EUFORIE
European Futures for Energy Efficiency

Consumers and energy efficiency

Workpackage 5

Identification of promising instruments and instrument mixes for energy efficiency

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Content

1. Introduction: The context

Energy efficiency is one of the priorities of the European Union, as reflected in the various documents, which place it at the heart of the European corpus on energy and environment policy. Most of the texts on energy efficiency adopted by the EU since early 2000 were written in the context of the fight against climate change, as is the case in the Member States.

The overarching goals of European energy policy are reducing energy demand, increasing security of energy supply and enhancing competitiveness. By 2030, it aims at cutting greenhouse gas emissions by 40% compared to 1990 level, increasing the share of renewable energy to at least 27%, and continuing the improvements in energy efficiency (at least 27% energy savings compared with the business-as-usual scenario). Little wonder then that most initiatives on the Member State level are not confined to energy efficiency improvements but combine them with measures to stimulate the generation of renewable energy and reduce carbon emissions in the same package. This holds true for the housing sector as well, as our stocktaking has shown.

Households, the focus of this WP, are one of the major energy consumers in the EU, and one which has not yet exhausted its enormous potential in fulfilling the EU energy policy objectives. Within households, low temperature heat generation for room heating (68%) and warm water (13%, 2013) holds by far the largest share in energy consumption. The heat sources are varying between households and Member States; they include coal, oil, gas, wood and electricity. Electricity use for lighting and household appliances is much less important (14%), but has received a disproportional share of public interest so far, plus the support by the EU . Financial support measures have to be shaped according to the prevailing institutional setting, and the level of incentives varies. To be effective it should correspond to local price levels.

Acknowledging this diversity, we refrain from suggesting any best practice or standard policy measures (which overwhelmingly would be in fields of national competence anyway) but analyse which instruments have addressed which causal factors, and – as far as information is available – how effective they have been under specific circumstances. The recommendation is then not one of a specific policy mix across Europe, but of a policy toolbox, with an indication which tools are recommendable under which circumstances.

2. The analytical structure

Households as final consumers are part of the energy system. Their influence on the total energy consumption and the efficiency of transforming primary energy into energy services cannot be identified exclusively by focussing on what is happening inside the house. Analysing energy efficiency contributions of households requires taking system effects into account as well. For instance, replacing individual stoves by electric or district heating will have different effects depending on the energy provision system into which the household is embedded, and recommendations for household choices must take those differences into account. Like for efficiency, this matters for carbon intensity: the relation of final energy consumption to primary energy consumption is to a large degree determined by the system.

To minimise energy consumption while maintaining a good supply of energy services, in particular in terms of low temperature heat, a household must confirm to a series of conditions which we first formulate on a level general enough to be applicable across the board in Europe. How these conditions can be fulfilled depends on a multitude of factors, such as the age and structure of dwellings, settlement structures, planning processes, income levels and human routines, habits and preferences. Electricity use for running household appliances follows different but related rules and is discussed in a separate section.

A building must be

- capable of keeping heat within the building envelope, by means of isolated walls and roofs and adequate windows, doors and shutters.
- equipped with low input service providing installations,
- offering energy security; as standard heat storage tanks offer supply for about 2 hours per m^3 of storage, external supply or in-house fuel storage must be available.
- used accordingly, which required adequate behaviour based on relevant knowledge, motivation and skills (management)
- built in a heat conservation and appropriation supporting way, based on local or regional planning (governance)
- part of an efficiency enhancing energy supply system.

In the following, this Deliverable highlights selected examples from the study (D5.1) and the national analyses (Annexes to D5.1) following the systematique describes, thus illustrating that it captures the empirical findings and is suitable to structure them.

3. Success factors for policy instruments

Concluding from the empirical data gathered and the analysis conducted, success factors are identified. As for all instruments not only the choice of instrument as such, but its design and application are decisive for the effect, we distinguish generally, i.e. under all conceivable conditions applicable success factors from those which refer to the process of policy development and implementation. Thirdly, there are conditionalities specific to the kind of instrument chosen; the most important ones are listed as success factors which apply to specific instruments.

Besides this, a set of generally counterproductive measures and attitudes has been identified which may prove to be major obstacles for energy efficiency policies.

