Combining theoretical analysis with empirical evidence from an international comparison: policy packages to make energy savings in buildings happen

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Abstract

What are the best policies and measures to stimulate energy efficiency in buildings and appliances? The debate around this is often quite controversial. It is time to address the question in a systematic way – by combining theoretical evidence on what policy support markets need, and evaluation results on which combinations or packages of policies have worked well.

In the project bigEE – "Bridging the Information Gap on Energy Efficiency in Buildings", we are implementing this systematic approach. The project develops an international Internet-based knowledge platform for energy efficiency in buildings and appliances. Hence, it must provide evidence-based information. On the theoretical side, the analysis identifies which policies and measures to combine to overcome market participants' barriers and strengthen their inherent incentives. On the empirical side, model examples of good practice for policy packages and their elements are compared. These model packages are used to validate the generic policy package identified in the theoretical analysis but do not assess the quality of each element. In order to identify what is "good practice" for a single policy or a package, the project uses a newly developed multi-criteria assessment scheme.

The public launch of the bigEE platform is planned for summer 2012. This paper showcases the application of the assessment methods, comparing five existing national policy packages and assessing one single instrument considered good practice. The analysis confirms the composition of the policy package for new buildings, but also shows the need for more high-quality impact evaluation to determine good practice policies.

Introduction

Buildings are frequently identified as one of the major sources of energy use and are therefore a – if not *the* – crucial area to target when it comes to seriously cutting greenhouse gas emissions. This is all the more obvious in light of the enormous energy saving potential available from the abundance of options for cost-effectively improving the energy performance of new and existing buildings and appliances. The long lifetime of buildings makes this even more valid, as the energy savings achieved through better building performance will persist for a long time.

In particular, the soaring rates of new construction in industrialising economies such as China and India urgently call for a radical change in the way we design and build new properties. Action needs to be taken now in order to avoid major "lock-in effects": high energy savings can be cost-effectively achieved when designing and constructing a new building. If this opportunity is missed, it will often not be cost-effective and sometimes impossible to add energy efficiency improvements later on, so the higher than necessary energy consumption will be locked in for many years. We have to abandon the prevailing 'as-fast-and-cheap-as-possible' construction approach, because it systematically ignores lifecycle costs and creates buildings that will be wasting enormous amounts of energy and money throughout their whole lifetime.

What is required instead is a u-turn in construction practice towards more sustainable, integrated design concepts that make ultra-low- or even zero-energy buildings possible. Such buildings already exist in many countries (Ürge-Vorsatz et al. 2012), and the technologies and the design know-how that are necessary to cost-effectively build them are available; however, the challenge remains to transform the building sector in a way that such ultra-low energy buildings will no longer be an exception but become the standard choice of market actors. The challenge is even bigger for existing buildings, an area which is far more important than new-build in OECD (Organisation of Economic Cooperation and Development) countries. Similarly, the market for appliances needs a transformation to highest energy efficiency levels as well.

Numerous studies (e.g., Ürge-Vorsatz et al. 2012; Laustsen 2008; WBCSD 2009) are confirming that enormous energy saving potentials – up to 80, 90 percent – can be realised by improving building and appliance energy efficiency, and also that most of the available improvement options are cost-effective from a life-cycle perspective as long as they are done in new built or in line with normal reinvestment cycles. Yet, at least as many papers have concluded that in spite of their cost-effectiveness, these savings are not going to be realised by market forces alone (e.g., Sorrell et al. 2004; Thomas 2007). This lack of market uptake results from a large variety of barriers and market failures. These are especially powerful and persistent in the case of buildings because of the complexity of the sector and the multitude of actors involved. And even though the history of policies and measures aimed at improving building energy performance is as extensive as the debate around them has been long and contentious, no optimal way to deal with these barriers has been found yet.

Within the new project bigEE – "Bridging the Information Gap on Energy Efficiency in Buildings"[1], we therefore tried to address in a different way the question of how improved building and appliance energy efficiency can be supported most effectively – by combining a theoretical, actor-centred analysis with empirical evidence on model examples of good practice. The bigEE project started from the finding that information on energy efficiency technologies and policies is, albeit abundant, very scattered and decision makers find it difficult to access. The project seeks to address this problem by summarising knowledge and presenting comprehensive, independent and high-quality information on energy efficiency in buildings on its international website. In particular, the project aims to make the information about existing policies and buildings / technologies throughout the world comparable and present it in a targeted way so as to support investors and policy makers in making the right – energy-efficient – choices.

