EU energy innovation policy: The curious case of energy efficiency

Jan Rosenow [a b], Florian Kern [b]

a: Centre on Innovation and Energy Demand, SPRU, University of Sussex,

b: Environmental Change Institute, University of Oxford

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1 Introduction

Technology and innovation is key to addressing a variety of European policy ambitions. Especially in the context of the economic recession after the financial crisis in 2007-8 and the austerity policies pursued in many European member states, the EU developed a 'Innovation Union' strategy which forms part of the Europe 2020 strategy that aims to create smart, sustainable and inclusive growth (EC 2013). In this chapter we focus on EU energy technology and innovation policy. In the past, EU energy technology and innovation policy was primarily concerned with energy supply technologies, energy market liberalisation and single market integration. A good example of this approach is the European Strategic Energy Technology Plan (SET-Plan) adopted in 2008. None of the ten European Industrial Initiatives mentions energy demand explicitly; the only initiative dealing with some aspects of energy demand is the Smart Cities and Communities Initiative. After criticism for example by the International Energy Agency (IEA 2008) attempts have been made to increase focus on energy efficiency within the SET-Plan but it still does not constitute a separate European Industrial Initiative. Similarly, not a single subject area of the 38 European Technology Platforms, which are industry-led stakeholder fora recognised by the European Commission for developing innovation agendas and roadmaps, deals with energy demand explicitly. Instead, the focus is on different energy supply technologies, smart grids and carbon capture and storage.

However, more recently, energy efficiency has become an increasingly important area of EU energy policy. The Europeanisation of energy efficiency policy (and energy policy more generally) accelerated after the 2007 Lisbon Treaty when energy policy was first formally recognised as a major competence of the EU (Solorio 2011). Prior to 2007 energy policy was largely a matter for policy at the national level, a result of it being seen as a high-priority national policy area given the energy security implications (Tews 2015).

There are two underlying concerns that stand out as the key drivers for this shift in emphasis: The first is energy security. The EU is a major energy importer, relying on non-EU sources for more than half of its primary energy in 2013 (Eurostat 2015). There are specific concerns where there is reliance on regions viewed as geopolitically problematic. These concerns focussed initially on oil in the wake of the crises in the 1970s (Hedenus et al. 2010), but are now extended to gas, particularly since the Russia-Ukraine transit disputes of the last decade (Stern 2006, Yafimava 2011). There was a recognition amongst member states that energy security challenges should be increasingly dealt with at the European level (Szulecki et al 2016). The rise in concern about climate change provides a second driver for action on energy efficiency, especially in the context of the global leadership role to which the EU has aspired since the negotiation of the Kyoto Protocol in 1997. Energy efficiency has been the only significant driver of greenhouse gas emissions reductions in the first decade of this century (Edenhofer et al. 2014) and now plays a key role in EU climate policy (Delbeke and Vis 2015). These multiple benefits of energy efficiency explain why it is one of the pillars of EU energy policy. There is also increasing interest in a whole suite of possible benefits from energy efficiency, from macro-economic effects, air quality and health improvements to delivering jobs (IEA 2014).

As a result, energy efficiency is one of the three key pillars identified in the EU 20-20-20 Strategy - a 20% reduction of projected primary energy consumption by 2020 (EC 2015a). The 2030 climate and energy framework, agreed in 2014, also features an 27% energy efficiency target, although not binding at this stage. The European Parliament called for a binding 40% energy efficiency target and it is likely that the 27% target will be revised upwards.

The Energy Efficiency Directive (EED) establishes a framework of measures to ensure the achievement of this target (EP 2012). Previous EU policies seek either to set common frameworks for energy efficiency policy in Member States, e.g. the Energy Performance of Buildings Directive (EPBD) and the Energy Services Directive (ESD), or to use EU competencies in trade policy to establish common labels and standards, e.g. through the Ecodesign Directive. Together these have increasingly influenced national energy efficiency policies of EU Member States.

