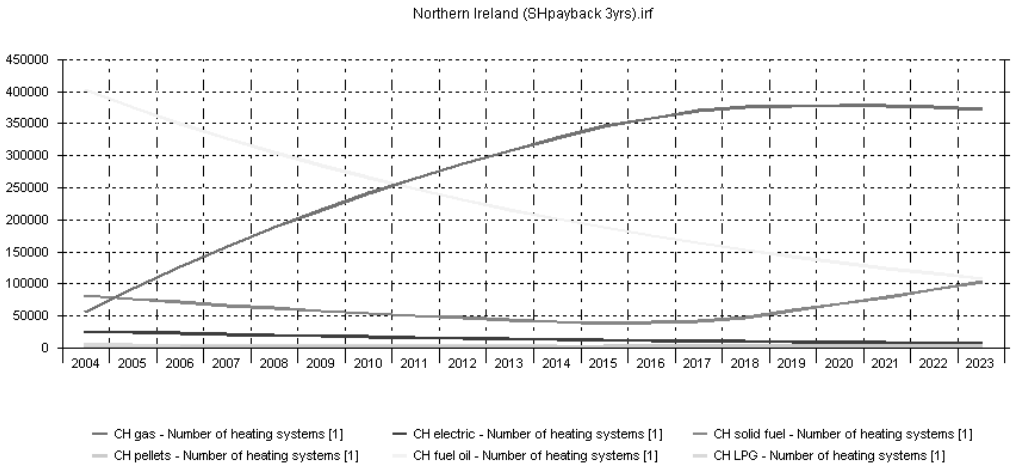

Figure 5: Baseline scenario, number of central heating systems

which has characterised the British energy and CO_2 emissions reductions profiles since the 1970s. However the fuel mix in NI is changing, with the development of gas interconnectors (the third came on stream in 2005) with the Republic of Ireland and with Scotland, and investment in wind energy. The principal mode of domestic heating remains oil, although in some parts coal predominates. In NI energy is a devolved issue, unlike the situation in England, Scotland and Wales where control is by the UK government. The development of an Energy Strategy has taken priority (DETI, 2004) with the publication of an aim to reduce electricity use by 1% a year in real terms from 2007 to 2012.

Several support schemes for RUE and RES heat are established in Northern Ireland. There are schemes which are related to low-income households providing grants for energy efficiency improvement and efficient heating systems (warm homes scheme). Special schemes exist also for social-rented dwellings. The Environment and Renewable Energy Fund Household Programme[2]: offers substantial subsidy of RES technologies for the residential sector, including for RES heat – solar thermal water heating, ground, water and air source heat pumps, wood pellet stoves and wood pellet boilers – funded by the Northern Ireland Department of Enterprise, Trade and Investment. Given NI's belated 'dash-for-gas', a typical scheme for Northern Ireland is the Gas Boiler Scheme: Northern Ireland's gas supply company, Phoenix Natural Gas, offers a £ 400 grant towards A-rated condensing gas boilers. In a similar way, other energy supply companies also provide support in order to fulfil energy saving obligations.

Efficiency of RES and RUE promotion schemes in the building sector

A detailed baseline model of Northern Ireland's residential housing stock (650,000 dwellings) was created in Invert using data from the 2001 NI House Condition Survey (NIHE 2005). This incorporates conservative estimates for fuel price development over the next 20 years, includes a technological database of different heating systems, insulation materials and window replacement options. It takes account of the rate of stock refurbishment, maintenance costs of heating systems and appropriate boiler sizing. A three-year 'stakeholder-payback time' has been chosen for the baseline. This short payback time is intended to reflect that in the UK, the payback time accepted by consumers is very short, predicated on the fact that even government programmes expect building measures to payback within five to seven years to consider them 'cost-effective' for energy reasons alone (Smith et al., 2005). The baseline also assumes full availability of natural gas; in practice this will be limited to those with easy access to the gas network but the stated policy aim is to have as many households connected as feasible consequently no alteration of the baseline is considered appropriate.

Figure 5 illustrates the development of the number of different central heating systems under the baseline scenario.

The baseline shows high take-up of gas central heating systems, mainly replacing oil central heating, and is higher than might be expected but for the unusual situation of Northern Ireland's geography and resources. This take-up tails off slightly around 2018, when households would start taking up solid fuel central heating up again if they make decisions based on cost alone. This is plausible on the basis of the development of the cost of coal compared to gas over time, but of course would not be if building regulations proscribed the installation of solid fuel central heating. The number of electric central heating systems declines steadily throughout.

