Abstract:

Improving energy efficiency in existing buildings represents a great opportunity for reducing greenhouse gas emissions. Numerous measures to increase efficiency and decrease emissions have been put in place in cities all around Europe and in the US. But there are some that stand out from the rest, like New York City, which is a remarkable example of commitment to the fight against climate change. This is due to the city’s special characteristics, with a great urban density and a large percentage of greenhouse gas emissions coming from its aged building stock, which has urged its authorities to take important measures in order to eliminate (or at least diminish) its adverse effects. However, there is always room for improvement. Thus, a comparative study between some of the most successful measures developed in selected European cities and New York City, will be aimed at giving some useful elements to legal professionals in order to improve the existing energy efficiency measures for greening the existing building stock in any city around the world.

Key words: energy efficiency, existing building stock, cities, climate change, energy savings, comparative-law.
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1. INTRODUCTION

Existing buildings offer substantial energy efficiency opportunities, in terms of energy and costs savings, and for the reduction of greenhouse gases (GHG) emissions. Indeed, existing buildings are responsible for 41% of energy consumption and 36% of carbon dioxide (CO2) emissions in the EU\(^1\), and 39% of total energy use and around 38% of CO2 emissions in the US\(^2\). In New York City (NYC), the building sector is responsible for around 75% of total GHG emissions in the city due mostly to the intense use of public transportation, resulting in relatively little emissions from cars\(^3\). Understanding the energy consumption in buildings requires insight into the energy levels consumed over the years and the mix of fuels used in that energy consumption. Given the predominance of existing buildings in major population centers around the world, adopting energy efficiency measures for existing buildings is one of the most important and cost-effective means available to combat climate change. Overall, energy use in buildings is rising in the entire world despite energy efficiency and mitigation efforts, and this trend is likely to continue if insufficient action to improve our buildings’ performance is taken and the world population continues to rise\(^4\). Although there are several ways to reduce GHG emissions derived from energy use in buildings, scientists and governments agree\(^5\) that improving the energy

\(^{*}\) This paper was prepared as part of a research conducted at The Sabin Center for Climate Change Law, Columbia Law School (Columbia University).


\(^{5}\) The majority of carbon emissions into Earth’s atmosphere are energy related and originated by fossil fuel combustion. In particular by the emissions from the so-called “diffused sectors”, that is, from sources that are not subject to the Kyoto Protocol (KP) emission trading mechanism (transport, residential, commercial, institutional, farming, waste treatment, and fluorinated gases). Furthermore, according to the United Nations, the world population is projected to reach 9.6 billion by 2050, which leads to an inevitable increase in the use of energy, especially in cities. The UN Report titled World Population prospects: the 2012 Revision, is available at: http://esa.un.org/wpp/ (accessed 23 May 2014).
efficiency of building systems and operations, as well as investing in cleaner on-site power generation, is a highly effective approach\textsuperscript{6}.

In Europe, some cities have developed interesting measures that have been evaluated as best practice examples by numerous reports\textsuperscript{7}. Also, NYC is committed to reduce its GHG emissions by 80\% below 2005 by 2050 through an ambitious Plan\textsuperscript{8} designed to address energy use improvement in the city’s building stock.

The aim of this paper is to try to find innovative measures that would improve the energy performance of the existing built environment\textsuperscript{9} contributing thereof to the mitigation of the effects of climate change. This focus will help fill the current void in the literature on GHG emissions reductions strategies in general, as it is primarily oriented towards new buildings. Also, by testing the most successful European practices as well as the ones implemented in NYC, considered to be one of the most advanced cities in the matter, the paper will go a step forward and draw some conclusions that would summarize best practices guidelines for any existing building in any city around the world.

The paper tries to outline some guidelines proposal for the energy improvement of the existing building anywhere in the world and for that purpose, it first, depicts the most important energy efficiency measures developed in a range of selected European cities and NYC as the most notable example in the U.S., and then, focuses in the best practices examples for overcoming the so-called split incentive, which appears to be the most relevant barrier for energy efficiency investment in the building sector.

\textsuperscript{7} The specific reports that have been used for this research will be listed further on.
\textsuperscript{8} This Plan is NYC Built to last, available at: \url{http://www.nyc.gov/html/builttolast/pages/home/home.shtml} (accessed 12 February 2015).
\textsuperscript{9} Built environment is defined as “the buildings and all other things constructed by human beings”, \url{http://www.collinsdictionary.com/dictionary/english/the-built-environment#the-built-environment_1} (accessed 1 April 2015).
2. ENERGY EFFICIENCY BEST PRACTICES EXAMPLES DEVELOPED IN SOME OF THE MOST IMPORTANT EUROPEAN CITIES AND NYC, AS A NOTEWORTHY CASE IN THE U.S.

The building sector is mainly composed of two categories of buildings: residential and non-residential\(^{10}\). Residential buildings comprise single-family houses (detached and semi-detached houses) and apartment blocks. Compared to the residential sector, non-residential buildings are more heterogeneous and are usually classified by type and by branch of activity\(^ {11}\). This paper will focus on the existing residential building stock, which has been calculated to consume two thirds of overall building energy consumption\(^ {12}\), with some references to the commercial and industrial sectors, as a means of facilitating the comparison among them.

The diversity of ownerships, housing types and ages, geographic locations, and climatic conditions, pose a real challenge for policy-makers seeking to design the most efficient measures for improving the energy performance of the existing building stock. Some measures will be directed to the building itself or its design, others to improve the main energy uses; these are: heating, cooling and electricity use for lighting and appliances, and finally other measures are designed to foster behavioral changes in those inhabiting (or using) the buildings. Even though this paper will be mainly focused on the two first groups of measures, the latter will also be addressed in a supplementary fashion.

Four main policy instruments are widely used to promote energy efficiency in the built environment worldwide: regulatory instruments, economic and market-based instruments, financial instruments and incentives, and support, information and voluntary actions. However, there is no such thing as an existing overall “best” policy package but instead, specific measures that have been very successful and brought attention to the particular city that has implemented

\(^{10}\) A building is regarded as a non-residential when the minor part of the building (i.e. less than half of its gross floor area) is used for dwelling purposes. Non-residential buildings comprise: industrial buildings; commercial buildings; educational buildings; health buildings; other buildings. Source OECD Glossary of statistical terms: [http://www.buildingsdata.eu/content/definitions/building-type-non-residential-building](http://www.buildingsdata.eu/content/definitions/building-type-non-residential-building) (accessed 8 November 2014).


them with best results. For any city, the challenge is to find the best combination of all policies in order to improve the energy efficiency of their existing building stock while also playing their part in the global fight against climate change.

The study of each type of instrument at a supranational (EU) and national (US) level was depicted in a previous Article\textsuperscript{13}, so the analysis now presented is focused on the specific instruments that have been especially successful in a certain country and/or city for the energy improvement of the building stock. The main purpose here is to ensure that the results extracted from best practice sharing\textsuperscript{14} benefit the measures developed in any city in the world.

A best practice example shows the measure that has been proven to be superior to others achieved with other means, but that can also be improved over time. The paper, thus, selects some cities that have shown a better performance in the main policy instruments and energy uses, and compares them in order to depict the possible improvements and, lastly, draw up some guideline proposals for boosting the energy performance in any building in any city anywhere in the world.

The selected cities include some European cities and NYC. All of them have unfolded singular attention to the mitigation measures adopted by their public authorities, in particular, with respect to their existing building stock, as it will be explained further on.

\textbf{2.1) The European study: main conclusions for selected best practices examples}

There are numerous reports that analyze the energy efficiency in the European building stock, but this paper will mainly take into account the cities’ scores extracted from six of them: four privately sponsored and two managed by European institutions\textsuperscript{15}. Other reports and studies will be also considered in a complementary fashion.

\textsuperscript{14} Shnapp, Sophie, \textit{op.cit.}, p. 35.
\textsuperscript{15} The selected reports are: the Economic Intelligence Unit and Siemens, the Global Buildings Performance Network, the Second edition of the 2014 International Energy Efficiency Scorecard, by the American Council for an Energy Efficient Economy (ACEEE), the bigEE project, an international initiative by research institutes for technical and policy advice and public agencies in the field of energy and climate, coordinated by the Wuppertal
According to these reports, the European cities (and countries, as their policies are largely linked) selected for this research are: Germany (Berlin), Sweden (Stockholm), Denmark (Copenhagen), United Kingdom (London), France (Paris), Spain (Madrid), Italy (Rome), and Lithuania (Vilnius). This sample includes some of the Nordic European countries, which are well known for being the most energy efficient in Europe, some Mediterranean countries, with more economic and behavioral difficulties but impressive achievements in specific areas, and the best ranked Eastern European city\textsuperscript{16}.

