Strategic policy packages to deliver energy efficiency in buildings – their international evidence

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Abstract

The project "bigEE – Bridging the Information Gap on Energy Efficiency in Buildings" presents comprehensive information for energy efficiency in buildings and the related policy on the international internet-based knowledge platform bigee.net.

To develop the evidence-based information required for bigee.net, we addressed in a different and more systematic way than usual the question of how policy can support improved building energy efficiency most effectively: We combined (1) a theoretical, actor-centred analysis of market-inherent barriers and incentives for all actors in the supply and use chain of (energy-efficient) buildings to derive a recommended package combining the types of policies and measures the actors need to overcome all these barriers, with (2) empirical evidence on model examples of good practice policy packages to check if advanced countries have indeed used the combination of policies we derived from the actor-centred analysis.

In this way, we found that the recommendable policy package for new buildings is similar to the well-known one for appliances, but with the objective to mainstream nearly zero energy buildings. By contrast, the task for existing buildings is two-dimensional – increasing the depth of renovation first, to savings of 50 to 80 %, and then the rate of energy-efficient renovation to 2 % or more p.a. – and so the policy package needs more emphasis on individual advice, incentives, and financing. The paper presents the recommended packages as well as a comparison of existing national policy packages from California (USA), China, Denmark, Germany, and Tunisia and what we learned from it for effective packages and implementation.

Introduction

Numerous studies (e.g., Ürge-Vorsatz et al. 2012; Laustsen 2008; WBCSD 2009) are confirming that enormous energy saving potentials – up to 80, 90 % – 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.

The project bigEE – "Bridging the Information Gap on Energy Efficiency in Buildings" (see next section), 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.

Many studies have argued that different types of policies – most notably regulation, financial incentives and information, or "the sticks, the carrots, and the tambourines" – need to be combined into packages in order for them to be effective and make energy efficiency easy and attractive for market actors. However, we are not aware of a systematic and comprehensive analysis to underpin and derive what kind of policies and measures the packages should consist of, and how they need to interact.

To develop the evidence-based information required for bigee.net, we addressed in a different way than usual the question of how policy can support improved building energy efficiency most effectively: We combined (1) a theoretical, actor-centred analysis of market-inherent barriers and incentives for all actors in the supply and use chain of (energy-efficient) buildings to derive a recommended package combining the types of policies and measures the actors need to overcome all these barriers, with (2) empirical evidence on model examples of good practice policy packages to check if advanced countries have indeed used the combination of policies we derived from the actor-centred analysis. While the actor-centred analysis has been presented before, this paper focuses on the empirical evidence.

In the paper, we will therefore first briefly describe the bigEE project to illustrate the project background and its scope. Next, the methodological approach to developing the recommended policy packages for energy efficiency in buildings will be presented. Then follows the resulting strategic package approach to energy efficiency policy for new and refurbished buildings, proven in practice by a comparison of the existing national policy packages from California (USA), China, Denmark, Germany, and Tunisia.

A web-based knowledge platform to demonstrate good practice buildings and policies

"bigEE – bridging the information gap on energy efficiency in buildings" is a project by the Wuppertal Institute and its international partners, with financial support from the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The main result the project continues to develop is the international internet-based knowledge platform "bigEE – Your guide to energy efficiency in buildings" for energy efficiency in appliances, building-related technologies and buildings overall. The platform is online at bigee.net. It addresses the needs of decision-makers in businesses and policy; a structured presentation makes it easy to find the information required. Three comprehensive guides – for building design and technologies, for appliance energy efficiency and for policy implementation present detailed information about how to increase energy efficiency and how policy can support those savings.

Apart from information being universally applicable, up to five partner countries will be addressed, starting with China, South Africa and Mexico.

A central task for bigEE is collecting and updating information on best available technologies (BAT) on a comparable basis, as well as the gathering of energy saving potentials, net economic benefits, and good practice policies. To achieve the required quality of information, the bigEE team collaborates with scientific institutes and with existing initiatives and platforms – international and in partner countries, including UNEP and IEA. Furthermore, bigEE engages in the active dissemination of information relevant for investors and policy-makers in the partner countries, by setting up and co-operating with a network of local partners.

Methodology

Market forces alone are unlikely to bring about the energy savings that the strategic approach to energy-efficient building design can enable. Value chains in the building and appliances sectors are complex. Many different actors – investors, end-users but also building developers, equipment or appliance manufacturers, designers, trade, and builders – have to work together for an optimal outcome. A well-designed package of policies and measures is, therefore, needed to assist the various actors in overcoming their specific barriers and strengthening their incentives. Experience from advanced countries and an analysis of market barriers show that several instruments will need to interact and reinforce each other in a comprehensive policy package. Every policy or measure has its own function in the package, its advantages, target groups and specific operational mechanisms. Each is tailored to overcome one or a few certain market barriers and to strengthen the actor-specific incentives, but none can address all of these barriers and incentives. Therefore, the impact of well-combined policies is often larger than the sum of the individual expected impact (IEA 2005).