However with the baseline as described, it might be necessary to promote a renewable heating option that compensated for a restricted gas network. The incentive in Figure 6 illustrates what happens if a 50 % subsidy is provided on the cost of a wood pellet boiler – this would prevent any increase in the number of coal[iii] central heating systems and has the additional benefit of containing the take-up of gas central heating to less than 50 % of the households without forcing an artificial constraint on growth.

In the same way as we did not consider constraints on the gas connection, we did not implement a constraint on the supply of wood pellets. In practice, opportunities for biomass development could be attractive to the Regional Development authorities. Invert indicates that substantial take-up of wood pellet boilers could be encouraged, even against the assumption of short-termism amongst households.

2. http://www.detini.gov.uk/cgi-bin/get_builder_page?page=2455&site=5&parent=21&prevpage=53

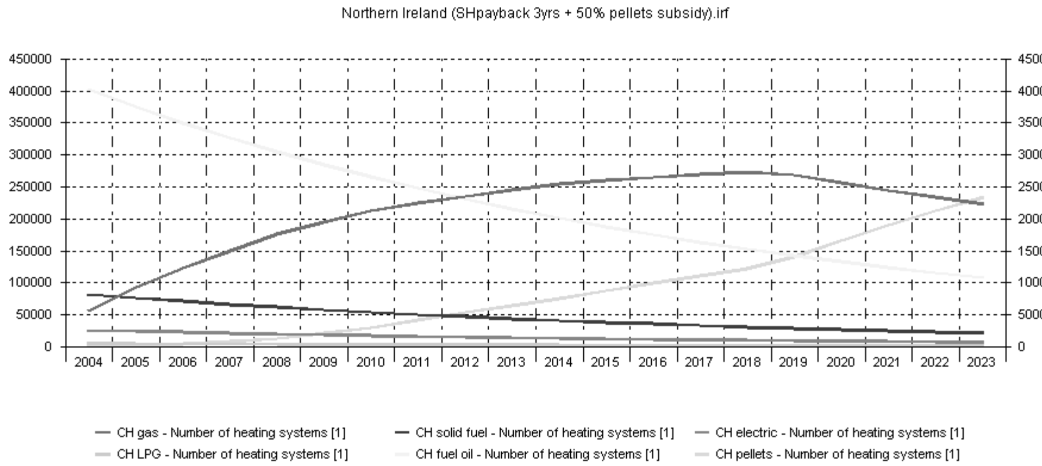

Figure 6: Baseline scenario with 50% subsidy on wood pellet heating systems

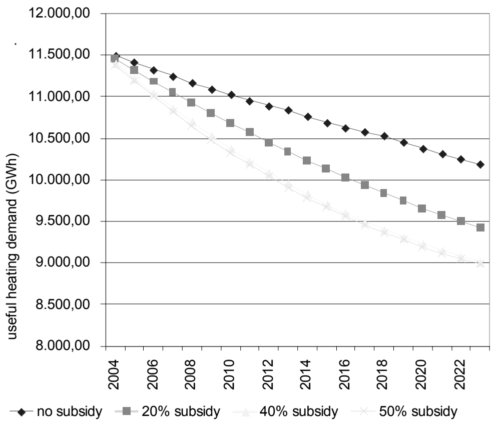

Figure 7: Scenarios for the development of useful heating demand with various levels of subsidy to wall and ceiling insulation

Figure 7 shows the fall in useful energy demand due to wall and ceiling insulation for various levels of subsidy. Similar to the other regions, we can observe a decline in heating demand even in the 'no subsidy' scenario, which occurs due to the price increase over the last few years. However, policies can help to substantially increase the uptake of measures. From the fact that we cannot identify much difference between the 40% and 50% subsidy, we learn that it is not efficient to provide subsidies above 50% because from this level on nearly all potentials for energy savings by those measures are tapped. There is additional potential that could be appropriated by subsidising window and floor insulation – in particular if the former is heavily subsidised. However, these measures are not viewed as energy saving measures in public policy terms in the UK and in Northern Ireland in particular.