While the bigEE web portal will include information on both new and existing buildings as well as appliances, for the purpose of this paper we focus the the theoretical and empirical analysis of policy packages, i.e., which policies need to be combined to overcome the multiple barriers for all market actors, on the case of new buildings. By closely analysing value chains and incentive structures in the building sector and then deducing implementation strategies and ultimately packages of policies from the findings, this paper aims to provide a solid methodological basis for the often-quoted necessity to implement comprehensive policy packages. Consequently, our focus here is rather on presenting the methodology we used for identifying the recommended general policy package - and its exemplary application in the case of new buildings - than the outcome, i.e. the recommended package itself. The methodological approach we use is based on and seeking to extend and refine the theory-based policy evaluation approach, which goes back to US experiences with energy efficiency policy evaluation (e.g., Blumstein et al. 2000) and was applied and developed further more recently within the EU project AID-EE[2] (cf. Ecofys et al. 2006). Originally, the theory-based approach was developed for ex-post evaluation of existing policies. It aims at understanding how policies work and the factors of success or failure by defining for each step of implementation a theory on the implementation mechanism or strategy of the step and indicators to measure success of the step and the instrument overall. It can be used both for process evaluation and for theoretically explaining the reasons for the impact achieved – success or failure. The AID-EE project has

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[1] www.bigee.net; the objective of the project is to create an Internet-based knowledge platform for energy efficiency in buildings and appliances. Hence, it must provide evidence-based information.
[2] www.aid-ee.org.

pointed out that this can also be used to examine ex ante whether policies are expected to be successful, and therefore guide policy design. In bigEE, we developed this further to analyse which implementation strategies and policies need to be combined to a package to achieve success in realising energy efficiency.

In addition to this analysis, we also present our refined set of criteria for assessing whether a single policy (an element of the package) can be considered "good practice". In order to also cover the appliance energy efficiency policy analysis in this paper, we present the use of this set of criteria for a policy example on appliances.

The remainder of this paper is organised as follows: first we describe the actor-centred approach, which starts from the analysis of barriers and actor-inherent incentives, then develops implementation strategies to address these barriers and incentives, and finally determines which combinations of policies and measures are needed to make these strategies work. Due to space constraints, we can only present small exemplary parts of the tables that we created for the analysis. The full versions can be found as a preview at www.bigee.net, which will be officially launched in summer 2012. We then compare the outcome of this analysis, i.e. the theoretically 'ideal' policy package, with empirical evidence on combinations of policies and measures that have actually worked and delivered significant energy savings. Finally, we also outline the newly developed multi-criteria assessment approach we use for identifying good practice.

Theoretical analysis – the actor-centred approach, example: new build

New construction of a building is a complex process consisting of different phases, namely design, financing, construction, installation of systems, commissioning (in case of commercial and large residential buildings) and operation/use[3]. This process also involves a significant number of different market actors, the most relevant of whom are architects, developers, financiers, builders, contractors, component/material suppliers, and finally building owners and possibly tenants. Throughout the different phases of planning and construction, all of these actors make decisions that can influence the energy performance of the new building in question. And they all have some inherent incentives to develop, offer, demand or invest in energy-efficient building solutions, but are on the other hand facing strong barriers that prevent them from choosing energy efficiency.

In order to be able to adequately design and implement energy efficiency policies and measures, political decision-makers must therefore have good knowledge of the concerned market actors and thoroughly analyse the specific incentives and barriers faced by each of them. The compilation of an adequate policy package should be based on the findings of such analysis insofar as the package should target all relevant actors and establish mechanisms to overcome the actor-specific barriers.

Analysis of actors and barriers

The complexities of the building sector require that all members of the value chain act in the right direction, or else the energy efficiency chain will break. It is therefore not sufficient to merely look into the factors that induce or prevent uptake of energy efficiency measures at the level of end-users (i.e. the incentive structures of building owners and tenants). Consequently, we seek to identify and closely examine the barriers and incentives of *all* relevant actors in the value chain. This enables us to understand more thoroughly why they often do not implement

[3] The bigEE project and this paper currently focus on improvement of energy efficiency during the use of the building, not of the total life-cycle energy and resource use. This is planned for a later stage in the project, as it is important too. It will then require to also consider the demolition and recycling of buildings.

energy efficiency; and is the basis for development of appropriate remedies in the form of tailored policy packages aiming to remove the barriers and strengthen the incentives identified.