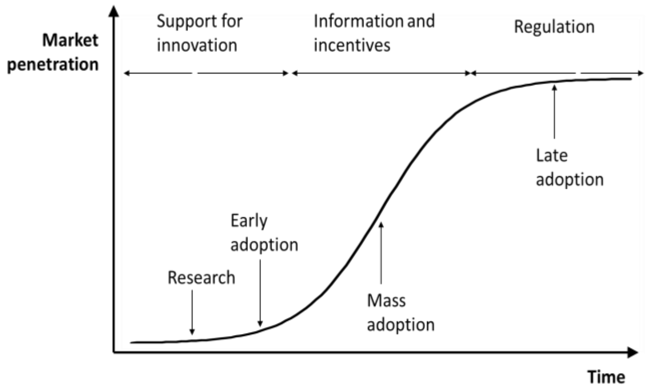
Even though both the ambition and number of EU policies has been increasing significantly, academic analysis of the role of such EU policies for innovation and deployment of energy efficiency technologies is scarce. In this chapter, we critically discuss the ways in which EU energy efficiency policy is driving innovation and technology deployment on the basis of a review of the existing literature on the issue. First, using the structure of market transformation theory, a common framework used to classify different policy instrument types, we position the various EU policy instruments in energy technology and innovation policy along the different stages of market transformation. We then identify key research challenges going forward, including (1) the role of EU energy efficiency policy within a multi-level governance structure, (2) the institutionalisation of EU energy efficiency policy, (3) the need for more comprehensive policy evaluations, (4) the importance of better understanding real world policy mixes, and (5) the potential for applying a socio-technical approach to energy efficiency in the EU. We conclude that the lack of an explicit innovation strategy for energy demand constitutes a barrier to achieving the energy efficiency targets going forward. Furthermore, the conventional understanding of market transformation is unlikely to allow for the transition at the scale and speed required to make a significant contribution to mitigating climate change.

2 Technology innovation and EU energy efficiency policy

EU technology and innovation policy generally is concerned both with the development of new and the deployment of existing energy technologies. The same is the case for energy efficiency, although as stated in the introduction the historic focus has been on energy supply technologies. In order to achieve those two goals a set of policies has been implemented which target the various stages from research and development through to mass market deployment.

The most prominent theoretical framework to understand the role of public policy in the process of energy efficiency technology innovation has been developed by market transformation scholars (Blumstein et al. 2000; Geller and Nadel 1994). Geller and Nadel describe the types of policy instruments used sequentially following the S-shaped logistic diffusion curve. They conclude that four types of policies and programmes are typically used to achieve a higher take-up of energy efficient technologies: (1) R&D to develop new energy-efficiency measures, (2) market-pull or bulk purchase programs to facilitate commercialization, (3) financial incentives to stimulate early adopters, and (4) efficiency codes and standards to eliminate inefficient technologies and practices (Figure 1). This framework emphasises the fact that successful innovation requires much more than inventing new technologies (e.g. through R&D) and that diffusion processes can be quite protracted and often need further support.

Figure 1: Market transformation as innovation and appropriate policy support



Source: Rosenow et al. (2015)

Based on the market transformation approach outlined above, we analyse the existing EU energy efficiency policies along the four market transformation stages by policy type and outline their respective impact on innovation and energy efficiency technologies. We argue that this conventional model of innovation is useful for understanding the challenges involved in upscaling energy efficiency and has informed much of EU and national policy thinking so far.

In section 3 we discuss the extent to which the market transformation approach is sufficient for understanding and informing EU energy efficiency or whether a more comprehensive transition framework is required.

2.1 R&D policies

The main rationale for R&D policies is that markets tends to underinvest in R&D due to knowledge spillovers. Therefore, public R&D spending is required to close this gap.

R&D both of new energy efficient technologies but also policy instruments and strategies is funded by the EU's Horizon 2020 programme. €198m was made available for Horizon 2020 in the energy efficiency call 2014-15, and €194m for the period 2016-17. This represents an average €98m per year over four years. In comparison, the predecessor of Horizon 2020, the 7th Framework Programme (FP7), contributed only €280m for 2007-13, i.e. €40m per year on average to R&D for energy efficiency (EC 2016a). In total, the EU spends more than €1.3bn on energy-related research and innovation projects through Horizon 2020 over the period 2016-2017. Hence energy efficiency now receives a significant but still relatively modest share (15%) of all energy-related research funding (EC 2016b).

The Horizon 2020 Energy Efficiency call 2016-2017 provides support for innovation through:

a) research and demonstration of more energy-efficient technologies and solutions; and
b) market uptake measures to remove market and governance barriers by addressing financing, regulations and the improvement of skills and knowledge.

