Energy efficiency and the policy mix

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Abstract

Energy efficiency policy is expected to play a key role for meeting the EU's energy targets (particularly for reduced energy demand and reduced CO_2 emissions) using a range of policy instrument combinations. However, most analyses undertaken so far have focused on single policy measures rather than developing a more generic framework for assessing to what extent a particular policy mix is effective and under which specific conditions. This paper both contributes to the theoretical literature on policy mixes, and undertakes an empirical analysis of the current policy mixes in buildings efficiency policy in 14 EU countries. Building on the existing literature, and using expert knowledge, an assessment of the interaction of 55 pairs of policies is presented. This identifies policy mixes likely to deliver more, less or the same energy savings in combination than singly. The theoretical assessment is compared to actual policy mixes present within the EU, highlighting that combinations of multiple financial incentives may need further investigation. By bringing these forms of knowledge together, the paper suggests how buildings policy mixes could be made more effective, shows gaps in current knowledge, and highlights key research needs.

Key words:

buildings, energy efficiency, EU, policy mix, public policy, regulations

1 Introduction

Buildings energy efficiency policy is expected to play a key role for meeting the EU's energy efficiency targets. EU Member States have a common policy goal under the Energy Efficiency Directive (Rosenow et al. 2015) to deliver 20% efficiency improvement by 2020, most of which will be via efficiency improvements and reduced energy demand in buildings. Each Member State faces different starting conditions and a different set of savings opportunities, influenced by history, geography, the nature of the current building stock, available fuels and energy conversion technologies and different cultural expectations and practices relating to thermal comfort. However, the range of technologies and techniques available to deliver efficiency savings are largely common across the EU. Member States and other policy actors face a choice of policies and policy mixes to try and deliver these savings.

A better understanding the effectiveness of different policy mixes is of practical as well as theoretical concern. In order to meet their efficiency targets, many Member States are introducing additional policies into an often already crowded policy space (ENSPOL 2015a, 2015b) resulting in an increasing policy heterogeneity (Constantini et al. 2015). Recent analysis suggests that the National Energy Efficiency Action Plans (which describe how Member States will meet their Energy Efficiency Directive savings targets) put forward to date may not be adequate, and further policies may be required (Rosenow et al. 2015). As efficiency targets continue to become more stringent, the need for a well-functioning policy mix will also increase.

The importance of policy mixes in energy efficiency policy has long been recognised, given the variety of instruments needed to overcome different ‘barriers’ or to support different technologies at various stages of development (Geller and Nadel 1994, Uyterlinde and Jeeninga 1999). Policy making is becoming increasingly complex as power is redistributed from the national level to supra-and sub-national actors, but also outwards to quasi-state actors and non-state actors (Flanagan et al. 2011). This multi-level and multi-actor governance increasingly requires policy mixes to be designed to take into account decisions at other levels in order to achieve policy goals (Betsill and Bulkeley 2006). However, most analyses performed so far have focused on single policy measures. There is currently a lack of research that describes the energy efficiency policy mixes used in different countries or analyses complementarities and trade-offs between policy instruments.

In this paper the aim is to both contribute to the theoretical literature on policy mixes, and to undertake an empirical analysis of the current policy mixes in buildings efficiency policy in 14 EU countries. By bringing these forms of knowledge together, it is possible to suggest how buildings policy mixes could be made more effective, show gaps in current knowledge and highlight key research needs. Building on the existing literature, a classification of current policy instruments is developed, and their interactions with each other in pairs described. The empirical analysis is based on a theory-based appraisal of policy instrument combinations as well as a survey carried out across 14 European Member States. The empirical part of the paper illustrates which policy instrument combinations are most common rather than how effective they are. Such an undertaking would require data from *ex-post* evaluations using similar methodologies carried out in the countries under investigation. Whilst there are some *ex-post* evaluations for individual policy instruments (Wade and Eyre 2015), the current authors are not aware of *ex-post* evaluations of policy mixes that provide insight into the effectiveness of different policy instrument combinations. Furthermore, the methodologies of existing evaluations are not consistent across Europe which makes a comparative assessment of effectiveness very difficult if not impossible. Hence the intention of this paper is to develop a theory-based appraisal of hypothetical policy instrument combinations that indicates their potential effectiveness. This is contrasted with how policies are actually combined with the aim to understand how common specific combinations are and whether they are the ones expected to be most effective based on the theory.

The paper is structured as follows. First, the literature on the policy mix is reviewed, in particular with regard to energy efficiency. Second, a theory-based appraisal of policy instrument combinations is presented. Third, the results of the survey including which types of instruments are used and which instrument combinations are prevalent is presented. Finally, findings are discussed followed by conclusions.

