Quaderni Innovazione

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QI13

Renewable energies and energy saving: scenarios and opportunities

2013 Edition

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Introduction

Lucio Pinto

This book comes out at the same time as the conference on the ***Second Report on Renewable Energies*** **and Energy Efficiency** " held in Milan February 12, 2013 in the Pirelli auditorium organized for Italy by Digital Italy Agency and the Silvio Tronchetti Provera Foundation and it is an update of the one published in 2012.
The Silvio Tronchetti Provera Foundation and Digital Italy Agency launched an "Observatory for Renewable Energy" in collaboration with Bocconi University, Milan Polytechnic and the University of Milan Bicocca to create a point of reference on the state of renewable energy in our country and to give an opportunity to consider these new technologies as areas in which to invest in research.

The book covers some of the most important technologies in the field of renewable energy and is an upgrade the previous edition.

In particular, the book presents two new observers: one on **photovoltaic** by VITTORIO Chiesa, professor at the Polytechnic of Milan, where he is a professor of strategy and organization of research, and a second one on **mini-hydroelectric** by GIANCARLO Giudice, associated professor of the Polytechnic of Milan.

The intent of the editors is to update the books' contents with new reports as soon as they are available.

The Photovoltaic

Vittorio Chiesa

Introduction

This report is an excerpt from "Solar Energy Report 2012" Energy & Strategy Group of the Politecnico of Milan, which describes and analyzes the technological aspects, of market and dynamics of the supply chain that have covered the photovoltaic sector in Italy in 2011.-2012

1. Technology

This chapter aims to illustrate **the main technological developments** that have interested photovoltaic in Italy and Europe in 2011. In particular we will discuss **the dynamics of price and cost of conventional modules** (silicon mono-and pole-crystalline) and those of thin film. An overview of trends in the photovoltaic inverter in the Italian and European market will be also shown. In this chapter, the results of a systematic review that was conducted in order **to determine the expectations and forecasts of the operators and industry experts** on the expected future evolution of some of the main variables that interest the photovoltaic technology are also reported and discussed, including the price of the modules, their efficiency and the cost of solar conversion. It also reports a study on the state of the art and future developments of the **technology of photovoltaic concentration** as well as the mapping of some of the research and development and innovative photovoltaic applications, according to the market operators, which may have a greater market potential in the near future.

1.1 The evolution of the price of modules and inverters

This section analyzes the trend of the sales price, in the European and Italian markets, and the changes in the cost of production of the main components of a photovoltaic implant (modules and inverters) experienced during 2011.

1.1.1 The evolution of the price of traditional modules

With regards to traditional modules, silicon mono-and pole-crystalline, **in 2011 there was a drastic fall in prices for both technologies**, on both the Italian and European levels. In particular, the decline in prices was around 42.6% for poly-crystalline silicon modules and 40% for mono-crystalline modules. This was accompanied by **a less than proportional reduction of the full cost industry,** which has contracted, in some cases significantly, the industrial gross margin producers, leading to the failure of many of them (SEE CHAPTER 3) .

FIGURES 1 and 2 show the trend in 2011, of the **average selling price of PV modules, respectively silicon poly-and mono-crystalline**, quoted by European producers (Italians and non), making a distinction between the case of average price sales in the European market and Italian market. In addition to this**, the trend of the average cost of production** that Italian operators have supported is represented. It is of course, especially with regards to the price variable, about average values that do not take into account, therefore, the differences between different types of supplies (for example for residential systems or for systems of large size) made by the producers of modules.

Figure 1: Trends in 2011 of the price and the full industrial cost (€ / W) of poly-crystalline silicon modules of European producers

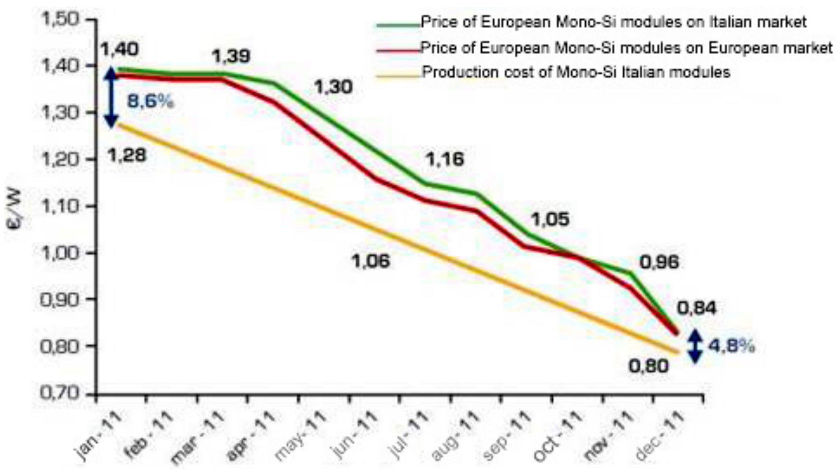

Figure 2: Evolution in 2011, of the price and the full industrial cost (€ / W) of mono-crystalline silicon modules of European producers

From the analysis of the figures we note first of all the substantial reduction in the price of the modules, in the order of 42.6% for the poly-crystalline modules and of 40% for mono-crystalline. The main reason for this sustained drop in prices, is to be found primarily in the **overcapacity worldwide, throughout 2011**, of both cells (essential components of the modules) and modules, which has been caused by a market demand that proved to be lower than expected (SEE CHAPTER 2). **To this a reduction in incentive tariffs is linked, which in 2011 became particularly important** in some leading European markets (such as Italy and Germany), imposing on producers an adjustment of market prices, worth a collapse in the demand.

It is also to be noted how **the price of modules has maintained on average at less than about 1-2 c € / W in the European market in respect to the Italian one**. The difference continued declining in the last months of the year, until it reached an average price similar in the two markets. This is explained by the fact that, despite the cuts imposed by the Fourth Conto Energia, rates in our country in 2011 have still remained at an average higher in respect to other major European markets (one for all, Germany), which prompted producers to apply sales terms slightly less advantageous to the Italian customer in respect to the European average.

It is also interesting to note how the European manufacturers have been able to significantly reduce their industrial full costs (in the order of 37.6% for the modules poly-crystalline, and by 36% for mono-crystalline), to front off the lower prices that the market has imposed.

The full industrial costs (ie, not including costs for the period) of the module manufacturers are composed essentially of two items:

- Purchase cost of the cells, which accounts for about 70% of the total cost of production;

- The cost of production of the module, representing the remaining 30% that can be divided into: (I) the purchase cost of the other components of the module, including glass, EVA, ribbon, junction box, (ii) depreciation of machinery, (iii) labor costs, (iv) cost of energy and other utilities.

The cost reduction which has taken place during the 2011 is attributable, as shown in FIGURE 3, to:

- Efficiency of the production process, which has allowed certain operators, to reduce the production costs of the modules of approximately 10%;

- Reduction of the purchase price of the cells. During 2011, on average, the purchase price of the cells decreased by about 40% due to the fall in the price of silicon for solar applications.

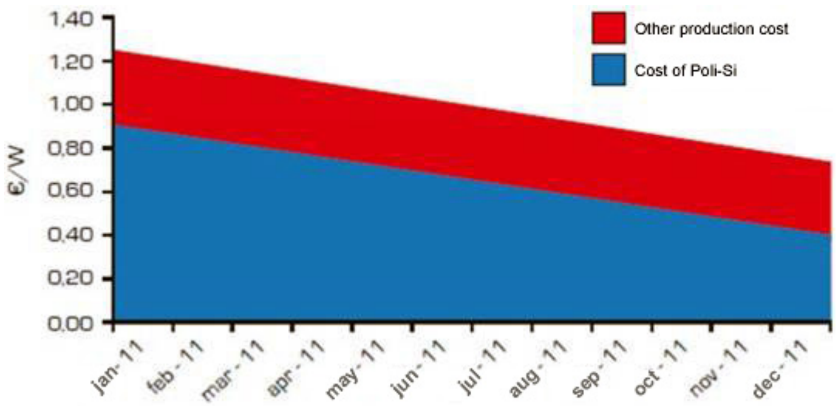

Figure 3: Trends during 2011 of the production cost of modules and the purchase cost of the cells in the case of poly-crystalline silicon

Thanks to the reduction of the full cost of industrial modules achieved by European producers, the **gross industrial margins** of these latter **have lessened in 2011 in respect to prices, in particular decreasing by 5.3% for manufacturers of technology centers -crystalline, and by3.8% for producers of modules mono-crystalline.** Although the reductions in margins in absolute value are not particularly large, the level of profitability in early 2011 was already very contracted, which led to the end of the year for several European manufacturers in situations of objective difficulties (SEE CHAPTER 3). In addition to the reasons mentioned above, the drastic reduction in prices in 2011 is also explained by **the increasing competition in the Asian manufacturers**.

Figure 4 shows the trend in the price of Chinese silicon polycrystalline modules on the Italian market (compared with the average price of the same modules from European manufacturers, as a benchmark), distinguishing between:

- Chinese high-end modules, made by Chinese companies with a known brand (including LDK Solar, Trina Solar, JA Solar). As you can see, on average, **these modules have registered a price 12% lower than those in Europe;**

- Chinese medium-low range modules made by companies with a less recognized brand on the market, but with important production capacities. In this case it can be noted **how the price has been as much as 25% lower compared to European producers**.

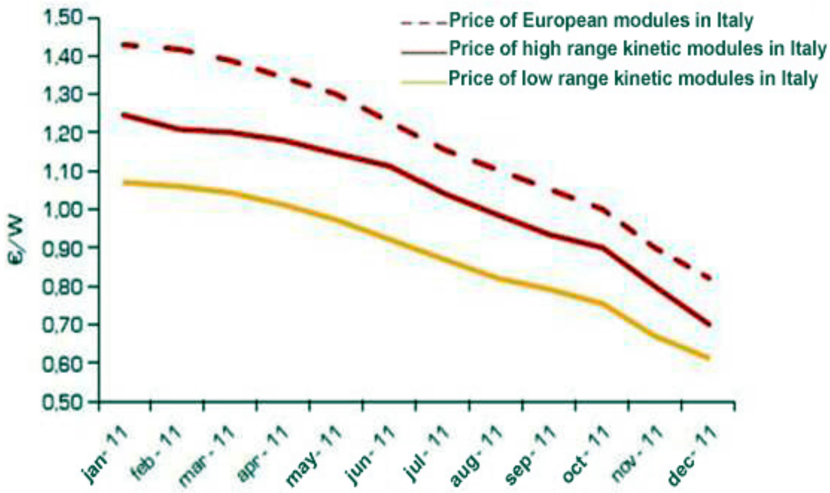

Figure 4: Trends in the average price of poly-crystalline modules made by high and medium-low range Chinese manufactures and sold in Italy in 2011

The main reason for this important difference between the selling price of modules in Europe and Asia lies first and foremost in the possibility for Chinese module manufacturers to exploit huge scale economies that allow to dramatically lower the cost of production. Consider that the top 3 manufacturers of Chinese cell and module for production capacity reach about 7.4 GW of aggregate capacity for the production of cells and 4.8 GW for modules.

In addition, access to factors of production (especially labor) at lower prices than European producers further help to explain the cost advantage enjoyed by Asian operators, who have won, as will be discussed later in Chapter 3, important market share in our country. Based on these data, it can be said that, **on average, in 2011 the selling price in Italy of poly-crystalline and mono-crystalline modules, produced in China, has been in the order of € 0.96 / W.**

1.1.2 The evolution of the price of thin-film modules

In 2011, partly due to the sharp reduction in the price which was discussed in the previous section, **the market share of traditional modules has been strengthened compared to 2010,** reaching a weight at international level on new installations of about 82 %, with thin-film modules that instead stop at 18%. Even in Italy, the thin-film modules have weighed in 2011 on about 8% of the total installed capacity. The year 2011 therefore marks a further slowdown of the expectations for the dissemination of second generation modules, already revised downwards by operators in 2010. This is easily understandable considering that **the strength of the thin-film modules should be just to have,** compared with contained conversion efficiencies and a greater uncertainty on the ability to maintain their performance in time, **a much lower cost in respect to traditional modules**. With the dynamics of the price of crystalline silicon modules which have been discussed above, the competitiveness of second generation technologies on the market is drastically reduced.

Obviously, the manufacturers of thin-film modules had to reduce significantly their sales prices too, not to see their market share evaporate. Figure 5 shows changes in the price of modules in CdTe (cadmium telluride) European markets (no special differences between prices in Europe and in Italy). It actually reflects the trade policies of the American First Solar, the clear leader in this technology, with a market share internationally by more than 35% of the installed thin film. As you can see, the selling price of the CdTe modules has decreased between the beginning and the end of 2011, of 33.3%, reaching a year-end value of 0,74 € / W.

Figure 5: Evolution of the sale price and the full cost of industrial CdTe modules in 2011

Figure 5 also provides a representation of the average of the full industrial cost, where it can be noted how the gross margins (which in fact refer to the case of First Solar) have suffered a sharp decline between the beginning and end of the year. The margins that in January 2011 were at around 25%, significantly higher than those experienced by producers of traditional modules, declined significantly since the average production costs fell at a rate much lower than the drop in prices. This is explained principally by the fact that **this technology, as the majority of those of the second generation, is characterized by major fixed costs stemming from the automated production lines**. It's interesting to note how at the end of 2011, the average gross margin that manufacturers of CdTe modules have been able to achieve is in fact lower than that experienced by the producers of Italian silicon modules.

Figure 6 represents the trend of the sales price of the modules in amorphous silicon (aSi) in 2011. Unlike CdTe, in this case there was some difference between prices quoted on the Italian and European markets, which are kept separate for the data in the chart. You notice a decrease in price during the year in the order of 44.6%. **Even the margins have shrunk considerably**, due to lower production costs less than proportional to the decrease in the price, **but to a lesser extent compared to CdTe**. Together with much higher values at the beginning of the year in respect to the technology of cadmium telluride, this explains why at the end of the year manufacturers of amorphous silicon have experienced gross margins more than three times higher than in the case of CdTe.

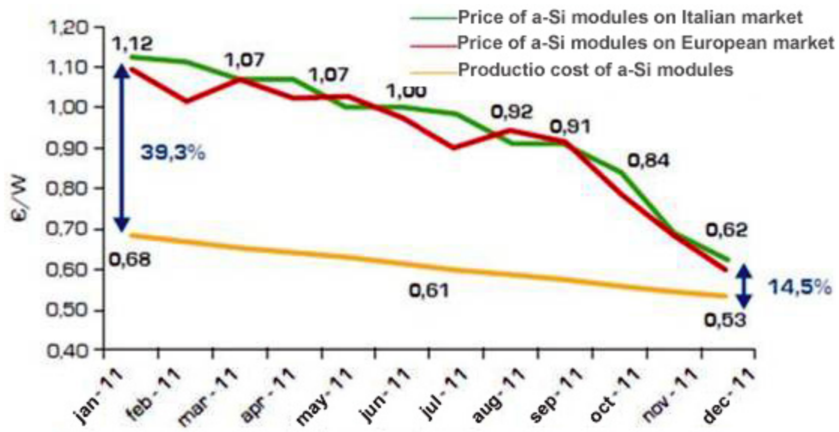

Figure 6: Evolution of the sale price and the full cost of industrial a-Si modules in 2011

Finally, as regards the modules of the second generation CIS (Diseleinuro di Indio and Copper), the price reduction during 2011, as shown in FIGURE 7, stagnated at around 43%. **The gross industrial margin, however, fell by only 1.6%**. This thanks to the ability of the main operators to put into operation new production lines decidedly more efficient, which ensured an important cost containment. Even for CIS modules a significant share of the full cost industry is represented by the amortization of automated manufacturing lines, while the costs of raw materials and labor are considerably reduced, which makes this technology competitive especially in the presence of large production volumes.

Figure 7: Performance of the sale price and the full cost of the industrial CIS modules in 2011

1.1.3 The evolution of the price of the inverter

As is known, in addition to the module, a key component of the photovoltaic system is represented by the inverter, which guarantees the achievement of high levels of efficiency of transformation and thanks to which the system is interfaced with the electricity grid. **The importance of the inverter is destined to increase soon in our country**, following the entry introduction of the technical standard IEC-021 and Annex A70 to the Code of Terna network,, which define the rules and technical requirements to which electricity production implants connected to MV and LV distribution networks have to respond.

The downward trend in the price of photovoltaic modules, which have been discussed in previous sections, **also affected the inverter**, although this component has been affected to a lesser extent than the before mentioned dynamics module. Just consider **that the average reduction in the price of inverters at international level in 2011 was 27%,** with significant differences depending on the size of the product:

- For up to 5 kW inverter, price reduction stood at around 32% reaching at the end of 2011 a value of € 0.28 / W;

- Inverter for 5 to 10 kW, the extent of the reduction was 37%, with an average year-end amounted to approximately € 0.18 / W;

- Inverter for 10 to 100 kW, the price drop was 19%, with values in December 2011 that have reached € 0.19 / W. As can be seen the specific price of these inverters is higher than those with sizes between 5 and 10 kW. This apparently may seem unrealistic, but it must be remembered that from 10 kW it is necessary to provide the inverter of additional components, such as a transformation group and control panels, which bump the specific price;

- For inverters with a capacity greater than 100 kW, the decline in prices was also about 19%, reaching a value at year end of € 0.15 / W.

The reduction in the price of the inverter, especially in the first half of the year, was caused by a phenomenon of over-offer, **which involved first the German market and which then influenced as a waterfall many European markets**. It is estimated that in early 2011 there were about 2.5 GW of stored inverters in German warehouses, probably to avoid another phenomenon of shortage of products similar to what occurred in 2010. When the inverter manufacturers realized that the demand in 2011 would be significantly lower than expected, the inverters stored were sold, in some cases, at lower prices, with the aim of getting rid of capital equipment which involved considerable expense to store.

The reduction in the price of the inverters wasn't as dramatic as in the case of modules and **it seems that the operators have been largely able to absorb without undergoing dangerous repercussions on their profitability and ability to survive**. The causes of the lower decrease in the price of inverters in respect to modules are to be found in more limited competition from manufacturers in the Far East, they encountered more barriers to attack the European and Italian markets. Consider that in 2010, on a global level, among the top five companies producing inverters worldwide there was no Asian reality. On average, the market share of Asian manufacturers in the European market in 2011 was 2.5% (SEE CHAPTER 3), a value significantly lower in respect to those registered in the modules field.

The main barriers that Asian manufacturers have encountered so far in an attempt to attack the European market are of two types:

- First of all the fact that the inverter is a **component that requires an effective after-sales service.** Often investors do not trust a Chinese brand, in average not well-known, as there is uncertainty about the guarantees that it is able to give in time in terms of assistance and support;

- In the second place, the technological gap **between European and Asian inverter has not yet been filled**, unlike what happened for the modules. Important differences are found in particular as regards to the reliability and sturdiness of the machine in the presence of voltages at variable input.

To complete the analysis, in FIGURES 8, 9, 10, 11 the trend in 2011 of the price quoted by European producers (Italian or non) on the European and Italian markets, in addition to the full industrial cost sustained, is shown, distinguishing between inverters of different sizes.

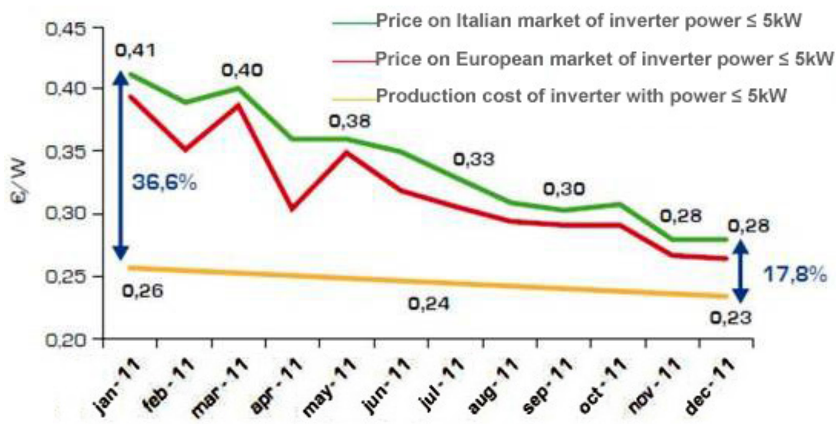

Figure 8: Performance of the sales price and the full cost of industrial inverters with a capacity less than or equal to 5 kW in 2011

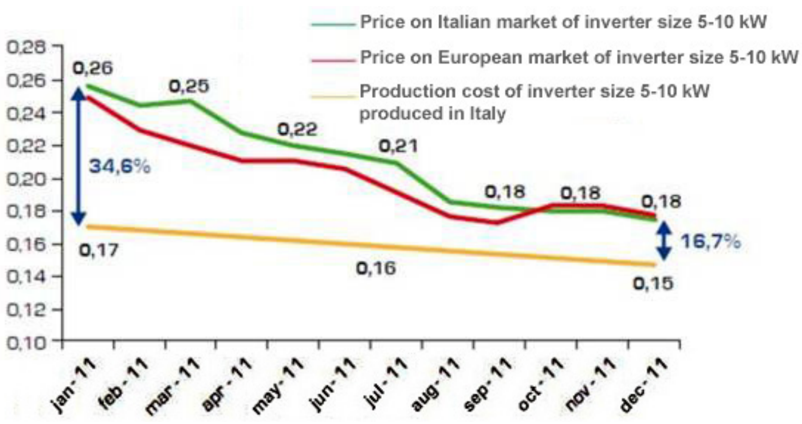

Figure 9: Performance of the sales price and the full cost of industrial inverters with a capacity of between 5 and 10 kW in 2011

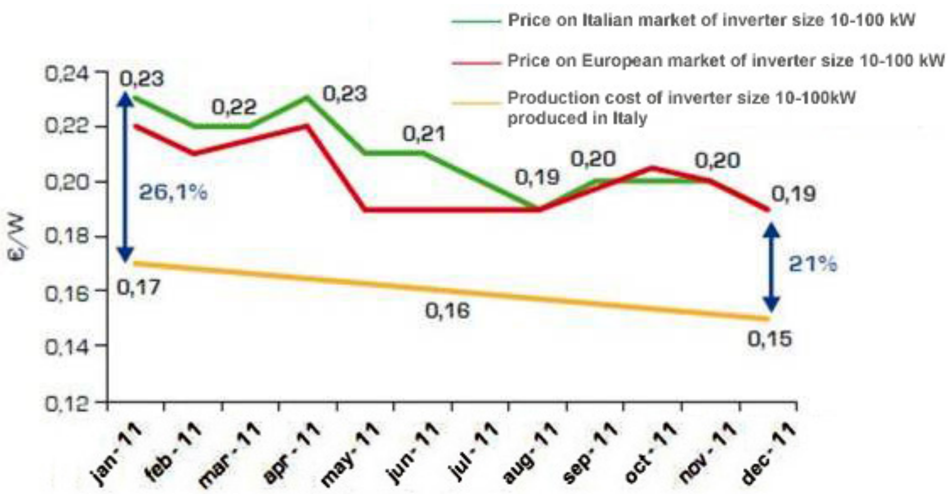

Figure 10: Performance of the sales price and the full cost of industrial inverters with a capacity between 10 and 100 kW in 2011

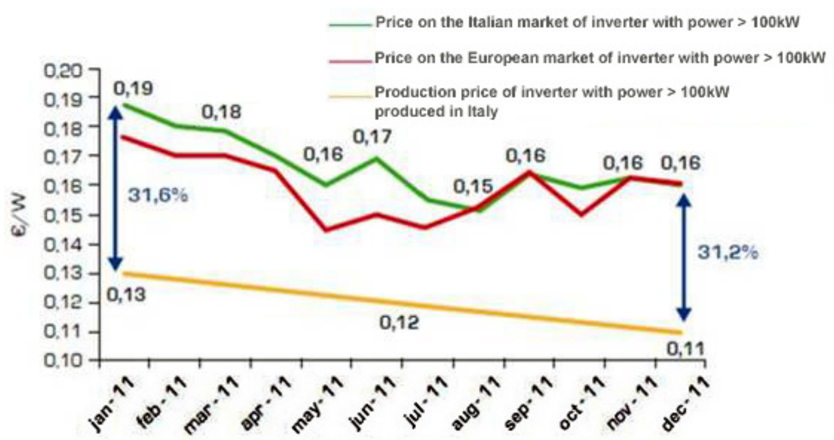

Figure 11: Performance of the sales price and the full cost of industrial inverter with power exceeding 100 kW in 2011

From the analysis of the figures it can be seen how **the movement of prices on the Italian market has remained, on average, at higher levels by 3-4% compared to the European one.** Then you notice an opposite situation in respect to the case with conventional solar panels, which could be explained by the fact that the European market has been greatly influenced by trends which affected Germany and in some periods of the year, it found itself dealing with a stock of material in stock causing a considerable reduction of the selling prices of components.

With regards to the industrial gross margins, the values they took earlier this year for inverters of smaller sizes (between 36 and 34%), were significantly reduced in 2011, halved and at a stall in December 2011 at around 16-18%. This is due, as is obvious, to a greater decrease of the price of the inverters with respect to the reduction of the manufacturing cost. The inverter with sizes between 10 and 100 kW instead have experienced a decline in gross margins of only 5 percentage points between the beginning and the end of the year, remaining by December 2011, at over 20%. Finally, the products with higher powers have maintained their margins at around 31%, with a slight decrease (0.4%) between the beginning and end of the year. In this case, the slight decrease in prices has been accompanied by a light and similar reduction in production costs. As can be seen from the graphs, however**, the margin guaranteed by the production of inverters is appreciably higher than that of the production of modules, especially for manufacturers who have a dimension such as to exploit important cost advantages due to the phenomenon of scale economies.**

1.1.4 The price of the components in the first months of 2012

After an analysis of the price of modules and inverters in 2011, it is interesting to provide an update of the analysis by considering the first three months of 2012. In particular, as regards the modules:

- The price of European modules in **poly-crystalline silicon** has decreased from a value of € 0.82 / W in December 2011 **to a value of € 0.74 / W in March 2012, with a decrease of 9.7%;**

- The price of European modules in **mono-crystalline silicon** has decreased from a value of € 0.84 / W in December 2011 **to a value of € 0.77 / W in March 2012, with a decrease of al'8%;**

- The price of modules in **amorphous silicon (a-Si)** on the Italian market, has decreased from a value in December 2011 of € 0.62 / W **to a value of € 0.59 / W in March 2012, with a decrease of 5%;**

- The price of modules in **Telluluro di Cadmio (CdTe**) on the Italian market, has gone from a value of € 0.74 / W in December 2011 **to a value of € 0.68 / W in March 2012, with a decrease of 8%;**

- The price of modules in **copper indium diselenide** (CIS) on the Italian market has decreased from a value of € 0.85 / W in December 2011 **to a value of € 0.76 / W in March 2012 with a decrease of 10.5%.**

As for inverters manufactured in Europe and sold on the Italian market, average prices were:

- For **inverter up to 5 kW, the price in March 2012 stood at around 0.26 € / W**, with a decrease compared to December 2011 of 7.1%, for 5 to 10 kW inverter, the price in March 2012 was in the order of € 0.17 / W, with a decrease of 5.5% compared toDecember 2011;

- For Inverter **from 10 to 100 kW, the price in March 2012 was around 0.18 € / W,** with a decrease of 5.3% versus December 2011;

- For inverters with a power **greater than 100 kW, the average price in March 2012 was equal to 0.14 € / W,** with a decrease of 12.5% versus December 2011.

The prices of the inverter in the first months of 2012 were, however affected by a great variability, due to regulatory uncertainties that lie ahead for the second half of 2012.

1.1.5 The purchase price of the turnkey systems and breakdown of costs

As can be easily understood in view of developments in the prices of its key components, also the price of the implant turnkey has been reduced considerably, in Italy and in Europe, in 2011. The following briefly describes the evolution of prices specific to a turnkey system (including VAT) installed in Italy with European components, broken down into market segments:

- Implants from 3 kW decreased from an average price in January 2011 which stood around € 4,500 / kW, at a price which in December 2011 had fallen to 3000-3100 € / kW. The reduction was 33% during the year. Also in the residential (0-20 kW), implants from 20 kW were sold at an average price in January 2011 amounted to approximately € 4,000 / kW, prices fell in late December to 2,800 € / kW;

- implants from 200 kW have gone from an average price in January 2011 which stood around € 3,500 / kW, at a price that was in December 2011 at an average of € 1,900 / kW, with a decrease of about 45% during the year;

- Implants from 1 MW decreased from an average price in January 2011 around € 2,800 / kW at a price that in December 2011 had become € 1,650 / kW, with a decrease of about 41% in the course of the year.

In 2011 the articulation of the turnkey cost of photovoltaic system in the various components of which it is composed has changed compared to previous years. In FIGURE 12, 13, 14 are shown divided costs for components for systems installed in December 2011.

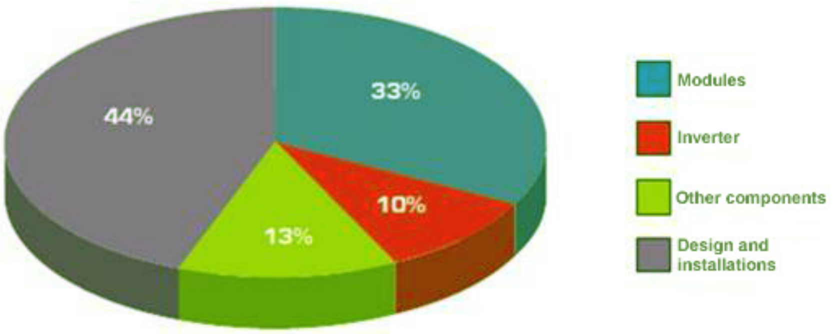

Figure 12: Breakdown of the turnkey cost for aplant of 3 kW til December 2011

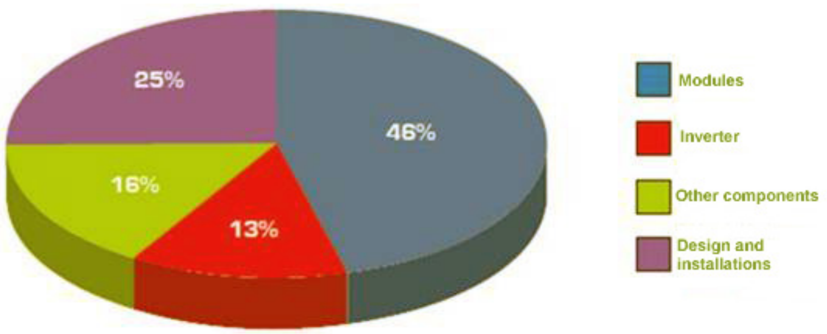

Figure 13: Breakdown of the turnkey cost for a plant of 200 kW to December 2011

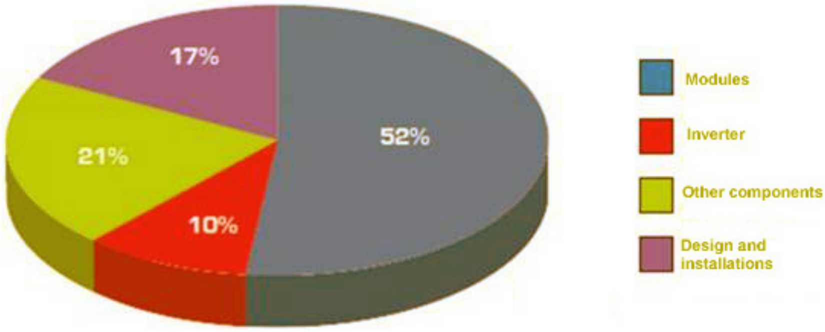

Figure 14: Breakdown of the turnkey cost for a 1 MW implant in December 2011

It 's interesting to note **how the percentage weight of modules increases significantly with increasing plant size** (from 33% for the plant from 3 kW to 52% for the 1 MW plant) as the cost of the turnkey implant decreases significantly while the price of modules decreases, due to the lack of surplus distribution activities and the benefits of scale resulting from the supply of large sizes, but in a less than proportional way in respect to the "turnkey" price.