All selected cities belong to the \textit{Covenant of Mayors}\textsuperscript{17} project, a European movement involving local and regional authorities voluntarily committing to increasing energy efficiency and use of renewable energy sources on their territories. By their commitment, Covenant signatories aim to meet and exceed the European Union 20% CO\textsubscript{2} reduction objective by 2020. Also, all of them (and NYC as well) but Vilnius belong to the \textit{C40 Cities Climate Leadership Group}\textsuperscript{18}, which offers cities an effective forum where they can collaborate, share knowledge and drive meaningful, measurable and sustainable action on climate change.

After a detailed analysis of the measures developed in those selected cities, the main conclusions could be summarized as follows:

<table>
<thead>
<tr>
<th>Country</th>
<th>Economic data (World Bank)\textsuperscript{19}</th>
<th>Energy efficiency best practices measure</th>
</tr>
</thead>
</table>
| Germany (Berlin) | GDP: $3.730 trillion Population: 80.62 million C02 emissions per capita: 9.1 metric tones | - Strong building codes
                  |                                                  | - Mandatory labeling programs
                  |                                                  | - Public-private partnership
                  |                                                  | - Knowledge sharing
                  |                                                  | - Holistic approach (comprehensive retrofit) |
| Sweden (Stockholm) | GDP: $579.7 billion Population: 9.593 million C02 emissions p.c.: 5.6 m.t. | - Strong regulation
                  |                                                  | - Mandatory labeling programs
                  |                                                  | - High insulation standards
                  |                                                  | - Extensive information and technical assistance, supported by the public sector via subsidies |

\textsuperscript{16} It should be noted that the research project conducted by the Economist Intelligence Unit, sponsored by Siemens, which ranked Vilnius (Lithuania) as the best Eastern city in terms of an overall energy performance, uses 2009 data. The group has not yet elaborated a newer report.

\textsuperscript{17} For more information, visit: http://www.covenantofmayors.eu/index_en.html (accessed 13 February 2015).

\textsuperscript{18} http://www.c40.org/cities (accessed 13 February 2015).

\textsuperscript{19} The GDP and the population information are 2013 data and the C02 emissions, 2010. The data is available at: http://data.worldbank.org/country (accessed 8 February 2015).
2.2) New York City: the noteworthy U.S. example

NYC is known for its urban scenery. Buildings define most of the City’s environment and because of that, making them more energy efficient is key for the accomplishment of the City’s...
GHG emissions reduction goal. PlaNYC (2007), the most recent effort of the City to address its greater long-term challenges\textsuperscript{20}, proposed several measures to reach a 30% GHG emissions reduction by 2030. The City’s ambition has gone even further; in 2013 NYC completed a comprehensive study of the technical potential to further reduce GHG emissions up to 80% by 2050 using current technologies and taking into account the uniqueness and complexity of NYC’s built environment. The New York City’s Pathways to Deep Carbon Reductions report\textsuperscript{21} found that 62% of the GHG reductions needed must come from more efficient buildings, resulting in the One City: Built to Last Plan\textsuperscript{22}, as it will be further explained below. Once again, the building sector is key in the decrease of GHG emissions and, therefore, in the fight against climate change.

Following an overview of the specific characteristics of NYC’s building stock, a description of the measures already developed in the City and the results of the assessment of all energy efficiency measures developed in the most important cities selected, the paper will try to point out some general energy efficiency recommendations that could valuable for the existing urban environment in Europe, NYC or any city and/or country in the world.

\subsection*{2.2.1) Characteristics of NYC’s building stock}

NYC has a diverse building stock encompassing approximately 1 million structures of almost every imaginable type and combination of uses. The great majority of NYC’s buildings are more than 50 years old\textsuperscript{23}. The City’s largest construction development peak was in the 1920s, and the lowest number of properties were developed in the 1930s and 1950-1960s\textsuperscript{24}. By 2030, at least 85% of the buildings will be made up of those already present today.

\textsuperscript{21} The report, which is part of PlaNYC’S Greener, Greater New York, is available at: \url{http://s-media.nyc.gov/agencies/planyc2030/pdf/nyc_pathways.pdf} (accessed 21 November 2014).
\textsuperscript{23} To see the exact age of any building in New York City, go to: \url{http://gizmodo.com/the-exact-age-of-almost-every-building-in-nyc-in-one-m-1348558392} (accessed on the 18th of November 2014).
Residential buildings dominate the building sector, representing 92% of buildings and 70% of built area. Commercial and institutional buildings (primarily offices, but also hospitals, universities, and municipal facilities) represent 5% of buildings, but a disproportionate 22% of the built area. Finally, industrial buildings only represent 3% of buildings and 6% percent of the built area.²⁵

Unlike most residents across the US, in NYC only 33% of residents own their apartment or house. This explains why in NYC the split incentive is one of the most important problems in order to achieve the energy efficiency goal of its building stock.²⁶

Despite the fact that emissions from buildings have fallen slightly since 2005 due to the conversion to cleaner burning natural gas for heat and hot water and to a cleaner electricity grid, the building sector in NYC is still responsible of about 75% of NYC’s GHG emissions. This proportion is almost twice the national average; however, this is due to the fact that most New Yorkers walk or use public transportation instead of driving, resulting in relatively little emissions from cars. Of the emissions coming from buildings, roughly 55% come from the onsite combustion of natural gas and liquid fuels to produce heat and hot water, and to cook; the remaining 45% of emissions stem from electricity production and consumption.²⁷ In general, the proportion of electrical use is much higher for office buildings (around 65%), which are cooling dominated, than multifamily ones (around 30%), which are heating dominated.²⁸ Steam use is insignificant except for multifamily buildings dating between 1960 and 1990, and onsite fuel use, natural gas and the dirty residual oils are equally used for multifamily buildings constructed between 1900 and 1970, before they were replaced by natural gas.²⁹

²⁹ New York City’s Mayor’s Office, PlaNYC, op.cit., p. 21.
2.2.2) NYC’s energy efficiency measures

What follows is a brief description of measures set out primarily by PlaNYC and its extension throughout One City Built to Last plan, the main policy instruments of the City that have resulted in a number of interesting and effective initiatives. They range from regulatory to voluntary actions, and are summarized down below:

<table>
<thead>
<tr>
<th>Type of measure</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Regulatory</td>
<td>- Zone Green: zoning regulation amendment to remove impediments to the construction and retrofitting of green buildings</td>
</tr>
<tr>
<td></td>
<td>- Local Law 84: Benchmarking submission by building owners for public disclosure.</td>
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<td></td>
<td>- Local Law 85: NYC Energy code, for all building types.</td>
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<td>- Local Law 86: LEED Law.</td>
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<td></td>
<td>- Local Law 87: Energy Auditing and Tuning.</td>
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<tr>
<td></td>
<td>- Local Law 88: Lighting upgrades and energy usage information in buildings over 50,000 sqf and tenant spaces over than 10,000 sqf.</td>
</tr>
<tr>
<td>Economic and market based:</td>
<td>Residential Programs:</td>
</tr>
<tr>
<td></td>
<td>- Home performance with Energy Star</td>
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<tr>
<td></td>
<td>- Solar Electric (PV) Incentive Program</td>
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<td></td>
<td>- On-Bill Recovery Loans</td>
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<tr>
<td></td>
<td>- Smart energy Loans</td>
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<td>- Home performance with Energy Star</td>
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<td>- Solar Electric (PV) Incentive Program</td>
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<td>- On-Bill Recovery Loans</td>
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<td></td>
<td>- Smart energy Loans</td>
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<tr>
<td></td>
<td>Multifamily - Advanced Submetering Programs</td>
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<tr>
<td></td>
<td>- Multifamily Performance Programs</td>
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<tr>
<td></td>
<td>- State Energy Investment Program (EnVest)</td>
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<td></td>
<td>Financial - American Recovery and Reinvestment Act</td>
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<tr>
<td></td>
<td>- Weatherization Assistance Program (for low income)</td>
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<tr>
<td></td>
<td>NYSERDA - Con Ed Multifamily EE Program</td>
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<tr>
<td></td>
<td>- Energy service Agreements (ESA)</td>
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<td></td>
<td>- Direct Loans</td>
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<tr>
<td></td>
<td>- Expenses for Conservation and Efficiency Leadership (ExCEL)</td>
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<td></td>
<td>Local - Green Roof tax abatement</td>
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<tr>
<td></td>
<td>- Solar Panels tax abatement</td>
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<tr>
<td></td>
<td>Support/Information and voluntary actions - Energy Aligned Clause (EAC)</td>
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<tr>
<td></td>
<td>- Green Light New York (GLNY)</td>
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<td></td>
<td>- GreeNYC</td>
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<td></td>
<td>- The Maryo’s Carbon Challenges</td>
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<tr>
<td></td>
<td>- Municipal Entrepreneurial Testing System (METS)</td>
</tr>
<tr>
<td></td>
<td>- NYC Cool Roofs</td>
</tr>
<tr>
<td></td>
<td>Packaged measures (public-private collaboration) - Retrofit Standardization Initiative</td>
</tr>
</tbody>
</table>

3. **BEST PRACTICE EXAMPLES FOR THE MOST IMPORTANT ENERGY USES IN BUILDINGS**

NYC’s efforts to improve the energy efficiency of its existing building stock is exceptional and represents an excellent example for any other city in the world, especially given the variety of its building stock’s characteristics. However, there is always something to learn, and it is the aim of
this paper to find the combination of practices that in each particular case best help a specific city to improve the energy performance of its existing building stock.