In the building sector, the most important barriers that have so far prevented a large-scale market transformation include lack of knowledge and awareness of energy saving options, uncertainty about the related monetary and other benefits, capital constraints and risk aversion, lack of motivation due to other priorities (e.g, investing in production or buying a new kitchen rather than in building energy efficiency), transaction costs and the small size[4] of achievable energy savings, and finally the so-called landlord-tenant or investor-user dilemma (cf., e.g. Sorrell et al. 2004). The latter refers to the fact that in buildings the actor bearing the costs of an energy efficiency improvement is often different from the one yielding the benefits (e.g., the landlord has to pay for the new heating system but only the tenant's energy bills are reduced).

Below we present an example of the actor-specific barriers and incentives which we identified across the complete value chain (based on the analysis in Thomas 2007 and available literature). The relevance of some of these barriers and incentives may differ from country to country depending on national circumstances.

Table 1. Actors vs. actor-specific barriers and incentives (example)

Actors	Actor-specific incentives	Actor-specific barriers
Property development companies	➢ Justification for charging higher rents (rent premium) ➢ Increase occupancy rates ➢ Increase (re-sale) value of the property ➢ Contribute to environmental protection ➢ Receive social recognition in return for environmentally-sound behaviour	➢ Lack of knowledge about the market demand for energy-efficient buildings: will customers be willing to pay a rent/sales price premium for a more energy-efficient building? ➢ Extra construction cost: risk of losing customers to the competition (assuming that customers look at first cost only) ➢ Investing in energy-efficient technologies is more expensive compared to conventional technologies → reduces my profits ➢ No direct economic benefit from reduced energy bills: only tenants will save energy costs!

Implementation strategies needed to overcome the identified barriers

Once we have identified the reasons that cause actors to be inclined towards or to refrain from choosing low-energy buildings, the question to be solved remains: How can the immanent incentives that market actors have be strengthened, how can the barriers they face be overcome? There are a number of direct ways to achieve this, which we call implementation strategies. By way of addressing the actor-specific incentives and barriers, these strategies aim to make energy efficiency feasible, easy, and attractive, and eventually even the default (i.e., the behavioural norm or even the legal standard). The following table, again showing only one example of our analysis, illustrates how the implementation strategies seek to influence each of the incentives and barriers identified.

Table 2. Implementation strategies vs. barriers / incentives (example)

Implementation strategy	Incentive strengthened or barrier tackled
Ensure architects, property development companies, construction companies, and contractors that there is a market	(Architects, property development companies, construction companies, and contractors) Present ourselves as innovative and gain competitive advantage and social recognition (Architects) Need to change proven designs and constructions: will there be a market worth the effort? (Component manufacturers) Increase our revenue and profits by offering more expensive energy-efficient products

[4] While for the individual house-owner or tenant the possible savings may appear small, they can contribute substantially to achieving the climate and energy policy goals mentioned above when they are aggregated over all end-users.

	(Component manufacturers) Risk of production and marketing: will there be sufficient demand so that the production change-over pays off, a minimum unit quantity is reached, and the price can be kept on a competitive level? (Component manufacturers, manufacturers of pre-fabricated houses) Risk of technical development: will there be a market for energy-efficient buildings or products? Will we be able to recover the development costs? (Property development companies) Lack of knowledge about the market demand for energy-efficient buildings: will customers be willing to pay a premium? (Property development companies, manufacturers of pre-fabricated houses, component manufacturers) Prevailing price competition or predominance of other product features over energy efficiency; therefore low priority/willingness to pay (more) for energy-efficient buildings

Policy packages to realise the implementation strategies

As a next step, political decision makers but also non-governmental actors such as, for instance, energy service companies must take concrete measures and enact actual policies in order to put the implementation strategies to work. For each of the implementation strategies, a package of policies and measures is needed to make it work, and since also a combination of implementation strategies is necessary to tackle the manifold barriers, these targeted policy packages must then be merged into a consolidated overall package which is ultimately capable of kick-starting a real market transformation in the building sector. This "ideal policy package" will be presented in the next section.

