PV Policy Group

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A National Position Paper and Action Plan

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EXECUTIVE SUMMARY

In the present document an overview of the Portuguese policy context for market deployment of photovoltaic technology is made and its results subjected to a critical review, followed by a policy recommendation.

The aforementioned recommendation is exclusively aimed at market deployment policies and associated instruments.

Presently the Portuguese PV market is at a stall as a consequence of policy-originated barriers. This however, constitutes an opportunity for setting up a stronger strategic orientation, as several governmental actions are at quest so to unblock the situation, namely:

- there is the need to either re-open the PIP call period or to create a new authorisation procedure framework, whether combined or not with the previous one. Inadequacy of the present format for small-scale, LV grid-connected systems is widely acknowledge, namely by governmental bodies;
- clarification is necessary of whether or not the rectified DL 33-A/2005 is in force. This also constitutes an opportunity for revising the structure of the feed-in tariff.
- There is inconsistency between the IPP and PC frameworks that is affecting exclusively PV, as this is the only energy technology positively differentiated in both. With present conditions, it is not expected that any PV system will be licensed within the PC framework, thereby loosing some unquestionable associated benefits, namely lower administrative costs.
- clarification on whether or not the present 2010 target will be revised is necessary, so to provide for a more transparent environment for the actors involved in market deployment activities. This eventual revision also opens up room for discussion on whether or not it is advisable to follow a capacity-cap policy, at least with no pre-determined prospective evolution, as it carries associated negative market stop-and-go effects. This is already considered one of the most important barriers hindering PV industry development.

Besides technology-caps, also important is to define which strategic orientations should be followed so to maximise overall present and future value of PV-electricity to the Portuguese society, including its contribution to fostering a PV innovation system. This brings us to the discussion of relative value of different PV applications.

The market for large and very-large scale ground-mounted systems can presently be considered a global one, and as such Portugal should be competing with other countries in the quest for interested developers and for financial resources. It follows directly that market deployment incentives should be put against those from competing countries, notably Spain. This country is presently the strongest competitor when it comes to attractiveness of investment, especially taking into consideration the higher and longer-term feed-in tariff, the geographical and language proximity between the two countries, as well as shared cultural roots, barriers that usually constrain global RE investors.

Moreover, it is apparent that the added-value for the Portuguese economy that can be brought by large and very-large scale systems has varying degrees of importance depending on the structure of investment. If, however, global trends of investment in RE market are followed by Portuguese investors, it seems obvious that this value should be mostly restricted to that of the electricity generated and of the associated reduction of CO_2 emissions. Other factors such as the potential for embedment of national competencies, industrial development and learning effects do not impact significantly on the overall PV-electricity value.

This situation could eventually be at least partially reverted with a tendering system asking for counterparts from the tenders, as has been done with the wind market in Portugal. Nonetheless, it must be clear that investors-willingness may freeze as it is already not high.

Small and medium-scale building-mounted/integrated systems in turn are expected to be the type of applications that deliver the highest PV-electricity value for the Portuguese society. Not only are the aforementioned factors contributing intrinsically to this higher value, but also the potential to incrementally reduce the amount of public investment for the same deployment rate, given the building-related added-values at the several user levels (e.g. end-user, building promoter, architect). Moreover, private investment barriers may somehow be overcome as investors are expected to be originated in non-traditional sectors, such as construction and tourism, as well as in building end-users.

Moreover, there is evidence that, as long as building-sector actors become educated about PV and there is availability of specialised engineering services, there is a fairly high willingness to adopt this technology in the building process and that, once adoption occurs, the willingness to keep using the technology in further projects is maintained. This in turn gives good prospects for the sustained development of the building (and other urban structures) PV market and eventually for its self-sufficiency in a well-designed regulatory framework.

When put against each other, large and very-large ground-mounted systems have the potential for considerably higher diffusion rates than small and medium scale building-mounted systems. When compared over time, however, the potential for longer diffusion paths, and therefore for long-term market sustainability, of small and medium scale building-mounted systems is far more reaching. This time sustainability can be measured in terms of evolution of surface area available – while it is expectable that the available land for large and very-large scale ground-mounted systems will attain saturation (e.g. because of competition with other energy and non-energy land uses), the area available in building surfaces increases as new buildings are built and the existing building stock is renovated.

This longer diffusion process may be beneficial in Portugal as it gives more time for the establishment of a Portuguese PV-based innovation system – while the market learns how to use the technology, competences are meanwhile being created in the industry and R&D spheres.

Table 5 summarises the policy framework proposed along the core design vectors of capacity cap, feed-in tariff and licensing framework and authorisation procedure.

Application Type	Application Size	Licensing Framework Authorisation Procedure	Feed-in Tariff [€/kWh]	Capacity Cap (2006-2008)
Façade	≤3,7 kVA 1-phase ≤11,1 kVA 3-phase	Producer-Consumer Notification	0,68	No
	≤100 kVA	Producer-Consumer Simplified local procedure		
	>100 kVA	Independent Power Producer DL312/2001	0,63	Yes Tender Process
Roof-mounted and other grid-connected urban structures	≤3,7 kVA 1-phase ≤11,1 kVA 3-phase	Producer-Consumer Notification	0,5	No
	≤100 kVA	Producer-Consumer Simplified local procedure		
	>100 kVA	Independent Power Producer DL312/2001	0,46	Yes Tender Process
Ground-mounted	≤3,7 kVA 1-phase ≤11,1 kVA 3-phase	Producer-Consumer Notification	0,30	Yes
	≤100 kVA	Producer-Consumer Simplified local procedure		
	>100 kVA	Independent Power Producer DL312/2001		Yes Tender Process

Table 5 – Summary of policy framework recommended regarding capacity caps, feed-in tariff and licensing framework and associated authorisation procedure

It is believed that this policy framework will provide the market with adequate signals both towards building applications and small scale systems. In fact, the simpler authorisation procedures associated with small scale systems increase the attractiveness of this type of systems to investors, as decisions on licensing timings are made more flexible and have potentially attached less transaction costs (i.e. financial costs associated with the licensing process). On the other hand, in this scale more attractive feed-in tariffs exist for building applications. Also, façade systems are fostered by setting the same playing level field between these and roof-mounted applications with the aim of getting a higher involvement of the Portuguese creative industries, and as such enhancing the potential embedded national value.

It is also expected that the combination of the recommendations on feed-in tariff and licensing framework will bias the market towards building-mounted medium to large scale systems, instead of ground-mounted systems. The development of very-large scale systems market is not expected to be significant, as this would imply a significantly higher allocation of financial resources to this segment so to make it competitive with other geographic markets such as the Spanish. This comes as undesirable as these applications have apparently little potential for fostering a high value national PV innovation system.

Finally, with respect to capacity caps a transition period is recommended in which the commitments with present capacity target are met, while a system of indicative targets is set for the medium term. In the short term, only systems in the medium to large scale will be subjected to these transitional dispositions, while small scale systems are exempted from any capacity cap associated actions.

In order to avoid capacity-caps stop-and-go effects, the indicative target system must be decoupled from financial incentives, especially from feed-in tariffs. No indicative targets are recommended for the medium term as this is a decision that must build upon information on the evolution of the market. For the short term, and regarding small scale systems, indicative targets of 1 and 2 MWp annual installed capacity are recommended for 2007 and 2008 respectively.

In addition, to these core policy actions, the following accompanying measures are recommended:

- develop a continuous communication strategy regarding activities of awareness and dissemination, namely to overcome barriers of lack of information and of biased perceptions. Several stakeholders should be targeted, from private to public bodies, from the building to the financial sectors;
- create the conditions for the provision of training and certification of installers;
- create the conditions for the provision of training of architects, engineers and eventually of the financing and insurance sectors;
- create the conditions for accreditation of training courses;
- establish a framework for product certification.

The design of the monitoring system is extremely important to enable a close evaluation of results of the policy framework recommended and to better inform posterior updates and revisions of such framework. As a corollary, it is also extremely important to have a clear definition of who are the responsible entities for providing the necessary data and for treating it according to the needs of the monitoring framework. As such, it is recommended upfront that an observatory is set. This observatory may not be exclusively oriented towards PV, as some synergies exist with the solar thermal market and the already constituted Observatory for Buildings related to the Energy and Air Quality Certification System of Buildings.

The monitoring system is recommended to consist of three sub-systems, namely:

- Sub-system aimed at monitoring the value of the overall installed PV capacity to the Portuguese society;
- Sub-system aimed at monitoring the value of PV systems for the different stakeholders and their willingness to pay;
- Sub-system aimed at monitoring evolution of barriers.

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I. OVERVIEW OF POLICY FRAMEWORK APPLICABLE TO PV TECHNOLOGY

1. Overview of Policy Framework Applicable to PV Technology

1.1. *Historical Background of the Context for Renewable Energy in Portugal*

Similarly to most of the developed countries, the Portuguese energy policy is presently strongly rooted on the main strategic vectors of increased security of supply, promotion of national competitiveness towards market liberalisation, while promoting environmental protection.

The promotion of market deployment of renewable energy (RE) technologies can be regarded as a major policy objective conducive to increasing security of supply, through diversification of energy sources, while reducing the environmental impact associated with the energy system.

This strategic orientation has been successively reaffirmed by different governments in the context of the Independent Power Producer (IPP) framework. The IPP figure has long been contemplated in the Portuguese energy policy framework – first legislative references to the small producer of energy are dated from 1944. Nonetheless, it was only in 1988 that a clear framework for the production of electricity based on renewable energies was set. This framework was reviewed in 1995, as a consequence of the National Electrical System restructuring, wherein the IPP figure was framed within the Independent Electrical System. Basically this framework regulated the independent power production activity, establishing a purchase obligation on the national grid for RE-based electricity, a feed-in tariff and the administrative, technical and safety rules. Under this framework, however, all renewable energies were given the same treatment, being the feed-in tariff smaller than the market price for electricity. Accordingly, only close-to-market technologies have been deployed, notably mini-hydro power and, to a lesser extent, wind energy.

In September 2001 the Portuguese Government launched the E4 (Energy Efficiency and Endogenous Energies) Programme (Direcção-Geral de Energia, 2001), a programmatic energy policy tool orienting and promoting new energy pathways for the future (Direcção-Geral de Energia, 2002). The E4 Programme provided essentially for a strategic orientation both in terms of energy efficiency and renewable energies, while drawing on the necessary tools and measures to achieve the stated goals. A major instrument was introduced through the decree-law (DL) 339-C/2001, where a technology-differentiated feed-in tariff for RE-based electricity was set, distinguishing for market maturity of the different technologies. In this context, photovoltaic (PV) technology was given the highest tariff as it was considered to be the least market-developed technology. In this instrument it was also, for the first time, implicitly established capacity goals by technology to be attained by 2010, i.e., the Portuguese policy for market deployment of RE technologies consisted on a combination of formal targets with feed-in tariffs, the later leveraging the former. In the case of PV technology an official goal of 50 MW was established. It should be noted that the IPP framework implies that all generated electricity is delivered to the grid, without any self-consumption.

The main deficiency of the DL339-C/2001 was the absence of a clearly defined period during which the tariff would be applicable for each installation licensed. In fact, it can be read in the legislative document that the value, for the Portuguese society, of a RE installation is not limited in time, but rather remains the same throughout its lifetime. Implicitly then, the idea was to have the feed-in tariff applicable until the RE system attained its end of life. Nonetheless, this interpretation was not assumed by the entity responsible for establishing the contract with the IPP (the transmission and distribution operators of the area in question), who included a clause stating that the tariff would be applicable for an undetermined period of time. This induced a higher risk to investors given the associated uncertainty in the financial performance of the system.

Just before entrance in force of the DL339-C/2001, the licensing administrative procedure (i.e. authorisation procedure) was reviewed through decree-law DL 312/2001, with the objective of increasing the system overall efficiency and transparency, in line with what has been laid down in RES-E Directive 2001/77/EC. This instrument, presently still in force, was mainly aimed at installations connected to the medium, high and very-high voltage grids, whereas low-voltage (LV) grid-connected systems were explicitly mentioned to be exempted from the established procedures. Nonetheless, further establishment of the rules for the later systems, to be licensed in the framework of the IPP, did never come to light. As a corollary, the authorisation procedure for a LV grid-connected system under the IPP framework had to follow exactly the same procedures as other systems connected to higher voltage levels grids.

In April 2003 the Portuguese Government set up a new energy policy framework reaffirming the strategic vectors of security of supply, diversification of energy sources, promotion of endogenous energy sources, promotion of energy efficiency and promotion of national competitiveness through the realisation of the liberalised Iberian Market. Although repealing it, this new framework built upon the E4 Programme, not only maintaining its main objectives regarding RE sources, but also setting up more ambitious goals for some of them, notably for photovoltaic solar energy. In fact, for the later the new framework set the goal at 150 MW for the same time horizon (2010). This goal refers to PV nominal installed power.

Already in February 2005, the feed-in tariff established in DL399-C/2001 was revised through the decree-law 39-A/2005, which also clarified the timeframe in which the tariff was in force. In April however, a rectification declaration issued by the Portuguese Directorate-General for Geology and Energy (DGGE), altered the feed-in tariff formula, affecting mainly PV installations and resulting in a decrease of the incentive.

With respect to incentives on investment, several programmes have already been in force supporting renewable energy technologies. The latest was set through the Operational Programme of Economy (PRIME), a support system that makes use of European Union structural funds. The measure aimed at supporting investment on RE technologies in the framework of the independent power producer, MAPE, set incentives at a maximum 40% of eligible costs, with an absolute ceiling of 300.000,00€ per project. Additionally, in the case of PV systems, a relative ceiling for the eligible costs was set at 3.000,00 €/kW delivered to the grid (e.g. nominal inverter output). Finally, half of the 40% incentive could be reimbursable. If this was the case, the reimbursement period was set at 9 years and would benefit from a grace period of 3 years. Given the rules associated with the usage of European Union structural funds, this incentives system was only applicable to IPP constituted as companies with business classification falling within energy activity. For the same reason, companies head-quarted in the region of Lisbon and Tagus Valley were not eligible for the funds from 2004. Finally, in order to re-adjust the use of funds to the new policy orientations introduced by the Portuguese Technological Plan, the MAPE programme was suspended in February 2006.

Recently, the development of renewable-energies related industries are the main target of investment support, not their deployment, except in the case of demonstration actions. Generally, there are three different programmes supporting technology development in companies: DEMTEC (demonstration projects), SIPIE (industry development) and SIME-IDT (industrial research and implementation).

The overall framework described above can be said to fall within a supply-side management philosophy and can be considered the main one for supporting RE deployment in Portugal. It is inline with the European Directive 2001/77/EC of the 17th of September 2001 regarding the promotion of RE electricity and by which Portugal is committed to attain a penetration of 39% of RE in the electricity system by 2010.

Introduced mainly as a demand-side instrument, in March 2002 a new framework for energy systems connected to the low voltage grid was launched, known as the Producer-Consumer (PC) Framework. This framework regulates the interconnection of micro-generation technologies with a connection power no greater than 150 kW and also establishes a technology-differentiated feed-in tariff of the excess power not consumed locally. PV is the only renewable energy technology explicitly mentioned within the micro-generation technologies portfolio considered, being therefore the only one that is positively differentiated, simultaneously, within the IPP and the PC frameworks. Unlike IPP, the PC has presently an obligation to consume at least 50% of the generated electricity.

In what follows, a detailed analysis of the financial and regulatory instruments presently in force, affecting PV deployment, either directly or indirectly, is given below.

1.2. *Financial Incentives: The Independent Power Producer Framework*

As mentioned previously, the only instrument presently in force for supporting market deployment of RE technologies is a feed-in tariff mechanism, as an incentive-on-production; incentives on investment are currently suspended.

As also mentioned previously, the feed-in tariffs for the different RE technologies are established in the DL 33-A/2005. Generally, the feed-in tariff, on a monthly basis, for any technology, is given by the formula presented in equation 1.

$$VRD_m = KMHO_m \times \left[PF(VRD)_m + PV(VRD)_m + PA(VRD)_m \times Z\right] \times \frac{IPC_{m-1}}{IPC_{ref}} \times \frac{1}{1-LEV}$$

EQUATION 1 – Formula for the monthly feed-in tariff of the electricity produced through renewable energy sources and delivered to the national electrical grid

The term $KMHO_m$ is a factor that modulates the hour of the day in which the electricity is delivered to the national electrical grid, benefiting systems that deliver energy during peak hours by a maximum of 25%. $PF(VRD)_m$ and $PV(VRD)_m$ are fixed and variable terms respectively that take into consideration the avoided investment in new conventional power plants and the associated operation and maintenance costs. The term $PA(VRD)_m$ relates to the environmental benefit introduced by the RE installation, although it is assumed the same independently of the specific technology considered. The differentiation factor among technologies is given by the factor Z. Even though it is affecting directly the environmental term $PA(VRD)_m$, it does not relate in any way with the environmental value of the technology at quest but rather to its market maturity. Finally, the term $\frac{IPC_{m-1}}{IPC_{ref}}$ introduces the actualisation of values relatively to inflation (consumer price index without housing effects), while the term $\frac{1}{1-LEV}$ takes into consideration transmission and distribution grid losses avoided by the distributed RE systems. It is important to note that, relatively to the feed-in tariff formula established in DL 339-C/2001, the reference month for the consumer price index in DL 33-A/2005 refers to the one that precedes the month the PV installation starts delivering electricity to the public grid, while in DL 339-C/2001 the reference month is set as December 1998. The feed-in tariff calculated through the settings of DL 339-C/2001 is more attractive than the one calculated through DL 33-A/2005 dispositions.

The technology-differentiating factor, *Z*, is defined in distinct ways depending on the technology under consideration. In the case of PV technology, a differentiation is made in relation to the system's dimension. In fact, for systems with a declared interconnection power equal or smaller than 5 kW, *Z* assumes the value of 52, while for systems with a higher interconnection power *Z* is set at 35. It can be easily derived from observation of equation 1 that there is not a fixed feed-in tariff for the electricity delivered by a PV system (or any other RE technology), although is possible to calculate an approximate value bearing in mind some assumptions, namely regarding actualisation factors and the relationship between declared and effective interconnection power. Accordingly, the feed-in tariff is calculated to be approximately equal to 54 c€ and 38 c€ for a PV system with a declared interconnection power below and above 5 kW, respectively.

As briefly referred, a declaration of rectification to DL 33-A/2005 issued by DGGE on the 15th of April 2005 altered the feed-in tariff formula with relevant implications to PV systems. In fact, according to this declaration, the factor *KMHO* would not be affecting all the terms in equation 1 but only *PF* and *PV*, as given in equation 2. This rectification introduces a decrease of about 18% in the calculated feed-in tariffs, as PV systems deliver energy essentially during peak hours and benefit from a close to maximum value of KMHO.

$$VRD_m = \left[KMHO_m \times \left[PF(VRD)_m + PV(VRD)_m\right] + PA(VRD)_m \times Z\right] \times \frac{IPC_{m-1}}{IPC_{ref}} \times \frac{1}{1-LEV}$$

EQUATION 2 – Formula for the monthly feed-in tariff of the electricity produced through renewable energy sources and delivered to the national electrical grid as given by the declaration of rectification to DL33A/2005

Nevertheless, the declaration of rectification is by many considered unconstitutional since it alters and contradicts directly the original legislative text. Since this rectification has not yet been cancelled, there are still some doubts about whether or not the original legislative text will be changed within legal limits to introduce the intended reduction in the tariff.