The programme focuses on six areas including 1) consumers, 2) buildings, 3) public authorities, 4) industry, products & services, 5) heating & cooling, and 6) innovative financing. A particular emphasis lies on multi-disciplinary projects integrating the social sciences and humanities. Compared to its predecessor, the 7th Framework Programme, Horizon 2020 appears to be moving towards covering the whole innovation cycle moving away from the linear innovation model acknowledging the feedback effects between the different parts of the innovation cycle. However, there are concerns that much of this shift is rhetorical rather than substantive (Young 2015). There are also concerns that within the Horizon 2020 energy efficiency programme, the dominant techno-economic conceptualisation of energy consumers could hinder long-term low-carbon aspirations and undervalue social science and humanity perspectives (Foulds and Haunstrup Christensen 2016).

2.2 Information policies

The rationale for introducing information policies is that the lack of information (or awareness) inhibits the diffusion of more energy efficient technologies. Hence the role for policy is to address this market failure, e.g. through initiatives like labelling schemes.

2.2.1 EU Energy Label

The most prominent information policy within the area of energy efficiency is the EU Energy Label which was first introduced through the EU Energy Labelling Directive (92/75/EC) in 1992 and later amended in a recast of the Directive (2010/30/EU) in 2010. The Directive requires manufacturers to label certain types of appliances (e.g. washing machines, refrigerators and cooking appliances) to provide consumers with information on the energy efficiency of the products available on the market. The innovation impact of the label is twofold: a) the label aims to encourage consumers to purchase more energy efficiency goods already on the market (upscaling existing technologies) and b) the label incentivises manufacturers of labelled goods to increase the energy performance in order to get a better label than competing products.

A recent evaluation of the EU Energy Label (Molenbroek et al. 2014) concluded that the EU Energy Label has an important role for innovation although it is difficult to quantify and attribute those impacts. The study also found that the EU Energy Label has had an impact on international product policy and markets, being widely emulated in other countries. The level of emulation can vary from simple adaptation of the label visuals, through to direct and literal replication of requirements.

The EU Energy Label is an excellent example for illustrating that policies need to be flexible to continue to support innovation. Research has shown that the extension of the seven point A–G rating scale by adding new classes A+, A++ and A+++ leads to lower perceived importance of energy efficiency when making purchasing decisions (Heinzle and Wüstenhagen 2012) and in turn impacts negatively on the efficacy of the EU Energy Label. As a result of similar arguments, on 15 July 2015, the European Commission proposed a revision of the EU Energy Labelling Directive that includes a return to a closed A to G scale (EC 2015b). At the time of writing the proposal had not been passed through the European Parliament yet but it can be expected that the scale will be amended.

2.2.2 Energy Performance Certificates

The Energy Performance of Buildings Directive (EPBD) recast (2010/31/EC) requires Member States to establish energy performance certificates (EPCs) for buildings that are sold or let. EPCs need to be included in all advertisements in commercial media when a building is put up for sale or rent. The EPC must also be presented to prospective tenants or buyers and handed over to them upon completion of a deal. EPCs contain an energy performance rating of the building and recommendations for cost-effective improvements.

In theory, this will enable the buyer or tenant to make more informed decisions and take the energy performance of the building (and thus its running costs) into account when deciding for or against a specific building. In turn, this should increase the value of a property that is more energy efficient compared to one that is less efficient. Empirical evidence suggests that this is a valid assumption to make (Fuerst et al. 2015).

The impact on innovation of EPCs is that they encourage building owners to invest in energy efficiency in order to achieve a higher sales price or rental value.

2.3 Financial incentives

The logic of providing financial incentives for the roll out of socially beneficial technologies is that they may not be competitive with conventional technologies and incur higher upfront capital cost but have societal benefits which justifies policy intervention.

There is no explicit financing mechanism for energy efficiency deployment at the European level at the moment, although this is being considered as one of the options going forward. Instead, funding for energy efficiency technologies is provided through two principal mechanisms. Most funding is provided at the Member State level and this is used by Member States to comply with the Energy Efficiency Directive (EED) and in particular Article 7 of the EED. Secondly, the EU Structural Funds provide funding to a wide range of areas including an increasing share for energy efficiency.

2.3.1 Energy Efficiency Directive

The EED (2012/27/EU) was designed to bring the European Union back on track to achieve the 20% energy consumption reduction 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 (EC 2011b).

