Reducing energy demand in existing buildings: benchmarking tool for best practice renovation policies

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Abstract

Globally, by 2050, energy consumption in buildings can be reduced by 30 % relative to today's levels. Realising this potential needs the development of a range of ambitious, complementary and sustainable energy renovation policies. The aim of this project was to support the up scaling of deep renovation across the residential building stock, by defining a state-of-the-art policy package and analysing best practice policies in consideration of this definition. State of the art was defined by identifying the key policy elements that ensure buildings are renovated deeply.

Six key themes were identified as intrinsic to a state-of-theart policy package: regulatory normative measures, building assessment, financial instruments, economic instruments, capacity building and overall performance indicators.

This project sought to learn from current best practice renovation policies in the EU and U.S. All of the selected jurisdictions were assessed against the same criteria. The chosen jurisdictions are Denmark, California, France, Germany, Massachusetts, the Netherlands, New Jersey, New York, Oregon, Sweden, the United Kingdom and Vermont.

The results of this study and the comparison of the best practice policy packages are presented as an online policy interactive comparison tool. The tool allows the user to develop their own analysis by selecting the criteria that are of interest to them. Policy packages can be compared using a single criterion or using multiple criteria. The tool allows the user to compare policy packages based on different criteria by selecting and deselecting criteria in the interactive tool area, generate graphs based on time series data for energy performance in the respective countries/regions; and access detailed information about each of the policy packages.

The tool's purpose is to strengthen today's renovation policy packages and encourage the adoption and implementation of state of the art policy packages around the world.

Introduction

The GBPN's report "Buildings for Our Future" (GPBN, 2013) shows that if best practices¹ are up scaled globally by 2050, energy consumption in buildings can be reduced by 30 % relative to today's levels. This is possible in spite of expected growth in population, floor space and comfort levels in developing regions. To achieve this, the 'deep' scenario requires that existing buildings will have to reduce consumption by 70 % globally, which has been shown to be technically feasible by mainstreaming building technology with the support of aggressive policies.

To support the feasibility of the 'deep' scenario, the GBPN recognises the need for the development of a package of ambitious, complementary and sustainable energy renovation policies that can ensure significant energy savings in existing buildings. Consequently, the aim of this project was to identify elements that are critical when developing future energy renovation policies for residential buildings. Focus has been placed on this building typology following the outcome of a scenario analysis, whereby the residential building stock has been calculated to consume two thirds of overall building consumption, globally (Urge-Vorsatz et al., 2012). This documentation

^{1.} A best practice is a method or technique that is proven to be superior to others achieved with other means. Best practice can be used as a benchmark but it can also be improved over time. (Source: GBPN Glossary.)



Figure 1. Best Practice Themes and Related Criteria.

includes an assessment of best practice policies, incentives and programmes that support energy renovation of buildings, with strong emphasis on 'deep' renovation².

In light of this situation, the GBPN developed a project to support the up scaling of deep renovation across the residential building stock, by defining a policy package for energy renovations and analysing current best practices in consideration of this definition. The results of this analysis are represented in an online interactive tool that can be accessed on the GBPN website.

Methodology

The project was undertaken in three phases:

• Phase 1 – Identifying best practice criteria for selection and evaluation. The GBPN developed a project that sought to identify key themes and elements that support the development of policy packages that drive the existing building stock towards deep renovation. Criteria for defining a state of the art renovation policy package was developed by reviewing current literature on policy packages, current best practice policy packages and using a panel of renovation policy experts who gave their input and reviewed all of the criteria. The desktop study reviewed research reports and academic papers (see Annex 1) on renovation policy packages from around the world, in order to gather information on best practice policy elements for renovation. The desk study also looked at current policies for renovation, specifically the jurisdictions that were deemed to have a best practice policy package set up, to ensure all possible energy renovation policy elements were included in the Renovation Policy Package Criteria.

A peer review process of review and modification was followed whereby the criteria were sent to an expert group following several rounds of modification. Thirty building energy efficiency renovation policy experts from academia, the private sector, national experts from different regions and international organisations, participated in the review of the criteria for a renovation policy package. An agreement was reached on the 14 criteria that form the basis of the assessment of the individual key themes.

 Phase 2 – Selection of best-practices study regions. In order to identify current best practice elements of policy packages for the residential building stock, the GBPN first conducted a desk study on the current state of play, searching for jurisdictions that have significantly reduced their energy consumption in existing buildings. Each country or state was selected based on two main criteria: demonstration of their policies including elements that cover energy renovations; and a reduction of residential energy consumption (relative, per capita, unit floor area, GDP and dwelling).

 Phase 3 – Developing the policy tool for existing buildings. The final stage collected the information and data gathered in these two phases, used the defined criteria to score each policy package and developed a comparative and analytic tool that allows the user to conduct a comparison of single or multiple elements of a best practice renovation policy package in selected countries or states.

A scoring system was devised with the help of the expert committee that used each of the sub-criteria as the basis for scoring each of the policy packages against each criterion. Each criterion was assigned a maximum score of ten points that were distributed according to the importance of the sub-criteria within the criteria. To receive a full 10 points for a specific criterion, the jurisdiction must have fully implemented the "state-of-the-art" policy measure and its implementation must be showing significant support towards the uptake of deep renovation.