2 Literature review

2.1 Public policy and the policy mix

The term ‘policy mix’ first emerged in the economic policy literature in the 1960s dealing with the relationship and interaction between fiscal and monetary policy (Mundell 1962). It was mainly used within the economic policy literature until the late 1980s and early 1990s when the concept started being discussed by political scientists (Flanagan et al. 2011). Since then there has been an increasing use in other fields of public policy, particularly in environmental policy (e.g. Gunningham and Sinclair 1999, Fankhauser et al. 2010, Sorrell and Sijm 2003).

Generally, there are two types of literature on the policy mix. First, there is a rich body of evidence on how policy, including the policy mix, emerges and changes over time (for a compendium of the most prominent theoretical approaches see Sabatier 2007). Second, there is an emerging literature on how to design an effective policy mix (Borras and Edquist 2013, OECD 2010, Rogge and Reichardt 2013, Oikonomou and Jepma 2008). This paper focuses on the latter subject, and that literature is described below.

In an idealised world where policy makers consider the optimal policy mix to address an issue area, three steps are involved in designing the policy mix (Borras and Edquist 2013): (1) a primary selection of the specific instruments most suitable among the wide range of different possible instruments; (2) the concrete design and/or 'customisation' of the instruments for the context in which they are supposed to operate; and (3) the design of an instrument mix, or set of different and complementary policy instruments, to address the problems identified. The underlying principle is the assumption for determining interactions originating from the theory of economic policy formulation as described by Tinbergen (1952, 1954). The core assumption of the theory is that policy formulation should in principle target to the maximization of the social welfare function, which can be replaced by prescribing fixed values of some variables and attribute them as targets. Tinbergen's theorem states that there should only be only one policy instrument per target in order to avoid redundancies in the policy framework.

In reality, the process of 'designing' policy mixes is much more complex and by definition inherently political (Bressers and O'Toole 2005, Howlett and Rayner 2013, Rogge and Reichardt 2013); Energy efficiency policy is no exception (Varone and Aebischer 2001). Interpretive flexibility of policy instrument types (Bijker, Hughes and Pinch, 1989) leads to implementation in many different ways (e.g. Slembeck, 1997). Policy instruments are often selected in an *ad-hoc* manner responding to issues that occur at the time of decision-making. Furthermore, policy instruments emerge depending on the political dynamics within a country with the potential of having unintended consequences which in turn impact on the development of the policy instrument itself (Béland 2010). Policy mixes are usually not designed but emergent (Cunningham et al. 2013) and interactions between the different policy instruments in the mix are characterised by both complementarities and tensions resulting, for example, from conflicting goals in public policy.

Given the complex nature of policy mix formation, how can theoretical understandings best engage with this reality? Firstly, this paper follows Flanagan et al. (2011) in assessing the degree of 'optimality' of different policy mixes, following economic definitions of optimality, faces significant difficulties. A recent review within the context of climate policy mixes (including energy efficiency) supports this view (Görlach 2013). Rather, evaluating which combinations are associated with synergies or trade-offs is more promising, and this paper builds on an existing body of literature in this tradition.

A number of studies have developed thinking on interactions between policy instruments. Recent work by the OECD (2010) emphasizes coherence and appropriateness of the policy mix. An extensive literature review by Rogge and Reichardt (2013) concludes that coherence goes beyond consistency (absence of contradictions) by focusing on synergies. Gunningham and Sinclair (1999) have developed typologies of different kinds of policy mixes: (1) mixes that are inherently complementary; (2) mixes that are inherently incompatible; (3) mixes that are complementary if sequenced; and (4) mixes whose complementarity or otherwise is essentially context specific. Howlett and del Rio (2013) also develop policy mix typologies proposing eight policy mix types determined by whether or not the mix involves multiple governments, consists of multiple policies and addresses multiple goals.

The discussion above illustrates that there is an increasing theoretical understanding of the role of the policy mix that has yet to be applied to different policy domains including energy efficiency.

2.2 Energy efficiency and the policy mix

2.2.1 Theoretical contributions

Energy policy is probably the sector most studied regarding the policy mix and innovation (Cunningham et al. 2013), with a main focus on emissions trading schemes and renewable energy policies and, to a lesser extent, energy efficiency. However, even within this policy domain, papers analysing the policy mix rather than individual instruments are scarce. Lee and Yik (2004) and Oikonomou and van der Gaast (2008) deal explicitly with the policy mix and energy efficiency in buildings. However, the analysis is largely based on theoretical expectations and undertaken within a cost-benefit framework, with little consideration of the interaction of policy instruments. Del Río (2010) Langniss and Klink (2006), Meran and Wittman (2008), and Perrels et al (2006) investigate interactions between energy efficiency and renewable energy support schemes focusing on whether different support schemes and design elements lead to different interaction results. The analysis is carried out at an abstract level and considers potential theoretical policy combinations including their complementarities and trade-offs. Similar studies by Oikonomou et al. (2014, 2011) assess renewable and energy efficiency policy as well as climate and energy instrument combinations against a number of criteria. However, the level of detail on combining different energy efficiency policy instruments does not allow for a more sophisticated understanding of the complementarities and trade-offs either. Thus understanding the interactions between building energy efficiency policies is an area requiring further work.

