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Reducing energy consumptions and CO2 emissions in European countries: a review on legal environment and increasing use of photovoltaic energy for Electric Propulsion Systems

C. Giaconia, D. La Cascia, F. Lo Bue*, R. Miceli Member IEEE, G. Zizzo

Università degli Studi di Palermo - DIEET (Dipartimento di Ingegneria Elettrica, Elettronica e delle Telecomunicazioni) Viale delle Scienze, Edificio 9, 90128 Palermo
E. mail:diego.lacascia@dieet.unipa.it

A. Le Mouel

EdF R&D - Electricitè de France, Clermant, France
E-mail: anne.le-mouel@edf.fr

Abstract: *Abstract--- In Europe, the building sector is ranked second in terms of CO2 emissions, just after transport. Particularly, it accounts for 25% of the overall CO2 emissions. Moreover, in order to reduce CO2 emissions, European legislations encourage the use of renewable energies and, among them, particularly the use of PhotoVoltaic (PV) one. This because the connection between the use of PV clean energy and the reduction of CO2 emission is well demonstrated. In this context, the first part of the paper is focused on the regulations related to building energy efficiency while the second part investigates the deployment of PV source all over Europe.*

Keywords: Index Terms--- CO2 reduction, legislations, energy efficiency, PV source

1. Introduction

Most of energy consumptions in Europe are located in the building sector. Particularly, it accounts for 40% of the overall European final energy consumption, being the rest divided in equal parts between Industry (30%) and Transport (30%) (fig 1). In Europe, the building sector is ranked second in terms of CO2 emissions, just after transport. Particularly, it accounts for 25% of the overall CO2 emissions. The overall energy consumption of buildings in Europe has constantly increased over the last years: it increased by 30 % over the last 30 years with an average of 1,4% each year over the last 10 years. Because of increasing building constructions and raising of new needs (air conditioning, new appliances, grow of electronic in house, etc), the energy consumption and the CO2 emissions reduction at buildings level represents a hard challenge to face. In this paper the total growth of PV market in Italy, Germany and Spain is focused. The spread of this PV clean energy source together with the use of an energy and load management unit inside apartments may allow to hope for a large reduction of electrical energy requests from the Utility grid. In this context:

- new regulations related to building energy efficiency constitutes the first step towards energy consumption management and are becoming an issue for European societies;
- in order to fulfil fixed objectives in CO2 emissions reduction, the use of renewable clean energy sources in Europe must be increased.

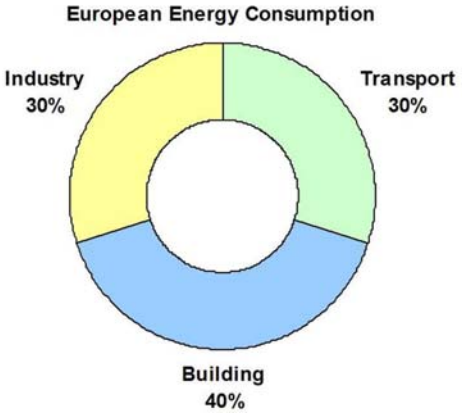

Figure 1: European energy consumption

2. Energy Efficiency Driving Factor

Among the energy efficiency driving factors for the building sector, there are:

• The Kyoto protocol (at international level);
• European initiatives (at European level).

A. The Kyoto Protocol

The Kyoto Protocol [1] is an international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC), initially adopted on 11th December 1997, entered into force on 16th February 2005, and today signed and ratified by 184 Nations in the world. The main feature of the Kyoto Protocol is that it sets binding targets for industrialized countries in terms of reducing GreenHouse Gases (GHG) emissions. For the European Union, the objective is to decrease GHG emissions by an average of 8% over the five-year period 2008-2012. The detailed rules for the implementation of the Protocol were adopted at the 7th Conference of Parties (COP 7) in Marrakech in 2001 and are called the "Marrakech Accords." Under the Treaty, countries must meet their targets primarily through national measures. Nevertheless, the Kyoto Protocol offers three additional market-based mechanisms to meet their targets:

• Emissions Trading, known as "the carbon market";
• Clean Development Mechanism (CDM);
• Joint Implementation (JI).