The question we had to answer was, therefore, which policies and measures should be combined in strategic policy packages to address all relevant market barriers and incentives of all market actors, and how they need to interact to achieve strategic energy efficiency targets. We used a two-step approach combining (1) an actor-centred theoretical analysis with (2) an empirical proof, for which Figure 1 presents an overview.

The methodological approach we use on the theoretical side is based on and seeking to extend and refine the theory-based policy evaluation approach, which goes back to experiences with energy efficiency policy evaluation in the USA (e.g., Blumstein et al. 2000) and was applied and developed further more recently within the EU project AID-EE (cf. www.aid-ee.org and 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 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

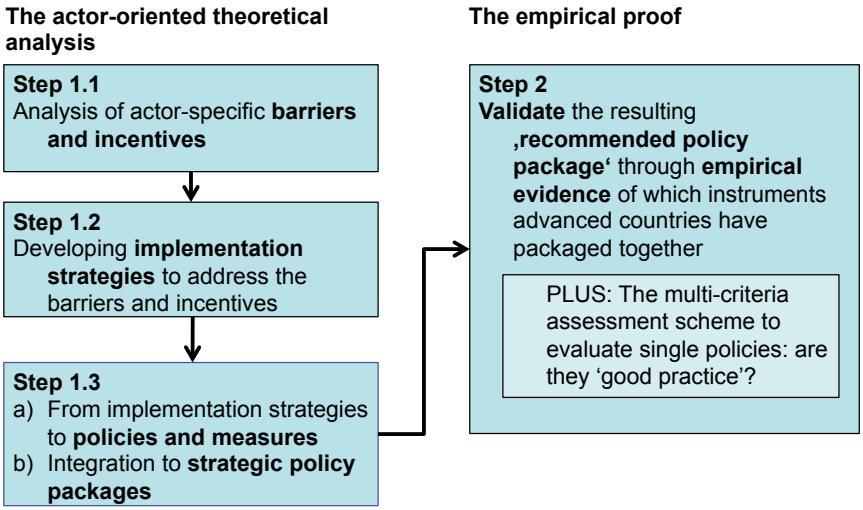

Figure 1. The two-step combination of theoretical and empirical evidence in bigEE analysis for recommended strategic policy packages.

developed this further to analyse, which implementation strategies and policies need to be combined to a package to achieve success in realising energy efficiency.

As the first step, a thorough analysis of the market incentives and barriers for energy-efficient new build, renovation/operation, and appliances, and what the different actors need to overcome their barriers and harness energy efficiency was performed by the bigEE team. Next, implementation strategies (such as providing transparency of certainty on finding a market) were devised. Often, several policies or measures alone or in combination are conceivable that can materialise such an implementation strategy. In the third step, first these policy combinations or alternatives were allocated to the implementation strategies. Second, the policy combinations for all the required implementation strategies were combined to form the integrated strategic policy package.

This actor-centred analysis has been presented in earlier papers (Höfele & Thomas 2011 for new buildings and Tholen & Thomas 2011 for appliances; full analysis available on bigee.net). We recommend that policymakers carry out a similar analysis for their country.

Even if the collection and assessment of barriers, incentives, implementation strategies, and policies and measures is also based on a lot of empirical knowledge, it may still suffer from misinterpretations or overlook aspects, and there is no guarantee it will work in practice. The second step was therefore the analysis of the policy packages that a number of countries have actually implemented to provide the empirical proof. Some of the results will be presented later in this paper.

The country analysis was to check whether the main elements of the theoretically adequate policy package can indeed be found in real life in the policy packages of advanced countries, so as to confirm the composition of the package. However, 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. 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. This is also mentioned in Figure 1 and presented in paper 2-155-13 (Tholen et al. 2013) in these proceedings, including its application for an example.

The strategic policy packages to deliver energy efficiency in buildings

The following paragraphs illustrate the two bigEE recommended policy packages for new and existing buildings and demonstrate how the individual instruments with their specific functions interact to make the packages work.

Different policies addressing the demand-and supply-side actors of markets should be properly combined according to national circumstances. This does not mean that governments seeking to improve the energy efficiency of buildings have to implement all possible policies in order to be successful, but they should combine a selection of instruments tackling the most important market barriers. As our analysis has concluded and successful countries have demonstrated (cf. also Table 1 below), a comprehensive and coherent policy package for energy efficiency in buildings will usually provide a sound balance between clear mandatory measures, incentives, information and capacity building. It also needs a governance framework to enable implementation of these policies.