The Energy Efficiency Directive puts in place a number of important provisions to be implemented by Member States including the requirement to establish binding national energy efficiency targets (Article 3), national building energy efficiency strategies (Article 4), a requirement to renovate 3% of public sector buildings each year (Articles 5 and 6), the need to establish energy efficiency obligation schemes (Article 7), and provisions for auditing and metering (Articles 8-12). The most important Article of the Directive (Article 7) requires Member States to implement Energy Efficiency Obligations and/or alternative policy instruments in order to reach a reduction in final energy use of 1.5% per year (EP 2012). Article 7 is expected to deliver more than half of the required energy savings of the 20% reduction target and is therefore the most important component of the EED in terms of its contribution (EC 2011a).

Analysis of the response from Member States to Article 7 (Rosenow et al. 2016a) shows that the largest number of policy instruments can be found in the category ‘financing schemes or fiscal incentives’ such as tax rebates (e.g. crédit d'impot développement durable in France or loans schemes (e.g. the KfW programmes in Germany). Together with Energy Efficiency Obligations they provide the lion share of the expected savings notified to the Commission.

2.3.2 Cohesion Policy

The EU’s Cohesion Policy provides an investment framework for energy efficiency, supporting the EU Energy Policy and targets, through the European Regional Development Fund (ERDF) and the Cohesion Fund (CF). These two funds represent the largest sources of EU financial support for energy efficiency. The ERDF aims to reinforce economic, social and territorial cohesion in the EU by redressing the main imbalances across EU regions through support for the sustainable development and structural adjustment of regional economies. The CF, which targets Member States whose Gross National Income per inhabitant is less than 90% of the Community average, aims to strengthen economic, social and territorial cohesion of the EU in the interests of promoting sustainable development, and invests in the environment, including sustainable energy.

In the 2007-2013 programming period, energy efficiency allocations from the two funds amounted to around €6 billion, which is around 2% of the total funds of €347 billion. Originally, energy efficiency investments were allowed in public and commercial buildings. For housing, up to 2008 ERDF investment was restricted to particularly distressed areas of the EU12 (Ramboll and IEEP 2015).

For the 2014-2020 period, a total of €23 billion (4% of the total funds) will be available for the low carbon economy, a significant increase from the 2007-2013 period. Under the ERDF, a minimum percentage of funding will be directed to the shift towards a low-carbon economy in all sectors: 20%

in the case of more developed regions, 15% for transition regions and 12% for less developed regions (ICF et al. 2014). As a result, a greater amount of funding will be available for the energy renovation of buildings, as compared with the period 2007-2013, although the exact share is not guaranteed.

2.4 Regulation

The role of regulation is normally implement certain technologies which are socially beneficial but would otherwise not be deployed widely even if financial incentives were offered. Regulation is often seen as ultima ratio if other policy measures do not deliver.

2.4.1 Energy Performance in Buildings Directive

Within the buildings sector, the Energy Performance of Buildings Directive (EPBD) (2002/91/EC) and the subsequent recast (2010/31/EC) is the most important piece of legislation at EU level delivering minimum energy efficiency standards for buildings. The EPBD is not setting EU-wide standards (unlike the Ecodesign Directive) because of the diversity of building types, climate and construction techniques across the EU. Instead, it requires EU Member States to set their own national building standards through calculating cost-optimal minimum energy performance requirements for new as well as renovated buildings. There are, however, concerns as to whether the requirements are met in reality due to the performance gap between theoretically expected and actually realised energy performance (Burman et al. 2014).

The EPBD is particularly important for the construction of new buildings as existing buildings are only subject to minimum standards in case of major renovations. All buildings that are constructed need to comply with the energy performance requirements in the national building codes, although there are clearly issues around enforcement.

In terms of innovation, the EPBD results in increasingly ambitious building codes forcing the construction industry to build more energy efficient buildings over time and banning construction types that are less efficient than the minimum requirements. In that sense building regulations can be seen as a key ingredient to policy strategies aimed at 'creative destruction' (Kivimaa and Kern 2016). Kivimaa and Kern argue that transformative change for example in building energy efficiency can only be achieved through a mix of instruments which support innovation (creation) as well as instruments which undermine currently dominant high energy practices (destruction).