Also, a great number of European cities are implementing a significant number of innovative energy efficiency measures. However, despite their impressive results, there is no single formula that would give a general solution to any city in the world. Instead, an array of actions are needed in order to best meet the specificities of each city, in a case by case scenario.

What follows is a selection of some of those energy efficiency measures that represent remarkable examples of the most important uses in buildings (space heating, water heating, space cooling and use of electricity for appliances and lighting) in certain EU counties –among those previously selected –as well as solutions implemented in NYC for that specific use.

It should be noted, before starting this process, that:

- In Europe, residential space heating represent more than 65% of total final energy use; water heating and appliances around 13% each, cooking 4% and lighting 3%. The contribution of natural gas accounts for the largest share, around 405, whereas coal represents only around 3% of total energy use\(^\text{30}\).

- In NYC, 55% GHG emissions from the building sector stem from onsite combustion of natural gas and liquid fuels for heating (space and water heating), and around 45% comes from electricity production and consumption (mainly used for air conditioning devices and electricity appliances, including lighting)\(^\text{31}\).

### 3.1) Most efficient space heating practices

The Netherlands is the country with the best performance among EU countries in space heating. Most Dutch homes are heated by natural gas and interestingly, it has a large diffusion of central


heating\textsuperscript{32}, just like NYC\textsuperscript{33}. The space-heating consumption per sqm and degree-day in The Netherlands is 40\% lower than France. Finland, Denmark, and Sweden are 30\% more efficient than France, but not as efficient as the Dutch.

However, The Netherlands has a greater share of individual dwellings, which are less efficient than collective ones, but this is offset by the fact that single family dwellings are mainly composed of semidetached houses (60\% of total housing compared with 20\% in France). The structure of occupation (owner versus renter) and the average age of building stock in The Netherlands is similar to France, therefore, these characteristics do not explain the performance difference. But the large diffusion of condensing boilers in the Netherlands (68\% of dwellings) significantly impacts the heating efficiency, hence, the specific consumption of energy.

The social housing sector in The Netherlands represent an important share of the total rental market, equivalent to around a 30\% of all the housing stock. According to the SHAERE database\textsuperscript{34}, the average energy index of the social dwellings in The Netherlands was really low, equivalent to a label D according to the Dutch energy labeling system\textsuperscript{35}.

The Dutch success in this case is due to active policies for the energy efficiency efforts in existing dwellings, which were enforced during the 80’s. In particular, the National Program for the Insulation (NPI) of existing dwellings (1978 to 1987)\textsuperscript{36}, applied to 2.5 million dwellings. While the energy performance of the Netherlands was 9\% lower than France in 1980, it became rapidly more efficient as early as 1986. In addition, The Netherlands implemented more thermal

\textsuperscript{32} The dwelling stock structure between individual and collective dwellings influence countries’ energy performance, since an individual dwelling consumes on average more energy per m² than a collective dwelling, and the share of individual and collective dwellings is substantially different from one country to another. Bosseboeuf, D. (Dir.), op.cit., p. 34.
\textsuperscript{33} Buildings in New York City, particularly multiunit apartments and commercial office buildings, use forced hot water or steam systems for heating. These types of systems use a boiler to heat water—the resultant hot water or steam flows through pipes to baseboard or free-standing radiators located in each room. http://www.edf.org/sites/default/files/10087_EDF_BottomBarrel_ch2.pdfMany (15th August 2014).
\textsuperscript{34} Sociale Huursector Audit en Evaluatie van Resultaten Energiebesparing, where all energy data is collected.
regulations (the highest number of thermal regulations in the EU in the past 30 years, with 8 updates) than France, and enforced more rigorous specific consumption norms for new dwellings.

The NPI provided subsidies for insulating techniques covering 91% of total costs. Until 1980, subsidy per dwelling could only be 30% of the investment, and dwellings without central heating could also apply for the subsidy. Social housing corporations were enabled to invest in insulation by offering them a special type of loan in cooperation with the banks. The available budget for the program included the cost for the organization and the execution of the program. It was decided that the Association of Dutch municipalities become members of the organizing committee\textsuperscript{37}. Although the NPI did not yet include a labeling requirement, the NPI still offers consumers an annual cost reduction in natural gas use of almost 800 million euros.

After the NPI, other policies were implemented. The Building Code (1992) introduced the minimal thermal resistance of buildings. The total energy consumption limit was later included in the Building Code in 1995, using the so-called Energy Performance coefficient. It roughly included space and water heating, ventilation, lighting, cooling, and renewable generation. During the following years, the coefficient was reduced and the energy quality of new buildings improved. The Energy Performance Certificate was introduced in 2008, after the European EPB Directive (2002). This energy label expressed the energy performance of houses by using letters (from A to G), and was compulsory in The Netherlands for dwellings that were going to be sold. Finally, the National Energy Saving Plan (2008-2020) was prepared to reduce the energy consumption in the built environment.

In short, the success of the Dutch space heating policy can be explained by five main factors: a large diffusion of gas condensing boilers, a rapid turnover of the dwelling stock, a higher updating rate in thermal regulations, the implementation of programs to speed up the retrofitting of the existing dwellings, and a high energy price policy.

\textsuperscript{37} Entrop, A.G. & Browers, H.J.H., \textit{op.cit.}, pp. 146 and 147.
In NYC, only 10,000 buildings burn heavy forms of heating oil, but they contribute more soot pollution than all of the cars and trucks on the City’s roads. The Clean Heat Plan[^38], Local Law 43 (2010), and other state legislation regulating heating oils (No. 4 and No. 6, both GHGs[^39]) were put in place to address the public health hazard presented by the burning of these fuels[^40], which emit sulfur dioxide (SOx) and fine particulate matter (PM 2.5). Under the new local rule, new boilers or burner installations had to switch immediately from No. 6 or No. 4 oils to cleaner fuels, such as a low-sulfur version of the No. 2 oil, biodiesel, natural gas or steam. Also, existing buildings that use No. 6 oil had to convert by 2012 to a cleaner fuel before their three-year certificate of operation expired to arrive to a full phase-out of No. 6 oil by mid-2015. Finally, boilers not replaced by 2030 would need to be modified to meet the new regulations[^41].

To accomplish this, the Plan provides technical assistance and information about financing and incentives. A number of financing solutions are currently available in the marketplace in partnership with financial institutions and other private and public entities[^42]. Also, several incentives and rebates have been developed for buildings that may be eligible when converting to cleaner fuels[^43]. Other incentives are intended to save money through incorporating energy efficiency measures at the same time.

