



Frontiers in the economics of energy efficiency



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ABSTRACT

Energy efficiency has become an essential instrument to obtain effective greenhouse gas mitigation and reduced energy dependence. This introductory article contextualizes the contributions of the supplemental issue by showing the new setting for energy efficiency economics and policy; discussing the role of price instruments to promote energy savings; presenting new approaches for energy efficiency policies; and placing energy efficiency within a wider energy and environmental framework.

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1. A new context for energy efficiency economics

Pursuing energy efficiency is becoming a priority for governments, firms and households across the world. Although the relevance of energy efficiency to reduce pollution and energy dependence has been widely acknowledged at least from the 1970s, the issue is gaining momentum. Several reasons are behind this, but probably the growing concerns on climate change phenomena and the related emphasis in greenhouse gas mitigation are playing a major role. Indeed, recent studies and reports that deal with the mitigation alternatives and paths that are compatible with the 2 °C climate policy objective underline the relevance of energy efficiency (e.g. IEA, 2015; IPCC, 2014). Yet other novel arguments, such as the competitiveness and distributional benefits of higher levels of energy efficiency for firms and households, are also increasingly present in the debate. It is worth noting too the growing interest of emerging and developing countries in improving their performance in energy efficiency terms, with an emphasis on the significant climate, local pollution and energy security gains that could be attained this way in countries that might be more reluctant to the implementation of explicit environmental policies.

Such socio-economic and political interest in energy efficiency is bringing about a considerable expansion in the scope and depth of academic enquiries within economics. It is true that the 1970s saw a remarkable interest in the economics of energy efficiency and that by the turn of the century many theoretical and empirical insights had provided a sound basis for the discussion of the so-called energy efficiency 'paradoxes' and for the design and implementation of corrective policies. It was then clear, based on a considerable economic literature, that standard regulatory approaches, proper energy pricing,

overcoming 'market barriers', and proper information could all contribute to improve energy efficiency indicators. However, much effort has been devoted in the last few years to try to explain the persistence of barriers to energy efficiency and to assess the ambitious regulatory tools put in place in the European Union, the U.S. and other developed countries. Moreover, innovative policy alternatives that explicitly consider free-riding and behavioral barriers, a remarkable progress in measurement and information technologies, and the strong irruption of quasi-experimental and field experimental approaches in the area, clearly define a new setting for energy efficiency economics and policy.

This supplemental issue therefore responds to the intense interest of academic economists in energy efficiency, with a clear bias towards energy efficiency policies, although it also includes a few papers less directly linked to the topic. The articles are authored by participants in the Sixth Atlantic Workshop on Energy and Environmental Economics, held in A Toxa (Galicia, Spain) in June 2014 under the title of this introduction 'Frontiers in the Economics of Energy Efficiency'. The Atlantic workshop, organized by the research center Economics for Energy with the collaboration of ZEW in its sixth edition, had already provided two supplemental issues of Energy Economics in 2011 and 2013. As guest editors we are thankful to Richard Tol (editor-in-chief of Energy Economics) for his continuous support, and also to the anonymous reviewers that made possible the quick and timely publication of the issue.

Besides explaining the reasons behind the supplemental journal issue, this introductory article intends to summarize and categorize the different contributions. As advanced before, most articles in this issue deal with the design and assessment of energy efficiency policies and thus the next three sections are devoted to price-based approaches, new policy approximations to improve energy efficiency and to the questions raised by the so-called rebound effect. The paper ends with a wider look at energy and environmental matters that can influence and/or be influenced by energy efficiency developments.

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But before proceeding with the next sections, it is particularly useful to shed light on the very concept of energy efficiency. Although energy intensity is often used as a proxy, particularly in energy policy analysis, there is no consensus on how energy efficiency must be defined and measured at the macro level. The article by [Filippini and Hunt \(2015\)](#), based on one of the keynotes of the workshop, precisely answers these two questions by reviewing the several attempts to define energy efficiency and by paying a special attention to both the econometric methods that are fit for a proper measurement and to the specific results from recent empirical work.

As hinted before, the EU has been emphasizing the role of energy efficiency in its energy and climate strategies and objectives since the late 1990s and thus provides a good laboratory for inferring conclusions that may be useful for the policymaking and academic communities. In this context, [Löschel et al. \(2015\)](#) are interested in showing the evolution of energy efficiency based on the above-mentioned concept of energy intensity. The authors analyze the decline in energy intensity in the EU-27 countries between 1995 and 2009, trying to identify the factors that explain changes in energy intensity of countries. More specifically, they focus on structural changes towards less energy-intensive sectors and changes in sectoral energy intensity as the potential channels that may explain this evolution. The article finds that both drivers were similarly important from 1995 to 2003 and that technological improvements in sectoral energy efficiency were the predominant drivers afterwards. In any case, there is significant heterogeneity between the 27 countries.

