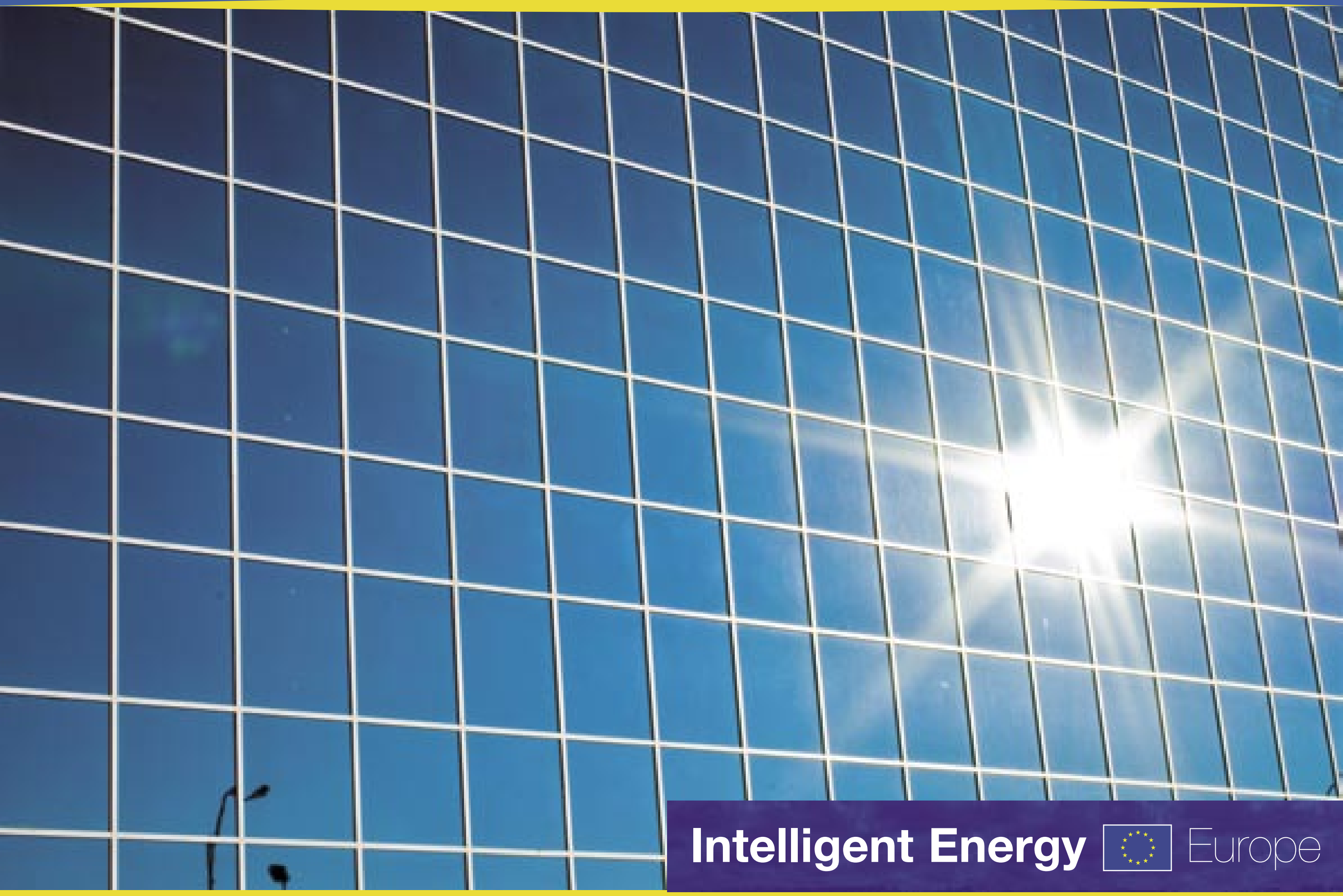
pvs in bloom



Intelligent Energy Europe

MATCHING MARGINAL TERRAINS WITH PHOTOVOLTAICS: A NEW CHALLENGE FOR THE SUSTAINABLE DEVELOPMENT OF THE EUROPEAN TERRITORY

Strategic Vision Document

PVS in BLOOM

STRATEGIC VISION DOCUMENT

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Introduction

The PVs in BLOOM Project is funded under the Intelligent Energy Europe Programme of the European Commission, managed by EACI (The Executive Agency for Competitiveness and Innovation).

The PVs in BLOOM Project obtained attention from the EACI for its unique yet simple-minded approach, which asks itself why not to tackle the current shortage of resources in Europe (energy resources, land resources, financial resources for local public administrations) in a synergic way. Promoting the increase of energy yield from Renewable Energy Sources in fact can be done in a way that produces income for local public administrations and at the same time valorises neglected, abandoned or useless marginal terrains.

The PVs in BLOOM Project has identified european Best Practices and models for recovering low/zero value terrains through ground PV plants (PVPPs)[1] *ranging from 50 kWp to 2-3 MWp; involved 60 local public administrations across Europe in its activities and produced pilot pre-feasibility studies for spurring the start-up of new PVPPs on landfills and quarries.*

Unexploited resources such as marginal areas ***can*** *be transformed into income generating investments for public administrations and private investors, many experiences of municipalities across Europe reported in this document demonstrate it.*

The projections and figures presented in this document must be considered just as broad general estimates; nevertheless, their dimension must lead public administrators (but also private investors) to start thinking over their attitude to investment and resource valorisation in the direction of a more modern and sustainable approach.

The resources at stake are significant.
The road to achieve them is already well known by many local communities in Europe and abroad, yet there is still not enough attention to these resources in the majority of European countries.

[1] PVPPs is the acronym developed in the framework of the PVs in BLOOM project to define small and medium sized ground Photovoltaic Plantations installed on marginal terrains.

1. PVPPS in marginal terrains, a strategic challenge for public administrations

European economies depend on natural resources. These include raw materials and ground surfaces (land resources).

Given the current unprecedented world economic conditions, a change in the exploitation and optimization of resources must occur. If new additional resources cannot be found in old Europe, the present resources must be exploited completely. Land is a resource that European public administrations can no longer afford to neglect.

In each European region, as in each European municipality, marginal areas[2] determined by different distinctive causes share a common feature: they are under valorised.

Where "green plants" cannot grow or have big difficulties in surviving (e.g. abandoned quarries, not irrigable barren lands, areas within/near industrial locations or near technology parks/schools, etc.), or where terrains must be maintained segregated or in limited-controlled access (e.g. waste dumps, water cleaning areas, sewage treatment areas, abandoned military sites, contaminated sites,…), there is an "unexploited richness": unused land.

PVPPs (Photovoltaic Panel Plantations)[3] represent a recovering solution for such underdeveloped resources, and have the power of re-delivering social consideration to "zero value" areas while conferring them new economic utility.

Ground photovoltaic plants are currently present in Europe under the form of big plants (bigger than 3-5 MWp). The smaller ones, owned generally by private land owners or small municipalities, have developed up to now more with more difficulty.

The point is that the European territory has all the needed resources for becoming the scenery of an environmental and energetic revolution centred on Renewable Energy Sources. Yet to do this it is necessary to pass from a logic of big centralized investments to one that recognizes the features and resources of each territory, thus valorising each small yet relevant piece of land.

1.1 Marginal terrains: the future fuel for the engine of european sustainability

In Europe, as in other parts of the world, natural conditions or human activities such as agriculture, industry and commercial activities have lead to irreversible land-use footprints and to the presence of consistent quotas of unexploited land.

Official figures show how in Europe the presence of marginal unexploited land is substantially high.

Although studies assessing directly the presence of marginal areas do not exist in the majority of European countries, for many countries and regions it is possible to find official censes and studies concerning one or more typologies of marginal terrains: the existing data outlines a rather eye-catching scenario.

[2]A study developed through the Project PVs in BLOOM has defined marginal areas as those areas that:

- Are not able to answer any more in a positive way to investments;
- Have completed their prime and exclusive function;
- Present such characteristics that prevent, or make difficult, their future use.

For a detailed classification of marginal areas see paragraph 2.1 of this document.
(PVs in BLOOM "Marginal areas: Approach and methodology of location and classification", 2009).

[3]PVPPs have been defined in the framework of the PVs in BLOOM Project as small-medium scale ground photovoltaic plants ranging from 50 kWp to 2-3 MWp.

1.1.1 Italy

In Italy a 2008 Legambiente Dossier[4] has censed the ***quarries*** that embroider the Italian peninsula. In the Dossier the first aspect that hits the eye is the fact that every area of the Italian peninsula is interested by extractive activity. According to the up-to-date figures, currently in Italy there are 5,725 active quarries and at least 7,774 exhausted ones.

This last figure is only partial, since in 9 regions the maps of the exhausted areas are unavailable; therefore the real number of exhausted quarries could actually be higher than 10,000.

The region with the largest number of active quarries is Puglia (617), followed by Veneto (594), Sicily (580), Lombardia (494), Sardinia (397), Piedmont (332), and Lazio (318). The region with the largest number of exhausted quarries is instead Lombardia, where the areas where extractive activities have been abandoned are 2,543, followed by Campania (1,237), Marche (1,041) and Sardinia (860). Calabria must be considered separately since there is no knowledge concerning the extractive activity on its territory and has transferred the authorization power to Municipalities with total absence of references to laws and regional control.

Of course not all of these sites are suitable for hosting a ground PV plant. Some conditions must occur, as for example an appropriate available surface, a certain distance from the grid connection, suitable cliviometry conditions, etc. Such conditions have been described in the PVs in BLOOM project document "Marginal areas: Approach and methodology of location and classification", 2009, summarizing them in technical-functional and localization criteria.

Hence, if we were to consider the potential PV power installable over exhausted quarries in Italy, we must skim from the total figure only the terrains that can reasonably be thought to meet the technical-functional and localization criteria. In order to make a rough estimate, let's say that a rounded down 5% of the exhausted quarries censed by Legambiente would reveal suitable for our purposes. 500 exhausted quarries in Italy turn out to be suitable for valorisation through PVPPs.