Another body of literature relevant to the policy mix and energy efficiency is market transformation research. Whilst not explicitly using the concept of the policy mix, Geller and Nadel (1994) analyse the role of different policies and programmes within the context of market transformation focussing on new energy efficiency products. They conclude that four types of policies and programmes are typically used to achieve a higher penetration of energy efficiency products: (a) R&D to develop new energy-efficiency measures, (b) market-pull or bulk purchase programs to facilitate commercialization, (c) financial incentives to stimulate early adopters, and (d) efficiency codes and standards to eliminate inefficient technologies and practices. Tholen and Thomas (2011) as well as Höfele and Thomas (2011) propose 10 criteria for judging the quality of energy efficiency policy packages. Whilst they make important contributions around the different policy requirements depending on the maturity of energy efficiency technologies and the different actors involved, they do not analyse the interactions between policy instruments. In addition, while market transformation theory provides useful insights, particularly around the timing of different policy types, the market for building refurbishment is different and more complex than that for products and appliances (Killip 2013). So findings from this theoretical perspective must be applied with caution.

2.2.2 Empirical analysis

There are a few papers which analyse case studies of the policy mix within the buildings energy efficiency policy domain. For example, Cunningham et al. (2013) contains a high-level discussion of the energy efficiency policy mix approach of the French Agency for Environment and Energy Management (ADEME). Schnapp (2015) looks at policy packages for the renovation of buildings, and presents best practice examples worldwide, where best practice is defined in relation to a number of indicators. An ‘ideal’ policy package was developed in two stages: (1) desktop study (2) review by local experts. Vringer et al (2015) carried out an impact assessment of Dutch policy to reduce the energy requirements of buildings. They concluded that it was not possible to establish the effectiveness and efficiency of individual policy instruments due to a lack of evaluation studies. However, they were able to assess the total policy mix using high level empirical data.

A number of researchers have made use of the MURE policy database for EU Member States (www.odyssee-mure.eu) and an IEA database for the wider OECD (www.iea.org/policiesandmeasures/energyefficiency). Constantini et al. (2015) carry out an analysis of the frequency and timing of policy instruments targeting energy efficiency in OECD countries showing an increasing policy heterogeneity. Using the MURE database Eichhammer et al. (2012) present ‘coherent combinations of policy instruments’ to address the upfront cost barrier to energy efficiency improvements. Boonekamp (2006) also uses the MURE database focusing on the Netherlands investigating the interaction effects of various energy efficiency policy measures. The paper systematically analyses whether or not combinations of policy instruments lead to higher or lower energy savings compared to using those instruments individually.

In summary, even though energy is probably the sector most studied regarding the policy mix, the evidence on energy efficiency and the policy mix is thin. In particular, there is a lack of research that a) describes the policy mixes used in different countries, b) derives typologies of typical policy mixes, c) analyses complementarities and trade-offs between policy instruments.

3 Definition and characterization of policy instruments

A wide range of energy efficiency policy instruments is used to deliver energy savings from buildings. However, the categorisation of those policy instruments is not consistent and differs between studies and countries. In this study, a recent classification is used, which is followed by all EU Member States in order to comply with the Energy Efficiency Directive, as listed in Article 7:

- energy efficiency obligations
- energy or CO2 taxes
- grants
- loans
- on-bill finance
- tax rebates
- regulations
- voluntary agreements
- standards and norms (that aim at improving the energy efficiency of products and services)
- energy labelling schemes

This categorisation is manageable in terms of potential instrument combinations whilst providing sufficient granularity. Furthermore, Member States have used it in their reporting for Article 7 compliance, meaning there is relatively consistent empirical data that can be analysed. Note that Member States can only notify energy efficiency policies under Article 7 as long as they a) deliver end-use energy savings and b) are additional to existing energy efficiency minimum requirements resulting from EU law. In case measures such as building regulations are used additionality to the existing requirements in the Energy Performance of Buildings Directive needs to be proven by the Member State.