Identify Best Practice Criteria for Selection and Evaluation

OVERVIEW

As the project sought to evaluate best practice policy packages for renovation to support a transformation of the building stock, the main focus of the research was on holistic and ambitious building energy efficiency renovation policy packages. Six key themes were identified that form the basis of the renovation policy package used to evaluate the best practice jurisdictions, these are: Regulatory normative measures, Individual building assessment, Financial instruments, Economic instruments, Capacity building and Overall performance. A detailed set of 14 criteria (2-3 per theme) was developed to rigorously assess the performance of policy packages. The first five themes assess policy package implemented by the jurisdiction. The sixth theme acts as an overall performance indicator that analyses the performance of a region's policy package in terms of energy consumption. Details of each of the six themes and the 14 supporting criteria can be found in Figure 1.

As can be seen in Figure 1, each theme comprises of 2 or 3 criteria that form the elements of a "state-of-the-art" renovation policy package. More detailed information on each theme, the criteria and how these support the assessment of each jurisdiction's policy package is outlined in Table 1.

Under each of the 14 criteria, sets of questions (sub-criteria) were developed that allowed for each jurisdiction to be assessed using the same amount of detail and rigour. The sub-criteria were set up in order to assess the individual elements of each of the policy measures.

^{2.} Please find a full definition of a "deep" renovation in the GBPN Report "What is a Deep Renovation Definition?", http://www.gbpn.org/reports/what-deep-renovation-definition.

Table 1. Best Practice Themes and their scoring criteria.

SELECTION CRITERIA	SCORE	SCORING CRITERIA									
Theme 1 – Regulatory Normative Measures											
1. Overall country reduction targets											
How committed to the target is the region?	3	An overall national target will set the level of ambition									
How ambitious is the reduction target?	4	for the jurisdiction in terms of energy or CO_2 savings.									
Has political action been taken?	3	different sectoral targets. The highest score is									
Total Score	10	awarded to a jurisdiction with a binding target that is ambitious and supported by a national action plan.									
2. Building & Renovation Targets (for existing residential building stock)											
Has the Government set national carbon/energy/energy efficiency reduction targets for the overall building stock?	3	Governments should set clear, binding and ambitious targets (in terms of depth and scale) that provide									
Are renovation targets included in the national carbon/energy/ energy efficiency targets?	3	direction to all parties involved and give a clear focus for investment and market development. Energy performance (EP) targets will require for the whole									
Is there a roadmap leading to these targets? Y/N (Description of roadmap). Do the roadmaps integrate energy performance of buildings with broader societal goals (social issues such as health, job creation, etc.)?	4	residential building stock to be improved/upgraded to a specific level in a certain number of years. The highest score will be given when a region has a full set of reduction and renovation targets for the existing									
Total Score	10	building stock.									
3. Public Building & Renovation Targets (for public building stock)											
Has the Government set carbon/energy reduction targets for public buildings?	3	In order to stimulate a 'deep' renovation strategy, specific policy targets for the renovation of public									
Are renovation targets included in the national carbon energy targets (no. of buildings, renovation rate and level of renovation)?	3	buildings should be stringent and ambitious and should set an example for the level of ambition for renovation of the rest of the building stock. The									
Is there a roadmap leading to these targets? Do the roadmaps integrate energy performance of buildings with broader societal goals (social issues such as health, job creation, etc.)?	4	highest score will be awarded to regions that have stringent public building reduction and renovation targets.									
Total Score	10										
Theme 2 – Individual	Building A	ssessment									
4. Building codes include requirements for renovations/existin	g buildings	5									
Technical requirements: Stringent component-based requirements for renovations in the code?	3	The highest score will be given to fully performance based codes, which take into account interactions									
Holistic approach: Are there performance-based requirements for renovations in the code?	3	between the different parts of building and technical systems and which stimulates use of integrated design principles.									
Implementation: good enforcement that support the code?	3										
Dynamic codes	1										
Total Score	10										
5. Labelling Schemes											
Is there a mandatory certification scheme for buildings in place?	2	Energy certification of buildings supports the									
Are there voluntary certification schemes set up in the country/state?	2	implementation of energy efficiency measures as it allows for the comparison of buildings and helps to document the impact of renovation: this will normally									
How frequently are certificates issued/renewed? Is there a publically available register of the energy performance of buildings?	2	be driven by enforcement mechanisms. Within a best- practice policy package, it is expected that a mandatory certification scheme set up in the studied									
What is the methodology when issuing certificate? Are energy audits the primary means for certifying a building? Are there training schemes set up for accreditors?	3	the ambitiousness of such instrument. The score will depend on how ambitious, comprehensive and reliable the labelling scheme is.									
Are there penalties for failure to comply, and are these enforced?	1										
Total Score	10										

The table continues on next page. \rightarrow

Table 1. Continuation.