Considering installing an average 500 kWp plant on each site (of course the power varies according to the extension of the site), ***an increase of a good 250 MWp of sun electricity could be achieved in Italy only considering one out of the 10 typologies of marginal areas*** classified through the PVs in BLOOM Project[5] (reported at page 20 of this document).

Yet the most interesting scenario for installing renewable energy devices in Italy seems to be landfills. In order to offer some figures concerning this other marginal area typology in Italy, the Lead partner of the PVs in BLOOM Project, Unioncamere del Veneto, has carried out a targeted analysis in order to identify the number of existing landfills actually suitable for installing a PVPP in the regional territory (the Veneto region, north-east of Italy). The analysis underlines that the presence of landfills in a territory characterized by a widespread urbanization like Veneto (therefore having much less available terrain than other Italian regions, e.g. in the southern part of the peninsula), is not at all marginal,

[4] Legambiente, "Il punto sulle cave in Italia: I numeri, le leggi e ei piani, le buone e cattive pratiche", 2008
[5] PVs in BLOOM "Marginal areas: Approach and methodology of location and classification", 2009

as far as covered square meters is considered. In the Veneto region PVPP have started to be installed over marginal terrains only since 2009, also thanks to the efforts of the PVs in BLOOM Project.

According to the study, that is based on the regional authority's official censes, in Veneto 257 landfills have been officially censed, and out of these 117 are active, 24 exhausted, 44 in the post mortem phase, 44 expired, and 19 in other conditions.

Table 1 offers an overview of the landfill situation in the Veneto region:

	VENETO	Belluno	Rovigo	Vicenza	Verona	Padova	Venezia	Treviso
TOTAL	257	68	11	38	57	7	11	65
Active	117	45	4	22	18	3	6	19
Exhausted	24	1	3	1	3	3	2	11
Post-mortem	44	1	3	11	18	1	0	10
Expired	53	18	1	4	10	0	2	18
Others	19	3	0	0	8	0	1	7

Table 1: *Status of Veneto landfills divided by Province*

On the total 257 landfills officially censed, 121 have been analysed for our purposes (the exhausted, expired and in post mortem ones). Among these 121, the sites that had a surface inferior to 1,500 square meters or superior to 6 hectares have been excluded, being out of the range of the PVs in BLOOM target applications (50 kWp to 2 MWp). We have considered a minimum gross surface of 1,500-1,600 square meters for installing 50 kWp of PV energy. The choice of a generous unit of measurement (1,600 square meters) is meant to provide realistic projections considering both the installation of the PV panels and the space needed for all other electrical and technical devices included in a PV ground plantation.

Therefore, after the exclusion of the not suitable sites according to the technical-functional and localization criteria, 59 sites have been considered suitable for hosting a PVPP.

Here below there is the table of the technical and functional criteria analysis, which allows us to have a complete picture of Veneto landfills.

The values of Table 2 represent an aggregated sum of the analysed sites. Some of the 121 landfills no more in use are characterized by more than one "unfavourable feature", so that they have been counted several times, on the basis of the number of detected constraints.

PROVINCE	Suitable	Unfavourable exposition	Distance from the grid	Presence of constraints	Inadequate dimension
Belluno	5	10	6	10	3
Padova	2		2	1	1
Rovigo	3		4		1
Treviso	27		12	1	
Venezia	3		1		1
Verona	13		6	10	5
Vicenza	6		6	4	3
Total	**59**	**10**	**37**	**26**	**14**

Table 2: *Analysis of Veneto landfills according to the technical-functional criteria*

In the Appendix Table 16 gives a detailed overview of the landfills considered suitable for installing a PVPP in Veneto subdivided by Province, estimating for each site the potential installable power considering an average of 1,600 square meters for 50 kWp plant (using monocrystalline silicon, the most diffused technology on the market).

The 59 selected landfills of the Veneto region alone could produce ***43.05 MWp*** of RES electricity. In other terms we are speaking of 1.368.500 square meters of unexploited potential sources of revenue for public administrations. Hazarding a rough estimate for the hole of Italy, considering only the main 15 Italian regions, ***645.75 MWp*** of solar electricity power could be produced again just considering one of the existing typologies of marginal areas (landfills) and just for one European country (Italy), without touching a single inch of valuable agricultural land.

The data is even more significant if compared to the total PV power installed in the whole country in 2008 (664 MWp)[6]. This means that the national installed PV power could be doubled by addressing only one of the 10 identified typologies of marginal terrains.

1.1.2 Spain

In Spain the potentiality enclosed by the two main typologies of marginal areas present on the national scenario, ***landfills*** and ***mines***, is crushingly higher than that of Italy.

Data related to the surface used for mines and landfills in Andalusia has been collected by the University of Jaén (Project partner). The source is an official cense carried out in 2008 by la Consejería de Medio Ambiente de la Junta de Andalusia (regional government).

The total surface covered by mines and landfills in the sole autonomous community of Andalusia is ***44,602.29 hectares,*** about 0.51% of the community's total surface.

Even considering that after a hypothetical assessment of the technical-functional and localization criteria of each site only 5% of them turn out to be suitable for installing a PVPP, we can estimate fairly realistically that the autonomous community of Andalusia has the potentiality to host 69.9 MWp of PV energy from the remains of mining activity. This again considering only two of the at least ten typologies of marginal areas classified through the PVs in BLOOM Project and considering about 1,600 square meters for a plant of 50 kWp (using monocrystalline silicon).

Table 17 in the Appendix gives a detailed overview of the landfills and mines identified for each municipality in the Andalusia province of Jaén.

Once again, if we were to consider such solar electricity power as a reasonable mean indicator for the main 17 autonomous communities of Spain, more than ***1.183 GWp*** of solar electricity could be produced once more, as for the example of Italy, just considering two typologies of marginal areas (landfills and mines) and just in one European country (Spain).

1.1.3 Slovakia

In Slovakia landfills play a relatively less interesting role for our purposes,

[6] Source: www.gse.it

since according to the Slovak Environmental Agency (SAŽP – COHEM Bratislava), in 2006 the number of exhausted landfills in Slovakia was a scarce 158.
Figure 1 gives an overview of the distribution of the sites over the national territory.

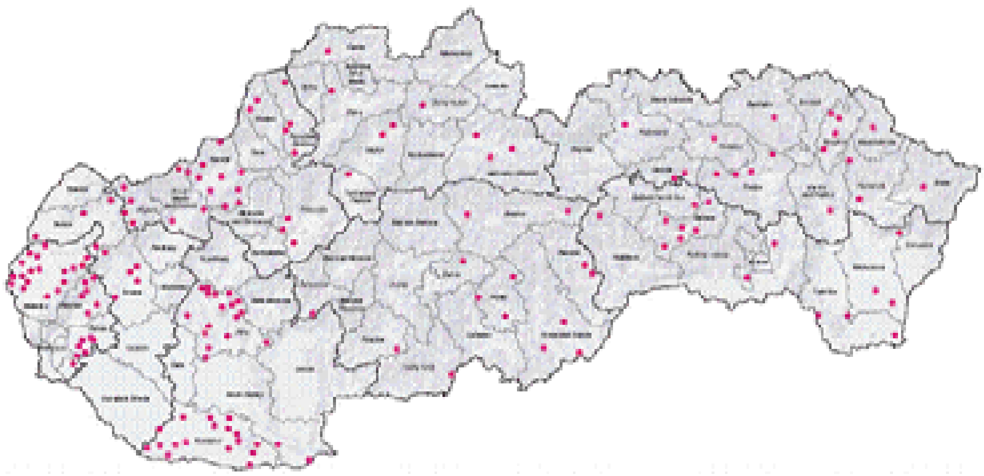

Figure 1: Exhausted landfills, Slovakia, 2006 (Image courtesy of Slovak Environmental Agency- SAŽP – COHEM Bratislava)

The most interesting feature of this country from the point of view of land valorisation has to do instead with contaminated soils.

According to a monitoring survey carried out by the Slovak Geology Research Office (Výskumný ústav pôdoznalectva a ochrany pôdy -VÚPOP) carried out from 1993 to 2009, the country hosts 25,154. 24 hectares of contaminated soils, areas classified as polluted or polluted that need to be reclaimed.
Figure 2 offers an outlook of their concentration on the national territory.

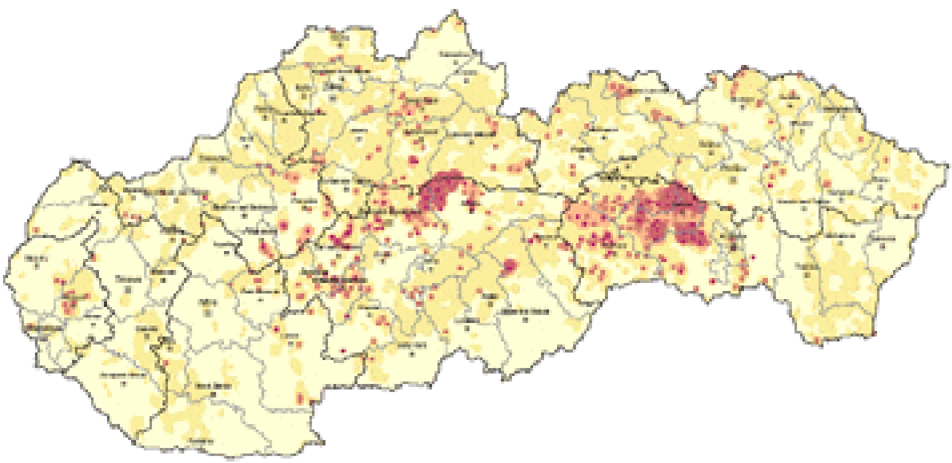

Figure 2: Contaminated soils, Slovakia, 2006 (Image courtesy of Slovak Environmental Agency- SAŽP – COHEM Bratislava)

Estimating that out of all these unused and under valorised hectares only 5% of this surface could realistically correspond to the required technical-functional and localization criteria, in a small country like Slovakia ***393 MWp*** of solar energy could be produces only considering contaminated soils (considering 1600 square meters for a monocrystalline silicon 50 kWp plant).