2.4.2 Ecodesign Directive

In order to increase the energy efficiency of products the Ecodesign Directive (2009/125/EC) establishes a framework to set mandatory energy performance requirements for energy-using and energy-related products. The Directive covers more than 47 product groups (such as heating systems, lightbulbs, white and brown goods, motors etc.) and the minimum standards are constantly being reviewed and amended as the market average in terms of energy efficiency improves over time. Through setting minimum standards, the Directive forces manufacturers to design their products in a more energy efficient way than they might do otherwise. The Ecodesign Directive is a framework directive and does not set the product standards directly. Instead, the standards are established through the so-called comitology procedure and implementing measures involving studies, impact assessments and consultations with stakeholders.

In some instances, the application of the Directive has led to an outright ban of certain products which is the strongest form of undermining the status quo (Kivimaa and Kern 2016). The most prominent example of this is probably the ban of incandescent lamps, for which a gradual phase-out started in the EU in 2009 (Commission Regulation (EC) No 244/2009), a move that was controversial and has sparked much public debate (Howarth and Rosenow 2014). However, it can be argued that such strong measures will be required to achieve the needed energy efficiency revolution.

2.5 Summary

[I think it would be nice to summarise this section here by pointing to some of the concerns and briefly reflecting why this state of the art is not sufficient to achieve the desired increase in EE, something along the lines of:]

Based on our discussion of existing EU energy efficiency policies along the four market transformation stages, we conclude that there are a number of issues [please spell out and add if you agree]: too little direct financing for EE investment, no real EE focused technology platforms, but increase in research funding for EE in H2020 from very low to modest share; implementation challenges remain (but are often with member states, e.g. building standards);

Besides these specific problems with the state of the art of EU energy efficiency innovation policy, there are also some reasons to suggest that the framing of the challenge through the market transformation perspective is too narrow which will be discussed in more detail in section 3.5. The next section will discuss a number of key research challenges for work on EU energy efficiency innovation policy.

3 Key research challenges

Drawing on the above, the list of research challenges and needs is long and in this chapter we cannot possibly discuss them all. Instead, we identify what we see as five key challenges going forward. First, the interaction of EU and national policies for innovation within the energy efficiency area is poorly understood. EU policies are often introduced with a view that Member States will translate those effectively into national law and the evidence suggests that the intent of EU policies often does not materialise in the actual implementation of related policies at the national and regional level. Second, there are important questions that need to be answered around the institutional set up of European innovation policies and what this means for energy efficiency in particular. For example, the lack of innovation platforms for energy efficiency raises the question of whether other (supply-side) technologies are advantaged and what this means for innovation and energy efficiency. Third, many of the policies driving innovation through upscaling deployment are currently poorly evaluated which results in a lack of understanding of what those policies deliver in terms of energy savings but also technology innovation. Fourth, there is an increasing policy heterogeneity across the EU Member States with often multiple policies focusing on achieving the same outcome. Our understanding of the impacts of such policy mixes on innovation is only starting to emerge and few studies have analysed the role of policy mixes within energy efficiency policy. Finally, research on socio-technical transitions suggests that conventional models of market transformation and the role of public policy may be too limited in being able to capture the multifaceted nature of transitions and innovation of the scale and pace required. In the following, we discuss each of those issues in turn.

3.1 Multi-level governance

One key research challenge is the multi-layered nature of EU policy making with regard to innovation and energy demand reduction technologies. While the European institutions set the policy framework (for example in the shape of directives or funding frameworks), innovation policy is often implemented at the national, regional or even local level. Each Member State faces different starting conditions and a different set of opportunities for innovation, influenced by history, geography, the institutional set up, the nature of the current stock of technologies, infrastructures, available fuels and energy conversion technologies and different cultural expectations and practices relating to energy use. However, the range of technologies and techniques available to deliver energy savings are largely common across the EU. Member States and other policy actors face a choice of policies and policy mixes to try and foster low-carbon innovation including energy efficiency (Rosenow et al. 2016b).

In order to meet their energy efficiency targets, many Member States are introducing additional policies into an often already crowded policy space (ENSPOL 2015a, 2015b) which has emerged over time in different ways in each Member State due to the lack of a clear European energy policy prior to 2007 (Tews 2015). This process results in an increasing policy heterogeneity in the energy efficiency area (Constantini et al. 2015). Some scholars (Tews 2015) have argued that the different national responses to EU policy result in 'laboratories of innovation' for policy instruments and outcomes.

Furthermore, 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).