[^38]: The NYC Clean Heat Program provides technical and financial assistance to property owners to convert to cleaner fuels at a faster pace than required by regulation. [www.nyc.gov/planyc](http://www.nyc.gov/planyc) (19th August 2014).
[^40]: Just 1 percent of all buildings in the city produce 86% of the total soot pollution from buildings—more than all the cars and trucks in New York City combined. They do this by burning the dirtiest grades of heating fuel available, known as residual oil, or No. 6 and No. 4 heating oil. [http://www.nyc.gov/html/gbee/html/codes/heating.shtml](http://www.nyc.gov/html/gbee/html/codes/heating.shtml) (19th August 2014).
[^42]: See a list of financing entities at: [https://www.nyccleanheat.org/content/financing](https://www.nyccleanheat.org/content/financing) (Accessed on the 30th November 2014).
[^43]: Example of this are: incentives such as i) discounted service contracts or group buying discounts, among other offers, to encourage buildings to convert from No. 6 or No. 4 heating oil to ultra-low sulfur No. 2 heating oil (ULS 2) with biodiesel, ii) refundable tax credits against personal income tax or franchise tax for the purchase of biodiesel fuel for residential space and water heating, iii) customized plans, such as Con Ed’s, to assist customers with the necessary capital to convert to natural gas, or National Grid’s, to cover up to 50% of conversion cost for business and multifamily customers switching from heating oil to natural gas, and iv) energy efficiency upgrades initiatives (Con Ed, National Grid, NYSERDA and NY State Weatherization Assistance program). More information at: [https://www.nyccleanheat.org/content/incentives](https://www.nyccleanheat.org/content/incentives) (accessed on the 30th of November 2014).
While levels of SOx have decreased in all heating oils (69% from 2008 to 2013), PM 2.5 levels (dropped 25% during the same time period) are only reduced when individual buildings take action and make the switch from heavy heating oils to cleaner alternatives. However, the proliferation of these new rules and the general strengthening of the city’s energy code is that the gap between what is required according to the code and what is actually being practiced in the city’s building stock will only continue to increase with the complexity escalation of the process. Hence, contractor and building manager education efforts should be unequivocal and have clear support.

3.2) Water heating best practice examples

Water heating represents around 13% of EU household consumption (2009 data). Energy consumption for water heating per dwelling has decreased in most EU countries since 1997, except in Spain, Cyprus, Belgium, Slovenia, and Hungary. In the US, water heating represents 18% of total energy consumption, and 17% in NY (2009 data).

The case of Sweden is very impressive with around a 12% reduction from 1997 to 2009. The heating sector in Sweden (to a large extent, district heating) is practically fossil fuel free as a result of the increased use of biomass and heat pumps. The same is true for the electricity sector, where the high share of renewable energy in the energy mix (47% in 2009), mainly hydropower and nuclear, stands for the bulk of production. Also, wind power is increasing rapidly. The main policy measures in Sweden are general economic instruments, providing financial incentives aiming for cost-effective solutions and promoting competition between technologies. This includes CO2 and energy taxation, emissions trading and tradable green certificates for renewable electricity. This is complemented with other measures, such as research, development, demonstration efforts, and information efforts to influence consumer behavior.

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44 [https://www.nyccleanheat.org/content/program-progress](https://www.nyccleanheat.org/content/program-progress) (19th August 2014).
In any case, solar energy has been promoted in the EU as a substitute for conventional energy currently used for water heating, especially in southern countries that have good solar radiation. At first, they received financial incentives (subsidies or soft loans) and fiscal incentives (tax credits). More recently, mandatory regulations for the installation of solar heaters in new buildings have been enacted in countries like Spain\textsuperscript{48}. Around 85\% of dwellings in Cyprus have solar heaters; 35\% in Greece; 17\% in Austria; and 11\% in Malta. A larger progression has been observed in Greece, Malta, and Austria. Indeed, Austria is the benchmark for most medium solar radiation countries\textsuperscript{49}.

Many buildings in NYC use forced hot water or steam systems for heating with fuel oil or natural gas. As indicated before, even though only 1\% of NYC buildings use dirty oil (No. 4 and No. 6), they represent around 85\% of all pollution coming from buildings. And this applies not just for space heating but also for water heating, as those buildings use fuels for all heating purposes. Despite the improvements already accomplished in this regard by the Clean Heat program, as indicated before, the City has advanced a state legislative and regulatory agenda intended to implement a number of energy-related PlaNYC goals, including a recent proposal to encourage solar development by broadening the terms under which solar arrays can feed unused power back to the electric grid\textsuperscript{50}. It should be noted, though, that according to a CUNY 2013 report\textsuperscript{51}, solar heating has not been incorporated yet into NYC’s efforts in energy efficiency. As a result, the City has implemented a major “Clean Heat” initiative to transition buildings using dirty oil to cleaner burning fossil fuels like natural gas or No. 2 oil, as explained before.

It seems that, enforcement of existing thermal (for space and water heating) regulations, implementation of high subsidies that include all costs of the investment chain, and the fulfillment of some economic instruments that have been proven to be very effective in Europe (like the Energy performance Certificate for homes and for appliances) might contribute to the

\textsuperscript{49} Petersdorff, C. (et. al.) ODYSSEE, op.cit., p. 31.
\textsuperscript{50} PlaNYC Progress Report 2013, op.cit., p. 38.
already successful space and water heating improvement measures in NYC. Particularly interesting is the firm Swedish commitment to a carbon tax and to innovation and technology promotion. Although a carbon tax would be a resounding and clear measure\textsuperscript{52}, it is still very controversial, not only in the US but in most EU countries.

3.3) Most efficient space cooling practices

There is a very strong relationship between air temperature and electricity consumption for air conditioning by households. In the US, household air conditioning (AC) has been widely used for several decades\textsuperscript{53}, whereas it has only recently begun to spread in Europe, but still contributes little to electricity demand in most European countries, as they have warm summers\textsuperscript{54}. Despite this, in the last years there has been a rise in the European average energy consumption for cooling, especially Southern countries (Italy, Spain, Malta, Cyprus and Greece)\textsuperscript{55}, hence, a regulation increase for requirements regarding thermal comfort. Indeed, the stock of air conditioners installed in Europe is expected to grow from today’s 40 million units to over 110 million units by 2020, with an energy consumption increase of 75 TWh each year (BAU)\textsuperscript{56}, and even more as the climate gets warmer. Also, due to the great amount of electricity

\textsuperscript{52} As was recently indicated by Michael B. Gerrard, “(a)lmost all economists agree that the best way to fight climate change is through a price on carbon, either through a carbon tax or a cap and trade system”: http://www.huffingtonpost.com/michael-b-gerrard/challenges-to-epa-propos_b_5698336.html (accessed on the 30th of November 2014).

\textsuperscript{53} In the US, AC systems use about 6% of all the electricity produced in the country, costing homeowners more than $11 billion a year. Also, 2/3 of all US homes have an AC device. According to the US Energy Information Administration, in NY, more than half of households (53%) use individual window or wall air conditioning units, while only 20% have a central air conditioning system. http://www.eia.gov/state/?sid=NY (accessed on the 18th August 2014).


\textsuperscript{55} By far the largest market of AC in the EU is Italy with 33% of EU sales, followed by Spain (21%), and Greece (13%). These three countries combined form 2/3 of the EU market for AC appliances. Since Greece is close to its expected maximum saturation, the main growth for the coming years will come from large markets such as Italy and Spain, unsaturated markets like France and UK, and the northern European countries for AC appliances that include a heating function. Petersdorff, C. (et. al.), ODYSSEE., op.cit., p. 48.

they use and the coolants they contain, ACs largely contribute to climate change. This is why it is worth addressing AC devices separately from the rest of electricity appliances.

Directive 2002/91/EC, recasted by Directive 2010/31/EU on energy efficiency of buildings, responded to this trend by requiring regular inspection of cooling systems to ensure a minimum standard of energy efficiency. Also, Directive 2009/125/EC, regarding ecodesign requirements for air conditioners and comfort fans, was amended in order to curb this trend. Indeed, thanks to efficiency improvements (helped with the labeling mechanism, also in effect since 2002), electricity consumption growth was lower than the growth in AC ownership. Lastly, Regulation (EU) No 517/2014, of 16th April, on fluorinated GHG, and repealing Regulation (EC) No 842/2006, strengthens the existing measures and introduces a number of far-reaching changes so that by 2030 the EU’s F-gas emissions will be cut by 2/3 compared with 2014 levels.

AC products are similar in all Member States. Most of them (55-75%) are split speed – inverter – air conditioners, which are today’s best available technology (BAT). Thanks to regulation, mainly to the new energy label, the increasing use of AC in Mediterranean countries has an important counterweight. Therefore, the implementation and control of use of the energy label, together with a subsidy policy for the replacement of old and inefficient AC units with best available technology, are key for improving cooling energy efficiency.

In NYC, in order to meet the City’s goal of reducing GHG emissions by 80% by 2050, the NYC Energy Conservation Code (NYECC, already mentioned) sets energy-efficiency standards for new buildings and for the renovation of the existing ones, with the purpose of: a) making sure buildings are properly sealed by providing a tight and insulated envelope (roof, walls, windows, foundation) to keep heating and cooling inside the building while still providing fresh outside air; b) illuminating buildings' interiors using efficient lighting and as much daylight as possible.