We deem useful to add to this analysis the fact that in the framework of the current land classification in force in Slovakia, areas inferior to 3 hectares can not be included as agricultural areas in the official land classifications. This leaves a question mark on the high potentialities of transforming non-classified often unused land into about 1 MWp PV plants.

A great number of potentially exploitable sites seem to be present in Slovakia, which could open interesting perspectives when using small-medium scale photovoltaics accessible in the first place to private or public-private investments.

1.2 Environmental and business opportunities that the diffusion of PVPPs implies

The previous paragraph gives an outlook on the potential opportunities linked with marginal area valorisation through Photovoltaics. It is interesting to point out some of the existing positive outcomes that a investment on a disused terrain can bring about, both from the environmental and business development point of view.

Among the environmental benefits linked with the installation of a PV device there are the following:

a. Electrical energy produced through photovoltaic systems does not produce any polluting emission. The functioning of a PVPP is zero-emission in case of grid connected systems and minimum in the case of stand-alone systems, linked exclusively to the substituting of the accumulation batteries.

b. Each kWh produced by a PV plant allows saving the emission in the atmosphere of roughly 540 grams of CO2 (keeping in consideration the current energy mix of the Italian market)[7]. This means, in the example of the 500 kWp plant of Carano mentioned in paragraph 2, currently producing on average 675,000 kilowatt hours a year of clean energy, that during its 30 year life-span it will allow to avoid the release of approximately 10,935 tons of CO2 emissions in the atmosphere.

c. The production of PV panels requires non negligible energy consumption, yet the positive energy balance of a PV plant over its minimum life-span (usually 20-25 guaranteed years) has been demonstrated since long time by various scientific sources. If one considers that the real life-span of silicon panels can be much longer than the usual 20 years (satellites demonstrate that after 40 years the energy production is still acceptable, with average reductions limited to 30%), one can think that, in actual terms, the balance can be even more positive in the long period. Moreover a PVPP, once installed, can be renewed after the life-span of its panels with new and more promising technologies. Where the area is already predisposed, the framework and electricity connection are

[7] Source: Italian Association of PV Industries (GIFI), http://www.gifi-fv.it/cms/it/notizie/1-mercato/328-il-fv-nel-2009-prospettive-di-sviluppo-e-strumenti-finanziari, 2009.

already available, the authorization path has already proven successful, refurbishing of pre-existing plants cuts down costs for continuing the production of renewable energy.

d. Investing in a PV plantation on specific marginal areas such as landfills or other areas actively producing CO2 emissions has a special value, since it can qualify the site as "zero-emissions". The investment moreover can also lead to take in consideration further interventions producing the reduction of CO2, such as biogas capitation plants or other devices.

e. Marginal areas such as no longer in use industrial sites or polluted terrains, which have heavy reclamation costs, or areas which require long biological or chemical regeneration periods, through a PVPP can start producing income straight away, allowing the terrain to re-establish its natural conditions during its non productive years.

f. Former military sites and other State-owned sites are also not easy to reclaim, and sometimes cover vast surface extensions of land. These environmental and landscape wounds can be medicated through the development of a low-visual impact PVPPs (also with modern green-mimetic geomembrane covers), reintegrating such location into the original landscape.

g. The use of marginal areas does not subtract terrain to agricultural land, exploiting instead land made useless by atrophic action. This is particularly valuable for countries in old Europe that cannot afford to use up large valuable-land surface extensions.

Alongside with unquestionable benefits for the environment, land valorisation through PVPPs brings about many development opportunities for local economies.

Among such opportunities, we can list the following points:

a. Local companies of the PV supply chain and linked industry develop and grow.

b. The PV industry is currently a strategic business sector: the European PV market is growing by 39% a year[8] and represents an opportunity that private companies and utilities can not step out of.

c. Opportunities for strategic alliances between utilities, the PV industry and other companies are created.

d. For utility companies, the possibility of attracting new customers occurs. This not considering that some attributes of photovoltaics could become crucially important for electricity suppliers or distributors in the future – e.g. PV as an opportunity for diversification and penetrating new markets or to improve the green image of utilities. Both points seem evident, considering the increasing amount of utilities offering green power products as a distinguishing element in liberalized and competitive markets.

e. The contribution of PV energy to the reduction of peak conventional electricity demand is also an important value to be taken in consideration.

f. Infrastructure development is strictly intertwined with the realization of new PV plants.

[8] EPIA, "Global market outlook for Photovoltaics until 2013", 2009.

g. The interaction with other RES sources will be enhanced giving way to a positive spiral of growth in the other sectors of the RES market.

h. The reclamation of marginal areas with PVPP investments will give additional value to the same marginal terrains and surrounding area, and positive spirals of growth towed by the recovering/reusing of the degraded/marginal areas will start-off (think of the creation of Solar parks, RES Parks, RES Platforms, and many other solutions).

i. Synergies with agricultural/commercial/industrial or other energy-consuming activities can occur.

j. Photovoltaic systems allow electricity rates to be locked at current prices. With fossil fuels likely to become more expensive in the future, purchasing a PV system today can reveal to be an intelligent economic move for private companies and citizens.

k. Independence can be achieved by the local industry with reference to power supply and the linked price developments.

In the Appendix, further indications are given also on the scale of the potential economic return on investment of a PV plant, through a three-case analysis. Considering all the direct and indirect advantages linked in the paragraph above, outcomes will reveal even more positive when installing a PV plant on a marginal terrain.

1.3 Marginal terrains: the "embedded treasure" of each European municipality

It is clear at this point that the potential impact of PVPPs on land valorisation in the EU-27 (considering especially the new member States) is remarkably high.

However, this vision must be compared with the existing policy framework of many European countries. The trend and sensitiveness of local, regional and national authorities is currently not so in line with the potential opportunities described through the figures above.

This document will show in the next paragraphs how many local realities in Europe are already projected in a modern, desirable, and economically advantageous future, being now able to answer to the demand of energy from local industry and citizens as well as ensuring environmental protection and producing economic income for the public administration's needs. Many local administration's best practices attached to this document in fact demonstrate that concrete results are possible both at the economic and at the environmental and energetic level, thanks to the re-valorisation of zero-value marginal areas through PVPPs. These real cases have been inserted in this document precisely for demonstrating that investing in PVPPS is not only possible, but can also be a far-sighted and convenient choice.

One for all, we anticipate a summary of the experience of the Municipality of Carano, (Trento, Italy), where a PVPP of 500 kWp has been installed over a former porphyry quarry on the side of a mountain at 1,200 meters over the sea level (Locality "I Corozi").

The "I Corozi" plant:

a. Covers the energy demand of three quarters of the Carano municipality's population;
b. Has avoided the high environmental reclamation costs of the area due to the former extractive activity;
c. Guarantees a return to the Municipality of approximately ***300,000 euro per year*** net after maintenance costs (the National Authority for Electric Energy and Gas grants, through the feed-in tariff system, 0.47 euro per kilowatt-hour produced), which allows the Municipality of Carano to maintain its balance in the black, to supply free services to citizens, to carry out supplementary investments for the growth and development of the local community;
d. Assures significant abatement in CO2 production;
e. Confers new social value to a dismissed extractive area with ongoing didactic activities for scholarships and citizens;
f. Guarantees energy security and self-sufficiency to a consistent part of the municipality's population and business tissue;
g. Will be allow the Municipality to amortize the cost of its investment in ten years (the total investment amounted to approximately 3.2 million euro).

Effective income for public administrations, real savings for families, social value for the community, positive impacts on employment with multiplier effects for the local economy are all achievable goals connected with the valorisation of zero-value terrains such as areas degraded by marginality.
Local policy makers and governments have the duty of contributing to increase societal welfare[9]. Societal welfare includes among others mediating the negative environmental consequences of land use, sustaining the production of essential resources, and safeguarding the competitive advantages of the sites which are degrading.

The responsibility of local public administrations in territorial planning is decisive for the future development of local environments and economies.

This responsibility can be used as an opportunity when including specific measures for enhancing the reclamation of marginal areas through PVPPs. The tools already available are many: favourable regulatory conditions, normative special terms, tax breaks, incentives, simplified administrative procedures, guidelines for reclamation through RES applications, directing European or regional/national funds to aid this kind of interventions, pilot initiatives. Each one of these measures contributes to channel investments in the direction of sustainable and qualified growth.

Laudable efforts in this direction have been made by the regions of Sardinia and Piedmont, in Italy.
The Sardinian Regional government in 2007 has enriched its regional legislative framework on RES by issuing "*Guidelines for the identification of potential impacts of photovoltaic systems and their correct inclusion in the territory*", which reads as follows:
"…*the installation of Photovoltaic plants is allowed on the following areas: a) areas belonging to manufacturing plants, to agricultural farms, water purifiers, purifiers for*

[9] IEA Report, "Analysis of PV System's value beyond Energy", 2008.

treatment plants, waste recovery and disposal plants, areas covered by water lifting equipment or service activities in general, for which the installation complements or replaces the energy supply in a self-production system, as defined in Article 2 paragraph 2 of the Legislative Decree of the 16th of March, 1999, number 79 …;
b) industrial areas or craft activities areas as identified by the existing public planning tools and categories such as: Plans for Productive Activities (in Italian "PIPs"), Industrial areas of regional interest ("ZIIRs"), Industrial Development Areas ("ASIs");
c) areas that are jeopardized from the environmental point of view, including: c.1) perimeters of controlled waste in landfills in compliance with the rules of the Decree 36/03;
c.2) perimeter areas of disused quarries, owned by public or private bodies… "

The Guidelines therefore declare explicitly which are the areas (marginal areas) where the installation of ground PV Plants is allowed, unravelling the many possible doubts regarding compliance with the administrative, landscape and urban planning lines set by the regional government. This is useful both for the investors (public or private) which find themselves in conditions of certainty when approaching an investment of one of the listed areas, and for the public offices in charge of the authorization procedures and of the eventual release of the Environmental Impact Assessment clearance.