Analysis by Tews (2015) shows that the multi-level governance approach of the European Union creates tensions between the degree to which European policy sets targets and rules applicable to all Member States and the extent of decentralizing policy decisions in line with the subsidiarity principle. Tews uses the example of renewable energy policy to illustrate this point - the European Commission favoured a quantity-based quota system for renewable energy whereas most Member States preferred priced-based economic instruments such as feed-in tariffs. This is also the case for energy efficiency policy. Attempts by the European Commission to harmonize energy efficiency policy through requiring all Member States to use energy efficiency obligations, utility-funded energy efficiency programmes, failed and after intense negotiations the Energy Efficiency Directive allowed Member States to also use alternative policy measures if they could show that similar levels of savings would be reached.

Future research should investigate further how EU energy efficiency policies are being implemented at the national level and beyond, but also the extent to which national implementation and policy making affects EU policy (for example 'uploading' of specific policy instruments to the European policy agenda) (Tosun et al 2015).

3.2 Institutionalisation of European energy efficiency policy

In the introduction of this paper we used the example of the European Strategic Energy Technology Plan (SET-Plan) and the European Technology Platforms to illustrate that energy efficiency does not receive the same amount of attention as supply-side technologies when it comes to EU technology innovation policy.

At the same time, energy consumers are increasingly recognized, not just as passive "load" on energy grids, but as potentially active partners, responders, or "prosumers" in energy service networks (Parag and Sovacool 2016). Commercial buildings, homes, and industrial facilities can play an important role in reducing energy consumption, and energy peak demands, thus reducing the volume of investments needed in generation, transmission and distribution infrastructure. But decisions relating to energy infrastructure have traditionally been made – and continue to be made – without consideration of the potential for lower-cost demand-side alternatives. They are also predominantly made at the member state level.

Future research should investigate a) both the underlying factors that led to the current institutional setting in which energy efficiency is structurally receiving less attention and support than other energy technologies and b) potential approaches to advance the status quo in such a way that energy efficiency innovation is put on a level playing field with supply-side options.

Recently, the concept of 'Energy Efficiency First' or 'Efficiency First' has found its way into the Energy Union Communication in February 2015 (EC 2015c). It has been invoked in statements by Vice-President Sefcovic and Commissioner Cañete, and recognized as an important principle in the Communication on new market design (EC 2015d).

Future research should analyse to what extent a principle such as Efficiency First could be integrated into the decisions governing investment in energy infrastructure and technology innovation. This requires identification of the many points at which these decisions are made, and of the actors involved. For example, investments relating to electricity and gas transmission and distribution infrastructure are made by energy companies and overseen by national regulatory authorities. The criteria for approving these projects are found in national legislation and European directives and regulations. Cross-border infrastructure projects will include a broader list of actors, including ACER, ENTSO-E and ENTSO-G.

3.3 Policy evaluation

Despite the rising influence of European legislation on national energy efficiency policy, the literature evaluating energy efficiency policy at the EU level is rather scarce. A recent systematic review of peer-reviewed energy efficiency programme ex-post evaluations (Wade and Eyre 2015) identified only four studies analysing the effectiveness of EU energy efficiency policies (Bertoldi et al. 2001; Saussay et al. 2012; Schiellerup 2001; SRC 2001). All of the other 67 papers found by Wade and Eyre deal with the evaluation of national energy efficiency policies. There are some studies that undertake pan-European analyses. For example, Filippini et al. (2014) carried out an econometric analysis of the level of energy efficiency across EU Member States and the impact of energy efficiency policies. However, they did not explicitly evaluate the impact of specific EU policies but instead focussed on the role of national policies adopted, some of which are driven by EU initiatives. With regard to ex-ante evaluations, we are not aware of any peer-reviewed papers carrying out ex-ante evaluations of EU energy efficiency policies – the available ex-ante evaluations of EU energy efficiency policy are all located in the grey literature (see for example the DG Energy website section ‘studies’). The lack of both ex ante and ex post evaluations of European energy efficiency policy is an important gap which future research should address in order to be able to provide advice to EU policy makers.

Future research should also analyse the national practices around evaluation with a view to understand how approaches to evaluation differ across the EU and what causes the differences regarding methodologies and robustness. Furthermore, it would be an interesting to know whether particular evaluation practices are more successful in contributing to the development of more effective innovation policies for energy efficiency, and how EU energy efficiency policy can be evaluated in a meaningful way given the heterogeneity of evaluation traditions in Member States and the need to rely on national evaluations in order to carry out European policies that are implemented at the national level.