To inform the policy mix appraisal, various characteristics of each policy type are described in Table 1. For each policy type, its function, the underlying theory of change and behaviour type are described. These descriptions are a shorthand for a more complex and nuanced reality, and consider only the primary energy-related policy functions and theories of change. Most policy types solely affect purchase decisions, with two potentially also influencing habitual behaviours. Energy Efficiency Obligations (EEOs) are classified here as purchase subsidies as they typically involve a financial contribution from the obligated parties to the overall investment cost of energy efficiency technologies/improvements. The remainder is paid by the beneficiary. Whilst there are exceptions to this, for example if EEOs target low-income customers (Rosenow et al. 2013), the majority of measures delivered by EEOs is only part-funded by the obligated parties (Rohde et al. 2014). From the perspective of the beneficiary EEOS provide them with an economic incentive to install energy efficiency measures.

By considering the 'policy function' and 'theories of change' columns it becomes clear that different policy types can deliver very similar interventions from the end user's point of view.. For example, energy efficiency obligations, grants and tax rebates all offer purchase subsidies to end users. While these policies may differ significantly in terms of total cost, public vs private cost, equity, or who delivers the policy, because the theoretical analysis concerns the effectiveness of the policy mix (see the following section), the end-user perspective is key. Thus the concept of a 'policy class' has been developed, based on both the policy function and theory of change columns, in order to help with the theoretical appraisal of policy mixes. Policy types which deliver the same type of intervention are assigned to the same policy class. The eleven policy types listed fit into six policy classes.

Table 1: Policy types and policy functions

Policy type	Policy function	Theory of change (for end user)	Behaviour type	Policy class
energy or CO2 taxes	To increase the price of energy or carbon-based energy in line with the polluter pays principle.	Response to economic incentives (dependent on elasticity of demand)	Purchase & Habitual	Taxation
Energy Efficiency Obligations	To reduce the price of energy efficient options (UK model)	Response to economic incentives	Purchase	Purchase subsidy
grants	To reduce the price of energy efficient options.	Response to economic incentives	Purchase	Purchase subsidy
tax rebates	To reduce the price of energy efficient options to tax payers.	Response to economic incentives	Purchase	Purchase subsidy
loans	To give people / organisations access to capital so they can buy energy efficient options	Lack of access to capital / high cost of capital as a barrier to investment	Purchase	Access to capital
on-bill finance	To give people / organisations access to capital so they can buy energy efficient options	Lack of access to capital / high cost of capital as a barrier to investment	Purchase	Access to capital
regulations	To set legally enforceable minimum standards of energy efficiency for products, vehicles & buildings.	Inefficient options no longer available.	Purchase	Minimum standards
voluntary agreements	To set minimum or fleet average standards of energy efficiency for products, vehicles & buildings.	Inefficient options no longer available.	Purchase	Minimum standards
standards and norms	To enable other efficiency policies to work.	n/a	Purchase	Underpinning measurement standards
energy labelling schemes	To enable individuals and organisations to take account of energy in their purchase decision-making.	Relevant information / advice provided at the right time can influence choices	Purchase	Information & feedback
information, advice, billing feedback, smart metering	To enable individuals and organisations to take account of energy in their purchase decision-making and/or habitual behaviours / practices.	Relevant information / advice provided at the right time can influence choices	Purchase and /or habitual (depends on instrument)	Information & feedback

4 Theoretical appraisal of policy mixes

4.1 Methods

To present a systematic assessment of the interactions between the eleven policy types identified, it has been necessary to simplify the analysis in two key ways:

1. Combinations of two policy types only are considered
2. Their interactions are analysed in terms of the net effect on energy savings.

Even just looking at pair-wise combinations, there are 55 policy combinations to consider. If all possible combinations of three policy types were considered, this would result in 160 combinations - too large a number to usefully report on. Given that in the real world, multiple policies are often combined, the current analysis is somewhat limited by focusing on bipartite policy mixes. However, the general principles being applied are also relevant for multi-instrument combinations.

The criterion against which policy combinations are judged is ‘effectiveness’, i.e. how much energy is saved in combination compared to what policies would deliver individually. The literature review suggests this may be the only assessment criterion for which there is much evidence (with, for example, an analysis based on cost-effectiveness being very difficult because the figures are often provided without the underlying assumptions such as energy savings and cost of delivery of the programme). Following Boonekamp (2006), the effects on energy savings of combined measures can be:

(i) Savings from combination of instrument 1, instrument 2 and instrument n < savings from all instruments individually (overlap)
(ii) Savings from combination of instrument 1, instrument 2 and instrument n > savings from both instruments individually (complementary)
(iii) Savings from combination of instrument 1, instrument 2 and instrument n = savings from both instruments individually (neutral)

In this analysis the policy instruments are assumed target the same sector and technologies at the same time (i.e. direct interactions as per Boonekamp’s (2006) classification). Boonekamp developed a logical framework for assessing instrument combinations in terms of net savings which he applied to a set of specific policies in the Netherlands. The current authors attempt to take this analysis to a more abstract level and provide general conclusions around the combinations of different types of policies rather than specific national policy instruments.