3.1. Capable of keeping heat within the building envelope, by means of isolated walls and roofs and adequate windows, doors and shutters

- In implementing the EU regulations, almost all countries have set efficiency standards for new buildings. However, the housing stock remains unaddressed by such regulations.
- In many countries the legislation obliges all individuals undertaking a major renovation, alteration or system renovation to incorporate measures enhancing energy efficiency. The targets set, and the threshold above which such measures are mandatory varies between countries; in Finland, for instance, it refers to all projects requiring a permission and aims at cost-optimal levels of minimum energy performance. With cost as a (variable) basis, Finland lags behind other EU countries in terms of energy efficiency increases in the residential sector despite offering subsidies to stimulate renovation.
- The Aid Programme for the Energy Renovation of Existing Buildings, Spain, supports integrated energy efficiency approaches, including measures improving a building's thermal insulation such as the renovation of windows and roofs.
- Thermal rehabilitation of apartment blocks and single-family residences is foreseen in Romania. Reflecting the countries housing stock.
- Building renovation measures in Latvia cover residential, central government and municipal buildings. The scheme is being changed from a 50% grant to a 100% low-interest loan, with the money flowing back used for additional measures; 35% of the loan can be waived if high energy efficiency achievements can be proven and repayment only starts after the measures have been completed so that they can be financed from the energy savings. The intention is that no up-front cost emerge, enabling willing households with insufficient capital to start a renovation (even with 50% grants) to get going.
- Energy efficiency enhancing renovation projects in multi-apartment building enjoy a 20% public co-funding in Latvia. Beneficiaries have been individual flat owners until 2013.
- In Germany, programs for thermal modernisation (including standards, building renovation programs and subsidised credit from the KfW) have a long history, but progress of acceptance is slow in residential building with rented flats due to the diverging interests of landlords and tenants (the situation where the landlord invests and only the tenant reaps the benefits), as in many Central European countries.
- In the UK, the building renovations strategy aims at making building more thermally efficient through better isolation and improved air-tightness, stringent building regulations are a key element. The landlord-tenant tension was addressed by the Green Deal enabling private firms to offer consumers energy efficiency improvements to their homes at no upfront cost, and get back payments through instalments on the energy bill. An important side effect of this model is, that if tenants moved out and ceased to be the bill-payer at that property, the financial obligation didn't move with them but moved to the next bill payer. In this way, the Green Deal differed from existing lending – it was not a conventional loan since the bill-payer was not liable for the full capital cost of the measures, but only for the charges on the energy bill. The Green Deal was

cancelled in 2015 due to lower-than-expected participation despite its interesting features. The additional tax relief system for landlords contributes to a situation where there is also no net or up-front cost to landlords.

- Hungary has a national target for efficiency increases in the building stock; priority is given to measures affecting the most common type of housing, single family homes built in the Communist regime time period.
- The Italian income tax deduction scheme aims at reducing heating demand by means of overall upgrading of the building's energy performance; it supports improvements of the building's thermal insulation (replacement of windows, including blinds or shutters, and insulation of roofs, walls and floors);

3.2. Equipped with low input service providing installations

- The Aid Programme for the Energy Renovation of Existing Buildings, Spain, supports incorporation of equipment to individually measure heating and domestic hot water consumption.
- The German approach is offering cheap credit and information to commercial house owners, hoping that market forces will promote energetic modernisation of installations, a strategy suffering from low energy prices. In some Federal States, in case of new buildings or major restorations, a fixed share of the buildings future energy consumption will have to come from renewable sources (regulations differ widely between Federal States and municipalities).

<u>Efficient heating systems like floor heating, boilers etc.</u>

- The Program of Building Rehabilitation, Spain, supports the renovation and maintenance of fixed installations and equipment of (mainly) residential buildings built before 1981 if the measures undertaken reduce the energy consumption be at least (certified) 30%. Main beneficiaries are property owners (individual or associations).
- The Aid Programme for the Energy Renovation of Existing Buildings, Spain, supports integrated energy efficiency approaches, including measures improving energy efficiency in thermal and lighting installations (including solar thermal) such as boilers, air conditioning equipment.
- In the UK, the building renovations strategy aims at improving the efficiency of heating systems through the use of more efficient boilers.
- In Germany, boilers older than 1978 have to be replaced by law, but there is no control or enforcement for this regulation.

<u>Renewable solar energy providing systems (thermal and electric)</u>

- Promoting the use of alternative heating systems based on solar, waste wood or geothermal energy to complement or replace traditional heating systems (Romania)
- The Italian income tax deduction scheme supports installing solar thermal panels;
- In Germany, the growth of household renewable energy production has been so significant that the government plans to dampen it by charging a tax on consumption of self-produced electricity (no such regulation is planned for solar thermal installations).

<u>Renewable geo-energy providing systems (heat pumps, geothermal energy)</u>

- The Domestic Renewable Heat Incentive (domestic RHI), UK, is a Government financial incentive to promote the use of renewable heating system targeted at, but not limited to, homes off the gas grid. The scheme covers single domestic dwellings and is open to homeowners, private landlords, social landlords and self-builders It pays beneficiaries a fixed amount of money for heat generated according to the heat source, calculated based on the expected cost of renewable heat generation over the next 20 years.