For the exemplary implementation strategies presented in Table 2, the corresponding policy package can be found in the following Table 3.

Table 3. Implementation strategies vs. policy packages (example)

Implementation strategy	Policy Package for this Implementation strategy
Ensure architects, property development companies, construction companies, and contractors that there is a market	Information and advice programmes both for building investors and for architects, construction companies, and contractors Financial incentives for very energy-efficient new buildings (in order to increase the demand) Social housing investment (to provide a first visible demand) Dynamic building codes: Step 1 remove conventional practice from the market; step 2 announce future tightened levels to create expectation of future market for energy-efficient designs Mandatory (initially maybe also voluntary) building energy performance or green building certificates to enable and prove differentiation Long-term strategies/ political commitments: e.g. Zero Net Energy targets and roadmap

The recommended policy package resulting from the theoretical analysis

If we want to afford heating, cooling and lighting our buildings in 10 or 20 years from now and prevent runaway climate change, we need to achieve that operational goal: make ultra-low-energy buildings (ULEB)[5] the standard in new construction. What can policy do to support making that happen?

Resulting from the theoretical analysis, we can derive the elements that should ideally be included in a comprehensive policy package to achieve that goal. We can only give here an overview of these elements and how they should interact as a package:

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[5] ULEB are what can be achieved by combining the most advanced design and technologies with regard to energy efficiency, but not yet building-integrated renewable energies. Adding the latter will bring purchased energy consumption down to the level of (nearly) net zero energy building (NZEB) or even plus-energy buildings.

- A Policy Roadmap towards ultra-low-energy buildings should guide policy-making, with a clear timetable and targets towards ULEB.
- The infrastructure and funding for the other policy elements need to be in place (i.e., an energy agency or similar and government funds, and or energy companies with the task to implement incentive programmes).
- Energy prices should 'tell the economic and ecological truth' (as stated by Ernst Ulrich v. Weizsäcker). In addition, they must also consider social issues and should encourage energy sufficiency. Energy production and price subsidies should be gradually removed (the budget saved should rather be used to fund energy efficiency schemes for low-income households, so as to keep their energy *bills* affordable instead of energy *prices* artificially low), and energy or CO_2 taxes should finally internalise environmental damage into final energy prices.
- Minimum energy performance standards (MEPS) for all new buildings (and building components where useful) are the most important policy for energy efficiency in new buildings. They should be created by law (in a transition period before a law can be passed, a voluntary standard may help). MEPS reduce transaction costs as well as the landlord-tenant and developer-buyer dilemmata by removing the least energy-efficient building practices and concepts from the market. They should, however, always be at least as stringent as the level of least life-cycle costs and should be strengthened step by step every three to five years, to finally require energy efficiency levels equivalent to ULEB. In order to be effective, compliance with MEPS must be controlled at the local level in both the design stage and after construction. Landlord and tenant laws may need to be revised, too, in order to make energy efficiency more attractive for both sides.
- A step in MEPS regulation should be prepared by education and training of architects, planners, developers, builders, contractors, lenders and other market actors, but education and training should also include the next steps up to ULEB. Easy-to-use design and life-cycle cost calculation tools are essential. Certification of training can make it more attractive for both the qualified market actors and their customers.
- The next step(s) to ULEB should, furthermore, be prepared by a building energy certificate scheme (and energy labels for components if useful), marketing of demonstrated good practice, advice and support for investors, and financial incentives for broad market introduction. Promotion of energy services for energy savings and voluntary agreements with large developers to build more energy-efficiently than required by MEPS may also support market introduction. Once a certain market share of (ultra) low-energy buildings of a specific energy performance level is reached, the professionals are trained and used to the required practices, and the cost-effectiveness of the next step is proven, then this next step can be mandated by the regulation.
- The steps after the next step should be prepared by R&D funding, demonstration (including in state- or municipality-owned buildings), award competitions, and maybe also already by financial incentives for broad market introduction.

Empirical analysis of good practice examples

As a next step we then wanted to find out whether the results of our theoretical analysis are consistent with actually implemented examples of successfully operating policy packages. Consequently, we had to search for empirical evidence of good practice packages in advanced countries. This search started from a number of publicly available databases (such as International Energy Agency, World Energy Council, the EU project ODYSSEE-MURE[6]) and

[6] www.iea.org/textbase/pm/?mode=pm; www.wec-policies.enerdata.eu/; www.odyssee-indicators.org/

was continued with in-depth literature review on candidates identified by the team and international experts we approached for advice.