The DL33-A/2005 also sets up the timeframe in which the feed-in tariff is in force – 15 years or until the system attains a production of 21 GWh per MW installed. This is equivalent to say that a reference annual system yield of 1400 kWh/(kWp.year) is assumed. If the system has a higher yield, it will receive the feed-in tariff for fewer years, although it also should attain the return on investment faster if system costs are of the same range as the reference system. If, however, the system presents a lower yield (e.g. a façade-integrated system), its economic performance will be penalised as compared to a reference system.

Finally, it should be noted that the feed-in tariff mechanism will only be applicable to new systems until the 150 MW capacity-target is attained (unless future revisions of this goal are provided). After that a Green Certificate Trading System will be applied, superimposed to the market price of the electricity.

As said previously, the administrative procedure associated with the licensing process is, in the context of the IPP framework, regulated by DL 312/2001, even in the case of small systems requesting to be connected to the low-voltage grid, as no other framework has been established meanwhile.

According to the existing framework, the licensing process starts with the so-called request for preliminary information (PIP), which can only be submitted to DGGE every first fifteen days of each quarter (i.e., the first 15 days of January, May and September). When the PIP submission period is over, DGGE has 40 days to analyse and decide upon the requests received.

This period includes consultation of grid operators for technical aid, namely regarding grid capacity availability, subjected to the capacity requested for each interconnection point. In the case of acceptance of the request, the IPP has 15 days to pay a deposit and then 70 days to request the interconnection point. DGGE then has 30 days to decide upon the request and in the case of acceptance the IPP is obliged to request immediately the establishment license. This license will be in force for 24 months during which the IPP will have to install and interconnect the RE installation. This is a time-consuming, lengthy process that has additionally the risk of further extending in time, as deadlines may be modified according to a set of exceptions. In practice it has been observed that the licensing process of a small PV system (e.g. less than 5 kW) can take over one year to finish. Larger systems, namely in the range of MW, tend to have longer licensing processes. The whole procedure is illustrated in figure 1.

In DL 312/2001 it is also established that the PIP period may be suspended by DGGE in case there is a risk of management of the processes or when the grid interconnection capacity is saturated. Also, the same legislative text establishes that the Portuguese government may substitute the ordinary licensing process to one based on a tendering system, namely as a means to effectively implement the different capacity goals established for the year 2010. The right to condition the PIP periods has extensively been used by DGGE, as detailed in section 2. With respect to the tendering instrument, both wind and biomass are presently being submitted to this framework. For PV technology, the ordinary PIP process is suspended since May 2005 and news is being spread that a tendering system will be imposed for the capacity that has not yet been allocated. The last requests that are presently in a licensing process were submitted in the PIP period of May 2004.

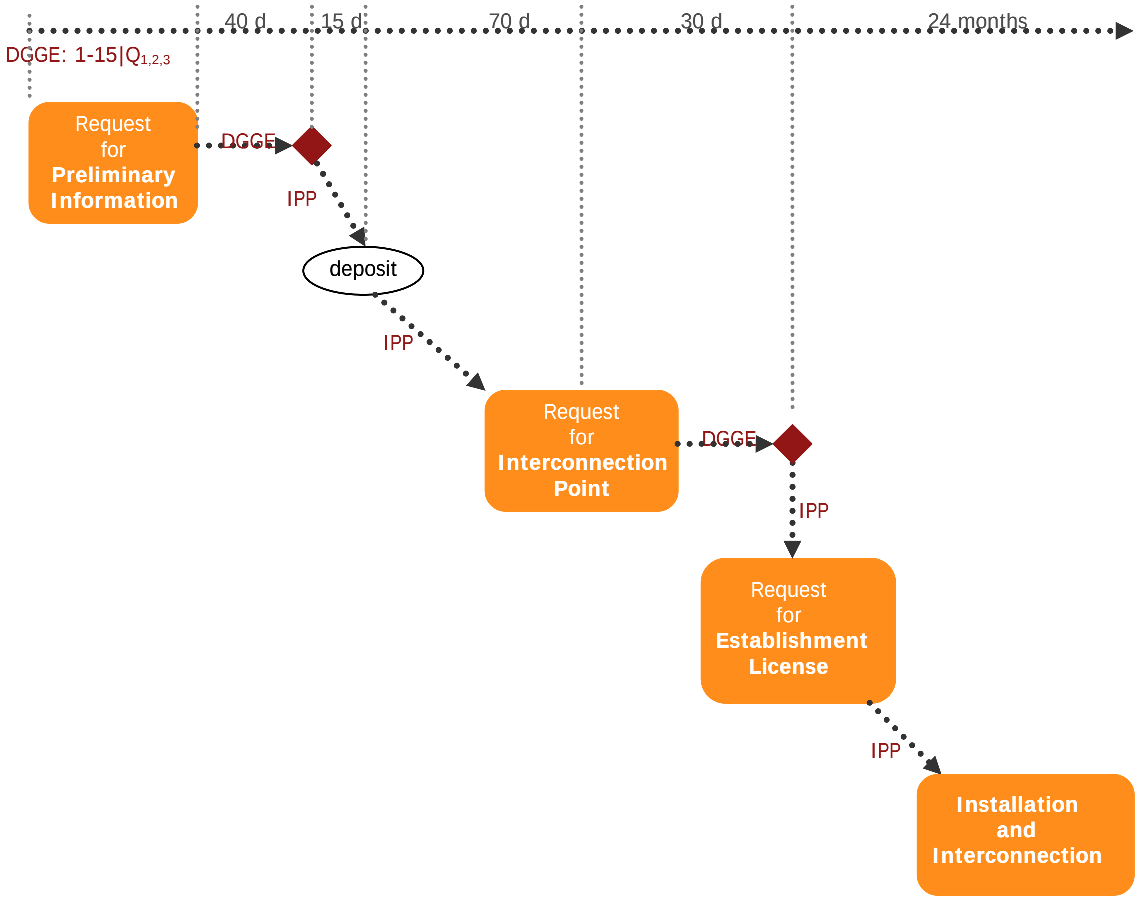

FIGURE 1 – Administrative procedure associated the licensing process of a renewable energy installation connected to the public grid in the context of the IPP framework

1.3. ***Financial Incentives: The Producer-Consumer Framework***

As mentioned previously, the producer-consumer framework is introduced essentially in the context of demand-side policies. Even if not mentioned explicitly in any associated legislative document, the producer-consumer framework concept relates strongly to buildings and the local provision of their energy needs within a decentralised philosophy. To this point it should be noted that although buildings represent approximately 27% of total final energy consumption (well below the European average), in what regards electricity, buildings are already responsible for more than 60% of total consumption of this final energy form in Portugal.

The DL 68/2002 constitutes the legal document regulating the mentioned framework and is therefore aimed at micro-generators with significant part of the generated electricity being used in self-consumption. As such, the producer-consumer is defined as an entity that consumes at least 50% of the electricity generated by autonomous electricity production equipment connected to the LV grid, with a maximum connection power of 150 kW. The excess generated electricity can be exported to the grid and is also benefiting from a feed-in tariff, which is established in the order in council PT 764/2002. The associated monthly-remuneration calculus formula is presented in equation 3. Accordingly, the monthly remuneration of the exported excess energy VRD_m equals the special (contracted power greater than 41,4 kW) LV regulated market price of the generated electricity ($VRD(BTE)_m$), added by a technology-dependent incentive actualised
relatively to inflation, where EEC_m is the monthly delivered electricity.

$$VRD_m = VRD(BTE)_m + C_t \times EEC_m \times \frac{IPC_{Dez}}{IPC_{ref}}$$

EQUATION 3 – Formula for the monthly feed-in tariff of the excess electricity exported to the grid under the Producer-Consumer framework (micro-generation)

The technology-differentiation factor C_t is highest for fuel cells and photovoltaic technologies (0,2); gas micro-turbines, Otto cycle engines and Sterling engines are the other technologies positively differentiated, though with technology factors approximately 10 times lower. The technology factor is actualised on a yearly basis so to reflect changes in technology priorities or technology evolution.

In order to get an approximate value of the unit remuneration of the electricity sold to the public grid by a PV system under the producer-consumer framework, assumptions have to be made regarding the time of day it is delivered, as the regulated low-voltage tariff has three different levels of remuneration depending on peaking hours (non-flat rate). Figure 2 shows the tariff in these levels in the associated daily schedules, as well as its seasonal variation. Figure 2 refers to the settings of the daily cycle, as opposed to the weekly cycle (i.e. different schedules for working and non-working days), which is assumed in the calculation of the feed-in tariff. Assuming that annually, on average, 20%, 75% and 5% of the PV energy is generated in peak, full and low load hours respectively, the feed-in tariff is calculated to be approximately 30,8 c€.

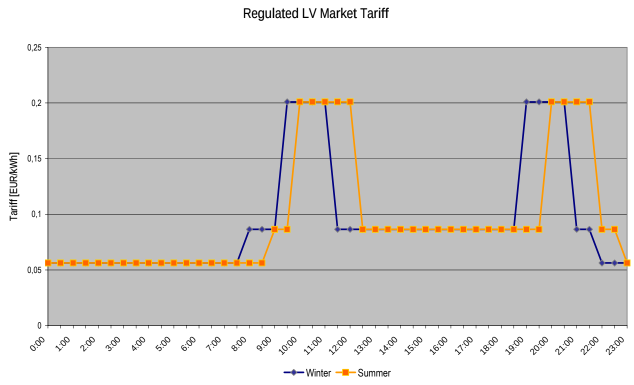

FIGURE 2 – Low voltage grid regulated market tariff applicable to the calculus formula of the feed-in tariff under the producer-consumer framework

Ten years is the timeframe in which the tariff is guaranteed according to equation 3. After that, the tariff is still calculated according to equation 3, but C_t is cut to half of its last actualised value. This tariff should be applicable until the system reaches its end of life.

One major advantage of the producer-consumer framework is the administrative procedure subjacent to the licensing process of the installation, which is strongly simplified when compared to the one associated with the independent power producer framework. Firstly, there are no pre-determined periods in which the licensing process has to be initiated, introducing a greater flexibility, especially if systems are to be installed in new buildings. Secondly, the procedure is geographically and institutionally decentralised, being the local regional delegation of the Ministry of Economy the responsible entity for the licensing process and not DGGE (which is a central organism). Thirdly, the authorisation procedure involves only a consultation to the local LV grid operator regarding technical conditions and constraints and the submission of the characteristics of the installation to the local regional delegation of the Ministry of Economy. It is important to note that the output of this process is a buy-sell contract with the LV grid operator.

II. OVERVIEW OF PORTUGUESE PV MARKET DEVELOPMENT

2. Overview of Portuguese PV Market Development

The evolution of PV installed capacity is shown in figure 3. As can be seen, market growth in 12 years has not been significant, topping in the later year a capacity of about 2,5 MW. Another striking fact, that is evident from observation of figure 3, is that market is dominated by stand-alone applications, which are not the target of the existing financial incentives just described. In fact, figure 3 allows concluding that market development in Portugal has been done essentially with non grid-connected systems, with no substantial growth of grid-connected applications (e.g. since 2001, the year in which the technology-differentiated feed-in tariff has been institutionalised), resulting in growing shares of the former over time. To this end it is important to bear in mind that the installed capacity goal of 150 MW to be attained in 2010 is exclusively targeted at grid-connected systems, as it was set in association with the IPP framework that implies that 100% of the generated electricity is delivered to the public grid. As such, it can be said that the goal realisation rate is still close to zero.

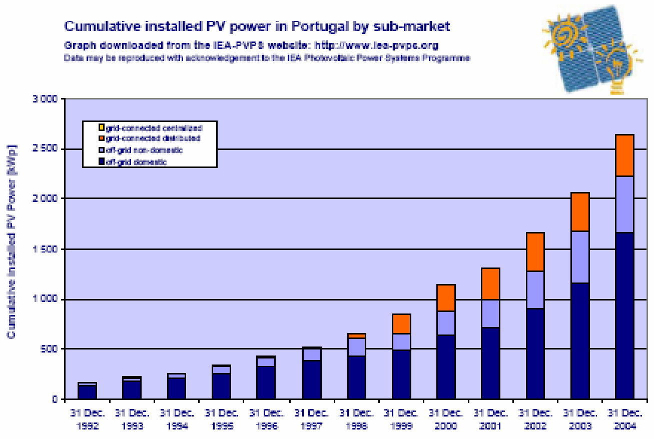

FIGURE 3 – Evolution of PV installed capacity in Portugal from 1992 to 2004

Nonetheless, in order to get a deeper grasp into these figures, it is essential to analyse the capacity under licensing in the framework of the IPP; with respect to the PC framework, it can be said that no PV system has yet been licensed in this context, nor is any licensing process ongoing.

According to data provided by DGGE, there is presently about 103,6 MVA PV capacity under licensing (requested interconnection nominal power), which roughly corresponds to 128 MWp if an inverter underrating factor of 80% is assumed. This means that a capacity of 22 MWp is still to be attributed, as also explicitly stated in DGGE dispatch number 26388-A/2005 from December 2004, relative to the PIP period of January 2005.

Moreover, it is also convenient to stress that the capacity under licensing refers to requests submitted in the period from January 2002 (following the introduction of the technology-differentiated feed-in tariff in December 2001) to May 2004. The main implication is that, as requests entered the licensing system before 2005, the applicable feed-in tariff and associated dispositions are those provided by DL339-C/2001 and not by DL33-A/2005. Accordingly, the feed-in tariff will be applicable by an undetermined period and is more financially attractive than the one provided by the later diploma, especially if the declaration of rectification is assumed as in force. Despite the comment made about higher risk perception from investors when describing the context for DL339-C/2001, apparently these actors are taking this as an advantage, eventually because the worst they can expect is to have a better guaranteed feed-in tariff during the period established in DL33-A/2005.

In the first PIP period in January 2002, only two requests entered the system, both relative to the Moura PV power plant. By then, a capacity of 65.300 kVA was requested and 49.600 kVA was conceded. As a consequence, already in the first PIP period, the 50 MW target was mostly attained, which brought some uncertainty about future possibilities to further install PV systems. Nonetheless, in the PIP call of May 2002 no restrictions were made to PV requests, although only three requests were made, totalling a requested capacity of 10 kVA. In September 2002, DGGE issued a dispatch inhibiting wind PIPs, given the high influx of requests for this technology in the two previous calls. The situation was maintained from then on. Coincidently or not, the capacity requested for PV installations started increasing, although some fluctuations existed given the restrictions introduced by DGGE in specific PIP calls. In the September 2002 PIP period, 10 requests were submitted, totalling a capacity of 13.120 kVA, of which only 5 were accepted, even if representing a capacity of 12.958 kVA; in January 2003, the 11 requests submitted were all accepted, representing a capacity of 36.429 kVA. Still in 2002, rumours already existed that the 2010 PV target would be revised, which occurred in April 2003, when the present 150 MW capacity goal was established in the Ministries Council Resolution 63/2003.

For the May 2003 PIP period a dispatch was also issued by DGGE in which a tendering process for wind was for the first time announced as the future procedure. In the case of PV technology, a constraint was put so to restrict requests in the capacity range between 100 and 300 kW. Twenty three requests were however submitted in and outside this range, representing a total requested capacity of 9.469 kVA; of these, 13 requests were attended summing up 4.329 kVA. Interestingly however, only one of the accepted requests (of 108 kVA) laid within the boundaries of the imposed range; 6 of the accepted requests refer to systems with capacity higher than 300 kW (three of 325 kVA; one of 360 kVA; one of 646 kVA and one of 2150 kVA). All the remaining accepted requests refer to capacities lower than 35 kVA, three of which are of 5 kVA. It should however be noted that requests for PV systems below 100 kVA were generally considered meanwhile, even in the presence of overall suspension of the PIP process. This can be seen for instance in the PIP period of September 2003, in which requests for all technologies were suspended, although 14 requests for PV were submitted – one of 100 kVA, 11 of 5 kVA, one of 3 kVA and one of 2 kVA – and three accepted (one of 100 kVA and 2 of 5 kVA). This allowance can be explained by the exception regime introduced by DL 312/2001 for systems with an interconnection capacity below 100 kVA. The same situation occurred in the January 2004 PIP period where again all but waste valorisation requests were suspended, even if 55 requests for PV systems below 100 kVA were submitted (representing a requested capacity of 1.179 kVA). Of these 55 requests only 17 were conceived, with a corresponding capacity of 187 kVA. It is interesting to see that, out of the 55 requests, 42 referred to 5 kVA systems; of these, only 16 were conceded.

In May 2004 a boom in below 100 kVA PV requests occurred, again in a situation where several technologies were left out of the PIP process. In this period, 414 requests were submitted, totalling 4.099 kVA. Surprisingly, of these only 6 requests were accepted, five of 5 kVA (out of 353) and one of 2 kVA. None of the nineteen 100 kVA requests were accepted. This boom motivated a bottleneck in the evaluation process at DGGE, who suspended the PIP period of September 2004 generally for all technologies, including PV and explicitly mentioning below 100 kVA installations. The January 2005 PIP period was reopened for biomass, biogas, mini-hydro (with some restrictions) and PV technologies. For the later, it was explicitly mentioned that a capacity of 22 MW was still available relatively to accomplishment of the 150 MW 2010 target. Nonetheless, DGGE failed to mobilise the necessary resources to evaluate the high affluence of PV requests (over 3000), which motivated their annulment. The May 2005 PIP period was suspended for all technologies and system sizes, a situation that is still maintained presently.

It can then be said that the licensing process in the IPP framework is still frozen due to administrative reasons, which is generally pointed out as the most important barrier for PV market deployment in Portugal. The 22 MW available capacity is now expected to be subjected to a tendering process, as has happened with wind (late 2005) and biomass (early 2006). All in all, it is interesting to point out that total requests submitted to DGGE from January 2002 to May 2004 are approximately equal to 130 MVA, which is equivalent to about 160 MWp, taking the same assumptions for the inverter underrating factor. Figure 4 shows the evolution of the number of requests submitted versus those that are actually under licensing. Figure 5 shows this evolution in terms of requested capacity versus capacity under licensing. Figure 4 clearly shows an exponential growth trend of the number of requests in time, even if in capacity terms this does not hold true, nor does it in terms of requests/capacity effectively under licensing.