SELECTION CRITERIA	SCORE	SCORING CRITERIA							
Theme 3 – Financia	Theme 3 – Financial & Fiscal Instruments								
6. Incentives (subsidies/loans/grants) available for renovation									
Are loans/subsidies/grants available for renovation of buildings and are they ambitious?	3	Financial incentives such as subsidies, grants and loans are effective in encouraging building owners and							
Are the incentives included in a long-term action plan?	2	occupants to invest in energy saving measures. These instruments, with better terms and/or reduced interest							
On what basis is the incentive distributed: "Conditionality" (only access to funds is allowed if substantial savings will be provided) or "Progressivity" (more financing for the most ambitious renovations)?	4	rates, for building energy efficiency improvements will finance all or most of the investment. Maximum points will be awarded to the most comprehensive subsidy schemes that encourage for holistic EE renovations.							
Are funding mechanisms promoting the involvement of private financing to leverage investments?	1								
Total Score	10								
7. Taxation Mechanisms									
a) Are tax exemptions, differentiations and/or reductions set up and is it ambitious?	3	The major barriers connected to energy retrofits are economic and financial; the possible remedies for							
Tax credit for a holistic renovation or specific components?	1	these are fiscal and economic instruments such as tax rebates. The highest score will be given to the region							
b) Is there a carbon/energy taxing system set up?	5	with the most ambitious taxation mechanisms.							
Is the tax ring-fenced (invested back into efficiency)?	1								
Total Score	10								
Theme 4 – Market-base	ed, financia	l instruments							
8. Utility-funded energy efficiency programs									
Does the scheme cover a large part of the consumers and does it of a significant size? Who is eligible? Residential, commercial, both?	4	Utilities provide a good opportunity for leveraging and partnering to pull resources into a renovation program. Utility programs are typically restricted to their							
Does the system cover all parts of energy efficiency improvements of buildings and does it support more holistic approach? What energy saving measures will be provided?	2	ratepayers, and may further be restricted to measures that relate to the fuel type they provide. Maximum points will be awarded to the most comprehensive utility-funded energy efficiency renovation							
If subsidies are given are these significant? Up to what percentage of the cost do the utilities pay?	2	programmes.							
Is the funding conditional and progressive: Does the funding increase the deeper the retrofit?	2								
Total Score	10								
9. Market development for ESCO based energy efficient renov	ations in th	e jurisdiction							
Is there a significant market for energy savings performance contracting/energy performance contracting system set up?	4	Specific market mechanisms can be implemented to promote energy renovations. Energy Service							
Is the ESCOs market for energy renovations well developed and does it cover most parts of building and the technical system?	2	Companies (ESCOs) and Energy Performance Contracts (EPCs) can be used as a mechanism to encourage deep renovation via third party financing.							
Are energy service companies supported by energy certificate schemes (white certificates)?	2	Points will be awarded to the jurisdictions providing they have the required market instruments in place							
Are targets for energy savings backed up by policies and ambitious public targets (a quantitative target for EE improvement and linked to ESCO funding) that include a system for monitoring and verifying savings?	2	that encourage for holistic renovation activities in the jurisdiction.							
Total Score	10								

Table 1. Continuation.

SELECTION CRITERIA	SCORE	SCORING CRITERIA							
Theme 5 – General information and capacity building									
10. Training and education campaigns									
Are consumers and market parties provided with energy saving advice and information about relevant incentives and campaigns for energy efficient renovation? Do these programmes include information for both owners and tenants and professionals?	2	When combined with other instruments, awareness and information campaigns are effective ways of getting people to use less energy and adopt energy measures. In order to get maximum points (and for							
Are there training activities and accreditation bodies in your region set up for building specialists (e.g. engineers, architects, inspectors, installers, builders, etc.) to increase and ensure their technical capacity for deep renovations?	4	energy renovations to become the mainstream), there must be appropriate educational programs, as well as certification and/or accreditation, as energy efficient building solutions often require the availability of strong technical capacity and expertise of all parties							
Have training and educational materials been developed for use in professional training and universities?	4	involved in the renovation.							
Total Score	10								
11. One stop solution centre									
Is there a public/national agency/coordinator supporting energy efficiency renovation activity in the jurisdiction?	4	One-stop solution centres for energy renovation are not very common yet but can play an important part in							
Are they providing advice, financing, quality control, safeguarding? Is there support available for individuals and/or large-scale investors?	3	informing consumers about how to implement a deep energy renovation from design to financing. Maximum points will be awarded when a jurisdiction has an active one-stop solution centre in place							
Is there a successful track record of implementing/ delivering DR projects through public-private partnership?	2								
Demonstration projects for progressive deep renovations in the region?	1								
Total Score	10								
Theme 6 – Policy Impact: Overall Performance									
12. Reduction in energy consumption/capita in residential building sector	10	Significant savings: the jurisdictions(s) with the most savings would score 10 points (given that this is very							
13. Reduction in total energy consumption in residential building sector	10	significant), others will score less based on relative distance. If no savings are achieved in the overall value -0 or 1 points will be awarded. If the							
14. Reduction in energy consumption/unit in residential building sector	10	consumption is small in the first place the region will also be awarded significant points.							

Each criterion was allocated a score between 0 and 10 points, 10 being the highest. In order to be awarded the maximum 10 points, the jurisdiction's current policy measures should be progressive and target deep renovations. In order to remove any subjectivity, the scoring of all of the chosen jurisdictions was carried out in two stages: initially a desktop study was undertaken by the GBPN and local experts in each of the regions that looked at and evaluated each of the policy packages separately against the criteria. The second phase invited a group of renovation policy experts to a workshop to finalise and agree on the scores for each of the policy packages against each criteria, ten renovation policy specialists from the EU, the US and international scene attended the workshop.