In Figure 8 the option of promoting wood pellet boilers ('P subsidy') compared with solar thermal technology is considered, each combined with insulation measures with varied levels of subsidy ('I subsidy'). Some interesting points emerge:

At the extreme left hand side, wood pellet boilers on their own have such little take-up until a 40% incentive is applied, that the early points on the graph are anomalous. However, when combined with insulation subsidies at various levels, wood pellet boilers become increasingly attractive. 'High' subsidies (60 %) for insulation (the outermost curve) promote take up at high levels of efficiency for the programme in terms of CO_2 saving per unit cost. However, of course a substantial further increase of the the subsidy level leads to a reduction of promotion scheme efficiency, due to increased public expenditure coupled with little additional take-up.

For solar thermal, the peak take-up is when a 50 % subsidy is applied, after which increasing the subsidy leads to little additional take-up and it is public money wasted. However, adding a 60 % insulation subsidy to the 50 % subsidy for solar thermal on its own leads to additional take-up so that this combination peaks in terms of efficiency at around 12 tonnes CO_2 per unit cost delivering nearly a 25 % reduction in CO_2 emissions in 2023 over the baseline.

However, this same effect could be delivered at lower cost with a medium (40 %) subsidy on insulation and 40 % subsidy on wood pellet boilers.

All the combinations of wood pellet boiler plus insulation subsidies lead to a point at which a 65 % reduction in CO_2 emissions could be achieved at around the same total cost of CO_2. This suggests a limiting factor on the take-up of this technology compared with other available systems. It also suggests that if NI wished to reduce its emissions further, some other combination would be needed, such as changes to building codes.

First conclusions

To what extent would programmes such as this be feasible? The indication of a cost-effective combination of measures does not assist programme designers to identify the total societal cost of the programme. A programme has to fit the budgetary constraints and sources of public finance. With the example of wood pellet boilers, this technology is currently in its infancy in NI. A UK government grant funded a plant in Enniskillen which now produces 50,000 tonnes per year from wood chippings and wood waste, sufficient to fuel 10,000 homes annually (RCEP 2004), and which makes it a considerable contributor to a low carbon future for Northern Ireland. However, successful development of local biomass resources will require government support, particularly in the early stages of development when new infrastructure is required, and also to develop the

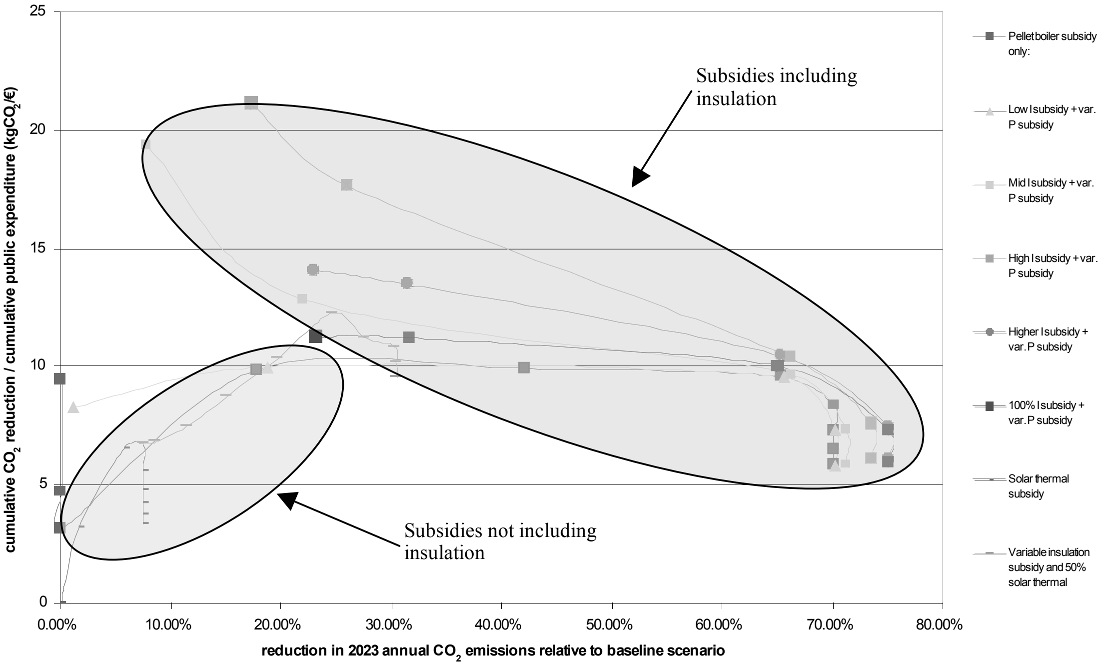

Figure 8: Efficiency-CO2 (PSE) curve for Northern Ireland; 'low' = 20%, 'mid' = 40%, 'high' = 60%, 'higher' = 80% investment subsidy