In addition, the design and installation decrease their percentage weight as the implant size increases. If we compare the breakdown of the costs of a 3 kW with that carried out in 2010, we see that the weight of the module decreased by 7% due to the decrease in price in 2011 and 1% that of the inverter, in this case also for the fall in prices during the year. The percentage of the other components increases of about 3%, as prices have remained virtually the same from one year to another, and also the weight of the activities of design and installation increases (+5%).

1.2 The future of photovoltaic

After having extensively discussed the main technological dynamics that characterized the 2011 PV in Italy and in Europe, in this section we report the results of a study that involved, in a systematic manner, all the main players of this market in Italy, to whom was administered a questionnaire that allowed to collect **their views on the future development that major technological variables (including the price of the modules and their conversion efficiency) is likely to experience in the coming years**. The results of this extensive survey were integrated with the base of qualitative data collected by conducting interviews with key informants.

1.2.1 The expected trend in the price of modules

We report the first results of the analysis on the expected price of photovoltaic modules. TABLE 1 contains the price range for the various PV technologies in the years 2012 and 2013, in the case of the sale of modules manufactured by European companies (including of course Italian companies) on the Italian market. The same information is represented in graphical form in FIGURE 15.

Technology	Year	Price of modules
Mono - Si	2011	1,19
	2012	0,75 - 0,77
	2013	0,69 - 0,70
Poli - Si	2011	1,18
	2012	0,72 - 0,74
	2013	0,66 - 0,67
A - Si	2011	0,94
	2012	0,55 - 0,60
	2013	0,52 - 0,56
CdTe	2011	0,93
	2012	0,63 - 0,66
	2013	0,58 - 0,60
CIS	2011	1,16
	2012	0,72 - 0,75
	2013	0,65 - 0,66

Table 1: The expected trend in the price of photovoltaic modules

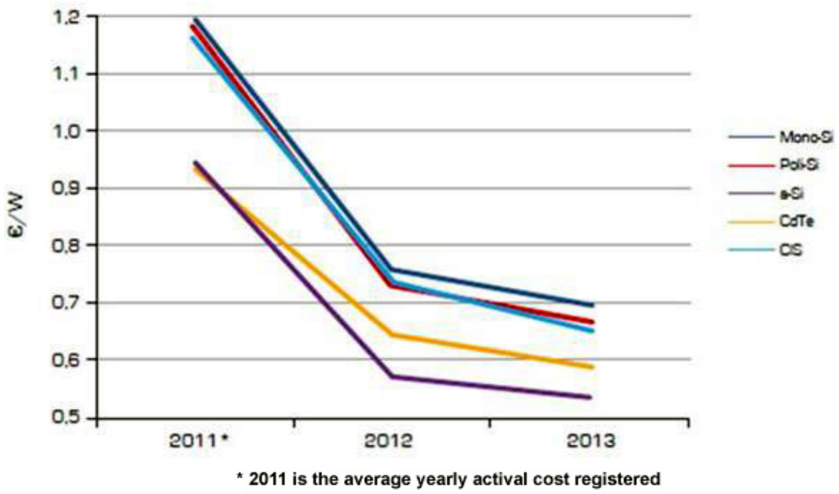

Figure 15: Evolution of the expected selling price of European modules on the Italian market in 2012 and 2013

As you can see, **the price reduction expected by operators** is particularly pronounced between 2011 and 2012 (in the order of 31% on average on different technologies), which suggests that the trend recorded in 2011 may continue in Italy. We must also consider that in TABLE 1 and FIGURE 15 are used as parameters the average price recorded annuall. As a result, much of the reduction in price between 2011 and 2012 has already been granted in the last months of 2011 and in early 2012, where the dynamics of price decline has been particularly marked.

As regards specifically the modules in mono-crystalline silicon, a decrease of 36% on the average annual price is awaited between 2011 and 2012. Whereas at the end of 2011 the average price of silicon mono-crystalline produced by European operators and sold on the Italian market had already dropped to 0.84 € / W, you can estimate a decrease in the price at the end of 2011 and an average price of 2012 in the order of 9,5%. **With every probability, therefore, the modules by the end of 2012 will have a lower price in respect to the 0.76 €/W, which is the average value over the twelve months of 2012**. It can be also noted that, between 2012 and 2013, there may be a further decline in the average price in the year of about 8,5%, according to operators. A very similar dynamic is expected for the poly-crystalline silicon technology, with a reduction in the estimated 38% between 2011 and 2012 and by 9% between 2012 and 2013 in terms of average values over the twelve months.

The amorphous silicon modules are those with lower expected prices in absolute terms, as is logical given that in 2011 they had a price much lower than other technologies. The expected decline in prices between 2011 and 2012 stood at 39%, while the decrease is forecasted between 2012 and 2013 by an average of 6%. Probably the lower cost of production of producers of a-Si modules will enable them to be able to act on the lever of the price more than manufacturers of traditional technologies will be able to do in future years , already widely under pressure with regards to the industrial margin. Of a lower percentage is the reduction year-on -year awaited for CdTe modules, equal to 30% for 2012 on 2011 and 9% in 2013 on 2012. Probably in this case, unlike a-Si manufacturers, operators of CdTe (first of all First Solar) would not have significant margins of reducing their industrial full cost purposes, which will impose the need to maintain almost unchanged the selling price, probably at the expense of the market share. Finally, it is shown how CIS modules will present it as possible, to lower the expected price in the order of 34% between 2011 and 2012 and by 11% between 2012 and 2013.

1.2.2 The expected trend of modules efficency

The efficiency of a photovoltaic module is calculated as the ratio between the electrical power output from the terminals of the module itself and the power of the solar radiation that affects its total area, using a value of irradiation of reference equal to 1,000 W/m2. In this section, we first consider the annual average levels of efficiency, that is based on volumes of module production that will be sold on the Italian market and designed by European manufacturers (including Italians).

In particular, in TABLE 2 the expectations of the operators in relation to the efficiency of media modules for the different technologies, in the years 2012, 2013 and 2014 are reported.

Technology	Year	Modules efficiency (%)
Mono - Si	2011	15,1
	2012	15,5
	2013	16,1
	2014	16,5
Poli - Si	2011	14,8
	2012	15,1
	2013	15,5
	2014	16,1
A - Si	2011	7,0
	2012	7,4
	2013	7,7
	2014	8,2
CdTe	2011	11,7
	2012	12,4
	2013	13,0
	2014	13,4
CIS	2011	12,3
	2012	13,6
	2013	14,1
	2014	14,6

Table 2: Evolution of the average expected efficiency of European photovoltaic modules sold in Italy

The analysis of Table 2 shows first of all **that there are expected improvements in efficiency rather heterogeneous among different PV technologies.** In particular, the less mature technologies (including obviously CIS and CdTe) register wider margins for improvement, as can be easily understood. For example, **it is expected that the CdTe modules can reach efficiency levels equal to 13.4% in 2014**, while the modules in CIS may even reach values of 14.6%.

Traditional technologies are expected to touch in 2014 levels of efficiency equal to 16.1% for poly-crystalline silicon modules and **16.5% for mono-crystalline silicon modules,** so separating of 1.5-2 points percentage modules in CIS, which could represent by 2014, the second technology in terms of efficiency. **It does not seem that operators believe there are significant margins for improvement of the efficiency of amorphous silicon modules.**

To complete this analysis, Figure 16 shows in short the improvement in percentage expected by average efficiency of photovoltaic modules between 2011 and 2014.

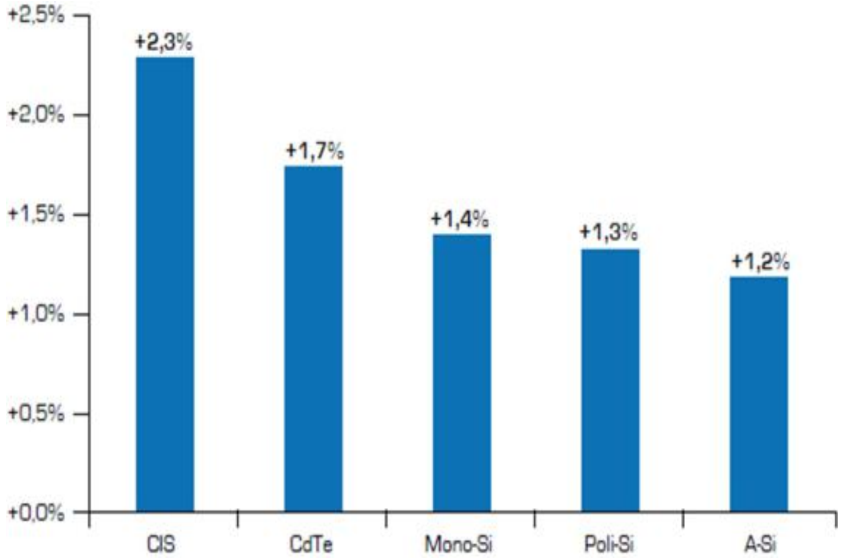

Figure 16: Improvement in percentage in the efficiency for different types of PV modules between 2011 and 2014

From the opinions of operators collected during the study it emerges how **the traditional technology of crystalline silicon still has quite good margins for improvement in conversion efficiency by 2014**, even higher than the a-Si modules, even though it's now approaching its maturity. Hardly can there be more tangible efficiency improvements, despite the companies put significant efforts in the field of R & D. The data given up to here, refer to **the average efficiency market that is expected to be seen in the coming years**. Our study has also enabled us to collect data about maximum efficiency expected that can be achieved in high-performance modules developed in the coming years. These data are collected by crossing the opinions of the operators with the analysis of scientific papers and technical reports prepared by research organizations active in the field (SEE TABLE 3).

Technology	Year	Forcast module efficiency at high performance (%)
Mono - Si	2012	20,5 - 20,9
	2013	20,5 - 21,4
	2014	21 - 21,9
Poli - Si	2012	18,4 - 19,5
	2013	18,6 - 19,7
	2014	18,8 - 20,0
A - Si	2012	10,0 - 10,5
	2013	10,5 - 10,7
	2014	10,5 - 11,0
CdTe	2012	12,4 - 13,3
	2013	12,7 - 13,7
	2014	13,1 - 14,2
CIS	2012	13,7 - 14,4
	2013	14,3 - 14,6
	2014	14,9 - 15,0

Table 3: Highest efficiencies expected for high-performance modules

1.2.3 The expected trend of the cost of solar conversion

To better illustrate the developing trends of the technology used in photovoltaic modules, in Figure 17 **the expected trend** is shown, **as revealed by our on the field analysis, the so-called cost of solar conversion. It is an indicator obtained by dividing the price of the module for its efficiency.**

This indicator is measured in € over Watt equivalent (€ /Weq) and compares the efficiency with the price of the individual technologies. The indicator, as can be seen, decreases both due to the effect of a reduction of the price of the module and by the increase of efficiency. The indicator shown in Figure 17 was obviously built considering the data of the above-mentioned average annual price on the Italian market and the average efficiency of European modules.

Clearly **this indicator is very useful to identify the best technologies for intensive applications, that is, where it is important to obtain the maximum power from a limited surface**, as might be the case of a roof implant of restricted dimensions. On the contrary, this indicator is not of fundamental importance when thinking of extensive photovoltaic applications, for instance where the surface of the photovoltaic field doesn't represent a stringent limit and therefore, the aspect of the price becomes more important compared to the efficiency of the module (ie the space required to reach a certain peak power).

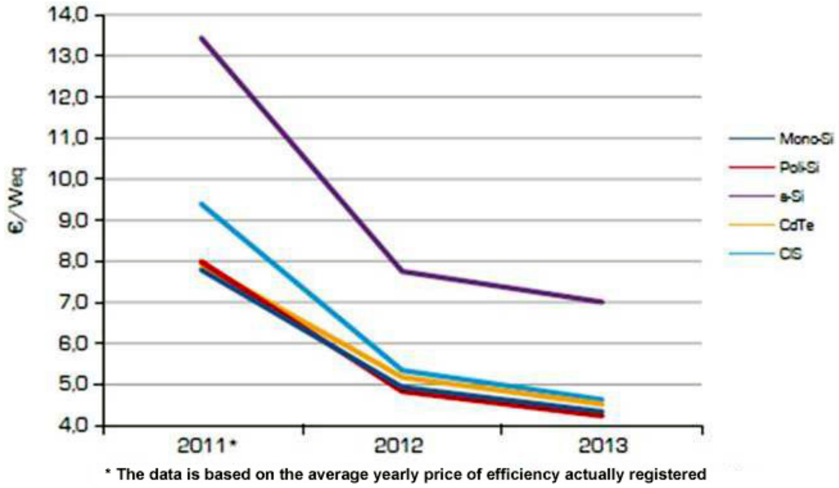

Figure 17: Evolution of the expected cost of converting solar for the main technologies of PV solar produced in Europe

Also from a future perspective FIGURE 17 shows how the cost of converting solar is lower for traditional technologies (silicon mono-and poly-crystalline). In fact, in respect to a slightly higher price of the modules of conventional technology compared to those of thin film, their efficiency more than counterbalances the difference in price., In the two years taken into account by this analysis, It would appear that **traditional technologies will realistically continue to have overall, especially for intensive applications** (ie those where the total area of the photovoltaic modules is a stringent limit in the design of the system), **a greater convenience in respect to the thin film**. Amorphous silicon, although being technology that experiments a lower price and that has more potential with a view to reduction of prices represents however the technology with a higher solar conversion cost, both expected and prospected.

This is obviously due to the fact that the efficiency values are significantly lower than traditional technologies and to the other second generation modules of. **The modules in CIS instead seem to have a combination of price and efficiency that allows them, especially in an optical future, to have a curve in the cost of conversion that is closest to the traditional technologies**. These modules, in fact, even though in 2011 remained above the CdTe as cost of conversion, from 2012 should be able to experience considerable improvements, returning to values lower than the CdTe.

1.2.4 The expected trend in the price of inverter

Unlike solar modules, the price of which is strongly influenced by the price of the fundamental raw material, namely the solar grade silicon, **in the case of the inverter the production process and cost of supply of the various components of which it is composed of, have a significant importance**. The most important manufacturers of inverters are particularly involved in the breaking down of production costs through a continuous improvement of the efficiency of the production process.

TABLE 4 shows the expected evolution of the average selling price of the inverter for the next two years, designed by European manufacturers and sold on the Italian market. The analysis are based on the same methodology previously described. In Figure 18 we report the same data in a graphical form and reported to the average price recorded in the final balance in 2011.

Technology	Year	Price of inverter (€/W)
< 5 kW	2011	0,33
	2012	0,24 - 0,25
	2013	0,2 - 0,22
5 - 10 kW	2011	0,21
	2012	0,16 - 0,17
	2013	0,15 - 0,16
10 - 200 kW	2011	0,21
	2012	0,16 - 0,17
	2013	0,15 - 0,16
> 200 kW	2011	0,17
	2012	0,12 - 0,13
	2013	0,11 - 0,12

Table 4: Average performance expected of the selling price of the inverters produced in Europe for different sizes

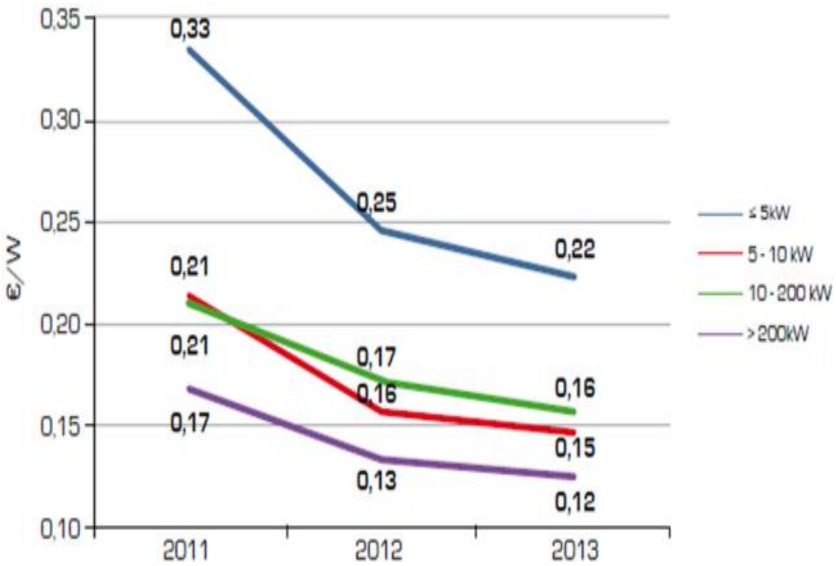

Figure 18: Average evolution expected of inverters price on the Italian market

From the analysis of the data it can be noted how the expected price reduction differs, even if not in an important way, depending on the implant size.

In particular:

- **For an inverter up to 5 kW**, the decrease in the expected price is around 24% for 2012 (in respect to 2011) and 12% for 2013 (in respect to 2012). **This type of inverter is the one that has highest potential to lower prices**, which would seem to suggest on the one hand that it is the less mature technology, on the other hand that the innovation efforts of manufacturers are particularly focused on this size of inverter, which is probably the one characterized by a greater market potential from the perspective of distributed generation and transition towards the *smart grid* paradigm;

- **Foran inverter from 5 to 10 kW**, the decline in prices forecasted for 2012 is 24% and a further 6% in 2013;

- **Inverter for 10 to 100 kW**, the amount of reduction in prices is expected to be in the order of 19% for 2012 and 6% between 2012 and 2013;

- Finally, **for inverters with a capacity greater than 100 kW**, a variation is expected in decreasing prices of 23% between 2011 and 2012 and by 8% between 2012 and 2013.

1.3 The concentrated photovoltaic

Interest from operators for the concentrated photovoltaic technology has continued in 2011, despite the installation levels remain very low. Consider that in 2011 the value of these systems installed in Italy amounted to little more than 30 kW, with three implants actually installed. The installed worldwide in 2011, although it is a little more than 30 MW, sees more than 550 MW under construction for the next year in countries such as the USA, Spain and Australia. For this reason we seek, in this paragraph, to provide an update on technological developments affecting this innovative solution. The principle at the base of concentrated photovoltaic consists of conveying the direct solar radiation on a photovoltaic cell of minimum surface, with the dual effect of reducing the cost of the cell (due to its limited dimensions) and of increasing the energy performance of the entire the system. The concentration of solar radiation is obtained by means of reflective optics (mirrors) or refractive (lenses).

These systems, **if placed in areas with a good irradiation, allow to increase the photovoltaic conversion efficiency** significantly compared to traditional technologies, still they have a more complex engineering plant and design due to:

- **The need of an accurate tracking system** that maintains the module surface always perpendicular to the direct radiation, with tolerances of a few hundredths of a degree in systems at high concentration;

- **The need of a cooling system of the cell** which, given the high radiation per unit area, tends to reach too high temperatures if not properly refrigerated. The average working temperature of a high concentration cell must then be kept below 200-250°C by air cooling systems, using small heat exchangers with metallic fins, often with natural circulation to not further complicate the system, or with liquid systems using micro-tubes and with the possibility of using the heat removed from the cells for cogeneration;

- **The need to put the implant in areas with high direct radiation**, which greatly complicates the analysis of the characteristics of the site in the design stage of the system and limits the number of areas suitable for installations of this type. In Italy, the lack of direct radiation, that only takes on interesting values for a few months per year in some areas of southern Italy (in particular Sicily), doesn't guarantee a much higher yearly production of these plants than what is achievable with conventional systems, which makes their realization not very convenient.

The concentrated photovoltaic implants present strongly heterogeneous characteristics to one another, especially as regards to the concentration factor.

One can distinguish between:

- **Low concentration systems** (with a concentration factor 2x-3x), which are based on very simple reflective systems consisting of "fins" of aluminum at the sides of a conventional photovoltaic module (see Figure 19). They were designed particularly in 2007 and 2008 to deal with a phenomenon of shortage of solar modules on the market, but today they are practically in disuse except for niche installations, such as floating photovoltaic, which will be discussed in BOX 2;

- **Medium concentration systems** (with concentration factor 10x-200x), using mono-crystalline silicon cells or thin film, often combined with a tracking system with one degree of freedom and parabolic concentrator mirrors (see Figure 20). This configuration is normally used in the case of construction of a cogeneration system.

- **High concentration systems** (with conversion factor 400x-1000x), using cells with high quality standards, usually at triple-junction and high efficiency (in some cases greater than 44%), point focus optics that concentrate the radiation in one point, consisting of convex lenses or Fresnel and by a very accurate tracking system with two degrees of freedom. These technologies make it possible to achieve an overall efficiency of the system that exceeds 30% (see Figure 21).

Figure 19: Low concentration PV system

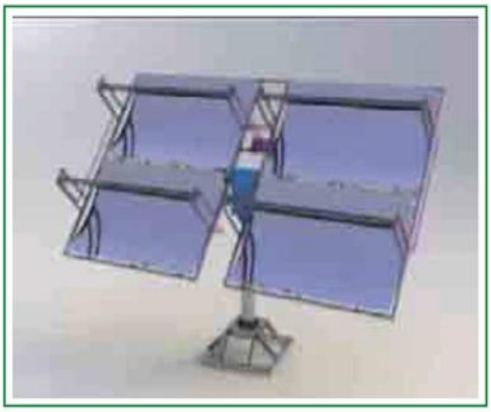

Figure 20: medium concentration PV system

Figure 21: PV system with a high concentration

Concentrated - solar power (CPV) represents a technology still under study and subject of numerous research and development projects, including several funded by the EU, who see in the forefront Italian companies. Thanks to these important innovation efforts, **over the past two years the implementation costs for a high-concentration with dual-axis tracking and calculated with a factor of direct radiance standard (Gd = 900 W/m2) arrived at about 3 - 3.5 €/W, starting from 4 to 4.5 € / W end of 2009**.

Consider that the **photovoltaic by concentration still has margins for improvement interesting both from the point of view of performance obtainable** (in particular in terms of increasing the efficiency of the cells and of the precision of tracking systems) and production costs. FIGURE 22 shows a rough indication of the breakdown of the cost of a high concentration photovoltaic system.

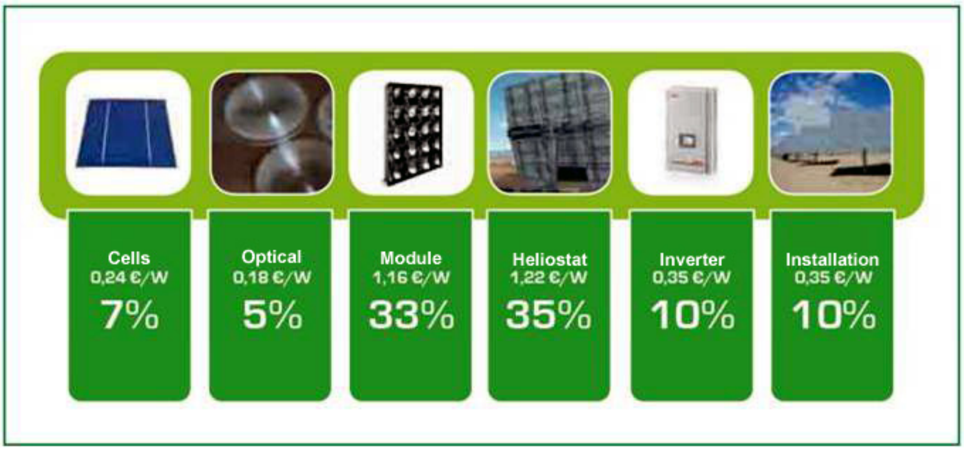

Figure 22: Breakdown of the costs of a high concentration photovoltaic system

For example, consider th high concentrated biaxial tracking system located in Sicily with a direct radiation per year (on two axes tracking) of 1,900 kWh/year. The construction costs of the plant would be 3.5 €/W, to which authorization costs must be added depending on the region where the installation takes place (in Sicily these additional costs can be estimated at € 0.25 €/W). The total turnkey cost would therefore be equal to 3.75 €/W. With this implant cost and with the incentives provided by the Fourth Conto Energia, it is possible to achieve an IRR of around 10%, but that could reach up to 14% depending on the interest rate of the loan. As you can see, **with the current system costs the profitability of these systems in the area with high direct radiation reaches an acceptable value for an investor today.**

1.3.1 The main companies active in Italy in concentration photovoltaic

The concentrated photovoltaic is **a technology towards which Italian companies have shown a particular interest in recent years**, driven into this also by the evolution of the regulatory framework that has, with the Fourth Conto Energia, reserved ad hoc incentives for installations that use this system. **The majority of active Italian companies in this sector adopts a business model that focuses on delivering in-house modules and heliostats** and provides the purchase of high efficiency solar cells from international suppliers as Spectrolab and Emcore . Other companies purchase instead on the market also the modules, as happens for Alitec and Telicom, or the heliostat, as instead is the case of CPower. TABLE 5 presents a list of the major companies with activities in the field of concentrated photovoltaic.

Company	City	Cell	Module	Heliostat
Becar (Beghelli)	Bologna	Multijunction purchased on the market	Created internally	Created internally
Angelantoni	Perugia	Multijunction purchased on the market	Created internally	Created internally
Pirelli	Milano	Multijunction purchased by Emcore	Created internally	Created internally
Cpower	Ferrara	Multijunction purchased by Narec	Created internally	Purchased on the market
Aest	Gorizia	Multijunction purchased by Spectrolab	Created internally	Created internally
Alitec	Pisa	Multijunction purchased by Emcore	Purchased by Emcore	Created internally
Telicom	Milano	Multijunction purchased by Arima Eco Energy	Purchased by Arima Eco Energy	Created internally

Table 5: Main active companies in Italy in concentrated photovoltaic

At European level different R & D projects are active on the theme of photovoltaic by concentration. The main ones are collected and briefly described in this box.

• **Project "EcoSole"**

Funded within the FP7, the project, which requires an investment of € 12 million, of which 7 are funded by the European Union, aims to achieve a high-concentration system based on optical reflection, multi-junction cells, innovative cooling systems and efficient tracking algorithm. All this together with the development of an efficient production line, capable of minimizing manufacturing costs through the use of automation. The companies participating in the project are: Becar-Beghelli (Italy), ENEA (Italy), Universidad Politecnica de Madrid (Spain), QuantaSol Limited (UK), Evonik Degussa GmbH (Germany), Aural (Italy), Fundación Tecnalia Research & Innovation (Spain), Optics and Energy Concepts (Germany), Plamtex (Slovenia), Ben-Gurion University Of The Negev (Israel).

• **Project "NGCPV" (A new generation of concentrated photovoltaic cells, modules and systems)**

Funded within the FP7, it is a project created by an agreement between Europe and Japan, which will require an investment of approximately € 7 million and has the following objectives: (i) implement a prototype system for cell concentration with 43% efficiency and develop a technology roadmap to reach the threshold of 50%, (ii) implement a module for implant concentration with an efficiency of 35% and develop a roadmap to achieve the goal of 40%, (iii) to develop tools for the characterization of manufacturing processes and cell photovoltaic by concentration modules, high accuracy, and (iv) develop accurate predictive models for the energy rating of photovoltaic systems in concentration, or calculate the expected annual production of the implant according to the place of installation. The industrial partners of the research are: Universidad Politécnica de Madrid, Fraunhofer Institute, Imperial College of Science Technology and Medicine, ENEA, BSQ, PSE, ¬ INES CEA, University of Tokyo, Toyota Technological Institute, AIST, SHARP, Daido Steel, University of Miyazaki, Asahi Kasei, Kobe University, Takano.

• **Convention ENEA-MATTM**

The project ENEA-MATTM aims at the development of hybrid photovoltaic-thermal concentrating, with an overall efficiency of 65%, able to produce heat at a temperature higher than 100°C developing a connection between electrical power and heat output of 1:4. The project has been funded directly by the Ministry with an investment of € 1.1 million, but still finds itself in its early stages of development: currently ENEA is working on systems of this type on the market to test them and evaluate them, identifying opportunities for improvement.

Box 1: European projects of research and development on the concentrated photovoltaic

1.4 Research projects and development

The objective of this section is to describe some of the main trajectories of innovation and technological development affecting at European and international level, the photovoltaic sector and which the operators interviewed during the study considered to be the most promising.

1.4.1 Quasi-mono-crystalline cells

The quasi-mono-crystalline cells are, as the name suggests, made from silicon which has an intermediate structure between mono-and poly-crystalline. **The method for obtaining silicon quasi-mono bars is quite similar to that of producing poly-crystalline silicon, which allows to replicate in fact also the costs content.** In particular, on the bottom of the crucible, where the silicon is melted to obtain bars of poly-crystalline, a crystal of silicon mono-crystal is placed which acts as a seed from which large crystals will form. The cooling of the bar must be very slow so as to allow the crystals to grow without fragmenting and it must be in the direction that goes from the germ of silicon upwards.

The cells resulting from this process have an intermediate efficiency between mono-crystalline and poly-crystalline cells with a cost of production that is close to that of poly-crystalline technology. Companies like GCL Poly, Renesola, GET, Solartech, Trina Solar, Jinko Solar, Phoenix, Canadian Solar Tainergy, Ja Solar, already carry quasi-mono cells reaching values of efficiency at around 18%.

1.4.2 Selective emitter

The selective emitter technique **allows to increase the efficiency of the cells up to 0.8% by increasing the concentration doping element (phosphorus) in the area beneath the metal contacts, so as to decrease significantly the resistance in that area, however without increasing the size of the metallic contact**. This technique therefore allows to decrease the contact resistance over the cell without reducing the intercepting surface and thus without worsening the optical efficiency. Some of the companies involved in the development of this technology include Canadian Solar cells and modules, Centrotherm for production lines and DuPont for the development of ink silicon necessary for this technology.

1.4.3 Micro-morpho silicon cells

The Micro-morpho silicon cells are also called tandem cells and **exploit the combination of a cell of amorphous silicon, which absorbs visible light, with a micro-crystalline silicon cell** (with very small silicon grains), that also absorbs infrared, allowing it to make the most of the sunlight. These cells thus provide excellent conductivity and excellent trapping of solar radiation. The efficiencies achieved are interesting: there is talk of 11,6% and 9% in the laboratory at the factory. This technology has already been adopted by companies such as Oerlikon Pramac and with good results.