In 2008 the Piedmont Region, in the framework of the Structural Funds (ERDF Regional Operative Programme 2007-2013) issued a Call granting "*Incentives for generating electricity from solar energy in exhausted landfills and landfills in the post-operative management stage*". The call promoted investments in PV plants over exhausted landfills and landfills that were in the post-operative management phase, in particular areas with the following features:

- Areas used as landfills for inert waste or non-hazardous waste;
- Areas with a minimum extension of 10,000 square meters;
- Areas located in the Piedmont Region.

Moreover, interventions, in order to be funded, were supposed to take into account the need of minimizing the impact of PV installations over the interested areas, to respect proper environmental and landscape integration, and to consider the reflecting effect linked with the panels and possible problems related to the surrounding environment.

Great experience and attention for valorisation of marginal areas can be found in Germany, and in particular in Baden Wurttemberg, where a recent study carried out in 2009 thanks to a parliamentary initiative photographs the following situation:

- In the Laender of Baden Wurttemberg 12 landfills with photovoltaic installations (operating or under construction) already exist;
- 16 facilities in landfill areas are planned to be newly built within the next five years [10].

[10] For additional details see "Landtag von Baden-Württemberg Drucksache 14 / 4441" – Wahlperiode, 05. 05. 2009

The Saarland Laender also has a strong focus on renewable energy development within landfill areas. The region in fact can boast the following experiences:

- Merzig-Fitten landfill, 2.9 MWp (in progress)
- Riegelsberg landfill, 1 MWp (planned) and Saarlouis-Lisdorf landfill, 2 MWp (planned).

These are just a few examples of how the regulatory framework can be used for directing investments towards winning solutions from the land optimization and valorisation point of view, producing a vast economic positive spiral (interesting occupation, growth of the PV supply chain industry, business and investor's cash flows,…), as well as guiding a territory towards its own future sustainable development.

Enlightened local policies can determine great environmental footprints and virtuous spirals of growth. Every missed investment is a missed opportunity for development.

2. PVPP implementations on marginal areas

2.1 Preliminary introduction

As mentioned in the previous paragraphs, the PVs in BLOOM Project moves from the consideration that valuable and fertile terrains are vital not only for agricultural purposes but also for many other activities and for territorial development in general. Yet, alongside productive terrains, another reality exists: that of unfertile, barren or non-used land, that the PVs in BLOOM Project has called "marginal areas" and accurately classified in order to enhance the identification of its most diffused typologies.

Preserving valuable and fertile terrains and finding ways to exploit marginal areas is a strategy that not only allows the optimization of existing resources, but also pursues sustainability by marrying profitability with environment-friendly solutions. Moreover, this approach generally allows recovering and giving back value to terrains that would have otherwise irreparably lost it.

To open successfully the way to an easier identification and assessment of existing marginal terrains, a shared European classification and methodology for identifying and quantifying marginal terrains has been created. The methodology allows operating at different administrative levels (municipal, provincial, regional), and was produced in collaboration with the Faculty of Architecture of the University of Venice (IUAV).

We report below a summary of the classification. The complete document[11]

[11] PVs in BLOOM "Marginal areas: Approach and methodology of location and classification", 2009 (contacts on the web-site: www.pvsinbloom.eu)

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- Riegelsberg landfill, 1 MWp (planned) and Saarlouis-Lisdorf landfill, 2 MWp (planned).

These are just a few examples of how the regulatory framework can be used for directing investments towards winning solutions from the land optimization and valorisation point of view, producing a vast economic positive spiral (interesting occupation, growth of the PV supply chain industry, business and investor's cash flows,…), as well as guiding a territory towards its own future sustainable development.

Enlightened local policies can determine great environmental footprints and virtuous spirals of growth. Every missed investment is a missed opportunity for development.

2. PVPP implementations on marginal areas

2.1 Preliminary introduction

As mentioned in the previous paragraphs, the PVs in BLOOM Project moves from the consideration that valuable and fertile terrains are vital not only for agricultural purposes but also for many other activities and for territorial development in general. Yet, alongside productive terrains, another reality exists: that of unfertile, barren or non-used land, that the PVs in BLOOM Project has called "marginal areas" and accurately classified in order to enhance the identification of its most diffused typologies.

Preserving valuable and fertile terrains and finding ways to exploit marginal areas is a strategy that not only allows the optimization of existing resources, but also pursues sustainability by marrying profitability with environment-friendly solutions. Moreover, this approach generally allows recovering and giving back value to terrains that would have otherwise irreparably lost it.

To open successfully the way to an easier identification and assessment of existing marginal terrains, a shared European classification and methodology for identifying and quantifying marginal terrains has been created. The methodology allows operating at different administrative levels (municipal, provincial, regional), and was produced in collaboration with the Faculty of Architecture of the University of Venice (IUAV).

We report below a summary of the classification. The complete document[11]

[11] PVs in BLOOM "Marginal areas: Approach and methodology of location and classification", 2009 (contacts on the web-site: www.pvsinbloom.eu)

can be requested to the Lead partner Unioncamere del Veneto, Italy.
Categories of marginal areas:

1. Open air extractive areas that are not in function any more;
2. Open air extractive areas that are near to exhaustion;
3. Landfills of any type that are not in function any more;
4. Landfills of any type that are near to exhaustion;
5. Degraded areas, where degrade is due to the absence of vegetation or to the exclusion from existing land classifications, including the urban area or transformation area classes;
6. Dismissed industrial areas;
7. Polluted areas to be recovered or other areas enrolled in the register of polluted areas;
8. Sowable terrains that have never vegetated (barren agricultural areas);
9. Agricultural areas that are not fit for agro-forestry and pastoral use;
10. Buffer zones (Clear areas):
    - **10.1.** Buffer zones around linear infrastructures (roads, railways, long distance power lines, long distance gas lines/oil lines, etc.);
    - **10.2.** Cemetery buffer zones;
    - **10.3.** Depuration plant buffer zones;
    - **10.4.** Airport buffer zones;
    - **10.5.** Radio antennas buffer zones;
    - **10.6.** Buffer zones around areas with high risk of relevant accidents;
    - **10.7.** Buffer zones of plants for the recovering and disposal of waste;
11. Militar areas:
    - **11.1.** Not functioning any more;
    - **11.2.** Being dismissed;
12. State-owned areas.

All these areas are to be taken in consideration when free from landscape, archaeological or environmental restrictions.

The methodology for the geographic identification of marginal areas and for assessing their number at the municipal, provincial or regional level, foresees the application of a four-step procedure. This procedure envisages the application of the criteria described below.

1. **Identification criteria**: An area is to be considered “marginal” according to its *function*. A terrain which has no possibility of being used has good chances of being tagged as “marginal”. The marginality of an area can refer to different cases: *intrinsic, induced or latent marginality.* Marginality is *intrinsic* when it is indivisible from the area itself, it can is *induced* when the area’s use or value is erased by political/legal/city planning or by other administrative choices. It is instead *latent* when an area, sometimes even a vast surface, is completely abandoned due to the specific legal bounds pending on it.

Several territorial elements characterizing potential "marginality" are identifiable when considering the general urban/landscape planning tools in force in European countries. A simple list of urban categories is not enough to state the marginality of an area: it can be the result of a combination of factors. That's the reason why starting from the first level analysis mentioned above, the marginality status must be linked to the negative or positive evaluation of some further features, which can determine a high or low level of potential marginality, as described in the following point.

2. **Primary criteria**: The water-impermeability of a terrain contributes to marginality since it prevents the ground from carrying out its basic functions damaging the eco-system. For the same reasons the areas jeopardized from a geological point of view can be considered marginal as well. If the modification of the geological conditions due to geological interventions involves the deeper layer of the terrain, this has to be considered irreparably damaged, so giving it a characteristic in favour of the attribution of marginality. The modifications of the geological horizons must be evaluated especially in the case of landfills and extractions activities. The presence of pollutants is another element which contributes to the attribution of marginality because of the expensive and time-consuming land reclamation needed. In agricultural areas, this means having to immediately cease all the agricultural activity, while in areas fallen into disuse, the reclamation must be all the same carried out before any future use is possible. In order to determine the presence of pollution it is necessary to verify that in the analyzed terrain there are no areas registered in the public register of polluted sites. Also other analysis by the public utility dealing with such issues must be taken in consideration. This will the presence of conditions favouring the attribution of marginality. The presence of economic activities excludes marginality and can be inferred from urban planning tools. If the urban planning tools envisage future economic activities on a specific area, a marginality evaluation is to be also definitively excluded. A preservation order is of course an undoubted signal of non- marginality due to the high values of the area generally from the landscape point-of-view, and therefore the area will be excluded from our marginality evaluation being not disposable. The presence of clear areas/anthropic constraints represents instead a potential marginality feature as it is usually just a matter of hygienic, sanitary or security problems, that don't exclude other uses such as the installation of a PV plant.

Once the marginal areas are located through the 2 steps above, a third step is needed for verifying functional and technical criteria to confirm the suitability of actually installing a PVPP.

3. **Technical and functional criteria**: The technical and functional criteria are needed in order to verify if the chosen area has all the necessary requirements for the installation of the Photovoltaic Plantation, such as accessibility to the needed facilities for building

and maintenance of the plant or the availability of connections to electrical distribution points that rationalize the investment cutting down costs. The identified functional criteria may be defined as:

- **a.** exposition of the area;
- **b.** cliviometry of the area;
- **c.** surface extension;
- **d.** proximity to the grid;
- **e.** adequate road conditions for heavy trucks;
- **f.** absence of geological risks;
- **g.** absence of hydraulic risks;
- **h.** absence of seismic risk.