57 The leading scientists in the field have recently calculated that if all the equipment entering the world market uses the newest gases currently employed in AC, up to 27% of all global warming will be attributed to those gases by 2050. Velders, G.J.M. (et al), “Preserving Montrela Protocol Climate Benefits by Limiting HFCs”, Science 24, February 2012, Vol. 335, n. 6071, pp. 922-923.
58 Petersdorff, C. (et. al.), ODYSSEE., op.cit., p. 49.
to accomplish this; and c) using as much recycled energy as possible to reduce buildings' power consumption\(^{60}\).

The City Housing Maintenance Code and State Multiple Dwelling Law in NYC requires building owners to provide heat and hot water to all tenants between October 1st and May 31\(^{61}\), but there is no regulation regarding the use of AC, only comfort guidelines\(^{62}\).

Due to technological improvements and possible adoption of correct habits of use (behavioral measures) and building design ("vernacular"\(^{63}\) and "passive house" standards\(^{64}\), on top of regulation, energy efficiency measures in AC systems can be more effective. There is large room for AC improvement, reducing energy consumption without affecting the energy service offered. Traditional practices base their good performance on three essential principles: minimizing solar radiation, lowering heat loads, and improving ventilation. Cooling demand depends precisely on the right execution of these principles and can be achieved with proper insulation of roofs, walls, floor, and windows, as well as with good ventilation. In the same line, there is strong evidence, following two important collaborative projects supported by the European Commission\(^{65}\), for more explicit action to ensure that building regulations include a requirement to minimize the need for cooling through passive means, including a provision for shading and additional ventilation in the summer.


\(^{61}\) N.Y. ADC. LAW § 27-2029. NY Code - Section 27-2029: Minimum temperature to be maintained: During the day (6 a.m. to 10 p.m.), when the outdoor temperature falls below 55° F, the minimum indoor temperature is required to be at least 68° F. At night (10 p.m. to 6 a.m.), when the outdoor temperature falls below 40° F, the minimum indoor temperature is required to be at least 55° F. [http://codes.lp.findlaw.com/nycode/ADC/27/2/2/8/27-2029](http://codes.lp.findlaw.com/nycode/ADC/27/2/2/8/27-2029) (accessed on the 19th August 2014).


\(^{64}\) The term passive building comprises both a set of design principles (or a design methodology) and a quantifiable performance standard that can be implemented in all building types (not only houses, but also apartment buildings, office buildings, schools, etc.). Buildings that meet the standard use dramatically (up to 80%) less energy than conventional code buildings, and provide greater comfort and excellent indoor air quality. Kingenberg, K. & Knezovich, K. “An Introduction to Passive House Principles and Policy”, Environmental Law in New York, Arnold & Porter LLP, Lexis Nexis, Vol. 26, No. 3, March 2015, p. 1.

A 2012 study on the impact of Directive 2010/31/EU\textsuperscript{66} concluded that, in moderate climatic zones, insulation has no significant effect on cooling demand, and, therefore, should only receive attention after the needs of reducing the heating demand are fulfilled. Cooling demand for residential buildings in the moderate climatic zone can be easily avoided by efficient shading systems, lowered internal gains\textsuperscript{67} and an adaptive ventilation strategy. In principle this is equally applicable to office buildings, but the building must be designed more carefully because of the higher internal gains. But this is not the case of NYC, which has a humid subtropical climate. As mentioned before, the city’s summers are very hot and humid, similar to some Mediterranean cities, like Madrid or Athens, in terms of temperature. However, in warm weather, the cooling demand can be drastically reduced by a combination of lowering the heat loads and ameliorating the insulation of the dwelling:

- **Heat loads** can be reduced through the use of shading devices, which, on top of combating heat gain, prevents glare, decreasing cooling energy requirements. However, the requirements are sometimes hindered by zoning regulations, which restrict their efficaciousness\textsuperscript{68}. In the case of an office building in warm weather, insulation of the façade does not have a positive effect because the heat load of the building compared to a residential building is still relatively high, and heat can be extracted either by ventilation or by wall transmission. On the contrary, in this case, roof insulation still has a positive effect on cooling demand with high heat loads\textsuperscript{69}.

- **Roof insulation** is a very efficient measure to minimize cooling demand with reduced heat transmission caused by heat and solar radiation. On the contrary, high insulation of the floor of a building causes an increase in cooling demand due to the avoidance of earth


\textsuperscript{67} The energy released by people, machines, lighting and other sources which are not part of the heating system are “internal gains”, and can have a profound affect on the indoor climate and need to be controlled. This information is available at: http://new-learn.info/packages/clear/thermal/buildings/active_systems/internal_gain.html (Accessed on the 25th January 2015).

\textsuperscript{68} This is the case of the proposal to amend the NYC zoning resolution & NYC Building Code, with respect to the “sun control device”. EF6: Increase allowable size of solar shades. Zoning Resolution NYC Building Code. Proposal developed by the Energy Ventilation Committee. EF6: http://urbangreencouncil.org/sites/default/files/a15U0000000LgLhIAK1388005367.pdf (16th August 2014).

\textsuperscript{69} Petersdorff, C. (et. al.), ECOFYS, op.cit., p. 25.
If the heat load is high, insulation can reduce the cooling demand by around 15%, but if heat load is low, the reduction can rise to 85%. Therefore, a combination of measures (on roofs, façades, windows and ground floors) is essential to reduce the cooling demand of a dwelling in a warm climate. In the case of an office building, roof insulation can result in a 24% reduction of cooling energy demand in spite of high internal loads. For cities like Athens or Madrid, the effect of additional insulation increases: with a hotter climate and lower heat loads inside the building, the benefit of insulation on the reduction of cooling energy demand grows.

As part of PlaNYC (2007), NYC launched in 2010 the °CoolRoofs initiative aimed at promoting and facilitating the cooling of NYC’s rooftops through a public-private partnership. As indicated before, it is designed to cool one million rooftops in NYC by applying a reflective surface to the roof to help reduce cooling costs, cut energy usage, and lower GHG emissions.

It is clear that the capacity to keep cool is strongly affected by buildings’ design (applicable to new but also to refurbished buildings), which may be more amenable to the usual forms of policy intervention. Vernacular architecture for warmer climates tends to incorporate features that are effective in limiting high temperatures in summer, such as the case of passive houses, or green roof practices, which are very extensive in northern Europe.

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70 The practice of building into the ground to take advantage of the vast thermal mass of the earth, which typically remains a constant temperature at a certain depth below grade (depending on the climate). 40 pp. Available at: [http://www.dictionaryofconstruction.com/definition/earth-coupling.html](http://www.dictionaryofconstruction.com/definition/earth-coupling.html) (16th August 2014).


74 Henderson, G. op.cit., p. 548.

75 Historically, turf roofs were common in northern Europe, but decreased in popularity as the industrial revolution progressed. However, modern extensive green roof practice was stimulated by improvements in roofing and waterproofing technology emerging from Germany in the 1970s and 1980s. Legislation was introduced to encourage the installation of green roofs, and, by 2001, 43% of German cities provided incentives for green roof installation. Other countries in Europe such as Switzerland and Austria also have a long tradition in using green roofs. More recently Canada, parts of the United States of America, Japan, and Singapore have experienced a growth in green roof uptake. [http://www.greenroofguide.co.uk/what-are-green-roofs/](http://www.greenroofguide.co.uk/what-are-green-roofs/) (accessed on the 13th January 2015).
NYC is also looking to passive house, carbon neutral, or “zero net energy” strategies to inform the energy standards as well as exploring innovative technologies to improve the energy performance of building appliances. Examples of these are: a) the Knickerbocker Commons, the first mid-sized apartment building designed to passive house standards in the US (located in Brooklyn, NYC), and b) the promotion of liquid desiccant air conditioning for AC appliances which dehumidifies and cools simultaneously and cuts conditioning loads by half or more\textsuperscript{76}.

There has certainly been progress, but there is still a lot to be done, especially with respect to cultural and behavior standards. Also, regulation should be enforced rigorously. Key policy recommendations include the use of a mandatory and clear energy label, the promotion of subsidies for the substitution of old and inefficient AC units for BAT, and the use of passive house standards when a building is going through major renovation.

3.4) Appliances and lighting most successful practices

Lighting represents around 10.5% of residential electricity consumption in the EU, and it is the third most important household use after electricity for heating and cold appliances\textsuperscript{77}, but with significant differences among countries. Electricity consumption in NYC homes is much lower than the US average, because many households use other fuels for major energy end uses like space heating, water heating, and cooking.