3.4 Policy mixes

So far, the majority of studies looking at the role of EU policy for innovation and energy efficiency have focused on single policy instruments and their role for achieving a greater uptake of energy efficient technologies. In reality, the EU itself and also most EU Member States employ a set of different policies aimed at innovation rather than just one single instrument. Policy mixes can be understood as “complex arrangements of multiple goals and means which, in many cases, have developed incrementally over many years” (Kern and Howlett 2009: 395). Recently, a number of studies have developed thinking on interactions between policy instruments aimed at innovation within a given jurisdiction. Recent work by the OECD (2010) for example emphasizes coherence and appropriateness of the policy mix. An extensive literature review by Rogge and Reichardt (2016) 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 developed 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.

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 (e.g. del Rio 2014; Sorrell and Sijm 2003) and, to a lesser extent, energy efficiency (Kern et al, accepted; Rosenow et al 2015). However, even within this policy domain, papers analysing the policy mix rather than individual instruments are very scarce. When analysing policy mixes, the focus so far has often been rather narrowly on the interactions of instruments. Rogge and Reichardt have already argued that research on policy mixes should not be confined to studying interactions between instruments, but also include attention to policy processes, characteristics of mixes (such as coherence or synergies) as well as elements of policy mixes (including policy strategies). There is also useful research within policy sciences on the processes through which policy mixes evolve which is considered important for their effects (Howlett and Rayner 2007; Kern and Howlett 2009).

Future research should investigate the role of the policy mix for innovation within the energy efficiency space as this becomes increasingly important given the diversity of national approaches to delivering EU energy savings goals. Practitioners increasingly observe that often a combination of policies is needed to achieve the same result more quickly and/or effectively which goes beyond earlier simplistic policy recommendations in the form of single optimal policy instruments. It is also true that increasingly national energy efficiency policy mixes become very complicated with many instruments (see Kern et al (accepted) for an analysis of UK and Finish energy efficiency policy mixes) but also many changes over time which needs to be studied systematically in order to assess potential effects of such policy mixes on innovation processes.

3.5 Socio-technical transitions: beyond bevaviour and technologies

The market transformation approach discussed in section 2 has informed much of EU and member state thinking on energy efficiency innovation policy design. However, the underlying linear pipeline thinking about innovation has long been discredited in the innovation studies literature. In contrast, a more sophisticated model sees innovation as arising from an innovation system, defined as a "network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman 1987, p. 1). This model highlights the interactions and feedback loops between the different phases of R&D, development, demonstration, market formation and diffusion and suggests that innovation processes are much less linear than suggested by the conventional model. Innovation is viewed as a collective activity involving many actors and knowledge feedbacks and strongly influenced by institutional settings (Gallagher et al. 2012).

Building on this understanding of innovation, over the last decade or so a field of research has emerged in which scholars are trying to understand the transformation of existing socio-technical regimes towards more sustainable configurations (Geels 2002, 2011; Smith et al. 2010; Markard et al. 2012). Much of the research has focused on the transition away from high carbon energy systems. The research on socio-technical transitions suggests that conventional models of market transformation and the envisaged role of public policy may be too limited in being able to capture the multifaceted nature of transitions and innovation at the scale and pace required. One of the most important insights of this literature of relevance to this chapter is that technological artefacts (such as consumer electronics) are embedded within wider socio-technical regimes which also involve user practices, markets, symbolic meanings, existing infrastructures (e.g. the electricity grid), regulatory frameworks like building regulations or electricity market rules, industrial structures, as well as knowledge. The alignment of these different components is very strong and arises over time through a process of co-evolution which makes it very difficult to change the trajectory of development (Geels 2002). While incremental progress in energy efficiency is certainly possible and useful, our argument is that in order to fulfil EU energy and climate change targets a transformation of current systems of energy demand and use is required.