The last set of criteria, listed in point 4 below, allows us to favour areas that allow the positioning of the PVPP in areas that absorb high levels of electrical energy and of course in proximity of the electrical grid.

4. **Localization criteria**
   - **a.** proximity of public service plants;
   - **b.** proximity to industrial areas;
   - **c.** proximity to big commercial areas.

Yet how to apply the selection criteria following a repeatable methodology? The cartographic identification of marginal areas is possible through the use of GIS softwares and by overlapping different maps reproducing the different criteria. In a first phase the non-marginal areas at the local scale must be excluded by overlapping the local and urban/landscape planning tools. In a following step the listed categories will be selected on the remaining areas in order to verify the presence of potential marginal areas. At the end it will be verified if and to what extent these areas meet all the technical-functional and localization criteria.

Once having defined marginal areas and a methodology for their identification, it is useful also to have a basic knowledge concerning different PVPP system typologies and their implementation, with a special focus on those located on, or in proximity of, a marginal terrains. The following paragraphs examine and codify in practical descriptive tables the existing PVPP systems, creating an inventory of the different existing technologies for PV modules and ground implementation systems. Moreover, grid tables for judging quickly the most suitable systems with reference to specific marginal terrains have been developed, for a first easy broad evaluation of a potential investment.

2.2 Differentiation of PVPPs according to technology and in-field application characteristics

A way to describe and evidence differences among PV technologies can be to compare their functioning and performance features.
The table below developed through a Degree Thesis of the Dept. of Mechanical Engineering of the University of Padua[12], Italy, assigns numerical evaluations to

[12] David Tosin, "Il solare fotovoltaico su terreni marginali. Valutazioni tecniche per guidare la scelta di tecnologia fotovoltaica e configurazione di un impianto in relazione alle condizioni dei siti marginali di destinazione", 2009.

the four main existing technologies according to their technical features.
The evaluation formulated for each aspect is not absolute but can be deemed to have only relative value with the purpose of confronting the different technologies among themselves.
The scale ranges from -2 to +2:

- (-2) the technology presents some big inefficiencies with reference to the considered technical variable;
- (-1) the technology presents some problems with reference to the considered technical variable that limit its performance in comparison to other technologies;
- (0) the technology does not present problems with reference to the considered technical variable yet this is not one of its strong points;
- (1) the technology presents some advantages with reference to the considered variable in comparison to other technologies;
- (2) the technology is very efficient and has better performances than the others with reference to the considered technical variable.

Table 3: *Matching PV technologies with technical variables*

Technology	Crystalline Silicon	Triple-junction amorphous silicon	CdTe	CIGS
Conversion effect	2	1	-1	0
Dep. from temperature	0	2	1	0
Performance in time	2	1	1	1
Sensitivity to shadows	-1	1	1	1
Tilt & orientation	0	1	0	0
Diffused radiation	0	2	1	1
Low radiation	0	2	1	1
Spectrum sensitivity	0	1	1	1

Once having offered an overview of single PV technologies, differences among PVPP systems can be described linking technology types to different ways of applying them on the ground (systems). We suggest an example of classification in Table 4 below.

Table 4: *Matching PV technologies with PV systems*

	TECHNOLOGY						
PVPP SYSTEM MAIN TYPOLOGY	**Sylicon mono-policristalline**	**Thin Film Sylicon amorphous (RIGID)**	**Thin Film Sylicon (multijunction) (RIGID)**	**Thin Film silicon (multijunction) (FLEX)**	**Thin Film CaTe (RIGID)**	**Concentration of light trough lens**	**Concen tration of light by reflecting curved surface -parables-**
FIXED PANELS (STEM GROUND SCREWED)	PVPP TYPE **A1)**		PVPP TYPE **C1)**		PVPP TYPE **E1)**		
SEMIFIXED PANELS (STEM GROUND SCREWED)	PVPP TYPE **A2)**	PVPP TYPE **B1)**			PVPP TYPE **E2)**		
FIXED PANELS (STEM OR SUPPORT POINT ON COCRETE BASE)	PVPP TYPE **A3)**		PVPP TYPE **C2)**		PVPP TYPEE **E3)**		
SEMIFIXED PANELS (STEM OR SUPPORT POINT ON COCRETE BASE)	PVPP TYPE **A4)**	PVPP TYPE **B2)**			PVPP TYPE **E4)**		
SUN TRAKING/ FOLLOWING PANELS	PVPP TYPE **A5)**				PVPP TYPE **E5)**	PVPP TYPE **F1)**	PVPP TYPE **G1)**
PV PANELS PLACED (e.g. ON TANKS) ON THE GROUND SURFACE	PVPP TYPE **A6)**	PVPP TYPE **B3)**	PVPP TYPE **C3)**		PVPP TYPE **E6)**		
CANVAS PLACED ON THE GROUND SURFACE				PVPP TYPE **D1)**			

2.3 Procedure for the preliminary evaluation of PVPP suitability referred to a marginal terrain: an easy-to-use assessment tool

Assessing the suitability of a marginal terrain for hosting a PVPP is not a simple issue. It is possible however to offer a easy-to-use assessment tool for verifying general conditions and supporting the first phase of decision making of public or private investors that wish to have an idea of which areas could be effectively addressed by re-qualification through a PVPP.

Before describing the procedure, some general considerations must be made. It can appear clear that rocky, sandy or subsidence terrain is not advisable for any PVPP typology, and that terrains with risk presence –geological, hydro or seismic- should not be considered. Regarding cliviometry, high land slope -above 5%- hinders the deployment of PVPP that use tracking techniques, but under certain conditions, high land slope is a neutral item in the case of static and semi static modules.

Terrains with indented surfaces should be avoided: this is a powerful barrier for the necessary civil works to deploy a PVPP. The operation and maintenance of the plant could also turn out to be a difficult task. Wet or waterlogged grounds may not pose obstacles for PVPPs. Regular surfaces are obviously the preferred ones.

As it may be easily understood, sites with high irradiation profiles will lead to a substantial solar electricity production. Terrains with an annual average horizontal irradiation below 900 kWh/m2 should be disregarded. If Crystalline Photovoltaic panels are to be installed, at least some annual average normal direct irradiation of 1800 kWh/m2 is recommended. Severe shadowing should certainly be avoided, but energy losses caused by small shadowing at the down and sunset in Winter may be not considered, and the area would be acceptable. Solar cell performance benefits from cooling through forced convection by means of wind, so in the case of static and semi static PVPPs, moderate windy areas (maximum wind speed of some 30-40 km/h) favour solar electricity production. However, highly windy zones (frequent wind peaks above 60 km/h) are not suitable for PVPPs that use tracking techniques. In such zones, at best, the tracking systems will frequently change their operation to the stow position and the energy yield will be negatively affected. At worst, some of these systems can be seriously damaged.

The negative effect of dust was underestimated in PVPPs in the past. Recent studies prove that energy losses up to some 15-20% might take place due to dust and dirtiness. Consequently, dusty marginal terrains should be avoided. Besides, special attention must be paid to the neighbouring areas of the marginal terrain where the PVPP is to be deployed. For instance, arable surrounding areas in dry climates are not advisable.

If the marginal terrain climate is not too cloudy: this would affect the annual average horizontal irradiation- rain may help to keep the PV modules clean. Consequently, moderate monthly average rainfall values (5-7 cm) are beneficial for any PVPP typology.

Easy access to grid connection is highly advisable, as well as easy road access to the marginal area is advisable for two reasons. First, transportation of all the necessary material to deploy any PVPP will be much easier and less costly. The same applies to the operation and maintenance tasks to be carried out through the useful life of the PVPP.

Communication coverage: Internet access availability, GPRS, etc- is increasingly becoming important. Electric companies: which in the end, buy the generated electricity- usually force owners of large and relatively isolated PVPPs in marginal terrains to provide remote access to their energy meters.

To preliminarily assess the suitability of a marginal terrain to host a PVPP, one can use the following Table with horizontal coloured band strips (Red = bad

matching; Green = positive matching; Yellow = matching requiring further specific considerations) and check by spots (x) how the characteristics of the marginal land under evaluation distribute along the colour band strips.
Naturally, when red bands occur and predominate on the other colours, this must be considered an alert or a prohibited situation for PVPP investments.

Table 5: *Tool for evaluating terrain characteristics with reference to a PVPP*

A) TERRAIN GENERAL CHARACTERISTICS	B) INFLUENCE OF LOCAL VARIABLES ON THE PVPP FEASIBILITY	C) MARGINAL TERRAIN CHARACTERISTIC MASK	D) REMARKS
	Red=critical **Yellow=acceptable** **Green=good**	**Marginal land to be evaluated:** **XY......... (example)**	**General remark:** red bands must be considered an alert of prohibited situation
TERRAIN CONSISTENCY			
- Rocky			
- Sandy			
- Subsidencial		X	
RISK PRESENCE			
- Geological			
- Hydro			
- Seismic		X	
CLIVIOMETRY			
Slope High (%)		X	
Slope Low (%)			
SURFACE /COUNTOUR			
- Wet/waterlogged			
- Regular		X	
- Indented			
OBSTACLES to SUNLIGHT			
- Morning			
- Evening		X	
INSOLATION			
High >1,400 KWh/m2/year			
Medium 900<.X < 1,400			
Low < 900 KWh/m2/year		X	
WIND SPEED			
High (m/sec)			
Low (m/sec)		X	
DUST			
High			
Low		X	
RAIN (Atmospheric events)			
High (Cm/month)		X	
Low (Cm/month)			
CLOSENESS TO the GRID CABIN			
Low Voltage			
- Distance (> 500 meter)			
Middle Voltage			
- Distance (>200 meter)			
High Voltage			
- Distance (>200 meter)			
ROAD ACCESSABILITY			
- Wide asphalted road		X	
- Narrow sandy lane			
COMMUNICATION COVERAGE (GSM, GPRS, GPS or…)			
Yes		X	
No			
			Summary remark: the marginal terrain, taken as an example (marked by an **X** in column C), demonstrates critical features for installing a PVPP

The evaluation could continue by comparing terrain characteristics of a marginal area with strength and weakness points of a PVPP system typology discussed in Table 5. The Table below offers an example considering the PVPP system typology A1) (silicon mono-policrystalline on fixed panels - ground screwed).