Using empirical evidence (alone) to measure the effectiveness of policy mixes is generally understood to be very problematic, given the lack of sufficiently good monitoring and evaluation of individual policies. Thus, these analyses have been made with reference to the literature, and using expert judgement from across the ENSPOL team, which includes experts from various EU Member States who have experience with energy efficiency policy mixes.

This matrix is in line with similar efforts carried out, for instance for the formulation of the Energy and Climate Policy Interactions Tool (Grafakos et al. 2010, Oikonomou et al. 2010, Oikonomou et al. 2012).

The literature (including Kosonen and Nicodeme 2009, Lee and Yik 2004, Sorrell et al. 2003, Gunningham and Sinclair 1999) suggests that combinations of policies fulfilling the same function (for the same technology and target group) are more likely to overlap than combinations which accomplish different functions. This is the approach followed here; policy types within the same policy class are generally assumed to overlap, with minor exceptions.

4.2 Results

The matrix in Table 2 provides a high-level overview of the potential interaction effects.

Table 2: Interaction effects of energy efficiency policy types

	energy or CO2 taxes	grants	loans	on-bill finance	tax rebates	Regulations	voluntary agreements	standards and norms	energy labelling schemes	information, advice, billing feedback, smart metering
Energy Efficiency Obligations	+	-	-	-	-	0	-	+	+	+
energy or CO2 taxes		+	+	+	+	+	+	+	+	+
Grants			-	-	-	0	0	+	+	+
Loans				-	-	0	0	+	+	+
on-bill finance					-	0	0	+	+	+
tax rebates						0	0	+	+	+
regulations							-	+	+	+
voluntary agreements								+	+	+
standards and norms									+	+
energy labelling schemes										+

+: complementary (savings from combination of policy A and policy B > than sum of savings policy A and policy B)

0: neutral (savings from combination of policy A and policy B > than sum of savings policy A and policy B)

-: overlapping (savings from combination of policy A and policy B < than sum of savings policy A and policy B)

The table shows that all policy types have positive interaction effects with some other policy types. It also shows that standards and norms, energy labelling schemes and information measures have a reinforcing impact on all other policy types. Combinations of policy types providing financial incentives (in the purchase subsidy or access to capital policy classes) are more problematic, and expected to overlap with each other.

A number of findings about particular combinations are highlighted below:

- Generally, energy and CO2 taxes are compatible with all other instruments as they increase the incentives for people and organisations to use financial incentives and implement regulations to reduce their energy consumption, and to adopt more efficient technologies.
- Combining purchase subsidies (Energy Efficiency Obligations, grants, tax rebates) with a provision of access to capital measures (loans, on-bill finance) for the same technologies is likely to deliver less savings compared to the sum of savings when those measures are used on their own. The same beneficiary can be over-paid for the same savings.
- Combining Energy Efficiency Obligations with additional financial incentives would not increase the savings beyond what would be delivered by the obligations on their own, as the policy design includes capped savings levels. Similarly, a combination with voluntary agreements targeting the same sector are unlikely to deliver additional savings beyond the targets. This assumes that the obligations levels are not influenced by the use of these other policies.
- Information and feedback policy types coupled with all other policy types, and other types in the same class, have reinforcing effects as they help facilitate effective implementation of all other instruments. This is because they influence decision-

making in a different way from other instruments, using psychological or behavioural economics mechanisms, rather than economic influences.
- Without standards and norms for measuring the efficiency of energy using equipment, buildings and building components most policy instruments would not be able to function. They are therefore not so much complementary as foundational for all policy instruments.

The analysis in Table 2 considers only policy combinations undertaken at the same time, where the single policy goal is to maximise energy savings. In reality, policy mixes are more complex than this: they must deliver multiple goals, which may include equity, providing an economic stimulus, and social cohesion.

Further reflections on these results, and their interaction with the empirical analysis which follows, are included in the discussion section below.

5 Appraisal of existing policy mixes for energy efficiency

The empirical part of this paper is based on information provided by EU Member States to the European Commission in order to comply with Article 7 of the Energy Efficiency Directive (2012/27/EU). The Energy Efficiency Directive was designed to bring the European Union back on track to achieve the 20% target and is one of key steps identified by the Communication on the Energy Efficiency Plan 2011 and the Roadmap to 2025. Previous analysis by the European Commission has shown that existing energy efficiency policy measures would not deliver the 20% target by 2020 and leave a significant gap of more than half of the required reduction (Hoos 2012).