- The Aid Programme for the Energy Renovation of Existing Buildings, Spain, supports integrated energy efficiency approaches, including replacement of conventional energy with geothermal energy in thermal installations.
- Romania promotes the use of alternative heating systems based on solar, waste wood or geothermal energy to complement or replace traditional heating systems.
- Heat pumps for detached and terraced houses are part of an energy efficiency obligation scheme in Finland.
- The Italian income tax deduction scheme supports replacing winter heating systems with condensing boilers or heat pumps, and replace electrical water heaters with heat pump water heaters.

Renewable bio-energy providing systems

Many of the national programs include support for biomass boilers, heaters and fireplaces as an incentive to make more use of renewable energies (although in fact – unlike legally – wood is not a CO_2 free energy source). However, this is not increasing energy efficiency, and can be detrimental to it. Before supporting such solutions a regional heat provision plan should be available, based on cost-effectiveness considerations, which identifies which areas are best supplied with external heat (municipal, district, settlement levels) and in which internal heating systems for all houses are preferable.

Even where this is the case, the balance of supply and demand needs to be managed: if due to subsidies biomass demand surpassed locally available biomass from sustainable production, either the impact becomes negative, or – if there are limits to harvest – the efficiency suffers from longer, energy consuming supply chains.

Grants can be conditioned to generate co-benefits; in Romania a condition is that applicants have no duties to public authorities and have not violated environmental protection regulations.

- The Domestic Renewable Heat Incentive (domestic RHI), UK, pays beneficiaries such as biomass boiler owners a fixed amount of money for heat generated according to the heat source, calculated based on the expected cost of renewable heat generation over the next 20 years.
- The Renewable Energy for Heating and Cooling Support Scheme, Italy, supports (for private parties) the replacement of existing systems for winter heating with more efficient ones (condensing boilers), and the replacement and, in some cases, construction of new renewable-energy systems (heat pumps, biomass boilers, heaters and fireplaces, solar thermal systems, including those based on the solar cooling technology)
- Promoting the use of alternative heating systems based on solar, waste wood or geothermal energy to complement or replace traditional heating systems (Romania)
- The Aid Programme for the Energy Renovation of Existing Buildings, Spain, supports integrated energy efficiency approaches, including replacement of conventional energy for biomass in thermal installations, replacing conventional energy with biomass.

3.3. Offering energy security; as standard heat storage tanks offer supply for about 2 hours per m^3 of storage, external supply or in-house fuel storage must be available

- Subsidies for district heating providers, Hungary
- Mandatory connection to local gas or district heat, Denmark
- Support for installing electricity storage (batteries) in private households in Germany, to be combined with self-generated solar electricity. Such installation can, if spread widely, help buffering demand peaks and smoothen the integration of renewables into the electricity grid. Since the feed –in tariff has been decreased so much that it is lower now than electricity bought from the grid, the economic incentive has stimulated in particular owners of detached houses to install such energy storage capacity (not available for heat yet). However, the German government plans to tax self-used electricity, making the subsidised trend economically unfeasible.

3.4. Used accordingly, which required adequate behaviour based on relevant knowledge, motivation and skills (Management)

Education

Information and education measures are used in all EU member states, as required by the EU directives. Different kinds of information can be distinguished: *pull information* requires end users to seek for information, pull them out from homepages, workshops, seminars, training courses, etc.: consumers have to become active first to get hold of the information. This kind of information provision regarding technology or funding is an excellent source for experts, but rarely used by households. If addressed to children e.g. in school, it may be helpful for awareness raising but will not influence household energy efficiency in the foreseeable time.

Push information is delivered by authorities, agencies and companies to household without prior demand articulation, e.g. by advertisements, TV shows, social platform network information or other campaign elements. It has a number of difficulties of its own: consumers can hardly distinguish reliable information from hidden advertising and from weird internet posting, and to reach all addressees, the information cannot be very specific.

A frequent argument for promoting energy saving (for labelling, eco-design, support for buying efficient equipment and renovating buildings) is the resulting cost saving, i.e. the rebound effect is used as an argument for the primary saving – maybe not the best possible and most logical argument. Overall, the hope that market mechanisms – information about cost saving guiding consumer behaviour – would be the most effective instrument have long been falsified by experience. This hope is one of the main reasons why a lot of information is intended to raise the environmental awareness in general but falls short on practical behavioural advice.

This points to another way of classifying information dissemination: what is the message conveyed? First of all, a more-than-proportional part of the information focusses on electricity as compared to heat generation and management. Secondly, most information accompanies or points to available technologies and financial incentives (and is indispensable for their success), i.e. they are not stand-alone energy efficiency education measures aimed at changing household energy management, but of a more explanatory and promotional role for other instruments.