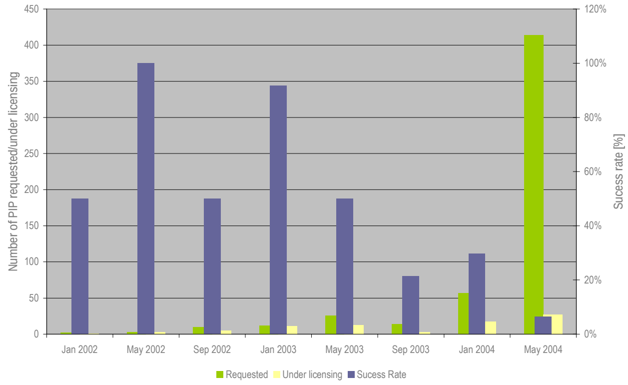

FIGURE 4 – Number of PV PIP requested against PIP actually authorised and under licensing in the IPP framework

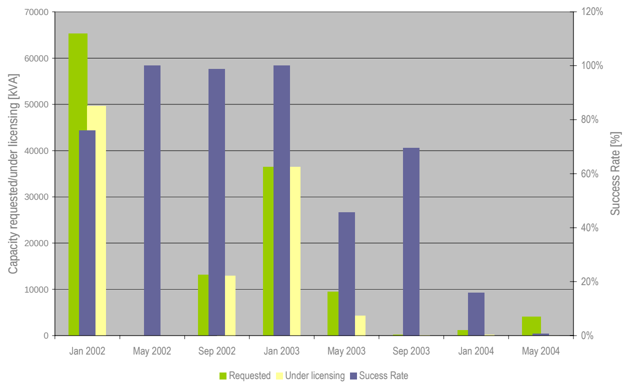

FIGURE 5 – PV capacity requested against capacity actually authorised and under licensing in the IPP framework

Figure 6 shows the distribution of the capacity effectively under licensing by size of system and discriminated relatively to the number of requests and promoters involved. With respect to size, the definitions provided by the Photovoltaic Power Systems Programme of the International Energy Agency are assumed. Accordingly, PV systems with a capacity smaller than 100 kWp are defined as small-scale; medium-scale when capacity lies in the range of 100 kWp to 1 MWp; large-scale between 1 MWp and 10 MWp and very-large scale for systems with capacities higher than 10 MWp.

As can be seen, the capacity under licensing in the small-scale range is negligible (391 kW) when compared with other system's size-categories, although it is in the former range that the higher number of requests has been made – approximately 73% of total requests (totalling 43 requests). It is also interesting to note that there is approximately an average of 1,5 requests per promoter, eventually reflecting the fact that the entities who are making the requests are willing to act in the business of micro-generation. In fact, it can be observed that slightly over half of the requests submitted are undertaken by companies. Also, in the case of individuals submitting requests, it can be observed that in some cases more than one request is submitted per person and/or that apparently there is a family relation between different individual promoters. Moreover, all of the requests submitted by individuals regard 5 kW systems, except 3 requests that relate to smaller capacities.

There are some possible interpretations of these facts with regard to possible market forces. One is directly related to the feed-in tariff structure, as it is possible that bigger than 5 kW systems are being broken down to smaller systems so to benefit from the highest tariff. Another possibility is that individuals are looking at PV systems as a good investment opportunity. This hypothesis may explain why most of the requests relate to systems with the cap capacity for receiving the highest tariff.

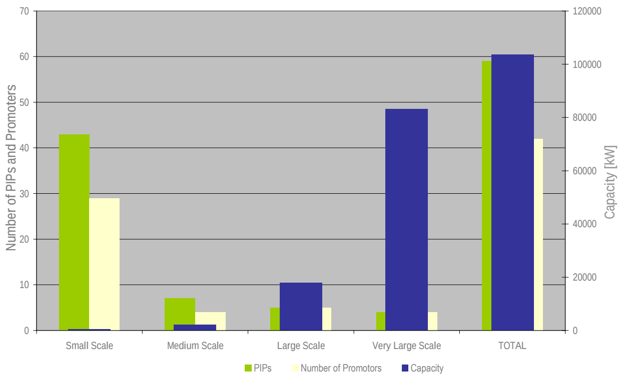

FIGURE 6 – Total PV capacity under licensing discriminated by size of installation and number of PIP and promoters associated

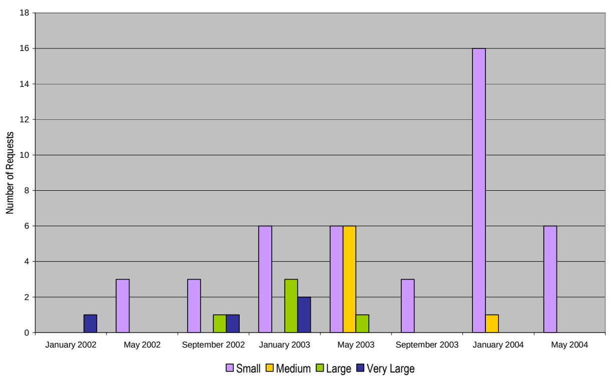

FIGURE 7 – Time evolution of the number of PV PIP under licensing in the small, medium, large and very-large scales

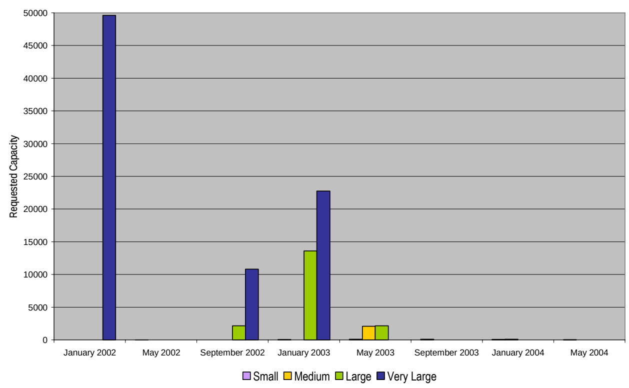

FIGURE 8 – Time evolution of PV capacity under licensing in the small, medium, large and very-large scales

All in all, independently of the type of promoter (company or individual), a striking majority of the small-scale-range requests (80%) relate to system capacities below 5 kWp, as it would be expectable given the feed-in tariff structure.

In the higher capacity scales, the tendency to have one request per promoter accentuates, especially in the large and very-large scales, whereas an average of almost two requests per promoter occurs in the medium-scale range. Also, most of the promoters of these capacity-range systems are companies either acting already in the renewable energy market (i.e. independent power producers) or companies incorporated with the one objective of exploiting the energy infrastructure to be installed. When it comes to these ranges of system dimension, this kind of behaviour is expectable, as it is inline with the way of operation of these entities within the context of renewable energies in Portugal. By other words, the policy framework for RE and its historical evolution, described in section 1, originated a new business segment within the energy sector that has been taking advantage of the different incentives, resulting in diversification of investment in RE technologies over time. To this end, it is important to reinforce that, besides the Moura PV power plant, all other requests from the medium to the very-large scales entered DGGE when this entity suspended requests for wind energy.

In order to better understand how the IPP business is being developed in the case of PV technology, it is adequate to present two of the most significant and internationally disseminated projects.

The most paradigmatic project is definitely the 62 MWp central in Moura, in the south part of Portugal, which will occupy an area of about 114 ha. This project was originally promoted by the Moura Municipality in association with the company Renatura, responsible for the involvement of BP Solar as the technology provider. It is not clear yet if BP Solar will also implement a module assembly factory in the same region, as information is contradictory. Moura is situated in the region of Alentejo and is one of the most economically depressed, coupled with an aged population and with accentuated soil desertification. In this sense, this project has always been considered as a means to invert this situation, having associated a number of other initiatives besides the module assembly factory. The company incorporated for the promotion of the project, AMPER, has been changing its participation structure to include successively partners with the different expertise and resources necessary to make the project a reality. As such, AMPER was detained in 88% by the Moura municipality, 10% by Renatura and 2% by COMOIPREL (a local cooperative promoting the region's development). Negotiations with the Portuguese government, namely regarding the applicable tariffs, implied in late 2005 the entry of BP Solar. Also, AMPER has been actively searching for an energy promoter partner among Iberian utilities and the most relevant IPP companies. In this case then, the initial promotion was not undertaken by an IPP but it is most probable that such a company will takeover the process. As a consequence, it is still not clear yet who will be the entity responsible for the exploitation of the system. Additionally, project finance is being assured by BCP, the biggest private banking institution in Portugal, involving raising funds in the order of 250 million euros. Unlike some other projects, it is not expectable that ownership of the Moura PV power plant will be in the hands of this institution, even though it is also not clear with whom ownership will stay. Again, it is worthwhile stressing that the Moura project is clearly different from other large and very-large scale projects foreseen for Portugal, as other added values rather than those associated with the RE-electricity production are being pursued. In this sense, the Moura project acts as an anchor to several other initiatives promoting regional economic and social development, of which the promotion of RE-related R&D activities offered by BP Solar is worthwhile mentioning.

Another project recently highlighted in international news in the very-large scale is an 11 MW facility in Serpa, which is also located in the region of Alentejo. This power plant, using PV and tracking technology from Powerlight Corporation (USA), has initially been promoted by a Portuguese IPP – Catavento – who has been the entity responsible for submitting the PIP in September 2002. Nonetheless, the project has been made viable by the involvement of GE Energy Financial Services, who is the entity responsible for the project finance operation and who will at the end own the facility. Besides providing the technology, Powerlight will also be responsible for the operation of the PV power plant. Catavento in turn is expected to ensure selected management services. In this case, it is apparent that most of the benefit will stay in hands of foreign entities, with little added-value for the Portuguese economy, while it is not clear if there will be any additional involvement of Portuguese expertise besides that foreseen through Catavento.

All other very-large scale projects under licensing are apparently being promoted by Portuguese IPPs, eventually in the same fashion as the Catavento project, except for ownership, which could in principle stay in the hands of the later, as it is a common way of operating (especially considering the particular entities involved).

The analysis so far has focused on the characterisation of the PV development in Portugal according to two possible classifications of the associated markets: the size of the system and whether or not it is grid-connected. To complete the discussion, it is also important to analyse the capacity under licensing according to the type of application – e.g. ground-mounted or mounted/integrated into buildings. Although definite data, allowing a clear statement, is not available, inference allows concluding that a fairly high majority of the systems will be ground-mounted. To this end, it is relevant to note that DGGE does not request information to promoters about the type of application, so the only possibility is to infer from the requests, namely through the required site plan that has to be provided. As such, it is evident that all of the above small-scale installations will be ground-mounted, except for the one requested for MARL, the wholesale market provisioning the Region of Lisbon, with a capacity of 6 MW to be in principle roof-mounted. In the small scale, there is more difficulty to make this kind of inference but sources inside DGGE refer that most probably the majority of the installations will be ground-mounted. Building-integrated applications appear therefore to be nil among the capacity under licensing. Mention to the new Solar XXI building should be made, the only building in Portugal with a PV façade of about 12 kWp, sited at INETI campus. Solar XXI is a demonstration building that incorporates several advanced energy technologies and management strategies. Although-grid connected, the PV-façade system was not subject to any licensing process and is not therefore benefiting from a feed-in tariff.

Adding up to the discussion, it can be seen that most of the expertise necessary for installing the ground-mounted systems will be originated abroad, as well as all the noble technology components – eventually there will be national provision of some of the BOS components (such as inverters and transformers), of mounting structures and of civil engineering services.

III. CRITICAL OVERVIEW OF PV DEVELOPMENT IN PORTUGAL

3. Critical Overview of PV Development in Portugal

Portugal is a country with a high availability of the solar resource, with annual irradiation in horizontal plane in excess of 1500 kWh/m^2 in mostly all the territory and attaining slightly over 1900 kWh/m^2 in best locations. Figure 9 shows the global irradiation on a horizontal plane in a northern (Bragança), a central (Lisbon) and a southern location (Faro). These high irradiation levels, combined with moderate air temperatures (illustrated for Lisbon in figure 10, with an yearly average temperature of 17,4 ºC), result in high PV energy yields, as illustrated in figure 11, where a 1 kWp, multi-crystalline, optimally-oriented, ground-mounted system is considered.

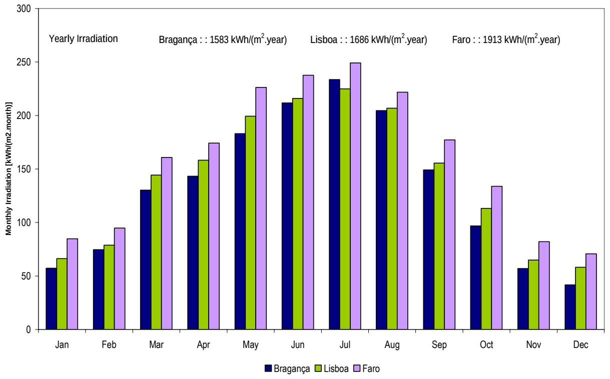

FIGURE 9 – Global Irradiation on a horizontal plane in three different locations in Portugal [Data source: PVSyst 4.0]

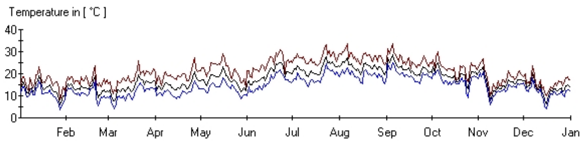

FIGURE 10 – Maximum, minimum and average air temperature in Lisbon [Data Source: EnergyPlus]]

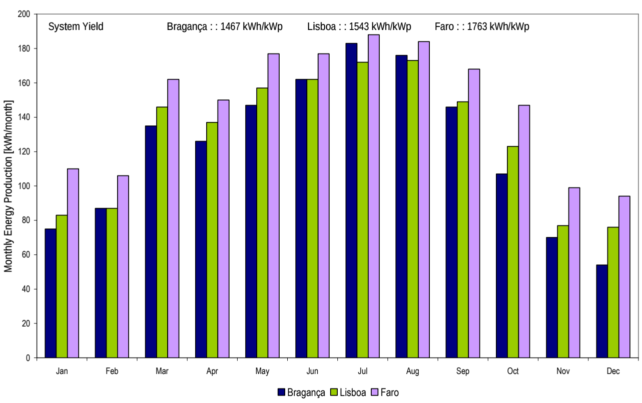

FIGURE 11 – PV-electricity generation in three different Portuguese locations of a 1 kWp, multi-crystalline, optimally oriented system [Data source: PVSyst 4.0]

The Portuguese solar availability and PV energy yield should be put against that of those countries presenting the most developed PV geographical markets. Figure 12 shows PV energy yield in Europe, assuming a performance ratio (PR) of 0,75, which is a typical value for roof-mounted systems.

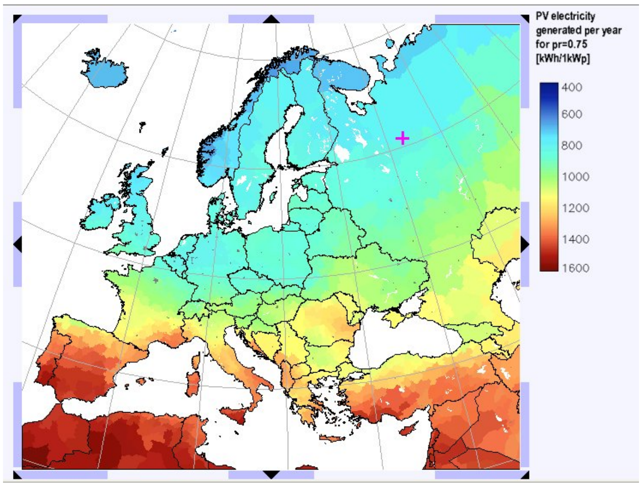

FIGURE 12 – PV-system energy yield in Europe for optimally oriented surfaces and a PR of 0,75 [Source: http://re.jrc.cec.eu.int/pvgis/regionframe.php]

Germany presents annual horizontal irradiation values between 940 and 1200 kWh/m^2 and PV system yields between 800 and 1100 kWh/kWp for optimally-oriented surfaces. This means that on average façades in Portugal (the least attractive surfaces from a PV-electricity production point of view) present a similar PV-system yield as that from best oriented surfaces in Germany. Notwithstanding, at the end of 2004, Germany attained an impressive 794 MW cumulative installed PV capacity, of which 363 MW were installed in 2004, representing a growth of 137% in relation to capacity installed in 2003. In world terms however, Japan is leading the way with total cumulative installed capacity at the end of 2004 of approximately 1.132 MW. Although leading in absolute installed capacity, Japan is surpassed by Germany when it comes to capitation figures – 9,62 in Germany against 8,87 W/person in Japan. Germany and Japan together represent 74% of total installed PV capacity in the International Energy Agency Photovoltaic Power Systems Programme (IEA-PVPS, www.iea-pvps.org) participating countries, a share that should not differ substantially from worldwide figures.

Both Germany and Japan share one common feature in this unquestionable success: the existence of long-term, ambitious and concerted public policies targeted at the same PV market segment – grid-connected applications.

Japan has an overall grid-connected share of 93%, of which almost 100% are decentralised applications, thereby maintaining its orientation towards small and medium scale systems, mostly building-mounted.

Germany in turn, has a penetration of grid-connected systems of 97%. Until the end of 2002, and in the context of IEA-PVPS, Germany reported the grid-connected segment disaggregated by size (i.e. decentralised vs. centralised) and one could clearly see that the decentralised segment was dominating with a share of 92% of the total grid-connected capacity This should not come as a surprise given the well acknowledged PV Programmes such as the 100.000 PV Roofs. From 2003 though, Germany just reports the aggregate grid-connected market, thereby disabling analysis of size-trends directly. If, nevertheless, information about projects under implementation is taken into consideration, it is then clear that also the German market is now being biased to higher capacity projects, in the megawatt range. Moreover, Nordmann (Nordmann, T., 2005) reports that in 2004, roof-mounted systems dominated the German PV market with a share of 70%; ground-mounted systems represented 29% of the installed capacity and BiPV the remaining 1%. It should be noted that the German feed-in tariff has been revised in 2004 withdrawing constraints on size of ground-mounted systems. In fact, the German tariff differentiates between applications and system size, as given in figure 13. Taking into consideration typical energy yields of the different applications, it can be inferred that, from an annual cash-flow point of view, the feed-in tariff is biasing investors towards roof-mounted systems. Nonetheless, if overall investment is also considered, then the costs associated with large-scale ground-mounted systems compensate for the less attractive tariff, thereby biasing the market towards this kind of applications.