Until 2002, the consumption per dwelling in the EU increased 1.4%/year, but since then, it has decreased by 0.2%/year\textsuperscript{78}. In countries like Bulgaria and Slovakia, with low levels of consumption, or Denmark and the UK, with higher levels, there has been a decreasing trend. In contrast, there was moderate progress in other countries with already high levels of electricity use, like Sweden and Germany, and fast growth in southern countries such as Cyprus, Spain or Greece. In any case, the strongest lighting consumption growth occurred on small appliances (6.5%/year, on average). Larger appliances registered a decline due to high levels of efficiency (almost 10% of refrigerators, washing machines and dishwashers sales correspond to highest

\textsuperscript{78} Petersdorff, C. (et. al.), ODYSSEE, op.cit., p. 46.
efficiency A class appliances, reaching around 40% in The Netherlands and 45% in Germany in 2009) and ownership saturation. Nevertheless, important efficiency potential remains unrealized, especially for refrigerators. In spite of that, energy efficiency of large appliances has been offset by an increase in equipment ownership.

Compact Fluorescent Lamps (CFLs) represent one of the most efficient solutions available today for improving energy efficiency in residential lighting. The recent drop in price, along with several information and promotional campaigns, has had a positive impact on sales. Also, specific national policies and measures were implemented in member states, such as the white certificate schemes in the UK and Italy.

With the Ecodesign Directive (2009) a phasing out of incandescent bulbs was implemented until 2012. Non-clear (non-transparent) incandescent lamps were required to be A-class (label), which means they had to be compact fluorescent lamps, saving about 80% energy compared with incandescent lamps. Also, less efficient clear lamps had to be phased out progressively, from 2009 till 2012 (first stage), and in 2016 (second stage). LEDs are the more promising technology, covered as A-class lamps in the Ecodesign Directive.

Also, Information and Communication Technologies (ICTs) are among the fastest growing electricity end-use in the residential and tertiary sector, currently growing at around 4% per year. Not surprisingly, the most advanced countries in ICT are the northern EU countries: Sweden tops the index, followed by Denmark, The Netherlands, Iceland, Norway, Luxembourg, Switzerland, Finland, and the UK.

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81 The level of consumption depends not only on the lamps efficiency (i.e. the penetration of CFL), but also on the number of lighting points per dwelling. Petersdorff, C. (et. al.), ODYSSEE, *op.cit.*, p. 48.
82 The CFLs stock in the residential sector grew by some 690 million units (3.47 CFLs/household) over the period 2003-2007, with a 340% increase in the apparent consumption of CFL from 145 million in 2003 177 million in 2004 to 214 million in 2005, a dramatic increase to 316 million in 2006, arriving at 628 million in 2007. The biggest part of these lamps is “CFLi”, used in the domestic sector, with estimated sales around 488 million units/per year in 2007. ENEFF report, *op.cit.*, p 42.
83 ENEFF report., *op.cit.*, p. 43.
84 ENEFF report., *op.cit.*, p. 45.
With respect to electricity consumption of televisions (TVs), the European Commission adopted the Commission Regulation implementing the Ecodesign Directive for the requirements for TVs on July 2009\textsuperscript{85}, demanding a minimum energy performance by 2010; 20% more efficiency for standard TVs and 30% more efficiency for full-HD sets. With energy labeling and performance requirements for TVs reaching full impact, estimated savings are expected to reach around 43 TWh/year by 2020\textsuperscript{86}. Expectations are that equipment for the reception, decoding and interactive processing of digital broadcasting and related services, will contribute substantially to the electricity consumption of EU households in the near future, adding another problem for EU environmental policies.

The largest electricity consumers in the tertiary sector are indoor lighting in commercial buildings (21.6% and 26.3%, together with street lighting), electric space and water heating systems (19.7%), ventilation (12.7%) and commercial refrigeration (8.7\%)\textsuperscript{87}.

In Germany, energy efficiency of major electrical appliances and equipment improved dramatically from 1996 to 2008, and electricity prices have risen. German energy prices are higher than those in the US; therefore, energy efficiency measures are more cost-effective in Germany than in the US. However, increases in demand for electrical services have more than offset the savings from efficiency appliances, particularly in commercial buildings\textsuperscript{88}.

The German Government's Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply, a long-term strategy for energy supply\textsuperscript{89}, specifies national efficiency goals, including an 80% primary energy demand reduction goal by 2050 for the building sector. Mid-term goals include reducing heating demand 20% by 2020; ensuring all new buildings are climate neutral by 2020; and increasing the thermal retrofit rate to 2%. Also, the Energy

\textsuperscript{86} ENEFF report., op.cit.,p. 49
\textsuperscript{87} ENEFF report., op.cit.,p. 85.
Efficient Renovation Program of the KfW Bank Group\textsuperscript{90} provides preferential loans and grants for single energy efficient components and for comprehensive retrofits. Energy audits (as desk advice provided by the German consumer association and on-site advice provided by the Agency for Economy and Export Control, BAFA), as have been shown to have a large impact.

A variety of informative instruments, like Energy Performance Certificates and billing information, although most important in early stages of the retrofit process, have been designed to support participants of building retrofit process, such as building owners, managers, residents/tenants, and construction industry professionals. Also, energy audits have had a large impact.

In any case, policies to reduce energy consumption from equipment and devices in buildings are mostly set at the EU level, mainly with the 2010/30/EU Labeling Directive and the 2009/125/EC Ecodesign Directive. These policies facilitate an EU-wide market for more efficient technologies, setting minimum energy efficiency standards, and requiring energy performance labeling for major appliances\textsuperscript{91}. As a consequence, almost 90\% of refrigerators, washing machines and dishwasher sold had an efficiency class equal to or above A+.\textsuperscript{92} Around 40\% of new refrigerators in The Netherlands and 45\% in Germany were labeled A or A+.

In NYC, the lighting and sub-metering provisions of GGBP require buildings to upgrade their lighting by 2025, but many people are not familiar with the new codes or new technologies. To overcome these barriers, NYC’s government launched Green Light New York\textsuperscript{93}, a lighting resource center where building professionals take classes and see lighting strategies demonstrated.

\textsuperscript{90} The KfW, a German government-owned bank, formed in 1948 after World War II as part of the Marshall Plan, is designed to assist developing countries and the German economy. The KfW bank lends to small and midsized German businesses and buys securitized small and midsized business loan portfolios from German banks in order to keep that area of lending robust. It also provides funds for housing, infrastructure, environmental protection and preservation, and venture capital. More information at: \url{https://www.kfw.de/KfW-Group/} (accessed 2 March 2015).

\textsuperscript{91} The European Commission has recently launched a study on the evaluation of Directive 2010/30/EU (Energy Labeling) and some specific aspects of the Ecodesign Directive, in order to prepare a review of both pieces of regulation. The report is available at: \url{http://www.energylabelevaluation.eu/eu/home/welcome} (22nd August 2014).

\textsuperscript{92} Bosseboeuf, D. (Dir.), ODYSSEE, op.cit., p. 44.

\textsuperscript{93} \url{http://greenlightny.org/} (accessed 19 August 2014).
Launched in 2009, the GGBP requires the city’s largest buildings to benchmark, or measure and report, their energy and water use annually, to complete energy audits and retro-commissioning of building systems, and to upgrade lighting. These properties constitute only 2% of the city’s building stock but comprise approximately 50% of the total built area. Compliance with the GGBP laws will result in a 5% GHG emissions reduction citywide by 2030, a net savings of $7 billion, and the creation of 17,800 jobs. But there is much yet to be done for buildings under 50,000 square feet, which collectively constitute about half of the City’s floor area. For that purpose, two GreeNYC (PlaNYC’s consumer engagement program) marketing campaigns were launched: one in 2009, promoting efficient use of residential air conditioners; and another, in 2010, advocating for energy-efficient light bulbs in homes.

As of December 2014, 52 out of 111 Green Code Task Force (GCTF) recommendations have been enacted or partially enacted, including: “Increase Lighting Efficiency in Apartment Buildings” (NYC Local Law 52 of 2010); “Use Manual On -Automatic Off Lighting” (NYC Local Law 48 of 2010); “Reduce Artificial Lighting in Sunlit Lobbies & Hallways” (NYC Local Law 47 of 2010); “Increase Lighting Efficiency on Construction Sites” (NYC Local Law 51 of 2010, and NYC Local Law 18 of 2014); “Ensure Lighting Systems Function Properly” (NYC Rules, Title 1, Ch. 5000 (DOB)); and “Expand Boiler Efficiency Testing & Tuning” (NYC Rules, Title 15, Ch. 2 (DEP)), among others. Others, such as “Don't Exempt Existing Buildings from Green Codes” (NYC Local Law 85 of 2009), are still partially enacted.