Article 7 of the EED requires Member States to establish either energy efficiency obligations (EEOs) or alternative policy measures, to achieve new energy savings each year, over the 2014-2020 period, amounting to 1.5% of the baseline annual energy sales to final customers. The European Commission expects that Article 7 will deliver an impact of around 10.5% by 2020 (EC 2011). This equals more than half of the 20% target set by the EED. Therefore, it is the most important Article of the Directive in terms of its estimated impact.

The Member States had to notify to the Commission by 5 December 2013 their detailed plans to reach the energy savings target under Article 7. These plans included, *inter alia*, the policy measures that Member States plan to adopt and their implementation methodology. Further information on Member States' plans was provided in their National Energy Efficiency Action Plans (NEEAPs) which had to be provided by 30 April 2014. It is this information that was used to investigate policy instrument combinations in the 14 countries analysed.

5.1 Method

Data on policy mixes in selected EU Member States was obtained from national experts working within the ENSPOL project. The countries analysed were Austria, Belgium, Bulgaria, Denmark, Estonia, France, Germany, Greece, Italy, Netherlands, Poland, Spain, Sweden and the UK. For the 10 most important energy efficiency policy instruments (in terms of expected energy savings provided in the Article 7 notifications on the European Commission's website) each country expert provided information on:

- **Type of policy measure**: using the categories listed above.
- **Sub-sector**: With regard to buildings, differentiating between residential (i.e. domestic buildings) and service sector including public buildings (i.e. non-domestic), new or existing buildings, appliances, heating cooling, and ventilation measures.
- **Technology focus**: This element focuses on whether or not the policy instrument supports specific technologies (e.g. energy efficient windows) or energy efficiency improvements more broadly (e.g. grants for whole house retrofits only specifying the level of energy performance required).

- **New versus existing technology**: Distinguishing between new or replacement/upgrade of existing technologies.
- **Cost of supported technology**: Cost includes all cost involved (capital cost and ongoing cost if applicable) regardless of how the cost may be shared across different actors. The cost categories are relative and refer to how a specific energy efficiency technology / measure relates to other energy efficiency technologies / measures.
- **Complexity of supported technology**: The complexity of implementing the technology / measure supported (not the policy measure supporting it). A boiler replacement for example would not be very complex whereas a whole-house retrofit is deemed highly complex.

Data collection was completed using a matrix with drop-down menus to ensure a consistent approach. The data was then aggregated and analysed with the aim of identifying different policy mixes and instrument combinations (a full description of all policies per country used to meet Article 7 targets is available in ENSPOL publications (ENSPOL 2015a, 2015b)).

Policies adopted by countries to meet their Article 7 commitments, cannot include those which are already required by other EU regulations. So standards and norms, energy labels and regulations are under-represented in Article 7 notifications compared with their actual use in the full national policy mixes.

5.2 Results: Instrument choice

All 14 countries had a mix of policies, with the exception of Denmark, which reported all its savings would come from EEOs. Figures 1 and 2 show the most commonly used policy types in the residential (i.e. domestic) and non-residential (i.e. non-domestic) buildings sectors. These are very similar, with grants being most popular across both sectors. The main difference is the absence of voluntary agreements in the non-residential sector. In the residential sector by far the most common instrument is grants (33%) followed by regulations (17%), loans (16%) and EEOs (11%).

Figure 1: Most common policy instruments in the residential buildings sector

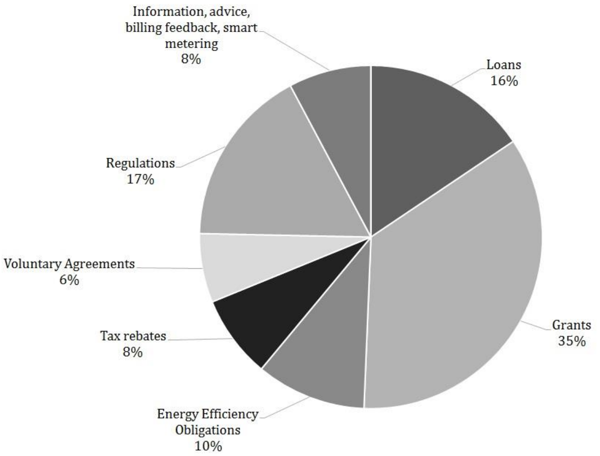
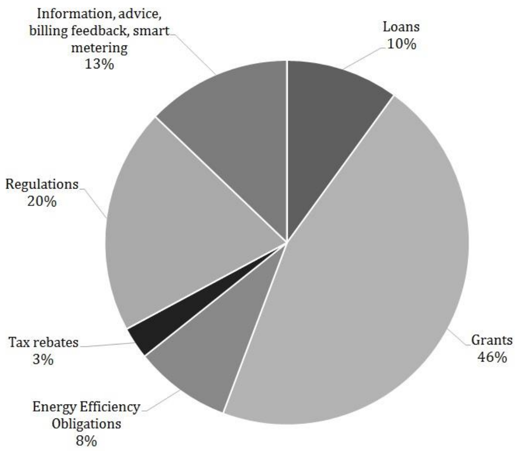