However, there are limitations to this approach: if the matter to be explained is complex and dynamic, good didactics cannot make it easier than it is – for instance, the regular change within the set of about 15,000 funding opportunities in Germany (loans and grants, tax benefits and technical support, with differing conditionalities and different modes of calculation, to be obtained from the national, state or municipal level, which can be combined or not) makes transparency impossible

and expert courses are outdated within a year. Consumers have to consult experts (and more expert involvement is foreseen by government in the process of receiving a grant or loan) at serious cost, denting deep into the support provided by the same government.

Finally, the educational programs aiming changing household management in favour of energy efficiency often do not reach their clients due to high cost (participation in courses, workshops, etc.), wrong timing (household members in paid and unpaid work have different, but always limited flexibility) or difficult language (technical, economic).

Information campaigns

- Information to consumers, house owners and rental flat management companies is a key pillar of all efforts for energy efficiency in Germany (together with subsidised loans).
- As energy efficiency and renewable energies are widely accepted in Germany, several leading companies in the household equipment, heating and sanitary installation sector offer training to their local contract companies, introducing new technologies and demonstrating upgrade potentials (B2B education & training).
- In Spain, the energy efficiency and renewable energy citizen information service provides sources of information, accompanied by public outreach through advertising and communication campaigns.
- The Latvian campaign “Let’s live warmer” is an integrated multi-media campaign, despite its title for energy saving, promoting the available information on housing insulation issues. It appeals to the quality of life in homes.
- In Hungary, the public awareness raising campaign goes under the title “the price of energy”, a mainly economic argumentation.

Energy audits

Voluntary energy efficiency agreements and audits have a long tradition and brought good results in Finland, but so far do not focus on households. In almost all countries they are foreseen, but do not necessarily play a central role.

- Energy audits in multi-apartment building receive a significant share of the annual energy efficiency support for households, which is more than 120 million € in Latvia.
- In Latvia as well, energy efficiency and traditional city competition have been brought together in the annual contest to identify the “Best Energy Efficiency” Building”

Efficiency labelling

Energy efficiency labelling applies almost exclusively to electricity consumption and thus plays a limited role in overall household energy efficiency, but receives a more than adequate attention. This success figures published are in so far questionable, as other reasons like modernity (would producers have offered outdated designs if they had not been discriminated by a low efficiency label?) are hard to disentangle from other motives. In particular the claim that lower bills have led to less consumption is implausible from an economic point of view.

In particular the fact that overall household electricity consumption for appliances has not been decreasing has a number of reasons (demography, technical progress), but the rebound effect from money saved by energy saving is certainly one of them as it allows households to replace durable consumer goods like TVs before the end of their technical life span, buy additional appliances and use the ones owned more intensively. As these effects are considered in none of the studies testifying for the effectiveness of ecolabelling (and for eco-design alike), the success figures should be taken with a grain of salt. Overall, promoting energy efficiency but highlighting rebounds (i.e. savings) seems to be an incoherent strategy if not combined with energy taxation which keeps the energy cost for users of efficient equipment rather constant and provides incentives for laggards to catch up in order to escape increasing prices.

Some of the least efficient products are off the market – it is an open question where this limit should be set, where the responsibility for environmentally benign behaviour of regulators and producers ends and that of consumers begins. For instance, if European minimum conditions would be set based on the best national average and deviations from the minimum efficiency standard were sanctioned, lagging countries might (correctly) feel pressurised, but could realise significant savings (for the resulting rebound effect see above).

Where labelling is used, some conditions should apply:

- Besides labels informing consumers on the electricity efficiency of appliances, boilers and heating systems could also be classified (although this may be more of an information for architects, installation firms etc. they share with consumers).
- As an "A" label plus different numbers of "plusses" has turned out to be less effective, an overhaul of the labelling system seems advisable; a ban on all products below class A would clear the ground for doing so.

3.5. Built or renovated in a heat conservation and appropriation supporting way, based on local or regional planning (governance)

Energy certificates

- In Germany, energy certification is part of a "Housing Pass" and must be presented to all potential clients by the landlord when a flat is rented out, i.e. with any change of tenants.
- In Finland, testified energy certificates have been one important item of governmental consumer information campaigns.

Technical inspections

- Technical inspections in multi-apartment buildings is a second field supported by the annual energy efficiency support for households, which is more than 120 million € in Latvia.
- In Germany technical inspections have been mandatory for a long time – done by installation firms, they check the overall heating system efficiency once a year, and have significantly contributed to avoiding accidents. In addition, emissions are controlled by a chimney sweeper every second year.

Land use planning

Planning for new settlements, with roads and thus houses laid out to enhance heat conservation and appropriation supporting way, for instance with large windows oriented southwards to capture solar warmth, or northwards to avoid this effect, depending on the local climate conditions.

While optimising spatial planning has long been an issue in urban planning and played a role in setting up energy-efficient and renewable energy supplied settlements, it seems to play no role in the energy efficiency policies of member states.