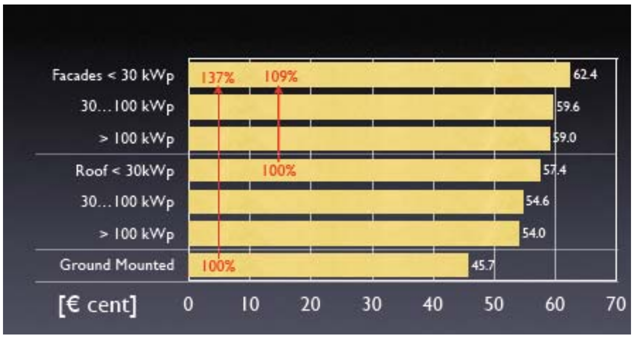

FIGURE 13 – The structure of the German PV feed-in Tariff [Source: Nordmann, 2005]

Also under focus presently is the Spanish market that is already referred to as a potential future world PV-leader, as highlighted in the May/June 2006 issue of the Renewable Energy World Magazine (Stirzaker, M., 2006). In fact, since the Royal-Decree 436 (RD 436) of March 2004, PV technology diffusion has only been slowed down by administrative barriers, which are expected to be mostly withdrawn soon. This diploma revised the overall RE feed-in tariffs, with PV being the main beneficiary. In this revision, the previously existing 5 kWp cap on top feed-in tariffs was withdrawn and put at the 100 kWp level. As such, systems below 100 kWp receive a feed-in tariff of about 42 c€ for 25 years, which is calculated as 575% of average electricity tariff. After that period, the feed-in tariff will be calculated as 460% the average electricity tariff. Also, in November 2005 the Spanish government passed the national renewable energy plan, raising Spain's installed PV target for 2010 from 135 MW to 400 MW. The market triggered as a consequence of RD 436 is presently biased towards large and very large scale systems, which are mainly being built as sets of 100 kWp systems so to take advantage of the most attractive tariff level. It should be noted that for systems with installed capacity higher than 100 kWp the feed-in tariff drops roughly to half. It is also interesting to note that grouping of 100 kWp systems into complexes of 1 to 2 MW is becoming popular and has attached a diverse investment structure. In fact, in these solar allotments, as they are known, the promoter asks private investors, usually locals, to buy at least one PV panel; overall costs, not just for modules but also for feed-in infrastructure, maintenance, security and plant management, are shared by module owners and promoter, who is responsible for operating the allotment and distributing benefits among the investors. This cooperative-like investment structure is known to have taken place elsewhere already – e.g. in Denmark and Germany. Taking in consideration that Spain has, as Portugal, a very attractive solar resource and high PV energy yields, this market is presently perceived by worldwide PV investors as highly attractive. This, anyway, goes inline with the overall investment environment in the RE Spanish market. Corroborating with this statement is the insights of the financial analysts Ernst & Young that at the end of 2005 listed Spain as 'the most attractive renewables market in the world' for investors and, jointly with Germany, the second most attractive PV market (Stirzaker, M., 2006).

It is important to stress that the Spanish policy environment is of particular importance for Portugal, as DL339-C/2001 was clearly inspired in the Spanish framework, namely by the introduction of the 5 kWp cap for the highest tariff. Also, it derives directly from what has been described that the Spanish PV market is far more attractive for investors than the Portuguese, both in terms of tariffs and of timeframe in which the later apply. Finally, it should be mentioned that large and very-large scale projects have licensing periods that range from 9 to 18 months. To this end, one should remember that the Moura PV power plant has already more than 4 years of licensing process, while it took about the same time for starting the construction of the Serpa project.

Figure 13 presents the PV diffusion curves (cumulative capacity) in Japan, Germany, Spain and Portugal from 1992 to 2004.

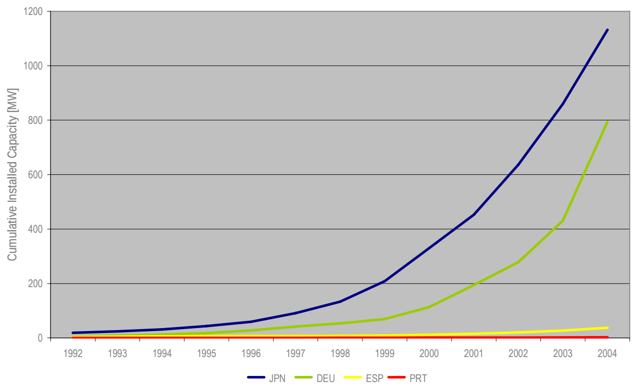

FIGURE 13 – Diffusion curves of PV in Japan (JPN), Germany (DEU), Spain (ESP) and Portugal (PRT) in the period from 1992 to 2004 [Data source: IEA-PVPS Programme, www.iea-pvps.org]

In Portugal, taking advantage of its major solar resource availability for electricity production using PV technologies seems obvious. This should be particularly true in a country presenting a high dependency of imported fossil fuels – from 80% to 90%, depending on hydropower production. The impact of this dependency on economy is considerably strong – for instance, in 2005 the net cost of energy imports represented 3,7% of the GDP. Even if the present oil price trends, which motivated a rise of about 1% of the share of energy imports in GDP from 2004 to 2005, suffer an inversion, the fact is that alternatives are necessary, namely in a context of growing energy consumption especially regarding electricity. This is a general motivation for introducing renewable energies in the fuel mix of developed countries, associated with its environmental performance. Nonetheless, when promoting market deployment of a high-cost energy technology, it is important to look ahead these immediate motivations and try to make this development as inclusive as possible. Discussion on the embedded national added-value of PV-generated electricity is not a trivial matter though, especially in a context of putting against distinct applications of the technology under a globalised technology and investment context. Moreover, this discussion must have underlying coupling with industrial development and R&D policies as embedded value of the PV-electricity generated.

Meanwhile, the governmental efforts towards market deployment of PV technologies in Portugal can be thought of as modest. In fact, despite of the apparently attractive feed-in mechanisms described previously, market deployment has not been consistently triggered, which presently derives directly from barriers generated within the licensing system and eventually from some non-optimised policy targeting (e.g. the 5 kWp cap for eligibility for the highest tariff).
The administrative barriers can be easily accessed when looking at the success rate of the PIP periods from 2002 to 2004 – 15% when referring to the number of requests submitted, even if in terms of capacity an approval success rate of 80% has been attended. Further evidence of administrative management difficulties are given by the success rate of the positively differentiated system sizes. In fact, although below 5 kWp systems are benefited against other system sizes, only 8,6% of the requests that entered the system were attended, representing 7,9% of the capacity requested. This low success rate can hardly be attributed to lack of grid-interconnection capacity, as the impact of these systems on the short-circuit current of the LV-grid branches and equipments is very low. As such, instead of about 2 MW of potentially installed capacity in the very-small range in the short term, only about 390 kW will be realised (assuming that all systems being licensed will in fact be installed). It then follows that total cumulative installed capacity in Portugal would almost duplicate if all the requests for below 5 kWp systems had been made viable. But clearly, the authorisation procedure is inadequate and leads to high administrative costs, as roughly the procedure workload involved is similar to that of higher capacity projects.

Most critically, the barriers introduced by the official suspension of PIP periods since May 2005 (as seen, in practice since September 2004) brought the market to a stall, as the PC framework is not considered at all to be attractive, especially for companies used to operate within the IPP framework. Eventually, the PC framework would be interesting for those aiming at operating in micro-generation niche-markets (e.g. new urban mixed-use developments or property developments for tourism purposes, namely those aimed at the Golf market), but not with a 50% cap on the electricity sold to the grid and with a much lesser attractive feed-in tariff fully guaranteed in a shorter period. In fact, some inconsistency exists in these matters. On one hand, within the IPP framework, very small installations are benefited in relation to higher capacities, even within the LV grid range, clearly therefore putting the promotion effort on the lower part of the micro-generation scale. On the other hand, and within a micro-generation context (i.e. the PC framework), PV technology is boldly promoted relatively to other micro-generation technologies (except for fuel cells) but is clearly in disadvantage when compared to the IPP framework in any capacity range.

Summing up to these administrative and policy barriers, in the small scale there is additionally a problem of grid-connection authorisation procedure framework. As noted previously, DL 312/2001 exempts LV grid-connected systems to follow the licensing procedures that have to be observed by systems connected to higher voltage networks.

Nonetheless, there is no specification of what this alternative framework should be, which pushes small-scale PV systems' promoters to follow anyway the regular RE licensing procedure. Meanwhile, in the PC framework a simplified procedure for the interconnection of small-scale systems is established but it is only applicable to the aforementioned framework. It seems therefore that, in what regards PV technology, harmonisation of the IPP and PC frameworks would in principle withdraw major barriers to market deployment in the small-scale range. All in all, the system is perceived by eventually interested actors as lacking transparency, a situation motivated by the apparent policy confusion environment.

In higher than small-system scale, it is apparent that the Portuguese market is operating according to a known pattern, which allows inferring that a stock of knowledge has been stored following mechanisms of learning-by-using (even if essentially focused on the project development and implementation methods pertaining to the technology in question, more than in the use of the technology by itself). Eventually in the case of PV technology, and with the exception of the Moura power plant, actors that were used to develop mini-hydro plants and/or wind farms, were not yet familiar with the associated processes and presented some initial resistance. This lack of confidence, originated in the lack of experience, was surmounted when requests for wind farms interconnection were suspended, after which companies started submitting requests for PV plants in the medium, large and very large scale (see figures 7 and 8). It is important also to note that the promoters of these plants are mostly well-known IPP Portuguese companies, most of them associates of the Portuguese Association of Independent Power Producers based on Renewable Energies (APREN), which corrugates the hypothesis of capitalization on previous learning processes and somehow justifies the option for higher capacities. It can then be concluded that investment in medium to very-large scale PV systems were seen by IPP companies as a moderate to high risk operation, especially when the wind investment alternative was a reality, a perception that was altered as wind investment opportunities were made more difficult.

This overall context can also in part explain the long licensing processes that are still currently running. On one hand, it is true that there may be some delays related to the administrative process by itself. But on the other hand it is apparent that a significant part of the delay is associated both with lack of experience in implementing PV projects and with difficulties in ensuring project financial resources. To this end it should be noted that, although it is not a formal requirement, the establishment license is emitted when there is little risk of unsuccessful project implementation due to inadequate project finance. Therefore, all projects with an establishment license emitted, expected to total 90 MW until the end of year 2006, are intended to be implemented until 2010, which in turn indicates that at least a capacity target success rate of 60% may be expected with limited uncertainty. However, this success rate depends strongly on the realisation of the Moura PV power plant; if this facility fails then roughly only 19% of the goal will be realised.

But, besides the intrinsic value of RE electricity production, what value has the realisation of this target for the Portuguese economy in general and for the sustainability of market deployment of PV in Portugal, in particular?

As can be seen from section 2, present market development in Portugal is dominated by large and very-large scale systems, representing almost 98% of the capacity under licensing. As introduced previously, the high-capacity investment trend is in fact identical to what is verified in the rest of Europe, namely in Germany and in Spain, as described. Overall, the main justifications for this trend are the feed-in tariff structures in these countries, coupled with present high cost of PV materials following the shortness of silicon. This in turn pressures the market into large, ground-mounted systems for its high energy yields (eventually boosted by tracking configurations), easiness of installation and for the volume discounts attained by large-quantity acquisition of panels.

Nonetheless, it is worthwhile reflecting whether or not this type of development is advisable within a broader perspective of inclusive development.
In countries like Germany and Spain, these market segments promote valorisation of local competencies at the most different levels, from applied R&D, to industry, to engineering services and specialised work. Germany and Spain are in fact European PV industry leaders: in 2004, the German company Q-Cells led the European PV production market attaining an output of 75 MW, while the Spanish company Isofotón ranked second with an output PV capacity of 53,3 MW. Also in terms of R&D, both countries present high activity in the most diverse areas, although data on researchers' employment is not readily available.

In Portugal, in turn, there is no real PV industry except for PV module assembly by big multinational companies (e.g. Shell Solar and eventually BP Solar) and about a dozen of distributors and installers of PV panels and BOS components from the EU, USA and Japan. In terms of R&D activities, about 6 institutions are currently active both in fundamental and applied research. Special mention should be made to the Laboratory of Photovoltaic Applications and Semiconductors of the Faculty of Science of the University of Lisbon, who has just signed a 0,6 M€ R&D contract with BP Solar in the field of EZ-ribbon growth of wafers. Also, the opportunities for the development of PV nano-technologies research activities in Portugal is currently under study in the framework of a master thesis at Instituto Superior Técnico in Lisbon.

As seen previously, there is a high probability that PV projects under licensing in Portugal will be realised not only with technology developed elsewhere, but also with foreign competencies regarding the noblest activities, which are also the ones with a higher added-value. In any case, the type of expertise associated with installation and operation of large and very-large ground-mounted systems is somehow limited, being system design and project a function easy to standardise, while the necessary installation skills are not demanding from a knowledge point-of-view (e.g. it requires electricity services with competencies in DC circuits and an engineering supervision function). Metalworking, provisioning the support structures, is another associated activity with a limited added-value.

Summing up to this, and although the comment may generally apply to all countries with significant feed-in tariff incentives, it is important to bear in mind that the type of market that insipiently exists in Portugal will only be a reality while the feed-in tariff exists. And there is also evidence that already with the conditions introduced by DL33-A/2005, investment in PV power plants in Portugal is no longer attractive for foreign investors. For instance, in the case of the Serpa power plant, licensing is made under the context of DL339-C/2001, where, as said previously, there is no time limit in which the feed-in tariff applies. According to the head of GE Energy Financial Services in declarations to the media, this is the only way in which is the attractiveness of investment is made possible, affirming that under the framework of DL33-A/2005 Portugal is no longer within the portfolio of future investment of GE. Again, Spain is, in this sense, the most preferred option.

It can then be said that the present trajectory of market deployment of PV in Portugal seems unsustainable, both in terms of market sustainability and of the associated economic value. In other words, Portugal will be valorising technology developed abroad, with most of the benefit staying in the countries of origin, both in economic terms and in terms of human capital valorisation. It is to this point important to note that market deployment of wind technology followed until recently a very similar path in what regards valorisation of Portuguese competencies in that accomplishment. The inadequacy of this path has been recognised by the Portuguese government, who tried to invert the situation by launching a tendering process for the interconnection capacity still available, coupled with an industrial development component. If Portugal does not want to resemble developing countries in their use of valuable energy resources in the future, it is necessary now to adopt a strong medium to long term strategy, not only with respect to market deployment but also in the spheres of industry and R&D, so to foster the development of a national PV innovation system. In an era where the knowledge-economy paradigm is prevailing, the focus should be on how to take advantage of domestic knowledge and expertise while producing self-sustained effects in terms of market deployment by focusing the target of deployment policies. As a corollary, the objective should be to let the market learn how to use the technology, while creating the conditions for developing and/or strengthening industry and R&D competencies. By doing so, it should be expected that every domestic innovation being introduced in the market in the future will in principle suffer from less adoption resistance.

In the short and medium term, which should then be the focus?

On one hand, it is evident that the rate of diffusion of PV technology will necessarily be slower if focus is put in the small-scale than it will be in higher-capacity applications. Nonetheless, higher diffusion rates do not necessarily imply higher benefits for Portuguese society, especially if the aim of developing a national PV innovation system prevails. Also, global competition from other markets such as the Spanish and German put a high pressure on the incentives format to be adopted if attractiveness of Portuguese large and very-large scale PV market among international investors is to be pursued.

On the other hand, as said previously, in Portugal market deployment of PV in buildings is nil or close to it. However, a recent empirical research targeted at the Portuguese construction industry points to the conclusion that this is the market that should be the most promising, in terms of: i) potential embedment of national competencies in market-deployment related activities; ii) in feed-back loops to the industrial development of PV-building and other urban structures products; iii) and in terms of eventual spillovers to R&D activities, namely in product development related applied research. The later effects confirm the premise that users can in fact act as sources of innovation. In this research, the potential for PV adoption in buildings and other urban structures has been accessed mostly among architects and building promoters and/or property developers, namely in terms of perceived values and barriers. Some engineering services companies have in the process been assessed too, although to a lesser extent. Also important, the assessment followed a participatory methodology, meaning that education, training and consultancy and project engineering services were provided as needed. The main conclusions are that, as long as the community assessed becomes educated about PV, there is a fairly high willingness to adopt this technology in the building process and that, once adoption occurs, the willingness to keep using the technology in further projects is maintained. This is certainly true among architects but also among building promoters and property developers. For the later, the main value is the potential to positively differentiate in a very competitive environment, in which green design and building are now starting to be considered as quality factors. Evidence of this can already be found in property advertisement in several communication media, namely in well-known newspapers, as illustrated in figure 14.

FIGURE 14 – Portuguese newspaper advertisement in which the main slogan is targeted at the bioclimatic characteristics of the property being sold

Of course that most of the willingness observed occurs, on one hand, in medium to high value segments of the building construction market. On the other hand, the willingness cannot be dissociated from the presence of feed-in tariff incentives. In fact, promoters and developers are considering and opened to diverse exploitation strategies, either passing on the whole benefit to the end user (as well as the cost), or investing themselves in the energy infrastructure, thereby turning them in a kind of IPP. In the later case, end-users just retain other than electricity values. This emerging PV market therefore represents a completely different investment structure in PV technology, mainly supported by the building industry and/or the end user (both residential and commercial). Property development in Portugal is presently highly attached to resorts, namely attached to the Golf Market. In the empirical research conducted, contact with three of those developments occurred, one of which was studied in depth. In all of the three projects PV is under consideration for integration within the to-build fabrics, either cottages, hotel buildings, parking shelters, to mention but a few. In these developments, the aggregate potential for integration of PV in the diverse buildings can be of the order of 1 MW. Attention should however be paid to the fact that, among the whole sample of projects observed in the empirical research, some have been discontinued as promoters felt the BiPV projects as highly risky. Some projects are under development and intended to be implemented – as long as the licensing administrative procedure opens up for new projects. These projects include integration into façades and roofs and represent several different building typologies – from tourism to residential projects, passing through office buildings. It is important to stress that all the creative and engineering consulting and services are performed by Portuguese actors. These are the functions that present high added-value for the Portuguese economy. Also, it is worthwhile mentioning that once adoption takes place, the PV-related expertise gained is used both within and outside Portuguese boundaries. In fact, at least three of the observations refer to projects that were to be developed abroad (one in Estonia, one in Spain and one in Angola), were originated in architects and engineering services companies, and represent undoubtedly a service export potential. This is especially true in the case of architects as it is common practice to apply to international competitions.

In any case, building promoters and property developers attach to PV an overall potential value of realising their investment quicker and with better returns by turning their products more attractive and with a higher status. This overall value is therefore a composition, to a greater or lesser extent, of objective and subjective values. The objective values are essentially connected with the utilitarian functions the PV materials can perform within buildings, while the subjective values are related to the embedded environmental excellence (at least as it is perceived by all actors involved in the process, including the end-user), the accompanying status that it carries and the aesthetic value. With respect to the utilitarian functions, of course that at the root is the generation of electricity as the basic function of a PV system. One should then bear in mind that the use of PV in buildings was first motivated by the evidence that such approach withdraws the need for dedicated land resources, therefore providing an effective means to reduce (avoid) cost(s) at the system level. This preliminary understanding has evolved to a wider view of the additional functional role that a PV system can potentially perform when integrated into a given building skin – PV can be part of the watertight and/or thermal insulation layers, thereby displacing other building materials; can be part of the daylighting and/or shading systems; can be an active element in a given bioclimatic strategy.