1.4.4 Dye Sensitized Solar Cells (DSSC)

The dye sensitized cells (literally dye sensitized cells), also called Greatzel cells, are the most promising evolution of third generation photovoltaic cells. **These cells exploit a physical principle similar to that of photosynthesis, with the photosensitive material which is represented by a dye of vegetable origin**. The efficiency of these cells has reached very interesting levels and continues to grow: the maximum efficiency measured in the laboratory is 12.3% and 10% for commercial applications, making this technology highly competitive for applications such as BIPV - Building Integrated Photovoltaitcs. In addition to good efficiency, the DSSC cells have a further advantage: they are not subject to losses due to recombination, a phenomenon of considerable importance in conditions of low irradiation, as in the presence of a cloudy sky, **which makes them work even in the presence of minimum illumination**. Their level of minimum irradiation of cut-in, required to spark off operation, is significantly lower than that of the conventional silicon cells. For this reason, their use has been proposed for indoor applications as well, collecting energy from the lights of the house. The development of DSSC cells is mainly carried out by the joint venture between Dyesol, an Australian company pioneer of this technology, and the giant Tata Steel; they have already built a pilot production line that is based on techniques of printing dye directly onto steel. A pilot implant is in progress of in the Sustainable Building Envelope Centre (SBEC) in Shotton, England, a research center and incubator of new "zero emissions" technologies for buildings. Other projects of industrialization of this technology are carried out by the American Konarka Technologies, the German Siemens, STMicroelectronics Swiss and the American Nanosolar. The results of these innovative efforts seem very promising: it seems that the costs on large scale may be such as to allow a sale price of the modules below 0.5 € W, with a energetic pay-back of the same of only 3 months.

1.4.5 Microinverter

Another area of innovation followed with interest by some manufacturers of inverter concerns the **tuning of micro-inverters for the photovoltaic market**. These machines are of very small size (180 - 320W), and are installed on each module.

This technology has already been introduced in the U.S. market and its launch took place in 2011 in Italy. The use of microinverter has some significant advantages:

- **Increased productivity of the implant**. Associating to each module an inverter, with its own MPPT system (Maximum Power Point Tracking), it allows it to work at its maximum performance, independent of the operating conditions of the other modules so that, for example in the case of shading, they don’t adversely affect the performance of the entire string or the whole implant, as occurs in implants built with central inverters. It should be noted, however, that this benefit on productivity is only relevant if the modules are subject to different irradiation values due to different angles or shadows, a situation that often occurs in a residential installation;

- **Increase in the reliability of the inverter** that, working at a much lower power in respect to conventional systems, has no need of cooling systems, such as fans or other moving parts, which are often the most liable to failures. In this way the probability of failure of the annual single micro-inverter can be up to 40 times lower than that of a conventional inverter;

- **Easy wiring and system design**. On the one hand, all the wiring of the system are made of AC and electrical components for DC are therefore not necessary. On the other hand, there is no need for optimal sizing and balancing of the strings, which reduces the design time and installation.

There are however a number of disadvantages, related to:

- Costs significantly higher, linked on the one hand to the lack of maturity of the technology, and on the other hand to the impossible exploitation of economies involved in purchasing large machines;

- The maximum efficiency of the micro-inverter in "optimal" conditions is lower than that of conventional inverters because of reduced size, with a difference of about 3-4%. This aspect makes them therefore advantageous only in the presence of installations where it is impossible for most of the year to have a condition of irradiation close to the nominal, due to the inclination of the modules not being optimal and the presence of shadows.

An interesting application, that has sparked some interest among operators, although there are several critical opinions on the economic feasibility of the technology and its large-scale photovoltaic floating implants, made on mirrors of dead water basins at high altitude, volcanic water and quarry ponds. These implants have a very simple configuration, but very practical. **They require that the implant is mounted on a floating structure of naval derivation** that can be fitted with hydraulic pumps for water cooling of the modules and tracking systems. There may be two systems of concentration to increase the incident radiation on the module.

These systems have some interesting features and benefits:

- **Cooling of the modules**: through a veil of water that flows on their surface, the temperature of the modules is maintained at values such as to ensure maximum efficiency. This determines an increase of the annual implant's manufacturability at around 10%. The consumption of the pump that ensures the cooling are minimal compared to the increase of energy obtained and of course the availability of water to make the cooling is not a problem;

- **The chase**: the floating platform can be easily transformed into a solar tracker with one degree of freedom, rotating around the axis zenith-nadir and chasing the azimuth angle of the sun, which in practice orients itself from east to west during the day. This movement is achievable with a system of gears or propellers by very low fuel consumption, as it is a floating platform, that allows an increase of the manufacturability up to 25% per year;

- **The limited visual impact**: the dead waters on which these floating implants are made are in fact very often located in areas without landscape constraints;

Given these advantages, there are obviously some problems, which make it difficult to use today:

- **The extra costs related to the floating structure**, to the tracking system and to that of cooling, which are estimated to around 0.8 €/W. In fact, this leads to an increase of about 50% of the turnkey price compared to the case of a plant of similar size made on a roof or on ground;

- **The effects of continuous water flow are up to today unknown** on the surface of the modules and the interactions with the aquatic flora and fauna in the long run.

In Italy, some companies have taken interestin this technology. This is the case of Imola Nrg Energy and Bryo (that made the floating unit of Bubano (BO) 500 kWp, the largest in Italy), the Indigo-6eco of Viareggio and Pisa Science Technology Industry (Scintec), which as a first is committed to the design and installation of this type of implant and has already made, in Italy, two implants using this technology:

• **The Colignola implant** (Pisa), which integrates a low concentration called FTCC (Floating Tracking Cooling Concentration). The implant has a power of 30 kW and a total cost of approximately € 65,000 (approximately 2.15 €/kW). This implant is characterized by modules arranged horizontally with mirrors inclined by 60/70°, on a platform oriented by means of helical motors and cooled with hydraulic pumps;

• **The Suvereto implant** (Livorno), located on a basin used for irrigation, uses traditional modules at an angle of 30° on platform, cooled with hydraulic pumps. The power of the implant is 200 kW, for a total cost of approximately € 435,000 (about 2.18 € /kW)

Box 2: An innovative application: the floating PV

2. The market

The year 2010 can be defined as "special" for the photovoltaic market, as it is characterized by the combination of two remarkable phenomena: on the one hand, the growth of "fast track" (to use a neutral term) of the Italian market because of the now famous Salva Alcoa Decree and, on the other hand, the appearance of new non-European countries competing for a leading role in the global photovoltaic, partly as a result of its "fatigue" of the German locomotive.

These features have undoubtedly characterized, in the expression of their effects, the year 2011. A year of growth yet again of "double digits" for the global PV, but where for the first time, Europe shows a decrease in percentage if one measures the new plants actually made in the year, well "masked" by the growth of the implants that came into operation on the long wave of extraordinary regulatory interventions just mentioned. A year where the role - especially from a future perspective - of countries such as the USA, India and China has become increasingly strategic in a possible movement of the market outside the Old Continent. In Europe, in fact, the real protagonists of the "brake", although for different reasons, were Germany and Italy, where they obtained a remarkable record in 2011 for the implants put into service.

2.1 The PV in Europe and in the World

The analysis of the PV market in the world in 2011 requires some more attention. If, as in Table 6, we analyze the performance of grid connections, which is **the real entry into operation of photovoltaic systems, the picture that emerges is very positive with a total of "new" implants of almost 28 GW (21 of them in Europe), an increase of over 86% compared 2010 , the previous year.**

Country	2011 (MW)	2010 (MW)
Italy	9.370	2.323
Germany	7.400	7.410
France	1.510	720
Belgium	850	n.d
England	700	50
Spain	500	100
China	2.000	-
USA	1.700	880
Japan	1.100	1.000
Australia	700	200
India	150	-
Total Europe	**21.000**	**11.950**
Total World	**27.700**	**14.850**

Table 6: The entry into operation of implants in 2010 and 2011 in the main European and international countries

The total power available in the World of photovoltaic thus rose to 67.3 GW in 2011, more than 3 times that measured at the end of 2009, with growth forecasts - to which we will return later - that reach 94 GW (with a further leap of 40%) in 2012.

Returning to the analysis of Table 6, it is possible to highlight that **Europe is firmly in the lead as regards to the monitoring of the global PV market, with a share in power output equal to more than 77%** of new connections to the grid occurring in 2011. **The year 2011 is also the year of Italy's "overtake" in respect to Germany. To our country goes the record of photovoltaic systems that forced into the World, a good 9.37 GW of power** (44.6% of share in Europe, and over 33.8% in the World), **against**

"only" 7,4 GW for the German market. A great success - if one looks at the mere numbers - when you consider that when, in 2007, in our country just 70 MW of photovoltaic were installed, Germany already traveled over quota 1 GW of new installations per year. The German "locomotive" seems to have stalled, and this feeling is reinforced by the analysis compared to 2010: **Germany is the only country in TABLE 6 to score a substantial "stall" in the putting into operation of new photovoltaic** (or to be precise a decrease of 0.14%).

Although the data is indisputable - and very often in public debate on the subject it was even abused - it is necessary to pay particular attention to the interpretation of these numbers**. It appears essential, in fact, to complement the analysis made so far to the "vision" provided by Table 7, which shows instead the data relating to the implants actually made in 2011**.

Country	2011 (MW)	2010 (MW)	Cumulated at 2011 (MW)
Germany	7.400	7.410	24.550
Italy	5.646	6.047	12.872
Belgium	650	n.d	1.750
England	700	50	750
Spain	500	100	4.200
France	220	2.010	2.535
China	2.000	-	2.800
USA	1.700	880	4.200
Japan	1.100	1.000	4.750
Australia	700	200	1.200
India	150	-	200
Total Europe	**16.270**	**16.840**	**46.862**
Total World	**22.970**	**19.740**	**67.300**

Table 7: Installations in 2010 and 2011 in the main European and international countries

The main difference between the two tables is linked to the effects of "distortions" generated inside from regulation "exemptions", such as the now famous "Save Alcoa" Decree in Italy or that, perhaps less well known, which affected the French market. In both cases **there is a significant difference between the systems actually installed in 2011 (5.65 GW in about 220 MW in Italy and France) and the ones connected to the grid (9.3 GW, up 63% in Italy and 1,5 GW, almost seven times as much in France).** In the Italian case, being the first market in the world for implants that entered "in force" the difference is not trivial.

The new photovoltaic systems actually installed in the World in 2011 are in power equal to23 GW (16.7 of which were built in Europe).

The picture that emerges is very different:

- **The growth experienced in the world compared to 2010 is therefore equal to a more "paltry" 16%.** It is still a growing "double-digit" and in the overall context of economic crisis certainly is not conducive to new investments, but it is clear that the disproportion compared to +86% measured on the basis of entries in force should make you think;

- Europe, which also holds by far the lions' share of new photovoltaic systems made in 2011 (16.3 GW, or 71% of the 23 GW worldwide) marks instead of a drop of 3.4% compared to 2010. A sign of slowdown that leads to a more careful analysis and that comes to terms with a particular non-European scenario in ferment;

- The leadership of Germany, both in Europe and therefore in the world, seems very "strong". What was possible to judge as a "stalemate" looking towards new connections to the grid, appears instead, as a **"hold back" in respect to the more decided drop of "followers": Italy and France, that measure a "collapse" of the new implants made** by over 2 GW in just over 200 MW. In this ranking, Germany is still the first global PV market with a market share of new installations equal to more than 45.5% in Europe and 32% in the world, almost ironically percentages very similar to those that for Italy were related to the one connected to the grid;

- Italy was affected in a very "heavy" way the effect of "Save Alcoa" and "turbulent" legislation of 2011, with a decrease of more than 6.6% in the new installed capacity. The gap with Germany remains therefore significant, although nearly halved compared to 2010. That path of "extraordinary" growth that had made Italy a "case study" worldwide pauses, being this perhaps the most significant fact.

One may be wondering how significant is the size of the installed implants - that is being used here – compared to that (which is simpler and more immediate) of connections to the grid of new photovoltaic systems. It is therefore necessary to add a few words about. It 's true, in fact, that what is connected to the grid “keeps faith" when it assumes the perspective of the public sector called to provide incentives on the basis of energy actually produced and it is equally true that it is that connected to the grid to determine electric load "problems" which often we heard of and to specifically inform the shares of Terna and the other energy Distributors. However, **when dealing with the "industrial system" of PV, there is no doubt that the reference should be the actually installed new power: this power is, in fact, what generates new orders along the supply chain (from installation to production of silicon), it is this power that operators size their production and investment in productive capacity to, it is for this power that the owners of implants have made investments and the banks have granted loans**. In other words, **it is around the power of new installations that the turnover and the photovoltaic business in our country is generated**.

If the actual analysis of the effective installations during 2011takes into evidence Europe’s “slow down ” compared to the rest of the world , it seems that growth forecasts for the year 2012 are equally significant and shown in FIGURE 23.

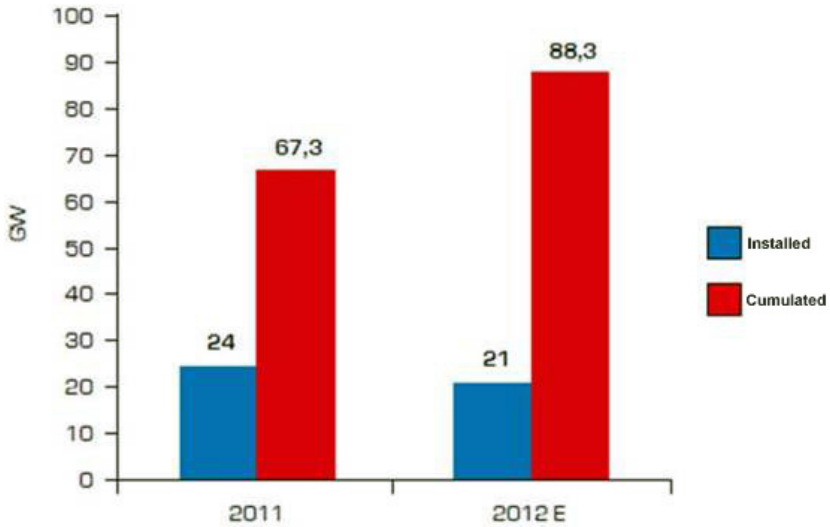

Figure 23: Forecast of installed worldwide in 2012

For the year 2012 installation of an additional 21 GW of new PV systems worldwide is expected, a decrease compared to 2011 due to the slowdown in German and Italian markets, with a rather significant change in the weight of countries outside Europe.

During 2010 - SEE TABLE 7 - **five were the countries in the world with newly installed PV capacity over 1 GW: in thefollowing order of Germany (7.4 GW), Italy (2.3 GW), France (2.1 GW), Czech Republic (1.4 GW) and lastly Japan (1 GW).** The predominant role of Europe is more than evident, as is the absence of key players in the global economy and industry like the U.S., China and India.

The same ranking in 2011 is rather different, yet the remaining five countries to have passed the threshold of 1 GW: always in order Germany of (7.4 GW), Italy (5.65 GW), China (2 GW), USA (1.7 GW) and Japan (1.1 GW). Apart from the exit from the scene of France, the Czech Republic in 2011 also saw - after cutting "sharp" incentives - basically its market disappear (with only 15 MW installed). **Two countries have forcefully appeared on the scene, China - jumping to second place in this special list - and the United States, so to say two among the "missing" in 2010.**

The U.S., in particular, have doubled in the last year their installed base and seem to have embarked on a path of growth that most analysts considered already inevitable, at least for the short to medium term. **China, playing as usual on the "scale" effect, launched in 2011 a new incentive system** through which it sets ambitious targets for new installations, already realized with the first 2 GW in the year. **India's absence is to be considered only temporary,** if one considers that **- in spite of a little over 150 MW installed in 2011 - the Indian operators of photovoltaic systems have already issued orders for the year 2012 for a number of modules and inverters corresponding to over 1 GW of power "installable".**

In general, **the percentage weight of non-European countries has steadily increased from 11% of installed in 2010 to 25% of 2011.**

In Europe, only in the UK has there been an interesting trend, with the installation – thanks to rather high incentive tariffs in spite of the lowering of implants' costs that led the British government to review in October 2011, the incentive system - of approximately 700 MW of new implants, especially in the small-medium size. While as regards to the main countries, besides Italy (which will be discussed in detail in the next section) **also for Germany a fall is expected for the year 2011 - according to some operators even potentially very sharp - of the installed.**

Therefore, if **the current distribution of accumulated of photovoltaic installations in the World at the end of 2011 (SEE FIGURE 24), yet rewards Europe with a market share of 70%** (and a gap of over 46 GW to 20 GW of the total of the other countries of the World), we should probably get used to in the near future to look more carefully at the markets that are more distant from our borders. Of the already mentioned about 21 GW of PV which is expected the installation during 2012, over 40% may not already be installed in Europe.

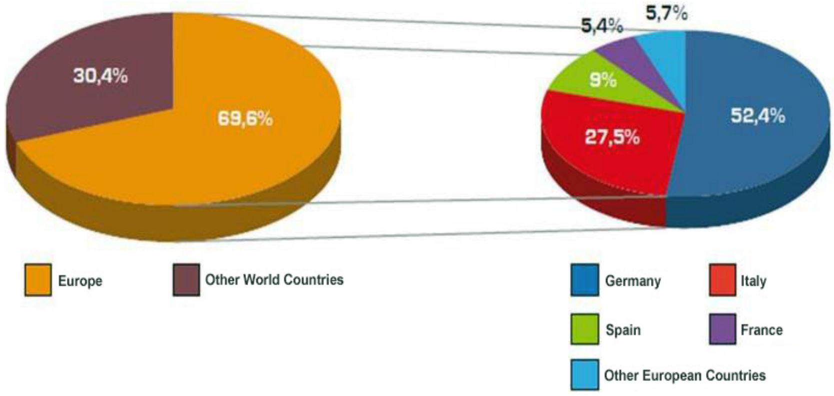

Figure 24: Worldwide power cumulated installed in late 2011

2.2 The PV in Italy

In the previous section we have already had the occasion to comment on how **the world record achieved by Italy on connections to the grid in 2011 hasn't given extraordinary opportunities for celebration, but rather has highlighted the "fragility" and the complexity of our market.**

Both the "long wave" of the "Salva Alcoa" and the turbulent regulations, such as the register of large implants, have characterized the market which have marked the life of Second (for Salva Alcoa), Third , Fourth and Fifth Conto Energia.

In this section we will face the issue with a double perspective: the first of "historic" character, which analyzes what happened in the Italian PV market in 2011, while the second of "prospective" character instead, investigates and documents, even in an original way compared to what was done in previous Reports, the expectations of operators in the industry on the future of photovoltaic in our country.

FIGURES 25 and 26 **show the trends of development of the PV market in Italy** if one looks at implants actually connected to the grid in the year (with the peak at almost 9.4 GW in 2011), or to the actual implants installed, with data 2011 firmly at 5.65 GW and the peak in 2010 at over 6 GW. **The total amount of photovoltaic implants in force at the end of 2011 is equal to 328,000 units, about 173,000 (53%) of them connected during the year, of which, however, "only" about 126,000 (38%) actually installed**. In both views**, the growth in the last two years is still "impressive", although very different is the interpretation that can be drawn from it**. If you look - a bit superficially – at the connections to the grid, one might erroneously conclude that the various cuts that were operated on incentive mechanisms in the last two years have not affected the growth and indeed have only partially contained the "explosion" of photovoltaic in our country. The more "realistic" vision – that is the one that examines implants actually made – shows instead signs of "fatigue" of our market, which still has to dispose of the Salva Alcoa "toxins".

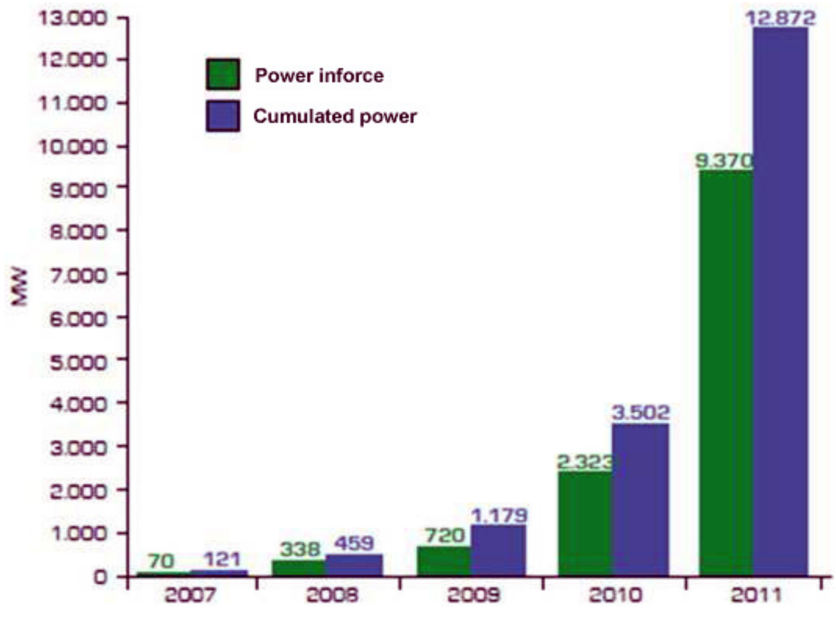

Figure 25: Annual and cumulated power in force in Italy

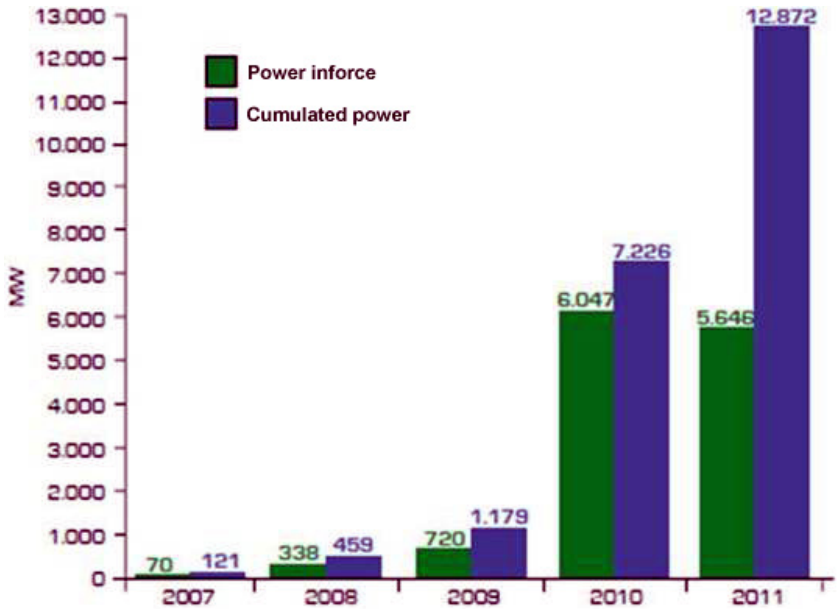

Figure 26: Annual and cumulated power made in Italy

If it is in fact true that **the acceleration of installations in 2010 has allowed the Italian market to "jump ahead" towards a size scale comparable to the German one, on the other hand, it has also burned part of the more profitable opportunities for growth arriving to fill up the new demand**, which in 2011 had settled at around 5 GW (similarly to what happened to Germany but on a level that in the past two years was around 7 GW).

This effect appears with even more evidence if - as is done in FIGURES 27 and 28 - one "colors" both the connected and the installed differently depending on the Conto Energia to which it refers. Overall, then, it is to the Second Conto Energia (both for the share connected in 2010 and in 2011 due to the "Salva Alcoa" effect), to which is attributed the lion's share of the Italian PV market. The Third Conto Energia (11.9% of the total installed), despite its short duration, and the Fourth Conto Energia (31.9% of the total installed, all concentrated in the course of 2011) move on much lower values. **The transition to forms of incentives following the Second Conto Energia is therefore translated concretely in a reduction increasingly more evident of the new installed power**. It is with this last data obviously that operators of the industry were set to confront during the past year.

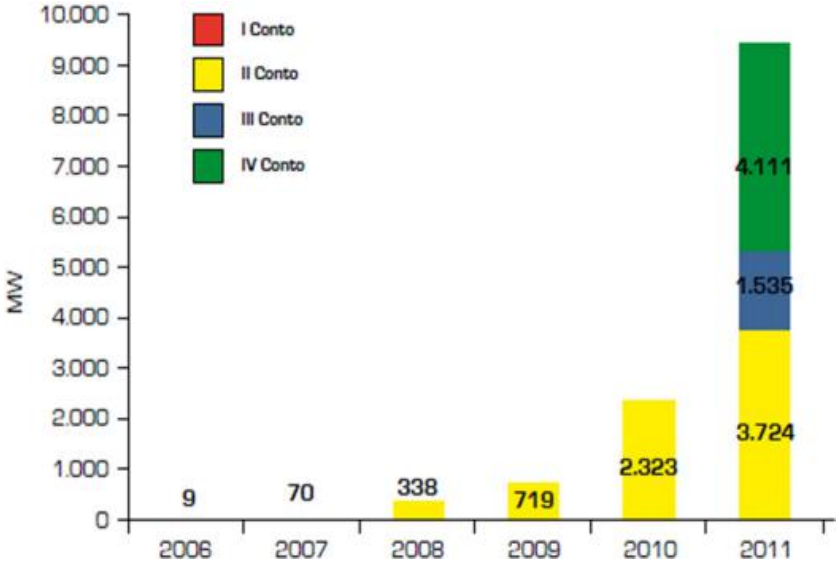

Figure 27: Annual power in force in Italy divided by Conto Energia

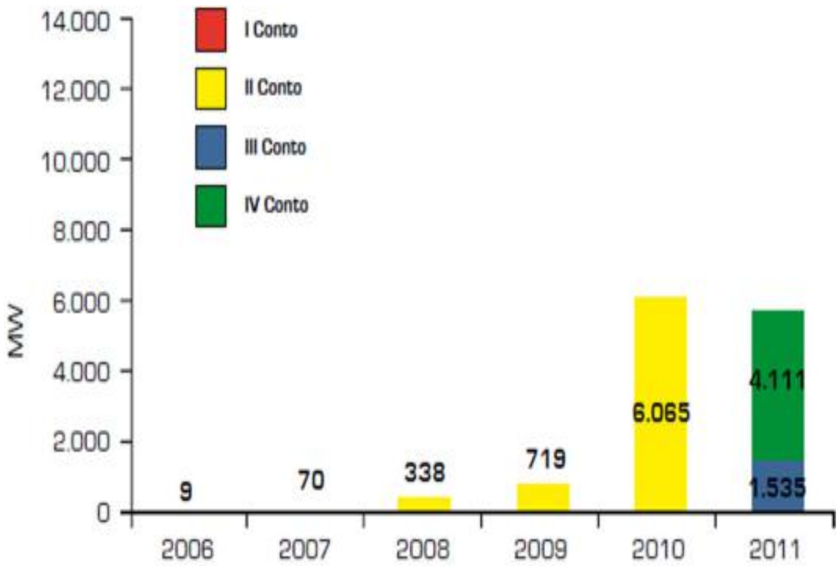

Figure 28: Annual power made in Italy divided by Conto Energia

The different systems of incentives that have supported photovoltaic in Italy over the years and have then **a very significant impact on the distribution per size of photovoltaic power in Italy**.

If one looks at the data relative to **the implants actually made in 2011 and compares it with what happened in 2010** (SEE FIGURE 29), one notices immediately how:

- The share of "solar power implants" has increased, that is implants of size over 1 MW, which increased from 22% to 31% **with a relative increase of more than 40 percentage points**. **This finding may appear inconsistent with estimates of cost** that show instead **how in the passage from 2010 to 2011 the profitability related to the construction of solar power implants has worsened**. In reality, **the operators are all in agreement in defining the phenomenon linked to the desire for investors who "attempted" (without success) to use the Salva Alcoa to finish the work, however, of making their systems in time to avoid the negative effects of activation in September 2011 according to the "Register of Large Implants".** In other words, we have assisted to another race to complete the work of installation and connection before 31 August 2011;

- **The proportion of “large” has in general increased, meaning over 200 kW** in our classification. **In 2010, 1,271 were installed, for the corresponding 67% of the total of new capacity, while in 2011 this percentage rose to 71% in 3403 implants**;

- The "commercial" segment contracted, that is the implants between 20 and 200 kW of power, **which instead was affected to a greater effect by the economic and financial crisis on the investment capacity of the parties / clients involved**;

- **The share relative to residential sized implants (about 634 MW of power implants and 101,300 in 2011) has essentially remained unchanged in the biennium, which are a sort of "bedrock" of all new installations**. For this type of installation an economic convenience is guaranteed and is significant also to changes in the incentive system, even if - as is natural - on an annual basis this component of demand cannot grow beyond a certain extent;

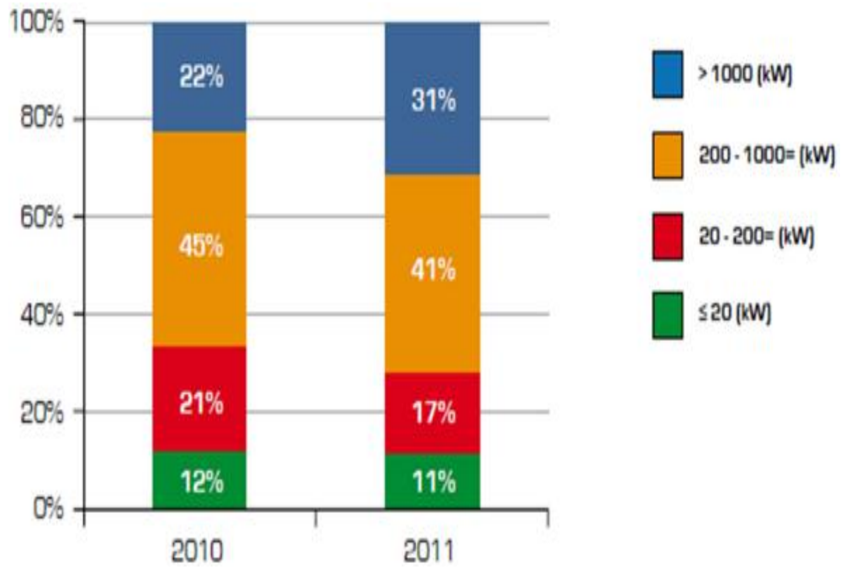

Figure 29: Segmentation of power relative to implants made in 2010 and 2011

In other words, **the expected effect of re-distribution of new installations in favor of smaller size systems - that was one of the inspirational elements of the reform of the incentive system - has not been realized in practice**.

These reasons are, on one hand, tue extreme legislation turbulence that clearly hit “weaker” operators (meaning the average investor in the section 20-200 kW) compared to those who still had "taken into account" higher sizes of investment, but on the other hand also the fact the potential markets are clearly different.