3.5) A best practice to be applied anywhere: an efficient consumer behavior

Besides technological improvement in energy efficiency, which has been the main focus of most policies, policymakers have recently centered their attention on the need to change consumer behavior and lifestyle, based on the concept of “sufficiency”. Policies targeting sufficiency aim
at capping or discouraging increasing energy use due to increased floor space, comfort levels, and equipment\textsuperscript{98}. This can be achieved through incentives like the feed-in tariff.

There are substantial differences in building energy use in the world driven largely by behavior and culture. In many parts of the world, high performance mechanical cooling systems are used capriciously, mainly due to bad architectural design (e.g. the so-called "Walkie Talkie" building in London, designed by Rafael Vinoly – although the “warming” effects in this case occurred to the outside of the building and its surroundings-)\textsuperscript{99}, the use of inappropriate materials for the climate (e.g. the overuse of glass in office buildings)\textsuperscript{100}, and lifestyles based on the excessive use of disposable products (in all developed countries, but especially in the US\textsuperscript{101}). Major characteristics of lower energy use buildings are windows that can be opened for natural ventilation, part time and part space control of indoor environment (thermal and lighting), and variable controllable indoor thermal parameters (temperature, humidity, illumination, and fresh air). Fully controlled indoor climates through mechanic systems result in significantly increased energy demand.

There are practices that have shown the effectiveness of promoting energy conservation behavior to achieve energy reductions by using various methods\textsuperscript{102}. Best behavioral energy practices to achieve energy savings indicate that: a) efficient thermostat settings are needed (cooler than average during the winter and warmer than average during the summer); b) dress codes and cultural expectations towards attires in offices can be relaxed; c) natural ventilation should be possible in any building\textsuperscript{103}, and d) lighting should be operational only during working hours (best 12h/day than 24h/day). Indeed, this last one is the case of the already mentioned French regulation that forces non-residential properties in Paris to switch off the lights at night.

\textsuperscript{98} IPCC Report, 2014, Chapter 9, “Buildings”, \textit{op.cit.} p. 57 and 64.
\textsuperscript{100} \url{https://www2.buildinggreen.com/article/rethinking-all-glass-building-0} (accessed 28 February 2015).
\textsuperscript{101} In 2010, the USA accounted for 37 % of food service disposables globally and is projected to remain the largest market for these consumable goods by a wide margin. Woods, Laura, and Bhavik R. Bakshi. "Reusable vs. disposable cups revisited: guidance in life cycle comparisons addressing scenario, model, and parameter uncertainties for the US consumer." \textit{The International Journal of Life Cycle Assessment} 19.4, 2014, 931-940.
\textsuperscript{103} IPCC Report, 2014, Chapter 9, “Buildings”, \textit{op.cit.} p. 28.
A benchmark example of this is, once again, Germany. Located in a temperate region with cool and wet winters and warm summers, a significant share of its building energy is spent on space heating in order to address thermal comfort. However, due to cultural preference for natural ventilation, demand for mechanical space cooling during the summer is very low\(^\text{104}\).

As stated by the AR5\(^\text{105}\), the goal is to use principles of low-energy design to provide comfortable conditions as much of the time as possible, thereby reducing the pressure to later install energy-intensive cooling equipment, such as air conditioning. These principles are embedded in vernacular designs throughout the world, which evolved over centuries in the absence of mechanical heating and cooling systems\(^\text{106}\). The Passive house methodology is resumes this philosophy.

4. **OVERCOMING THE SPLIT INCENTIVE: THE MOST IMPORTANT BARRIER FOR ENERGY IMPROVEMENT INVESTMENT IN THE EXISTING BUILD STOCK**

The split incentive is one of the most important problems in the pursuit of energy efficiency investment in rental buildings. This is particularly relevant in NYC, as most of its residents (around a 77\%) rent the home they live in. The split incentive arises when the tenant pays the operation costs for the space while the landlord/owner of the apartment/building pays its capital costs and its energy-using amenities. Hence, the landlord/owner of the building, who wants to minimize capital costs and maximize rental revenues, has no incentive to invest in measures that would improve the energy efficiency over time, as the tenant will be the one benefiting from it.

Policy experts around the world agree that there is no single solution for the split incentive problem (as in many others). The solution has to arrive, therefore, from the best combination of different measures designed (for best results) in a case-by-case basis. However, some general ideas could be extracted from best practices examples, in order to try to resolve this important barrier for the energy improvement investment in buildings all around the world.

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\(^{106}\) IPCC AR5, WG III, Chapter 9, *Buildings, op.cit.*, p. 27.
Article 19(1) of Directive 2012/27EU on energy efficiency recognizes the importance of addressing the barrier of split incentives in the building sector\textsuperscript{107}. Practices from Italy, The Netherlands, the UK, Denmark and Sweden have shown some interesting results in both, the social housing sector and in private residential units.

Some of the most successful practices to overcome the split incentive include various types of measures, as follows:

- **Regulatory measures** such as building codes, energy codes and appliance standards that promote high-energy performance would obviate the tenant-landlord investment problem over time\textsuperscript{108}. However, regulatory measures mostly apply to new buildings or include norms that are more suitable for commercial or industrial buildings, and they are not usually considered appropriate for the social housing sector as low-income rental mandates are often politically unacceptable and can disincentive landlord participation. To overcome this problem, an average energy index for social housing dwellings (label B) has been set in The Netherlands\textsuperscript{109}. Also, the social rent evaluation has incorporated the energy performance of the building. A total housing cost guarantee that includes the base rent and utility costs, and ensures that social tenants are protected against increase in their total housing costs in case of an energy renovation\textsuperscript{110}.

It should be indicated that all selected EU countries have stated overall regulatory reduction targets. However, this type of measure is the necessary but not sufficient point of departure

\textsuperscript{107} "1. Member States shall evaluate and if necessary take appropriate measures to remove regulatory and non-regulatory barriers to energy efficiency, without prejudice to the basic principles of the property and tenancy law of the Member States, in particular as regards: (a) the split of incentives between the owner and the tenant of a building or among owners, with a view to ensuring that these parties are not deterred from making efficiency-improving investments that they would otherwise have made by the fact that they will not individually obtain the full benefits or by the absence of rules for dividing the costs and benefits between them, including national rules and measures regulating decision-making processes in multi-owner properties;”. Directive 2012/27/EU is available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:en:PDF (accessed 23 February 2015).

\textsuperscript{108} Economidou, Mariana, \textit{op.cit.} p.5.

\textsuperscript{109} The average energy index of the Dutch social dwellings previous to this measure was 1.73, which is equivalent to label D according to the Dutch energy labelling system. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC90407/2014_jrc_sci_pol_rep_cov_template_online_final.pdf (accessed 28 February 2015), p. 13.

\textsuperscript{110} Economidou, Mariana, \textit{op.cit.} p. 9.
for best example practices. Complementary measures, in the form of financing contracts, information and educational campaigns, are necessary to achieve a greater effectiveness.

- **Financing contracts:**

  o “Green lease”, a rental agreement in which tenants gain incentives by participating in all kinds of sustainable actions applicable to the building, among others, energy efficiency renovations. It could be a two party or a three party agreement. The first one places a surcharge on the rent each month in an amount that is less than the savings realized by the tenant, but sufficient to provide a revenue stream to the landlord in order to payback the energy efficiency capital investment. The three-party agreement includes an energy service company (ESCO). It has been mostly used in the US, and in the EU is considered part of the corporate social responsibility marketing and image programs of the companies that apply them\(^\text{111}\), but are not yet widely used. Experience in Denmark has shown that a standard green lease based on energy label improvements made publically available can increase awareness and guide other landlords and tenants in this type of practice\(^\text{112}\).

  In NYC, the green lease would work best for large institutional, commercial or industrial tenants with large energy loads and that foresee a protracted rental period. Adding a third party, an ESCO, would be essential to the success of this model due to the enormous costs of the projects and the competitiveness of the market\(^\text{113}\).

  o On-bill financing schemes, designed to provide incentives to all stakeholders as they offer attractive solutions for addressing the split incentive. Examples are:

    ✓ *Pay-as-you-save* (PAYS) scheme enables building owners or tenants to purchase and install energy efficiency products with no up-front payment and no debt-

\(^{111}\) [http://www.mondaq.com/x/167624/Renewables/Study+On+The+Use+Of+Green+Lease+Clauses+In+Europe](http://www.mondaq.com/x/167624/Renewables/Study+On+The+Use+Of+Green+Lease+Clauses+In+Europe) (accessed 25 February 2015).

