Impact of energy efficiency goals on systems of building regulations and control

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Abstract: Considerations of climate change, but also other political and economic reasons urge for the reduction of use of fossil fuels and the minimization of environmental impact by the built environment. The energy saving potential of the building stock is large and considered to be the most cost efficient sector to contribute to the CO2 reduction ambitions. Goals set by the European Union are to build net zero energy buildings in 2020 and to reach a neutral energy building stock by 2050. As long as the price of renewable energy is still not competitive with fossil energy, the energy saving goals can only be reached by strict governmental policies. In Europe the Energy Performance of Buildings Directive and the Energy Efficiency Directive are driving forces for EU Member States to develop and strengthen energy performance regulations for new buildings and energy performance certificates (labels) for the building stock. The goal of this paper is to analyse the consequences of these developments on the systems of building regulations and control. It appears that, apart from adding new subjects, these new and very ambitious goals require systemic innovations in the regulatory systems. The current structures and approaches might not be adequate to deal with the new challenges. This is concluded from ongoing research that shows that aims of regulations in general and energy saving goals in particular, are hardly realized in practice.

Keywords: Energy Saving, Energy Performance, Building Stock, Building Regulations, Building Control

Introduction
Climate change mitigation is maybe the most important driver for the ambitions to reduce the use of fossil fuels. There are also other reasons for implementing energy efficiency policies in the EU and its Member States. These include the wish to diminish the dependency on fuel imports, the increasing costs and the fact that fuel resources are limited. The European building sector is responsible for about 40% of the total primary energy consumption. To reduce this share, the European Commission (EC) has introduced the Energy Performance of Buildings Directive, the EPBD (2010/31/EC) and more recently the Energy Efficiency Directive (EED – 2012/27/EU). These frameworks require Member States to develop energy performance requirements for new buildings, a system of energy performance certificates for all buildings and policy programmes that support actions to reach the goals like building only ‘Nearly Zero Energy Buildings (NZEB)’ by 2020 and realizing an almost carbon neutral building stock by 2050. Formulating ambitions and sharpening regulations are relatively easy to do. Technical solutions are currently available to realise the NZEB standard in building projects and more and more projects of this kind are being build. There is quite some evidence however that the mainstream of building processes does not lead to the pre-defined quality or that the instruments are not adequate to reach the goal. What is perhaps even more important in this respect is that focus predominantly should be directed on the existing...
building stock. About 75% of the buildings that will make up the housing stock in 2050 have already been built today.

This paper sketches the main developments in the field of building regulatory systems and building practice in the context of the increasing energy saving target, both for new as well as for existing dwellings. The main question addressed is whether the current regulations and forms of building control are adequate to realize the energy saving goals set by the EU and its Member States.

**Developments in building regulatory systems**

Building regulations are continuously the subject of debate. On the one hand regulations should be minimized to reduce the administrative burden on citizens and businesses. On the other hand new quality themes emerge that require regulatory intervention. Energy and climate change is such a theme. The European Union and its Member States have developed regulations and enforcements schemes that ensure very energy efficient new buildings and instruments that stimulate the improvement of the existing stock. Although the general development in European countries leads to less government intervention in the building sector, in the field of energy efficiency the number of regulations increases and become more stringent. Currently in the Netherlands the debate is very alive. The desire for deregulation is leading to the opinion that greater emphasis should be placed on the responsibility of property owners, which could lead to less governmental intervention. However, the existing forms of quality control for private actors in the Dutch building industry appear to be not adequate enough. Incidents occur and the physical quality sometimes falls short of the expectations. As the CO2 reduction and energy efficiency targets increase, stronger regulations and accurate building control become a priority.