Seen from a transitions perspective, one of the shortcomings of the current EU approach to energy efficiency has been the dominant techno-economic paradigm underlying EU funding programmes. A recent commentary in Nature Energy argues: "The 2016–2017 Energy WP is thus replete with technological deterministic assumptions, whether they are about the linear uptake, interpretation and use of technologies, or about intentionally overlooking consumers as part of going straight to technologies to solve our energy challenges" (Foulds and Haunstrup Christensen 2016, p. 3). This is problematic as "At best, the techno-economic paradigm confuses our understanding of the actual dynamics behind energy consumption and energy saving; at worst, it produces inefficient and impractical solutions" (ibid). From a socio-technical perspective the focus on either developing technological solutions ignoring consumers or trying to educate consumer about beneficial behavioral changes is too simplistic. Instead research needs to focus on how current energy systems have evolved in a way which emphasizes the alignment and co-evolution between policies, market structures, infrastructures, technologies, culture, etc. Seen from a sociotechnical perspective, innovation is understood as a social process with complex interactions between multiple actors (firms, researchers, policymakers, consumers) who develop strategies, make investments, learn, open up new markets, and develop new routines. Innovation also spans both supply and demand and entails active contributions from consumers that go beyond the purchase and adoption of new technologies (Geels et al 2015).

Much research on transitions focuses on explaining through which kinds of mechanisms radical change in such configurations occur (e.g. Geels and Schot 2007). The second main insight of this research of relevance to this chapter is that transitions can be understood to happen as a consequence of developments across three analytical levels: the niche level where new technologies, business models or practice emerge, the regime level which contains the currently dominant configurations to meet energy demand and the landscape level which contains macro-political and –economic developments and trends such as climate change, globalisation or demographic changes which are beyond the influence of actors from the niche and regime level but impact upon them. The main argument is that transitions occur when landscape developments put pressure on the existing regime and niche developments gather momentum until they can break into and eventually replace the previously dominant socio-technical configuration. This means for research on EU energy efficiency (innovation) policy that the analytical focus needs to shift towards a much wider range of actors and processes than simply detecting cost effective reduction potentials and identifying barriers to their adoption. There is so far very little research on energy efficiency from a socio-technical transitions point of view (exceptions include e.g. Tambach et al 2010). We argue that this is an important gap as framing the challenge of energy demand reduction in this socio-technical way encourages a move away from the individualist and incremental focus of current policy approaches and towards more overarching visions of long-term, systemic change (Sorrell 2015). More thinking about how to design and implement a transformative innovation policy (Schot and Steinmueller 2016) is needed at the European level, and not just on energy efficiency innovation.

4 Conclusion

Historically, much of EU energy technology and innovation policy was primarily concerned with energy supply technologies, energy market liberalisation and single market integration. While this remains the case to some extent, in this chapter we have discussed how over the last few years, EU energy policy has increasingly developed a wider set of activities in order to foster innovation and deployment of technologies aimed at reducing energy demand and increasing energy efficiency. We have discussed these policy developments (and the associated academic literature) through a market transformation framework which informs much of the policy thinking at EU and member state level. Building on this review we then outlined a number of key research challenges on EU technology and innovation policy for energy efficiency. These include: (1) the role of EU energy efficiency policy within a multi-level governance structure, (2) the institutionalisation of EU energy efficiency policy, (3) the need for more comprehensive policy evaluations, (4) the importance of better understanding real world policy mixes, and (5) the potential for applying a socio-technical approach to energy efficiency in the EU.

While we argue that the increased focus on energy efficiency within EU energy policy is a very welcome development, we conclude that the lack of an explicit innovation strategy for energy demand, as well as an insufficient institutional set up of EU energy efficiency policy, constitutes a barrier to achieving the challenging energy efficiency targets the EU has set. Furthermore, we argued that policy design which is based on the conventional understanding of market transformation is unlikely to allow for the rapid transition at the scale required to meeting long term EU targets. We suggest that policy makers need to embrace a much wider conceptualisation which sees energy efficiency and energy demand reduction as a core component of the transformation of the entire European energy system. This does not just involve changes in consumer behaviour, technological artefacts and infrastructures such as the housing stock, but also related changes in institutions, policy frameworks, culture, industrial structures and the like. We advocate a socio-technical lens which seems changes in technologies as closely co-evolving with all these other changes. Focussing narrowly on bringing certain technologies to market, or incentivising their diffusion, is insufficient.

Instead we propose a kind of transformative innovation policy (Schot and Steinmueller 2016) which not only supports alternative low energy technologies and practices but also actively phases out highly energy consuming processes and practices (Kivimaa and Kern 2016). In order to achieve this ambition, a well-designed policy mix (Rogge and Reichardt 2016) in support of a transformation of the European economy is required. If the EU adopts an experimental approach which is trying to make the most of the experiences gathered in member states, and internationally, then the EU can lead the world in the transformation towards more efficient and clean energy systems.

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