\(^{112}\) Other green lease example is in Boston: even though there has been limited uptake of green leases, some recommendations have been extracted from practice examples in this city: broker education and outreach, additional outreach to real estate lawyers, joint Boston’s buildings energy ordinance (BERDO) and green lease outreach, engage large property management directly, City or state buildings as models, increase collaboration in tenant build-outs and encourage landlord-tenant cooperation, and showcase case studies\(^\text{112}\). Economidou, Mariana, *op.cit.*, p. 21.

\(^{113}\) See Bashford, Kate, *op.cit.*
obligation. Those who get the savings pay for these products through a tariffed charge on their utility bill (on-bill mechanism), but only for as long as they occupy the premises where the products were installed. Hence, the PAYS mechanism is transferable to the subsequent tenant or, in the case of a small appliance (such as an AC unit) the energy service charge would be transferred to the new residence, along with the appliance. The mechanism could include a third party that verifies the efficiency and savings of the products (energy contractor), and a local utility that gives the billing and transfer of chargers to the provider of the PAYS product and the provision of capital to finance the cost of the product. The EU FRESH project\textsuperscript{114} conducted in Italy demonstrated that energy contracting can be used for energy efficiency upgrades in the social housing sector on a large scale\textsuperscript{115}.

The PAYS scheme is most common in the UK and Ireland\textsuperscript{116}, as well as in the US and Canada. In NYC, there have been successful PAYS projects, but some political barriers still need to be overcome\textsuperscript{117}. However, electricity prices in the City are among the highest in the US, therefore, any savings on the electricity bill could have a great impact. Also, this scheme needs little public funding and there is no subsidy involved, which makes it more likely to be supported from a political perspective.

✓ The UK’s \textit{Green Deal} (2013)\textsuperscript{118}, which allows owners to install measures at no upfront costs and enables repayments to be made through a charge on the occupants’ utility bills. The repayment stays with the utility bill rather than the occupier and gets transferred to whoever is the electricity supplier. One of its weakness is the high interest rate attached to the loans, considered uncompetitive

\begin{itemize}
\item \textsuperscript{114} It is an Interreg IV C Project promoting eco innovation through sustainable construction in eight European regions. For more information visit: \url{www.freshproject.eu} (accessed 1 April 2015).
\item \textsuperscript{115} Economidou, Mariana, \textit{op.cit.} p. 15.
\item \textsuperscript{118} \url{www.gov.uk/green-deal-energy-saving-measures/overview} (accessed 1 April 2015).
\end{itemize}
compared to traditional commercial bank loans\textsuperscript{119}. Also, the loans are linked to the property that has been energy upgraded, which creates uncertainty on its future sale.

✓ In social housing units, landlords should be compensated for transaction costs in order to undertake the energy investments.

- **Tax break schemes**, used in the UK, that allows landlords to deduct the cost of acquiring and installing certain energy savings measures against their income tax. It has had limited impact\textsuperscript{120}.

- **Incentives** for both the tenants, subject to the repayment fee in their utility bills, and for landlords, in the form of small share of savings, covering the transaction costs attached to the energy upgrade, are critical to overcome the split incentive problem. The property's value increase due to the energy improvement should be very attractive for the landlord's interest. Also, utilities should be protected from risk/default while decoupling legislation\textsuperscript{121}, to allow them gain incentives to implement energy efficiency programs. A revolving fund\textsuperscript{122} with a benefit charge or a carbon charge system could provide guarantees, address default and risks concerns for financing the energy upgrades, and lower the interest rates\textsuperscript{123}.

- **Information and educational measures:**

  - **One-stop solution center**, such as the one implemented in Sweden or in The Netherlands, would help provide market incumbents with clear information and tools on energy renovation projects, including deep renovation.

  - Especially important is the construction and real estate sectors training, which should be constantly updated according to the latest technological upgrades.

\textsuperscript{119} Economidou, Mariana, \textit{op.cit.} p. 19.
\textsuperscript{120} Economidou, Mariana, \textit{op.cit.} p. 19.
\textsuperscript{121} Decoupling is a tool intended to break the link between how much energy a utility delivers and the revenues it collects. Decoupling is used primarily to eliminate incentives that utilities have to increase profits by increasing sales, and the corresponding disincentives that they have to avoid reductions in sales. The Regulatory Assistance Project. “Revenue Regulation and Decoupling: A Guide to Theory and Application”, June 2011.
\textsuperscript{122} A revolving fund is an account established to finance a continuing cycle of operations through amounts received. \url{http://www.businessdictionary.com/definition/revolving-fund.html#ixzz3T5d1LN8j} (accessed 28 Febrero 2015).
\textsuperscript{123} Economidou, Mariana, \textit{op.cit.} p.9.
Experience has shown, for cost-effective energy efficiency practices in general, and for overcoming the split incentive in particular, that:

- A single-type measure solution has been proven to be unsuccessful. Denmark has put into place packaged policy solutions that include: mandatory energy savings, a revised rent act, green leases, improved energy labels and actions to further facilitate ESCO activities\textsuperscript{124}.

- Comprehensive retrofits deliver the highest average savings and are significantly more cost-effective than other measures. However, they are more complex, therefore, demand more information and training. The richer the country, the more willing it is to develop this type of measures. Incentives and educational campaigns should be promoted in order to make this approach more accessible to all cities.

Finally, attention should be paid to housing units in which reverse split incentives are found, such as in the case of university housing and public housing projects, where the tenants are not responsible for paying their utility bills. In Sweden the dominating residential lease type is the so-called inclusive rent, in which all operating expenses are borne by the landlord. Tenants pay the inclusive rent directly to the landlord whom is responsible for the contract with the utility company. While tenants have no direct incentives to save energy, this method boosts the energy efficiency of the building by the landlord. Individual metering, where possible, and measures aimed at providing information and education on the benefits of energy savings should be applied in order to motivate the users\textsuperscript{125}.

5. \textbf{GENERAL PROPOSALS FOR THE ENERGY PERFORMANCE IMPROVEMENT OF THE EXISTING BUILDING STOCK}

From the above analysis of the energy efficiency measures carried out in a representative part of the world’s existing building stock, some guidelines may be laid down in order to contribute to the energy improvement of any existing residential building in the world. The guidelines can be summarized in the following table:

\textbf{Proposal:}

\textsuperscript{124} Economidou, Mariana, \textit{op.cit.} p.10.
\textsuperscript{125} Economidou, Mariana, \textit{op.cit.} pp. 23 and 24.
1. Regulation: Must be clear and accessible to the general public and especially to the stakeholders. Must meet the latest technology. Must be accompanied by measures involving education on its implementation: it should provide an investment on training. Should take into account other regulations in order to remove impediments to energy improvements (e.g. zoning). Should be enforced rigorously to ensure compliance.

2. Energy labels for appliances: Must be mandatory but flexible: it should be able to adjust to the different baselines levels. Must be upgraded according to the best technology available. Public subsidies/loans should be put in place for replacement of old technologies.

3. Energy labels for buildings (rating): Must include a specific requirement for energy efficiency.


5. Information: Regulation in fore and sanctions in case of non-compliance. Available mechanisms for energy improvements in both, the building elements and materials, and the home appliances, classified by type. Financing instruments available and specific characteristics, indicating the most suitable for each type of renovation. Best examples sharing: publication of the programs results, including data regarding the number of homes that accessed to the measures, the cost and energy saved, and the default rate associated to them. All information should be in a one-stop source.


7. Innovation: Special efforts to invest in new technologies and ideas. Promotion of competition for original energy efficiency solutions, such as the retrofit standardization initiative. Comprehensive retrofits should be promoted.

8. Split incentive: Packaged policy solutions with combination of measures. For all buildings: Education campaigns Revolving funds with a benefit charge supporting energy efficiency. For large buildings: standard third-party lease (with an ESCO) based on energy label improvements and sufficiently publicized (green lease). For smaller buildings: On-bill financing (PAYS), designed to provide incentives to all stakeholders. For social housing: Social rent evaluation included in the energy performance of the building. Staggered energy improvement requirements.
Considering that these proposals have been extracted, as previously indicated, from best practice examples, it would be accurate to say that any of them could ultimately inspire the measures that could be carried out in any city around the world, improving, thereof, the energy efficiency of their respective existing residential building stock and contributing consequently, to the mitigation of the effects of climate change.
RECOMMENDED BIBLIOGRAPHY