Model examples of advanced policy packages: proving the actor-centred approach right

As some of the most advanced countries show (cf. Table 4), the policy package that we derived from our actor-centred analysis is exactly what these countries have introduced to approach very high levels of energy efficiency in new buildings. Many of the elements of their national policy packages also address existing buildings. These can be considered good practice for the consistent packaging of policies; however, more research is needed to analyse whether each element is a "good practice" policy of its kind and which country has achieved the biggest progress towards very energy-efficient new buildings. The table can thus not be read as giving any statement on these further questions.

Table 4. Comparing the recommended policy package with good practice from five countries

Category of policies and measures	Subcategory of policies and measures	Implementation in California, USA	Implementation in China	Implementation in Denmark	Implementation in Germany	Implementation in Tunisia
Governance framework						
Energy efficiency targets and planning	Policy roadmap and targets towards ultra-low energy buildings/ retrofits	Climate Change Scoping Plan and Long Term Energy Efficiency Strategic Plan (Updated 2011)	Overall target of 4 % / year improvement of energy efficiency; gets broken down to sectoral and provincial targets	Energy Strategy 2050 (Feb. 2011) – to make the country independent from fossil fuels by 2050	Energy Concept by federal government; i.a., target to reduce primary energy consumption in buildings by 80 % by 2050	
Infra-structure and funding for energy efficiency pro-grammes and policies	Energy agencies	Buildings and Appliances Office in the California Energy Commission (More a co-ordinating role; setting of MEPS and outreach)	No central energy agency but organisations such as China Society of Urban Studies; local authorities responsible for implementing national programmes	Danish Energy Authority	DENA (German energy agency), some state and local agencies	ANME (National energy agency)
	Overall co-ordination and financing	Public Goods Charge collected and used by energy companies under regulatory oversight (since the 1980ies); budget for California Energy Commission	No explicit mechanism; funding provided by state budgets	Energy saving obligations for distribution network companies (1.25 % per year overall); Danish energy saving trust	No clear mechanism	National Energy Fund (FNME)
Eliminating distortions	Removal/reduc-tion of subsidies on end-user energy prices and on energy supply (if they exist)		China likely to remove subsidies in the long run; has a crude oil and natural gas tax of 5% of sales-value since November 2011	Denmark was among the first countries to introduce an energy tax on heating fuels and electricity	Energy tax exists for heating fuels and electricity	
	Removal of legal barriers (if they				Allowance for landlords to	

Category of policies and measures	Subcategory of policies and measures	Implementation in California, USA	Implementation in China	Implementation in Denmark	Implementation in Germany	Implementation in Tunisia
	exist)				increase rent (by 11 % of energy efficiency investment)	
	others					
Specific policies and measures						
Regulation	Minimum energy performance standards (MEPS) for buildings & equipment (incl. compliance regime)	Yes, these exist	For three major climate zones; require energy performance levels saving 50 to 65% of energy relative to 1980ies buildings	Require low-energy buildings (below 50 kWh/m^2/yr) since 2011; for 2015/2020 ultra-low energy buildings	Require relatively low-energy buildings (ca. 60 to 70 kWh/m^2/yr) since 2009; for 2021 ultra-low energy buildings planned	Yes, these exist
	Individual metering legally required		no		Yes, for heating energy and electricity	
	others					
Information	Energy performance certificates & equipment labels (incl. compliance regime)	Energy Star label (only voluntary) for new homes and appliances labels (introduced by the federal government of the USA)	Only voluntary energy efficiency and green building labels for large buildings	Danish Energy Labelling Scheme since 2002; voluntary energy label for windows	Energy performance certificates mandatory since 2009 upon sale or letting, for new buildings since 2002	Yes (for offices and apartment buildings; planned for municipal buildings and factories)
	Energy advice/ audits & assistance during design and construction/ retrofit	Savings by Design programme for new non-residential buildings	Four-stage controls during design and construction	A main programme area for the energy companies to fulfil their energy-savings obligations	Several programmes via consumer agencies, KfW, energy agencies, energy companies, independent advisors	Mandatory energy audits for large end-users (industrial facilities and appartment buildings)
	Information centres		Information centres can be found throughout China		Some local energy agencies, consumer agencies or energy companies	
	Demonstration buildings (new/ refurbished)		100 Green Buildings and 100 Energy Effi-cient Buildings, started 2007	Many demonstration buildings, cf. www.energymap.dk	Demo programmes, many buildings, e.g., www.enob.info	Yes
	others			Information campaigns by government, Energy Saving Trust, energy companies	Information campaigns, online advice tools	
Financial incentives & financing	Financial incentives	Utility energy efficiency programmes for new and existing buildings (Most important policy instrument in California)	Financial subsidy for heating metering and energy efficiency retrofit of existing residential buildings in North China; also lighting.	Increasing number of financial incentive programmes by energy companies; government programme to replace oil boilers	Some grants for very energy-efficient new buildings or refurbishment as part of soft loan programmes (see below)	PROMO-ISOL, (for thermal insulation of roofs), and PROSOL, (for solar water heaters)