It is not possible, in fact, to reach levels of over 5 GW of installed if one doesn’t access to segments of "power". Just to give an idea, if one had wanted to - for the same total installed - switch the power that in 2011 went to the "big" implants and to "central" implants of "average" size (20 - 200 kW) about 52,000 implants would have had to be installed (+ 350% compared to the number actually recorded in 2011). **A substantial change in the mix of implants towards “low” sizes can only be accompanied by a reduction of the annually installed.**

What we assisted to - and that deserves to be mentioned - is the portion share of implants installed on the roofs in respect to those on ground. In particular, the installed relative to the Fourth Conto Energia highlights how **the percentage of implants installed on building in 2011 was overall equal to 38%, but**

with an increase of implants on building for the sector of big implants (with peaks of 35%) in respect to the previous year.

In Figure 30 the distribution of implants on building and on ground in various Italian regions is reported. Also, **implants with a power exceeding 200 kW of installed power on building reached in 2011 a value equal to 2.15 GW.** Lombardy in this ranking is positioned at the top (about 400 MW), Piedmont at the second (about 250 MW) and Veneto at the third (about 217 MW). It 's interesting to note that Puglia, while leader in the installed PV industry, installed in 2011 only 81 MW implants on rooftops with a power superior to 200 kW. Of these 2.15 GW more than 80% could be installed on commercial surfaces or industrial buildings.

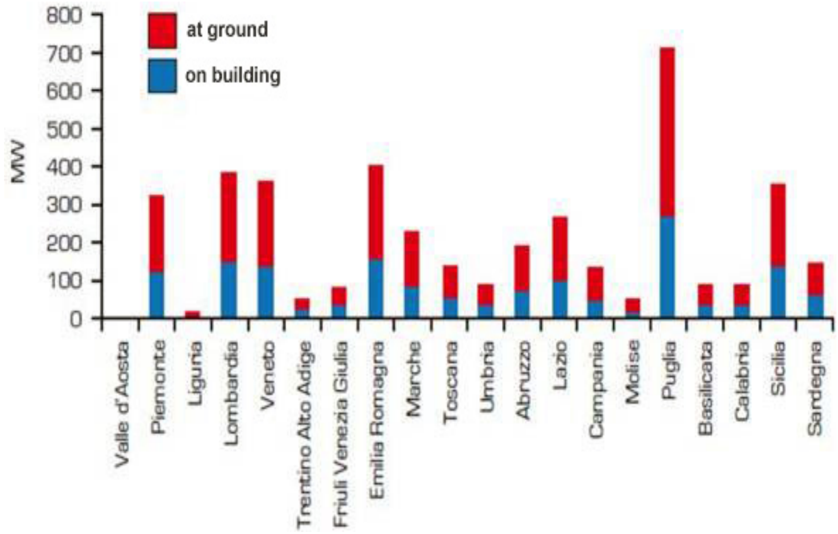

Figure 30: Distribution of installed implants on ground and on building installed with the Fourth Conto Energia

To complete the picture of market data, it is more than ever necessary to analyze what happened in the different Italian regions. **FIGURE 31 shows the trend of implants entered in force in 2010 and 2011 and the cumulative total divided per region, whilst FIGURE 32 reports the picture of implants actually installed in the past two years.**

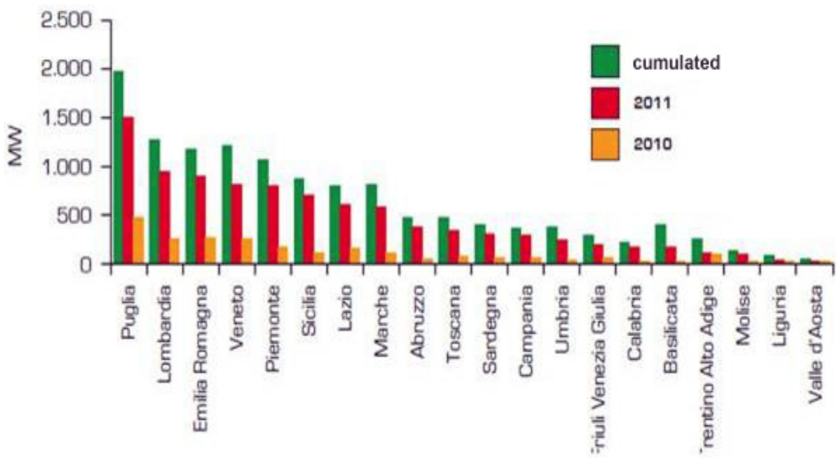

Figure 31: Annual and cumulative power in force in 2011 in the different Italian regions

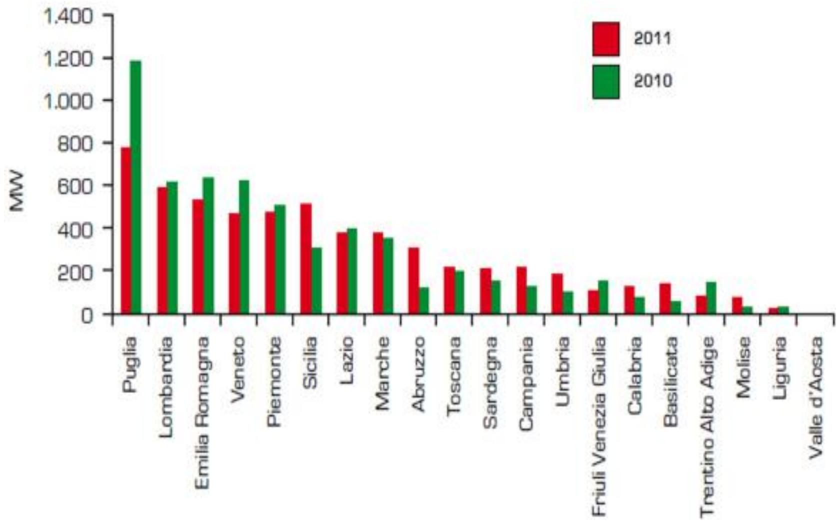

Figure 32: Annual Power made in 2011 in the different Italian regions

It 's still Puglia the leading region in Italy - both if one looks at the installed (785 MW, 13.4% of the total) and to the in force (1,502 MW, 16% of the total) - followed by Lombardy and Emilia Romagna.

However, **if we consider the growth rates of the implants that came into force, the region that has experienced the highest growth in 2011 is undoubtedly Molise**, **with a record increase of 1,263%** (but still an installed total of 606 MW) . Following in the ranking are Abruzzo (+821%), Basilicata (+736%) and Sicily (+548%), **while Trentino is the only Italian region that does not grow on the connected by "three digits" stopping only at 20%.** If one looks at the installed, it is interesting to note how the vast majority of leader Regions installed in 2011a lower power than they did in 2010.

If we move to analyze the distribution by size of implant, and more correctly, we look at the actual power installed in 2011, **the regional distribution does not reserve many surprises, except for the case of Lazio that comes before Puglia in the special ranking list of the installed in the "solar power plants"** (330 MW against 291 MW). Puglia, however, remains in first place when one considers the total of "large" implants meaning over 200 kW and **in general the Central and Southern regions confirmed themselves with 48% of the total, as the most "popular" for investment in photovoltaic implants of greater size**.

Lombardy is confirmed instead also for 2011 as the region of reference for commercial installations (20 to 200 kW), which totaled a good 226 MW, followed by Veneto (156 MW) and a bit detached from Emilia (75MW) . **It 's Veneto, finally, to contend with 106 MW the record for small implants to Lombardy.** Even in this case **it is not surprising that the North also controls for 2011 about 62.7% of total installations under 200 kW.**

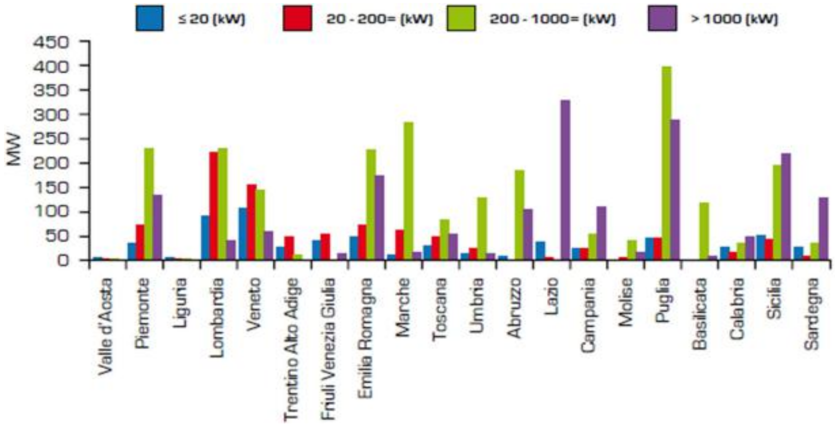

Figure 33: Segmentation per implant size of the installed power in 2011 in the different Italian regions

It 's clear, however, that the representation of Figure 33 does not allow to grasp immediately the relationship between the "weights" of the different Regions. FIGURES 34 and 35 thus **provide a "relative" vision that shows the picture of the overall total installed at the end of 2011 to the number of inhabitants and to the regional size.**

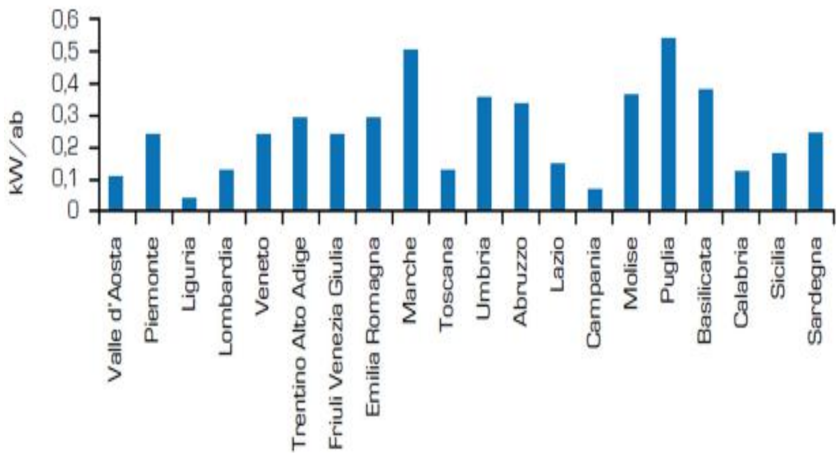

Figure 34: Power cumulated per capita in different Italian regions in 2011

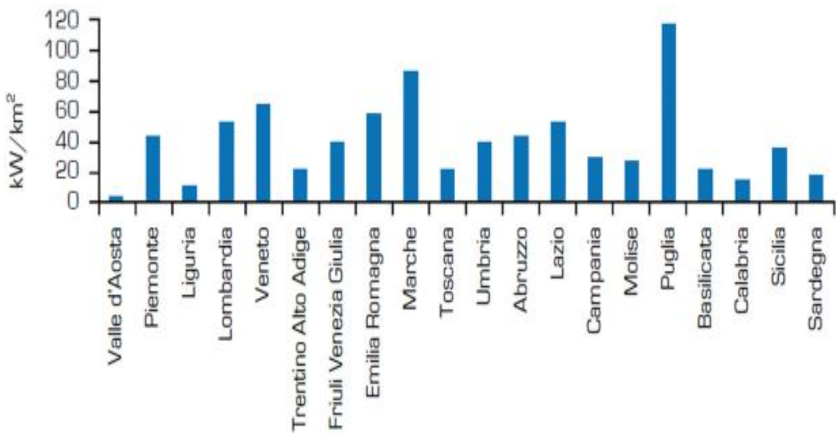

Figure 35: Cumulative installed power per Squarekmin the different Italian regions in 2011

The "density" of installations is highest in both the prospects for Puglia, followed at a short distance - and probably in an unexpected way **- from Marche, which in respect to cumulative power "as absolute value" is at the eighth place in the ranking for Regions.**

Lombardy comes only in fifth if one looks at the territorial extension, and in fifteenth place if one takes into consideration the number of inhabitants, and below the average of the Northern Regions as power per inhabitant (19.5 kW and 36.3 kW per inhabitant per km2).

Apart from the special case of Valle d'Aosta, **data for Liguria and Campania hit on hard, as they show an overall total installed in 2011 decidedly well below expectations.**

3. The value chain

The year **2011 was a particularly difficult year for companies active in the Italian PV marke**t, due to different moments of discontinuity caused by the framework of incentive mechanisms. The Renewables Decree approved March 3rd has effectively suspended the system of feed-in premium in the months of 2011, which obviously has blocked the activities of operators, with negative repercussions on employment levels. The market started again with the approval of the Fourth Conto Energia, issued by the Ministerial Decree of 05/05/2011 and published in the Official Gazette 109 of 12/05/2011, which, however, required **a change in the business model of Italian operators of photovoltaic systems**, many of which traditionally focused on large implants on ground that had to convert, especially in the second half of the year to compete in the market, much more fragmented and complex, than roof implants, the most interesting with Fourth Conto Energia. There was then a mad dash to connect by June 2011 systems already installed in the last months of 2010, taking advantage of the Salva Alcoa regime. To this followed an attempt, on the part of all the major players in the industry, to install and connect the largest possible number of implants before the entry into force of the mechanism of the Register of Large Implants in September 2011. Up to the early 2012, when to operators was prospected by the Government a future interruption of the Fourth Conto Energia, as early as the second half of the year, by effect of achievement, earlier than expected, of the limit of 6 billion € of annual cost of incentives.

As is easily understood, **in this context the players in the Italian PV could not in any way plan their investments and their activities**, "sailing on sight" and seizing opportunities that time to time the market presented them. They were also exposed to considerable tensions and contractions of their margins, due to decreasing trends in prices as discussed in the chapter on technology, which had the effect of putting many of them in serious trouble and even causing the failure of some of them. This did not prevent to the total installed capacity in 2011 to reach levels similar to those facts recorded in 2010, **but significant market share went to the prerogative of the Italian and European manufacturers**, much less exposed to the dynamics of our market.

The objective of this chapter is **to study the dynamics that have affected the photovoltaic supply chain in Italy in 2011**, starting with an analysis of the turnover and gross margin generated along the phases of the chain, passing through the mapping and studying of the characteristics of the actors in the different business areas of photovoltaic in Italy, ending finally with an estimated employment impact of PV in our country.

3.1 The turnover of PV in Italy

The total turnover produced by the photovoltaic sector **in Italy in 2011 was calculated considering only implants that have been made during the year**. Thus, implants, using the mechanism of the Salva Alcoa, installed in the last months of 2010, but connected and which came into operation in the first half of 2011 were of course not taken into account. According to this hypothesis**, in 2011 the Italian PV generated a turnover of 14.8 billion €, with a decrease of approximately 31% compared to 2010** (SEE FIGURE 40). The decrease in turnover was mainly due to a lower volume of installations compared to 2010 (which also included the systems installed under the Salva Alcoa) and to the significant decline in the turnkey price in all major market segments.

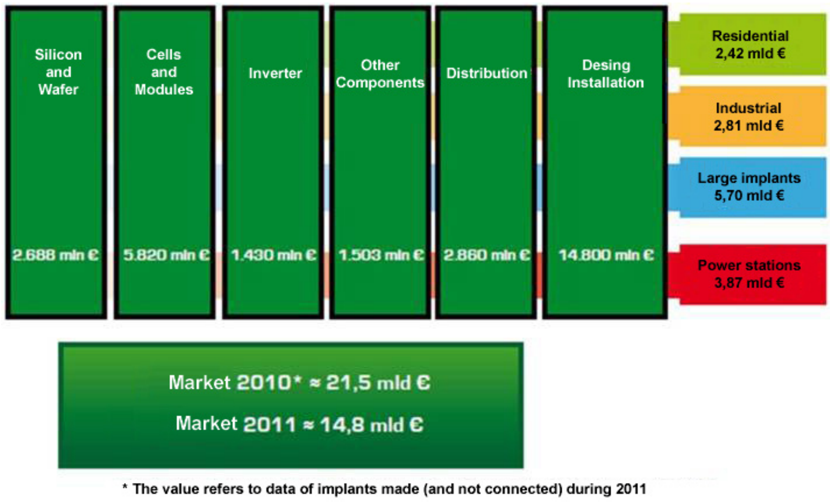

Figure 36: Main areas of business in the Italian PV sector and turnover in 2011

The segment of residential and commercial installations (which includes systems up to 20 kW of installed power) **recorded the lowest turnover among all segments of the market**, with a decrease compared to the 2010 value by over 30%. **A dynamic not unlike is observed in the sector of industrial implants**, with size between 20 and 200 kW. This experienced the most significant reduction compared to the turnover of 2010 between the various market segments, with a decrease of 38%. These implants, as well as the residential ones, have seen a decrease in their weight in the total business volume due to the increasing attention that traders and investors have reserved to greater size implants in an attempt to take advantage of the last opportunity to invest in these high-performance facilities, before the revision of the Fourth Conto Energia penalizes them excessively. This is evident if we look at the segment of large implants with sizes between 200 and 1000 kW, **which in 2011 generated a total turnover of 5.7 billion €**, more than double than that of residential and industrial buildings. The segment of the implants, meaning implants with size greater than 1 MW, in 2009 represented the less important sector for turnovers, while in 2010 the residential segment exceeded. **In 2011, it overtakes even the segment of industrial implants, with a total turnover of 3.9 billion €.** This is due first of all to the run for the installation of these facilities by August 31, 2011, point from which the complex and expensive mechanism of the Register of Large Implants entered into force.

It was also decided to analyze what is the portion of the volume of business, in different business areas, that remains "in the pockets" of Italian companies. The estimates refer only to the domestic market and are purified by turnovers that Italian companies realized through export activities in foreign markets. The results of this analysis are summarized graphically in FIGURE 41.

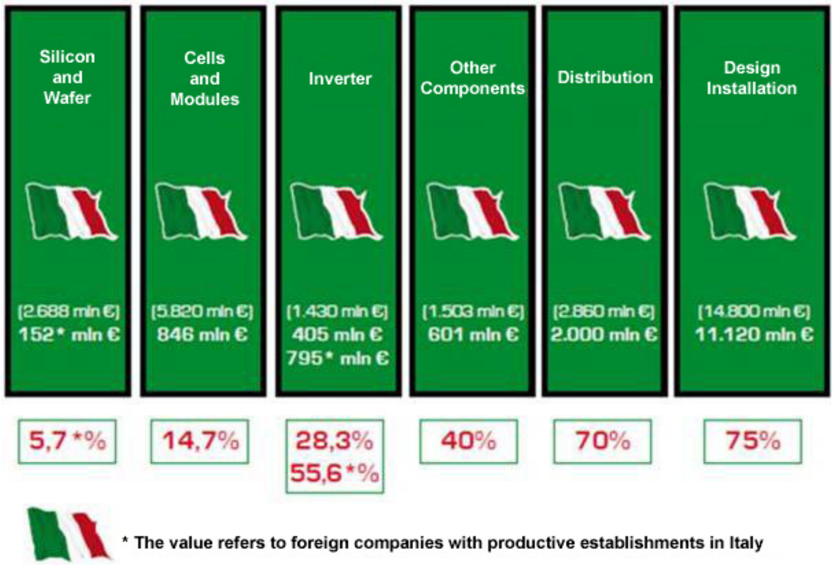

Figure 37: Main areas of business in the Italian PV sector and business volume generated by Italian companies in 2011

Firstly we can **notice how the Italian presence in the silicon and wafer field is due solely from the sales of the American MEMC** through the Italian productive establishment, which account for about 5.7% of the total turnover generated in our country. As for manufacturers of solar cells and modules, the turnover of which the Italian companies are able to able to appropriate themselves of represents 14.5% of the total, for a total of approximately 850 million €. As for the Italian inverter manufacturers, the volume of business generated by them in 2011 was approximately € 400 million, representing 28.3% of total revenues. However, we must consider that, in the course of 2011, the Italian manufacturer of inverters have exported about 20% of their production. In addition, if we include Power One, an American company with production facilities in Italy, the share of the total turnover in Italy remains well above 50%. Finally**, the Italian distribution companies are able to take ownership of 70% of the overall total turnover**, while for the area of business relative to the design and installation we reach a weight of 75%, for a total of about 11.1 billion €. Of this volume of business that stays in Italy, the part relative to the residential and industrial segment is mostly made up of designers, installers and Italian system integrators. For the design and installation of large implants and power stations, the turnover in Italy by the foreign EPC reached together even 35-40% of the total, with an even stronger presence in the segment of large power implants.

3.2 The players in the photovoltaic sector in Italy

Our analysis allowed us to estimate an increase of the total number of companies operating along the entire photovoltaic value chain in Italy by about 6% between 2010 and 2011. In particular, as shown in FIGURE 42, the solar industry has been characterized by an increase in the number of Italian companies:

- **In the area of cell and module business the companies exceed 50**% (an increase of 5 percentage points compared to 2010) of the total market players. Also the share of foreign companies, having sales office in Italy (42%) increased compared to last year. In addition to the main European companies that had already opened in recent years sales offices in Italy, also the larger Asian companies now have their own sales office in our country. Smaller Asian companies remain active with the simple channel of exports that sell medium-low products;

- **The inverter business area is gradually increasing the percentage of Italian companies (47%)** in respect to foreign companies having Italian subsidiaries and to foreign companies operating in our country without subsidiaries. Also in this foreign operators operating through exports are Eastern producers or small sized European companies that sell products directly to distributors present on the territory;

- **The business area relative to distribution consists of about 85% of Italian companies and 15% of foreign companies with branches in Italy**. Foreign firms without branches are not present, as is obvious considered that this activity requires the presence of warehouses for the storage of the components on site. In the last year (SEE PARAGRAPH 3.7) the proportion of European distributors (mainly German ones) which opened new sales offices in our country has increased;

- **The business designing and installation area is composed by 80% of Italian companies**. In particular, between late 2010 and early 2011 various foreign EPC entered into the Italian market to seize the good opportunity arising from the Salva Alcoa and from the period leading up to the opening of the Register of large systems.

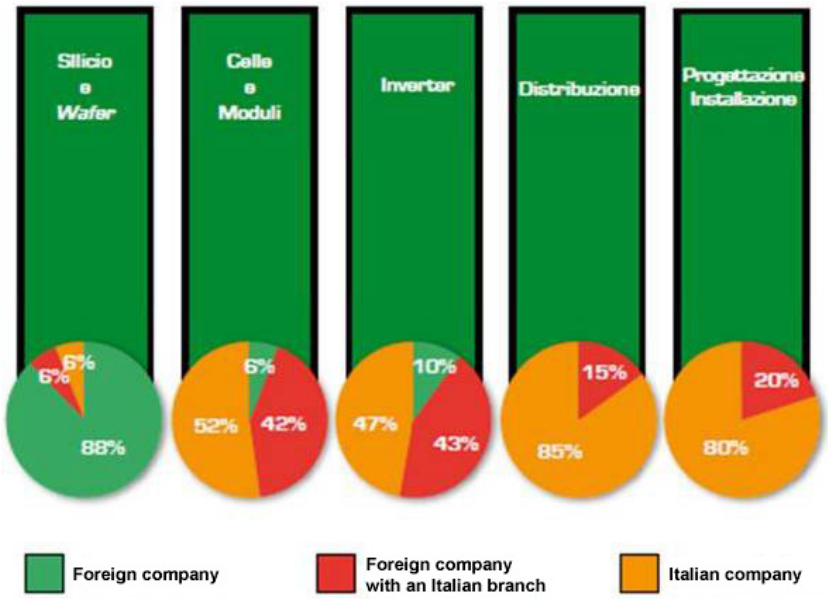

Figure 38: Companies in the Italian photovoltaic sector

3.3 The margins

Following is an analysis of the gross operating margin (EBITDA margin) of companies operating on the Italian market, in comparison with the margin recorded in 2010 and 2009. Data on margins in 2009 and 2010 are derived from the analysis of financial statements for 2010, while for the year 2011, just ended, the data are derived from the empirical analysis conducted on the sample of companies interviewed and are to be considered estimates.

FIGURE 43 shows the average values of margins of active operators in different business areas of the chain, as well as highlights the variance of the collected data.

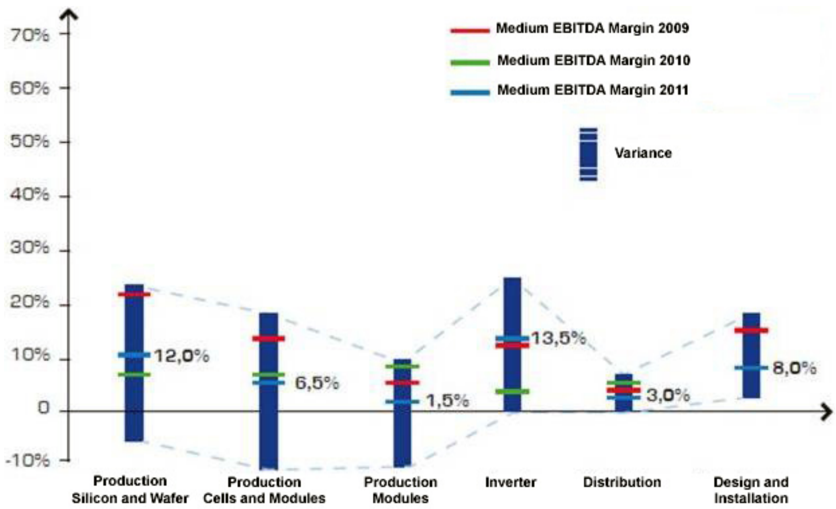

Figure 39: The margins of operators along the photovoltaic chain

From the analysis of figure two interesting trends are deduced. **First, there is a general decrease in margins in all stages of the supply chain**, with values amounting to even lower values than in 2009.

Secondly, it is evident how the variance **of the data of marginality is particularly wide**: in the business area relative to silicon, wafers , cells and modules production; for example, we switch from EBITDA Margin below zero to values around the 20%. This is explained by the fact that, especially with regards to the upstream stages of the chain, differences in efficiency and competitiveness among the leading markets have expanded during 2011, with high production volumes and large production capacities, and the smaller sized players, have definitely lost ground and profitability over the past 12 months.

With regards to the individual business areas, it is interesting to notice that the manufacturers of silicon wafers have experienced an average margin of only 12%, the lowest figure ever reached in recent years. It is sufficient to think, to understand the extent of the phenomenon, that **the margins at the end of 2008 were around 40%, a full 30 percentage points higher compared to the data at the end of 2011.** The compression of margins is even more impressive for manufacturers of silicon and wafer if we consider that they have a cost structure in which the impact of amortization of manufacturing equipment is very important.

A similar dynamic is observed for integrated producers of cells and modules, which in 2011 recorded a significantly lower profitability (6.5%) compared to the previous year (which stood at a levels of 14%). The average margins are much tighter for producers of only modules that have experienced in 2011 an EBITDA Margin average equal only 1, 5%, in "free fall" compared to last years' 7%. There are also cases of European companies with consistently negative margins (think of Solarworld, Centrosolar and Aleosolar), which have undermined their own very survival.

The inverter manufacturers are the only ones who experienced a margin in growth in 2011, albeit mild, compared to 2010, at around 13.5%. It is about a higher average margin even to the level reached in 2009, the year that in general was very favorable to producers of technologies that, due to production processes put in place, were able to maintain profit margins despite a rather high average price decrease occurred in the course of the year.

In the case of distribution, the provisional very low values of EBITDA Margin are confirmed with a slight decrease (4-3%), compared to 2010. **A more important percentage decrease was recorded by the EPC *Contractor and system integrators*** that work in the field of design and installation of implant systems, with values in average equal to 8%, sharply dropping compared to14% in 2010. With the exception of the inverter, therefore, the picture that emerges from this section is that of a very difficult 2011 for traders active in the Italian PV market, which had to cope with fierce contraction in margins to maintain as much as possible unchanged its market share. Mainly for Western traders this has been a goal not quite centered, given the extent to which they have given way to Chinese producers and, more generally, to Orientals also them still affected by the crisis in the sector and by a strong decline of margins.

In the following paragraphs we consider separately the different business areas in which the photovoltaic chain can be broken down and the characteristics and the strategies adopted by major international and Italian players can be analyzed in detail.

3.4 The business area of silicon and wafer

TABLE 8 shows the data of capacity and turnover of the major players in the business area of manufacturing of silicon and wafer worldwide.

Company	Type of Company	Nation	Productive capacity 2010 (tons)	Productive capacity 2011 (tons)	Profits 2011 (mln €)
Hemlock Semiconduct or Corporation	Polysilicon	USA	36.000	40.000	4.901
Wacker Chemie	Polysilicon	Germany	30.000	35.500	4.800
Tokuyama	Polysilicon	Japan	8.200	10.000	3.491
OCI Company	Polysilicon	South Korea	21.000	42.000	2.890
GCL Company	Polysilicon + Wafer	China	21.000 (3,5 GW wafer)	46.000 (6,5 GW wafer)	2.497
MEMC Electronic Materials	Polysilicon + Wafer	USA	14.500	14.500	1.981
LDK	Polysilicon + Wafer	China	10.000 (3 GW wafer)	17.000 (4 GW wafer)	1.692
REC	Polysilicon + Wafer	Norway	13.600 (1,725 GW wafer)	19.000 (0,95 GW wafer)	1.086

Table 8: The world's leading manufacturers of silicon wafers

First, it is interesting to note **how the production capacity of silicon in 2011 has increased by an average of 58%** among the top players in the sector, with an increases of 100% for some large production companies in the Far East (such as GCL Poly). The world production of solar grade silicon in 2011 exceeded 210,000 tons, enough to meet a demand of 20 GW of installations, compared to about 150,000 of silicon produced in 2010. Over 60% of the supply of poly-silicon comes from America and China. Europe in this business area, has a non leading role.

Globally photovoltaic has registered a growth of 16% in the last year, which explains the investment put in place by these operators, always seeking, inter alia, to increase their economies of scale in such a *capital intensive* industry. Without forgetting that the production of purified silicon that they produce is also used for the production of semiconductors for the electronics industry (**in 2011, about 80% of global production was directed to the photovoltaic marke**t). Probably due to an overestimation of the growth in the photovoltaic market experienced in 2011, there is still a certain percentage of unsaturated capacity in this business area. This is clear if we consider that the only the productive capacity of the top eight players at a global level exceeds 220,000 tons, while the total production amounted to 210,000 tons.

Nevertheless, the growth forecasts of production capacity for late 2012 and early 2013, especially as regards to Oriental companies, remain in growth. For example, **the Korean OCI Chemical has plans to increase production capacity to 62,000 tons/year by the end of 2012**.

As for the **price of silicon**, as effect of the fall in prices on the world's major markets, it decreased from about 57 €/kg at the end of 2010 to more than 26 €/kg at the end of 2011, recording a still strongly fluctuating trend during the last twelve months. To counteract this effect, it was consolidated in 2011, involving in a particular way Eastern companies (such as GCL Poly), the trend towards a vertical integration downstream of the operators, in the wafers production.

With regards to market positions, TABLE 8 shows **how the industry leadership remains in the hands of the American Hemlock**, followed shortly by Wacker Chemie, both with revenues of around €5 billion.