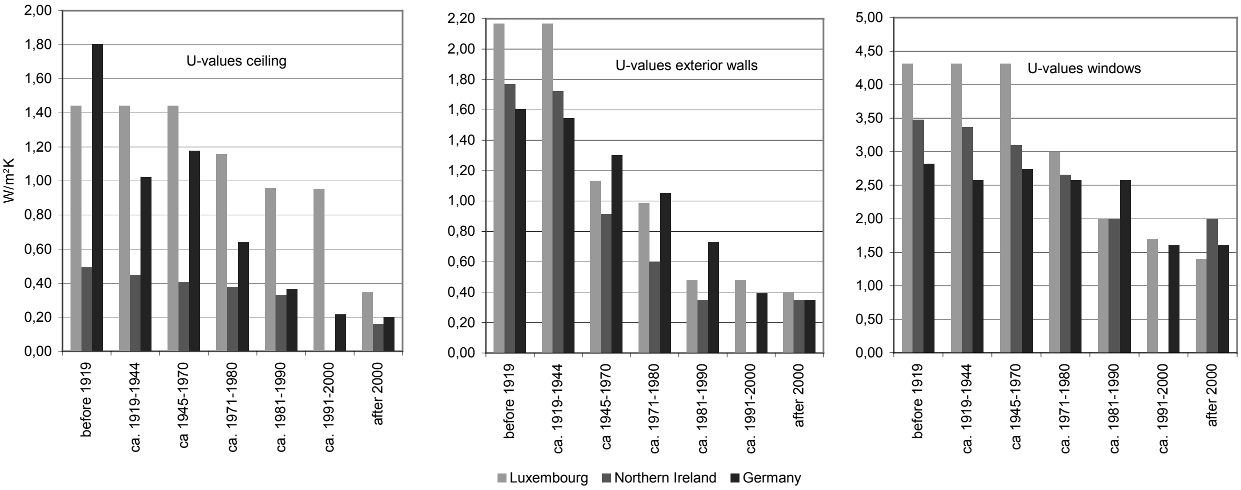

Figure 9: Comparison of U-values in Luxembourg, Northern Ireland and Germany

local skills base, raise public awareness and to establish a competitive market (Carbon Trust 2005).

This highlights the key stakeholder risk areas that the Invert project identified for promotion schemes, particularly the need for a strong commitment from government, involvement of the stakeholders in the new supply chain, and support for the technology including education, demonstration and marketing. The choice of which programme, or combination of programmes to choose will depend to a great extent of the involvement of stakeholders, their capacity to produce the necessary systems and fuels, and the rate of change in societal understanding of the technologies. However the cost of these programmes can be seen through the Invert model, and the benefits clearly described. If such an approach is adopted in NI it will also require interdepartmental working of a high order. At present there is some division of accountability and therefore need for agreement on priorities and objectives, but there is evidence of cross-departmental working both within NI and inter-UK, thus NI should have the ability to makes these changes should the political will (and ministerial commitment) be there.

Comparative discussion of results

CURRENT BUILDING QUALITY

Analysing the energy efficiency of buildings (U-values) from various construction periods in the three case study regions showed that the building standard of new buildings is in a quite similar range. However, the U-values of buildings constructed before 1980 show considerable deviations. In particular, buildings in Luxembourg before constructed before 1945 have significantly higher U-values than in Northern Ireland and Germany, whereas buildings in Northern Ireland constructed between 1945 and 1980 are substantially more efficient than