Selection of Best Practice Renovation Policy Packages

To identify best practice policy packages for existing buildings, the GBPN conducted a desk study (see Annex 1) to locate the countries and jurisdictions that significantly reduced the energy consumption of their existing residential building stock. For the first stage of this project, the GBPN focussed on two of its regions, the EU and the U.S. In both of these regions, the majority of the buildings that are expected to be standing in 2030 are already built and renovation activity is already extensive and an essential measure.

In order for a country or state to be selected for the GBPN's Renovation Policy Comparison Tool, it must have (i) reduced the energy consumption of their existing residential building stock over the past decade and (ii) have a policy package in place that supports the uptake of energy renovations.

The best practice regions were selected following a literature review of current best practice renovation policy packages in the EU and the U.S. and information from other databases (such as the BigEE³ and the IEA). The GBPN's regional hubs, the BPIE (EU), IMT (U.S.) and external partners supported

^{3.} http://www.bigee.net/en/

the selection of best practice policy packages by reviewing the jurisdictions selected following the literature review. The selection of the jurisdictions was a complex task given the scarcity of jurisdictions that fully implemented a package of measures that support the uptake of efficient renovations. For the second phase, in order for a country or state to be selected as a study region in the GBPN's Renovation Policy Comparison Tool, their consumption data had to show a clear reduction trend in consumption reduction over the past decade, total consumption, consumption/capita, consumption/unit of floor area, consumption/household – will decrease if other two criteria are met, consumption/GDP and representative sample of countries/states (in terms of size, population and climate zones).

Use of a combination of indicators provides insight as to where policies have been effective in reducing the energy consumption in buildings in the past, and will help to eliminate those results that are due to non-efficiency related savings such as economic turmoil. The chosen countries in Europe are Denmark, France, Germany, the Netherlands, Sweden and the United Kingdom. The chosen states are California, Massachusetts, New Jersey, New York, Oregon and Vermont. It is to be noted that for a few special cases (Denmark and California), the jurisdiction was selected based exclusively on the reputation of their best practice policy package, providing the consumption indicators remained steady.

THE EU

While 13 countries in Europe have managed to decrease their total residential energy consumption since 2000, this study has focused on six of these that are best suited to our objective criteria described in the section above. The consumption data for the EU countries was sourced from ODYSSEE, who provide detailed energy statistics for the European Union and candidate countries and is seen as the primary source for reliable building performance data in Europe. To secure integrity, the ODYSSEE's data was compared with the International Energy Agency's (IEA) and the EU's statistical office Eurostat's residential data sets. For the chosen countries in Europe the ODYSSEE data showed very similar trends to that of the IEA and hence, was regarded as being robust. The data for population and floor area were sourced from Eurostat.

THE U.S.

Although GBPN also used consumption/capita as objective criteria in Europe, we have noticed that most countries in Europe have not increased their population dramatically enough to have a significant impact on the total energy consumption. This, however, is not the case in the U.S. as many states have significantly increased their population and, hence, this study deems the consumption/capita as being one of the most important criteria when choosing the six participating states in the U.S. The total consumption data for each state was sourced directly from the Energy Information Administration (EIA), the Official Energy Statistics from the U.S. The IEA's total consumption data for the U.S. was then compared with the International Energy Agency's (IEA) data set for the U.S., these both showed similar trends; the total residential consumption in the U.S. has increased by 0.2 % between 2000 and 2008. The number of dwellings was sourced from the U.S. Census Bureau, Housing Units Intercensal Estimates (2000-2010), Annual National and State Housing Unit Estimates, the floor space was sourced directly from Pacific Northwest National Laboratory (PNNL) and the population estimates were sourced from the U.S. Census Bureau, State Intercensal Estimates (2000–2012), Annual Population Estimates.

BEST PRACTICE JURISDICTIONS – OVERVIEW

The sections below provide detailed information on the twelve chosen policy packages.

California

California has set a state target to reduce GHG emissions to 1990 levels by 2020 and to further reduce emissions to 80 %below 1990 levels by 2050. A specific target has been set that aims to reduce household energy use by 40 % by 2020. Since the mid-1970s, California has implemented energy-efficiency measures such as building codes and appliance standards with stringent efficiency requirements. New legislation (AB 758) that provides financing for building owners to undertake efficiency improvements was adopted to encourage energy retrofit efforts. The California Public Utility Commission (CPUC) organises and regulates all utility-funded energy efficiency programmes. The CPUC acts as a central hub for energy efficiency retrofits in California working with investor-owned utilities, programme administrators, and merchants to develop programmes and measures to transform technology, increase communications and advice and promote the uptake of energy retrofits.