Table 6: *Suitability of a PVPP system typology for a marginal land*

TERRAIN GENERAL CHARACTERISTICS	MARGINAL LAND	PVPP TYPOLOGY		REMARKS/ RACCOMANDATIONS
	Marginal land type: LANDFILL ...... (example)	PVPP TYPE A1) .... to be evaluated		
		STRENGTH	WEAKENESSES	
TERRAIN CONSISTENCY			X	
- Sandy			X	
- Subsidencial	X		X	
RISK PRESENCE				
- Geological			X	
- Hydro			X	
- Seismic	X	NEUTRAL	NEUTRAL	
CLIVIOMETRY				
Slope High (%)	X		X	
Slope Low (%)		NEUTRAL	NEUTRAL	
SURFACE /COUNTOUR				
- Wet/waterlogged		NEUTRAL	NEUTRAL	
- Regular	X	X		
- Indented			X	
OBSTACLES to SUNLIGHT				
- Morning			X	
- Evening			X	
INSOLATION				
High >1,400 KWh/m2/year		X		
Medium 900<.X < 1,400		NEUTRAL	NEUTRAL	
Low < 900 KWh/m2/year	X		X	
WIND SPEED				
High (m/sec)		NEUTRAL	NEUTRAL	
Low (m/sec)	X	NEUTRAL	NEUTRAL	
DUST				
High	X		X	
Low		NEUTRAL	NEUTRAL	
RAIN (Atmospheric events)				
High (Cm/month)	X	NEUTRAL	NEUTRAL	
Low (Cm/month)		NEUTRAL	NEUTRAL	
CLOSENESS TO the GRID CABIN				
Low Voltage				
- Distance (> 500 meter)			X	
Middle Voltage				
- Distance (>200 meter)	X		X	
High Voltage				
- Distance (>200 meter)			X	
ROAD ACCESSABILITY				
- Wide asphalted road	X	NEUTRAL	NEUTRAL	
- Narrow sandy lane		NEUTRAL	NEUTRAL	
COMMUNICATION COVERAGE (GSM, GPRS, GPS or…)				
Yes		X		
No			X	

The evaluation could continue by comparing the terrain characteristics of the marginal area with the strength and weakness points of a PVPP system, in order to be able to choose the most suitable PVPP system with reference to a specific marginal area.

In the following Table 7 shows in a very simple and intuitive way how different PVPP system typologies fit (red=no matching, yellow=matching with reserve, green=good matching) with the most diffused kinds of marginal terrain typologies.

Table 7: *Matching PVPP systems with different terrain typologies*

	HIGH INSOLATION (1,400 - 1,600 kWh/mq/year)				LOW INSOLATION (900 - 1,100 kWh/mq/year)			
PVPP SYSTEM TYPE	LANDFILL	OPEN QUARRY	MINING AREA	AREA in PROXIMITY OF MARGINAL TERRAINS - FLAT AND REGULAR	LANDFILL	OPEN QUARRY	MINING AREA	AREA in PROXIMITY OF MARGINAL TERRAINS - FLAT AND REGULAR
A.1	NO	YES	YES	YES	NO	NO	NO	NO
A.2	NO	YES	YES	YES	NO	YES	YES	YES
A.3	NO	YES	YES	YES	NO	NO	NO	NO
A.4	NO	YES	YES	YES	NO	YES	YES	YES
A.5	NO	YES	YES	YES	NO	YES	YES	YES
A.6	YES	NO	NO	NO	YES	NO	NO	NO
B.1	NO	YES	YES	YES	NO	YES	YES	YES
B.2	NO	YES	YES	YES	NO	YES	YES	YES
B.3	YES	YES	YES	YES	NO	YES	YES	YES
C.1	NO	YES	YES	YES	NO	YES	YES	YES
C.2	NO	YES	YES	YES	NO	YES	YES	YES
C.3	YES	NO	NO	NO	YES	NO	NO	NO
D.1	YES	YES	YES	YES	YES	YES	YES	YES
E.1	NO	YES	YES	YES	NO	YES	YES	YES
E.2	NO	YES	YES	YES	NO	YES	YES	YES
E.3	NO	YES	YES	YES	NO	YES	YES	YES
E.4	NO	YES	YES	YES	NO	YES	YES	YES
E.5	NO	YES	YES	YES	NO	YES	YES	YES
E.6	YES	NO	NO	NO	YES	NO	NO	NO
F.1	NO	NO	NO	YES	NO	NO	NO	YES
G.1	NO	NO	NO	YES	NO	NO	NO	YES

Legend:

NO	No matching
YES	Matching with reserve
YES	Good matching
A.1	Sylicon mono-policristalline - Fixed Panels (Stem ground screwed)
A.2	Sylicon mono-policristalline -Semifixed Panels (Stem ground screwed)
A.3	Sylicon mono-policristalline - Fixed Panels (Stem or support point on concrete base)
A.4	Sylicon mono-policristalline - Semifixed Panels (Stem or support point on concrete base)
A.5	Sylicon mono-policristalline - Sun tracking/ following panels
A.6	Sylicon mono-policristalline - PV Panels placed (e.g. on tanks) on the ground surface
B.1	Thin film Sylicon amorphous (RIGID) - Semifixed panels (Stem ground screwed)
B.2	Thin film Sylicon amorphous (RIGID) - Semifixed panels (Stem or support point on concrete base)
B.3	Thin film Sylicon amorphous (RIGID) - PV Panels placed (e.g. on thanks) on the ground surface
C.1	Thin film Sylicon (multijunction) (RIGID) - Fixed Panels (Stem ground screwed)
C.2	Thin film Sylicon (multijunction) (RIGID) - Fixed Panels (Stem or support point on concrete base)
C.3	Thin film Sylicon (multijunction) (RIGID) - PV Panels placed (e.g. on tanks) on the ground surface
D.1	Thin film Sylicon (multijunction) (FLEX) - Canvas placed on the ground surface
E.1	Thin film CaTe (RIGID) - Fixed Panels (Stem ground screwed)
E.2	Thin film CaTe (RIGID) - Semifixed Panels (Stem ground screwed)
E.3	Thin film CaTe (RIGID) - Fixed Panels (Stem or support point on concrete base)
E.4	Thin film CaTe (RIGID) - Semifixed Panels (Stem or support on concrete base)
E.5	Thin film CaTe (RIGID) - Sun Tracking/following panels
E.6	Thin film CaTe (RIGID) - PV Panels placed (e.g. on tanks) on the ground surface

If one would wish to complete the assessment cycle, it could be useful to pass from a pure qualitative three level go-no go representation like the one above (Table 7) to a ranking comparative table, which compares the matches between marginal area typologies and PV technologies, in order to get back to their performance differences. A very useful effort in this direction has been carried out by the above mentioned Degree Thesis of the University of Padua, Italy (the analysis considers as base conditions the features of the Veneto region, northern Italy).

Table 8 below summarizes the results of the carried out evaluations: for each site the related classification of most performing technologies is evidenced.

Table 8: *Ranking of some technology/ terrain matches*

Technology	Veneto	Embossed Landfill	Landfill on Slope area	Landfill in Pit	Terrace Quarry
Crystalline silicon	2°	1°	1°	1°	1°
Triple junction amorphous silicon	1°	1°	2°	2°	2°
CdTe	3°	3°	4°	4°	4°
CIGS	3°	3°	3°	3°	3°

The results reported in Table 8 need some explanations in order to be understood in their full meaning.

It is possible to verify how, for applications located in the Veneto region, amorphous silicon generally stands at the first place, while with reference to specific terrains it does not stand at the first place except for the case of embossed landfills. This can be explained by the fact that amorphous silicon in an open area with no limit to surface occupation (given the same climatic conditions) proves to be more performing than other technologies. For every installed kWp the implementation surface goes from two to three times that of the one required by other technologies. This explains why mono and polycristalline silicon are at the first places of our ranking, even though the reduction of the cost per panel and of the BOS (Balance of System) for amorphous silicon and CdTe are drastically lower. Moreover, it is actually rare to find existing applications in amorphous silicon, since industrial applications in multi-layer amorphous silicon are new technologies and there is little knowledge regarding their reliability in time.

Reliability and durability are important items to be considered when deciding which technology matches best a given terrain. New technologies lack of on-field experience concerning reliability and durability over time, so perhaps recommending an unproven new technology as the most performing one could be risk-ful. The results of Table 8 therefore must be intended as figure to be linked with considerations of reliability and durability of the technology.

2.4 Models at the base of the decision to set up a PVPP on a marginal area

2.4.1 The PVPP applications censed during the first phase of the PVs in BLOOM project

In the framework of the PVs in BLOOM project existing or in progress PVPPs on marginal areas of different European countries have been identified. Overall more than 50 Best Practices have been collected and laid down in descriptive tables, catalogued as follows:

- Landfills/waste dumps
- Quarries/mines
- Industry areas
- Brownfields/dangerous industrial sites
- Degraded/contaminated areas
- Bounded areas/access limited areas
- Former military sites/airports
- Buffer zones

It is worthwhile to stress that while many best practices regarding landfills have already been implemented in Europe, and many are also the cases of installations on terrains surrounding industrial areas, both where industrial activity is active and abandoned (brownfields), still little has been carried out on active or abandoned mines and quarries, for which it is only possible to find preliminary studies or projects.

2.4.2 Models decoded from Best Practices and enriched with interviews to municipalities, suppliers and stakeholders

Looking at the best practices gathered by the PVs in BLOOM partners concerning marginal area valorisation through PVPP applications, one may say that the operative models on which they are based are directly or indirectly related to PVPPs.