The presentation starts with this overarching governance framework for energy efficiency that is general to new and refurbished buildings as well as appliances, for which bigEE also developed a strategic policy package (cf. paper 6-359-13, Barthel et al. 2013 in these proceedings). Afterwards, the two sector-specific parts of the packages with specific policies and measures for energy efficiency in new buildings, and in renovation and operation of existing buildings follow suit. As these include a number of common elements, the separation is somewhat artificial to demonstrate the differences, but implementation in practice usually integrates policies for energy efficiency in new build and renovation as we will see afterwards.

THE GOVERNANCE FRAMEWORK FOR ENERGY EFFICIENCY

In the bigEE recommended policy packages, the general governance framework serves to guide and enable implementation of the sector-specific policies, as well as to remove price dis-

tortions in energy markets that would make energy efficiency improvements appear less cost-effective than they are.

A Policy Roadmap with a clear timetable and targets will guide policy-making and signal to the market a reliable political support for energy efficiency. The targets should, of course, be specific to the three subjects we address in bigEE:

- For new buildings lay out the road for mainstreaming ultra low energy buildings (ULEB).
- For renovation and operation of existing buildings pave the way for high energy savings in each retrofit and in operation, and for increased rates of energy-efficient retrofit.
- For appliances prepare markets for mainstreaming highest energy efficiency levels.

The *administrative infrastructure and the funding* for the other policy elements need to be in place. This includes (1) an **energy agency** or similar institution for co-ordinating activities. To ensure (2) **stable funding**, government energy efficiency funds and/or energy companies with the task to achieve energy savings via energy efficiency programmes are also required.

Energy prices should 'tell the economic and ecological truth'. In addition, they must also consider social issues and should encourage energy sufficiency. It is essential that subsidies for energy production or on energy prices be gradually removed – governments are advised to rather use the budget saved to fund energy efficiency schemes for low-income households, so as to keep energy bills affordable instead of keeping energy prices artificially low. In addition to **removing energy subsidies, energy or CO_2 taxes** will finally internalise environmental damage and threats to health into final energy prices.

HOW THE SPECIFIC POLICIES AND MEASURES FOR ENERGY EFFICIENCY IN NEW BUILDINGS INTERACT

If we wish to afford heating, cooling and lighting our buildings in 10 or 20 years from now and aim to prevent disastrous climate change, we will need to achieve one operational goal in new construction: making ultra low energy buildings (ULEB) the mainstream standard.

This can save 60 to 90 % of energy compared to new conventional buildings at costs below market-based energy prices and create enormous job opportunities. In the buildings sector, it will allow us to decouple growth from energy consumption and greenhouse gas emissions.

Figure 2 and the following text present the policy instruments we recommend to combine in a package for achieving this goal. The bigEE Buildings Guide includes more detail on ULEB. See also paper 5A-426-13 (Moore and Schüwer 2013) in these proceedings.

- **Mandatory 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 and then strengthened step by step every three to five years, to finally require energy efficiency levels equivalent to ULEB. MEPS reduce transaction costs as well as the landlord-tenant and developer-buyer dilemmas by removing the least energy-efficient building practices and concepts from the market. They should, however, always be at least as stringent as the energy performance level leading to least life-cycle costs. In order to be effective, compliance with MEPS must be controlled at the local level in both the design stage and