2. Prices and energy efficiency

Market instruments that directly impact energy prices are a preferred energy-efficiency policy because of their simplicity, cost-efficiency and easy implementation, even though their effectiveness in this area may be reduced when price elasticities of energy demand are very low. Price instruments generate incentives to reduce energy consumption by either using taxes that penalize energy consumption or subsidies or tax deductions that encourage energy savings (see, for example, [Markandya et al., 2015](#)).

In many developed countries energy taxes have been instrumental in controlling energy consumption and, by doing so, they have also limited carbon dioxide (CO₂) emissions and reduced energy dependence through energy efficiency improvements. Besides achieving environmental, energy and other economic objectives, these instruments have the advantage of being capable of generating public revenues. This is the case of several developed, mainly EU, countries which implemented environmental tax reforms since the early 1990s, raising taxes on energy sources and using the extra revenue to reduce personal income taxes or/and social security contributions (see [Gago et al., 2014](#)).

This is the setting for [De Miguel et al. \(2015\)](#), who analyze a green tax reform aiming to improve the Spanish social security system and that could generate significant reductions in energy demand and contribute to a better environment. Yet the authors also highlight the difficulties of implementing such a policy despite its potentially beneficial effects, mostly due to the different ways in which the policy affects several age groups. This is something that needs to be taken into account when considering the design and implementation of such a package, clearly beneficial from economic, energy and environmental point of views, but potentially subject to socio-political barriers that should be targeted.

Another set of price instruments seeks to generate energy savings through subsidies in the form of rebates or loans that might have a positive effect, for example, on the choice of more efficient appliances. This can be done by subsidizing the replacement of inefficient products for new ones with certain energy efficiency requirements, as actually discussed by several papers in previous supplemental issues related to the Atlantic workshop (see, for example, [Galarraga et al., 2013](#)). Yet there are several negative aspects of subsidies such as the revenue

(fiscal) costs of providing the subsidy, free riding, or the possible presence of the so-called rebound effect. The latter happens when the subsidy reduces the price and can lead to an increase in energy consumption, and will be analyzed in [Section 4](#).

In this issue [Nauleau et al. \(2015\)](#) discuss, from a theoretical point of view, how to design a program of subsidies to promote energy efficiency improvements in a market under several market failures. The authors explain that the presence of energy use externalities and price-quality discrimination causes low energy efficiency levels. As a major result, the paper indicates that differentiated subsidies can generate the social optimum.

An extensive empirical literature has analyzed the effects of introducing different subsidies in view of the free-riding phenomena (see e.g. [Linares and Labandeira, 2010](#)). Within this journal issue and with the above-mentioned objectives [Alberini and Bigano \(2015\)](#) analyze the role of both monetary and non-monetary incentives in encouraging households to replace their heating systems with a more energy efficient system. Using a survey of homeowners elaborated by the own authors, the analysis focuses on Italian households. As a major contribution, the authors fit an energy-efficiency renovations curve that predicts the share of population willing to undertake these improvements for any given incentive level.

As indicated in the introduction, competitiveness and distributional considerations are occupying an increasing space in the energy efficiency debate. Indeed, trade flows across countries can also have significant implications on energy and the environment in an increasingly globalized world. There is actually an extensive literature that deals with the link between climate policy and trade from both a theoretical and empirical points of view (see, for example, [Copeland and Taylor, 2003](#)). Among the factors that may influence trade flows, the empirical literature has generally paid less attention to energy costs differences among countries despite its potential importance. Differences in energy costs are a very important factor as producers of a country can respond to higher energy prices producing less of the energy-intensive goods at home or even partially relocating their production to countries with lower energy prices. From the environmental point of view this is important as the reduction of emissions in a country might simply be offset by increases in other regions. [Sato and Dechezleprêtre \(2015\)](#) contribute to the literature that empirically analyzes the relationship between energy prices and trade, estimating a gravity model using a panel that covers tens of countries and sectors for the period 1996–2011. They find a significant but very limited impact of energy price gaps on imports, although this is larger for energy-intensive sectors.

3. New approaches for energy efficiency policies

As stated in the introduction, in the last few years there have been important efforts by academics and policymakers to tackle the pervasive barriers to energy efficiency improvements. The supplemental issue pays a particular attention to this topic by providing an updated survey on new developments in energy efficiency policies and by presenting one of the first empirical assessments of such innovative approaches.

[Ramos et al. \(2015\)](#) explore a relatively new field in energy efficiency policies: instruments that provide information to consumers as a way to solve the informational failures present in the residential sector. The article reviews the available evidence on the relevance of informational and behavioral failures related to residential energy savings and then analyzes the performance of three instruments that try to address informational failures: energy certificates and labels, provision of feedback to consumers, and energy audits. The paper shows that energy certificates and labels and the provision of feedback show better results than energy audits. The authors conclude that, although these instruments show some promise, several shortcomings should be overcome if they are to solve the energy efficiency paradox and make energy efficiency happen significantly in the residential sector.

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