Denmark

Adopted in 2011, Denmark's "Energy Strategy 2050" includes stringent and ambitious targets that are intended to make considerable cuts in future energy use, with the aim of independence from fossil fuels by 2050. Within the strategy, it is stated that the building sector will have a key part to play in realising this goal being one of the largest consuming sectors in Denmark, mostly through heating. Since the 1960s, Denmark has had policies in position targeting renovation of the building stock. Their package of measures range from mandatory building codes for renovation, energy taxes, labelling schemes and energy savings obligations. Denmark's building code complements this ambitious Energy Strategy, and has been gradually tightened since its adoption in 1960s. The intention is for the implementation of progressively rigorous building codes until the zero energy requirement is achieved.

France

In 2007, the "Grenelle de l'environnement" round table brought together representatives of both national and regional governments and organisations with the objective of establishing an agreement on key issues surrounding the environment and sustainable development. From this, ambitious targets were set for reducing France's carbon emissions by 75 % by 2050, compared to 1990. The Grenelle de l'environnement also established specific building sector targets taking into account a reduction of energy consumption in the building sector by 2050 (of 38 %) and a target number of buildings to be renovated per year as of 2013. Alongside the Grenelle de l'environnement, a number of other policy measures exist that aim to reduce the consumption of energy of the existing building stock that include tax reductions, tax credits and zero interest loans. France introduced their version of Energy Performance Certificates (EPCs) called 'Diagnostic de Performance Energétique' (DPE) in 2006.

Germany

Germany has a direct target for its building stock aiming to use close to zero energy by 2050. This is to be achieved by both new and existing buildings to greatly increase their energy efficiency while using renewable energy sources to cover the remaining energy demand. Germany's "Energy Concept" of 2010 requires that the primary energy demand of buildings be reduced by 80 % in 2050, with an intermediate milestone of a reduction in heat demand of 20 % by 2020. The targets are to be achieved based on three pillars: legislation (codes and labelling schemes), financial support and provision of information and advice on energy efficiency measures. The current energy efficiency efforts are well packaged. The state bank, KfW, and the German Energy Agency (Dena) are the federal government's official agencies designated to support energy efficiency in Germany; Dena provides citizens with information and advice and acts as a "centre of expertise", as a one-stop shop, while the KfW provides financial incentives and loans to promote energy efficiency.

Massachusetts

Massachusetts' Green Communities Act, 2008, requires utilities to increase their investment in energy efficiency measures. This Act requires adoption of three-year revision planning cycles, with the 2013 goal requiring utilities to save 2.76 % by 2015 by developing cost-effective energy solutions for the building sector. The 2008 Global Warming Solutions Act sets an overarching national target for Massachusetts to reduce its GHG emissions from 80 % below 1990 levels by 2050. The Massachusetts' "Stretch Energy Code" is a voluntary appendix to the Massachusetts Building Code that allows cities to elect to adopt more demanding requirements. Massachusetts has a home energy certification scheme currently in a pilot phase, the Energy Performance Score. The Mass Save programme acts as a one-stop solution centre that provides advice, information and financial guidance to all citizens of Massachusetts. Massachusetts, for the third year in a row, won first place in the American Council for an Energy-Efficient Economy's (ACEEE) annual energy efficiency state scorecard.

The Netherlands

Under the Energy Agreement (dEA) for Sustainable Growth, the Netherlands has set a goal for a sustainable energy supply system by 2050. The Agreement sets overall building targets for the Netherlands, establishing specific building sector targets that take into account a target number of buildings to be renovated by 2020, and an increase in energy labelling for the existing building stock by at least two label steps. By 2030, the average for the existing building stock is targeted to be label A (or better). The dEA for Sustainable Growth calls upon market parties to actively promote ESCOs and "Green Leases" and has introduced a National Energy Saving Fund as a new financial mechanism in 2014. Since the 1990s, the Netherlands has had strong taxation mechanisms in place to support energy efficiency efforts, as of 2000, energy premiums on the purchase of energy-efficient appliances and other energy-saving measures for households were made available.

New Jersey

The New Jersey Global Warming Response Act (2007) sets an emissions target of 1990 levels by 2020 and 80 % below 2006 levels by 2050; however, no targets for the building sector (neither new build or renovations) currently exist. New Jersey's Clean Energy Programme (NJCEP) offers financial incentives, advice and services to residents, business owners and local governments to help them save energy and money. Through the NJCEP energy savings have continued to increase in the past few years. Running alongside the NJCEP is the Edison Innovation Clean Energy Fund that sponsors research on energy efficiency and development. New Jersey State offers financial incentives for energy efficiency improvements.

New York

New York State has an energy efficiency portfolio standard target for all of its buildings. Energy savings targets are planned every three years with a goal of reducing the state's energy consumption in building energy use by 15 % by 2015. New York's overall national policy goal is to reduce GHG emissions by 5 % below 1990 levels by 2010, 10 % below 1990 levels by 2020, and 80 % below 1990 levels by 2050. New York State offers tax credits and bonds that encourage energy efficiency investment. Home energy improvements are exempt from property taxation up to the amount that the improvements increase the value of the home. Electricity and natural gas efficiency programmes are run by the utilities and New York State Energy Research and Development Authority (NYSERDA), and have achieved significant energy savings in past years. NYSERDA acts as New York's one-stop solution centre, providing individuals with advice and guidance on energy efficient design, finance and solutions for reducing their home's energy consumption.