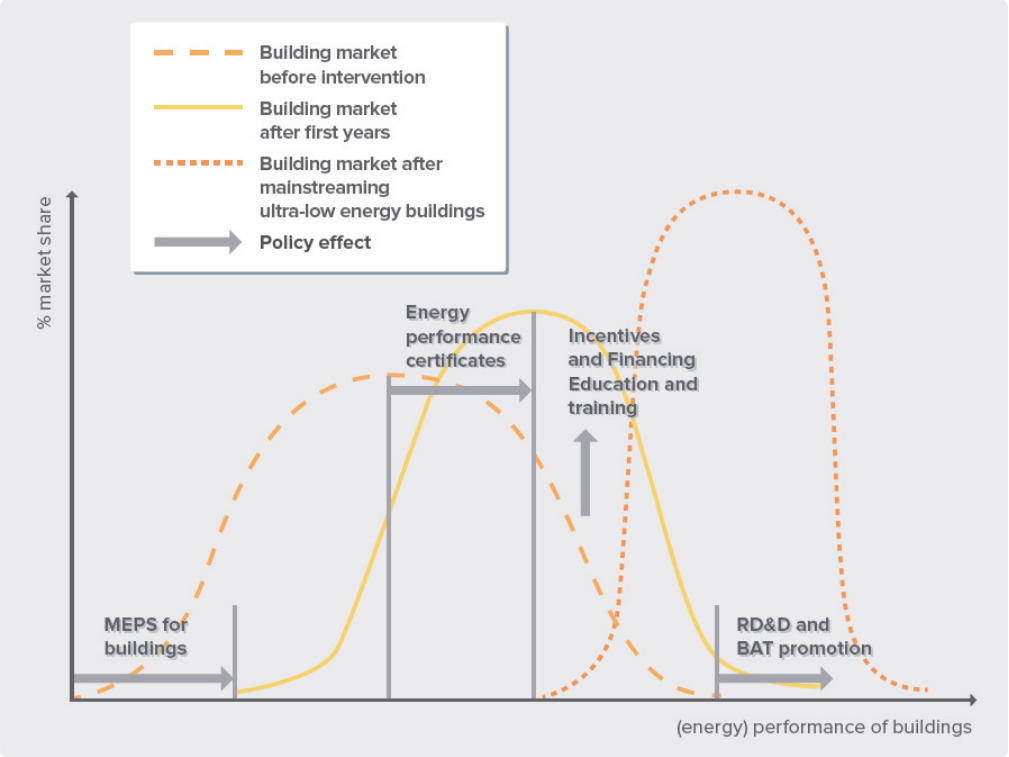

Figure 2. The interactions of policy instruments for energy efficiency in new buildings. Source: Wuppertal Institute (2012), adapted from Klinckenberg & Sunikka (2006).

after construction, as in China (cf. Table 1). A threat of appropriate sanctions following non-compliance detected in such controls will usually be needed to ensure compliance. In a transition period before a law can make MEPS mandatory, a voluntary standard may help. Especially in developing countries, it may be useful to combine such voluntary or even the introduction of mandatory MEPS with financial incentives or financing for meeting the MEPS requirements, at least for poorer households (Iwaro and Mwasha 2010). Preferably, **other statutory requirements** such as individual metering, energy management for larger buildings and building portfolios, or regular inspections of heating, ventilation, and air conditioning systems would complement the legal framework.

- **Education and training** of building professionals (architects, planners, developers, builders, building and installation contractors, financiers and other relevant market actors) is essential to *prepare introduction and further strengthening of MEPS regulation* up to ULEB. Easy-to-use **tools** for energy-efficient building design and for life-cycle cost calculation are important for the training. **Certification** of successful participation to the training can make it more attractive for both the qualified market actors and their customers.
- *The markets should, furthermore, be prepared for the next step(s) of MEPS regulation* towards ULEB through policies tackling the substantial information deficits and financing barriers. These include building **energy performance certificates** (and energy labels for components where useful), **showcasing** of demonstrated good practice buildings, **advice** and **financing support** for investors, and **financial incentives** – such as grants and tax incentives – for broad market introduction of ULEB. It is mainly for such information and financial programmes that energy efficiency funds or energy companies must contribute. 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 breakthrough.
- 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 this energy performance level step is proven, this level can then be mandated by the regulation to become the new MEPS level. This would be *one step of MEPS regulation* towards ULEB in new build.
- *Future steps of MEPS regulation* towards ULEB should be prepared by innovation support through **R&D funding, demonstration** (including in public buildings), **award competitions**, and maybe also already by financial incentives for broad market introduction. The **public sector** should **lead by example** through energy-efficient public procurement and ambitious targets for its own buildings, thereby paving the way for the other sectors to follow.

HOW THE SPECIFIC POLICIES AND MEASURES FOR ENERGY EFFICIENCY IN BUILDING RENOVATION AND OPERATION INTERACT

In Europe, the existing building stock provides larger potential for cost-effective energy savings than new construction by 2050 (cf., e.g., Ürge-Vorsatz et al. 2012). It is also the bigger challenge to retrofit the walls, roofs, windows, and heating and cooling systems of existing buildings to highest energy performance levels in an integrated way. The operational goal for energy efficiency in existing buildings thus has two dimensions:

- Achieving very energy-efficient and comprehensive, "deep" retrofits whenever a building is renovated, and
- increasing the rate at which buildings undergo such "deep" energetic renovations.

Figure 3 and the following text present the recommended combination of policy instruments for achieving this two-dimensional goal.