Figure 2: Most common policy instruments in the non-residential buildings sector



Standards and norms are almost non-existent, which reflects the fact that they are mandatory at EU level, and not part of national policies to meet Article 7.

5.3 Results: Policy type mixes

The next step of analysis is one level deeper. Interaction of policy instruments only happens in each sub-sector (e.g. retrofits of existing residential buildings or changes to the heating system). An analysis was therefore carried out of the frequency of policy instrument combinations in each subsector within the residential and non-residential sector. For presentation purposes the results are presented across all sub-sectors in Table 3 below. In order to derive the number of policy instrument combinations a model was used that allowed to investigate the database of policy measures created and to identify which countries combine specific instruments to target the same sub-sector (e.g. existing residential buildings). The figures in the table represent the number of combinations within one country and in the same subsector. By restricting the combinations to the same sub-sector it is possible to identify genuine combinations i.e. those mixes where policy interaction occurs.

The analysis of combinations shows the following:

- *Purchase subsidies*: There is a high frequency of purchase subsidies (provided through grants, loans, tax rebates and EEOs) combined with other policy instrument types and they are combined with all other instrument categories.
- *Voluntary agreements*: Many purchase subsidies are combined with voluntary agreements.
- *Regulations:* Regulations are combined with all other instrument types.
- Information measures: Those are combined with many other instruments and specifically with regulations.
- *Standards and norms and energy labelling schemes*: No combinations of those instruments with other policies were identified. This is because the Energy Efficiency Directive does not allow Member States to include policy measures which are non-additional as they are already a requirement under EU law.
- *Taxation*: Taxation measures are not combined with many other measures primarily because it is not used as much as other policy instrument types for compliance with Article 7 and because there are no taxes targeting specifically the energy consumption of buildings (most taxes are cross-cutting).
- *On-bill finance*: No combinations because on-bill finance is not used by many EU Member States on a large enough scale to be a 'top ten' policy.

Table 3: Combinations of policy instruments across the building sector (only if in the same sub-sector)

	grants	loans	tax rebates	regulations	voluntary agreements	information, advice, billing feedback, smart metering
energy efficiency obligations	4	4	1	1		1
grants		9	7	9	6	4
loans			2	7	6	
tax rebates				1	1	
regulations					2	6

6 Discussion

This paper has contributed to thinking on policy mixes by developing and applying a method for considering policy interactions in theory, and by gathering and analysing empirical data on policy mixes for building energy efficiency across the EU. To assist the theoretical analysis, the concept of 'policy class' has been developed. This was helpful to the authors in thinking through all 55 combinations systematically.

Given the simplifications made to undertake the theoretical analysis, particularly the need to look at one success criterion only, and to disregard many important contextual factors, it would be wrong to over-claim its usefulness. Factors not considered include context and calibration of individual policies, which are different in each country, and will affect energy savings as a single policy and in combination. Maximising effectiveness of a policy mix, misses out many other possible important policy goals – e.g. cost effectiveness or equity – and prioritising these might lead to quite different policy mix decisions. Nevertheless, this systematic analysis offers a clear way of thinking about policy combinations, and identifies areas of potential under-performance. It provides a foundation for further, more detailed analysis.

Building on the existing literature, definitions for three possible interactions between policies - complementary, neutral, and overlapping - have been developed. These have been used to analyse all possible two-way interactions between policy instruments. This analysis has showed which combinations are likely to increase policy effectiveness, decrease it or be neutral. All other things being equal, decisions makers should favour policies which are complementary, and try to avoid those which overlap. A number of policies appear always to interact in a complementary way with others – energy or CO_2 taxation, standards and norms, and those in the information and feedback class. There is a relatively small number of policy instruments combinations which can deliver less than the sum of their parts – and these are largely feature policy types from the purchase subsidy and access to capital classes – policies largely under control of national governments, and which feature heavily in their Article 7 compliance plans.