All this while **the activity and production of the companies in Italy seems to be slowing down**. In particular, the American MEMC Electronic Materials SpA suspended to the end of 2011, production at the South Tyrol implant in Merano, and has officially announced its closure due to high energy costs and supplies. It must be said that MEMC seems to have started a process of rationalization of production in factories in Kuching, Malaysia, and in Portland, Oregon, with plans to reduce staff by 20% worldwide. **The Ned Silicon project**, for the production of bars of pure silicon for the production of photovoltaic modules, seems not to have progressed during 2011 and 2012, due to the difficulty in finding the necessary financial resources to achieve the production plant. Finally, the **Lux Srl**, a solely Italian company located in Pozzolo Formigaro in the province of Alessandria, engaged in the manufacture of wafer, after having produced about 8 MW in 2011, **declared at the beginning of 2012, the blocking of activities**. The market dynamics that characterized the 2011 PV and the wider economic downturn negatively affected the development of these projects.

3.5 Business area of cells and modules

TABLE 9 shows some information about the key world players in photovoltaic cells and modules production , including both manufacturers and assemblers of integrated modules only.

Company	Type of company	Nation	Productive capacity cells 2010 (MW)	Productive capacity modules 2010 (MW)	Productive capacity cells 2011 (MW)	Productive capacity modules 2011 (MW)	Profits 2010 (mln €)	Profits 2011 (mln €)
Suntech	Cells + Modules +Wafer	China	1.800	1.800	2.400	2.400	2.070	2.365
First Solar	Cells + Modules	USA	1.500	1.500	2.300	2.300	1.830	1.981
Yingli Solar	Cells + Modules +Wafer	China	1.000	1.000	1.700	1.700	1.351	1.753
LDK Solar Co. Ltd	Cells + Modules +Wafer	China	180	1.500	1.260	2.500	921	1.692
Trina Solar	Cells + Modules +Wafer	China	1.200	1.200	1.700	1.700	1.845	1.539
Canadian Solar	Cells + Modules +Wafer	China	980	1.000	2.000	2.000	1.495	1.429
JA Solar	Cells + Modules +Wafer	China	2.000	300	3.000	1.200	1.271	1.278
SolarWorld	Cells + Modules	Germany	250	940	800	1.400	1.305	1.047
Q-Cells	Cells + Modules	Germany	1.100	-	1.200	230	1.354	1.023
Hanwha SolarOne	Cells + Modules +Wafer	China	500	900	1.300	1.500	1.140	882
Sharp	Cells + Modules	Japan	1.015	800	1.400	1.400	n.d	n.d
Jinko Solar	Cells + Modules +Wafer	China	600	600	1.500	1.500	267.7	n.d
Conergy	Modules	Germany	-	250	-	350	665	754
Motech	Cells	Taiwan	1.150	-	1.500	-	720	716
Solon	Modules	Germany	-	450	-	439	555	500
Aleo Solar	Modules	Germany	-	280	-	390	553	462
Centro Solar	Modules	Germany	-	200	-	350	403	293

Table 9: Leading worldwide manufacturers of solar cells and modules

The data in Table 9 highlights firstly the increased competitiveness of Chinese enterprises in this market segment. It is interesting to note how **in fact the first 7 companies by revenue are Chinese, with the exception of the American First Solar**, a company that produces CdTe modules, which is second for total revenues, but remains in the lead for the quantity of modules sold (over 2 GW, compared to the 1.9 GW of Suntech). Clearly this is explained by the fact that the selling price of CdTe modules was lower in 2011 compared to those of the first generation (SEE CHAPTER 2). In particular, **Chinese companies have gained significant market shares at the expense of European producers and, in particular, Germany**. Consider that the German Q-Cells was overtaken, in terms of sales in 2011, by Eastern Yingli, LDK, Trina, Canadian, JA. The German company, a historic producer of cells in 2011 has implemented a downstream integration in the production of modules. It suffered severely from the market downturn and the fall in prices of cells, recording a negative EBIT, at the end of 2011, of 717 million €. All this has led to a restructuring of the company's resources, the dismissal of 250 workers at the end of the 2011 and to the renegotiation of the payment term of the bonds of Q-cells. Nevertheless, the company is confident of returning to positive earnings in 2013.

We can also see **how the Eastern companies are characterized by a higher degree of vertical integration compared to Western manufacturers**. This, together with more favorable cost structure, enables them better to benefit from significant profit even in front of extremely lower selling prices, increasing its competitiveness. It should be noted in this regard that all Eastern businesses in TABLE 9 are integrated in the production of cells and modules, while the largest pure assembler modules are actually European, mainly German. In addition, all Eastern producers have expanded their degree of vertical integration upstream, increasing the installed capacity of wafers to cover almost all the domestic needs. Some companies have gone or are pushing themselves even further, producing internally the solar grade silicon they need. It 's the case of LDK, which has plans to increase production capacity of poly-silicon to 55,000 tons/year by 2012.

All this has had **a negative impact on the competitiveness of important Western manufacturers**.Just think that German companies listed in TABLE 9 experienced a fall in their total revenues between 2010 and 2011, of over 16%, because of their inability to compensate the drop in prices of modules with a more than proportional increase in sales. **Many of them for the first time in 2011 have experienced negative net operating margins** (for example, -365 mln € EBIT at the end of September 2011 for QCells, -230 mln € in December 2011 for Solarworld, -105 mln € at the end of September 2011 for Conergy, -3 million € at the end of September 2011 for Centrosolar). Not to mention the numerous cases of bankruptcy, with Solon that triggered the bankruptcy proceedings in late 2011 and the British BP Solar that in 2011, after the rationalization of production modules built in 2009, decided to leave the sector.

Even **the Oriental manufacturers, which in 2010 had experienced margins even superior to 20%, have recorded margins close to zero or even negative in some cases during 2011**. It is sufficient to say that the EBITDA Margin of Suntech in 2011 was slightly higher to 2.4% while Yingly, from the available data, traveled on levels of -1%. Nevertheless, companies in the Far East and some European companies have increased production capacities. In particular, thanks to the investment of Chinese enterprises, the increase was more than 120%. For some companies such as Jinko Solar, Solar Hawnka and Solarworld which came to exceed 150%.

BOX 3 describes the case of India, which in addition to being an extremely attractive market for photovoltaic in the near future, saw significant increases in production capacity of its companies in this business.

The production capacity of solar cells and modules of the Indian industry has grown significantly in 2011, rising from just 200 MW in 2010 to over 1,700 MW of modules and 700 MW of cells, with forecasts indicating a significant growth for the coming years. India has recently experienced the birth of new Indian manufacturers firms such as Alfa Solar, JBM Group, Vorks Sonali Energies and Energy, which have expanded their activities in the energy sector to the production of modules, in addition to growth of the existing large producers such as Tata BP, EMMVEE, Moser Baer and XL Energy. A significant example in the growth of the Indian industry is represented by Tapan Solar Energy Pvt, which has engaged, at its plant in Neemrana, the production of polycrystalline silicon modules branded Elecssol. The current production capacity of the implant is 20 MW per year, but the company plans to bring it to 40 MW by the end of 2012. The technology and automated production lines in the plant are European and the module efficiency is around 15%.

Box 3: The production of cells and modules in India

Compared to the dynamism and growth rates recorded by producers of solar cells and modules at international level, and especially in the Far East, the Italian photovoltaic industry in this sector has been much more stable. FIGURE 44 shows the development of productive capacity and the total production of cells and modules in Italy and the forecasts to 2012.

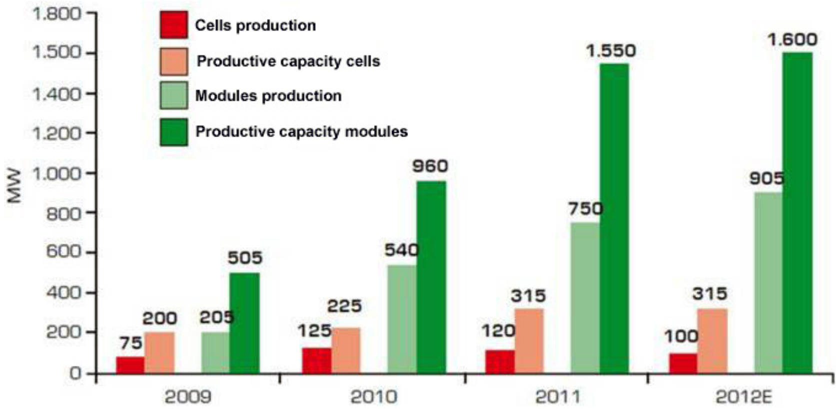

Figure 40: Trends of production capacity and of total production of cells and modules in Italy (with forecasts for 2012)

As shown in FIGURE 44, **the production of cells in 2011 decreased compared to 2010 by 4%,** despite an increase in the available production capacity (+40%). **The production of modules in 2011 increased by 39% in respect to 2010**, reaching an overall 750 MW. It 's interesting to notice how about 35% of module production is at the prerogative of medium-small enterprises (about 35), with an installed capacity of less than 30 MW. A good eleven of these companies have a production capacity of not more than 5 MW. It 's obviously very difficult to estimate what will be the production of modules in Italy in 2012. Considering the market forecasts presented in the chapter relative to the market and of the views of operators interviewed in this research, a decrease in the total production the of cells in the course of 2012 approximately equal to16% could intervene compared to 2011, whilst the production of modules put in place by the major Italian companies, despite the probable or in some cases already occurred closing of productive factories on the one hand and the potential increase in production of some top Italian players on the other (SEE TABLE 10), for the year 2012, is offset by the entry in regime of the activities of 3Sun, which in late 2011 began the production of thin-film modules with a double micro-morph silicon junction in the plant in Catania (although production for 2011 was almost absent). On the basis of these considerations**, a production of modules of about 905 MW can be expected for 2012**, with an increase of 20% compared to 2011 despite the effective entry in production of the 3Sun plant, which at full capacity should weigh for approximately 21.5% of the Italian production.

Company	Productive capacity 2010 (MW)	Productive capacity 2011 (MW)	Production 2011 (MW)	Turnover 2011 (mln €)	Production forecast 2012 (MW)
Solsonica	35 cells	40 cells	25 cells	106.6	15 cells
	70 modules	150 modules	95 modules		80 modules
Helios Technology	60 cells	60 cells	40 cells	38*	45 cells
	55 modules	57 modules	40 modules		45 modules
Omniasolar Italia	10 cells	10 cells	8 cells	8.5*	8 cells
X-Group	90 cells	140 cells	45* cells	n.d	n.d
	55 modules	100 modules	40* modules		n.d

Table 10: The main Italian integrated manufactures of cells and modules

Overall, and as is easy to see, **2011 has been for Italian manufacturers of solar cells and modules a very difficult year** for a number of reasons:

- The increased Asian competition and the sustained decline in the price of the modules on the European and Italian markets (SEE CHAPTER 1) which, according to many players, arrived below the minimum price sustainable in the long run, at least for the Italian producers;

- the reduction of installations on the local market, caused by the period of regulatory uncertainty that characterized the first half of 2011;

- The credit crunch made by banks with the intensification of economic and financial crisis, which caused liquidity problems for many producers, "crushed" between wafer and cell suppliers (which, in exchange for reasonable prices, have increasingly often required cash payments) and distributors and customers (who demanded particularly delayed payment terms).

All integrated producers in 2011 have experienced considerable economic and management difficulties. In particular, **all**, to a greater or lesser degree, **have had to stop or reduce production shifts, also drawing on layoff** due to a lack of orders and contracts for the block of the market occurred between March and May as a result of the decree on Renewables. In addition, even during the year the contracts were rather discontinuous and businesses have found themselves having to manage production activities and the relations with the suppliers with a "schizophrenic" market.

By analyzing the specific Italian integrated producers, it is possible to identify what were the balances of power in 2011 and the main problems that they have had to face.

For example, Solsonica proved to be the leading integrated manufacturer in Italy, with a module production increased by 48% compared to 2010, which ended with an output of 64 MW. The company has however decreased cell production by 28% in 2011, compared to 35 MW in 2010, recurring mostly to external suppliers. Solsonica, despite having used the “cassa integrazione ordinaria” for about 200 people from the end of March 2011 until the beginning of May and having blocked the purchase of raw materials in the months of March and April, seems to have been able to stay among the more competitive Italian business during the last months of 2011 and in early 2012. This is also thanks to the ability to renegotiate contracts for the supply of silicon in 2011 that, given the dynamics of prices, were becoming unsustainable. Already by the end of 2011, production has resumed at full capacity. Helios Technology, which in November 2010 had already laid off 190 of 200 employees due to the lack of cash to buy raw materials needed for production (after having lost the lawsuit with LDK Solar) went through critical moments in 2011, repeatedly blocking the production. The signs are encouraging, however, because in the early months of 2012 it started again to produce at full capacity and production forecasts for 2012 are higher than at the end of 2011. A critical situation is the one that XGROUP Spa is experiencing: in November 2011,when the regional agency for Veneto Development, which held 7.5% stake in the company, has deviated demanding payment for the shares it held. This problem, accompanied by a significant decrease of the required volumes and liquidity problems, resulted in the blocking of the plants of San Pietro in Viminario (as regards to the production of cells) and Tank of Latina (as regards the production of modules) and the use of layoffs. It is currently implementing a corporate restructuring.

TABLE 11 reports instead information about the main Italian manufacturers of modules only.

Company	Productive capacity 2011 (MW)	Production 2011 (MW)	Turnover 2011 (mln €)	Production forecast 2012 (MW)
MX Group	180	73	108*	100
Solon	95	40,5	132*	0
Moncada Solar Equipment	100	40	250**	100
Renergies	45	30	45	40
Brandoni	55	27	36	50
Eosolare	50	15	15	20
Solar Green Energy	50	12	8,4	n.d

* Turnover relative to EPC activities
** Turnover relative to Moncada Energy Group (active in EPC and in the managing of PV Hydro Implants and Biomasses)

Table 11: The main Italian manufacturers of modules only

In TABLE 11 the German Solon appears as, although the parent company is in Germany, it operates in Italy through an Italian company, Solon Spa. In 2011 the company, despite being one of the leading manufacturers of modules only in Italy, moved its *core business* from module production to design, installation and maintenance of photovoltaic systems, all of which determined more than half of its turnover. At the end of the year, in addition to this**, the problems of the parent company and the liquidity problems of the Italian subsidiary intensified, which led Solon to decide to stop the production** of the plant in Carmignano del Brenta (Padua), with more than seventy employees, focusing entirely on the design, on the development, on the implementation and on the maintenance of turnkey photovoltaic implants. As regards to the other operators, MX Group, thanks also to the completion of the acquisition of Solarday, **reconfirms itself as the first modules manufacturer purely Italian** (second in absolute only Solsonica), while Renergies and Brandoni Solar retain their production to levels not dissimilar from 2010.

In the same way as the integrated companies also manufacturers of modules, downstream the approval of the Renewable Decree, were forced to completely stop the production lines, to reduce the processing shifts with the use of “cassa integrazione”, and in some cases , also to carry out cuts in staff. In the case of MX Group, after two months of layoff, which involved only a third of the resources involved, in mid-November 2011 the company was able to resume production on two shifts instead of three.

Some companies, even though experiencing significant problems, **have completed the investments started before the crisis occurred in 2011**. For example, Ferrania Solis ended the use of “cassa integrazione” June 13, 2011, and again in the month of June has completed the installation of the works for the commissioning of the second production line from about 15 MW for 70,000 photovoltaic modules. The companies have also had to give up contracts, required once incentives were back in force. It is sufficient to say that VEnergy had to give up existing contracts for a total value of approximately € 5 million.

Strategies that manufacturers of solar cells and modules have tried to make changes so as to cope with the decline in profitability and market share, which represent the main likely trajectories they will try to follow in the coming years to continue to operate on the market, can be summarized as follows:

- **Seeking opportunities for differentiation and uniqueness of the "system" PV,** rather than simply focusing on cost and efficiency of the modules, creating devices that are adapted to particular needs, especially in the residential and industrial sectors. An example of this is represented by the photovoltaic modules with colored cells, which can adapt to any type of construction, developed by Solar Brandoni. The company of Castelfidardo (AN) proposed on the market "red brick" cell modules, supported by fixing of the same color, to help camouflage the modules on buildings and greatly reduce the visual impact. Another example is that of hybrid thermo-fotovoltaic modules, allowing the simultaneous production of hot water and electricity, which both Brandoni and FOTOTHERM Solar have worked on, the latter being a company that operates in Udine and that has developed a patent for hybrid photovoltaic thermal module obtained by modifying a commercial module (provided by Canadian Solar). Also in this direction is the attempt to focus on architecturally integrated photovoltaic systems, as is the case of fully integrated photovoltaic windows produced by Union Energy Glass and Glass;

- **Focusing even more on internationalization**, trying to enhance the quality of the product made in Italy and focusing on those segments that require a product of mid-high range, as it has become impossible to compete on the price of the modules, at least for the first generation technologies. For example MX Group, after having opened in December 2010 the American factory MX Solar USA, that in 2011 contributed to 26% of production (in MW of modules) and 24% of total sales, is planning to open a new production plant in Serbia in 2012, in order to meet the huge order of 1 GW of implants, to be installed between 2013 and 2015, that the company settled in Brianza, awarded as EPC contractor and modules supplier. The customer is a Luxembourg company Securum Equity Partners Europe SA that has signed a framework agreement with the Republic of Serbia for a total investment of approximately € 1.75 billion. It is in fact the world's largest solar park, called "Onegiga Project", made of one hundred implants of 10 MW each, installed near electric power conducts and on non-agricultural land. The other module manufacturers also are looking for major contracts, mainly from emerging Eastern markets with the hope of contributing to increase the saturation of their production capacity. **Of course on the internationalization Italian producers still have to work a lot.** Consider that, on the whole, considering both manufacturers of solar cells, modules and pure modules manufacturers the average incidence on the export turnover amounted in 2011 to around 5%.

A company that seems to have a clear commitment in foreign markets is the Italian Moncada, which is described in Box 4.

Moncada started in 1991 in Agrigento, as a company specialized in construction and public infrastructure. At the end of the 90s, the company diversified by acquiring a stake in a company that is engaged in the installation and operation of systems of supervision and remote control. Following the liberalization of the Italian electricity market, Moncada faces the field of renewable energy from wind power. In 2008 he formed the Moncada Energy Group Holding, which controls directly twelve companies active in different business areas and different markets, focusing on the production of energy from wind, solar and biomass, also taking care of their design and implementation. Also in 2008, the company acquired a line for the production of solar panels in thin films of amorphous silicon and begins the construction of large modules (2.20 x 2.60 m). In 2011, the group increased its production capacity of thin-film modules bringing it to 100 MW per year. In 2011, the Group has a portfolio of its own facilities of328 MW, of which 234 MW from wind power, 50 MW photovoltaic and 44 MW of biomasses facilities. The aim of the company is to strengthen its presence in the energy sector in Italy, but also, and increasingly, on the international market. Moncada is already actively engaged in the development of projects in Romania, Bulgaria, USA, South Africa, Tunisia and Malaysia.

Box 4: Moncada

Both integrated operators and module manufacturers **see 2012, especially in the second half of the year, as a discriminating factor important to understand the chances that they will have to maintain productive activity in our country.** Some companies have been able to stop in time the building of new facilities and the increase in production capacity that had planned to take in the light of the pace of growth that the market had shown in recent years. It’s hard to believe, however, that companies will be able to saturate the installed capacity in 2011 and it will be important to understand which manufacturers will have more buffer available to achieve further reductions and containment costs and increase revenues, for example, achieved with a push in activities of internationalization (for instance, to the promising Eastern European countries). Moving on to manufacturers of thin film, BOX 5 gives some information about the world's leading manufacturers of second generation modules.

La TABELLA 12 fornisce alcune informazioni riguardo ai principali produttori di moduli in film sottile a livello

Company	Country	Technology	Production 2010 (MW)	Production capacity 2011 (MW)	Production 2011 (MW)
First Solar	USA	CdTe	1.412	2.300	1.900
Solar Frontier	Japan	CIS	74	980	350
Sharp	Japan	μSi/a-Si	250	320	280
Trony Solar	China	a-Si	145	295	190
GS Solar	China	a-Si	55	400	180
Sungen Anwell	China	a-Si	15	225	170
Kaneka	Japan	μSi/a-Si	60	150	115
NexPower (UMC)	Taiwan	μSi/a-Si	84	130	100
United Solar Ovonic	USA	a-Si	90	120	80
QS Solar	China	a-Si	70	165	80
Saint Gobain Solar	France	CIS	30	130	30

Table 12: The main module thin-film producers worldwide

As you can see,
First Solar is the absolute leader in this ranking, surpassing the cumulative output of all other top players of thin film and projecting in addition to this, a further increase in production capacity to 3 GW in 2013. However, there is a significant increase in production capacity and production in general by all operators, which together increased the production by 52% between 2010 and 2011 and have plans to increase total production capacity on average more than 80 % over the next two years. The biggest "leap" forward in this direction was taken by the Japanese Solar Frontier, active in the production of CIS modules, whose installed capacity has increased from 80 MW in 2010 to 1,000 MW in 2011, an increase in production from 70 to 350 MW. Two important new entries are GS Solar and Sungen, Chinese companies producing amorphous silicon modules, earning the fifth and sixth position globally and that are planning major expansion plans and in particular to bring production capacity by 2013 to 550 MW for GS Solar and to 1500 MW for Sungen, an increase in the production capacity of more than five times in two years. The historical American manufacturer Solyndra is definitely out of the industry, declaring bankruptcy in September 2011. Certainly the Solyndra cylindrical thin-film modules had problems competing with the polycrystalline panels in China. The sophisticated manufacturing process in fact led to a sale price much higher than the competition from China and the U.S. panel could only be installed on flat roofs. As for the Italian manufacturers of thin film, the most interesting are undoubtedly Moncada Solar Equipment, as shown in Table 12, which has expanded its production capacity from 40 MW in 2010 to 100 MW in 2011, and the consortium 3Sun, consisting of Enel Green Power, Sharp and STMicroelectronics, that opened in Catania a factory for the production of thin-film micro-morph silicon modules that will produce in 2012 about 1.5 million modules with a capacity of approximately 195 MW.

Box 5: The main thin-film producers in the World

3.6 Inverter Business Area

With regards to the inverter, TABLE 13 lists the main producers in the world. In particular it is noted that **SMA firmly maintains the first position of this rank with a production in 2011 of over 7 GW**. SMA is followed in this particular ranking by Power-One, which increased its production capacity from 3 to 7 GW in just over a year, with the opening of three implants in the U.S. (1 GW), Canada (500 MW) and China (1 GW), which in 2011 produced a total of 670 MW of inverters. Kaco has also greatly increased its production capacity, reaching 4.2 GW with the opening of a new plant from 2 GW in Ontario (Canada), which in 2011 already produced about 700 MW, primarily for the Canadian market. At the moment, on the international scene, **there are just over 150 inverter suppliers, but the 10 major producers have controlled** during 2011 a market share of **between 70 and 75% of the installed worldwide base**. Moreover, it seems that this number is not likely to change significantly for at least the next two years. In this segment there are relatively few operators globally, but the brand is still an essential element in the choice of the component which now accounts for about 10-12% of the total costs of photovoltaic (SEE CHAPTER 1). In addition, as already mentioned in the section on margin (paragraph 3.3), these operators were the only ones in 2011 **to maintain a margin significantly higher than those working in other business areas**. In addition, the scale effect and international presence in 2011 was a key factor in achieving higher margins. Consider, for example, SMA and Power One, which in 2011 experienced an average EBITDA *Margin* of respectively 23.2% and 26.8%, considerably higher than the industry's average.

Company	Nation	Production 2010 (GW)	Production capacity 2011 (GW)	Production 2011 (GW)	Turnover 2011 (mln €)
SMA	Japan	7,5	11	7,6	1.710
Power One	USA	2,6	7	2,9	1.020
Kaco	Germany	1,5	4,2	3	870*
Fronius	Austria	1,5	2,5	1,3	380
Danfoss	Denmark	1,2	3,5	1	290*

Table 13: The world's leading inverter manufacturers

It must be said that during 2011, especially in the early months of the year, the inverter market was affected by a phenomenon of over-supply, particularly in Germany, which affected the whole of Europe. **It is estimated that in early 2011 there were about 2.5 GW inverters stored and unsold in German warehouses**. The market has therefore not been able to absorb the whole production, with the consequence of a remarkable lowering of the prices of inverters, in average of 27% (see Chapter 1).

TABLE 14 shows instead the Italian inverter manufacturers with higher installed capacity.

Company	Location	Production 2010 (MW)	Production capacity 2011 (MW)	Production 2011 (MW)	Production forecast (MW)
Power One Italy	Terranuova Bracciolini (AR)	2.600	4.500	2.300	3.000
Elettronica Santerno	Imola (BO)	880	1.199	900	850
Aros Solar Technology (Riello Elettronica)	Lissone (MB)	310	1.000	500	100
Siel	Cormano (MI)	380	650	250	300
Answer Drivers	Montebello Vicentino (VI)	195	225	200	225
Astrid Energy Enterprises	Poppi (AR)	185	180	180	n.d
Fimer	Ronco Briantino (MI)	n.d	145	125	200

Table 14: The main Italian manufacturers of inverters by installed capacity

The total production of inverters made in Italy in 2011 stood at 4.7 GW, which is slightly lower than the values of 2010 (-2%). The first position of this ranking is occupied by Power One, which produced in Italy 2.3 GW of PV capacity in the last year, a data in decrease compared to 2010 (-300 MW). During 2011, the company carried out a process of adjustment after the boom of 2010, reorganizing the staff of its plant in Terranuova Bracciolini, from 950 units in 2010 to 850 in 2011 and 1,100 external employees (from subcontractor companies) to deal with production peaks. Elettronica Santerno, despite having gone through difficult moments in 2011 as a result of rumors of a possible partial sale of the company and the use of layoffs, has maintained a production of 900 MW, in line with the figure for 2010.

It must be underlined **how also in 2011 the Italian market for inverters was affected by the Asian competition in a smaller extent than that of solar cells and modules**. It is estimated that the market share of Chinese operators in the inverters business in Italy does not exceed 2.5%. Although the performance of the Chinese inverters have decidedly improved over the last year, both as regards the levels of efficiency and reliability, there are still some problems related to the variations of voltage and current at the input. It must be said that the price of Asian inverters remained 10-15% less on average than those in Europe and the after sales service is not performed by the Asian, but typically is assigned to be outsourced to a European partner. The most active Asian manufacturers in Europe in this business area are Sungrow, Eversolar and Samil Power.

Finally, **the Italian manufacturers of inverters in 2011 have continued to exploit significantly the export opportunities that the international market offered them**. Export represents a vital part of the business of these operators. **It is estimated that the exports share in their turnover has reached 20% in 2011**, the highest in the early months of the year, when the domestic market was almost blocked due to the approval of the Renewable Decree. These levels of export have been achieved thanks to the opening of commercial subsidiaries abroad, in order to ensure a strong local presence. Emblematic in this case is the experience of Elettronica Santerno, in Imola, present in the World with seven branches and sales offices located in the countries of greatest interest, namely in Spain, Russia, USA, Brazil, China, Germany, India and Canada. In 2011, the company had an export turnover close to 30%, but the goal of the company is to arrive up to 70% of exports in the next two years. In this sense, the Italian inverter manufacturers will probably be more able, compared to modules producers, to cope with the possible further downsizing of installations.

With regards to the installation of smart inverters despite the technical requirements of standards are not complex from a technological standpoint, the time to implement the changes for operators is very limited, and in fact, several operators will find difficult to implement the changes necessary to adapt in a timely manner. In addition, for large inverter manufacturers, which also serve international markets, a multitude of adjustments in order to comply with the rules in force in each country, different from each other and requiring a redesign of the changes for each country is prospected. This activity of modification and of adaptation is likely to continue till the end of 2012, as legislation similar to the CEI 0-21 are under evaluation in Spain, Portugal, England, France and Slovenia and, in all likelihood, will come into force during 2012. For the development of "smart" inverter, able to communicate actively with the network, choosing the optimal moments for the sale of energy to the grid and for own consumption, with the help of batteries, you will have to wait for the first month of 2013, in part because these systems require an electrical system different from the present, a system that does not depend only on the production of energy but also and mostly on consumption.

3.7 Distribution and installation business areas

TABLE 15 shows the major Italian operators in the distribution of photovoltaic systems.

Company	Country	City	MW 2011 (modules)	MW 2011 (inverter)	Profits 2011 (mln €)
Enerpoint	Italy	Nova Milanese (MB)	58,2	109,5	100*
Sunerg	Italy	Città di Castello (PG)	64*	64*	86
Tecnospot	Italy	Brunico (BZ)	35	140	83
Vp Solar	Italy	Treviso	40	40	55
Saint Gobain Solar System**	Italy	Milano	21	5	29
Enereco	Italy	Sarcedo (VI)	15	15	20
Dea	Italy	Cori (LT)	13,5	13,5	18
Galeo Energy	Italy	Roma	8,5	8,5	12
*Refers to the only activity of distribution			**Italian company with French headquarter		

Table 15: The main Italian distributors of photovoltaic systems

The business area of distribution in 2011 was **under particular pressure in our country**, primarily as a result of increased international competition, which occurred in the first 9 months of 2011, mainly due to the Germans and the Spanish operators (Energiebau , IBC Solar, Krannich Solar and Proinso), whose market share in Italy is around 20-25%. **To this a more recent phenomenon should be added, that of the photovoltaic *brokers*,** small companies both active in the photovoltaic since a few years and in different fields, which have taken the opportunity given from the decreasing price of the sector and which have acquired during the 2011 large stocks of modules (especially in Asia) to sell to installers at very low prices, often without due assistance and level of service.

The active distributors in Italy have tried to respond to this difficult situation in various ways, by putting in place strategies which are likely to grow stronger in the coming months. **Operators with the necessary expertise have strengthened their presence in downstream activities,** of planning and installation of medium-large sized implants. Think of Enerpoint, that received more than 52% of its turnover in 2011 through the activities of design and installation. **Others have tried to revive the concept of an "all inclusive" photovoltaic package** for systems of standard sizes (for example 3 to 20 kW). This is the case of Galeo Energy, that has begun by marketing a kit the size of a pallet containing all the components of the system, from the inverter modules to the fastening systems. **Finally, other Italian distributors have tried to enter into collaboration agreements, or even mergers and acquisitions, with major foreign operators**, with the aim of exploiting synergies and scale economies in the *procurement* activity. This is the case of Tecnospot, that in 2011 signed an agreement with the German giant distributor BayWa, a company with € 7.9 billion turnover and that works in logistics, in distribution and in sales in the agricultural field, of building materials and of energy, which acquired 70% stake of the South Tyrol company. In particular, in the energy sector, the company is engaged in distribution activities in the field of renewable energy.

Moving on to the design and installation of the system, Table 16 reports the main players in the Italian market, ranked by installations in 2011.