Architects play in the adoption process a fundamental role. Architectural integration of PV materials is essential in order to optimise the combination of the utilitarian and aesthetical attributes, so to maximise the overall value of the PV system for the building promoter and end-user. To this end, it is important to refer that Reijenga (2002), defines five levels of increasing architectural integration: applied invisibly (e.g. roof-mounted); added to the overall architectural design; adding to the architectural image; determining the architectural image; and leading to new architectural concepts. Each level corresponds to an increased affirmation of the PV material in the overall architectural concept of the building. It goes without saying that the optimisation of the binomial function/form can correspond to a situation where the system is not optimised for its energy output, as a conventional engineering approach could suggest. In this sense, for each object being designed there will be such balanced combination of form and function, subjected to the constraints of the design process, which will deliver a high-value product. To this end, architects perform therefore a transfer function both to developers and end-users; their aim will be that of optimising the value of PV for these actors, while retaining their own set of perceived PV values. This added-value approach is illustrated in figure 15, where a constant future conventional energy price is assumed, even if this trend is most surely not realistic given the current trends in oil prices.

From a policy-making point of view, this figure illustrates the potential for providing more rational incentives to those applications in which the investor internalises other values than just that associated with electricity-selling revenue. This in turn will revert to the society as a benefit, as less financial resources are being deployed with a higher value, i.e., by knowing the full integrated value of PV in a region or country the public costs to promote PV are minimised (López-Polo, A., Rodrigues, M.J., Herig, C. and Suna, D., 2005)
.
It derives directly that the establishment of such a framework of added values is also necessary from a government point of view so to allow for value comparison among distinct PV applications (e.g. ground-mounted vs. building-integrated). It should then be clear that the value of PV-electricity arises from a cost-benefit analysis and that policy efforts should be focused on applications in which the benefits are higher than the costs. Such a framework will be presented in section 4.

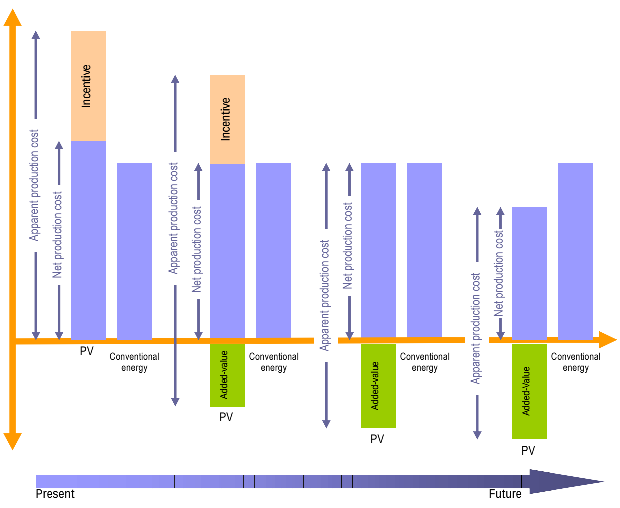

FIGURE 15 – The added-value effect on the apparent production cost of PV-electricity and its competitiveness with conventional production means [Adapted from (Watt, M., 2001)]

Contributing to this overall favourable environment regarding green building at general is certainly the new energy performance building regulation framework. The European Directive 2002/91/EC of the 16th of December 2002, relative to the energy performance of buildings, set the need for a revision of the existing energy building regulations and the establishment of a Building Energy Certificate System, which occurred in April 2006. In Portugal there are two distinct building regulation diplomas – RCCTE, which essentially regulates the energy performance of residential buildings and small service buildings without active acclimatisation systems; and RSECE, oriented towards service buildings generally. These regulation diplomas set the minimum energy performance standards both in terms of the building envelope and in terms of the conditioning equipments using specific and overall energy performance indicators. In addition, a novelty introduced by the revised RCCTE is the obligation to install solar thermal panels to provide for domestic hot water in residential buildings. To some extent, this measure constitutes an enforcement of the Programme Solar Hot Water for Portugal, which sets up a goal of 1.000.000 m^2 of solar thermal panels to be installed until 2010 in residential and service buildings and in industrial applications. Although apparently not related to a favourable environment for PV in buildings, there are two factors that are impacting positively. The first is introduced by the regulation itself, as the obligation to install solar thermal technologies has the exception that other RE technologies may be installed instead, subjected to the constraint of equivalent installed power. The other factor relates to the apparent confusion that still exists among actors in the building sector regarding the differences between solar thermal and solar photovoltaic technologies. This, coupled with existing incentives for the later (which has not a mirror in the case of solar thermal), is biasing actors towards PV.

With respect to RSECE, the use of more efficient technologies is fomented, whereas all clean energy options with payback time periods (with calculus method defined in the regulation document) less than 8 years have to be implemented. To this end, the regulation document imposes a set of technologies that are of mandatory consideration in new buildings and big refurbishments: solar thermal systems for hot water production; systems valorising biomass or residues; geothermal-based systems; autonomous systems, combining different RE technologies, in places far away from the national electric grid. This set of technologies may be revised on a yearly basis, which may constitute an opportunity for explicitly including PV in this portfolio.
In any case, the Certification System gives an incentive to use best available technologies as a means to be ranked high in the performance scale, which eventually will be concurrent with a competitive advantage in the fierce environment the real estate market is presently facing.

The discussion so far has focused on the market potential for PV in Portuguese buildings and other urban structures, putting in evidence the potential embedment of Portuguese expertise in high added-value functions, as well as the potential for investment originated in two of the most important sectors in Portugal – the construction industry and the tourism sector. Also put in evidence was the potential for a more rational allocation of public budget in the pursuance of market deployment of PV technologies.

Another initiative launched within the empirical research mentioned was an international design competition – Lisbon Ideas Challenge: Urban Design with Photovoltaics – under the auspices of the Photovoltaic Power Systems Programme of the International Energy Agency and with sponsorship from PME Investimentos (www.lisbonideaschallenge.com.pt). This competition asked for new ideas for PV in the built environment with the potential to be mass-diffused and was fundamentally aimed at young architects and designers (e.g. under and post-graduated students and professionals with up to five years experience). In Portugal the activity was accompanied by dedicated presentations of the competition at the most important Portuguese Universities, with an education and training component. In what concerns Portugal, this strategy was mainly aimed at a preliminary assessment of the potential for entrepreneurship among actors that are usually “passive” users of the technology, reflecting a potential for generation of new products. The competition is presently in the evaluation phase, with confidentiality issues attached, and as such it is still difficult to draw final conclusions. Nonetheless, several indicators are relevant. Firstly, 132 expressions of interest were submitted from over 30 countries, representative of all continents. The USA dominated with 24 expressions of interest, closely followed by Portugal with 20 expressions of interest. Of these expressions of interest, 22 projects were actually submitted, dominated by Portuguese participants with six entries. From the USA, in turn, only two projects were actually submitted. Except for one, the Portuguese projects were submitted by teams of young architects and designers who presented innovative ideas regarding urban structures that actually have a fairly high potential of replication. Even if it is true that the Portuguese efforts for the promotion of LIC were stronger than those in other countries, namely because of the university-based information strategy, it is also true that the response from Portuguese young designers and architects exceed all initial expectations, especially because little or no previous contact with the technology had taken place. As such, even if this is a restricted conclusion, there is apparently a potential for PV-based urban-scale product development in Portugal.

Another evidence of this potential, that also illustrates the potential for feed-back loops into applied product-development research, is given by a project that arose from the empirical research in which a conceptual exercise, named “Casa-não-Casa”, was performed to be presented at the Lisbon Design Biennale, Experimenta Design 2005 (EXD05). In the context of EXD05, 12 Portuguese architects were invited to present proposals on houses that reflect today’s needs and concerns, resorting to new technologies, using recycled materials and factoring on sustainable development.

The Casa-não-Casa project combines the traditional architectural style of the Mediterranean patio houses with the use of innovative photovoltaic cladding material on its façades. The Casa-não-Casa concept incorporates the idea that the façade should be a reflection of the surroundings in order to create a mimetic relation with the ambient. From this conception, the idea of cladding the house with a mirroring material arose. Further, the cladding material should follow the form of a pyramid resembling spikes, an ancient concept traditionally used in Portuguese architecture, of which “Casa dos Bicos” is a paradigmatic and extreme example. Finally, the cladding material should also be energy-active, thereby arriving to the photovoltaic concept. Combining all these constraints resulted in a conceptual PV cladding material that suffered a preliminary optimisation process so to optimally orient the PV surfaces into the sun, even if installed on a façade. Views of the maquette of the Casa-não-Casa are shown in figure 16.

The repercussions associated with this project are somehow impressive. After EXD05, first expression of interest in the project came from the Dutch MARK magazine, a quarterly about architecture, associated to the Frame magazine (www.framemag.com). The project was published in issue number 2, spring 2006. Furthermore, the project was submitted to the annual design competition Next Generation 2006, promoted by the New-York-based magazine Metropolis, and was one of the eleven projects distinguished (http://www.metropolismag.com/cda/story.php?artid=1936). As a consequence, the project deserved several articles in the most diverse national and international media, of which it is worthwhile highlight the article at the US magazine Business Week (http://images.businessweek.com/ss/06/07/nextgen_design/index_01.htm?chan=innovation_architecture_architecture).

In addition, the PV-cladding product is being developed in the context of a master thesis in Engineering Design from Instituto Superior Técnico, Technical University of Lisbon, within an industrial design approach. It is foreseen that a project will be submitted to applied research funds with the aim of developing a product prototype.

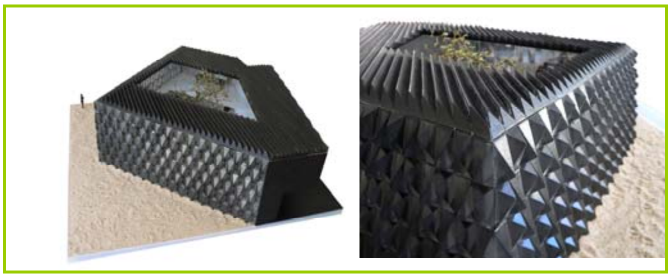

FIGURE 16 – Maquette of Casa-não-Casa presented at Experimenta Design 2005. The pyramidal, spike-alike, cladding elements incorporate PV materials [Courtesy of Pedro Campos Costa Arquitectos]

Concluding, presently the Portuguese PV market is at a stall as a consequence of policy-originated barriers. This however, constitutes an opportunity for setting up a stronger strategic orientation, as several governmental actions are at quest so to unblock the situation, namely:

- there is the need to either re-open the PIP call period or to create a new authorisation procedure framework, whether combined or not with the previous one. Inadequacy of the present format for small-scale, LV grid-connected systems has been made clear previously.
- clarification is necessary of whether or not the rectified DL 33-A/2005 is in force. This also constitutes an opportunity for revising the structure of the feed-in tariff.
- There is inconsistency between the IPP and PC frameworks that is affecting exclusively PV, as this is the only energy technology positively differentiated in both. With present conditions, it is not expected that any PV system will be licensed within the PC framework, thereby loosing some unquestionable associated benefits, namely lower administrative costs.
- clarification on whether or not the present 2010 target will be revised is necessary, so to provide for a more transparent environment for the actors involved in market deployment activities. This eventual revision also opens up room for discussion on whether or not it is advisable to follow a capacity-cap policy, at least with no pre-determined prospective evolution, as it carries associated negative market stop-and-go effects. This is already considered one of the most important barriers hindering PV industry development.

Besides technology-caps, also important is to define which strategic orientations should be followed so to maximise overall present and future value of PV-electricity to the Portuguese society, including its contribution to fostering a PV innovation system. This brings us to the discussion of relative value of different PV applications.

The market for large and very-large scale ground-mounted systems can presently be considered a global one, and as such Portugal should be competing with other countries in the quest for interested developers and for financial resources. It follows directly that market deployment incentives should be put against those from competing countries, notably Spain. This country is presently the strongest competitor when it comes to attractiveness of investment, especially taking into consideration the geographical and language proximity between the two countries, as well as shared cultural roots, barriers that usually constrain global RE investors. With Spain leading the global-investment race, Portuguese investors, in particular IPP companies, are expected to be the main interested parties in the national large and very-large scale ground-mounted PV markets. Attention should be paid however to the fact that presently there is an apparent mild interest of these investors in the context of DL 33-A/2005, considering its declaration of rectification of 15th of April 2005. For instance, the Portuguese national utility EDP, who invests in PV market through its RE company ENERNOVA, says that under the rectified DL 33-A/2005, PV projects do not have attached an interesting financial return.

Moreover, it is apparent that the added-value for the Portuguese economy that can be brought by large and very-large scale systems has varying degrees of importance depending on the structure of investment. If, however, global trends of investment in RE market are followed by Portuguese investors, it seems obvious that this value should be mostly restricted to that of the electricity generated and of the associated reduction of CO_2 emissions. Other factors such as the potential for embedment of national competencies, industrial development and learning effects do not impact significantly on the overall PV-electricity value. This situation could eventually be at least partially reverted with a tendering system asking for counterparts from the tenders, as has been done with the wind market in Portugal. Nonetheless, it must be clear that investors-willingness may freeze as it is already not high.

Small and medium-scale building-mounted/integrated systems in turn are expected to be the type of applications that deliver the highest PV-electricity value for the Portuguese society. Not only are the aforementioned factors contributing intrinsically to this higher value, but also the potential to incrementally reduce the amount of public investment for the same deployment rate, given the building-related added-values at the several user levels (e.g. end-user, building promoter, architect). Moreover, private investment barriers may somehow be overcome as investors are expected to be originated in non-traditional sectors, such as construction and tourism, as well as in building end-users.

Moreover, there is evidence that, as long as building-sector actors become educated about PV and there is availability of specialised engineering services, there is a fairly high willingness to adopt this technology in the building process and that, once adoption occurs, the willingness to keep using the technology in further projects is maintained. This in turn gives good prospects for the sustained development of the building (and other urban structures) PV market and eventually for its self-sufficiency in a well-designed regulatory framework.

When put against each other, large and very-large ground-mounted systems have the potential for considerably higher diffusion rates than small and medium scale building-mounted systems. When compared over time, however, the potential for longer diffusion paths, and therefore for long-term market sustainability, of small and medium scale building-mounted systems is far more reaching. This time sustainability can be measured in terms of evolution of surface area available – while it is expectable that the available land for large and very-large scale ground-mounted systems will attain saturation (e.g. because of competition with other energy and non-energy land uses), the area available in building surfaces increases as new buildings are built and the existing building stock is renovated.

This longer diffusion process may be beneficial in Portugal as it gives more time for the establishment of a Portuguese PV-based innovation system – while the market learns how to use the technology, competences are meanwhile being created in the industry and R&D spheres.

IV. POLICY RECOMMENDATIONS

4. Policy Recommendations

4.1. Introduction

As an introductory note, it is important to stress that the present recommendation is exclusively aimed at market deployment policies and associated instruments. In a broader perspective of a Portuguese National Plan for Photovoltaic Technology, the innovation system spheres of industry and R&D must also be taken into consideration and be target of dedicated recommendations. The present recommendation nonetheless takes these spheres into consideration in what regards effects resulting from feed-back loops originated in the users' sphere (i.e. market).

4.1.1 Recommendation Structure

Bearing in mind all the considerations made in the section 3, the present recommendation is strongly rooted on fostering the market for PV in Portuguese buildings and other urban structures, even if not excluding ground-mounted systems.

In the building segment, the underlying vision is that experience improves performance, maximises value, reduces resistance to the adoption of new concepts, and that these are of paramount importance especially in a sector that is generally considered conservative, is project-based and thereby involves a fairly complex network of actors and of processes. As such, learning processes are more complex and need continuous nurturing in its initial stages of development so that success is attainable. In this sense, public policies should be aimed at:

- eliminating the licensing and authorisation procedure barriers, as these are the main reasons why some of the observed building-related PV projects, briefly mentioned in the previous section, were perceived as highly risky, i.e., eventually compromising the overall project timings;
- revising the structure of the feed-in tariff so to create the same playing level field for the different building surfaces that deliver different sets of values, cross-referenced with system size considerations;
- deciding on the evolution and applicability of capacity caps;
- implementing a monitoring system that will allow for informed updating of policy framework.

These may be considered core policy actions. However, these cannot be decoupled from relevant accompanying measures, in particular:

- develop a continuous communication strategy regarding activities of awareness and dissemination, namely to overcome barriers of lack of information and of biased perceptions. Several stakeholders should be targeted, from private to public bodies, from the building to the financial sectors;
- create the conditions for the provision of training and certification of installers;
- create the conditions for the provision of training of architects, engineers and eventually of the financing and insurance sectors;
- create the conditions for accreditation of training courses;
- establish a framework for product certification.

Moreover, anticipation and monitoring of other barriers is necessary, as well as the development of a frame of action to overcome them. Most important barriers that may arise and can already be anticipated are:

- barriers related to building safety issues, both of constructional and electrical nature;
- barriers related to authorisation procedures at local level, in particular those related to building permits;
- barriers related to local urban planning instruments (e.g. master plan), namely restrictions related to visibility of PV systems in historic areas;
- barriers related to insurance of PV systems within the context of other building-related insurance packs;
- barriers related to financing of PV systems within the context of housing long-term bank loans.

Most of the required framework of action to deal with these prospective barriers should then be of normalisation and/or regulatory nature. To this end it is important to mention that a Portuguese working group has been established recently at the Portuguese Electrotechnical Institute to follow and participate in PV-related standardisation activities by CENELEC (Comité Européen de Normalisation Electrotechnique) and IEC (International Electrotechnical Commission). These activities should be target of public support too.

The present recommendation is essentially aimed at the core policy actions: technology capacity caps; feed-in tariff structure; licensing framework (e.g. IPP and PC) and authorisation procedure; and monitoring system. Further developments should be made in what regards accompanying measures and its detailed establishment (e.g. development of the communication strategy and of training and accreditation programmes for installers). Moreover, the recommendation is split into two distinct timeframes – from 2006 to 2008 and from 2008 on.

4.1.2 Considerations on Building Applications and System Sizes

PV systems in buildings can be of several sizes, even if it is expectable that the small-scale will prevail. Medium and large-scale building-mounted PV systems are nevertheless also observable in other countries. In the large scale, a paradigmatic example is that given by the Herne Academy in Germany, shown in figure 17. This building has a 1 MWp PV installed capacity, mostly realised in the roof-integrated, overhead glazing sub-system. In the medium scale, a good example is provided by the 290 kWp PV awning shading system in the Zurich Airport, shown in figure 18.

When it comes to building typology, it is expectable that industrial and large commercial and public buildings offer the opportunity to install medium to large scale roof-mounted systems, an option that should be fully incorporated in the building-targeting philosophy, as it consubstantiates the type of applications that incorporate the first steps in the learning process, given the historical evolution of the Portuguese PV market. In these system-size ranges therefore the existing licensing framework and authorisation procedure should be maintained, even if an overall effort to reduce licensing times generally applies to all RE. In the small-scale however, there is the need for revising the existing frameworks (IPP and PC) towards harmonisation and fulfilment of existing lacks.