With the Emission Trading mechanism, GHG emissions are controlled by providing economic incentives for achieving their reduction. With CDM, industrialized countries are allowed to invest in projects for reducing GHG emissions in developing countries as an alternative measure to more expensive emission reductions in their own countries. With the Joint implementation mechanism, countries can invest in emission reduction projects (referred to as "Joint Implementation Projects") in any other Annex I country (Annex I countries include 40 countries and separately the European Union), where the costs are cheaper, as an alternative to reduce emissions domestically. These market-based mechanisms help to stimulate green investment and help Parties to meet their emission targets in a cost-effective way.

B. European Initiatives

In order to build a better energy framework for Europe, a lot of initiatives like the Green Book on Energy Efficiency, the Action Plan for Energy Efficiency and several directives for energy efficiency in buildings have been taken.

The European Green Book on Energy Efficiency [2] describes the global strategy and objectives for all Europe, taking into account the necessary development of renewable energies and concentrating on an efficient control of energy demand. The Green Book states that is possible to decrease energy consumption by 20% before 2020. Europe, moreover, can benefit from energy savings in many ways, reinforcing industry competitiveness thanks to energy savings, creating new jobs in the sector of the energy efficiency and above all, fulfilling its commitment towards the Kyoto protocol. The Green Book addresses 3 different sectors and proposes the following actions to invert the current increasing trend for energy consumption:

1. Promote clean, efficient and cheap vehicles for transport;
2. Use more efficient energy conversion techniques (60% of energy losses are due to inefficiency within the production processes).
3. Achieve important savings with specific measures in buildings (homes and offices).

The Action Plan for Energy Efficiency (2007-2012) [3] establishes concrete actions to achieve the objectives described in the Green Book. The Action Plan considers avoided energy consumption the most important European energy resource. The Action plan supposes that from now on until 2020 it is still technically and economically possible to save 20% of the total primary energy that is consumed within the European Union, not taking into account the energy savings that can be achieved through strict price policies, structural changes in the economy, technologies renewal and current measures.

Finally, the Action Plan proposes, in accordance with the Green Book:

• improvements in energy production processes;

• specification of energy performances for products that need energy, for buildings and energy services;
• promotion of advances in transport;
• a cultural change regarding energy behaviour.

At European level, several directives have been issued. Among these, the most relevant are the "Energy Performance of Building Directive" (EPBD) , directive n. 2002/91/EC, adopted in December 2002 and the "Energy Labelling of Domestic Appliances" (ELDA), directive n. 92/75/CEE, adopted in July 2003.

Energy Performance of Building Directive" (EPBD) [4]. The 27 European Union Members States adopted the EPBD with the purpose to enhance buildings energy efficiency. It is estimated that the EPBD could be able to ensure a 20%saving of the energy regularly consumed in buildings. The Directive defines the general framework for the calculation methodology of energy efficiency in buildings. According to the Directive, building thermal properties, space and hot water heating installations, air conditioning systems, artificial lighting, building geometry, solar systems, external and internal environmental conditions have to be taken into account in the above mentioned calculation methodology. For the calculations, buildings will be classified into: houses, apartment blocks, offices, schools, hospitals, hotels and restaurants, sports centers, shopping centres and other buildings having an energy consumption. The Directive, moreover, foresees an energy certification for buildings (EPC = Energy Performance Certificate). The EPC is an energy indicator which takes into account the characteristics of the building equipments like: heating and cooling systems, domestic systems for hot water production, ventilation, lighting etc. The building energy ratings range from A to G, A denoting the most energy efficient building class and G the least efficient. To each class a precise value of efficiency of a given system is associated. Such certificates are mandatory whenever a building is being constructed, sold or rented. The EPC takes into account two labels: one is for the primary energy use (primary energy per unit floor area per year kWh/m2/year) and another label is for the impact of energy consumption on greenhouse gases emissions (also per unit floor area and per year: kgCO2/m2/year), (fig. 2). Finally, according to the Directive, a periodic inspection of heaters and air conditioning systems must be accomplished and, moreover, the state of heaters with more of 15 years of operation must be evaluated.