Category of policies and measures	Subcategory of policies and measures	Implementation in California, USA	Implementation in China	Implementation in Denmark	Implementation in Germany	Implementation in Tunisia
	Financing instruments (e.g. soft loans)	Property Assessed Clean Energy (PACE) programme (24 states of the USA)			Large soft loan programme via government bank KfW; EUR 1.5 bn / yr govt. subsidies to loans and some grants	PROMO-ISOL and PROSOL
Capacity building & networking	Education & training for supply chain actors	Integral part of MEPS implementation	Integral part of MEPS implementation	Knowledge Centre for Energy Savings in Buildings (for professionals)	Several state programmes	Training courses, design tools, technical guidelines
Promotion of energy services	Promotion of third-party-financing		General Technical Rules for Energy Performance Contracting	Committee working on policy proposals	Some public sector schemes; advice to customers by state energy agency of NRW	
Promotion: Research, Develop-ment & Demo and Best Available Technology	Public sector programmes ('Lead-by-example', energy-efficient public procurement)	Green Buildings Initiative for state-owned buildings (Save 20% between 2004 and 2015)	Requirements for energy management; special investment funds	Requirement for public buildings to disclose energy performance certificate	Several federal programmes to fund R&D and demonstration; some authori-ties decided to only build ultra-low energy buildings	
	others					
Achievements						
		Kept per capita electricity consumption stable since the 1970ies (rest of USA increased by 30%)	New buildings saving 50 to 65 % of energy relative to 1980ies buildings; over 90% compliance	New buildings are low-energy buildings; improved household energy efficiency by 16% between 1990 and 2008	New buildings are relatively low-energy buildings; however, only about 1/3 of potential in refurbishment cases gets used	In 2007 to 2011, the total size of solar water heaters increased by 500.000m2

Source: bigEE analysis (will soon be online including all sources at www.bigee.net)

How to select good practice examples

Even though "good practice" is a heavily used term in policy analysis and evaluation, it nevertheless remains rather vague. An assessment of the success or failure of the policy in relation to other policies of the same kind is often not possible. This is why we felt the need to find a new and more exact definition for it in the course of the bigEE project.

For this purpose, we have developed a multi-criteria assessment scheme with a set of selection criteria, which can be used to determine whether or not a certain policy (or policy package) qualifies as "good practice". The aim of the assessment scheme is to make policies comparable and to highlight worldwide good practice policies.

The criteria range for instance from appropriateness of the policy design to availability of *ex-post* evaluation to questions of effectiveness. These criteria were operationalised, including a ranking for some factors between 1 and 10. The policies and measures are then weighted according to their relevance as can be seen in the table below, which also presents the full range of criteria applied. This procedure results in an overall score, which then indicates whether the policy actually is considered to be good practice or not.

Taking account of the fact that there may be policies that will not be able to fulfil certain criteria (mostly those addressing quantitative impacts) simply because they are too recent, we differentiate between so-called proven and innovative policies and measures. In this context, we apply a slightly different assessment scheme to the innovative ones, with less focus on achieved results and instead putting more weight on promising design elements that seek to make policy more effective, for instance by targeting actors and/or barriers so far neglected.