Company	Country	Italian branch	Installed 2011 (MW)
Enel.si	Italy	Roma	180
ABB	Switzerland	Milano	106
Ecoware	Italy	Padova	80
Terni Energia	Italy	Terni	76
Sun Edison	USA	Milano	70
9REN	Spain	Milano, Roma	60
Enerray	Italy	Bologna	50
Energy Resources	Italy	Ancona	45
Arse (Acea)	Italy	Roma	44
Opde (Gruppo Opde)	Spain	Torino	40

Table 16: The main EPC and System Integrator active on the Italian market

From the analysis of Table 16 **we see a consolidation of the leadership of Enel.si, reaching 180 MW of installations in 2011 (value 20% higher compared to 2010),** expanding its franchise network with more than 700 affiliated total installed at the end of 2011. The franchise model seems well suited to the recent development of the Italian PV market, especially with regards to the remarkable decline in the price of residential implants even of small sizes,. Being able to perform centralized purchasing, for all affiliated installers, this model allows to obtain significant discounts on volume purchased. A similar model was implemented by Sorgenia. In the first quarter of 2012, 600 contracts were signed, 206 of them in the month of February; of these, in total in March result as connected 42 implants with a total power of 185 kW. In addition, always Sorgenia signed in January a national framework agreement with the ABN consortium that provides both the Re-launch of previous 1000 photovoltaic roofs' bans, that thanks to an agreement become "1000 photovoltaic roofs - sole mio", and the realization of 640 implants in Sicily and Friuli Venezia Giulia, of these, 70 implants are already completed and under connection to the national grid. This program is part of the reorganization of the business units related to photovoltaic, with the progressive abandonment of the "ground", generation implants to focus on the distributed generation with implants on roof and coverings.

To be noted is also the case of ABB, that has always had a strong specialization on central stations above 1 MW of power thanks to its expertise in design activities for large systems. Having taken advantage of the opportunity offered by the Save Alcoa in 2010, it was able to achieve several solar power implants before the opening of the Register of Large Plants in the second half of 2011, which raised the level of the total installed capacity in the year. For this company, like other multinational companies active in the activities of EPC for large systems (such as Siemens and Schneider) results more complex to re-focus on the design and installation of small to medium size implants, especially if on the roof.

Ecoware and Terni Energia follow in this particular ranking, which amounted to values of installed in line with the previous year. The strategy of these two operators, in particular Terni Energy, has been to build its one implants and manage them for a limited period of time and to sell on the market at the moment when the incentives should be reduced significantly.

Clearly, this area of business, in 2011, was deeply influenced by some of the dynamics that have created tensions and difficulties between the major operators. **Firstly, the "vacuum" of normative early in the year and the monthly reduction in tariffs of the Fourth Conto Energia in the second half of the year**, have helped to greatly increase the uncertainty about the expected economic returns of a PV implant, especially for installations of large size. This meant that a mere delay in installation work or authorization procedures would have led to a transition to the next month, with a decline in profitability of the investment. Secondly, **the credit crunch and the high uncertainty of the return on investment** that was just mentioned, have resulted in a significant increase in the cost of capital for debt financing of the implant which amounted on average in around 8% during the second half of 2011. This has favored larger players, which boasted more credit from banking institutions or offered vendor finance solutions through a strong postponement of payments due, at subsidized interest rates. Finally, we must consider **the expected *shift* of the market**, which has not been as significant as in 2011 (as opposed to expected) due to the Registry of Large Plants which became effective from September 2011, and only in late 2011 and early of 2012 (and probably throughout the year) will require to these operators a re-focusing of the occupied market segments. This **has prompted to ask and will ask to EPC to regroup and heavily revise their business strategies**.

In this context, the main actors in the design and **installation have tried to extract greater value from the assets of O&M**, for example by developing in-*house* monitoring systems and SCADA systems for the integrated management of photovoltaic parks, of its own construction like Siemens and ABB or made by third parties, such as the Roman and Lombard Kenergia Vesta. Some operators like Martifer Solar, have gone beyond the simple activity of O&M, acquiring existing implants after careful due diligence, fielding specific *performance improvement* activities aimed at increasing the value of the implant, which was then resold on the secondary market. In addition, few are the cases of undertakings engaged in consulting and due diligence for the development of implants that put alongside these activities also O&M&I (Operation, Management And Improvement). For example Kenergia created this type of activity on about 60 MW implants trying to repair the defects in design of the defective modules installed and of consumption of non-budgeted auxiliaries (excessive cooling of the inverter) in addition to the traditional activities of O&M. This is a business model that could spread in 2012, where focus has already been put or may be put in EPC Contractor that are unable to refocus on medium implants. In addition, **also the EPCs have moved a lot in the international market**, using as main entrance strategies the opening of branches in the countries of interest, usually in partnership with local companies already active in the market. This is the case for Enerpoint (that acquired the Israeli company Friendly Energy), Energy of Terni (Terni that founded Energy Hellas in Greece) and Padua Ecoware (that gave rise to Ecoware South Africa). The focus on O&M activities of and on the secondary market, as well as the growing promising international markets, are two trends which are likely to confirm themselves in the coming months. BOX 6, 7 and 8 show the cases of three companies active in the design and installation of photovoltaic systems that are reviewing or have reviewed their business models. Terni Energia diversifying its business in foreign markets and on activities related to energy efficiency is trying to carve out a leadership position for 2012. Ravano Green Power, that began as a company active in electricity generation and that has expanded its activities to the design and installation and O&M for photovoltaic systems for third parties, is trying to focus for 2012 exactly on O&M activities. The same goes for Vesta, an engineering and consulting company in the world of renewable energy that is expanding its core business to other activities related to photovoltaic.

Founded in 2005 and part of Terni Research Group, the company operates both as an EPC Contractor, providing turnkey implants for third parties, and as a producer of energy from photovoltaic. Since 2008, TerniEnergia is listed on the Italian Stock Exchange and, in 2010, in the STAR segment. As EPC, the company takes care of all the activities necessary for the construction of the plant, from design, installation, remote monitoring and maintenance, specializing mainly in industrial implants and power stations. Since 2007, the Group is also active in the production of electricity by photovoltaic technology, through a joint venture with EDF Energies Nouvelles Italy SpA. In addition, through its subsidiary Lucos Alternative Energies, it operates in the development of systems for energy efficiency. The Group TerniEnergia is aimed at customers consisting mainly of large industrial groups, municipal or national electricity companies, local authorities, private investors and investment funds. At 31 December 2011 the Group has assets of 193 MW of PV installations, including 76 installed in 2011 between private implants and systems designed for third parties. In particular, at the end of 2011, the Group manages approximately 62 MW of its own photovoltaic implants (61 implants) through 12 equal Joint Ventures that guaranteed during 2011 a production of about 80 million kWh. The group also has a strong presence abroad, especially in South Africa and Greece, where it has already achieved 10 MW of photovoltaic systems.

Box 6: TerniEnergia

The Group Ravano was founded in 2006 with the objective of investing in renewable energy, through its subsidiary Ravano Green Power. The company's mission is to build and manage owned power stations, powered by renewable sources, in particular from the sun, biomass, wind and water. Up to date, the group owns and operates 16 MW of property (photovoltaic, biogas, wind and hydro). In 2008 it began to operate in the market as an EPC Contractor, providing turnkey implants for third parties, using their skills and a sales network spread all over the country. Is also engaged in the activity of O&M, both on its plants and on third-party plants. In 2011, the company has a cumulative installation for systems realized for third parties of 31 MW, taking care also of the maintenance of 12 MW of these systems.

Box 7: Ravano Green Power

Vesta is an engineering and consulting firm that since 2012 has expanded its own range of services with the private construction of hybrid photovoltaic systems (with heat recovery), supplemented with electric heat pumps and interventions on the building. Vesta thus responds to the need for a market niche sensitive to issues of environmental sustainability, meaning to provide residences of energy efficient integrated systems. Founded in 2007, Vesta was responsible for project management for the construction site of ground power plants: from research license to the content management of EPC and O&M, an experience that led it to be a founding member of two leading National photovoltaic modules. Today Vesta performs technical due diligence of power plants already connected to the grid, with the review of O&M contracts and the offer of control and management services of the operational activities of maintenance performed by contractors, as a third party and with proprietary software.

Box 8: Vesta

To conclude this section, we report an estimate of the impact on employment that PV had in 2011 in our country.

As mentioned several times previously, companies in the photovoltaic sector in Italy have made extensive use of the instrument of redundancy, in addition to the layoffs. For this reason it is not easy to define the exact number of people employed in the photovoltaic supply chain at the end of 2011. FIGURE 45 shows a synthetic indication of the number of employees in the various stages of the supply chain. In total, we can estimate, a direct employment of 18,000, to which we should add 40.000 to 45.000 employees working in the inducted areas . It can be noted, compared to 2010 a decrease in direct employment equal to about 3%. In all likelihood, the employment levels registered at the end of 2011 are destined to go down in 2012, due to the probable or announced closure of some factories, including that of MEMC Merano (already announced) and integrated companies and pure modules providers.

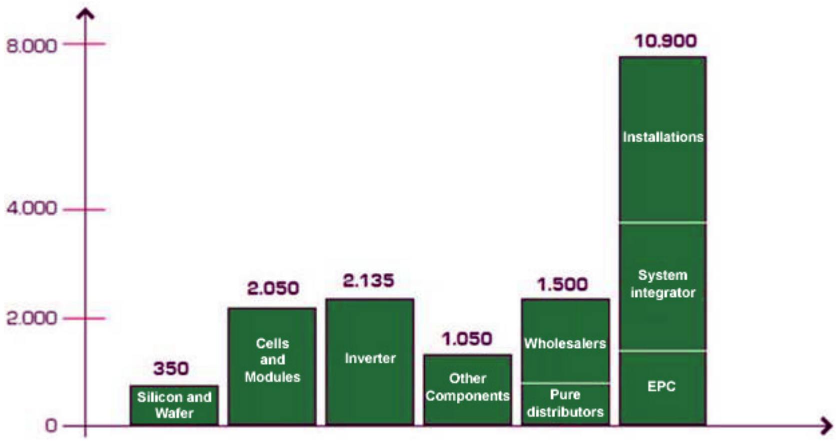

Figure 41: Employment Impacts of PV in Italy, broken down in business areas

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MINI-HYDRO

Giancarlo Giudici

Introduction

Hydroelectric in Italy represents the main renewable source for the production of electric energy. According to Terna (2012) in the course of 2011 energy produced by hydroelectric plants in Italy has overrun 50 terawatt-hours (in decrease of about 11% on the previous year), contributing for almost 15% to the energy balance of the national grid, whilst all the other renewable sources together stop at 8%. The gross power installed has reached by the end of 2011 the threshold of 18 GW.

Use of kinetic energy of a water flow for the production of work is probably one of the most ancient methods of efficient exploitation of a renewable source. Starting from the 19th century hydroelectric has been one of the most used methods for the production of electricity and for industrial activities in general by use of generators as alternators.

In hydroelectric power plants waters' potential energy is used relatively to the difference in height between the stream and the power plant, that is transformed by means of a turbine into mechanic energy to end with a production of electric energy.

Hydroelectric in Italy has experienced an enormous development in the first half of the last century; starting after the second World War but competition of fossil fuels for energy production caused a progressive disinterest. Only half way through the 70's, due to an increase in the price of crude oil, hydroelectric came back to be competitive in terms of production costs. Nevertheless nationalization of electricity in ENEL - has concentrated attention on large power plants with a progressive abandoning of smaller sized-plants.

Only at the end of the '90s, thanks to the liberalization of the energy market and the introduction of public incentives related to renewable sources (as a consequence of the efforts in reducing the use of fossil fuels), hydroelectric experienced a new development mainly in the so-called "mini" plants, that is plants of small dimension.

According to the official ranking of UNIDO (United Nations Industrial Development Organization), we can identify 4 main types of smaller-sized plants:

"Small plants", characterized by an installed power inferior to 10 MW;

"Mini" plants, with a power inferior to 1 MW;

"Micro" plants, in case power is inferior to 100 KW;

"Pico" plants, that is those with a power inferior to 5 KW.

In reality this distinction doesn't keep in account the specificities of each Country, related to geographical features and in force regulations. Concerning Italy, in fact, the most relevant threshold is that of 1 MW, below which it is regulated by the feed-in tariff and above which is by green certifications.

1. Technology

A hydroelectric plant, regardless of the installed power, is composed of a series of elements which allow an efficient transformation of the potential energy contained in water into electric energy. The two fundamental parameters from which to start to define a hydropower plant are:

- the head, defined as the difference in height between the water intake and where it is turbinated. The head in particular determines the number of revolutions of the operating turbine.

- the discharge, or rather the volume of inlet water in the turbine. Given the number of revolutions defined by the head, the discharge determines the section of the nozzle, therefore the dimension of the turbine and the nominal power. Whilst the head is defined and fixed (unless few variations due to abundance or not of water that could raise or lower the stream level) the discharge, in flowing water plants, is a variable parameter according to seasonality and rain conditions.

It is possible to distinguish hydroelectric plants according to their typology.

“Basin” plants (or “reservoir”) are those most common for the production of large power, superior to 10 MW. They present a strong environmental impact due to significant needed engineering works (barrages or dams) and to the dimensions of the reservoirs. This type of plant is released from single hydro-stream regulations, as it uses basin water allowing to regulate flow and therefore electric production. Depending on the needs it is possible to operate the facility or modify the flow in a few minutes; reason for which they are considered useful energy reservoirs to cover the load of the periods of greatest demand.

“Pumped - storage plants” are characterized by the presence of a higher and lower basin of accumulation. At night hours, by using lower energy costs, the water below is pumped into the higher basin and then used again for energy production, that will be sold at peak daytime hours, characterized by a higher demand and so at a higher energy price, which enables an arbitrary economic profit.

“Water flowing plant”, differently from the previous ones, don’t present any possibility to accumulate and regulate flows: as a consequence environmental impact is usually limited. Turbines in flowing water plants are usually powered by river water. Normally the difference of the head is minimal if compared to that of plants and reservoirs. Production of electricity depends on the exploitable flow of the river that there is in the course of the year, determining therefore a variation of production on a seasonal basis.

Lastly “water pipelines” are made inside artificial plants, as for example, aqueducts or lead channels or outgoing flows of industrial or purification complexes.

Figure 1 describes the typical structure of a mini-hydro power plant, in a mountainous area. Figure 2, instead, describes a typical structure in a flat area.

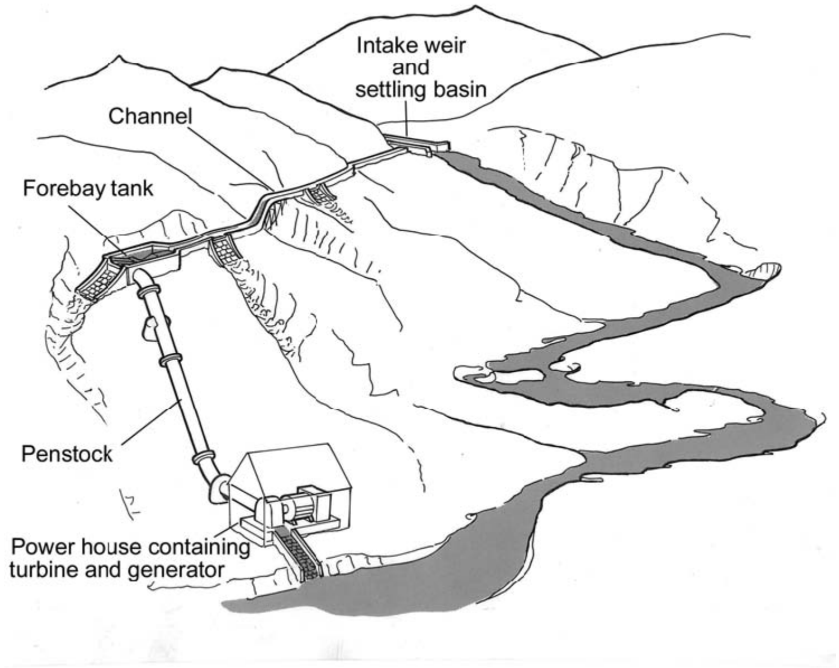


Figure 1. Schema of a mini-hydro power plant located in mountainous area.

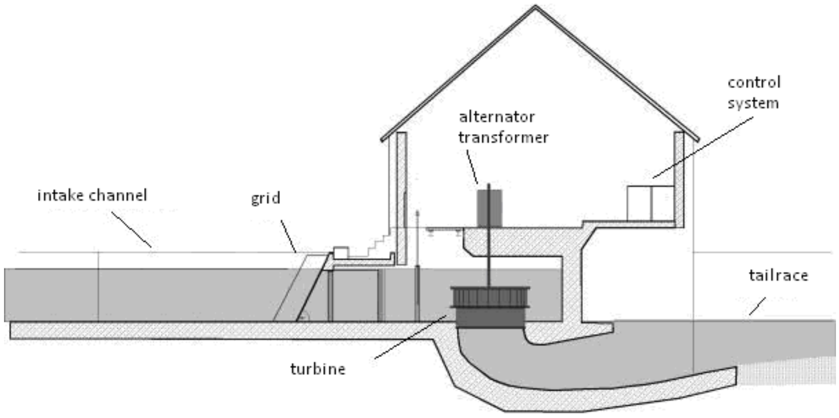


Figure 2 . Schema of a mini-hydro power plant located in flat areas

The design of a small-sized hydropower plant is divided in three activities: engineering civil construction work, design of the electro-mechanic components and the building of the lines for the connection to the grid.

In natural streams, to conduct the flow in an efficient way the latter is deviated laterally, intercepted through intake system works and conveyed through grids in order to prevent the entrance of material other than water, until reaching the turbine through penstocks. The energy of the flow is transmitted to the turbine blades causing the rotation of the impeller. The latter is connected to an electric generator that uses this rotation motion for the production of electricity. At times, specially for small plants, there can be a gearbox between the turbine and the generator. A transformer raises the output voltage from the generator at power line level, which connects to the grid through switchboards that handle the timing of the voltage. Control and tele-control systems allow the plant management also in remote, eliminating the need of the presence of personnel, that will ensure occasional cleaning and maintenance.

The turbine water through tailrace works is released in the river bed. Particular devices have to be respected to enable the passage of the fish (for instance secondary channels at intermediate heads) rather than keeping in the stream a minimum discharge volume necessary for the survival of flora and fauna (the so-called "minimum vital flow").

The theoretical electrical power obtainable by the turbine-generator group is expressed by the following relation:

P = r x 9.81 x Q x H

where:

P = power expressed in KW

r = efficiency of the production turbine-generator group (usually for small plants it varies according to the typology of the machine and of the alternator, in the characteristics of the plant in respect to pressure drops and the variability of the flow curves, between 50% and 85%)

Q = water flow expressed in cubic meters per second

H = net head engine (prevalence) expressed in meters

An important difference between mini- hydro power and the other renewable energies is the specificity of each type of plant compared to the above characteristics. In fact, different typologies of turbines exist, suitable for different combinations of different discharges and prevalence. Pelton type turbines are characterized by spoon shaped blades and suitable mainly for plants with relevant water drops. Turbo turbines are similar to Pelton ones, but cheaper to build. Cross-flow turbines (also called Banki-Michell) have radial arranged blades similar to those used by windmills.

Kaplan turbines are similar to propeller ones, with blades that can be adjusted in pitch relative to the flow to maintain a constant efficiency. Francis turbines are characterized by a centripetal blow that reaches the impeller through a spiral duct that wets it totally, then it is directed onto the impeller blades; also they, can be adjusted.

“Very low head” (VLH) turbines are propeller turbines made especially for smaller water drops, with small loads and easily movable.

Also screws (Archimedes’s screw) found an application in mini-hydro power, that have the advantage of being very strong, they offer good performances also with small drops and give less problems to fish.

There are also machines that derive from reversible pump technologies, which transform a pressure drop into kinetic and/or electric energy.

Lastly, also traditional rotors, typical of mills, have found their own application space, although the performance of these machines is not comparable to that of traditional turbines.

Various types of technology exist, especially developed for small-sized plants, up until “craft” type products thought for Pico plants, for example, in alpine huts or for self-consumption in rural areas.

Figure 3 shows a map that identifies, in respect to the different conditions of prevalence and discharge, the optimal conditions of use of the different types of plants mentioned. It is to be noted that a physiological limit exists to the possibility of exploiting in correspondence to discharges inferior to 0.1 cubic meters per second, and of heads inferior to about 2 meters. Under this threshold the economic profitability of exploiting hydro power is difficult to reach. The bet is therefore that of identifying solutions characterized by low cost, that can render exploitation in limited conditions interesting.

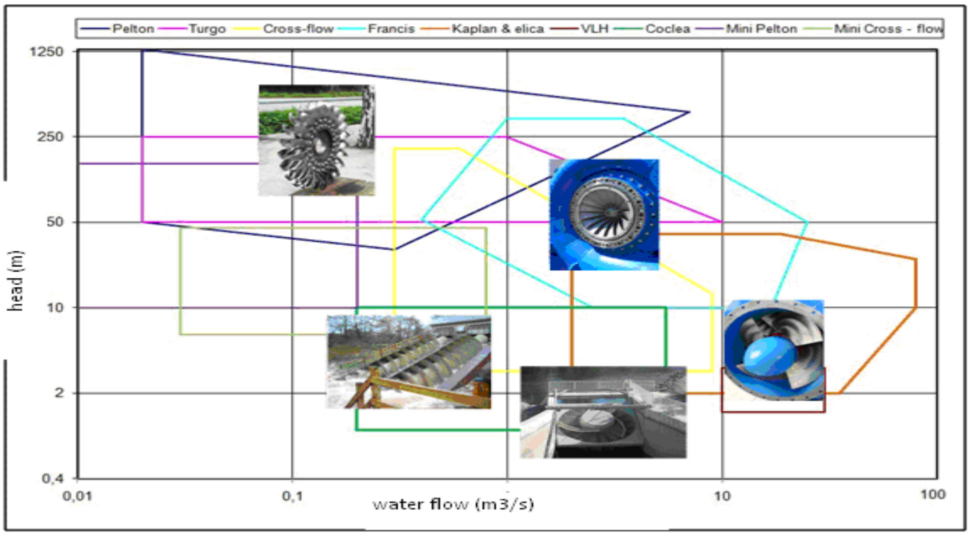


Figure 3. Optimal combinations of application of technologies for mini-hydro power, in function of prevalence and discharge.

2. Comparison with other renewable energies

The mini-hydro power, as well as exploiting a mature and tested technology, presents undisputable advantages both regarding large plants and other renewable sources.

First, investments for the construction are quite low: creating a small plant usually occurs on floating water that doesn't require the construction of costly works (such as large dams). This allows a quick economic return of the investment, that usually varies between three to seven years, according to the water flow conditions. Also mini-hydro plants are less invasive environmentally, and in some cases have no bad effects on the ecosystem (think of plants installed in aqueducts or waste water channels). Costs of management and maintenance are particularly low, thanks to the possibility of remote distance tele-control and automation.

Compared to the other renewable sources, that in these years enjoyed greater visibility (i.e. photovoltaic and wind energy) the mini-hydro power can claim a better sustainability, greater availability and therefore less costs for both installment and energy production, as described in the estimates made by the department of energy of the Milan Polytechnic and reported in table 1.

Type of Source	EROEI index	Yearly availability (h/y)	Installation cost (€/kW)	Energy Production cost (€cent/kWh)
Mini-hydro	30-270	4,000-7,000	1,000-3,000	6-29
Photovoltaic (silica)	3-9	1,000-1,400	3,000-6,500	20-57
Wind Energy	5-80	1,500-1,800	1,200-4,500	7-29
Biomasses (solid)	3-5	6,000-8,000	2,800-7,500	11-27
Geothermic	2-13	6,000-8,000	1,600-6,300	3-9

Table 1 – Comparison between mini-hydro and other renewable sources. Source: Politecnico di Milano (2011)

From a sustainable point of view, given the current technologies, the mini-hydro power is certainly "greener" compared to the other renewable sources. The index EROEI (Energy Returned on Energy Invested) is the ratio between energy needed to produce and dismantle a determined plant and energy produced by the latter throughout its profitable existence and therefore it shows the convenience of a system for energy production from an energy balance point of view. The higher the indicator is the better the contribution that its relative energy source gives to environmental sustainability.

For what concerns the annual availability, in reference to Italy, a mini-hydro plant works potentially most of the year (avoiding only periods of freezing in mountainous areas and in periods of particular draught, as well as in hours needed for maintenance and cleaning of the plant) whilst the photovoltaic and wind energy are constraint to the relative presence of light and wind.

Concerning installment costs, to current technologies, hydro power reveals itself to be competitive, mainly compared to photovoltaic and biomasses. Concerning operating costs only the geothermic is more competitive in respect to the mini-hydro power. It must be remembered that a mini-hydro plant, if well maintained, can last several decades, whilst other types of plants (mainly photovoltaic ones) are subject to a certain deterioration in performance and after some years have to be completely replaced with the burden of disposal costs.

3. Legislation in Italy

The Italian legal framework in which mini-hydro is placed is rather segmented and as such complex. It changes in fact from region to region concerning compatibility of works in respect to the environment, licenses for water use, connection to the grid and regulatory approvals for building a productive activity.

The legislative reference of water use in Italy is Directive 2000/60/CE (Direttiva Quadro sulle Acque – DQA) which outlines a picture for the protection of the inland surface waters, transitional waters, of coastal and underground waters by reducing at the source pollution and optimizing of uses. The directive mainly underlines the need to manage this resource through a planning at river basin level, according to an ecological perspective that considers water cycle and not the administrative borders of provinces, regions or states.

The license for obtaining public water deviation or hydro power use represent the most critical factor and sometimes limited in the start of a mini-hydro power plant. A fundamental turning point was the Article 12 of Legislative Decree 387, aimed to simplify and speed up procedures for obtaining grants, by permission only (aimed to reduce time required by a reduction of the fragmentation of procedure) and by creating the "conference of services" (with the aim of bringing together in a single counterparty administrations concerned). Nevertheless time required for obtaining it in reality are very long (in the order of 3-4 years with rare cases in which more were required) and it is not possible to establish which grant will be actually released. Water in fact represents a particular public good, as evidenced by the attention of public opinion also shown in the outcome of the 2011 referendum.

Grant has thirty years duration with the possibility of renewal at maturity. The legislation in this matter classifies leads based on their nominal power, distinguishing between: (i) small leads, with nominal power lower than 3 MW, whose license is released by the Province (ii) large leads, with nominal power higher than 3 MW, whose competence is instead given to the Regions-.

To obtain the grant it is necessary to present various documents which describe all the main characteristics of the basin and the project, including: hydraulic reports, drawings and technical reports of the project, financial and economic guarantees for the implementation of the project, a document of impact assessment (in case of projects in SIC or ZPS1 area subject to particular environmental constraints), request for the exclusion of the VIA process (only when holding the requirements). In fact, mini-hydro power plants have a rather limited impact on environment, and for this reason it is sufficient most of the time to obtain the Verification of Subjection, without having to use the Verification on Environmental Impact.

Particular attention should be paid to the legislation on the so-called "Minimum Vital Flow" (DMV): it concerns the quantity of water that cannot be exploited for energy production, being the minimum quantity to guarantee survival of the river, of animals whose life depends on the water course in question, and on other human activities that it will support (tourism, fishing, etc.) and which is determined on a case by case basis by evaluating the environmental conditions.

4. Incentives for mini-hydro power

In the context of the general legislation valid for all renewable energy sources and introduced by the resolution CIP6 of 1992, that introduces “guaranteed minimum prices” for the withdrawal of energy from the Italian national grid, since 2005 mini-hydro in Italy has the opportunity of accessing a single feed-in tariff for plants that have power inferior to 1 MW, equal to 0.22 €/kWh. Such a tariff has to be understood as including all forms of possible incentives. The foreseen incentive for plants that have a power superior to such a threshold is instead foreseen by “green certifications” introduced by law decree no.79 of 1999 (better known as “Decreto Bersani”) whose withdrawal is up until now guaranteed by the State.

The Finance Act of 2008 established the deadline for access to the all inclusive tariff to 15 years. It’s a significant advantage, that pushed in 2009 and in 2010 numerous subjects to request new grants (very often with bitter competition on the same sides between different candidates) and to grow the evaluation of existing plants on the market. A quick calculation can be efficient. An plant with a power slightly less than 1 MW and available for 80% of annual hours would generate gross profits from transfer of power to the grid for about 1.5 million € a year, ensuring a time to repay the initial investment on the order of very few years.

The Decree-Law no.28 of 2011 introduced some innovations on the incentive mechanism, advancing a rate review of the tariffs of small plants, and the progressive exceeding of the “green certification” mechanism, definitive from 2016. In fact, auction procedures will be introduced (for plants over 5 MW of power) for the allocation of incentives.

The Decree-law of the Ministry of Economic Development of July, 6, 2012 has further better defined the framework for incentives, valid for implants that entered into operation from January, 1, 2013. The novelty is the introduction differentiated tariffs per range of power (see Table 2), to keep count of medium decreasing managerial costs, when power output increases. The second novelty is the extension of the incentive validity to 20 years, for implants of power up to 1 MW.

Renewable source	Type	Power	Life of implants	Basic incentive tariff BASE (for 2013) (Tb)
		kW	Years	€/MWh
Hydro	at flowing water (including implants on aqueduct)	1<P≤20	20	257
		20<P≤500	20	219
		500<P≤1000	20	155
		1000<P≤10000	25	129
		P>10000	30	119
	at basin or tank	1<P≤10000	25	101
		P>10000	30	96

Table 2 –Inclusive incentive tariffs for hydropower defined by the Ministerial Decree 6, July, 2012

5. The state of the art in Italy

In Italy by 1/1/2012, 2.902 hydroelectric power plants were connected to the national grid, of which 10% with a power superior to 10 MW, 26% included between 1 and 10 MW and 64% under 1 MW. In reality if we look at the installed power, as much as 84% is related to 301 large plants, whilst mini-hydro plants contribute only for 3% of installed power.

The distribution on the territory is, without any surprise, not homogeneous. More than two thirds of the plants are located in five provinces: Bolzano, Trento, Sondrio, Verbano-Cusio-Ossola, Aosta.

The Legambiente report (2012) indicates that the Italian towns in which at least one hydroelectric power plant is installed inferior to 3 MW are 1.021. Of these, 514, already today, thanks to this technology, produce more electricity than that necessary to satisfy the needs of residential families, whilst another 132 can satisfy more than half of this need.

The provisional data collected by the Milan Polytechnic indicated that today the threshold of 3.000 active plants has been overcome, of which almost 1.900 with a power inferior to 1 MW.

Type	Number of installations	Total power installed (MW)	Average size(MW)
Power > 10 MW	301 (10%)	15.196,20 (84%)	50,49
Power between 1 and 10 MW	743 (26%)	2.328,30 (13%)	3,13
Power <1 MW	1.858 647%)	567,70 (3%)	0,30
Total	2.902 (100%)	18.092,30 (100%)	6,23

Table 3 – Authorized hydro power plants in Italy, by 1/1/2012. Source: GSE (2012).