- Every year, many existing buildings undergo renovation for maintenance or beautification anyway. These opportunities should be harnessed to improve energy efficiency by adding thermal insulation or shading and using more energy-efficient windows, heating, and cooling systems, instead of just replacing paint, tyles, or windows as they were before. The reason for this recommendation is that it is very often cost-effective to add the incremental energy efficiency investment at the time of renovation—possibly even for well-planned 'deep' renovations saving up to 80 % of energy—but usually not cost-effective to repay the full renovation cost from energy savings. Renovation without improving energy efficiency therefore means a lost opportunity and will likely lock in high energy consumption until the next renovation. Mandatory **minimum energy performance standards (MEPS)** for existing buildings undergoing major renovation (e.g., more than 10 or 20 % of the building shell or of the walls, windows, or roofs) as well as for building components and heating and cooling systems are *therefore an important policy for energy efficiency in existing buildings, too*. They should be created by law and then strengthened step by step every three to five years, to finally require energy efficiency levels equivalent or close to ULEB also for existing buildings when the technology is mature and cost-effective enough. MEPS reduce transaction costs as well as the landlord-tenant and seller-buyer dilemmata by removing the least energy-efficient building practices and components from the market. They should, however, always be at least as stringent as the energy performance level leading to least life-cycle costs. In order to be effective, compliance with MEPS must be controlled at the local level in cases of major renovation. In a transition period before a law can make MEPS mandatory, a voluntary standard may help. However, for existing buildings it is much more important to accompany MEPS with individual advice as well as financial incentives or financing for meeting the MEPS requirements, since otherwise building owners may wait with major renovation. A possibility may be to mandate the rate at which the portfolio of large building owners has to undergo energy-efficient renovation each year, as the European Union has recently decided for national government buildings in its Member States.

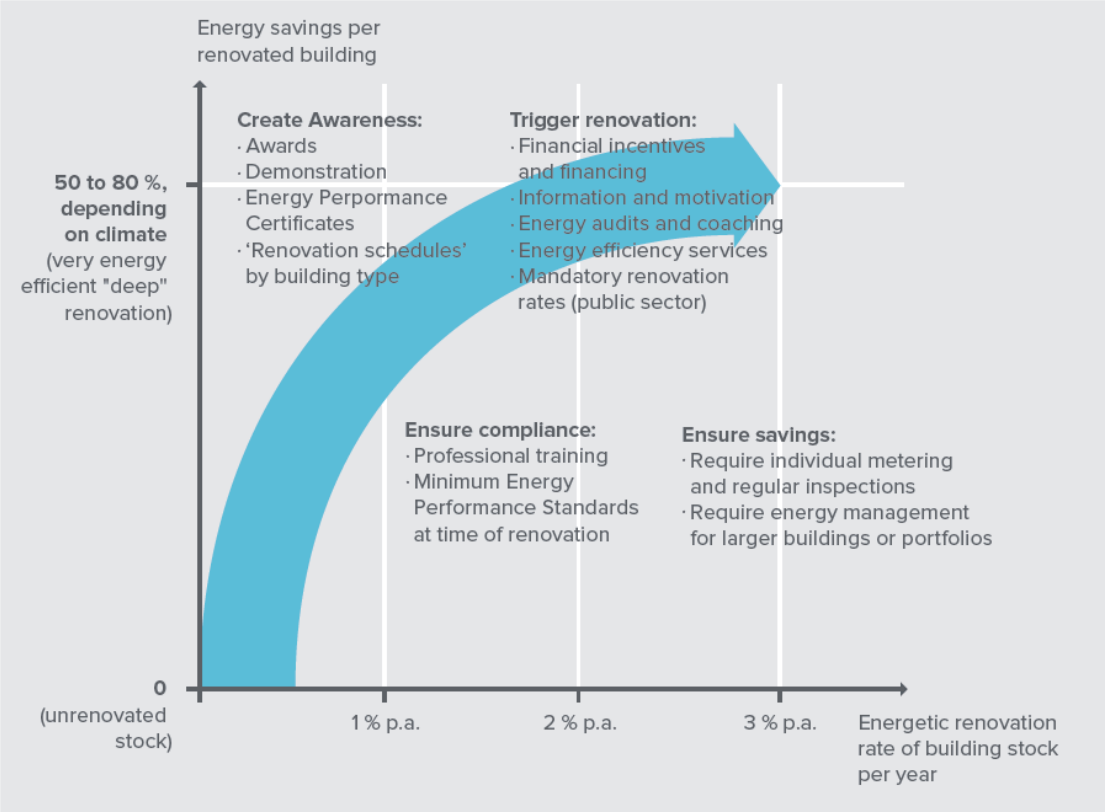

Figure 3. The interactions of policy instruments for energy efficiency in building renovation and operation. Source: Wuppertal Institute (2012).