Table 5 presents the evaluation process including selection criteria, their application and operationalization for one example: the Refrigerator Replacement Programme from Brazil. The programme donates new energy-efficient refrigerators (class A labelled products) to low-income consumers with the aim to save money and to reduce the energy consumption. The low-income households receive the new appliance in exchange for an old and inefficient refrigerator at no costs to them. The programme is financed by a charge collected from all electricity consumers. During 2008 to 2010, 45 electricity companies (distribution and supply integrated) participated in the programme, replacing more than 380,000 refrigerators saving almost 190,000 MWh/year and reducing peak demand by more than 23,000 kW.

These first impressions indicate a "good practice" policy. To verify the assumption, we analyse the refrigerator replacement programme with the multi-criteria assessment scheme. In the right column of Table 5, you can find the ranking of the policy according to the selection criteria. The result is that the programme addresses selected market players and overcomes existing barriers. It avoids lost opportunities and aims at a dynamic market transformation. The policy has innovative elements and increases the energy efficiency of refrigerators. The high energy savings confirm the success of the programme.

The overall ranking is 7 out of maximum 10 points. According to our scheme a policy can be considered "good practice" if there is a total score of more than 5 points. This means the Refrigerator Replacement Programme from Brazil can be seen as a "good practice" policy. Table 5 presents a detailed description and analysis of the Brazilian policy example.

Table 5. Selection criteria for good practice of policies and measures and application for one example policy: the Refrigerator Replacement Programme from Brazil.
Abbreviations: P&M – Policies and measures; BAT – Best available technology; LLCC – Least lifecycle costs – n/a : Not available

Selection Criteria Good Practice P&M		**Operationa-lisation**	**Weight for selection**		**Comments**	**Example**
			Proven P&M	**Innova-tive P&M**		**Refrigerator Replacement Programme Brazil**
The policy has been **successfully** and durably **implemented** into the market		Implemented	Eligibility	Eligibility	P&M is in force at least in one country; no special preconditions that prevent transfer to other countries	The policy was implemented in Brazil.
		At least 2 years in place	Eligibility	n/a	At least in one country	The start year was 2008.
Recent P&M		Not older than 10 years	If not, justifi-cation required	If not, justifi-cation required	Last revision date of the P&M counts	The last revision of the programme was in 2011. It is a recent P&M.
Appro-priate design of P&M	Addresses **all relevant market ac-tors** and **most rele-vant bar-riers and incentives**	Ranking as a whole on a scale between 0 and 10	30%	40%	Often better achieved when policy is part of a package	Target groups are wholesalers, retailers, banks and end-users (especially low income households and their barrier to afford energy-efficient appliances). .
	Is designed to **avoid lost**				For example, addresses the energy-efficient solutions in the right	The programme avoids low-income households buying another cheap and

Selection Criteria Good Practice P&M		Operationa-lisation	Weight for selection		Comments	Example
			Proven P&M	Innova-tive P&M		Refrigerator Replacement Programme Brazil
	opportuniti es				manner and moment, e.g., by taking into account the investment cycle of the target group	inefficient refrigerator when their current appliance breaks down.
	Aims at **dynamic** market transformati on				For example, promotes innovations to make BAT even more energy-efficient, and/or, increasingly removes inefficient technology/practices from market	The regulator aims to promote market transformation. The aim is to remove least efficient refrigerators from the market and replace them with energy-efficient ones.
	Achieves **lasting results**				For example, no snap-back effect	Snap-back effects are likely to be low in this case. The programme is effective for more than 10 years.
	Positive **spill-over** effects should be an objective				Large multiplier effects	Spill-over effects might result from other consumers who get to know the possible energy savings from programme participants.
					Ranking "Appropriate Design of P&M"	***6***
Includes **innovative P&M elements** or combines them into an innovative P&M package		Ranking on a scale between 0 and 10	10%	30%	Outstanding compared to other countries, e.g.: market actor addressed who is not included in other P&M; an innovative way to overcome barriers; innovative package of P&M	The replacement programme interacts with a recycling programme and a social tariff on electricity. The programme is subjected to measurement and verification (M&V). The programme benefits from the Brazilian energy label for appliance.
					Ranking "Innovative elements"	***8***
Does the P&M foster **worldwide BAT** or country-specific **LLCC solutions**?		Close to BAT/LLCC = 10; Substantially different from BAT/LLCC = 0	10%	15%	Dynamic life-cycle cost analysis including typical interest rates	The new refrigerators must be labelled as 'A' and the programme must achieve a cost-benefit-ratio less than 0.8.
					Ranking "Worldwide BAT"	***8***
A satisfying **ex-post evaluation** exists		Yes = 10; no = 0	10%	n/a *ex-ante* data if possible	*Ex-post* evaluation usually gives more reliable data than ex-ante evaluation	An *ex-post* evaluation exists. A monitoring system is in place, run by utilities. Economic benefits have been evaluated, too.
					Ranking "Evaluation"	***10***
The energy savings are **cost-effective** (for consumers and the economy)		Benefit-cost ratios from different perspectives	If no data or not cost-effec-tive, justi-fication required	n/a *ex-ante* data if possible	Dynamic life-cycle cost analysis including correction factors and typical interest rates	The energy savings are cost-effective for consumers and the economy.
Effectiveness I: The P&M leads to **energy savings per unit** (per appliance, per building)		Data on energy savings per unit available?	Not eligible, if no data	n/a *ex-ante* data if possible	Expected additional, yearly energy savings in %/yr and in kWh/yr per unit (appliance, m2 or	The programme achieved 81% reduction in refrigerator electricity consumption. Average total