Oregon

Oregon's Strategy for GHG emissions reductions includes statewide emissions targets set at 10 % below 1990 levels by 2020 and 75 % below 1990 levels by 2050. Oregon's building code has more stringent requirements than the standard U.S. building code, IECC 2009. Energy Trust of Oregon and utility companies have organised electricity and natural gas efficiency programmes that provide funding and advice to citizens. Alongside these incentive programmes, Oregon set up a tax deduction scheme that supports efficiency improvements. Oregon is home to a number of research centres that focus on energy efficiency, specifically the Energy Trust Oregon acts as a one-stop solution centre which provides energy efficiency advice on incentives, services and how to reduce the amount of energy used in a building.

Sweden

Sweden has adopted policies focusing on the environment since the 1960s. The government has set a stringent national zero-net greenhouse gas emissions target for 2050. In 2009, Sweden's 'Integrated Climate and Energy Policy' (ICEP) introduced the goal of increasing energy efficiency in buildings by 20 % in 2020 and 50 % in 2050. Supporting these ambitious targets, Sweden's building code's energy requirements are extremely rigorous for both new builds and building renovations. The package of measures supporting energy renovations range from mandatory building codes that target renovation, energy taxes, mandatory and voluntary labelling schemes and education and training schemes. By 2007, Sweden's subsidies for renovation measures were abolished due to the fast market uptake of energy efficient materials and design, for this the renovation industry remained strong.

United Kingdom

In 2013, the United Kingdom introduced the "Green Deal", a loan system designed to encourage and assist citizens to undertake energy renovations using a package of measures, rather than merely targeting individual measures. The aim of this is to realise larger energy and carbon savings per property. These loans are attached to the electricity meter of the building, not the resident, and thus encourage higher investment by allowing a longer payback period, which is not constrained by a possible future sale of the property. The Green Deal policy is still at a very early stage of adoption and has not yet reached significant market uptake. The government has not set national targets for the renovation of the building stock but estimates have been made for the quantity of specific measures that will be undertaken by the Green Deal. The United Kingdom has set obligations for energy companies, under the Energy Company Obligation (ECO), that realise a significant amount of energy savings in the residential sector each year. This obligation began under a different name in the 1990s. Energy Performance Certificates (EPCs) were introduced in the United Kingdom in 2007.

Vermont

As of 2007, Vermont introduced sector specific targets related to building energy efficiency. These include reducing both fuel use and energy bills by 25 % in 60,000 homes by 2017, and 80,000 homes by 2020 and reducing fuel needs and fuel bills by an average of 25 % in housing units served by energy utilities. Vermont's building requirements complement the reduction targets set and are more stringent than the standard US

Table 2. Best Practice Regions: standout policy elements.

code of 2009, IECC. Funding is offered by utilities in Vermont to support energy efficient improvements to homes. Efficiency Vermont works together with the utilities to promote the financial programmes offered. They also develop local partnership programmes that focus on energy saving opportunities; these programmes include providing consumers with guidance, educational materials, training and financial support.

SUMMARY OF THE 12 BEST PRACTICE JURISDICTIONS

Table 2 summarises the findings of the analysis of each of the best practice jurisdictions. It is possible to see the standout policy elements from each of the 12 jurisdictions in the table. The Policy Tool for Renovation highlights the key areas where the jurisdiction's Renovation Policy Package excels.

Developing the Policy Tool For Renovation

This tool supports policy makers to understand the combinations of policies and supporting measures that have been successful in reducing energy consumption in renovated residential buildings in the selected countries/regions. The tool allows the user to develop his or her own analysis by selecting and deselecting the criteria that are of interest, generate graphs based on time series data for energy performance in the respective countries/regions and access detailed information about each of the policy packages.

SCORING OF THE BEST PRACTICES

A Scoring Committee was assigned to award the scores to each jurisdiction. This ensured the process was not biased and removed any subjectivity from the scoring process. During a One-Day Workshop the Scoring Committee awarded each sub-criterion within each of the policy packages a score that re-

Jurisdiction	Overall national targets	Residential buildings	Public buildings	Code requirement	Labelling schemes	Incentive Schemes	Taxation mechanisms	Utility-funded Programmes	Market instruments	Training and education	One stop shop
California	Х			Х				Х	Х	х	
Denmark	х	Х	Х	х	Х		х	Х		х	
France	Х				Х	Х				Х	
Germany	Х	Х	Х	Х	Х		Х	Х		Х	
Massachusetts	Х			Х				Х		Х	Х
The Netherlands	Х				Х	Х	Х	Х		Х	Х
New Jersey	Х							Х		Х	
New York	Х					Х		Х	Х	Х	
Oregon	Х			Х							
Sweden	Х			Х	Х					Х	х
United Kingdom	Х			Х	Х	Х					Х
Vermont	х							Х			х