We can say there is an indirect relationship when the PVPP investment is only a part of the overall investment (sometimes even a minor part). This is the case of the development of RES Parks in marginal areas, where PVPPs are generally just one of the components of the different installations foreseen.
In other cases, the PVPP represents the main investment in the area concerned, and this case becomes a case of excellence when PVPPs generate the electricity needed to allow the functioning of new infrastructures on the marginal area in question. Really we can say that a direct relationship links the operative model with the PVPP device.

The investment models also can differ from a marginal area typology to another.

For this reason, in the following paragraph, investment models will be divided according to main different marginal area typologies: landfill, open quarry, mining area, ex military terrain, terrain in a industrial area, degraded (brownfield) or contaminated terrain, terrain subject to operative or administrative bounds, etc.

In all cases, three main approaches of recovering or revalorization of marginal areas can be identified from the financial point of view, involving three main actors: public organizations, private organizations or Private-Public Partner (PPP) organizations.

Generally, the public investor moves from finding free-grant financial support or special conditions loans (low interest rates or favourable reimbursement terms) in order to face the initial investment. In alternative or in addition to the initial free-grant financial support generally feed in tariffs or green certificates, tailored on the specific nature of the public body. The spirit is to valorise the territory in question for the benefit of citizens and to pay the expenses linked with the operations and maintenance of the area in question, yet in a period of financial crisis municipalities do not disregard also the net revenues obtained thanks to the feed-in-tariffs.

When an investor is a private subject, the feed in tariff and the initial free-grant contribution generally do not cumulate. In this case, the spirit is to valorise the terrain in question for the benefit of the investor himself as well as making profit from the renewable energy produced along time.

In the case of a Private-Public Partner organization, the two approaches mix together with generally the private approach prevailing in time, if the public reasons are not clearly identified, separated and safeguarded since the beginning.

The two different actors (public and private) differ also for the different financial points of view. The pubic organization will use the availability of terrains and sometime the presence of permissions for building PVPPs as leverage for obtaining a leasing for installing the plant at special conditions or for being part of a PPP vehicle company at better conditions (thanks to such initial dowry) and without exposing itself to financial risks. The private instead usually has the money for investing in total or for covering a 20-30% of the investment, involving the latter case a specialized funding organization for covering the remaining amount.

Tables from 9 to 14 summarize different operative and financial models decrypted from various European best practices.

Table 9: *Open quarry and mining area PVPP models*

OPEN QUARRY AND MINING AREA MODELS				
N.	**Soil recovery and reuse model**	**Operative model**	**Best Practice**	**Remarks**
1	The model represents a new proposal for a "photovoltaic landscape" based on the integration of photovoltaic panels with the natural mountain scenery (1,100 meters on the sea level) on the area above a former porphyry quarry. It is actually difficult to see the PVPP from the valley below the site, being surrounded by conifers, and in the distance it can be confused for a lake in the woods.	The investment was a public initiative by the municipality owner of the terrain. The plant is managed by the municipality through a professional studio.	PVPP "I Corozi", Carano Municipality – Trento – Italy (see paragraph 2.4.3.a. of this text)	• 500 Kwp, in function since 2008 • The plant generates annual revenue for the municipality (approximately 300,000 euro net after maintenance costs) which is used to pay back the investment loan (60%) and to yield resources for the municipality's balance (the remaining 40%).
2	It is a model of territory reconstruction through Photovoltaic technology. The PVPP is situated over a former lignite-mine ash deposit.	The investment was a public-private initiative, co-funded by the public administration. The power generated from the solar park is fed into the grid and will be sufficient to meet the electricity demand of about 1,800 households.	PVPP of Espenhain, near Leipzig –East Germany (see paragraph 2.4.3.a. of this text)	• 33,500 modules, for a 5 MWp plant. • The PVPP provides income for local area activities and will save some 3,700 tonnes of carbon dioxide emissions annually.
3	It is a model of PV panel localization on ground-terraces of a former quarry on the areas more exposed to the sun, in the framework of a conversion programme into residential and commercial flats of a former quarry area, with strong attention to sustainable use of space and renewable energy, with zero emission targets for energy needs of commercial, recreational and leisure buildings.	The investment was a public initiative by a municipality. A municipality-owned organisation will manage the solar plant, with local consumption of PV electricity. The investment has been dimensioned in such a way that it can meet the daytime peak energy demand in summer periods.	Stone quarry of Ghigliazza, Finale Ligure – Liguria Italy	• 1 MWp • The Feasibility study has been inserted in the public energy plan
4	It is a model of connection between the anthropogenic and natural tissue with integration of electricity production through the photovoltaic process in the framework of boosting the sustainable development of the municipality and surrounding areas. The plant integrates photovoltaic and hydrogen production processes. Compost will be reintroduced into the fertilization cycles in place in the area, increasing the environmental sustainability of the initiative. The study and development of demonstration and education paths blends energy production with daily life and natural landscape.	Not Yet defined	Project " Social Energy". The project received special attention in the "competition for ideas" promoted by the Municipality of Mores for the redevelopment of the former quarries of "Coperchia" in the Mores Municipality-Sassari-Sardinia-Italy	• About 1 MWp • The management of the project will be carried out by a TBD organization
5	Panoramic cableway in a tourist-cultural route, emphasizing the connection between marble extracting activity with tourism/culture and renewable energy. The PVPP is seen as renewable electricity generator at the service of the local mining activity. Another area, Campocecina-Murlungo could also be used as a PVPP providing energy for at least a part of the quarries of the underlaying mountain territory.	Not Yet defined	Project by the interdisciplinary team SOLARSYNERGY of Berlin carried out in Carrara, Massa Carrara – Toscana - Italy	
6	Reintegration of the territory into the natural landscape, restoring of an area spoiled by past human excavating through a Mine park, a Wildlife zone, the use of renewable Energy (biomass and Photovoltaic) with a new Zero Emission identity.	Public-Private Partner organization initiative	Asbestos mine of the XXth Century in Balangero Turin-Pedmont -Italy	• Feasibility study included in regional energy plan
7	For more information see below (Table 12: Brownfield - dangerous industrial site PVPP implementation models and paragraph 2.4.3.a. of this text)	For more information see below (Table 12: Brownfield - dangerous industrial site PVPP implementation models and paragraph 2.4.3.a. of this text)	Former coal mine in Heusden-Zolder – Belgium (see paragraph 2.4.3.a. of this text)	For more information see below (Table 12: Brownfield - dangerous industrial site PVPP implementation models and paragraph 2.4.3.a. of this text)

Table 10 part 1: *Garbage-dump and landfill PVPP implementation models*

GARBAGE DUMP AND LANDFILL MODELS				
N.	**Soil recovery and reuse model**	**Operative model**	**Best Practice**	**Remarks**
1	It was necessary to find an ecologically valuable future destination for the landfill site. The landfill gas collection was active in the mid 90s prior to the construction of the CHP for the energetic use of the gas. The landfill area was then planted with the maximum capacity of wind turbines. In 2004 a PVPP adds further value to the landfill creating co-generation: landfill biogas – wind-photovoltaic. Standing example of how a "non- lieu" becomes "a combined renewable energy generation park" integrated in the local natural landscape.	The initiative is managed by the Public utility of the Municipality of Hamburg (Stadt Reiningung Hamburg)	Landfill of Wulmstorf in Hanseatic city of Hamburg. Deutschland (see paragraph 2.4.3.b. of this text)	• The solar plant was built in 2005 • The active modules produce up to 501 kWp (maximum) at full exposure. • The photovoltaic system provides very good and reliable income in the order of about 450,000 kWh/year
2	Re-qualification of a vast landfill area based on the full exploitation of different renewable energy sources in conjunction with the (partial) opening of the area to visitors. The site is composed by different parts: A) Mountain Energy (wind, gas, PV, Hydrothermal) B) A lookout point exploiting the view offered to the height of the place C) Exhibition site, with an information pavilion (landfill recovering history, aftercare, area's natural habitat, sustainable energy devices used) The initiative represents an important component of the future of the Hamburg metropolis.	Pubic administration of the site with a strong commitment towards the increasing of green investments for the sustainable future development of the Hamburg Province.	Former landfill of Georgswerder – Hamburg Germany ("*He who sows the garbage can harvest wind*") (see paragraph 2.4.3.b. of this text)	• Source: FHH, Ministry of Urban Development and Environment, Soil / contaminated sites, Dr. V. Sokollek • Installed wind power 2 x 2 MWp (Current annual yield: 6 million kWh) • PV system: 500 kWp (Current annual yield: 400,000 kWh) • Additional options: able to accept biogas, thermal energy, leachate and / or drainage water devices)
3	Demonstration of solar plant implementation over a landfill collecting industrial waste, sewage sludge and inert waste in the municipality of Furth, the Center of Photovoltaic technology in Germany.	The PVPP is managed by a local utility company. The demonstrative investment was made by a private company, Jiuwi.	Former landfill of Atzenhof, Fürth, in northern Bavaria, Germany (administrative region of Middle Franconia)	• built in 2004-5 • 1 MWp
4	PVPP installed over a sealed landfill (post mortem phase). Such condition assures greater returns from the investment, since the site will be dedicated to the production of solar energy for more than the standard 20-30 years.	The management of the site is currently limited to the ordinary maintenance of the PV installation.	Former landfill of Hessen Wicker near Flörsheim- Wiesbaden in south-western Germany	• Built in 2005 • Engine capacity of about 440 kWp • 20,000 square meters • 400,000 kWh of electricity per year • The modules are mounted on the frame upright row, they are frame-like feet of guard rails driven into the ground
5	PVPP installed over a sealed landfill (post mortem phase). Such condition assures greater returns from the investment, since the site will be dedicated to the production of solar energy for more than the standard 20-30 years.	The management of the site is currently limited to the ordinary maintenance of the PV installation.	Former landfill site in Stockstadt, close to Aschaffenburg in Lower Franconia, Germany	• built in December 2008, it is the largest facility of this kind in the whole Rhine-Main area. • 2.5 MWp • Uses the Auflast-system, developed specifically for landfills, does not penetrate the protective film of the landfill.