**The realisation of required energy performances in practice**

In 1995 energy performance regulations for space heat and cooling of newly built constructions were introduced in the Netherlands. It consist of a standard for the calculation method which is called the Energy Performance Norm. The norm results in a non-dimensional figure called the Energy Performance Coefficient (EPC*). Every few years the level of this Energy Performance Coefficient was decreased, representing a lower energy use demand for heating. In 2020 new dwellings must be energy neutral. Since the introduction only a few studies were conducted to assess the effect of the regulations on the actual energy use. The samples were of limited size as well. Two studies found no statistical correlation between the energy performance coefficient level and the actual energy use per dwelling or per square meter. Analysis of the WoON (2009) survey, (that was carried out on behalf of the Dutch government in 2006 containing a representative sample of 5000 dwellings), also found no correlation between the different levels of the energy performance coefficient and the actual energy use per dwelling and per square meter (see Figure 1). Guerra Santin (2009, 2010) compared the actual and expected energy consumptions for 313 Dutch dwellings, built after 1996. The method included an analysis of the original EPC* calculations that were submitted to the municipality as part of the building permit application, a detailed questionnaire and some day-to-day diary’s. These combined approaches generated very detailed and accurate data of the (intended) physical quality of the dwellings and installations, about the actual energy use (from the energy bills) and of the households and their behaviour. The dwellings were categorised according to their EPC*. In energy inefficient buildings with a high EPC*, actual energy consumption for heating was almost twice lower than expected. Whereas in buildings with a high energy efficiency, the expected and actual energy use coincided much
better. Due to the relatively small sample size, the differences between the actual heating energy of buildings with different EPC* values were insignificant. Nonetheless the average consumption was consistently lower in buildings with lower EPC*. Guerra Santin found that building characteristics (including heating and ventilation installations) were responsible for 19% to 23% of the variation in energy used in the recently built building stock. Household characteristics and occupant behaviour seemed to be responsible for 3% to 15% of the total variance. On the basis of our study and other literature studies one can state that building characteristics, household characteristics and occupant behaviour altogether are responsible for at most 38% of the variation on energy consumption of dwellings built after 1995. Therefore at least 62% of the variation in energy use was unexplained by theoretical performance and behaviour and must be caused by other reasons.

Figure 1 Yearly gas consumption in m3 in Dutch dwellings (WoON 2009)  
(note: non linear proportions)

Figure 2 Actual energy use in relation the Energy Performance Coefficient per Type of dwelling  
(Guerra Santin, 2009)

There are indications that some of the explanation could be related to the fact that buildings are constructed differently in practice than is described in the design documents and that
HVAC services operate in very different conditions than assumed beforehand. Nieman (2007) showed that in a sample of 154 dwellings, 25% did not meet the energy performance requirements because of incorrect calculations. Nevertheless the building permit was issued. In 50% of the dwellings, the realization was not in accordance with the design. These results match with findings about inadequate performance of both building control as the building industry in the Netherlands and other countries (Meijer e.a. 2002, 2006, 2008). Taking into account the above findings, one can have some doubts if a further tightening of the energy performance regulations will lead to a better energy performance in practice. Perhaps there are other and more efficient solutions to decrease the energy consumption of newly built dwellings in practice. Important ingredients of the solution are: ensuring that appliances and installation are correctly installed, monitoring the calculated performances in practice; enlarging the know-how and skills of building professionals and putting in place an effective and efficient building control and enforcement process.

**Policies and instruments for energy reduction in existing dwellings**

It is relatively easier to apply energy saving measures in newly built buildings. However the largest energy saving potential is in the existing building stock. On average new dwellings add less than 1 per cent per year to the housing stock. The most important policy tool required by the EPBD in the European Member States is the issuing of Energy Performance Certificates (or EPC’s). The EPC gives an indication of the energy demand necessary to realise a certain average temperature in the building and depends on physical characteristics of the building. The EPC indicates the energy demand for heating and cooling. The certificate has no mandatory implications in the sense that owners could be forced to improve their buildings to certain levels. Nonetheless it could be a crucial instrument for benchmarking and formulating policy goals. Building owners in all Member States have to produce an EPC for a building at the moment it is sold or re-rented. This is not yet current practice everywhere, mostly due to lacking of enforcement. This especially applies to the private housing stock. In the Netherlands however, the complete social housing stock is labelled with an EPC. The social sector in the Netherlands is still relatively large (35%) and well organised. For the social housing stock the EPC’s are collected in a database. With this database the progress of the renovation practices can be monitored. Besides that the relation between the EPC’s (with the calculated energy use) and the actual energy use can be studied. A few years ago the sector formulated ambitious programmes, but these have been scaled down because of several reasons. The economic crises reduced the financial position of the housing associations. The housing market also dramatically slowed down which also affected the funding for renovations because this largely depends on the sales of property. Also it proved to be difficult to get approval of tenants for renovations that require an increase of the rents (70% of the tenants have to agree). It is hard to assure the saving of energy costs resulting of the improvement of the dwellings. All in all the progress of renovations and energy upgrading measures stays far behind expectations and formulated ambitions in 2008 when most of the policies, covenants and improvement programmes were set up.