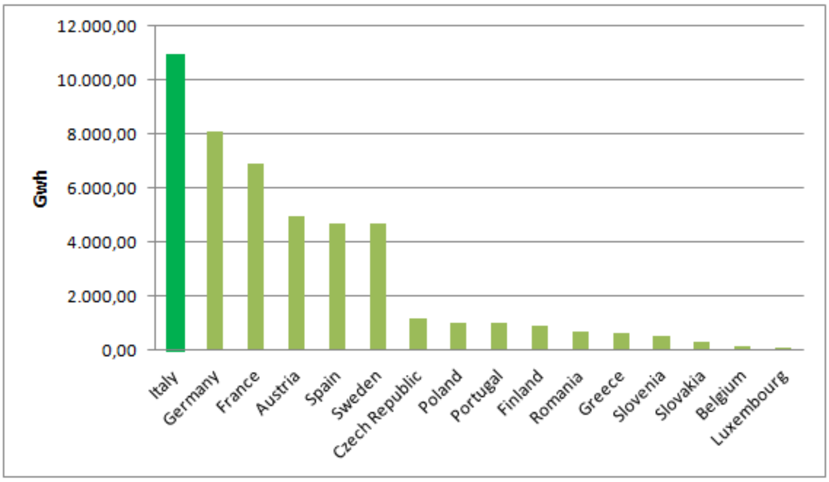
Table 4 gives us an idea of the time evolution of the plants entered into operation since 2004 up to today. Whilst opportunities for large plants are substantially sold out (the net increase in the last seven considered years was only of 7 units, with an absolute increase of 2 per cent), you can see that "small hydro" plants (from 1 to 10 MW) have grown of 161 units (+28%) whilst "mini hydro" ones even of 713 units (+62%), with a significant increment starting from 2008, with the entry into force of the all inclusive tariff. Their contribution to total power available is therefore limited, but it is in this field that the highest potentials and opportunities of a further growth are recorded.

Power range	Year									Annual
	2004	2005	2006	2007	2008	2009	2010	2011	2009 vs. 2004 increase	increase %
> 10 MW	294	293	294	293	296	297	302	301	3	1,02%
Between 1 - 10 MW ('small')	582	598	613	641	665	682	700	743	100	17,18%
< 1 MW ('mini')	1.145	1.164	1.186	1.194	1.223	1.270	1.727	1.858	125	10,92%
Total	2.021	2.055	2.093	2.128	2.184	2.249	2.729	2.902	228	11,28%

Table 4 – Development of the number of plants in Italy from 2004 to 2011 per power band. Source: GSE (2012).

Italy is among the main hydroelectric energy producers in Europe, not only for large plants, but also for small plants. Figure 4.a highlights that our Country is the first in Europe for the production of energy from hydroelectric power plants with a power inferior to 10 MW, in front of France and Germany, whilst figure 4.b (that reports energy production in GWh only for plants under 1 MW) sees us in second place behind Germany. It is then perceivable that there is more space for development in this typology of plants.

(a)



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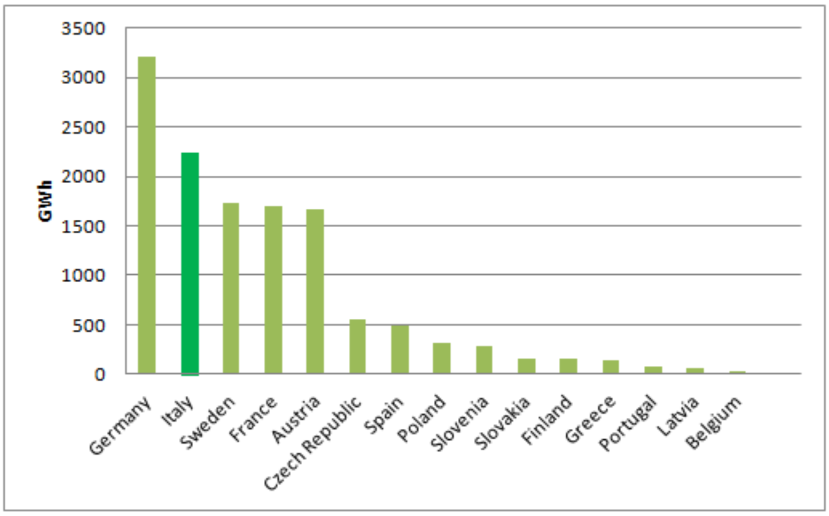

Figure 4 – Hydroelectric energy produced in Europe in 2009 by plants with power inferior to 10 (a) and 1 MW (b). Data in GWh. Source: ESHA (2013).

Figure 5 compares the medium size of "small" plants (a) and that of "mini" plants (b) in the five most significant countries for hydroelectric power in Europe: Italy, Germany, France, Sweden and Austria. The interesting data is that four "small" plants Italy is very near to the average, whilst for "mini" plants we are significantly above average. Even in Germany the medium size is inferior to 100 KW. So, the presence of significant spaces for a further expansion of mini-hydro power in Italy appears, mainly for very small sizes. This would not give a significant contribution to the national energy balance but would certainly go in the direction of "distributed generation" by many desired.

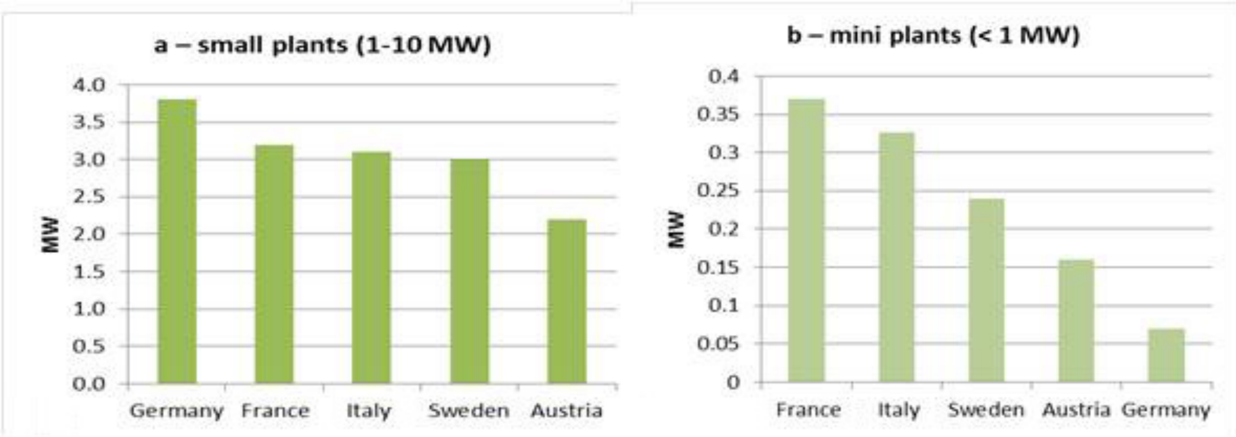

Figure 5 – Average power of "small" plants (a) and "mini" hydro plants (b) in Europe. Comparison between Italy, France, Sweden, Germany and Austria. Data in MW. Source: ESHA (2013).

6. The cost function

The cost items to consider for a project in a mini-hydro plant are substantially divided between initial investment costs and management costs.

Concerning initial investment, we have:

1. the design and the costs of authorization;
2. civil and hydraulic works;
3. electromechanical equipment;
4. connection to the grid.

The most important items are surely the purchase of electromechanical equipments and civil and hydraulic works. Each of these affects on average 40% of the investment value. Concerning management costs, the most relevant item is certainly maintenance (often outsourced to specialized firms), followed by periodic fees payable to public bodies (and any royalty in case of agreements with local administrations for environmental compensation).

The automation of the control is certainly a factor that contributes to management cost reductions.

Figure 6 reports an estimate of average management costs (in euro per megawatt-hours) in function of the annual production, made by the FEDERPERN association (for plants with high and low heads) put in comparison with those estimated by APER association, with an all inclusive tariff recognized up to 31, December, 2012 (220 euro megawatt-hours) and with a guaranteed minimum tariff established by the authority for electric energy and gas (AEEG). Costs also include plants depreciation.

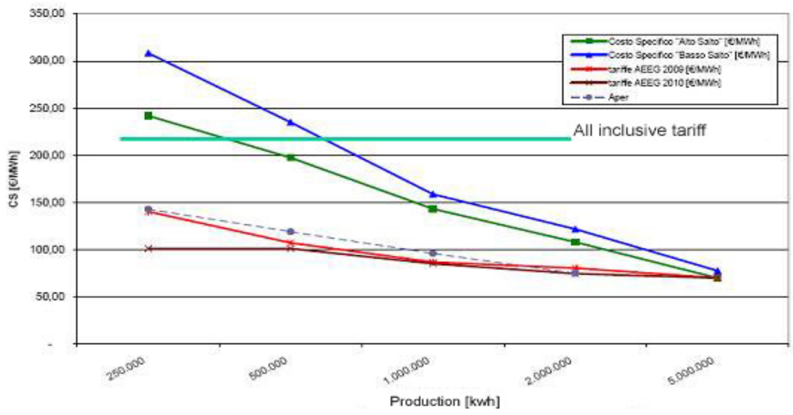

Figure 6 – Estimate of the function cost for mini-hydro power plants. Source: FEDERPERN (2011).

Plants at high head (that is with a prevalence higher than 80 meters) usually use Pelton turbines, that are less costly.

We can notice how the presence of economies of scale make the all inclusive tariff totally advantageous for larger-size plants, whilst average costs result higher for small-size plants.

7. The production chain

The industrial chain of the mini-hydro power can be described in two main sectors, and in a series of ancillary services, as reported in Figure 7.

Managers of plants in the world of hydroelectric power are very fragmented (at 1/1/2011, 982 accredited agents existed in Italy at GSE for the access to public incentives) and can be distinguished in four categories. The first is represented by utilities that carry out as a main activity production and injection of energy into the grid. They manage more than anything else plants of greater dimensions, and have diversified portfolios in alternative energy sources. We then have private investors, that tend to be specialized in mini-hydro power, and mainly seek a remuneration at low risk of invested capital. The third category is represented by local bodies and consortiums in the public sphere, that use control on territory and on water sources through aqueducts and irrigation canals to obtain an additional source of income, that, however, does not represent the main activity in reference. For this reason, often, they make use of a private specialized partnership or of utilities. Finally, we have subjects such as businesses, micro-businesses (huts, farms) or consortia of users that exploit hydro power essentially for self-consumption, with the objective of reducing energy costs.

The management and maintenance (service) support is generally carried out by the same business managers, or by multi-year contracts to specialized firms.

Concerning ancillary services, the design is in the hands of offices with specific technicians, that deal with both gross system design of the plant and economic and technical evaluation, but mainly of geological and of water studies which are needed to observe the reliability of the plant, the environmental impact, the theoretical annual production. We then have suppliers of the mechanical and electrical parts, that generally offer "turn-key" solutions using in turn a network of sub-suppliers for the single components (turbines, impellers, over-gear systems, alternators and transformers, switchboards, tele-control systems). It is about a very focused industry, both in Italy and abroad, because necessary skills for designing a plant of quality are very specific and a certain experience is needed especially in regards to the evaluation of the efficiency of the turbine, that is estimated based on historical data, or simulations of fluid dynamics, or in a laboratory with scale models.

A different matter goes for civil works and hydraulics, as they are usually contracted out to local companies.

The integration degree along the industrial chain is increasing, as different companies, since long active in one of these sectors, are conducting acquisitions to occupy spaces both at the start (managing their plants, even maybe abroad where there are higher development opportunities) and at the end (ensuring the supply of electro-mechanic components).

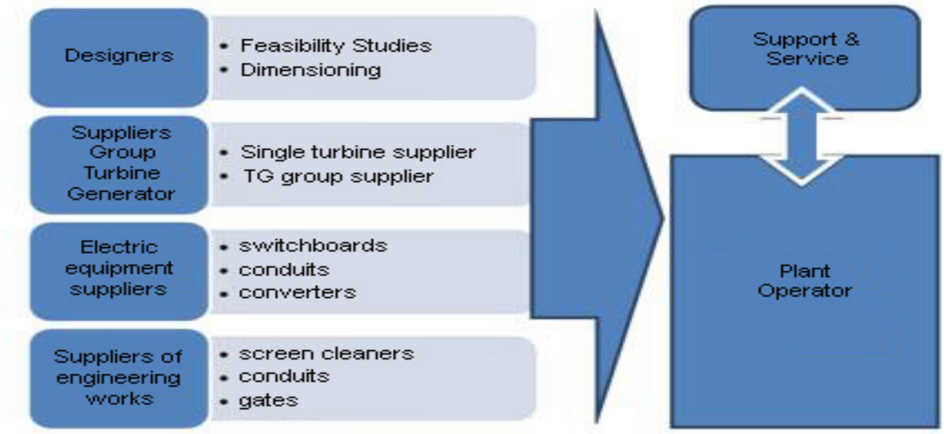

Figure 7 – The industrial chain of mini-hydro

The survey carried out by the Milan Polytechnic – Territorial Pole of Lecco under the aegis of the Silvio Tronchetti-Provera Foundation – has allowed to interview the most important player existing on the Italian market in the business area of plant construction and to segment the market according to two dimensions: the market served (distinguishing between National, European and Worldwide markets) and the plant typology (of large, medium or small size). A not exciting framework came out in the Italian industry, and mainly for the Lombardy one, that in the past could boast excellence in the hydroelectric power sector now abandoned or absorbed by international groups, but that was able to partially recuperate thanks to the activism of entrepreneurs with distinctive skills in related fields(often plants, electricity, or civil construction sites) who have been able to take in time mini-hydro opportunities.

The three industrial giants at a global level, leaders in the market of large sized plants, are Andritz VA TECH, Voith-Siemens e Alstom.

The key companies of national importance, that have purchased also some spaces out of the borders, are: Franco Tosi (today purchased by the Indian group Gammon), the well-known De Pretto of Schio (today in the MAN-Sulzer group), STE Energy, Zeco, the Cover of Verbania (whose mini-hydro division has been acquired with a majority investment by the private equity fund Palladio Finanziaria). In Piedmont a good slice of market is the preserve of Scotta from Cuneo (that has invested directly in numerous plants managed, even abroad, and has concluded a strategic agreement with the research center Turbo Institute of Ljubljana) and of IREM for small plants, and also “portables”. The Trentino Alto - Adige region can boast centers of importance like Troyer of Vipiteno and the Tamanini. in Lombardy, we have to put in evidence the Camuna installation of Pisogne, that quickly integrated from design to “turn-key” supplies , investing directly in Albany.

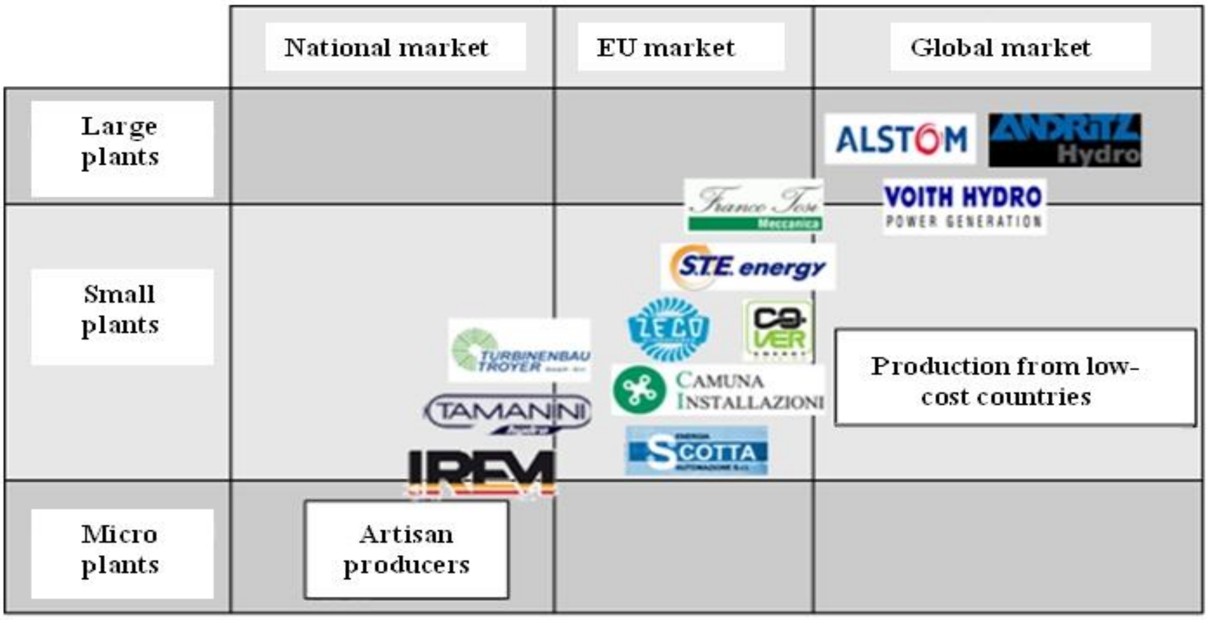

Figure 8 – Competitive matrix in the supply business of mini-hydro power plants

In recent times also the entrance on the Italian market of producers from low cost labor countries, like China, through representative and local importers, has been recorded. Results aren't always satisfying compared to the price advantage, in particular in respect to quality and reliability of the mechanic components.

Finally, on the national territory there is a multitude of micro-businesses specialized in supplying "standardized" small size plants, also of portable type.

8. Potentials for the future

Research has been made that has tried to estimate the potential of mini-hydro for the future in Italy. The National Plan for renewable energies of the Ministry of Economic Development published in 2010 shows the objective of new installations for about 581 MW in the next few years. The European Small Hydro Association (ESHA, 2010) estimates for Italy a much higher potential, 2500 MW. ARPER (Association of Producers Energy from Renewable Sources) indicates a potential between 1500 and 2000 MW whilst FEDERPERN (that groups almost exclusively operators of mini-hydropower plants) indicates a range between 1500 and 3300 MW. In reality are estimates that relate to the theoretical potential, but in reality everyone admits that is concerns not easily attainable goals, mainly for the complex authorization procedures and for the substantial moratorium that is in force for new installments in some territories. In the research carried out at the Territorial Pole of Lecco of the Milan Polytechnic and financed by the Silvio Tronchetti-Provera Foundation more than 1000 requests for new authorizations have been recorded in the Italian territory in date 15/01/2013. In the same way it is estimated that the "attainable" potential in 10 years' time is that of adding a further 1000MW to installed power. It is a negligible percentage in respect to the current availability (equivalent to 5% more in National production from hydroelectric energy, and to an increment of less than 1% in National production from renewable sources), but which is equivalent to the possibility of avoiding CO_2 emissions in the atmosphere for about 3700 tons a year. It also equal to a potential value of new investments for about a billion euro. There are in fact some difficulties that hinder a complete exploitation of existing potentials. Firstly, the hostility of the local population, in some mountain valleys, in respect to further exploiting of natural streams, also on a small scale. In fact, it is about protecting tourism and the ecosystem and avoiding that stream water is subtracted from the environment. Secondly, completion for the award of concession is usually very high, and it is not rare that the development of new plants is hampered by claims and contentious that delay construction. Finally, it can happen that there are disputes in skills between private and local bodies, claiming a role in decision making.

On the other hand, there are some areas in which an easier development of new initiatives can be seen. This can refer to mountain aqueducts for instance, where it is possible to install plants with particular characteristics, that enable to recuperate energy where tank rolling is usually inserted used to reduce the strong pressure (that would damage households, but with an energy dissipation that could be recuperated). The research group of the Milan Polytechnic identified dozens of municipalities and local bodies that (directly or through multi-service companies or concessions to private use) have installed hydroelectric plants or have started an authorization process in this respect. A strong determinant in this case is the constraint imposed by the stability pact for local bodies, with progressive large cuts in state transfers to municipalities, that has led many mayors to seek alternative income opportunities. Also on flat land there are interesting potentials, and only partially used. The agricultural consortia reclamation and water management, federated in the National Association ANBI, are engaging with zeal to promote in their areas of competence the recovery of old mills and factories, as well the installment of small power units on intake channels, where favorable head conditions exist. To date many as 16 consortia ANBI result credited to the GSE for the withdrawal of energy produced, and the total power installed of the 116 plants managed is equal to about 50 MW. The consortia with the highest number of plants in operation is the Consorzio Est-Sesia based in Novara.

On occasion, educational and museum pathways are equipped, integrated with cultural and gastronomic ecologically sustainable itineraries. The Cremona Province , participated in a project funded by the European Union, SMART, to identify in the area suitable sites for hydroelectric plants. The European Union, once again, financed a project to which the Italian Association APER /RESTOR-Hydro) participates, that aims to the requalification of old windmills abandoned though the installation of micro-hydroelectric implants, stimulating the birth of local co-operatives.

Another border area is the exploitation of water heads at the discharge of purification plants and those of water treatment. It should not then be forgotten that the necessary requalification of existing plants, both of small and of large dimension, must be made to maintain efficient the civil structures and the barriers (which in some cases are ultra-centenary and that pose problems also for the resident populations). This also will be an occasion for a strengthening and for an efficiency of the production, which may further contribute to the development of production of renewable energy.

Separate attention is needed for pumped storage power stations (which essentially serve as a basin for energy storage), which will require a strategic indication at National level, in function of macro-policies that the National system will undertake.

Ultimately the new incentives entered into force with the 6, July, 2012 Law, propose again favorable conditions for the micro and mini-hydropower, amongst the most appealing in Europe.

Therefore there are all the prerequisites for further development in this sector.

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The strategic role of energy efficiency within the Italian Green Economy

Massimo Beccarello

Preface

The European Union has definitely started an irreversible path taking on the global leadership in the struggle of climate change. With the last measures of the better known "Energy-Climate Package", and in particular the 406/2009/EC Decision, The European Union has undersigned a unilateral objective to reduce greenhouse gas emissions by 20% in respect to the values of 1990 (-14% in respect to 2005). Recently, the same European Parliament had evaluated the hypothesis of expanding from 20% to 30% the reduction of emissions by 2020[1], but the decision was rejected.

Europe, moreover, engaged in reaching a 30% reduction of emissions in case of a ratification of a new international agreement for the period post 2012, provided that also the other industrialized Countries undertake objectives equivalent to those of the European Union and that developing Countries give a appropriate contribution to the reduction of emissions. The means to reach such objectives are detectable in the promotion of renewable sources and energy efficiency. In reference to energy efficiency we need to consider that although the European Council of March 2007 had considered in the sustainable environmental strategy also a reduction objective of 20% of the end uses of 2020 energy, nevertheless this target hasn't declined in a binding directive. With the lack of a long term European political strategy on energy efficiency, the objectives of energy saving, of average term, remain effective, fixed by the 2006/22/CE Directive of the European Parliament and the Council of April 5, 2006 regarding efficiency of end use of energy and energy service bearing abrogation of the 93/7/CEE Directive of the Council, that establishes for each State member an approximate National objective of energy saving to 2016 equivalent to 9% of the average consumption of 2000-2005, to be obtained by energy services and other measures of energy saving improvements. This Directive was put into force in Italy with the National Action Plan for Energy Efficiency of 2007 that established an objective to 2016 of a 9.6% of saving in respect to 2005 (10.8 Mtep).

On the front of National initiatives the Government intervened to strengthen action on energy efficiency with the May 30, 2008 Decree nr. 115 that puts into force the Directive 2006/32/CE identifying article 5 with which it is stated that the Ministry of Economic Development issues by June 30, 2011, the second PAEE and afterwards, by June 30, 2014 a third PAEE. Straight after with the Law 99/2009 article 27 comma 10, it is fixed that by 2009 the Ministry of Economic Development has to issue the New Plan for Energy Efficiency updating data in respect to the objectives of 2016. On the European front it is important to remember two recent interventions. On March 8, 2011 two important documents were presented, regarding the European strategy on Climate-Energy: The 2011 Plan on Energy Efficiency and the Low Carbon Economy Roadmap 2050.

The 2011 Plan on Energy Efficiency doesn't define binding targets of energy saving but establishes a strengthening of the current measures through a more compelling monitoring of The 2011 Plan of Energy Efficiency and their revision for 2012. Only if the National Plans' result insufficient, the Commission will

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1 Cfr report Eichhout rejected by the European Parliament July 5, 2011.

consider the option of binding National targets, measured on the basis of starting conditions, population, economic performance.

According to the Roadmap if the target of 20% of energy efficiency by 2020 is reached, this will enable the EU to reduce emission costs of 5% more in respect to 20% by 2020 and therefore to establish a new upstanding target of 25% on climate changes.

The Commissions' document of March 2011 has assumed very high programmatic reductions of CO2 emissions to reach a cut of almost 80% in respect to the 1990 levels.

Greenhouse gases reduction per sectors following 2050 Roadmap (%)			
GHG reduction vs 1990	**2005**	**2030**	**2050**
Total	-7	-40 a -44	-79 a -82
Sectors			
Energy (CO_2)	-7	-54 a -68	-93 a -99
Industry (CO_2)	-20	-34 a -40	-83 a-87
Transport(CO_2 per aviation included maritime excluded)	+30	+20 a -9	-54 a -67
Residential and services (CO_2)	-12	.37 a -53	-88 a -91
Agriculture (non CO_2)	-20	-36 a -37	-42 a -49
Others(non CO_2)	-30	-72 a -73	-70 a -78
Source: Roadmap for moving to a competitive low carbon economy in 2050 – Comunicazione Commissione Europea			

The European Commission is certain that to fulfill this program, in the next 40 years, the Union will have to make further investments but a good portion of these will be counterbalanced by a less onerous energy bill for gas and oil and by a social-economic impact that will take European industries to reach a technological leadership in sectors linked to sustainability.

The investments will also reduce Europe's dependence on energy imports and hence our vulnerability versus possible oil price fluctuations, will stimulate new sources of growth and will create new employment. The data of reduction per sector are however worrisome: if we look at the term "power", in the table reported above, it can be noted how the percentages of reduction are extremely high both for 2030 (up until -68%), and for 2050 (up until -99%).

This paper aims to evaluate the green growth potentials of sustainability linked to energy efficiency by means of costs and benefits analysis in the attempt to assess the effectiveness of incentive policies not only with respect to environment but also in terms of industrial growth and employment. .

1. The relationship between energy efficiency and sustainability goals

To understand the leading role of energy efficiency it is necessary to consider the strong complementary connection towards reaching binding targets for renewable sources granted to Italy by the European directives. The relationship between the two instruments has to be considered with reference to the assumptions on the evolutionary scenarios on the energy's final consumption. Table 1, below, allows us to analyze how, from 2007 to 2010, the weight and the strategic role have so deeply modified in respect to the Community commitments undertaken by our Country on the subject of sustainability: in the table along the lines is reported the time evolution of the "energy scenario" foreseen for Italy; along the columns are reported respectively the final consumptions for 2020 (column 1), the evolution of the objective of 17% on final consumption of renewable sources (column 2) and finally the size of the objective of energy efficiency to fulfill binding targets.

In the first row of the table the foreseen scenario for our Country at the beginning of 2007 is reported, in which, on the basis of the data collected among the State Members, the European Commission estimated for our Country a consumption trend to 2020 equal to about 166.5 million tons of oil equivalent[2] to that (following Mtep, first row). In the same year the European Commission anticipated the agreements of burden sharing, that would be ratified with the 28/2009/CE Directive, which assigned to Italy a target of 17% of produced energy by renewable sources in final energy consumptions, to be reached in the electric, thermal and transport sectors. Observing the data along the second column, that report in Mtep the target of 17% of renewable sources assigned to Italy, it emerges that if the final trend evolution consumptions were of 166 Mtep, the target of 17% would correspond to 28 Mtep of energy from renewable sources: it was a target impossible to attain, as also stated by the same Italian Government that had estimated in 2007 the potential theoretical maximum of renewable for our Country in 20.97 Mtep[3].

In 2009 the National trend scenario to 2020 was revised (second row in table 1) at 145.6 Mtep. The revision was necessary by effect of the severe economic crisis that hit the main European Countries determining a strong shock in energy consumption. The economic crisis determined a reduction in consumption trend of 10.1 Mtep. To this reduction in 2009, a further amendment was added, as in the meantime the plan for energy efficiency through PAEE[4] (Action Plan for Energy Efficiency) had been presented, in implementation of obligations introduced by Community regulations in the 2007-2009[5] period. The objective expected by the Plan envisaged to reach by 2016 a decrease in a consumption trend of 10.8 Mtep (second row, third column). The conjunction of these two effects determined a reduction of final gross consumption equal to 20.9 Mtep in respect to the anticipation of the scenario of 2 years before. Nevertheless, despite this strong reduction of consumption by 2020, the binding target for renewable sources would be equal to 24.8 Mtep even higher to the potential maximum value for our Country.

Mtep	Forecast of final energy consumption by 2020	Forecast objectives Renewable/Efficiency	
		Objective RES 17%	Energy efficiency objective
2007 Estimeed trend	166,5	28,3	0
2009 post crisis and PAEE trend	145,6	24,8	10,8
2010 in accordance with PAN trend	133	22,6	12,6
	Total efficiency objective		23,4

Table 1 – Trend consumptions, efficiency objectives and renewable by 2020

[2] The estimate has been carried out by the Directorate General Energy and Transport and reported in "European Energy and Transport-trends to 2030" of 2008.
[3] Position Paper of the Italian Government of September 10, 2007.
[4] Ministry of Economic Development "Action Plan for Energy Efficiency 2007" July 2007.
[5] 2006/32/CE Directive concerning the efficiency of the final energy uses and of energy service repealing the 93/76/CEE Directive of the Council.

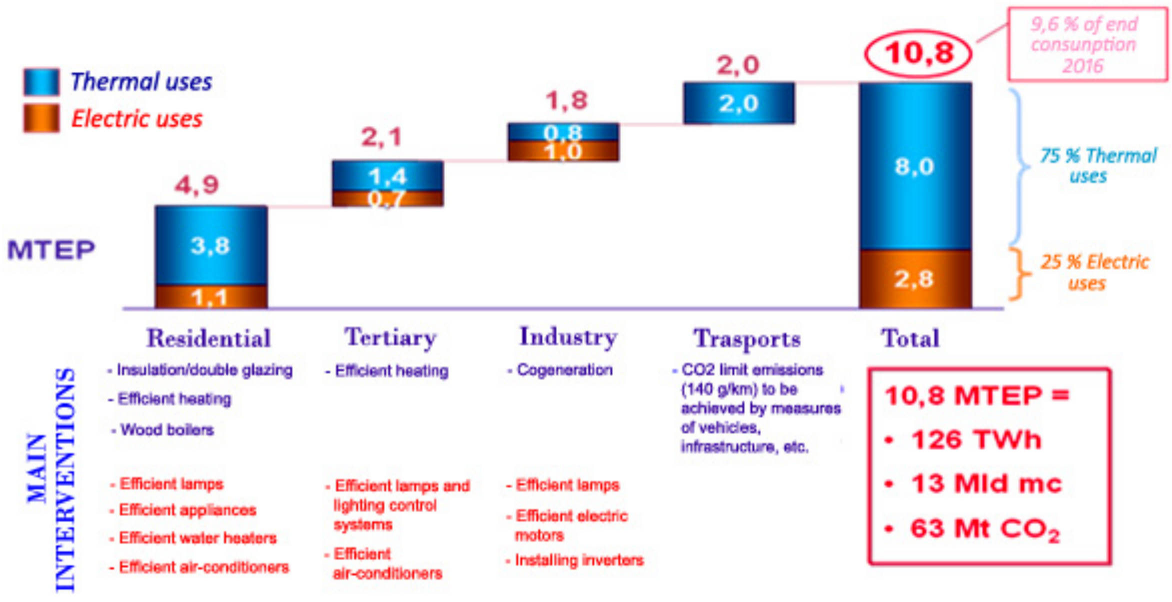
The third scenario update is the one that the Italian Government presented in 2010 contextually to the disposition of the Action Plan for Renewable[6] Energy (third row, table 1).