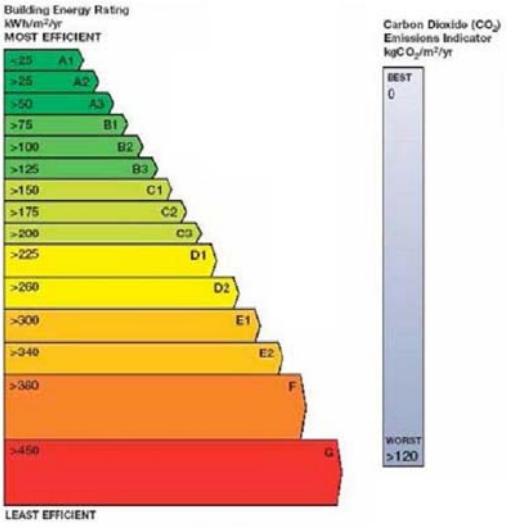

Figure 2: EPC labels

Energy Labelling of Domestic Appliances" (ELDA) [5, 6]. The Energy Labelling Directive requires that appliances are labelled to show their power consumptions in such a manner that it is possible to compare the efficiency of two appliances. The intention is that consumers will prefer more energy efficient appliances to those with a higher consumption, resulting in less efficient products eventually being withdrawn or decommissioned. The actual format of the label depends on the appliance, and its text needs to be translated to the local language of the country where the appliance is sold. Fig. 3 shows the format for a washing machine.

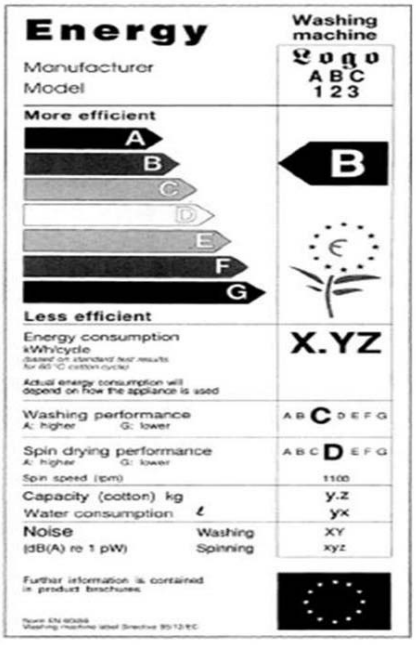

Figure 3: Energy label for a washing machine

The energy label of a washing machine contains information on:
• the total consumption per cycle;

• the washing performance - with a class from A to G;
• the spin drying performance - with a class from A to G;
• the maximum spin speed;
• the total cotton capacity in kg;
• the water consumption per cycle in litres;
• the noise in the washing and spinning cycles dB(A).

In Fig. 4, the energy correspondence between the class and the energy efficiency for a washing machine is reported.

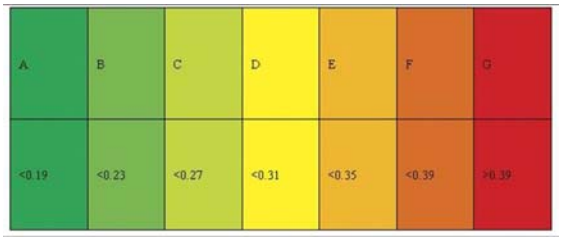

Figure 4: Energy efficiency for a washing machine

3. Use of PV renewable energy

Key European legislations and national regulations encourage the increasing use of renewable energy in Europe in order to fulfil fixed objectives. On 1st June 2006, the European Parliament approved the Innovation Framework Program (CIP) [7], which supports renewable energy sources, energy efficiency and innovative use of Information and Communication Technology (ICT). The Intelligent Energy-Europe Program aims at increasing the use of renewable energy to reduce greenhouse gases emissions by assigning a total budget of €730 millions in order to achieve the specific objective of each member states of the European Union. The most common renewable source adopted at the home level in order to observe the international agreements undertaken in the Kyoto agreement protocol is the PhotoVoltaic (PV). The PV world market has been increasing a lot during the last years. At the end of 2000, the total PV power installed all over the world was about 1,2 GWp; at the end of 2007 about 9,2 GWp and at the end of 2009 about 15 GWp [8]. It means that during the last nine years the total PV power installed has increased about 1250%. Figure 5 reports the total power installed all over the world at the end of 2008. It can be seen that Europe is a protagonist in the PV power installed over the world. In the first five places, in fact, there are Germany, Spain and Italy whose total PV installed power amounts to 9 GWp, that is the 60% of the total PV power installed all over the world. After Europe, United States and Japan follow up, respectively, with 15% and 8%.