Besides the physical characteristics, the actual energy use is largely influenced by the use and behaviour of the tenants. Some preliminary figures demonstrate the difficulty in ‘forcing’ reduced energy use by improvements of dwellings. The dwellings with the worst EPC (G) in practise use far less energy as expected, while the most advanced dwellings (A) use much more. This is probably due to a combination of the rebound effect and an increase in comfort level of the dwellings (Majcen et al 2013a, 2013b) and underperformance of the buildings and installations. Figure 3 shows the actual and theoretical gas consumption per dwelling per EPC. In the homeowner sector the issuing of EPC’s stay yet far behind the expectations. This means that the intended purposes are not reached. When EPC’s become common practice they could affect the sales price. There is no enforcement system in place to guarantee that only buildings with an EPC can be traded on the housing market.
Impact on the systems of building regulations and control

Without any doubt there is a necessity to drastically reduce the use of fossil-fuel energy sources by reducing the demand for energy and switching from fossil to renewable sources. Buildings account for 40% of Europe’s energy consumption and three-quarters of the floor area of the building stock is residential. The targets are clear and the technical solutions are available. Severe insulation and product innovations can reduce the energy demand for heating and cooling for a large part. The remaining energy demand can be delivered by renewables like sunlight and heat, district heating, heat pumps, etc. The remaining electricity demand for appliances can in the first place be reduced by further product innovation and then be provided by photovoltaic panels. There are no reasons not to apply these solutions in new buildings at a large scale on the short term. Evaluations of the current practice show however that there is a lot to be gained here. To improve this situation it has to be assured that constructions and installations are installed properly and in such way that they are not vulnerable for unpredictable or misuse by the occupants. This will set demands on both the construction industry as on the control and enforcement process (and the parties responsible).

Better quality control during the whole process is absolutely essential. It is quite feasible to charge the building professionals with this task. Our international comparative research into building regulatory systems shows a tendency to put more emphasis on the responsibilities of owners and private parties (instead of local authorities) to control and ensure the minimum quality of construction works. For a successful transition towards energy neutral construction stricter demands must be set on the knowledge and skills of these building professionals (designers, engineers, installers, constructors, etc.). They will have to use new techniques and improve the quality and accuracy of the work. This means that they not only will have to improve their operating procedures but also have to implement performance guarantees. Owners and users will require quality guarantees from the designers, installers and constructors. Certification and accreditation of parties, processes and products will become more important for building processes in general. For the realization of high energy performance standards, a reliable quality assurance system will be very important. In most countries that have some experiences with passive houses some form of performance
guarantee and associated quality assurance scheme exists. It is important to study these examples.

For new constructions a successful transition lies easily within the bounds of the possible. The existing building stock forms a far greater challenge. The potential energy savings are far bigger, but the barriers to overcome are also higher. As stated before almost three quarters of the future housing stock (2050) has already been built. Studies show however that it is hard to increase the rate and depth of energy renovations of the existing stock. Actual energy (and financial) savings in renovated dwellings stay behind expectations because of rebound effects. There are important barriers. Many owners believe that the benefits of the measures do not outweigh the costs. Besides that, the cost of improving the energy performance of a dwelling does not (proportionally) increase the value of the dwelling.

We are faced with the difficult task to increase the energy renovation pace. The question is how this process can be accelerated. Maybe there is still room for further smart product development. Innovative products that that contribute massively to the reduction of energy demand, that are cheap, easy to apply and to handle by occupants and users. The fast decrease of the price of PV cells is promising.

Climate change and the related demands on buildings will have a profound impact on the design of building regulatory systems. The past few years OTB – Research for the Built Environment has been involved in studying alternative visions on building regulatory systems in international comparative projects. What we see in most countries are discussions (or sometimes even concrete developments) where the balance slowly shifts from:

• Command and control regulations towards more economic incentive based policies;
• Public control and enforcement towards a more dominant role of private parties/building professionals (together with the materialisation of far more robust and reliable certification and accreditation schemes);
• A strong focus on control of the design to monitoring of the building process and testing of the quality of the final building and post occupancy monitoring.

At the same time the role of regulations for existing buildings come under scrutiny and from a range of stakeholders attempts are undertaken to search for solutions. Instant solutions are not easy to give. None the less along the most probable solutions will move in the directions sketched above.

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