3.6. Part of an efficiency enhancing energy supply system

An energy system within which significant amounts of heat escape unused into the atmosphere while nearby energy carriers are used to produce fresh heat is easily energy inefficient (depending on distances, transport modes and external circumstances). Making use of nearby heat sources is the probably most efficient way of providing heat to households. District heating (like in DK) offers even the possibility to completely phase out fossil fuels from household heat generation – a much more efficient solution than electric heating as it was promoted in some new Member States when they were still part of the Soviet Union.

- Community Energy Saving Program, UK

- Support for co-generation (combined heat and power CHP) is one element in the effort to reduce fossil fuel use in Germany, albeit so far underexploited. Such installation can cater for one residential building or for a block of such houses.
- The Danish approach seems to be quite unique in the EU. Under the current legislative system, households have to connect either to a district heating or a gas supply net – connection is mandatory, and thus the choice of the heating system is predetermined. The basic idea is to assess if enough heat sources are available at suitable distance, and then go for a distant heating network, and otherwise enforce the use of efficient and low-emission natural gas. This is probably the most effective system for enhancing system efficiency rather than efficiency at household level which can still lead to inefficiencies at a larger scale.

3.7. Standards

Building standards should not be set in stone, but be flexible enough to evolve with conceptual and technological developments. Legislation requiring an advanced state of the art, or even better the state of science and technology is open to such improvements, and what is the state can be pushed forwards by economic incentives.

In all EU countries standards are set, implementing the EU directives and demanding that new buildings have to require near-zero energy standards.

3.8. Economic instruments

Financial support measures should be focussed on cost-effective, long-term sustainable solutions to urgent problems (i.e. neither focus on fringe problems not support solutions which will have to be dismantled with future sustainability-enhancing system changes). They have to be regionally differentiated, shaped according to the prevailing institutional setting, and the level of incentives must be oriented by the local price levels to be effective. Energy efficiency criteria to be applied are:

- Incentive effect
- Affordability effect
- Time horizon (for investments beyond the usual household calculation time horizon)

In general, the public preference is for grants and subsidies, rather than for subsidised soft loans. Government policies set different priorities, preferring loans to grants, for more or less convincing reasons, like the ease of implementation by the banking sector (not really convincing), the limited funds available (more a matter of political prioritising), the possibility of creating a rolling fund which lends out all interest and payment for new energy efficiency programs (a point to consider) and the possibility for low-budget households to start energy renovation programs without up-front cost (a good argument).

Tax modifications (income tax, VAT) are also potential economic instruments, but so far rather unused. VAT changes would have to be agreed on the EU level (legally and to avoid distortions of the EU's internal market), and reducing VAT would dent on the EU budget. Similarly, income tax modifications rewarding energy efficiency investments remain hypothetical in most member states, but Italy, Spain and Finland have some experience to provide.

- In Finland, taxpayers can currently deduct from their taxes 45% of the value of household service or maintenance work conducted at the taxpayer's or his/her parent's home, up to a maximum value of €2,000 per year (€4,000 for a couple). However, due to overcapacities in electricity generation, the electricity price is very low, and drags down the price of heating energy as district heating holds a high share in apartment blocks and it is argued that the heat is available anyway as a co-product from electricity production.

- In Italy, tax deductions for the energy upgrading of buildings have been key drivers of energy efficiency improvements in the housing sector over the last ten years. Tax deductions can be claimed by all taxpayers, including natural persons, professionals, companies family members living with the owner or possessor of the property and tenants holding a regular letting agreement. They reduce the personal or corporate income tax with respect to measures taken improving the energy efficiency of existing buildings. Eligible measures include improving a building's thermal insulation (replacement of windows, including blinds or shutters, and insulation of roofs, walls and floors), installing solar thermal panels and replacing heating systems (winter heating with condensing boilers or heat pumps, electrical water heaters with heat pump water heaters).
  Although the system is comprehensive and effective (it has been identified as best practice by the IEA), it has three downsides (1) the income tax base causes regressive effects (the higher the income and thus the tax rate the higher the tax savings), (2) the income tax is national and permits no regional differentiation, and (3) it is expensive, so that the government plans changes to rationalise cost (which undermines the longer-term reliability criterion).

When discussing financial instruments, one prominent consideration has been how to avoid free riding effects. Doing so requires knowledge about not yet realised intention, which is hard to get and even harder to administer. From our point of view, this demand from economic theory is not necessary, even dangerous or at least counterproductive: whoever takes the financial support to implement efficiency enhancing measures does what was the intention of providing the incentive, regardless of her earlier intentions – the direct link of investment and efficiency effect is unchallenged. Furthermore, making support conditional on earlier unwillingness to go beyond compliance is discriminating those who as first movers have been or would be willing to take initiatives which – in the interest of energy efficiency – have the potential to transform the market. Dropping this consideration will also help to minimise the administrative burden, thus reducing the cost of the overall programs. Tariff modification that worked are for instance:

- The feed-in-tariff scheme for electricity from renewable sources in Germany is the oldest one in Europe and currently being dismantled to slow down renewable energy generation growth. Similar schemes are implemented in most EU member states.
- The progressive cost structure for household electricity consumption in some regions of Italy has led to substantive savings there.