The universally complementary policies, with the exception of taxation, are in many cases already in place at an EU level for energy-using products, buildings and building components. This includes energy labelling schemes, a requirement to introduce smart meters, and test standards and procedures (which may be international, rather than just EU-level). Their usefulness has been recognized by policy makers. The policies which tend to be neutral in their interactions, regulations and voluntary agreements, also have a strong place in EU as well as national level policy. Where these policies are missing for sectors or sub-sectors, their introduction should be considered.

While theoretical analysis suggests carbon or energy taxation would be complementary with all other policy types, countries take very different views on taxation of energy of different types and across different sectors (Eurostat 2015). Some countries have high rates of taxation, while others are as low as EU legislation allows. Theoretically useful policies can be politically unacceptable (e.g. the history of public opposition to household energy taxation in the UK (Dresner, Jackson et al 2006)), or not fit with other policy goals. This illustrates one weakness of this method, which is that it can only consider the effect of a policy mix on a single goal (effectiveness), whereas policy is usually required to deliver multiple goals simultaneously.

The empirical analysis shows that nation states rely strongly on policies in purchase subsidy and access to capital classes to deliver their Article 7 commitments. This is in part a reflection of the rules surrounding Article 7 (as explained earlier). Given that theory tells us these combinations are at risk of overlapping, a more detailed examination of policy mix design could be helpful to nation states in enabling them to deliver their targets. With the exception of Denmark, all have chosen a policy mix, and it would be essential to understand the extent to which their policy mixes are designed to meet multiple goals.

One potential explanation for the use of energy efficiency obligations with potentially overlapping instruments such as grants, finance mechanisms and voluntary agreements is that the scale of obligations may be dependent on the existence of other mechanisms. There is clearly overlap if other mechanisms simply help obligated parties deliver their obligations. However, in most cases the obligations will be the outcome of a policy negotiation with other key actors. If the scale of obligation can be increased by the use of other mechanisms in parallel, it may be more effective to have a combination. The extent to which this explains specific policy mixes in individual countries can only be determined by detailed case studies.

In addition, the scope of Article 7 is largely limited to policy instruments at the national level (although some Member States have notified policy instruments at the regional level as well) and not all national policies are notified. At the regional and local governance level often a range of policy mixes are employed and combined with national policies (Van der Heijden 2014). This means that other studies focusing on areas outside of the scope of Article 7 are likely to find different policy mixes and effects.

Using the theoretical approach here, it is difficult to explicitly analyse combinations of more than two policy types for all combinations given the way in which the numbers escalate for combinations of three or more. However, there are ways to usefully expand the analysis. Firstly, using the policy class concept, the analysis could extend to a mix of four or five policy instruments, provided they originate from just two policy classes. Alternatively, expanding on the empirical analysis in Table 3, key combinations of more than two policies could be identified, and theoretical insights brought to bear on these mixes. The focus could be on mixes at risk of overlap, to help identify risks of under-achieving savings targets.

7 Conclusions

This paper has contributed to an emerging debate around the role of the policy mix within innovation studies and the energy efficiency literature. Whilst the theoretical conceptualisation of the policy mix has recently advanced there are still few empirical studies accessing policy mixes within specific policy domains. This paper fills that gap for energy efficiency policy in buildings. Developing a method based on the literature, combined with expert judgement, 55 different combinations of policy instrument types have been assessed for their effectiveness. Combinations which deliver more, less and the same as the sum of individual policies have been identified. This analysis was based on the concept of effectiveness, which is of key importance in policy making. However, theoretical analysis necessarily has to simplify reality, and is unable to incorporate the full complexity of multiple goals and contextual factors which affect national policy mixes.

In addition, empirical data has been gathered and used to describe and analyse the policy mixes in 14 EU Member States. Reflections on how reality matches the policy combinations theoretical analysis suggests were presented. The current buildings energy efficiency policy mixes are dominated by combinations of purchasing subsidies providing a financial incentive to end-users to adopt more energy efficient technologies. Theoretical analysis suggests that combining such instruments focusing on the same segment is likely to deliver less savings than using them individually.

Future research should analyse why certain policy instrument combinations are particularly prevalent and what the political dynamics behind adopting those are, especially where the combinations adopted appear to have potential overlaps. Furthermore, research on the precise calibration of blends of purchasing subsidies in different countries is needed to better understand under which conditions such combinations are effective and why they may (or may not) be desirable even though theoretically one would expect this is not necessarily to be the case. An important issue for energy efficiency policy for buildings will also be the inclusion of the operation phase to ensure the potential energy savings from an interventions (e.g. a technological change) are realised in practice and maintained over the long term. Finally, the increasing Europeanisation of energy efficiency policy and its effect on the policy mix in EU Member States constitutes a promising avenue for future research.

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