- Preferably, **other statutory requirements** such as individual metering, energy management for larger buildings and building portfolios, or regular inspections of heating, ventilation, and air conditioning systems would complement the legal framework to ensure energy-efficient operation of buildings.
- *The most important policies and measures for energy efficiency in existing buildings* are those tackling the substantial information deficits and financing barriers, in order to *first move markets towards very energy-efficient retrofit levels ("deep renovation") and then to trigger energy-efficient renovation at all, to increase retrofit rates*. These instruments include building **energy performance certificates** (and energy labels for components where useful) with mandatory display upon advertisement, rental or sale, **showcasing** of demonstrated good practice building renovations, and **award competitions** for very energy-efficient renovations, combined with **information and motivation programmes** to disseminate the results, to *raise awareness* for energy efficiency opportunities in renovation and to develop more energy-efficient and cost-effective technologies and concepts for building renovation. In addition to these instruments, **individual advice**, such as **energy audits** need to show building owners what they (or their tenants) can save and what is cost-effective, and **coaching** can be essential to assist investors in implementing the retrofits. Still, due to long pay-back times and/or lack of finance, **financing support** for investors, and **financial incentives** – such as grants and tax incentives – for broad market breakthrough of very energy efficient retrofits. Although even deep renovation may often be cost-effective at incremental costs when renovation occurs anyway, the high full cost of renovation may cause building owners to postpone it. Financing and incentives may help to overcome that barrier and trigger renovation, adapted to the needs of different types of investors. It is mainly for such information and financial programmes that energy efficiency funds or energy companies must contribute. Promotion of **energy efficiency services** for guaranteed energy savings and voluntary agreements with large developers to renovate energy-efficiently at an increased rate may also support market breakthrough. Only all of these instruments together are likely to achieve the double goal of very energy-efficient retrofits at increased rates.
- In addition, there must also be a sufficient number of skilled providers willing and able to perform the energy-efficient renovation tasks. **Education and training** of building professionals (architects, planners, portfolio managers, builders, building and installation contractors, financiers and other relevant market actors) is essential *to increase renovation rates and ensure high quality and very energy-efficient retrofit*. Easy-to-use **tools** for energy-efficient building design and for life-cycle cost calculation are important for the training. **Certification** of successful participation to the training can make it more attractive for both the qualified market actors and their customers.
- Once a certain market share of retrofits to a specific energy performance level is reached, the professionals are trained and used to the required practices, and the cost-effectiveness of this energy performance level step is proven, this level can then be mandated by the regulation to become

the new MEPS level for major renovations. This would be *one step of MEPS regulation* towards energy efficiency levels equivalent or close to ULEB in existing buildings.

- *Future steps of MEPS regulation* towards energy efficiency levels equivalent or close to ULEB should be prepared by innovation support through **R&D funding, demonstration** (including in public buildings), **award competitions**, and maybe also already by financial incentives for broad market introduction. Reducing the costs of very energy-efficient renovation ('deep renovation') may also be an important target for R&D and demonstration. The **public sector** should **lead by example** through very energy-efficient renovations and ambitious energy savings targets for its own buildings, thereby paving the way for the other sectors to follow.

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

As discussed in the methodology section above, the second of the analysis was 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[1]) and was continued with in-depth literature review on candidates identified by the team and international experts we approached for advice.

As some of the most advanced countries show (cf. Table 1), 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. Paper 2-155-13 (Tholen et al. 2013) in these proceedings presents bigEE's assessment tools for "good practice" policies of a kind and an example.

DISCUSSION: WHAT THE COUNTRIES DO VS. BIGEE'S RECOMMENDED POLICY PACKAGE

A look through the table confirms that the empirical evidence proves the composition of policy package developed with the actor-centred theoretical analysis and presented above to be the right combination of policies and measures.

The governance framework for energy efficiency

All five countries have a policy roadmap for energy efficiency. However, it is more or less explicit regarding energy-efficiency transformation of new build and the building stock. By 2020, California aims for the zero net energy standard in new buildings and the two EU member states Denmark and Germany have to achieve nearly zero energy buildings by then. China and Tunisia do not (yet) have such explicit goals for new build or refurbishment, but China breaks down its national energy productivity target to the sectors. Only Germany appears to have an explicit energy-saving target for the building stock of reducing primary energy consumption in buildings by 80 % by 2050. This supports the finding that a policy target and roadmap is an important element guiding policy implementation, but it seems that historically only after some years of experience with and trust in energy efficiency policy-makers dare to adopt concrete *high efficiency* targets and roadmaps.

In terms of the infrastructure and funding for energy efficiency programmes and policies, all countries except China have a national or state energy agency. In China, the ministries fulfill this role themselves. China is also a country using normal government budget to finance energy efficiency policies and programmes, as does Germany, although the latter recently set up an energy and climate fund fed by revenues from auctioning EU emissions trading certificates. The other three countries have more explicit mechanisms for financing and organising energy efficiency programmes, particularly with financial incentives, in a manner independent from normal government budgets: while California and Denmark heavily involve their energy companies in this task, through energy saving obligations, Tunisia uses an energy efficiency fund. Taken together, all of this proves that a stable framework for financing and organising energy efficiency policies and programmes is a must, which does not come as a surprise.

