Energy Policy 59 (2013) 633–642

Contents lists available at SciVerse ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Setting up GHG-based energy efficiency targets in buildings: The Ecolabel

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HIGHLIGHTS

- In this paper we consider the interaction between greenhouse gas emission reduction targets and building energy efficiency.
- Specifically we propose an "Ecolabel" for buildings that is a GHG emissions liability index, which forms a labeling process.
- The label follows the Kyoto Protocol philosophy and translates national GHG targets to targets for each and every building.
- The approach provides both a new form of efficiency rating on which emissions reduction policy can be based.

ARTICLE INFO

Article history:
Received 3 June 2011
Accepted 5 April 2013
Available online 11 May 2013

Keywords:
Building certification schemes
Energy policy
Kyoto Protocol
Ecolabel

ABSTRACT

The European Union has recently updated the regulations for energy performance of buildings and on the certification of energy-related products. The world is in the process of constructing policy frameworks to underwrite carbon emission reduction targets, best exemplified by the Kyoto Protocol. This requires complex technical and economical concepts to be presented in an understandable, transparent, and justifiable format.

A building's energy efficiency was traditionally determined based on its annual consumption relative to some average performance level. Emissions are calculated as a derivative of consumptions and their aggregated values allow verification of the level of fulfillment of the objectives. Here we take a different approach: considering that the greenhouse gas emissions (GHG) objectives *must* be achieved; hence, we fix the efficiency standard based on emissions objectives, and then derive the corresponding reference values of consumption.

Accordingly, we propose a certification scheme for energy efficiency in buildings based on targets of GHG emissions levels. This proposed framework includes both a label, namely the *Ecolabel*, and a fiche showing a set of indices and complementary information. The Ecolabel is designed to provide a flexible, evolvable, simple to use at the point of application, and transparent framework.

1. Introduction

The European Union (EU) is determined to solve the climate change through the promotion of *energy efficiency* (European Commission, 2005). In fact, the EU is a worldwide reference in this discipline. As an example, in 2008 in order to produce one unit of their gross domestic product (GDP), China and the United States spent 4.2 and 1.1 times the energy invested by the EU, respectively (International Energy Agency, 2010a, 2010b).

From 2005 on, the most plentiful European energy source is indeed the "negajoule". This is the energy made available by reducing consumption by means of a saving strategy (European Commission, 2006). In short the energy you save is energy you can use elsewhere, or later. In addition, the energy available from negajoules is directly related to the reduction in carbon emissions.

Promoting energy efficiency does not only reduce the energy consumption but also generates an important byproduct: the reduction of the greenhouse gas (GHG) emissions. Within Europe, this is critical in reaching the EU commitment to a 20% reduction on GHG emissions by 2020.

Continuous improvements in energy efficiency are important for every economic sector, but crucial to those with the highest energy demand such as buildings (Intergovernmental Panel on Climate Change, 2008; Pérez Lombard et al., 2008). Buildings are responsible for 30%–40% of the primary energy consumption and up to one third of the subsequent GHG emissions worldwide (United Nations Environment Programme, 2007). This consumption is done over a

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http://dx.doi.org/10.1016/j.enpol.2013.04.021

variety of different types of buildings and will be held over a long period of time (Jones, 1998). It requires:

(i) Embodied energy: The energy required for the fabrication and transport of its materials, and its own construction.
(ii) Operation energy: The energy demands resulting from its ordinary use (heating, cooling, ventilation, lighting, and hot water supply).
(iii) Demolition-recycling energy: The energy required to dismantle the building and dispose of its materials.

The operation energy depends on the life-cycle of the building, often between 50 and 100 years. Typically the uses of buildings evolve through this life-cycle, hence the energy use in the operational phase can significantly vary (Dodoo et al., in press). The impact of the global warming on buildings energy performance was studied in Wang et al. (2011), where the authors also analyzed the efficacy of different emission reduction strategies. Buildings represent a real opportunity for energy saving in every phase of their life-cycle (Uihlein and Eder, 2010). There is potential from innovation in construction materials, the design of their enclosures, the energy supply systems, and the behavior of their users.

The significance of buildings for achieving energy efficiency has been reflected in European regulations, where 3 of the 10 priority measures in the Action Plan for Energy Efficiency (European Commission, 2006) pertain to buildings. In fact, in the past years, the EU has issued two main directives, the Energy Performance of Buildings Directive (2010/31/EU, 2010) (EPBD) and the Directive 2010/30/EU (2010/30/EU, 2010), to refocus the actions that were put in place following the previous legislation in order to meet the original objectives. This novel regulatory framework will be studied in Section 3.