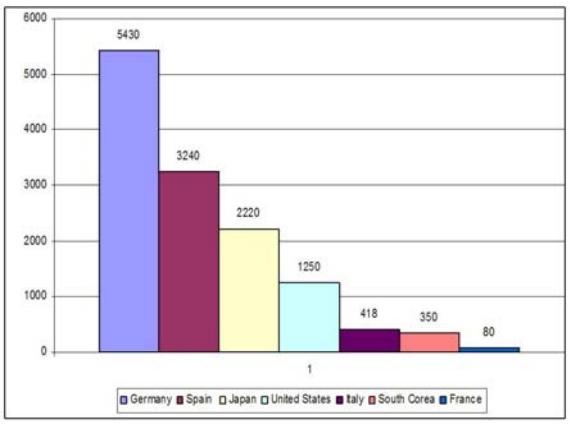

Figure 5: Total PV power installed in each country

Focusing the attention on the EU-15 countries, the absolute predominance of Germany stands out. Germany represents, by itself, the 50% of the total PV power installed in the EU-15 countries.

4. Deployment of PV energy in Europe

In the last years, the total PV power installed in the EU-15 countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Holland, Portugal, United Kingdom, Spain, Sweden) has considerably increased (Table 1) From 2005 to 2006 and then from 2006 to 2007, the annual percentage increases have been more or less equal to 50% (respectively equal to 43% and 59%) while from 2007 to 2008 the annual percentage increase has been higher than 90%. Moreover, the total PV power installed in the EU-15 countries has nearly increased twofold reaching the value of 9503 MWp [8].

Focusing the attention on the EU-15 countries, the absolute predominance of Germany stands out. Germany represents, by itself, the 50% of the total PV power installed in the EU-15 countries. Moreover, together with Spain, Germany represents, since many years, more or less, the 90% of the European PV installed power. With regard to the data related to 31st December 2008, the PV power deployment all over the EU-15 countries is reported in Table 2.

Table 1: PV power [MWp] in EU-15 countries

Year	EU-15 value	EU-15 percentage increase
2005	2171,496	
2006	3112,163	43%
2007	4933,110	59%
2008	9502,869	93%

Table 2: PV installed power all over EU-15 countries at 31th December 2008

EU-15 country	PV value	EPV percentage value
Germany	5430	57,14%
Spain	3240	34,1%
Italy	418	4,4%
France	80	0,84%
Belgium	71,2	0,75%
Portugal	67,9	0,71%
Holland	54,9	0,58%
Denmark	32,1	0,34%
Austria	30,2	0,31%
Luxembourg	24,4	0,26%
U.K.	21,6	0,22%
Greece	18,5	0,19%
Sweden	7,9	0,08%
Finland	5,7	0,06%
Ireland	0,4	0,004%
Total	9502,87	100%

The same data are depicted in Fig 6.

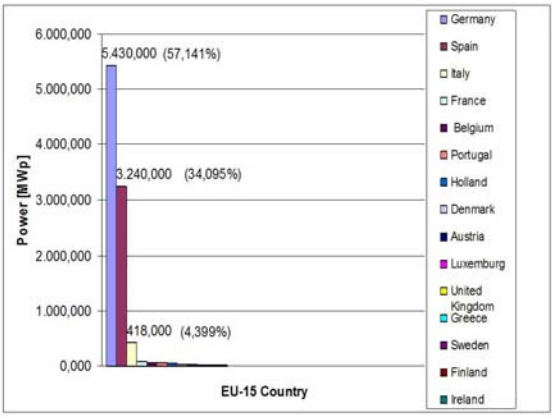

Figure 6: EU-15 country PV power distribution

Table 3: PV power [MWp] in Germany, Spain and Italy

Year	Germany	Spain	Italy
2002	277,6	20,42	22,0
2003	431,0	26,91	26,0
2004	1044,0	43,1	30,7
2005	1,910,0	57,6	46,3
2006	2741,0	143,0	50,0
2007	3846,0	733,84	120,2
2008	5430,0	3240,0	418

It is interesting to notice that the PV installed power increasing in Germany, Spain and Italy, the three EU-15 countries having the highest value of PV installed power in EU-15 till 31th December 2008. The PV power growth in these countries is reported in Table 3 depicted in Fig. 7. Table 4, moreover, reports, for each country (Germany, Spain and Italy), the percentage growing up PV power values in each year with respect to the previous year.