Eliminating market or legal distortions, e.g., on energy prices, will improve the cost-effectiveness and level the playing field for energy efficiency. The five countries show that policy-makers in an increasing number of countries share this view. While California and the two EU countries have an emissions trading scheme, the latter and China have energy taxation, and Tunisia aims to phase out energy price subsidies.

Specific policies and measures for energy efficiency in buildings

All five countries have Minimum energy performance standards (MEPS) for buildings and equipment, which proves the importance of this instrument for energy efficiency in buildings as an element of the overall package. However, this does not mean that the MEPS are always so stringent as to require very energy-efficient buildings and equipment. In fact it is difficult to make the different requirements comparable, as climates, metrics, and methods differ a lot. The Global Buildings Performance Network recently published an effort for such a comparison at www.gbpn.org. It also includes compliance, for which California, China, and Denmark perform best among the five countries analysed in Table 1.

Mandating regular inspections of boilers and air conditioners can contribute to their energy-efficient operation, and requiring individual heat and electricity metering is supporting efficient use of buildings. Germany has both, while we are not aware in detail about such regulations in the other countries except Denmark. China is currently developing an innovative regulation for a trading system on the overall energy performance of existing larger public and commercial buildings, called the Energy consumption quota management.

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

Table 1. 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	Quadrennial plans set targets for overall national energy efficiency improvement.
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 since 1976	DENA (German energy agency) since 2000, some state and local agencies; KfW and BAFA in charge of financial incentives and financing programmes	ANME (National energy agency), established in 1985
	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 (central and provincial governments)	Energy saving obligations for distribution network companies (1.25 % per year overall, soon 2 % per year); Danish energy saving trust	No explicit mechanism; mostly government agencies (KfW, BAFA) and budget, including special Energy and Climate Fund	National Energy Fund (FNME)
Eliminating distortions	Removal/reduc-tion of subsidies on end-user energy prices and on energy supply (if they exist); Energy/ CO_2 taxation and emissions trading	Greenhouse gas emissions cap and trade programme introduced September 2012	China likely to remove price 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; EU Emissions trading scheme	Energy tax exists for heating fuels and electricity; EU Emissions trading scheme	By 2017 energy price subsidies are to be phased out
	Removal of legal barriers (if they exist)				Allowance for landlords to increase rent (by 11 % of energy efficiency investment)	

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
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. Four-stage controls during design and construction.	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	There are insulation and thermal requirements for new buildings
	Other legal requirements		Energy con-sumption quota management and trading scheme under development	Regular inspections of boilers, ventilation, and air conditioning systems	Regular inspections too; Individual metering for heating energy and electricity	
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; Bygningsklasse 2020	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	Energy audit programme for larger non-residential buildings	A main programme area for the energy companies to fulfil their energy savings obligations; Energy Service Denmark	Several programmes via consumer agencies, KfW, energy agencies, energy companies, independent advisors	Mandatory energy audits for large end-users (industrial facilities and apartment buildings)
	Information centres	E.g., Pacific Energy Centre as a part of the PG&E. (no state-wide network structure)	Information centres can be found throughout China	Knowledge Centre for Energy Savings in Buildings	Some local energy agencies, consumer agencies or energy companies	A Local Energy Information Network is planned in cooperation with France.
	Demonstration buildings (new/ refurbished)	yes	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 and energy compa-nies, websites, informative bills		Information campaigns by government, Energy Saving Trust, energy companies	Information campaigns, online advice tools	There is a communication and awareness programme

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
Financial incentives & financing	Financial incentives	Utility energy efficiency programmes for new and existing buildings (Most important policy instrument in California); some state-funded programmes too	Financial subsidy for heating metering and energy efficiency retrofit of existing residential buildings in North China; also for lighting and non-residential energy management	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)
	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)	German federal states (Länder), chambers of architects, or KfW	Training courses, design tools, technical guidelines
Promotion of energy services	Promotion of third-party-financing	Legislation enables and promotes usage. Some energy company programmes	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, Development & 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	10 % savings target for government buildings; Curve breaker agreements for other public bodies; Requirement to disclose energy performance certificate	Some authorities only build ultra-low energy buildings; many have energy management, saved up to 50%	

Note: the table only shows the priority types of policies in the bigEE recommended policy package. Source: bigEE analysis (online including all types of policies and all sources at www.bigee.net).

All countries seem to acknowledge the usefulness of building energy labelling, while only the EU so far has made Energy Performance Certificates mandatory for all types of buildings and Tunisia for some types of buildings – in contrast to appliance and equipment labels, which are mandatory in all five countries.