The resulting measures must consider energy efficiency under a twofold perspective that accounts for the reduction of both energy consumption and GHG emissions. Failing to consider climate change in the development of strategies for improving energy efficiency in buildings, could result in a dramatic reduction of their expected benefits. From a regulatory perspective, this means that efficient solutions that are only focused on energy consumption may not address an optimal environmental result (Hamdy et al., 2011).

Despite all the effort in promoting energy efficiency in buildings at present there is no standard measurement for it, as we pointed out in Rodríguez González and Vinagre Díaz (2011). A common standard of energy efficiency in buildings is required to establish a fair comparison between different countries (Pérez Lombard et al., 2009; Olesen and de Carli, 2011).

But this is not the only issue that we must face. The practical problems of establishing a full indexing process are compounded by some very basic issues and fundamental requirements. Firstly, we need a simple connection between the indexing process and the GHG emissions. Next, we need to establish a means of fair comparison not only between countries but also between different buildings, different building types, different regions, etc. It is also essential that the framework has the ability to adapt to changes in policy and technology, so that they can aim at new objectives in the reduction of energy consumption and GHG emissions. The process for applying the calculation of the index has to be simple and straightforward. It has to be based on the data that is available to both the end user and the government body responsible for the administration of the system. It should be possible for the building owners to calculate the liability (index level) for a given year, without reference to data from other building owners, that would only be available after all the calculations are performed. The values calculated should be transparent and easy to explain and justify.

In order to fulfill this set of requirements, we will focus on finding a universal dynamic energy efficiency index (EEI), based on particularized emissions objectives. In the present work we propose the Ecolabel, an energy efficiency label, based on an index that relates the emissions of the building under study with a reference value of emissions that is calculated from the emissions objectives of the building's country and sector. The Ecolabel will not only act as an indicator of the energy performance of a building but also as a means of promoting energy efficiency through the reduction of GHG emissions. In addition, following the present European legislation, we propose a fiche including other indices and complementary information regarding the building's performance in terms of energy efficiency.

2. Emissions objective and inventory

In order to construct this Ecolabel based on emissions objectives, we must first check the validity of this approach in achieving a significant reduction of the GHG emissions. Then we must make sure that there is an available historical emissions database that we can use to find the reference to which we will apply specific reduction objectives.

The validity of using objectives to reach an emission goal has already been shown by the reduction that has been accomplished thanks to the commitment of participants following the Kyoto Protocol. In addition, historical information regarding GHG emissions has been recorded in recent years, in the so called *GHG inventories*. We will describe both the Kyoto Protocol and the European Union greenhouse gas inventory in the next subsections.

2.1. The Kyoto Protocol

About 38 countries around the world agreed to limit their GHG emissions in the Kyoto Protocol (United Nations, 1998). The Parties listed in Annex I of the Kyoto Protocol undertook to individually or jointly reach the objective of achieving from 2008 to 2012, a 5% reduction on the GHG aggregate anthropogenic emissions (expressed in carbon dioxide equivalent) released in 1990. In order to achieve this global objective, each Party committed to a particular percentage of reduction (or limitation).

Let us now consider Europe as an example of how this commitment has been implemented. In 2002 the EU approved the Kyoto Protocol in its Council Decision (2002/358/CE, 2002). The EU and its member states will jointly fulfill these commitments, which were quantified in a set of percentages. Nevertheless, the levels of emissions to which these percentages should be applied were fixed in 2006 (2006/944/EC, 2006). Due to the joint nature of this acceptance, the EU plans to manage the achievement of these objectives through an internal reallocation scheme. These reallocated percentages are included in the text of Decision (2006/944/EC, 2006). The corresponding emission levels allocated to each Member State in the EU for the first period of commitment (2008–2012) were also fixed in 2006/944/EC (2006).

Following the Kyoto Protocol, the EU has been successful in reducing the GHG emissions as can be observed in Fig. 1. A significant percentage of this success could be attributed to the flexibility that the Kyoto Protocol gives for its implementation, based on three mechanisms: (1) The *Joint Implementation* (JI), via cooperative projects executed by the different Parties, each generating *emission reduction units* (ERU's); (2) The *Emissions Trading System* (ETS) that allows the Parties in Annex I to purchase *assigned amount units* (AAUs) from other Parties; and (3) The *Clean Development Mechanism* (CDM), which allows the Parties in Annex I