Cost transparency

Individual metering is a preferred measure and made compulsory by European legislation. Giving consumers information about their actual energy consumption, even in real-time, was expected to motivate energy saving behaviour. However, it seems to have the highest impact amongst owners of detached houses, while the savings amongst tenants of multi-resident houses are rather small –the structure of the housing stock is decisive for the obtainable impact. So far, experiences are mainly from electricity metering, individual gas metering is spreading slowly.

The reasons are easy to understand: smart meters that facilitate real time and tailored monitoring and feedback provide many advantages for energy companies and Distribution System Operators (DSOs) in terms of operation cost reductions; they rolled them out enthusiastically. The impacts on the household side are less clear: while real-time information about load dependent electricity prices can lead to time shifts in electricity consumption to save cost, it does not reduce energy consumption, on the contrary: saved money causes a rebound effect of additional energy consumption, which makes the net balance negative.

Furthermore, the situation is different between electricity and gas consumption: while the elasticity of electricity consumption is limited by household convenience (cooking will not be shifted to low price periods in the night), but significant potentials exist to use electricity consuming appliances like

washing machines in the night with automatic timers, the elasticity of heat demand is almost zero: neither room temperature nor showering will be adjusted to price fluctuations.

Prominent programs include:

- The Aid Programme for the Energy Renovation of Existing Buildings, Spain, supports integrated energy efficiency approaches, including incorporation of equipment to individually measure heating and domestic hot water consumption. For central heating serving more than one household, and for district heating, individual metering has been made compulsory.
- To improve performance, households installing metering and monitoring packages get an extra 230 £ for heat pump users and 200 £ for biomass boiler owners under the Domestic Renewable Heat Incentive, UK. By 2020, 53 million gas and electricity meters in 30 million households will be replaced.
- Individual metering of electricity consumption is the norm in Germany, but not (yet) of gas or district heat consumption; cost transparency regulation obliges owners of rental flat to detail the information provided to clients. Utilities offer extra services like distant metering or account management. Reverse metering is spreading with local renewable energy generation to assess the feed-in tariff entitlement.
- In Italy, the replacement of traditional by smart electricity meters started as a voluntary initiative, but has become compulsory in 2006. As gas meters are also smartening up following the regulatory framework, Italy is ahead of the European average in this field.

Social and distributional aspects

Economic incentives can have regressive effects which might undermine the acceptability of efficiency policy as such. Thus social concerns are not only an important issue in itself, but can also be decisive for the program implementation success.

- The Spanish PAREER-CRECE Programme offers a money allowance, composed of a Base Aid and an Extra Aid, the latter for public housing, housing subsidised for social reasons and urban regeneration areas, i.e. targeted at socially deprivileged housing conditions (for ambitious energy efficiency upgrades and comprehensive approaches).

To design effective policies, the difference between energy-supply affecting income poverty (not enough income to pay for energy supply) has to be distinguished from energy poverty (a too high share of energy in household expenditure), as for both situations the remedies are different. Where both overlap, both kinds of measures are needed to overcome the problem.

- Both forms of energy poverty have been an issue long discussed in the UK. Recent measures like the Warm Home Discount aim at the second form, by specifically reducing the electricity bill by a one-off discount of £ 140 during the winter heating period. Some suppliers offer reduced rates for low income households (in particular to those with a small child).
- The second form of energy poverty is addressed by the UK Green Deal Home Improvement Fund, enabling private firms to offer consumers energy efficiency improvements to their homes, community spaces and businesses at no upfront cost, and get back payments through instalments on the energy bill.

Regional distribution plays a role for social and for climate reasons; in Spain and Italy special programs, partly financed by the European Investment bank, apply to provinces most in need of support.

- In Romania, a project funded by UNDP-GEF offers specialisation of architects, building engineers, qualified auditors through training and postgraduate courses in energy efficiency of buildings to address energy efficiency in low-income household and communities.

Tax incentives, i.e. income tax reductions for efficiency increasing investments have a regressive effect wherever progressive taxation is in place; in Finland (unlike in Italy) the effect is limited by an annual cap per person. Compensatory measures are not foreseen.

Housing structures

Housing structures have predominant impact on the energy consumption during the use phase of 50,100 or more years. So far, many EU member States subsidise detached house construction; in most Member States house ownership is a widely spread social demand (however receding in the younger generation, and often specific to a house designed to meet one's personal need and taste. Inherited houses are often not seen as realising this ambition).