Similarly, all countries appear to value individual advice or energy auditing, as well as information centres, as highly important particularly for triggering energy-efficient renovation. However, the intensity of such programmes may vary, and only Tunisia has made energy audits mandatory so far for large end-users. Demonstration buildings or programmes also exist in all of the countries, and the same is probably true for information campaigns and other information tools and measures, although we did not systematically collect information for China here.

Financial incentives are another type of policy that is proven to be very important by looking at the examples. All five countries have financial incentive programmes for energy efficiency in buildings, although they vary in subject and intensity, and also energy efficiency requirements. While Tunisia promotes action on single components, Germany also promotes high overall energy performance in new buildings and refurbishment. California too addresses both new buildings and retrofits, while China so far focuses on retrofit in some sectors and areas.

Not all countries, in contrast, seem to see a need for financing assistance through preferential loans as in Germany or more innovative financing schemes such as PACE in the USA or the Tunisian programmes. We did not find information on such schemes in China and Denmark.

For all countries, education and training for supply chain actors is part of their package, although we are not sure about the intensity of their efforts.

For all countries except Tunisia, we can also say they promote energy (efficiency) services such as energy performance contracting. The same is true for public sector programmes.

Taken together, we have seen that most of our five countries have implemented nearly all or even all of the priority elements of the policy package recommended by bigEE for energy efficiency in new and existing buildings. The intensity of implementation and the stringency of energy efficiency and compliance requirements may vary but what was to be tested here is the composition of the package.

Did we encounter any surprises we had not expected after the theoretical analysis? Yes, there is one innovation, which is China's new quota system. China is currently developing a trading system on the overall energy performance of existing larger public and commercial buildings, called the Energy consumption quota management. This deserves closer analysis in the future as to how effectively it operates and creates energy efficiency action. It introduces a MEPS for the building stock independent of renovation but with the flexibility of trading.

DISCUSSION: WHAT ARE THE ACHIEVEMENTS?

As said before, the comparison between these five countries served as an empirical proof for the composition of the recommended policy packages for energy efficiency in new build and renovation. Still, one question remains. Can these five countries also be considered successful in terms of energy saved – relative to baseline trends or even in absolute number; overall or on average of new and refurbished buildings per m^2; in new build and the existing building stock? And what has been the contribution of policy packages? Unfortunately, information that would make the countries' achievements comparable is not easily available, if at all.

- California has kept electricity consumption more or less stable since the 1970ies, whereas it increased by 30 % on average in the rest of the USA[2]. This includes a lot of the energy used in buildings: as California has a warm climate in most regions of dense population, air conditioning and electricity is much more important than in Europe. Natural gas consumption in residential buildings even reduced by about 10 % between 1967 and 2009, despite the number of customers about doubling (energyalmanac.ca.gov).
- In China, according to the MEPS, new buildings in cities are saving 50 to 65 % of calculated energy consumption relative to 1980ies buildings. While some OECD countries have achieved up to 75 % of savings in this manner, China does very well for an emerging economy. And compliance rates in the cities where the codes apply are higher than in most OECD countries, with over 90 % due to inspection in both the design and construction phases (Zhou et al. 2012). Still, real life energy consumption may have increased, as thermal comfort requirements have increased as well since the 1980ies.
- New buildings are low-energy buildings in Denmark and close to this level in Germany (cf. MEPS values mentioned in Table 1). In Denmark, the energy efficiency of households was improved between 1990 and 2008 by almost 16 % (Odyssee & MURE 2011). Still, although energy-efficient renovation projects supported by the government achieve energy savings of 31 % (IWU & BEI 2011), this is only around half of what would be feasible through "deep" renovation.
- In Tunisia, between 2007 and 2011, the PROSOL programme contributed to the total size of solar water heaters increasing by 500,000 m^2 (bigEE.net online file on PROSOL).

What can we conclude here? All of these countries or states are in one or more aspects advanced in energy efficiency among their peer countries or states – and still they all have a long way to go towards a truly energy-efficient building stock. But the same is true for all other countries. We hope they all can benefit from the wealth of information that bigee.net presents.

Conclusions

With the two-pillar approach to policy analysis used here, we have been able to add new foundation, both theoretical and empirical, to the conclusion about what is a necessary and advisable package of policies to effectively advance high energy efficiency improvements in new build and renovation of existing buildings:

As the first pillar, the actor-centred approach to policy analysis 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 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. The first important result are thus the policy packages we now recommend on bigee.net. There are sometimes alternative policies for one strategy, so the final composition of the package will depend on the circumstances in a specific country.

As a secondary result, we have also advanced the methodology that governments and consultants can use to assess given

2. Rosenfeld, Arthur at http://coolwhiteplanet.org cited in Buchan 2010.

buildings markets and the policy support that all relevant actors need to harness energy efficiency.

As the second pillar, 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. This is presented by Tholen et al. (2013) in these proceedings, including its application for an example.

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 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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