FIGURE 17 – The Herne Academy in Germany, with a 1 MWp PV installed capacity [Source: IEA-PVPS, www.iea-pvps.org]

FIGURE 18 – The PV awning shading system at Zurich Airport, with an installed capacity of 290 kWp [Source: Arge Zayetta]

In addition, and in order to create the same playing level field for façade-integration and roof-mounted/integrated PV applications, the tariff should be revised to differentiate by application and system size. Application-differentiation would allow a much higher involvement of the creative industries in Portugal (e.g. architecture, engineering and design) as resistance from building promoters would be alleviated as a consequence of the same level of economic return. Further societal-value considerations of this differentiation are discussed in section 4.1.3.

With respect to system size, consideration on whether or not the 5 kWp cap should be maintained is also important. In fact, if PV in buildings is to follow a typical technology diffusion pattern, it will start in projects in the medium to high value market segments, both in residential and service buildings. In the first, it may be expectable that a 5 kWp capacity will be adequate but only in the case of dwellings; in all other building typologies this high feed-in tariff capacity cap will be prejudicial if the same level of attractiveness is to be motivated and the diffusion process enhanced. It follows that this cap should be withdrawn.

4.1.3 PV-electricity Societal Value: Framework of Analysis

As it is the aim of this paper to recommend focus on projects with additional values besides that of delivering PV-electricity into the Portuguese national electrical grid, a comprehensive framework of analysis is then necessary so to enable comparison of the different applications and to fine tune policy instruments.

Departing from the framework developed by Oliveira (Oliveira, A., 2006), and combining with work being developed at the project Task 10 – Urban Scale PV Systems – of the IEA-PVPS Programme, a new framework has been developed and is presented in table 1. This framework represents the values that may be embedded in the generated PV-electricity, determining its overall impact on the Portuguese society. Detailed description of this matrix is given in section 4.5.2.

The developed framework has attached a set of indicators for each attribute (or value) and can be used at project level as well as aggregately. From a government point of view, the overall value of PV-electricity for the Portuguese society must arise from an optimum between social, economic and environmental values. Obviously that these are not mutually exclusive, as social, economic and environmental values permeate each other. For instance, although avoided CO_2 emissions is listed under environmental performance, the fact is that the impact is of social as well as of economic nature, the later as a result of ratification of the Kyoto protocol. Figure 19 illustrates the evolution of market value of CO_2 in the later year. Another important comment is that the use of this framework for comparative purposes implies upfront establishment of relative importance between attributes and among indicators in each attribute, which is essentially a political decision. This recommendation will not therefore permeate these edges.

Adding to the discussion on the type of projects that should be fostered, in projects such as the one being developed in Serpa it can easily be inferred that only a few indicators are applicable, such as the environmental, in some of the indicators listed under security of supply and eventually in social perception.

Also interesting is the discussion about social perception and education. Large-scale PV systems have an important visual impact over extensive land areas that may generate social resistance to the technology, especially coming from local populations, similarly to what happens with wind energy to some extent. On the other hand, if a policy of architectural integration is followed, than building PV systems can actually convey an attractive sustainability message, reducing social resistance, while raising awareness.

This is especially true in visible, façade systems, being actually one of the most important differentiating attributes of this kind of applications. Building typologies are not independent of the potential impact on public awareness and education. Buildings that are public in nature, namely those owned by public bodies, may set the example and more easily embed active means of advertising the system. Also, in schools the educative potential is higher. As already mentioned, façade systems also have the potential to create more attractiveness of the technology to architects and to motivate them to maximise its value over that of the electricity generated, thereby having the potential to reduce the overall public expenditure for the same level of benefit to Portuguese society, while strongly involving the creative industries in Portugal. It is also important at this point to mention that in Japan, the most developed country in what regards roof-mounted systems, that visual impact issues are now becoming important as a barrier because of lack of consideration of architectural integration at first stages of diffusion.

FIGURE 19 – Evolution of market price of CO2 from July 2005 to July 2006 [Source: www.ecotrade.pt]

The attribute Spillover Effect also deserves some considerations. This attribute intends to capture economic effects that cannot be captured with a traditional industrial development approach, such as that given by input-output analysis, as these are direct impacts resulting from development of an industrial chain. As an example, projects may have a significant impact on the tourism sector and this may be different depending on the type of application. Large scale systems are likely to generate revenues in the scientific tourism" segment, as has been reported for instance for the Solar Platform of Almeria in Spain. On the other hand, large tourism developments with PV integration, such as resorts, have the potential to attract scientific tourism as well as sustainability-driven tourism.

Type of Attribute	Social	Economic				Environmental
Attribute	Social Perception and Education (SOC)	Security of Supply (SS)	Industrial Development and Job Creation (IND)	Spillover Effect (SPILL)	Learning Potential (LEARN)	Environmental Performance (ENV)
Indicators	Number of persons acquainted with the technology	Annual energy yield [kWh/(kWp.year)]	Direct gross added-value [€/MWp]	Number of projects and other related initiatives [unit]	Yearly installed capacity in each segment [MWp/year]	CO_2 emissions avoided [ton/MWh]
	Number of persons in favour of the technology	Avoided primary energy [tep/year]	Total number of direct jobs created [person/MWp]	Number of new jobs in R&D [person/MWp]	Yearly average PR in each segment [%/year]	CO_2 cost avoided [€/MW]
	Number of persons involved locally in market deployment activities	Local grid carrying capacity (Instantaneous energy production/Instantaneous energy demand) [%]	Number of new jobs in manufacturing [person/MWp]	Number of sectors in economy indirectly impacted [unit]	Yearly turn-key system price in each segment [€/MWp]	NOx emissions avoided [ton/MWh]
	Number of persons induced towards adoption of energy saving behaviours	Local grid peak-shaving capacity (Instantaneous energy production in peak hours/Instantaneous energy demand in peak hours) [%]	Number of new jobs in installation and maintenance [person/MWp]	Indirect gross added-value [€/MWp]	Number of new actors involved in market deployment activities [unit]	SO_2 emissions avoided [ton/MWh]
	Number of persons distinguishing between solar thermal and photovoltaics	Capability of energy provision in blackout situation [%]	Number of new jobs in engineering services [person/MWp]	Local attractiveness to new investment projects [$€_{invested}$]	Number of pos-graduation jobs created [unit]	Health savings [€/MWh]
	Number of people willing to own a PV system	Share in total installed capacity [MW_{PV}/MW_{total}]	Exports of PV-related goods [€/MWp]	Local attractiveness to new visitors [unit]	Number of graduated jobs created [unit]	Energy Payback time in each segment [years]
			Exports of PV-related services [€/MWp]		Number of under-graduated jobs created [unit]	Total and degraded land use [$m^2_{PV}/m^2_{available}$]

Table 1 – Embedded values on PV-electricity from a society perspectiv

The Moura project provides also a good example of a project with prospective positive impacts over the spillover attribute. As seen, this PV power plant may be considered the anchor to a wider set of initiatives that may generate local industrial development, R&D employment and improved awareness to the technology, especially in younger spheres through the announced programme for installation of PV in public schools. If all the announced initiatives become a reality, than the Moura project can be considered a reference when it comes to the development of large and very large PV facilities in Portugal.

4.2. Recommendation 1: Capacity Cap

As a preliminary comment, it is important to note that the recommendation on capacity cap cannot be decoupled from the recommendations regarding the feed-in tariff and the licensing framework, as made clear in what follows. Also, it must have into consideration that such a cap already exists and that theoretically there is still a 22 MWp capacity that has to be attributed so that the 150 MWp 2010 goal is attained.

Considerations on the adequacy of capacity caps have already been made and the argument that it delivers unwanted market stop-and-go effects has been defended. As a consequence, serious reflection must be made on these matters. On one hand, in order to foster an inexistent PV market such as that associated with buildings, a stable environment must be such so to imprint the necessary confidence in the market players, as well as inducing stable and reinforced learning processes. From a policy point-of-view, though, targets are important to monitor the adequacy of the policy instruments in force.

In the present document it is recommended that a transition period exists in which the commitments with present capacity target are met, while a system of indicative targets are set for the medium term.

4.2.1 Timeframe: 2006-2008

In the short term, the recommendation must aim at the capacity still to be attributed, which has to be fulfilled. This recommendation is done in section 4.4 and points to the realisation of a tender process relative to the capacity not yet attributed, for systems in the medium and large scale, an exception foreseen in DL 312/2001. LV grid-connected systems should be left out of this process, as well as from the licensing system underlying the IPP framework. In fact, for small scale systems, it is recommended that a simplified procedure building upon the current PC framework is applicable (c.f. 4.4), which implies that systems can be licensed in any point in time. For these systems there should be no cap associated. Nonetheless, an indicative target for the period in question should be clearly set. It is recommended that such target equals 1 MWp of licensed systems in 2007 and 2 MWp in 2008, the later being subjected to the success rate of the first year of observation and eventually to revision. Of course that the capacity installed in the small-scale should be considered when accounting for the cumulative installed capacity in 2010 and as such included in the observance of the 150 MW goal. These targets can be further detailed to differentiate between building and ground-mounted systems. Nonetheless, no such differentiation is made because the philosophy within which the feed-in tariff is designed (c.f. 4.3) has intrinsically associated already market signalling considerations.

Despite of the non-applicability of capacity caps to the small-scale range, the capacity installed meanwhile should in any case be considered when accounting for the cumulative installed capacity in 2010 and as such included in the observance of the 150 MW target.

4.2.2 Timeframe: From 2008

For the medium term, it is recommended that different targets are set for building applications and ground-mounted applications, so to enable close monitoring of market evolution and of the effectiveness of the policy measures. In order to avoid capacity-caps stop-and-go effects, these targets must be decoupled from financial incentives, especially feed-in tariffs. Note that indicative targets are in nature independent from financial incentives, as they can be easily coupled with regulatory instruments, such as building performance regulations. It follows that revision of targets should be made according to observed market development and should be of regular nature. In this sense, yearly revisions seem appropriate. No indicative targets are suggested for this timeframe, neither for ground-mounted systems, nor for building-mounted systems, as any of these establishments require information of the outputs from the previous ones described in 4.2.1.

4.3. Recommendation 2: Feed-in Tariff Structure and Support Level

As referred at the end of section 3, the uncertainties associated with DL 33-A/2005 and its declaration of rectification open up an overall opportunity for revising the present feed-in tariff structurally. Considerations about the 5 kW cap adequacy have already been made in section 4.1.2 and point to its removal. Moreover, the declaration of rectification is clearly violating the overall dispositions of DL 33-A/2005, namely in what regards definition of the $KMHO_m$ parameter in equation 1. Therefore the rectification should be abolished and the calculus formula of equation 1 assumed as in force. In fact, and inspired in the German model, the present recommendation assumes differentiation of applications, namely for façade, roof and ground-mounted PV systems, subjected additionally to system size constraints. As such, the design adopted for the feed-in tariff follows a philosophy of providing the market with adequate signals regarding the type of PV application that is preferred. It is important to bear in mind, however, that this is done in combination with the measures assumed for the licensing framework and associated authorisation procedures. As such, it must not be taken as guaranteed which dynamics the market will assume and to where will it move. To this end, close monitoring of the evolution and revision of the feed-in tariff should be pursued on a yearly basis, as detailed in 4.3.2.

4.3.1 Timeframe: 2006-2008

As just mentioned, in the short term the tariff structure should be revised to differentiate among applications, and within these, among size. Applications are divided into façade, roof and ground-mounted PV systems. To the later does not apply any size differentiation factor, meaning that all systems are given the same incentive level independently of its dimension. To the remaining applications, differentiation is made between small-scale systems and higher capacity ones. Small-scale is here understood as a system that is eligible within the PC framework, which implies that a maximum interconnection capacity of 150 kW is allowed. As argued in section 4.1.3, roof and façade applications should be given the same playing level field in terms of attractiveness of investment and should be preferred over ground-mounted systems.

In order to allow for calculations, it is essential to make assumptions about reference yields and systems turnkey cost. These are given in table 2. System reference yields for façade and roof-mounted systems are taken as the mean values given by the Joint Research Centre on-line PV yield calculator (http://re.jrc.cec.eu.int/pvgis/regionframe.php). For ground-mounted systems the present reference yield introduced by DL 33-A/2005 is assumed.

Some comments regarding assumed reference system costs are pertinent.

The cost assumed for ground-mounted systems is typical for the large and very-large scale applications; roughly will smaller systems be capable of ensuring such low system costs, given the present global market conditions (especially those related with silicon availability). This in turn signals the market about preference of other applications, especially for small and medium sized systems. As such it is expectable that this will bias the market towards roof-mounted systems, as system costs for the later should be of the same level in each size category. This is as truer as the necessary installation-related competencies are developed and consolidated. To this end, attention should be paid to the initial considerations of the present section regarding accompanying measures.

System costs for façade and roof-mounted systems are taken to be of the same order in each capacity range considered. Nonetheless, in gross terms this premise does not hold true. In fact, façade systems tend to have a higher cost per unit power installed because of higher installation costs; architecture and engineering design costs; and of higher module costs eventually occurring because of customisation. Considering that these extra costs result in an aggravation of 25% in the turnkey cost, results in an extra cost of 180 €/m^2 of façade systems relatively to roof systems. However, it is expected that the displaced costs of other building materials and its respective installation costs cover for this difference, which will most likely occur in the medium to high segment of the building sector and in principle in non-residential buildings.

The avoided building materials and installation cost is in fact the only added-value taken into consideration when designing the feed-in tariff; other eventual values, as those mentioned in section 3, may be internalised within the adoption structure (e.g. building promoter and end-user), thereby raising the overall value of the electricity generated to these actors. This may eventually lead to distortion and should be closely monitored so that excessive private gains do not occur. However, in the short-term this option should be preferred for two reasons. Firstly, façade systems may convey a perception of higher risk, e.g., associated with eventually more complex engineering issues. Letting private investors internalise a part of the public benefit constitutes a premium to risk-taking attitudes within a context of first movers, as well as an incentive to learning. Secondly, also related to learning is the fact that in the first stages of the diffusion process, actors will most likely not take full advantage of the potential system maximum value.

The differentiation of cost between small-scale and higher scales façade/roof systems is exclusively rooted in considerations of economies of scale.

Assuming further in the design a simple pay-back time period of 10 years results in the indicative feed-in tariffs, as well as the associated *Z*-factors, presented in table 2. For the calculation of the former it is assumed that DL 33-A/2005 is in force, especially in what regards the calculation formula given in equation 1.

Application Type	Application Size	Reference Yield [kWh/kWp]	Reference Investment [€/kWp]	Feed-in Tariff *Z*-Factor
Façade	≤150 kVA	880	6.000,00	0,68 €/kWh Z = 67
	>150 kVA		5.500,00	0,63 €/kWh Z = 61
Roof-Mounted	≤150 kVA	1200	6.000,00	0,50 €/kWh Z = 47
	>150 kVA		5.500,00	0,46 €/kWh Z = 43
Ground-	All	1400	4.200,00	0,30 €/kWh

mounted				Z = 26

Table 2 – Proposed new feed-in tariff structure, level of incentive and underlying assumptions

4.3.2 Timeframe: From 2008

If market develops according to expectations (as inspired, for instance, by the empirical experiment described in section 3), a stock of knowledge will start building up that will allow construction-industry actors to easily adapt to a situation in which the technology will be mandatory through building energy performance regulation. On a first approach, this obligation will most probably have to have associated a feed-in tariff, although not necessarily as high as the ones foreseen for the short-term. It is relevant to note that this is actually what is already in force in Spain.

The level of incentive for building-mounted systems must be correlated with market maturity indicators, namely those related to installed system prices, willingness-to-pay of adopters and to other learning effects. Also, it is important to take into consideration what has been said about the internalisation of public benefit by adopters. Close monitoring of these issues implies careful design of the monitoring system.

In any case, the feed-in tariff should be continuously monitored and revised on a yearly basis.

It is also important to note, to this end, that if revision of tariffs are well-designed and soundly supported on operational data, it will be possible to have payback time periods coming down to 8 years, calculated in accordance with RSECE methods, and taking into consideration other PV-related added-values. The exact calculation method should however be clearly stated as the use of the present formula may rise some questions in these matters. It is believed that provisions for obtaining such calculation method should be anticipated as soon as possible. The reason is that there could already be situations in which a mandatory constraint on the implementation of PV in some buildings may already be a reality.

Regarding residential buildings, PV may become a worthwhile option with respect to solar thermal, as the imposition on the later is withdrawn if another RE is being installed instead with equivalent installed power.

The appropriateness of stimulating the ground-mounted PV market through the feed-in tariff mechanism should be assessed. This should be done by evaluating a relevant sample of projects licensed under the IPP framework taking as a tool the value matrix of table 1. Total projected expenditure with these systems should then be put against the generated benefits. Also attention should be paid to the results of the tendering process, described further in section 4.4, as it will be by then apparent how the market responded to the signals embedded in the feed-in tariff towards roof-mounted systems.

It is also important to monitor how the market of small and medium scale ground-mounted systems evolves in rural areas for two reasons. Firstly, in this kind of applications interesting forms of organisation from a society point of view may be occurring, such as local cooperatives. This kind of organisation creates a strong commitment of populations with the technology, eventually creating the potential for triggering and stimulating other type of applications, while impacting strongly on the levels of awareness and education. Secondly, if such forms of organisation occur, it is most likely that low-value soil is used, which is in turn less penalising from a land use point of view.

A final general comment for the medium term should be made regarding the appropriateness of the feed-in tariff model. This model is generally acknowledged as the preferred one for triggering development of insipient markets. However, when market attains a certain level of maturity, the use of this instrument may result in important market distortions, eventually giving rise to monopolist gains. As such, it is expected that a green certificate trading model should then be used and that this will enhance competition among RE technologies. The appropriateness of such a model for PV is nonetheless questionable while technology costs are high when compared to other RE-technologies. Therefore, the time of transition to such a trading system, already foreseen in DL 33-A/2005, should be carefully assessed when it comes to PV technology and should build upon information generated within the monitoring system, namely that related to market maturity.

4.4. Recommendation 3: Licencing Framework and Authorisation Procedure

For the short-term (2006-2008), prosecution of the national target should be aimed for, which implies that an additional capacity of 22 MWp has to be licensed and installed until 2010. This recommendation points out to the realisation of this capacity in the medium and large scale and associated to a tender system. This goes inline with the exception dispositions of DL 312/2001.

Also inline with dispositions of DL 312/2001, it is recommended that different authorisation procedures are set for small scale and higher capacity systems. For small-scale LV grid-connected systems, a licensing framework based on the PC framework is recommended. It is further recommended harmonisation of the PC and IPP framework regarding the applicable feed-in tariff. This recommendation follows directly a recent proposal from APREN. For medium to very-large scale systems, the IPP framework should be applicable, independently of the timeframe under consideration, although it is generally recommended that an effort is made towards reducing observed authorisation procedures, namely by further constraining the validity time of the establishment license.

4.4.1 Timeframe: 2006-2008

4.4.1.1 Small-scale systems

The need for harmonisation of the frameworks of the IPP and of the PC with respect to micro-generation (i.e. systems with a capacity less than 150 kW) and to fill in the omission of DL312/2001 regarding the licensing process of low-voltage grid-connected renewable energy systems, has been already recognised by the competent government bodies. This recognition followed intervention from APREN who, as a consequence, was invited to present a proposal on what such harmonisation should consist of. This proposal was presented to the Ministry of Economy and Innovation late 2005 and is currently under discussion at DGGE.