In some countries, user-owned flats in the city play an important role, causing problems in energy efficiency improvements in particular in those cases, when installations in multi-flat buildings are shared and can only be upgraded by joint decision (often, but not exclusively in cases where former rental flats were privatised).

To limit energy consumption per household, subsidies for detached and semi-detached houses should be phased out, and those for terrace house in urban areas should be limited (a beneficial side effect would be less support to transport provoking settlement structures). This would also limit the living space per capita which through its permanent increase has massively reduced the absolute gains from reducing heating energy demand per square meter. Alternatively or complementary – but without the positive side effects – strict standards could be set for such dwellings, beyond the "almost zero" required by the EU.

4. Conclusions

The achievable effect of energy efficiency policies depends not only on the local or national circumstances and the policy instruments chosen, but also on the design of the instrument and the process of developing, implementing and adapting it, to degrees varying with the situation.

General success factors include

- A motivated government not ideologically biased against specific instruments such as plans or standards, dedicated to respecting EU standards and going beyond to meet the Paris targets.
- Using an instrument mix with special emphasis on building energy codes which have been demonstrated to have a significant effect on the improvement of residential space heating energy efficiency. They include e.g. energy performance standards, minimum thermal insulation standards including glazing and airtightness, and standards for the efficiency of fixed building services such as heating, lighting and controls. Such regulatory policies have been found to have more impact than financial or informative instruments. One reason probably is that they ensure that the desirable energy performance of e.g. building components and (especially) heating equipment is achieved even when its purchaser has no manifest interest in obtaining particularly efficient products (due to either behavioural failure or lack of incentives).
- Effective multi-level governance permitting lower levels to test means of implementation in a niche, with the perspective of upscaling (in line with the subsidiarity principle, realised for instance in Sweden and recently abolished in the UK). Scales reach from neighbourhood plan and local plans to reginal, provincial and national plans.
- Sufficiently high energy prices (by government intervention in case of collapsing world market prices) to allow for a decent return on energy efficiency investment (social vulnerabilities need to be taken into account)
- Competitive markets as a condition for informal and fiscal/financial incentives to be effective; in oligopolic markets e.g. in the construction sector new buildings are rather are set up following established practice than making use of best available technologies BAT (housing construction in the UK was mentioned as one example in our interviews).
- A national space standard limiting continuous growth of flat sizes is a main tool for limiting the energy consumption per household and to avoid the overcompensation of efficiency gains by increased heated area. Building standards and fiscal measures might be used to implement it.

Other success factors refer to the *process of policy development and implementation*:

- Stakeholder participation in design and implementation of policy measures helps public acceptance and easy implementation.
- Continuous revision and improvement of an instrument during the implementation phase: Regulatory mechanisms need to be monitored, evaluated and updated regularly to remain in touch with societal trends and technical developments.
- Smart integration of policy instruments into effective policy packages: larger energy savings are potentially possible if measures aiming at technical, infrastructural and behavioural improvements are applied in combination, mutually reinforcing each other.
- A building code or other forms of rules signalling the future direction of building regulations in relation to carbon emissions from, and energy use in homes can provide more regulatory certainty for the homebuilding industry, investors and households.
- Easy procedures for changing energy suppliers can be an effective support in a competitive market, but need to be supported by information about both the possibilities and the performance of different suppliers. National regulation should make sure that efficiency-conscious package deals carry the best economic bargain.

Finally, *some success factors are instrument-specific*.

Standards

- Standards need to be monitored and updated regularly to remain in touch with technological developments. Emphasising the best available technology BAT or – even better – the state of science and technology in building standards can introduce an inherent dynamic, like the top-runner approach can do for electrical and other appliances (the eco-design directive does not fully exploit this potential so far). Standards supporting the use of renewable energy include
  - Minimum solar contribution rules for hot water supply in new and renovated buildings
  - Minimum photovoltaic contribution standards to electricity supply
- Product related rules and standards have individual problems to deal with, such as
  - Minimum efficiency standards for boilers: the wide variation across EU member states would imply that all boilers usually built in had to be taken off the market in some MS. An EU-wide Top Runner approach in the Ecodesign Directive could implement that.
  - Compulsory replacement of old boilers above a certain age: This is long mandatory in a number of member states including Germany, but there is no monitoring and enforcement which makes the regulation rather ineffective.
  - Periodic mandatory inspection of boilers: Implemented in a number of MS, with positive impacts on accident risks. Again, enforcement is the challenge, and matters of responsibility and liability are important.
  - Periodic mandatory inspection of Heating/Ventilation/AC (HVAC): see above
  - Mandatory heating pipe insulation: for obvious reasons, every cost-saving household and every installation form will take care of this. The only relevant case will be old houses not undergoing renovation. While probably feasible for multi-flat buildings, enforcement for single family houses is almost impossible.
  - Mandatory use of solar thermal energy in buildings: This is already the case in some Mediterranean countries and (for all kinds of renewables) in some German Federal States. Problems arising in multi-owner buildings require an adequate legal basis for problem solving.