In such a scenario a new energy consumption trend level is established of 133 Mtep to 2020 and, simultaneously, it is expected that the 17% target of renewable on final consumption will be reached with 22.6 Mtep. By what emerged from the evolution of scenarios and on the basis of the binding target defined by our Government for renewable sources, it is possible to define the implicit objective of energy efficiency equal to 23.4 MTEP on the trend. We are dealing with an ambitious objective, essential to achieve to be able to attain the Italian objectives of sustainability.

2. Energy efficiency and developing opportunities for the Italian industry

Once identified the objectives of sustainability on the programmatic plan, the ability of transforming the challenge of National green economy in an opportunity of technological development and economic growth becomes of strategic relevance. For this reason it is very important to coordinate measures on environmental policy with objectives of industrial development that is identifying policy measures starting from an analysis of the strategic positioning of the Italian industry in technologies for sustainability. The starting point of our analysis is the Governments' PAEE presented in 2007.

By the Action Plan for Efficiency intervention guidelines were set out that regard mainly (about 75%) the thermal uses, in particular more efficient heating systems and building insulation and for 25% the electric uses, which would allow a reduction of 34 Mt of CO2. In reference to the intervention sectors the main target of the 2016 plan is furthermore subdivided between the domestic sector (4.9 Mtep), the industrial (1.8 Mtep), the tertiary sector (2.1 Mtep) and the transport one (2.0 Mtep). Graph 1 summarizes the main areas of PAEE intervention and the main industrial sectors involved.



Graph 1 – PAEE 2007 objectives and industrial sectors involved

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[6] The Action Plan for Renewable Energy to 2020 has to be presented and updated in via biennial according to the dispositions of the 28/2009/CE Directive.

Considering the main technological sectors involved in achieving goals of energy efficiency it is easy to identify a direct comparison with many manufacturing sectors that are already present in the Italian industrial scenario.

Making use of the Istat data on manufacturing divisions it is possible to trace back the macro categories of the Italian economic sectors involved directly or indirectly in these technologies. Table 2 reports a first elaboration of this data.

Sectors	N. of enterprises	N. employes ULA	Production mln €	VA mln €
Manufacturing ofmachinery and mechanical appliances	41.497	619.900	124.309	36.700
Manufacturing of electrical machinery andelectrical and opticalappliances	47.513	467.500	75.714	25.105
	7.648	266.300	73.373	14.170
Electrical energy, gas and water production and distribution	3.016	129.700	84.995	31.251
Constructions	615.862	1.970.900	204.802	86.975
TOTAL	715.536	3.454.300	563.194	194.199
based on ISTAT 2008 data				

Table 2 – Industrial dimension of macro-sectors involved in the policies for energy efficiency

From the previous table it emerges that the macro-sectors linked to energy efficiency represent a considerable portion in the Italian industrial sector with over 600.000 businesses and over 3 million employed people. It is about a relevant result on the potential plan that could be furthermore strengthened by the growing demand of technologies for sustainability in the Italian and European context.

At this point it becomes important to identify the guidelines for a correct *policy* action able to combine the orientation on choices of energy efficiency policies with an industrial policy that should stimulate innovation and growth in the Italian manufacturing sectors. To draw a correct policy in favor of energy efficiency, it is necessary to carry out a preliminary strategic analysis turned to:

- identifying the sectors that by dimension and by potential savings result more potentially interesting and more efficient in reaching targets by 2020;
- identifying the technologies that result being more promising on a potential plan and favoring investments in research and development;
- identifying technologies currently available for implementing programs of energy efficiency based on an analysis of costs/benefits.

It therefore becomes relevant to identify guidelines of a strategic environmental policy on the industrial plan, based on technology scenarios from which to draw useful indications of energy policy able to identify the relevant areas in which it appears more effective to incentive an improvement of energy efficiency.

Potentially, as reported in the previous table, the industrial development of energy efficiency can involve multiple manufacturing sectors, whose technological applications are related to the transport, the domestic and the electric switching sectors.

Nevertheless, without forgetting that the measures for energy efficiency are mainly traceable to the general tax system, it is necessary to evaluate its effects on the entire economic system, verifying the advantages for the Community and the consequences on the State balance and deepen the investment return analysis of efficient technologies.

3. The estimate of the economic impact of energy efficiency: general methodological aspects

To analyze the effects of the energy efficiency policies both under an efficiency profile (in respect to sustainability objectives) and in respect to economic growth objectives, an economic analysis has been carried out assuming a structural intervention aimed to reach the expected objectives in the action renewable plan by 2020.

The evaluation of the effects has been carried out keeping in consideration in a separate way the objectives of effectiveness both environmentally (primary energy saved and reduction of CO" emissions), and in terms of effectiveness of the incentive policies in the socio-economics', on the growth in domestic production between the different sectors involved and the impact of employment and the relative costs charged to the general taxation. On the basis of this assumption the PAEE outlined an analysis of impact that concentrated on the following industrial segments and technologies for efficiency:

1. Trucking (vehicles and light commercial vehicles)
2. Electric motors and inverters
3. Lighting in the industry, in tertiary and public lighting
4. Building upgrade in the domestic and tertiary sector
5. Air-conditioning systems (condensation boilers and heat pumps)
6. Household appliances (domestic appliances for refrigeration, washing and cooking: fridges, freezers, washing machines, dish-washers, ovens, heat pumps for hot sanitary water, fireplaces and biomass stoves, portable air-conditioners)
7. UPS systems (continuity static groups)
8. Co-generation
9. Power Factor Regulation

To facilitate the analysis of impact a scenario based on a structurally stable approach of policy for energy efficiency has been assumed, that is on methodological plan all the simulations were carried out adopting the assumption that the measures for energy efficiency existing in 2010 are to be kept steadily in force up until 2020.[7]

In the simulation it has been assumed maintaining by 2020, therefore for 10 years, the current incentive system and precisely: transport (no direct incentive, R&D structural support), lighting (20% deduction on sale price), housing (55% tax deduction), condensation boilers (55% tax deduction), co-generation (incentive of about 10 euro per MWh without impact on the State), household appliances (20% deduction on sale price), heat pumps (deduction of 55%), UPS systems (20% deduction on sale price), engines and inverter (deduction of 20% on sale price).

[7] Since the end of the '90s all the main studies on Energy efficiency have focalized attention on these industry sectors, see example of Jaffe et al (1999).

Sectors	Incentive needed
TRANSPORTS	No direct incentives, R&D structural support
MOTORS AND INVERTERS	20% tax deduction on sale price for 10 years
LIGHTING	20% tax deduction on sale price for 10 years
RESIDENTIAL CONSTRUCTION	55% tax deduction for 10 years
CONDENSING BOILERS	55% tax deduction for 10 years
CO-GENERATION[8]	About10 euro per MWh incentive, without impact on the State, for 10 years
HOUSEHOLD APPLIANCES	20% tax deduction on the sale price for 10 years
HEAT PUMPS	55% tax reduction for 10 years
UNINTERRUPTABLE POWER SUPPLY (UPS)	20% tax reduction on sale price for 10 years

Table 3 – Incentive assumption for the different technologies for energy efficiency

Such sectors, if correctly and adequately sustained by a serious and concrete policy in favor of the spreading of energy efficiency products, can give a substantial contribution to re-launch, also internationally, of the Italian manufacturing industry.

With reference to the evaluations relative to benefits from the introduction of incentives for the purchase of high energy efficiency goods, the impact analysis on energy consumption by 2020 has been led through a methodology subdivided in three phases of analysis. In the first phase the potential effects on end consumption of energy have been considered. The support of trade associations[9] have been worked out which have given the estimates relative to the increment of turnover (net of VTA) following the introduction of incentives in the production sector which they refer to[10]. In particular, the given data cover a period between 2009-2020 and indicate two alternative scenarios:

- BAU (Business As Usual) that indicates the "natural" trend of demand in the goods market reference to technology conditions already defined to this day and in implementation;
- BAT (Best Available Technology) which refers, instead, to increased consumption of goods favored by an improvement in energy efficiency (and therefore of technology) and to incentives linked to such progress[11].

Afterwards, in the second phase the effects of public finances of incentive policies have been evaluated. An increase in the demand of high efficiency energy goods produces effects on the State balance, in particular on tax revenue flows (direct and indirect taxes). In respect to direct taxes (IRES, IRAP, IRPEF), against a

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[8] It should be stated that incentive to cogeneration do not have an impact on the general taxation but on para fiscal components of the component A3 through duty exemptions of green certifications. The assumed value is determined with reference to an incentive level in line with executive lines of the 20/2007 legislative Decree that that implements the European Directive on the Cogeneration at High Efficiency.

[9] Data has been collected by member associations to the Federations ANIE and ANIMA.

[10] Each sector has worked out its own demand increase estimates in the assumption of continuative support policies and incentives for all the considered period (2010-2010).

[11] For methodological deepening, see the study "Confindustria's Proposals for the Extraordinary Plan of Energy Efficiency 2010".

decrease in taxes paid by the industries of the energy sector (that have to reduce their own incomes) an increase has been recorded in the tax revenues of manufacturing companies that produce efficient technologies and of the subjects (workforce and suppliers) that work for these same. Concerning indirect taxes (TVA and excise duties), against a higher yield of TVA taxation for the sale of efficient technology, a significant reduction is recorded for the decrease of TVA yield and of excise duties paid on saved energy (and in the petrol/diesel for traction and gas for heating excise duties are equal to over 60% of the final price).

Finally, in the third phase, the overall socio-economic impact has been rated. An increase was charged[12] to the demand in the production of goods subject to incentives in the carrier of the final demand of input-output charts. A scheme was therefore obtained on the effects of such an increase in consumption in the entire economic system and more in detail, in the production of goods subject to incentives. The impact has been evaluated on some significant variables referred to both on the entire economy and on the single production branch[13].

1. Production value;
2. Employment, measured in thousands of ULA (employment standard units) overall;
3. Total added value and distinct in its components (wages and salaries, payroll taxes, other incomes and amortizations).

3.1 Effectiveness of measures for energy efficiency on environmental sustainability and the reduction of energy consumption

The first evaluation has been carried out with reference to the potential of trend saving in terms of energy efficiency. In other terms the evaluation brings back the effects of reduction on consumption of energy trend and of reduction on climate-altering gas (CO2) as an effect of an incentive policy able to structurally promote the *best available technology* in the field of energy efficiency. In the evaluation the quantitative effects of reduction on final consumption of energy trend (table 4) have been considered separately, from cumulative effects, or else the overall energy saving in the period 2010-2020 (table 5).

Table 4 reports an estimate of consumption energy trend effects till 2020 comparing the values foreseen by PAEE of 2007 (column 1) and the relative biannual update till 2011[14] (column 2), with the possible potential incremental values (column 4) that could be obtained in the event of maintaining structural the incentive

[12] Thanks to the estimates given by interested associations.

[13] The impact analysis was carried out by the means of a matrix of the industrial sectors to thirty sectors of the input-output charts, the latest available in reference to the year 2005.
These give a systematic description of the inter-industrial relationships and of the Italian economic structure and enable to evaluate, through parameters that express the degree of the sectors' independency, as a variation of the demand of any good in a determined sector that develops and spreads to the overall economic system (cfr. Miller 1985).
The advantages of these input-output charts are clear. They, however, contain limits that constrain the use or at least that risk to distort at a lesser extent the medium-long term estimates. In the case in point, three constraint limits are available:

1. The commitment of the input-output models has to be intended, in fact, in terms of comparative static analysis, in the sense that the differential impacts of variations of final demand on levels of production or of application of the primary factors are estimated *being equal to every other consideration*.
2. Moreover, the parameters in reference to the sectors' independence refer to a single year, till 2005. The assumption subordinate the impact analysis is that such integration degree is constant all along the referred to period (2009-2020). In other words technological and structural changes aren't kept into account which could be verified in the Italian productive system. A lack (obliged) of consideration of such changes could translate in a overestimation of the employment impact that is referred to, in our evaluations, to unvaried technology. Technological changes, in fact, lead to a redistribution in favor of the capital of intensity in use of the job factor. It must be underlined, however, that technological and structural changes occur very slowly in mature industrial systems such as the Italian one. The final effects on the estimates to 2020 could therefore also be rather low.

[14] Data taken from the National Action Plan for Energy Efficiency till June 30, 2011.

hypothesis foreseen for the different technology sectors in table 3. Along the lines of table 4 the consumption reduction effects are subdivided by sector (Domestic, Tertiary, Industrial and Transport) separating the saving in final thermal and electric uses. In column 3 is reported also the estimated potential till 2020 evaluated by the Government in 2011.

		Action Plan Energy efficiency MSE 2007 *Scenario to2016*	PAEE 2011 - Additional savings not foreseen	Action Plan Energy Efficiency MSE 2011 *Scenario to2020*	Proposals Estimated potential Energy efficiency *Scenario ao2020*
		Potential savings (MTEP)			
Residential	Thermal usage	3,8	0,02	6,63	3,2
	Electrical usage	1,1	0,51		1,9
Tertiary	Thermal usage	1,4	0,03	2,55	0,6
	Electrical usage	0,7	0,34		0,7
Industrial	Thermal usage	0,8	0,21	2,47	0,4
	Electrical usage	1	0,21		0,5
Transports	Thermal usage	2		4,23	2,5
	Electrical usage				
TOTAL	Thermal usage	8	0,26		6,7
	Electrical usage	2,8	1,06		3,1
GRAND TOTAL		10,8	1,32	15,88	9,8

Table 4 – Estimates of incremental energy efficiency potential in respect to PAEE 2007

The results of table 4 have to be compared to the objective of 23.4 Mtep necessary to make compatible the final trend consumptions with the binding of renewable objectives (cfr. Table 1). Two data emerge on which it is worth pausing: the update on the plan of energy efficiency highlights (total sum of column 1 and column 2) that till 2016 with the in force measures the trend reduction of final consumption is equal to 12.12 Mtep, or else still 11.28 Mtep of energy saving are missing to make the objectives till 2020 compatible. Secondly, also along the projections of the potential saving estimated by the Government till 2020 (column 3) equal to 15.88 Mtep highlight however a distance equal to 7.52 Mtep. In other words, an increase in the renewable target to almost 23.9 Mtep in respect to 22.6 Mtep indicated as a maximum potential for our Country would be necessary. And it is striking that if we don't intervene structurally with new measures our Country wouldn't achieve more that 17% and more generally would see jeopardized the general targets of sustainability.

At this point the possible incremental results that our Country could reach by effect of a policy that aims at energy efficiency should be considered. Column 4 presents the result estimate made with the simulation model according to the assumptions previously illustrated. The total potential estimated in the analysis is equal to 9.8 Mtep. If we add the Governments' foreseen total till 2016 (columns 1 and 2) equal to 12.12 Mtep, we obtain an overall potential equal to 21.92 Mtep inferior however to the necessary potential target equal to 23.4 Mtep.

Table 5 reports, instead, the cumulated saving in terms of energy (first column) in the 2010-2020 period, with reference to the different technologies and the relative savings, in the same period, in terms of CO2 (second column).

From table 5 it emerges that through a correct incentive policy of energy efficiency in Italy, this could lead to achieving a saving on final energy consumptions of over 51.2 Mtep[15] in the 2010-2020 period, with a following reduction of CO2 emissions equal to 207.6 million tons[16].

[15] The potential savings, equal to 51.2 Mtep as an integral value 2010-2020, are calculated in terms of final energy consumption, according to the methodology foreseen by the European regulation (2006/32/CE Directive annex 1): "Member States shall use the annual final inland energy consumption of all energy users within the scope of this Directive for the most recent five-year period previous to the implementation of this Directive for which official data are available, to calculate an annual average amount of consumption. This final energy consumption shall be the amount

SECTORS	Saved Energy(Gross final consumption)	Saved CO_2	Saved Energy	Saved CO_2 2)
	Mtep	*Mt*	*milionis i €*	*milions of €*
Transports	12	36	4.926	900
Motors and inverter	2,7	12,6	1.108	315
Lighting	8,9	42,2	3.653	1.055
Constructions	8,8	20,4	3.612	510
Boilers	4,9	11,4	2.011	285
Heat Pumps	5,1	27,2	4.802	680
Hous.Applianc	5,3	25,1	2.175	628
UPS	0,7	3,5	304	88
Cogeneration	2,8	29,2	3.025	730
Rephasing	-	-		
TOTAL	**51,2**	**207,6**	**25.616**	**5.190**
(1)Calulated assumir ing 75 $ per barrel for oil and an exchange rate of Dollar/Euro of 1,25				
(2) Caalculated assur suming the value of 25 €/ton of CO2				

Table 5 – Effectiveness of energy efficiency measures on sustainability

At this point it becomes important to make a first evaluation of the economic benefits that can derive in terms of saving on the energy bill and in terms of the avoided CO2. A first estimate on economic benefits will have to be then compared to the relative structural incentive cost in time, so to determine the net benefit for the Community. To carry out this estimate it has been supposed a long term value of standard reference of the cost of oil estimated at 75 US$/Barrel and a perspective cost of CO2 of 25 €/T[17]. Based on these values it has been possible to reach an evaluation of the cumulative benefit for the 2010-2020 period on the energy bill with a total saving of 25.6 billion euro, and of an avoided cost for effect of CO2 emission reductions in the period equal to 5.19 billion euro. The estimated benefits will be compared to the incentive costs estimated in the following paragraph.

3.2. The socio-economic impact of policies for energy efficiency

The socio-economic impact analysis has been carried out considering apart the effects of general taxation of structural incentive mechanisms by the effects of growth of the industrial and employment sectors. The general taxation impact is surely the most delicate evaluation aspect of a cyclical trend where the majority of State Members of the European Union have had to face situations of crisis that have had a strong impact on public debt. As seen in the previous paragraphs the incentive mechanisms of energy efficiency are mostly related to fiscal instruments. For this reason it becomes extremely important to carry out an impact analysis on public accounts in relation to objectives of sustainability.

In table 6, the possible estimated effects on public Finance are shown. The typology of incentives assumed in table 3 is mainly of fiscal nature. Also in this case the impact analysis refers to two alternative scenarios (BAU and BAT). The evolutionary one (BAT) is based on the assumption of an increase in the demand for high energy efficiency goods due to a long term regulatory and statutory framework in favor of the spreading of high energy efficiency products. Therefore the overall estimated effects are the impacts on the various components of general taxation generated by a higher energy efficiency technological demand. Specifically it has been considered that: the State contribution, in the form of incentives in the consumption of high energy efficiency goods, the higher TVA deriving from the increase in goods' sales, the increase of IRPEF for higher employment due to the development of the industrial sectors, of IRES and IRAP for higher

of energy distributed or sold to final customers during the five-year period, not adjusted for degree days, structural changes or production charges."

[16] To simplify the comparison between the different sectors considered it has been assumed that saved fossil fuel is always the natural gas (coeff. of emission: 2.32 tCO2/tep), except for the transportation sector where it's a mix between gasoline, diesel and gpl (coeff. of emission: 3 tCO2/tep). The efficiency of conversion, transmission and distribution of electric energy was hypothesized equal to 48%.

[17] Long term oil values and CO2 have been determined based on the values used by the main international research institutes. The values of reference are to be intended as prudential values for the 2010-2020 period.

earnings of the industry linked to energy efficiency, the reduction of excise and TVA due to less consumption of electric energy and gas[18].

Along the lines of table 6 the cumulative effects of the 2010-2020 period associated with the different technologies are reported. Along the column the items of impact on general taxation are shown. The "tax increase" impacts of costs for general taxation are represented by the supposed tax incentives "State contributions" (column 3) and those associated with the reduction of "Excise and TVA" as an effect of a lower energy consumption. The "reduction" impacts of costs for general taxation are represented by the increase of the "IRPEF" revenues as an effect of the increase of employment (column 1, based on the data reported in the following table 7), the greater VAT revenue (column 2), and the estimated increase of IRES+IRAP as an effect of a higher industrial growth (column 5).

SECTORS	EFFECTS					
	Direct Taxes	Indirect Taxes				TOTAL
	IRPEF (+employment)	TVA	State Contribution	Excise andTVA(-consumptions)	IRES + IRAP	
	millions of €	millions of €	millions of €	millions of €	millions of €	millions of €
Transports	1.364	4.309	(1)	-8.759	471	**-2.615**
Motors and inverters	132	511	-346	-116	62	**243**
Ligthinng	141	570	-388	-383	67	**7**
Constructions	1.395	6.501	-14.931	-1.601	968	**-7.668**
Condens.Boilers	99	409	-2.036	-1.197	47	**-2.678**
Heat Pumps	12	49	-1.146	-4.479	6	**-5.558**
Househ. Appliances	866	3.860	-3.860	-917	450	**399**
UPS	22	110	-110	-220	13	**-185**
Cogenerazion	517	1.947	(2)	-103	224	**2.585**
Riphasing	7	36	-	-6	4	**41**
TOTAL	**4.555**	**18.302**	**-22.817**	**-17.781**	**2.312**	**-15.429**

Table 6 – Effects of energy efficiency policies on State budget

Column 6 of the table reports the overall net effect on general taxation of incentive measures. In detail an increase of the IRPEF revenue, between 2010 and 2020, can be observed, by 4.55 billion euro, due to employment increase.

The highest yield of TVA, estimated equal to 18.3 billion euro, (always for the 2010-2020 period), is offset by Government grants that are equal to 22.8 billion euro. In terms of excise and TVA, the reduction of energy consumption in the considered sectors generates, instead, between 2010 and 2020, lower revenues for 17.8 billion euro. The net cost to the State budget is equal to 15.429 million euro. The cumulative total charge in the 2010-2020 period, will be then compared to the positive estimated effects with reference to the energy bill and to the cost of avoided CO2.

We then analyzed the impact effects on the industrial sectors both in terms of production growth and on employment. From the analysis carried out the presence in Italy of a series of sectors emerges, which already represented historically and traditionally, leading sectors in the manufacturing National industry, currently with innovative and advanced technologies in terms of energy performance.

The economic impact effects on the industrial sector and on employment have been estimated using ISTAT cross charts as illustrated in the previous paragraph. The effect cumulated in the 2010-2020 period, has been estimated assuming that the industrial sectors are interested in the increasing demand of energy efficiency

[18] The rates of reference that have been applied in the analysis refer to medium reference values thus determined: IRES 27.5%; IRAP 3.9%; IRPEF 20.15% (calculated on gross pay net of workers' taxes).

technologies due to the incentive structural hypothesis considered in table 3. Table 7 reports the summary of results. In the first column are reported the estimate of the overall increasing demand at current prices in the 2010-2020 period, which has an impact on the various industrial sectors and that results in being overall equal to130 billion euro. It is appropriate to underline that the assumed increase is that of National domestic demand. Therefore the overall effect could be underestimated, as external demand isn't considered, which reasonably could occur by the effect of putting into force energy efficiency policies in all the main European Countries.

SECTORS	Demand increase	Impact on single sectors		Inpact on total economy	
		Production	Employment	Production	Employment
	Millions of €	*Millions of €*	*Thousands of ULA*	*Millions of €*	*Thousands of ULA*
Transports	55.305	42.712	196	106.567	625
Motor and Inverters	3.659	2.697	14	6.723	43
Ligthinng	3.333	2.519	18	886	38
Constructions	32.507	26.210	407	61.674	556
oilers	2.448	2.383	12	3.927	27
Heat Pumps	383	262	2	660	5
Hoseh.Appliances	19.518	15.798	98	31.998	220
UPS	1.498	1.106	7	2.462	17
Cogenerazion	10.924	8.511	42	22.646	131
Riphasing	543	399	2	886	6
TOTAL	**130.118**	**102.597**	**798**	**238.427**	**1.667**

Table 7 – Cumulated socio-economic effects of energy efficiency policies

In table 7, the "direct" increase effects of demand (column 2 and 3) and "indirect" ones (column 4 and 5) on the whole economy due to sector interdependences, are considered apart. Direct effects are relevant and result in an increase of the value of cumulated production in the period and over 102 billion euro with a potential increase of about 800.000 units of standard work. The overall effects on the total economy are estimated to almost 240 billion euro and over 1.6 million units of standard work. From a sector point of view, the impact in terms of production would be favorable for the transport sector (+43 billion euro); the construction sector, characterized by a high intensity usage of the work factor, would instead benefit more from an employment profile (+ 407 thousand ULA added).

The overall effect on the whole economy is particularly significant as it could give an important contribution to the GDP growth of 2010 values, for the period in reference by means of 0.3 percentage points. An important result that confirms how a structural approach towards *green economy* would lead to a concrete advantage in terms of economic and employment growth.

3.3 Overall effects of energy efficiency policies

In the previous paragraphs, the effects of energy efficiency have been estimated separately in reference to the impact on the energy bill, the general taxation and the socio-economic impact. At this point it is necessary to bring back all the elements to a unified synthesis for an overall evaluation of efficacy of the incentive policies' efficiency of energy efficiency. Table 8, reports the synthesis of the previous results analyzed in tables 5-6-7 and it enables us to evaluate the overall results compared to three effects:

- Net effect on the public budget, calculated considering direct and indirect taxes. Specifically it has considered: the Government grant under the form of an incentive to consumption of goods with high energy efficiency, the increased tax resulting from increased sales of goods, the increase of IRPEF for higher employment due to a development in the industrial sectors, the IRES and IRAP for more revenues of the industry linked to energy efficiency, the reduction of excises and TVA due to less electric energy and gas consumption. The net charge for the State budget is equal to 15.429 million euro.

- Benefits due to lower energy bill and environmental costs, calculated as an economic value of saved energy and of not produced CO2. Such a value represents a positive impact equal to 30.806 million euro.

- Benefits due to economic and employment growth. The overall measures of energy efficiency in the various sectors would lead to a potential savings of our Country in the 2010-2020 period, equal to more than 86 Mtep of fossil energy, to achieve a socio-economic impact equal to about 130 billion euro of investments, an increase in the industrial production of 238.4 billion euro and an employment growth of about 1.6 million units of standard work engagements.

Inpacts on State Budget	
Irpef on most employment	4.555
Ires e Irap greater industrial income	2.312
TVA for greater consumptions	18.302
State contributios for incentives	-22.817
Exise and TVA for reduced energetic consumption	-17.781
TOTAL IMPACT ON STATE INCOMES	-15429
Economical Impact on Energy system	
Economic valorization of saved energy *	25.616
Economic valorization of saved CO2 **	5.190
Effects on industrial development	
Demand increase	130.118
Production increase	238.427
Employment increase (thousands of ULA)	1.635
Overall impacts on country system	**15.377**
*Calculated assuming 75$ per barrel the price of oil and an exchange rate Dollar/Euro of 1,25	

Table 8 – Overall effects of measures for energy efficiency of cumulated effects 2010-2020

In detail an increase of the IRPEF revenue, between 2010 and 2020, of 4.55 billion euro can be observed, due to higher employment. The most tax revenue, estimated equal to 18.3 billion euro (always for the 2010-2020 period), is offset by Government grants that are equal to 22.8 billion euro. In terms of excise and TVA, reduction of energy consumptions in the referred to sectors, instead, generates between 2010-2020, lower revenues for 17.8 billion euro. Nevertheless, it is appropriate to consider also the positive effect of the economic impact of efficiency measures on the National energy system in terms of primary energy saved and CO2 emissions avoided. If we confer a medium value of 75 dollars a barrel of oil for the whole 2010-2020 period, it is possible to increase the value of the total primary energy saved in the period referred to, considering a Dollar-Euro change of 1.25. The value of this saving is equal to 25.6 billion euro. Giving a medium value of 25 Euro per CO2 ton, it is possible to quantify economically the overall value of avoided emissions, equal to 207.8 million tons. The value of such a saving is equal to 5.19 billion euro.

Overall therefore, considering both the impact on the State budget and the economic impact on the national energy system, the effects of energy efficiency measures in the 2010-2020 period on the County's system is highly positive, with an economic value equal to 15.4 billion euro.

This result highlights clearly that the measures of environmental policies aren't a cost but represent an advantage and an opportunity for the growth of the Country.

4. Conclusions

The previous paragraphs highlight that energy efficiency is a very effective tool to reach objectives of environmental sustainability. Energy efficiency seems to satisfy all the main foreseen Community's objectives from the climate-energy package: reductions of climate-altering, security of supplies, technological development opportunities for the European industry.

From the results, it emerges that energy efficiency gives an undisputed support to the first two objectives. With reference to the first objective the reduction of CO2 avoided for over 200million tons, supplies a significant contribution to the 2020 objectives in the new foreseen targets at Community level with an overall savings that exceeds 5 billion euro. With reference to a reduction of the Italian energy bill the result is likewise significant as the possibility of reducing consumptions by 51.2 Mtep with a saving of 25 billion euro, becomes essential for a Country that by now imports over 90% of primary consumed energy from abroad.

Concerning the opportunity of industrial development, we have seen that the increase of energy efficiency objectives are able to engage a consistent increment in demand of high efficiency technologies activating involvement in a significant way of the Italian manufacturing sector. This is mostly due to the fact that the strategic positioning of the Italian manufacturing industry presents a strong growth potential on these technologies. For sure a phase of large debate on developing and growth policies would be extremely important to transform the general interest and environmental safeguard in an opportunity of growth. As we have seen in the simulations the direct and indirect effects are significant with a potential of an average annual contribution of GDP growth superior to 0.3 percentage points. Furthermore, even if it hasn't been an object of our survey, the positive effects that the reduction of energy consumption implies in terms of greater economic-productive efficiency on the industrial system has to be considered (reduction of productive process costs and increase of competitiveness on International markets).

The assumptions made on incentive mechanisms have focused mainly on general taxation a prevalent measure. In a Country with a high public debt like Italy, the particularly high level of public debt raises understandable concern.

For this reason hypothesis on additional mechanisms haven't been made, but all the evaluations have been carried out based on existing schemes but steady for the 2010-2020 period.

What our conclusion wants to highlight is that the real strength of policies for energy efficiency is the certain statutory *framework* and the definition of an incentive strategy with a temporal horizon in the medium-long term period, that enables operators to plan investments and the strategy of industrial growth in a context of stability. Such an approach cannot prescind from a strong action of administrative simplification and harmonization of the energy efficiency standards, not only at a European level but also at an international one, that allows companies to have a competitive even approach able to exploit strong competences already existent in the Italian industrial sectors. The incentive cost estimated borne by general taxation is superior to 15 billion euro in 10 years, but results greatly exceeded in terms of benefits almost double for 30 billion euro due to reduction of the energy bill and the avoided cost of CO2.

If the objective of *green economy* is to become an engine for development and technological *leadership*, the policies for energy efficiency can bring our Country to win the challenge under a net social profitability for the whole Country.

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