Jurisdiction	Overall national targets	Residential buildings	Public buildings	Code requirement	Labelling schemes	Incentive Schemes	Taxation mechanisms	Utility-funded Programmes	Market instruments	Training and education	One stop shop	Consumption/ capita	Consumption unit	Total Consumption
California	6	4	4	5	3	4	2	7	6	7	5	0	0	0
Denmark	8	6	1	8	6	3	5	5	1	5	4	1	4	0
France	6	3	3	5	6	6	3	2	5	5	5	3	6	1
Germany	7	5	1	5	6	7	5	1	3	8	7	2	3	3
Massachusetts	6	1	3	5	3	5	2	7	5	6	5	4	4	4
Netherlands	6	5	1	5	6	6	5	0	2	5	7	3	4	2
New Jersey	5	1	0	4	3	5	1	6	5	7	3	3	3	2
New York	5	3	4	5	5	5	4	7	7	7	5	4	4	4
Oregon	5	2	1	5	4	4	2	5	2	5	4	0	0	0
Sweden	8	3	1	6	7	2	4	0	2	8	6	4	6	3
United Kingdom	7	3	2	5	6	7	3	5	3	5	6	6	2	4
Vermont	5	2	1	4	3	4	2	5	2	3	5	0	0	0

Table 3. Score of each policy package against each criterion.

flected the jurisdiction's progress in that field. Each jurisdiction was awarded a score by the committee that was then reviewed against each of the other jurisdictions, with a view to eliminating any unrepresentative scores. None of the jurisdictions were awarded the maximum score in any of the criteria as further improvements could be made in all areas. It is to be noted that it is only possible way for a jurisdiction to score the maximum points for a criterion if the policy measure (criterion) that is being assessed supports the uptake of deep renovations. The results of the workshop provided each region with a score under each criteria, see Table 3.

The scores for each jurisdiction are illustrated in the Policy Tool for Renovation "Interactive Tool" area. Users of the tool are encouraged to play with the tool by selecting and deselecting different elements of the criteria. The overall score of a jurisdiction will change when specific elements of the policy package are selected and deselected, the scores that appear for each study region in the tool are based on the average of the selected criteria. Figure 2 illustrates the interactive element of the Policy Tool for Renovation.

GENERATE GRAPHS

It is possible to generate graphs using data that was collected to analyse each of the jurisdiction's consumption indicators. The graphs show a change in energy consumption over time, the base year (2000) is indexed to 100. Figure 3 demonstrates an example of a graph generated by the tool showing the trend in consumption of four of the studied jurisdictions. Figure 4 demonstrates an example of a graph generated by the tool showing the trend in Sweden's consumption, consumption per GDP, consumption per floor area and consumption per capita.

It is possible to compare the data in two ways:

- Single energy consumption variable across multiple countries/regions.
- Multiple variables in a single country or region.

The possible variables for selection are: Total Consumption, Consumption per GDP, Consumption per Capita, Consumption per floor area, Consumption per dwelling, Population, Floor Area, Number of dwellings and GDP.

POLICY PACKAGES

This area of the online tool provides the user with a full set of information on each of the jurisdiction's policy elements. It is possible to click on a country or state and view a detailed case study of each of the themes and sub-criterion in the policy package. Each country or state's case study is downloadable as a PDF document. Figure 5 shows a screenshot of the tool's policy package, using Denmark as an example.

Conclusions

The main outcome of the GBPN project has been the development of a set of fourteen criteria that define the key elements of a best practice policy package for the renovation of residential buildings. With the support of a panel of international experts in the field of energy renovation, twelve best practice policy packages have been scored against the criteria to capture their current performance, enable comparison and provide insight into what needs to be done to accelerate more and deeper renovation policies and supporting elements.

The results of the research are represented in an online tool that allows the interactive visualisation of the scoring of each jurisdiction under each criterion. The tool's purpose is to



Figure 2. Image of GBPN Policy Tool for Renovation (All criteria selected top, 4 criteria selected, bottom).

strengthen today's renovation policy packages and encourage the adoption and upscale the implementation of "best practice" policy packages around the world.

A number of key findings have emerged from the research:

- 1. Energy renovation policy is an emerging field and there is scope for further progress. The tool shows elements where positive steps have been taken and where countries and states can learn from these actions.
- 2. The countries and states that were successful in reducing all consumption indicators were found to have holistic policy packages in place that address key aspects of the renovation process.
- 3. The countries and states that were successful in reducing all consumption indicators were not found to have the same criteria that scored highly, this shows that there is no such thing as an overall "best" policy package, a policy package



Figure 3. Change in energy consumption over time in France, Germany, Massachusetts and New York.



Figure 4. Change in several consumption indicators over time in Sweden.

must be developed with the policy measures that target the specific needs of the country/state in question.

4. Among the current best practice renovation policies, there is a general absence of clear and ambitious targets for the renovation of the existing building stock.

Jurisdictions must go beyond current best practice in order to encourage the wide scale up take of deep renovations of the building stock. The GBPN supports a holistic approach; what makes a good renovation policy package is the proper combination of all the best practice elements. Each region can learn from others and use those lessons to find the right balance of elements adapted to their local context.

References

- DSIRE, 2013, Database of State Incentives for Renewables & Efficiency. Used for all U.S. States. http://www.dsireusa. org/incentives/incentive.cfm?IncentiveCode=NJ22F, Accessed: October 2013 – January 2014.
- EIA, 2013, Consumption Indicators for States in the U.S. Available at: http://www.eia.gov/consumption/commercial/census-maps.cfm, Accessed: August 2013.
- Enerdata, 2012, Energy Efficiency Trends in Buildings in the EU. Lessons from the ODYSSEE MURE project. September 2012.
- Eurostat, 2013, Consumption Indicators for Countries in the EU: Available at: http://epp.eurostat.ec.europa.eu/portal/ page/portal/eurostat/home/. Accessed: August 2013.