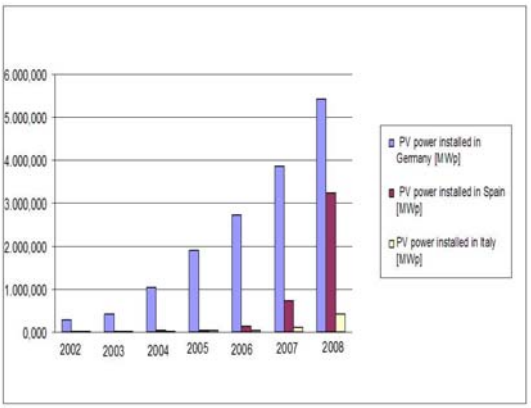

Figure 7: PV installed growing up curve progress in Germany, Spain and Italy between 2002 and 2008

Table 4: Growing up PV annual percentage values with respect to the previous year, in Germany, Spain and Italy

Year	'03	'04	05	06	07	08
Germany	155	242	183	144	140	141
Spain	132	260	134	248	513	442
Italy	118	118	151	108	240	248

By observing the data reported in the previous tables and figures it can be stand out that:

- the growing up has had a strong impulse during 2004. Germany increased its PV power installed of about +242% from 2003 to 2004. This thanks to the fact that Germany, in that year, changed its way of incentive adopting the "conto energia" incentive mechanism.
- Spain increased its PV power installed too. It increased by 513% (from 2006 to 2007) and by 442% (from 2007 to 2008). This thanks to very attractive incentive tariffs with respect to the rest of Europe.
- The same interesting results have been shown in Italy where from 2006 to 2007 the percentage PV installed power has grown up till to +240% and since 2007 to 2008 till +348%. These increases are explained by the adoption of the conto energia" incentive mechanism.

5. Conclusions

Since the connection between the need of energy savings in building sector and the CO2 emission reduction is well known in scientific literature (the building sector is ranked second in terms of CO2 emissions, just after transport) then world and European regulations related to building energy efficiency are here investigated. Moreover, key European legislations and

national regulations here taken into account encourage the increasing use of PV energy source in order to fulfil national fixed objectives. For this reason, the deployment of PV source all over Europe is here investigated. It is shown that Germany and Italy are two of the first three countries for installed PV power in Europe and, thanks to the “conto energia” mechanism, the percentage PV installed power has grown up till to +242% (Germany) and to +348% (Italy).

Acknowledgement

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References

[1] Kyoto Protocol To The United Nations Framework Convention On Climate Change. Kyoto, Japan. 11 December 1997. http://unfccc.int/resource/docs/convkp/kpeng.pdf.

[2] Green Paper on Energy Efficiency or Doing More With Less. Brussels, 22 June 2005. eurex.europa.eu/LexUriServ/site/en/com/2005/com2005_0265en01.pdf.

[3] Action Plan for Energy Efficiency: Realizing the Potential. Brussels, 19 October 2006. Available at : http://eur-lex.europa.eu/LexUriServ/site/en/com/2006/com2006_0545en01.doc.

[4] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, published on the Official Journal of the European Communities, 16 December 2002. Available at: http://eur-lex.europa.eu/LexUriServ/site/en/oj/2003/l_001/.

[5] Council Directive 92/75/EEC on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances, published on the Official Journal of the European Communities, 22 September 1992. Available at: http://eur-lex.europa.eu/LexUriServ.

[6] Commission Directive 95/12/EEC of 23 May 1995 implementing Council Directive 92/75/EEC with regard to energy labelling of household washing machines, published on Official Journal of the European Communities, 23 May 1995.Available at http://eur-lex.europa.eu/LexUriServ;

[7] European Commission, Competitiveness and Innovation Program for 2007-2013, 12 October 2006. Available at: http://ec.europa.eu/cip/index_en.htm;

[8] EurObserv’ER, Photovoltaic Barometer, published in the ‘Journal des Energies Renouvelables’ Number 184, Avril 2008. Available at : http://www.energies-renouvelables.org/barometre.asp.