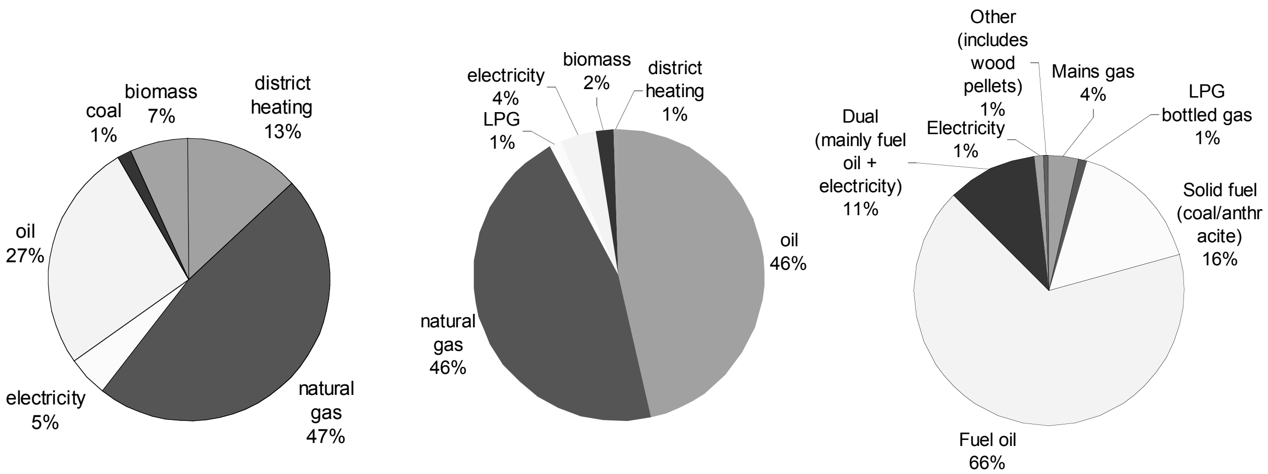

Figure 10. Energy carrier mix for heating in Germany (left), Luxembourg (middle) and Northern Ireland (right).

in the other regions. This leads to different need for building renovation activities and energy saving potentials.

For the uptake of insulation measures and window replacement, energy prices and public support are the most important impact parameter. However, even in low-energy price scenarios and in the case of no public support, useful energy demand for heating declines by about 5-10 % up to the year 2020. This is because the energy price increase within the last few years provides enough incentive for DSM, even if prices will not increase further. Since it can be expected that within these regions substantial public effort for energy efficiency will occur, a significant decrease of useful heating energy demand in the range 15 % to 25 % compared with 2005 can be expected. However, it should be taken into account that parts of these savings could be compensated by rebound effects, e.g. by increasing service factors when switching from single stoves to central heating systems (Kranzl et al 2005).

HEATING ENERGY CARRIERS

The energy carrier mix in the three case study regions varies considerably: Germany shows the highest share of natural gas with about 47 % of total final heating energy demand, oil has a share of about one quarter. Luxembourg covers its heating energy demand with identical shares of natural gas and oil (each about 46 %) and in Northern Ireland, two thirds of heating energy demand is covered by heating oil and a relatively high share of 16 % by coal.

So, the need for a shift to low carbon energy carriers is quite different in these three regions from a climate mitigation point of view. However, despite of these different structures, in all these regions a strong tendency from oil to gas (and partly district heating) can be observed. In Germany, this shift already occurred to a quite high extent in the past, whereas in Northern Ireland this probably will occur mainly over the next 10-15 years, although it might be partly restricted by limited gas interconnectors.

THE IMPLICATION OF RUE POLICIES ON RES DEVELOPMENT AND VICE VERSA

A general aspect of integrating RES and RUE policies which holds for all case studies, is the impact of RUE policies on the up-take of various heating systems (among them RES-heat) and vice versa. One core reason for this linkage is the different structure of investment and fuel costs of various heating systems. In general, RES heating systems show higher investment costs and lower fuel costs than conventional systems. This is especially true for the period since the oil price increase over the last few years. Of course, a building that has been insulated shows a lower fuel demand. Therefore, for such an insulated building, heating systems with lower investment costs become more attractive, since the fuel costs are reduced by the insulation measures anyway. Thus, in low-energy buildings there is a tendency towards heating systems with low investment costs and thus conventional, fossil systems. This, of course, is the result of a pure economic analysis. Actually, behaviour of people living in low energy buildings could as well show a tendency to higher investments (i.e. low interest rate). This aspect remains for future investigations of the behaviour and actual decision making process of corresponding consumers and investors.