Selection Criteria Good Practice P&M	Operationa-lisation	Weight for selection		Comments	Example
		Proven P&M	Innova-tive P&M		Refrigerator Replacement Programme Brazil
compared to reference case	Please give absolute and relative numbers.			building) compared to baseline projections	monthly consumption among a sample of customers of a utility fell from 167 kWh to 94 kWh after the programme. This suggests that each household saved almost 900 kWh per year of electricity.
Effectiveness II: The **effectiveness** is high: How many % of the energy savings potential available within a specific time frame due to normal investment/ refurbishment cycles in the target area (**region/country**) have been implemented?	Please give absolute and relative numbers (BAT or LLCC vs. reference; including correction factors), and then rank on a scale between 0 and 10.	30%	n/a *ex-ante* data if possible	E.g., at least 30% of the potential has been implemented; or the share of energy-efficient technology has increased considerably; or the price premium on energy-efficient technology has decreased; or a service has saved on average at least 30% of the customers' energy consumption	45 utilities were carrying out refrigerator replacement programmes, totally 383,760 appliances from 2008 to 2010 that would save 186,294 MWh/year and reduces peak demand by 23,277 kW. The share of low-income households that benefitted is not known but growing.
				Ranking "Effectiveness"	**7**
The policy is in line with other **sustainability** criteria	Ranking on a scale between 0 and 10	10%	15%	Other aspects like material efficiency, health or employment aspects taken into account	The policy is in line with sustainability criteria: Old refrigerators will be replaced and recycled and jobs are created.
				Ranking "Sustainability"	**8**
Mix of countries / continents	Final selection of portfolio	Global perspective, mix of countries			Brazil is a country from South America.
Result of the ranking				***Overall score of the policy***	***7***

Discussion and conclusions

The actor-centred approach has confirmed our presumption that there is not one silver bullet that will kick-start a real energy efficiency transformation in the building sector. What is urgently needed instead are consistent packages of policies and measures, carefully tailored to the needs and incentive structures of all actors in the building value chain. Our theoretical analysis along this value chain has given us good insight as to which implementation strategies can successfully tackle the many existing barriers and which combinations of policies are needed to put these strategies into practice. There are sometimes alternative policies for one strategy, so the final composition of the package will depend on the circumstances in a specific country.

We also ascertained that the main elements of the theoretically adequate policy package can indeed be found in real life in the policy packages of advanced countries. This does not yet include an assessment of whether all of the policy elements these countries have combined to their package are good practice for themselves. But it confirms the composition of the package.

In addition, we have therefore conceived a set of criteria that makes it possible to identify policies and packages of policies that are likely to be very effective and therefore qualify as good practice according to our criteria. We have demonstrated its application for an example here.

During our research on such model examples, we found, however, that the lack of thoroughly documented and evaluated policies and measures (both for single policies and for sectoral policy packages) makes the search for good practice and the application of our multi-criteria assessment scheme quite difficult. Accordingly, resulting from our analysis there are two key messages for policy makers planning to implement a new policy or measure: it is crucial already in the policy design phase to bear in mind both the actors concerned *and* the data needs and other requirements in terms of monitoring and evaluation of the impacts, costs and benefits as well as for compliance with the policy, in order to ensure its effectiveness.

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