The present recommendation fully acknowledges APREN proposal.

Basically, the APREN proposal withdraws the 50% self-consumption imposition within the PC framework, thereby allowing for the micro-generator to sell all the generated electricity to the LVG operator. Also, and in the case of PV, it is proposed that the calculus formula for the remuneration of the injected electricity is the same as that established in DL 33-A/2005 (equation 1). According to what has been previously laid down, this calculus formula should further observe the recommendation given in section 4.3. Finally, the licensing procedure is proposed to be further simplified in the case of systems with an injection current of 16 A per phase (i.e. 3,7 kVA and 11,1 kVA in single and 3-phase configurations respectively). This simplified procedure would consist of a mere notification of the competent entities with at least one month anticipation. For the remaining cases, still a simplified procedure is set close to that previously established for the PC framework.

In both cases the institutional framework pertaining to the authorisation procedure is exclusively of regional nature and is continuous in time.

It is believed that within this context most of the licensing barriers are withdrawn, notably for buildings, as a better match exists between ordinary project implementation and PV-licensing timings. Also, as noted in section 4.2, systems licensed under this framework should be left out of existing provisions for the short-term capacity cap, namely of the tendering system described in section 4.4.1.2.

4.4.1.2 Medium to very-large scale systems

Generally, the IPP framework should be maintained for licensing systems in the medium to very-large scales. In the short-term, the provisions of DL 312-/2001 regarding an exceptional regime based on a tendering system should be taken. The tendering process will be aimed at medium to large scale systems, letting out of the process small and very large scale systems. Arguments for excluding small scale systems have already been made.

Very-large scale systems in turn are left out of the tendering process mainly because of two reasons.

Firstly, the capacity available for the tendering process is relatively small. If very-large scale systems were considered, then a maximum of two installations would be realised and would be certainly ground-mounted. In the process, opportunities for starting biasing the market towards building applications and for involving a maximum possible of new actors would be lost. In turn, by focusing the tendering process on the medium and large scales, and combining with what has been recommended for the feed-in tariff, it is possible to bias the market towards roof systems mounted in industrial and large commercial and public buildings. This would allow building upon previous experience gained meanwhile in the Portuguese market, while pushing the market forward to the most preferred applications. Depending on the design of the tendering process, it is also possible to maximise benefit related to potential raise public awareness and education levels, e.g. by giving preference to proposals aimed at public buildings or buildings with an elevated public exposure.

Secondly, as has been made clear previously, in the very-large scale PV market it is expectable that a mild international financial interest appears, as a consequence of existence of more attractive PV geographical markets, especially Spain. This in turn might eventually jeopardise the attainment of the 2010 goal if these systems were included in the tendering process.

Another major decision associated with the tendering process should be on whether or not all the capacity available should go alone to a unique tender call or if it should instead be split into yearly processes. In the present document it is recommended that 3 tendering calls are set, assuming a call already in the year of 2006. This should allow for the market to adjust to the new dispositions and to search for the necessary human and financial resources. The capacity in each tender should be set the same, thereby splitting in three the overall 22 MWp available. Dispositions should also be made so to transfer capacity among tender calls, thereby anticipating eventual shortness of proposals in the first call.

4.4.2 Timeframe: From 2008

Both PC and IPP frameworks are expected to be maintained in the medium term, subjected eventually to revisions so to accommodate observed barriers. To this end, in the PC framework especial attention should be given to barriers originated in lack of response capacity of regional authorities and eventually originated in lack of knowledge from distribution grid operators. With respect to the later, these barriers would eventually arise if doubts about the allowed penetration of PV systems in the LV-grid arise. In fact, this is an issue that has been target of several research projects, namely at the IEA-PVPS Task 5 project, and is presently actively being researched in Japan. As such, it is recommended that active participation of distribution grid operator technicians in related international cooperation programmes is supported, notably at the IEA-PVPS relevant projects (e.g. Task 10 and 11).
Within the IPP framework, close monitor of project implementation timings should be pursued so be enable identification of barriers hindering system installation. This should be concurrent with the overall objective of shortening licensing timings.

4.5. Recommendation 4: Monitoring System

As made clear previously, the design of the monitoring system is extremely important to enable a close evaluation of results of the policy framework recommended and to better inform posterior updates and revisions of such framework. As a corollary, it is also extremely important to have a clear definition of who are the responsible entities for providing the necessary data and for treating it according to the needs of the monitoring framework. As such, it is recommended upfront that an Observatory for Photovoltaic Technology (OPT) is set. This observatory might not be exclusively oriented towards PV, as some synergies exist with the solar thermal market and the already constituted Observatory for Buildings related to the Energy and Air Quality Certification System of Buildings. As such, OPT could be a unit of a broader observatory. Governmental decision on these matters is of paramount importance.

The monitoring system is recommended to consist of four sub-systems, namely:

- Sub-system aimed at monitoring PV-System level indicators
- Sub-system aimed at monitoring the value of the overall installed PV capacity to the Portuguese society;
- Sub-system aimed at monitoring the value of PV systems for the different stakeholders and their willingness to pay;
- Sub-system aimed at monitoring evolution of barriers.

In the following these sub-systems are specified. The outputs from the PV-system level monitoring sub-system constitute a basis for evaluation on the remaining monitoring sub-systems, as systematised in figure 20.

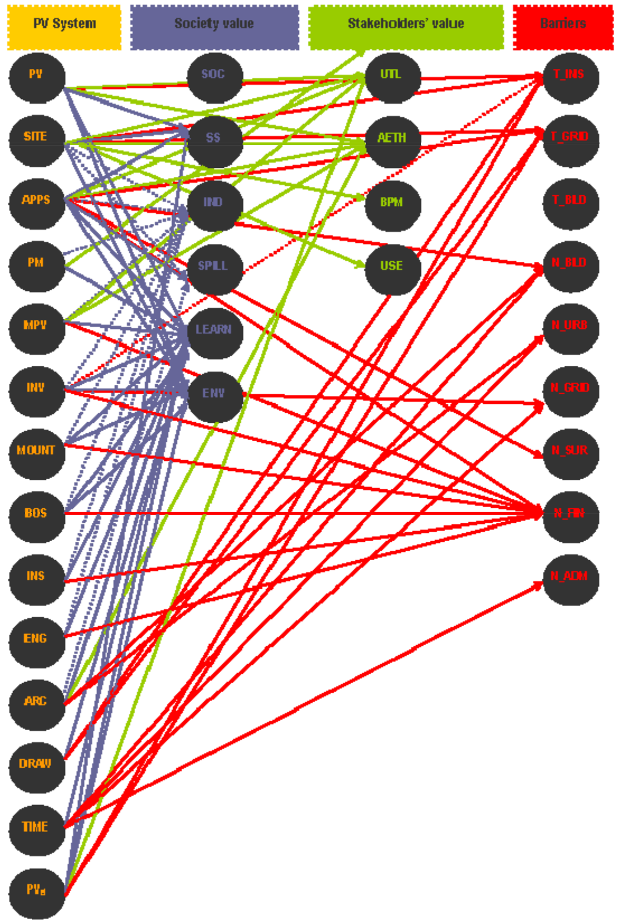

FIGURE 20 – Information flows from the PV-system level monitoring sub-system to the remaining monitoring sub-systems

4.5.1 PV-system Level Monitoring Sub-system

This monitoring sub-system depends essentially on information gathered both at licensing and operation phases of the PV systems. It comprises 14 group variables, totalling 44 individual variables. In tables 3 and 4 these variables are listed for the IPP and PC frameworks respectively and the timing of information gathering is identified. It should be noted that information gathered in the IPP and PC frameworks is basically the same, with only slight variations occurring, although the information sources vary as well as the timings. In the tables the information sources are also listed. Links to other monitoring sub-systems can be inferred from figure 20.

It is worthwhile noting that for IPP framework it is necessary to elaborate standard information forms so that information gathering is done in a systematic and coherent way. With respect to the PC framework, most of the information needed is already systematised in relevant forms in the APREN proposal, needing just slight adaptations in order to have the full information range covered.

Besides serving as a basis for the remaining monitoring sub-systems, the data gathered at the PV-system Level monitoring sub-system will enable deliverance of comprehensive standard and advanced statistics with possibility to differentiate by geographic location, type of application and size of application.

4.5.1.1 IPP Framework

VARIABLE GROUP NAME	INDIVIDUAL VARIABLES	PHASE SOURCE	INFORMATION SOURCE[1]
Installed Power (PV)	Nominal Installed PV power $[P_{PV}]$=Wp	Licensing: PIP	DGGE
	Nominal Interconnection power $[P_{INV}]$=VA	Licensing: PIP	DGGE
Location (SITE)	Geographical coordinates $[SITE_{LAT,LONG}]$ = degrees	Licensing: PIP	DGGE
	Interconnection Point $SITE_{IP}$	Licensing: PIP	DGGE
Type of Application[2] (APPS)	Type of Application APPS	Licensing: PIP	DGGE
Promoter[3] (PM)	Promoter Name PM_{name}	Licensing: PIP	DGGE
	Promoter Type PMt_{ype}	Licensing: PIP	DGGE
Equipment: PV Modules (MPV)	Manufacturer Name MPV_MAN_{name}	Licensing: Exploitation license	DGGE
	Manufacturer Nationality MPV_MAN_{nation}	Licensing: Exploitation license	DGGE
	Retailer Name MPV_RETAIL_{name}	Licensing: Exploitation license	DGGE
	Retailer Nationality MPV_RETAIL_{nation}	Licensing: Exploitation license	DGGE
	Number of Modules MPV_NUMBER	Licensing: Exploitation license	DGGE
	Modules certification MPV_CERT	Licensing: Exploitation license	DGGE
	Cost of Modules MPV_COST	Licensing: Exploitation license	DGGE
Equipment: Inverters (INV)	Manufacturer Name INV_MAN_{name}	Licensing: Exploitation license	DGGE
	Manufacturer Nationality INV_MAN_{nation}	Licensing: Exploitation license	DGGE
	Retailer Name INV_RETAIL_{name}	Licensing: Exploitation license	DGGE
	Retailer Nationality INV_RETAIL_{nation}	Licensing: Exploitation license	DGGE
	Number of Inverters INV_NUMBER	Licensing: Exploitation license	DGGE
	Inverters certification INV_CERT	Licensing: Exploitation license	DGGE
	Cost of Inverters INV_COST	Licensing: Exploitation license	DGGE
Equipment: Mounting Structure (MOUNT)	Manufacturer Name $MOUNT\_MAN_{name}$	Licensing: Exploitation license	DGGE
	Manufacturer Nationality $MOUNT\_MAN_{nation}$	Licensing: Exploitation license	DGGE
	Retailer Name $MOUNT\_RETAIL_{name}$	Licensing: Exploitation license	DGGE
	Retailer Nationality $MOUNT\_RETAIL_{nation}$	Licensing: Exploitation license	DGGE
	Cost of Mounting Structure MOUNT_COST	Licensing: Exploitation license	DGGE
Equipment: Other BOS components (BOS)	Type of BOS components BOS_TYPE	Licensing: Exploitation license	DGGE
	Countries of origin BOS_NATION	Licensing: Exploitation license	DGGE
	Cost per country BOS_COST	Licensing: Exploitation license	DGGE
Installation services (INS)	Installer name INS_NAME	Licensing: Exploitation license	DGGE
	Installer Country INS_NATION	Licensing: Exploitation license	DGGE

	Installation Cost INS_COST	Licensing: Exploitation license	DGGE
	Installer certification INS_CERT	Licensing: Exploitation license	DGGE
Engineering services (ENG)	Engineering company name ENG_NAME	Licensing: Exploitation license	DGGE
	Engineering company Country ENG_NATION	Licensing: Exploitation license	DGGE
	Engineering services Cost ENG_COST	Licensing: Exploitation license	DGGE
Architectural services (ARC)	Architect name ARC_NAME	Licensing: Exploitation license	DGGE
	Architect Country ARC_NATION	Licensing: Exploitation license	DGGE
	Cost of PV in total building cost ARC_PV	Licensing: Exploitation license	DGGE
System layout (DRAW)	System layout DRAW	Licensing: Exploitation license	DGGE
Licensing time (TIME)	Time to exploitation licence [TIME_PIP] = days	Licensing: Exploitation license	DGGE
	Time to interconnection [TIME_EXP] = days	Licensing: Interconnection	DGGE
PV system electricity production (PV_{EI})	Monthly energy delivered to the grid [PV_Elect_{month}] = kWh	Operation	TDGO/DGGE
	Instantaneous energy production profile [[PV_Elect_{inst}] = kW	Operation	TDGO/PV owner

[1] DGGE: Directorate General for Geology and Energy; TDGO: Transmission and Distribution Grid Operators
[2] GM_{RURAL}: Ground-mounted on rural areas; GM_{URBAN}: Ground-mounted on urban areas; RM_{SERV}: Roof-mounted in service buildings; RM_{DOM}: Roof-mounted in domestic buildings; FM_{SERV}: Façade-mounted in service buildings; FM_{DOM}: Façade-mounted in domestic buildings; OTH: Other, including other urban structures. Roof-mounted includes car-shelter systems. Façade includes façade-mounted shading systems.
[3] BDL_CLT: building client; BDL_PM: building promoter; PD: Property developer; ESCO: Energy Services Provider; UTL: Utility; IPP: Independent Power Producer; COOP: Cooperative arrangement; OTH: Other

Table 3 – PV-system level monitoring sub-system in the IPP framework

4.5.1.2 PC Framework

VARIABLE GROUP NAME	INDIVIDUAL VARIABLES	PHASE SOURCE	INFORMATION SOURCE[1]
Installed Power (PV)	Nominal Installed PV power [P_{PV}]=Wp	Licensing (simplified/ordinary)	DRE
	Nominal Interconnection power [P_{INV}]=VA	Licensing (simplified/ordinary)	DRE
Location (SITE)	Address $SITE_{address}$	Licensing (simplified/ordinary)	DRE
	Interconnection Point $SITE_{IP}$	Licensing (simplified/ordinary)	DRE
Type of Application[2] (APPS)	Type of Application APPS	Licensing (simplified/ordinary)	DRE
Promoter[3] (PM)	Promoter Name PM_{name}	Licensing (simplified/ordinary)	DRE
	Promoter Type PMt_{ype}	Licensing (simplified/ordinary)	DRE
Equipment: PV Modules (PV)	Manufacturer Name PV_MAN_{name}	Licensing (simplified/ordinary)	DRE
	Manufacturer Nationality PV_MAN_{nation}	Licensing (simplified/ordinary)	DRE
	Retailer Name PV_RETAIL_{name}	Licensing (simplified/ordinary)	DRE
	Retailer Nationality PV_RETAIL_{nation}	Licensing (simplified/ordinary)	DRE
	Number of Modules PV_NUMBER	Licensing (simplified/ordinary)	DRE
	Modules Certification PV_CERT	Licensing (simplified/ordinary)	DRE
	Cost of Modules PV_COST	Licensing (simplified/ordinary)	DRE
Equipment: Inverters (INV)	Manufacturer Name INV_MAN_{name}	Licensing (simplified/ordinary)	DRE
	Manufacturer Nationality INV_MAN_{nation}	Licensing (simplified/ordinary)	DRE

	Retailer Name INV_RETAIL_{name}	Licensing (simplified/ordinary)	DRE
	Retailer Nationality INV_RETAIL_{nation}	Licensing (simplified/ordinary)	DRE
	Number of Inverters INV_NUMBER	Licensing (simplified/ordinary)	DRE
	Inverter certification INV_CERT	Licensing (simplified/ordinary)	DRE
	Cost of Inverters INV_COST	Licensing (simplified/ordinary)	DRE
Equipment: Mounting Structure (MOUNT)	Manufacturer Name $MOUNT\_MAN_{name}$	Licensing (simplified/ordinary)	DRE
	Manufacturer Nationality $MOUNT\_MAN_{nation}$	Licensing (simplified/ordinary)	DRE
	Retailer Name $MOUNT\_RETAIL_{name}$	Licensing (simplified/ordinary)	DRE
	Retailer Nationality $MOUNT\_RETAIL_{nation}$	Licensing (simplified/ordinary)	DRE
	Cost of Mounting Structure MOUNT_COST	Licensing (simplified/ordinary)	DRE
Equipment: Other BOS components (BOS)	Type of BOS components BOS_TYPE	Licensing (simplified/ordinary)	DRE
	Countries of origin BOS_NATION	Licensing (simplified/ordinary)	DRE
	Cost per country BOS_COST	Licensing (simplified/ordinary)	DRE
Installation services (INS)	Installer name INS_NAME	Licensing (simplified/ordinary)	DRE
	Installer Country INS_NATION	Licensing (simplified/ordinary)	DRE
	Installation Cost INS_COST	Licensing (simplified/ordinary)	DRE
	Installer certification INS_CERT	Licensing (simplified/ordinary)	DRE
Engineering services (ENG)	Engineering company name ENG_NAME	Licensing (simplified/ordinary)	DRE
	Engineering company Country ENG_NATION	Licensing (simplified/ordinary)	DRE
	Engineering services Cost ENG_COST	Licensing (simplified/ordinary)	DRE
Architectural services (ARC)	Architect name ARC_NAME	Licensing (simplified/ordinary)	DRE
	Architect Country ARC_NATION	Licensing (simplified/ordinary)	DRE
	Cost of PV in total building cost ARC_PV	Licensing (simplified/ordinary)	DRE
System layout (DRAW)	System layout DRAW	Licensing (simplified/ordinary)	DRE
Licensing time (TIME)	Time to exploitation license [TIME_EXP] = days	Licensing: ordinary	DRE
	Time to interconnection minutes [TIME_INT] = days	Licensing (simplified/ordinary)	DRE
PV system electricity production (PV_Elect)	Monthly energy delivered to the grid [PV_Elect_{month}] = kWh	Operation	DGO/DGGE
	Instantaneous energy production profile [[PV_Elect_{inst}] = kW	Operation	DGGE/DGO/PV owner

[1]
DRE: Regional Delegation of the Ministry of Economy and Innovation
[2] GM_{RURAL}: Ground-mounted on rural areas; GM_{URBAN}: Ground-mounted on urban areas; RM_{SERV}: Roof-mounted in service buildings; RM_{DOM}: Roof-mounted in domestic buildings; FM_{SERV}: Façade-mounted in service buildings; FM_{DOM}: Façade-mounted in domestic buildings; OTH: Other, including other urban structures. Roof-mounted includes car-shelter systems. Façade includes façade-mounted shading systems.
[3] BDL_CLT: building client; BDL_PM: building promoter; PD: Property developer; ESCO: Energy Services Provider; UTL: Utility; IPP: Independent Power Producer; COOP: Cooperative arrangement; OTH: Other

Table 4 – PV-system level monitoring sub-system in the PC framework

4.5.2 PV-electricity Embedded Value Monitoring Sub-system

This monitoring sub-system has as underlying tool the value framework introduced in table 1 and is therefore intended to assess, in absolute and comparative terms, the embedded value of the licensed PV systems to the Portuguese society, which should be put against total expected public expenditure. To this end, some methodological issues are in need of definition, as given in the following.