Especially in scenarios with a longer time horizon, analyses have shown that the heat load of buildings (under central European climate conditions) can be expected to decrease substantially, in average by about 40-50 % (Müller et al. 2006). In such scenarios, especially in the high quality and efficiency segment of the building stock, there is a strong tendency towards electric heating systems since these are the systems with the lowest investment costs (see also Torakov et al 2007). This tendency is partially reversing the positive impact of RUE-measures on GHG reduction. Hence, it is crucial to set specifically targeted measures for low energy buildings, for example regarding the promotion of heat pumps, pellet stoves, tiled stoves etc. Such policy measures can ensure that the positive impact of DSM is not countered by adverse development of heating systems.

In particular, the RES-heat scenarios in the case of Germany (figure 2) show a high uptake of grid connected RES-heat (biomass, geothermal, solar). More generally, district heating is expected to become increasingly important in the future heat market. However, substantially declining heat loads of buildings and thus a declining heat density, especially in non-urban regions will occur in the next decades. Since district heating grids represent quite long-term investments, especially in rural areas, the heat demand – such as of new biomass district heating systems – should be calculated with a dynamic point of view considering probably occurring investments in insulation and thus dynamically decreasing heat demand. Thus, this aspect will be a core challenge for the integration of RES and RUE policies.

POLICIES: CURRENT STATE AND DISCUSSION OF VARIOUS OPTIONS

Current policy structures in the three investigated regions are quite different. Due to variations in historical background, potentials of renewables and climate conditions, the approaches turn out to be quite different. To some extent they represent typical cases of various policy cultures.

In Luxembourg we can see a case of quite low energy taxes for fossil fuels. In order to provide enough incentive for RES heat systems, relatively high subsidies are granted. Also for energy efficiency measures quite attractive monetary incentives are in place. However, due to administrative and other barriers, the uptake of these measures turns out to be lower than could be expected. For the discussion of future policy options the geographical structure of Luxembourg, and its limited domestic biomass potentials have to be taken into account. Moreover, there is hardly any tradition of biomass heating systems – accompanied with historically quite low energy taxes on fossil fuels. Thus, current ideas for climate policies in the heating sector focus strongly on the promotion of DSM. An innovative approach is the idea of coupling the promotion of both RES and RUE for heating with the energy certificate for buildings and the skipping of energy efficiency classes by introducing energy saving measures.

Current RES-heat policies in Germany are characterised by moderate investment subsidies by the federal government which are partly accompanied by additional schemes within the *Bundesländer*. For the current discussion, we have to consider that Germany has made the experience with effective feed-in tariffs in the RES-E sector EEG (*Erneuerbare Energien Gesetz* – Renewable Energy Law). Thus, it is apparent that there is the idea of transferring the results for RES-E to RES heat. Within a project [Nast et al 2006] commissioned by the German environment ministry, budget-independent schemes have been developed in order to provide similar stable and attractive conditions for RES in the heat market as it has been done for RES-E. The integration of RES heat with RUE policies is just emerging and will be subject to investigation of a subsequent project.

In Northern Ireland currently there is a broad set of policies which are primarily household related and not building related and have a strong social motivation. The role of energy suppliers in fulfilling energy savings obligations is much higher than in the other case study regions. Thus, the Energy End-use Efficiency and Energy Services directive could provide an incentive for strengthening this tradition. The further development probably will also depend on the cross-departmental working within the Northern Ireland administration.

Conclusions: Challenges for integrated RES & RUE heat policies in Europe

Despite the analysis of the Stern Review identifying the need to invest now to achieve only 1% loss of GDP as apposed to a major downturn later (Stern, 2006), the need for the public expenditure to be cost-effective remains. In its proposals for an energy policy to 2020 (EC, 2007a), the Commission proposes a binding target in renewable energy systems, including a renewables legislative package to facilitate market penetration of biofuels, heating and cooling. What the case studies described above indicate is that this market penetration can be managed cost-effectively if careful combination of measures takes account of the interactions between instruments. The Commission specifically cites the key measures of 'rapidly improving the energy performance of the EU's existing buildings' and ' coherent use of taxation to achieve more efficient use of energy' (EC 2007a, p12).

The potential for demand side management in the building sector lies not only in new buildings, but in fact primarily in renovation. It is not feasible to consider wholesale replacement of old inefficient buildings with new, and the case studies have demonstrated that substantial CO2 savings can be made through renovation at appropriate stages in the life of a building and its appliances. Promotion schemes for DSM, coupled with energy performance certificates for buildings, combine not only to make sense in policy terms but in market terms, as experts anticipate that a property with a good energy rating will maintain or improve its value compared with lower energy performance under all future scenarios (Guertler et al, 2005).