Denmark		000
Summary	* Europe	^
Adopted in 2011, Denmark's "Energy Strategy 2050" includes stringent and an targets that are intended to make considerable cuts in future energy use, with of independence from fossil fuels by 2050. Within the strategy, it is stated the building sector will have a key act to play in realising this goal being one of	mbitious Denmark h the aim France hat the Germany	
Largest consuming sectors in Denmark, mostly through heating. Since the 196 Denmark has had policies in position targeting renovation of the building stor package of measures range from mandatory building codes for renovation, en taxes, labelling schemes and energy savings obligations. Denmark's building	60s, Netherlands 60s, Sweden rergy United Kingdor p code	n
complements this ambitious Energy Strategy, and has been gradually tightene its adoption in 1960s. The intention is for the implementation of progressive building codes until the zero energy requirement is achieved.	ed since United States	~
The Policy Tool for Renovation highlights seven key areas where Denmark's R Policy Package excels: overall country reduction targets, building reduction ta building code requirements for renovations, labelling schemes, taxation mech- wildin, builded energy efficience recommense and taxation can educate and	Renovation argets, hanisms, palans	
In the early 2009s, Denmark's residential energy consumption remained const however, since 2006 the total consumption, consumption/capita, m2 and in d have all been steadily decreasing. The GDP bas generally remained stable, co	stant; Regulatory Measur stant; Overall National Tan Residendial Buildings Public Buildings	2015 8 2015 8 1 6 1
downward trend steeper than the other indicators, apart from a slight bump in during the financial crisis. Population is 5.6 million (Eurostat, 2012).	in 2008 Building Assessmi Code Requirements Labelling Schemes	0 0
Regulatory Measures Building Assessment	Financial Instrume Incentive Schemes Tasation Mechanian	3 3
Financial Instruments	Economic Instrume Utility-Funded Progr Market Instruments	ammes 5
Economic Instruments General Information & Capacity Building	Capacity Building Training and Educat One Stop Shop	ion 5
Overall Performance	Overall Performant Consumption/Capita Consumption/Int Total Consumption/Int	1 1 4 0

Figure 5. Screenshot of the "Policy Package" tab of the Existing Buildings Tool – Denmark's Case Study.

Annex 1. Research reports and academic papers studied

- ACEEE, 2013, The State Energy Efficiency Scorecard. Source: ACEEE Website – State Sheets for all U.S. States.
- Agence Française de Dévelopment, 2008, Promoting Energy Efficiency Investments – Case Studies in the Residential Sector, IEA.
- BPIE, 2013, A Guide to Developing Strategies fir Building Energy Renovation. Delivering Article 4 of the Energy Efficient Directive. Published in February 2013 by the BPIE.
- DENA, 2013, REnovation through QUality supply chains and Energy performance certification STandards.
- Diana Urge-Vorsatz, 2012, "Best Practice Policies for Low Energy and Carbon Buildings. A Scenario Analysis". Research report prepared by the Center for Climate Change and Sustainable Policy (3CSEP) for the Global Buildings Performance Network.
- ENTRANZE, 2013, Overview and assessment of new and innovative integrated policy sets that aim at the nZEB standard, May 2013.
- ENTRANZE, 2013, Building policies and programs in the EU-27. EU overview. Update March 2013.
- EURIMA, 2006, Better Buildings Through Energy Efficiency A Roadmap for Europe. Annex A Fact Sheets.
- European Commission, 2009, Low Energy Buildings in Europe: Current State Of Play, Definitions and Best Practice. Brussels: EC, September 2009.

- Field & Soper, 2010, Comparing building performance assessment in the UK the U.S.A and Sweden – lessons and opportunities for harmonization.
- GBPN, 2013, Buildings For Our Future, The Deep Path for Closing the Emissions Gap in the Building Sector, Paris, 2013
- Geller, H., Attali, S., & Consultants, I. C. E., 2005, The experience with energy efficiency policies and programmes in IEA countries. Learning from the Critics. Paris: IEA. IEA Information Paper.
- IEA, 2013, Policies and Measures Databases. Energy Efficiency Database. Accessed for all EU Member States.
- IEA, 2008, Promoting Energy Efficiency Investments Case Studies in the Residential Sector. IEA, Agence Française de Dévelopment, 2008.
- IEE, 2010, Implementing the Energy Performance of Buildings Directive (EPBD) – Featuring Country Reports.
- NYSERDA, 2013, Residential Programs. Available at: http:// www.nyserda.ny.gov/Energy%20Efficiency%20and%20 Renewable%20Programs/Residential.aspx, Accessed: December 2013.
- UNEP SBCI, 2009, Buildings and Climate Change Summary for Decision-Makers. Available at: http://www.unep.org/sbci/ pdfs/SBCI-BCCSummary.pdf, Accessed: December 2013.
- UNEP, 2007, Assessment of Policy instruments for Reducing Greenhouse Gas Emissions from Buildings.
- UNEP, 2012, The Emissions Gap Report 2012 A UNEP Synthesis Report. Paris.