4.5.2.1 Social Attributes

The only social attribute considered isolatedly is social perception and education, as other are embedded in economic and environmental attributes. This has already been discussed when introducing table 1. Six performance indicators are considered under this attribute, which are mostly difficult to assess. The methodology for assessing these indicators must necessarily pass through surveys. Reflection on the workability of such surveys must be made, especially regarding the selection of a significant sample. In principle these surveys should be coupled with specific PV projects and their impact on the local populations, as the overall impact in the Portuguese society must recur to massive survey techniques. These methods involve significant financial resources and its adequacy should be weighted. To this end, it is advisable that protocols of cooperation between the OPT and relevant academic institutions are signed, as this type of work is commonly within the research agenda of, e.g., social sciences R&D units. Nonetheless, effort within the OPT could be made directly to assess the social perception and education in relevant specific PV projects. When referring to large and very large scale projects currently under licensing in Portugal, such an effort should not be unbearable as projects are well contained geographically and involved relative small populations. When it comes to small-scale systems though, especially those mounted in buildings in urban environments, the population to be assessed may be somehow scattered and difficult to define by nature. It is then advisable that further detailed specification of assessment methods for social attributes is undertaken in collaboration with DGGE.

4.5.2.2 Economic Attributes

Four economic attributes are considered: security of supply; industrial development and job creation; spillover effect; and learning potential.

Security of Supply

With respect to security of supply, it must be clear that indicators regarding risks associated with conventional primary energy sources, namely price and availability, were not taken in consideration. As such, any revision of the present framework could in principle take these aspects into consideration, although these are complex issues in methodological terms.

The indicators considered are mostly based on operational parameters of the PV system as given by the PV-system level monitoring sub-system. Both in the IPP and PC frameworks, the licensed installations are closely monitored in terms of electricity output by the transmission and distribution grid operators as these are the entities responsible for buying the generated electricity. Provisions should be made to have the collected data shared with OPT as this is the minimum data required to assess the first three indicators listed under security of supply in table 1.

Regarding carrying and peak-shaving capacity, additional information on load profile of the network area under question is necessary. This may not be trivial in the LV grid level, being necessary to further define with the distribution grid operator how these measurements can actually be conducted and which type of data is readily available.

Capability of energy provision in blackout situation is an indicator that intends to capture the level of penetration of distributed systems. In other words, if systems are distant from loads, as happens in large and very-large scale ground-mounted applications, it is expectable that in blackout situation the electricity generated cannot be used due to unavailability of the grid that supports its distribution. On the other hand, systems that are close to the loads they are supplying, such as building mounted systems, have the potential to continuing supplying the internal building grid and associated loads. However, one technical comment is necessary. Presently, most of the inverters in use do not allow continuance of operation in case of grid failure, essentially due to considerations on human hazard risks (e.g. islanding and its potential hazards). However, technical advancements already exist that will in the short run allow for simultaneous backup and grid-connection functionalities. It is expectable that the introduction of such technological developments will face some resistance from grid operators, which should constitute an emerging barrier that must be monitored.

Industrial Development and Job Creation

Industrial development and job creation intends to capture the direct impact of the PV chain in the Portuguese economy. If anticipation of impacts is pursued, then it is adequate to employ an input-output matrix methodology. However, this is a time consuming task that depends on data series that often is outdated (e.g. the last actualised input-output matrix for the Portuguese economy is dated from 1990). Moreover, the existing matrices have an aggregation level that is inadequate to capture the impacts of the industrial chain under development.

As such, and given that impacts are to be assessed subsequently, it is recommended that data gathered within the PV-level monitoring sub-system (national equipment and service providers, both manufacturers and retailers) is used to define a sample to be assessed directly using a survey. The results will be of first order in the sense that only companies directly involved in PV market deployment will be assessed. In order to capture second order effects (e.g. increase in glass production due to PV manufacturing) can be further assessed using the same methods inherent to the input-output methodology, again recurring to detailed surveys targeted at the relevant companies.

Spillover Effect

As already mentioned, the spillover effect attribute intends to capture indirect impacts of PV market development in the Portuguese economy, namely those that are not captured within the industrial development attribute. As with social attributes, the spillover effect is more difficult to assess as most of impacts may only be inferred. The indicator "number of sectors in economy indirectly impacted" is a very good example of this difficulty. In fact, it was already discussed that sectors such as tourism may suffer a positive impact deriving from new PV installations (e.g. scientific and sustainable tourism). In this case, only correlations can be derived with respect to baseline values and their evolution in time. Other sectors may as well be impacted which are not directly related to the PV chain. These should be continuously identified and methods for inferring the associated impacts developed.

Also, referring to number of new jobs in R&D activities, synergies with already existing instruments should be pursued, e.g., with the Portuguese Science and Technology Foundation Survey to the Scientific and Technological Potential, and with Regional Delegations of the Ministry of Economy and Innovation.

As a general comment it should be said that the spillover-effect attribute needs to be further detailed in methodological terms.

Learning Potential

The learning potential attribute is intended at mapping the evolution of the learning processes in market deployment activities, as well as its impact on knowledge-based employment.
Most of the indicators within the learning potential attribute can be easily derived from data made available through the PV-system level monitoring sub-system combined with the recommended survey assessment within the Industrial Development and job Creation attribute.

4.5.2.3 Environmental Attributes

A common framework for assessing environmental impacts of a given economic activity is that provided by the life cycle assessment (LCA) methodology. The activity targeted in this attribute refers mainly to electricity production using PV technology. As the system's life phase in which electricity is being produced does not have any emissions or other impacts associated, the assessment of this attribute is mainly concentrated in the production phase of equipments and, to a lesser extent, to their disposal at end-of-life. In practice, a detailed assessment for each system installed is a time-consuming task and eventually an impossible one, as data required from manufacturers for such an enterprise is usually unavailable. As such, reference values should be used and then coupled with accurate information regarding the Portuguese energy mix. A simplified method is detailed in (Pinto, 2000) for the calculation of CO_2 emissions avoided and energy payback time. Calculation of CO_2 avoided cost derives directly from the later coupled with information such as that provided in figure 19. It should be noted that presently there are at least two ongoing European projects aimed at delivering more accurate reference values, the results of which should be used to update the monitoring system. With respect to NO_x and SO_2 emissions avoided and health savings simplified methods can also be derived based on LCA calculations with reference systems.

Also, in the future methods for deriving the avoided emissions associated with the additional functions of PV within buildings and other urban structures should be developed and fully incorporated with the monitoring system.

4.5.3 Stakeholders Embedded Value Monitoring Sub-system

The relevance of this sub-system arises from considerations on added values internalised at the adoption structure (e.g. building promoter and end-user), as already discussed in association with the feed-in tariff structure. As such, this monitoring sub-system must provide relevant information regarding willingness to pay and private gains so to adjust the feed-in tariff mechanism or other subsequent instruments, of which the building performance regulations are an example. Also, such monitoring sub-system will allow for inference regarding the involvement of the creative industry in Portugal in PV market deployment activities.

It is recommended that three different types of stakeholders are monitored: building promoters (or property developers, as adequate), architects and end-users. As discussed previously, it is foreseen that commercial end-users are the main short-term target of this monitoring sub-system, although relevant residential end-users should also be assessed, e.g., related to paradigmatic projects.

The type of attributes considered imply that a thorough observation of particular projects is made, which should be accompanied by detailed calculations. As such, special agreements with stakeholders involved in specific, pre-selected projects are necessary. The sampling method and sample size should be decided upon realisation of the first building-mounted projects that are expected to arise from the policy framework recommended throughout this section. Independently, the sample will have to be selected based on the indicators provided by the PV-system level monitoring sub-system.

For the projects selected for further detailed analysis, the attributes that should be considered are described in the following.

4.5.3.1 Utilitarian values

For each project selected, a first assessment of the utilitarian functions performed by the PV system should be listed. To this end, not only the functions that are assumed by the stakeholders should be taken into consideration but also others that those actors may have not identified. As a corollary, a subjacent educative function from OPT is performed by informing the relevant stakeholders of all the impacts their decisions have on the value of the PV system.
In methodological terms, assessment of the value of such functions must recur to detailed energy simulation tools of the building as a whole so to assess the impacts on building energy fluxes. Currently, methodological specifications are under development at IEA-PVPS-Task 10 that should be adopted by OPT within this monitoring sub-system once finalised.
Further, it is necessary to map which utilitarian values pertain to which stakeholder, i.e. how these values are being distributed among promoters and users, including the electricity-production function.
In figure 20 the utilitarian values are labelled UTL under the stakeholders value monitoring sub-system.

4.5.3.2 Aesthetic value

Considerations on how to estimate the aesthetic value of a PV system within the overall building aesthetics are difficult and not exempt from controversy and subjectivity. As such, this attribute as it is considered in the present framework intends to capture the perception of architects in the use of PV materials and its evolution in time. For this purpose, a questionnaire should be developed based on work currently under development at IEA-PVPS-Task 10.
In figure 20 the aesthetic values are labelled AETH under the stakeholders' value monitoring sub-system.

4.5.3.3 Building Promoter Values

Independently of the outcomes from the utilitarian value assessment, further value assessment for building promoters and property developers should be conducted, namely to infer the overall market value of buildings incorporating advanced energy technologies such as PV systems. It has to be noted though that hardly the PV value can be isolated if other advanced energy strategies are used, as a technology-bundling effect will most surely occur and impact on client's willingness to pay. Eventually, in some projects clients may be assessed too using survey methods, which could be done in association with the end-user value attribute, described in the next section. It should here be stressed though that client and end user are often not the same entity.

Nonetheless, the primary focus of building-promoter PV attribute assessment should be put on surveying the building promoters and property developers regarding attractiveness of real estate as measured by time to sales and sales revenue. These indicators should be taken relatively to average market values in the building segment considered.
In figure 20 the building promoter values are labelled BPM under the stakeholders' value monitoring sub-system.

4.5.3.4 End-user Values

Since the objective, utilitarian values are already assessed, this attribute intends to capture the subjective values pertaining to the end-user, such as subjective environmental value, aesthetics and social status. For this purpose a questionnaire should be developed. Also, this questionnaire should include relevant questions that will allow informing the PV-electricity embedded value monitoring sub-system, in particular regarding the social perception and education attribute. In figure 20 the end-user values are labelled USE under the stakeholders' value monitoring sub-system.

4.5.4 Barriers Monitoring Sub-system

As already noted, this monitoring sub-system is intended at capturing the existence and emergence of barriers so to inform policy decisions regarding regulation and accompanying measures (e.g. installers' certification system).

Within this context, barriers are split into technical and non-technical. Technical barriers considered are the quality of installation; building safety issues (of constructional and electrical nature); and grid capacity. These are labelled T_INS, T_BLD and T_GRID respectively under the barriers monitoring sub-system in figure 20.

Quality of installation can be monitored by the performance ratio, which is already derived within the PV-electricity embedded value monitoring sub-system. The anticipation of this barrier is inspired by the German experience as within the first editions of the roofs programmes several installation errors were detected that compromised the system's performance.

Constructional and electrical building safety issues are actually a matter of discussion presently at relevant international certification bodies (e.g. IEE and CENELEC). Also, drafts have been produced unilaterally by some countries, such as the Netherlands. It is expected that a best practice manual should be delivered by OPT so to avoid problems and increase the rate of learning of the relevant stakeholders. This best-practice manual should be informed both by internationally activities already undertaken and underway, as well as from assessment of implemented projects in Portugal. To this end, a selection of projects for close observation should be made, based on criteria derived from the mentioned international activities.

Grid-capacity barriers should be assessed in close cooperation with transmission and distribution grid operators, namely by evaluating the operational impact on the grid resulting from higher penetration levels of PV systems within a certain grid area. In parallel, provisions should be made for the development of models informed by the empirical data gathered meanwhile. The use of these models should be of paramount importance for anticipating limiting penetration levels, as well as to contribute to change of negatively biased perceptions from grid-operators.

On the non-technical side, the barriers considered are:

- barriers related to authorisation procedures at local level, in particular those related to building permits (labelled N_BLD under the barriers monitoring sub-system in figure 20). These barriers can be assessed from information delivered by the PV-System level monitoring sub-system regarding licensing times and from the detailed assessments foreseen in the stakeholders' value monitoring sub-system through directed questions.
- barriers related to local urban planning instruments (e.g. master plan), namely restrictions related to visibility of PV systems in historic areas (labelled N_URB under the barriers monitoring sub-system in figure 20). These barriers can be assessed from information delivered by the PV-System level monitoring sub-system regarding licensing times and from the detailed assessments foreseen in the stakeholders' value monitoring sub-system through directed questions.
- barriers related to insurance of PV systems within the context of other building-related insurance packs (labelled N_SUR under the barriers monitoring sub-system in figure 20). These barriers can be assessed from information delivered by the PV-System level monitoring sub-system regarding licensing times and from the detailed assessments foreseen in the stakeholders' value monitoring sub-system through directed questions.
- barriers related to financing of PV systems, e.g. within the context of housing long-term bank loans (labelled N_FIN under the barriers monitoring sub-system in figure 20). These barriers can be assessed from the detailed assessments foreseen in the stakeholders' value monitoring sub-system through directed questions.
- Grid operators perception barriers (labelled N_GRID under the barriers monitoring sub-system in figure 20). Here, two different types of barriers should be considered: PV grid penetration perception barriers and new inverter functions. Regarding the former, considerations have been made associated with grid technical barriers. Regarding the later, it could be expected that advanced inverter functions, such as those enabling continuity of operation of PV systems in case of grid failure for supplying local loads (e.g. at building level), may face resistance from grid-operators based on human hazard considerations. As such, OPT should continuously monitor and assess these advancements and eventually enforce by law the use of such advanced devices when guarantee of quality exists.
- Administrative barriers (labelled N_ADM under the barriers monitoring sub-system in figure 20). These barriers can be assessed from information delivered by the PV-System level monitoring sub-system regarding licensing times and from the detailed assessments foreseen in the stakeholders' value monitoring sub-system through directed questions.

4.6. Summary of Policy Framework

The present recommendation is exclusively aimed at market deployment policies and associated instruments. In a broader perspective of a Portuguese National Plan for Photovoltaic Technology, the innovation-system spheres of industry and R&D must also be taken into consideration and be target of dedicated recommendations. This recommendation nonetheless takes these spheres into consideration in what regards effects resulting from feed-back loops originated in the users' sphere (i.e. market).

Table 5 summarises the policy framework proposed along the core design vectors of capacity cap, feed-in tariff and licensing framework and authorisation procedure.

Application Type	Application Size	Licensing Framework Authorisation Procedure	Feed-in Tariff [€/kWh]	Capacity Cap (2006-2008)
Façade	≤3,7 kVA 1-phase ≤11,1 kVA 3-phase	Producer-Consumer Notification	0,68	No
	≤100 kVA	Producer-Consumer Simplified local procedure		
	>100 kVA	Independent Power Producer DL312/2001	0,63	Yes Tender Process
Roof-mounted and other grid-connected urban structures	≤3,7 kVA 1-phase ≤11,1 kVA 3-phase	Producer-Consumer Notification	0,5	No
	≤100 kVA	Producer-Consumer Simplified local procedure		
	>100 kVA	Independent Power Producer DL312/2001	0,46	Yes Tender Process
Ground-mounted	≤3,7 kVA 1-phase ≤11,1 kVA 3-phase	Producer-Consumer Notification	0,30	Yes
	≤100 kVA	Producer-Consumer Simplified local procedure		
	>100 kVA	Independent Power Producer DL312/2001		Yes Tender Process

Table 5 – Summary of policy framework recommended regarding capacity caps, feed-in tariff and licensing framework and associated authorisation procedure

It is believed that this policy framework will provide the market with adequate signals both towards building applications and small scale systems. In fact, the simpler authorisation procedures associated with small scale systems increase the attractiveness of this type of systems to investors, as decisions on licensing timings are made more flexible and have potentially attached less transaction costs (i.e. financial costs associated with the licensing process). On the other hand, in this scale more attractive feed-in tariffs exist for building applications. Also, façade systems are fostered by setting the same playing level field between these and roof-mounted applications with the aim of getting a higher involvement of the Portuguese creative industries, and as such enhancing the potential embedded national value.

It is also expected that the combination of the recommendations on feed-in tariff and licensing framework will bias the market towards building-mounted medium to large scale systems, instead of ground-mounted systems. The development of very-large scale systems market is not expected to be significant, as this would imply a significantly higher allocation of financial resources to this segment so to make it competitive with other geographic markets such as the Spanish. This comes as undesirable as these applications have apparently little potential for fostering a high value national PV innovation system.

Finally, with respect to capacity caps a transition period is recommended in which the commitments with present capacity target are met, while a system of indicative targets is set for the medium term. In the short term, only systems in the medium to large scale will be subjected to these transitional dispositions, while small scale systems are exempted from any capacity cap associated actions. In order to avoid capacity-caps stop-and-go effects, the indicative target system must be decoupled from financial incentives, especially from feed-in tariffs. No indicative targets are recommended for the medium term as this is a decision that must build upon information on the evolution of the market. For the short term, and regarding small scale systems, indicative targets of 1 and 2 MWp annual installed capacity are recommended for 2007 and 2008 respectively.

In addition, to these core policy actions, the following accompanying measures are recommended:

- develop a continuous communication strategy regarding activities of awareness and dissemination, namely to overcome barriers of lack of information and of biased perceptions. Several stakeholders should be targeted, from private to public bodies, from the building to the financial sectors;
- create the conditions for the provision of training and certification of installers;
- create the conditions for the provision of training of architects, engineers and eventually of the financing and insurance sectors;
- create the conditions for accreditation of training courses;
- establish a framework for product certification.

Also identified is the adequacy to support the relevant actors to participate in existing standardisation activities, namely those occurring at CENELEC and IEC. Additionally, in order to reduce barriers deriving from lack of knowledge on the impact of increasing penetration rates of PV systems in the LV grid, participation of distribution grid operators in relevant international cooperation programmes, such as those occurring at IEA-PVPS level, is advisable.

The design of the monitoring system is extremely important to enable a close evaluation of results of the policy framework recommended and to better inform posterior updates and revisions of such framework. As a corollary, it is also extremely important to have a clear definition of who are the responsible entities for providing the necessary data and for treating it according to the needs of the monitoring framework. As such, it is recommended upfront that an observatory is set. This observatory may not be exclusively oriented towards PV, as some synergies exist with the solar thermal market and the already constituted Observatory for Buildings related to the Energy and Air Quality Certification System of Buildings. Governmental decision on these matters is of paramount importance.

The monitoring system is recommended to consist of three sub-systems, namely:

- Sub-system aimed at monitoring the value of the overall installed PV capacity to the Portuguese society;
- Sub-system aimed at monitoring the value of PV systems for the different stakeholders and their willingness to pay;
- Sub-system aimed at monitoring evolution of barriers.

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