The new (or restated) policy framework for the EU stresses that the targets are ambitious. Our contention for RES & RUE policies in particular is that as long as the externalities of energy use are not included in a level high enough to foster these technologies, other incentives have to be set in order to achieve the ambitious targets. For an optimum design of related policy instruments it needs an analysis of many interconnected circumstances and side conditions. The following lists and briefly describes some of them:

- Interactions of technologies and policies:
  Technologies and policies show multiple interdependencies. They influence each other and thus can help to increase the efficiency and effectiveness of the policy mix or conversely they 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. Decreasing heat demand in the building stock will need to be considered when designing district heating systems and corresponding CHP in the future in order to avoid lack of adequate heat demand and inefficient operation modes in the future.
  - Third, potentials (in particular biomass potentials) are restricted. Thus, a competing situation between various sectors may occur, affecting efficient policy portfolios.
- 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. For example, 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. For example, 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.

- For a comprehensive analysis and optimisation of policy instruments at least these 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. CO2-reduction) can be achieved by using a certain amount of public money in terms of kg CO_2/€. The effectiveness measures how much this instrument can contribute to reaching a certain target in absolute terms (e.g. kg CO2-reduction). Both aspects have to be considered at the same time. Taking into account only one of these aspects in isolation may lead to fallacy, but may also ultimately depend on the acceptable cost of CO_2 mitigation as balanced against climate change policy requirements. In this paper, for Northern Ireland a CO_2-efficiency graph is presented combining these two aspects. This clearly shows that the optimum policy mix is a matter of the policy target. Which level of CO_2 reduction should be achieved by a certain year? What additional targets should be met (energy security, energy saving, reduction of other emissions)?

The presentation of the case studies in Germany, Luxembourg and Northern Ireland has found commonality in several issues: substantial uptake of DSM in the building sector can be expected in the next decades. The level of energy prices as well as incentives or compulsion provided by policies will have a considerable impact for this development. A share of these energy savings will be compensated by rebound effects. One of the challenges for future policies will be to minimise such negative side-effects, such as by an efficient integration and adjustment of RES and RUE policies. The trend from oil to gas will continue in the future and one of the crucial questions is how RES heat systems will cope with declining heat loads of buildings. Compulsion may have an increased role to play to avoid a tendency towards less capital-intensive but more carbon-intensive heating systems. On the other hand, the paper has identified that natural resources, policy culture and applied energy carriers lead to very different requirements for the choice of combinations of policy instruments.

A common general condition is the requirement of stable surroundings and policy framework. Market development needs confidence and at least medium term security. Promotion schemes based on investment subsidies in general depend on availability of the according public budget. This can be a considerable reason for market uncertainty. The development and implementation of budget independent instruments could provide more secure conditions and an extended time horizon for the market participants. This can be done by related obligations towards energy suppliers (as it is partly the case in Northern Ireland), obligations and standards oriented towards end users or coupling RES bonuses with taxation of fossil energy (as it is currently under discussion in Germany, see Nast et al 2006) and partly also by connecting RES heat promotion to the energy certificate for buildings (as it is currently under discussion in Luxembourg). In any case, the success of promoting RES heating and cooling will depend heavily on designing policy instruments that provide not only attractive but also medium to long term secure and trustable conditions.

The design of such policy instruments that represent an optimum of efficiency and effectiveness requires identifying the interactions between policies, the existence of competing schemes, understanding the growth paths of new technologies, understanding the dynamics of scheme application, ensuring that incentives are compatible, and then applying a well designed analytical tool to a built environment as near as possible to the real world.

Acronyms

CHP	Combined heat and power
DSM	Demand side measure
EPBD	Energy performance of buildings directive
GHG	Green house gas
LPG	Liquified petroleum gas
PSE	Promotion scheme efficiency
RES	Renewable energy sources
RES-E	Renewable electricity
RES-H	Renewable heat
RUE	Rational use of energy

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Endnotes

[i] See also www.invert.at

[ii] As ambitious DSM policy in Luxembourg a range of 30 up to 75 €/m² subsidy was introduced, depending on the level of energy efficiency standard that can be achieved by the insulation measure.

[iii] Solid fuel boilers provide the technology to use coal or wood logs, but coal is the most available solid fuel in Northern Ireland