Economic instruments

- Economic incentives must be high enough to be effective, making investments into energy efficiency (for new buildings beyond standards, for renovations, CHP, or renewables) profitable. They should be targeted at actions which are cost effective from a collective point of view (e.g. avoiding externalised cost), but which would not otherwise have been undertaken by consumers (no free riding, no crowding out – but effects last only as long as payments are made and budgets should be sufficient to deal with higher-than-expected demand to avoid frustrations). The level will be differing between countries, mainly according to disposable income levels– not GDP/cap, if households are the investors. Profitability can often not be achieved efficiently with one policy instrument but requires a combination of several tools such as grants, reduced interest (soft) loans and tariff reductions. Such packages can be effective incentives for measures to be taken by economic agents, beyond compliance. Subsidising energy audits and the purchase of highly efficient appliances can also be an incentive, but could also be offered by banks as soft loans, repayable from the energy savings.
- In order not to lose effectivity, fiscal incentives should be dynamic, linked to the overall income index (otherwise the incentive declines with raising income). Individual billing in multi-household buildings for instance is only an effective incentive if energy process are high enough.

- Economic incentives must be set in a socially responsible manner. Instead of lowering energy prices for social reasons, adapting transfers and maintaining the efficiency incentive seems to be more promising without reducing social security (a package concept).
- If energy efficiency gains lead to decreasing energy expenditure and thus to increasing rebounds, they should be coupled with energy taxation which makes sure that the average energy cost is at least not sinking, and increasing for the laggards not making use of energy efficiency improvement opportunities.

Education and information

- Consumer education should focus on making people familiar with energy sensitive behavioural routines, in particular in the use of heat (for room heating and warm water). For this behalf, all members of a family could be addressed (parents most effectively learn from their children), like in the case of "stop stand-by" information. Product design plays a major role in this case.
- Regarding information relevant for purchasing decisions, the target group should be analysed and the information specified. For instance, for durable consumer goods it is adults taking the decision, and for white goods women dominate while for technical equipment like TVs males have a higher influence (and are less energy efficiency sensitive). Communication linking efficiency to modernity might be more effective than emphasising energy saving potentials.
- Training measures should not only target households and their in-house energy management, but also enhance the qualification of local authorities supervising standard implementation, and the respective businesses.

Counterproductive Factors

- Falling short of implementing the EU targets like Finland, Romania, Croatia, Cyprus, Greece, and Portugal. Most MS implement the Directive and nothing but the directive, only few make use of the possibility to set a number of more ambitious targets (Hungary, Italy, Spain, Denmark). As the directives lag behind what is technically possible and environmentally desirable (in particular after the Paris agreements), sharpening the standards in the coming revision is advisable.
- Applying energy efficiency measures (standards, guidelines, financial incentives) to new constructions, or to major renovations (size matters – the UK took steps to exempt smaller renovations from efficiency standard application) without a clear program addressing the building stock. Spain sets such targets for the building stock and is among the MS with the lowest household energy consumption.
- Using energy efficiency to enable lower energy prices for households and industry (Romania), pursuing the reduction of energy cost (Finland) and considering energy price a matter of competitiveness (Hungary). Economic considerations should not neglect the fact that instruments such as energy efficiency standards (e.g. Energy Performance of Buildings Directive) and energy pricing have been one of the main drivers of innovation.
- Building sustainability indices aggregating energy, water and waste issues pose the risk of camouflage – progress in one field can cover-up deficits in another. A certified Building Pass with standardised categories similarly informs households before renting or buying, but leaves less room for misinterpretations; it can be combined with ratings to allow for easy comparison, but should also include absolute figures.
- A serious obstacle to achieving improved energy efficiency in the residential sector, not only to privately owned housing, is if house owners experience excessive administration and procurement procedures, delays and cost, as reported from Latvia.
- Reliance on informational methods seems to be a safe receipt for failure – they can accompany other tools to enhance public acceptance but were found to be ineffective on themselves.
- Economic incentives can be effective, but carry the risk of regressive effects. Enhancing social distribution problems can put energy efficiency policies at risk. On the other hand, regional and social targeting (overcoming energy poverty) may increase the standing of energy efficiency policies.

5. Outlook and research needs

A decade ago a Dutch study found that energy saving - energy costing about 2% of business expenditure – was not a paying investment, but if combined with resource efficiency, the balance was attractive. Not narrowing down the horizon in case of cost problems but widening the perspective and increasing the ambition turned out to be the economically most promising solution. No such studies are available for the household sector; further research on this aspect is warranted.