Table 10 part 2: *Garbage-dump and landfill PVPP implementation models*

GARBAGE DUMP AND LANDFILL MODELS				
N.	**Soil recovery and reuse model**	**Operative model**	**Best Practice**	**Remarks**
6	PVPP installed next to a functioning landfill in order to offset the environmental damage produced by the landfill itself.	Public-private investment through bonds (citizens and local utilities) with the possibility to recover the investment after a fixed period of time (10 years) and of multiplication of the investment in the long term (doubling after 20 years). The initiative was started by the municipality, which decided to pursue sustainable development goals sharing them with the local community.	"*One hectare of Heaven*", Former landfill site of Peccioli (Pisa) - Italy	• built in 2007 • 1 MWp
7	The PVPP project will re-qualify the Municipal Solid Waste landfill area of Roncajette combining the building of the PV plantation with the already existing biogas energy recovery system. Subsidence of the ground due to the garbage assessments overcome through the use of floating plastic tubs supporting the PV panels.	The administrative body in charge of waste management for a consortium of 42 municipalities of the area has developed the project and will manage the PVPP's maintenance. The whole project will be financed through a direct public investment.	Former landfill site of Roncaiette, Municipality of Ponte San Nicolò, Padua, Italy (see paragraph 2.4.3.b. of this text)	• Environment impact assessment authorization released in July 2009 • 1 MWp
8	The PVPP of Malagrotta is a a higly significant re-qualification model of a former landfill though thin film technology. The public-private ownership intended to increase the waste recycling power of the site (the biggest landfill of Rome) and to convert biogas into electricity and fuel. In a second phase the idea of installing also a PV plant over the landfill's buttresses was added to the area's efficiency-increase plan.	The plantation has been realized by the Consorzio Laziale Rifiuti (administrative body for waste management) and by Solar Integrated Technologies. The ambitious project aims at transforming the site into the biggest supplier of 100% green electrical energy of the Region.	Active landfill site of Malagrotta, Rome - Italy (see paragraph 2.4.3.b. of this text)	• 1 MWp divided in 2 parts: 752 kWp over the south oriented slope of the landfill, and 245 kWp over the roof of the roof of the near building. • Thin film technology over flexible geo-membrane used as impermeable layer over the buttresses of the landfill (being waterproof also reduces leachate production). • During the first year of life the PVPP produced more than 1,000,000 kWh (that is 1,432 kWh/year). • Covers a surface of 21,300 square meters.
9	In October 2008 the Province of Cremona launched an "Ideas competition" for projects for the realisation of a PV Park and the environmental recovering of the area centered around the ex landfill of Castelleone. The project, part of the Administration program of promoting the diffusion of renewable energies, should be realised within the end of 2010. the Province attributes great consideration to correct insertion of the plant in the extra-urban landscape, and to the didactic opportunities linked with its realization.	The competition foresees the implementation of the winner project within the end of 2010.	Former landfill site of Castelleone, Cremona - Italy	• The aim of the Province of Cremona is to acquire models for the future replication of RES solutions also in other degraded areas (former quarries, industrial areas, etc.).
10	One out of the 2 re-qualification projects elaborated by a consortium from northern Italy to carry out the recovering of landfill areas. A PVPP has been deployed over 2 landfills (one in Carbonia, Sardinia, and one in Oleggio, Novara) allowing to avoid the use of valuable terrain (like agricultural terrain) for the production of energy.	The promotion and realisation of the initiatives was managed by a private society, "Unendo Energia" that is part of a financial holding company.	"*Sole a Carbonia*" and "*Sole a Oleggio*" plants, former landfill site of Carbonia, Serra Scirieddus, Sardinia – and former landfill site of Oleggio – Novara - Italy	• 12,500 square meters of gross covered surface • 1 MWp

Table 11: *Industrial site PVPP implementation models*

INDUSTRIAL SITE MODELS				
N.	**Soil recovery and reuse model**	**Operative model**	**Best Practice**	**Remarks**
1	The PVPP has been implemented in the establishment of Riardo of the company Ferrarelle S.p.A,, the an Italian bottled water company. The initiative is part of the company policy to be environmentally sustainable uniting a project for the recovery and reuse of PET (polyethylene, used for the production of beverage containers) with a PV implementation project, marrying green packaging and green energy.	Private cost-effective investment managed as a company's productive asset.	Establishment Riardo, Caserte (50 kilometers north of Naples), Campania - Italy	• 1 MWp
2	The model, employing thin film modules partially on the ground and partially on the roof of the establishment of an company (producing gaskets, metal parts, moulded rubber diaphragms and other devices for every type of industry) aims at safeguarding the company itself from the peaks of energy demand that could negatively effect production and at the same time allows the company to give to workers and local citizens the message that the industry is acting also for the protection of the environment.	Private cost-effective investment that is managed as one of the company's productive asset.	Establishment of Alonte, Athena S.p.a., Vicenza – Italy (see paragraph 2.4.3.c. of this text)	• 1 MWp divided in 2 parts: 274,05 kWp on the ground, and 588,6 kWp on the roof.
3	The PVPP has been implemented in the Industrial Development Area of Oristano by the company Soluxia (Sorgenia Solar), whose 80% is owned by the company Sorgenia Spa, which produces electricity and gas with the project of development of renewable energy sources. The industrial nature of the area assures a low environmental impact by taking advantage of the existing electric distribution network created for the surrounding industries.	Private investment	Establishment of Marrubiu, Oristano - Italy	• 1 MWp
4	Part of the requalification plan of Sardinia Region, the implementation of photovoltaics in this industrial buffer zone is formed by 5 different areas producing about 1 Mwp each, managed by Sorgenia (De Benedetti Group)	Industrial private investment	Municipality of Villacidro (VS) - Italy	• 5MWp

BROWNFIELD - DANGEROUS INDUSTRIAL SITE MODELS				
N.	**Soil recovery and reuse model**	**Operative model**	**Best Practice**	**Remarks**
1	PVPP implemented over a decontaminated and redeveloped area in the municipality of Maò through an ecosustainable investment.	This PVPP was a private initiative, but the investment was partially supported by the Municipality of Maò. The system was also funded by the Spanish Ministry of Science and Technology together with the Insular council of Menorca. All this, combined with a generous feed-in-tariff translates into some 8-year payback time.	Brownfield in the Maò municipality, Menorca –Spain (see paragraph 2.4.3.d. of this text)	
2	Requalification of a degraded industrial land in the framework of a re-qualification program. Surface decontaminated but not yet ready to host houses or other human activities.	This PVPP was a private initiative, partly supported by the Municipality of Hamburg. For the realization of the project, the federal government offered legal support, and as further advantage public depreciation of part of the investment was granted.	Nordhacksted, Hamburg – Germany (see paragraph 2.4.3.d. of this text)	• 985,400 kWh/year • in function since 2008
3	It is a model of mitigation of the negative environmental impact of a former coal extraction activity and linked presence of heavy industry through a redevelopment program of the area availing itself of financed projects (ground and roof PV plants). The decline in employment of the population of the area, resulting from the closure of coal mines, has been limited and investment in photovoltaic has allowed to produce income over time to sustain the local economy. The area became a model of RES PARK.	Setting up a program for revitalizing the area through the creation of an organization dedicated to supporting infrastructural investments in the area and the participation of companies in sustainable development projects and initiatives aimed at diversifying development paths. The initial infrastructural investments were supported by ERDF Funds (Objective competitiveness and employment).	Former coal mine in Heusden-Zolder – Belgium (see paragraph 2.4.3.a. of this text)	The RES Park is composed by 3 parts: A) PVPP over the former coal mine • In function since 2009 • It is the largest PV system in Benelux (2009) • 4.7 MWp • Number of PV modules: 23,500 • Expected annual output: 3,000,000 kWh/year B) PV roof Glas Caissons • Total installed power 350 kWp, polycrystalline PV-modules • In function since 2004 C) Semitransparent BIPV system at CeDuBo Centre • Peak output: 13 kWp • 72 modules of 120 x 140 cm (Module area :121 m2)
4	Balancing of fossil extractive activity with renewable investments model.	Private investment by the owner of the lignite site.	Former lignite site near the "Energie strasse", in the north of Neurath, Germany (see paragraph 2.4.3.d. of this text)	

Table 12: *Brownfield and dangerous industrial site PVPP implementation models*

Table 13: *Former military site and airport PVPP implementation models*

FORMER MILITARY SITE AND AIRPORT MODELS				
N.	**Soil recovery and reuse model**	**Operative model**	**Best Practice**	**Remarks**
1	Strategic investment for the energy supply security of the airport. Integration of a green energy investment with the airport area's activity.	A fund marketing and administration company of Sachsen LB Group supported the initial investment (profit) and offered equity to interested investors in the form of closed-end funds.	Former military airfield near Leipzig in Waldpolenz - Germany	• Operator/EPC: Juwi GmbH • Total peak power of all the lots: 40 MWp • Functioning since 2007-2008 • System supplier: First Solar • The plant covers an area 2km long by 600m wide
2	Strategic investment for the energy supply security of the airport. Integration of a green energy investment with the airport area's activity. No special maintenance required. Sheep are used to graze the terrain. The environmental upgrading of the area allowed to reach an agreement with local environmentalists.	Operation inserted among the investment activities of the airport. Investment with positive payback.	Saarbrücken Airport in the suburbs of Ensheim – Germany (see par. 2.4.3.e. of this text)	• The photovoltaic plantation was built the three lots near the airstrip respectively of 1.4 MWp, 1.8 MWp and 0.8 MWp
3	Strategic investment for the energy supply security of the airport. Integration of a green energy investment with the airport area's activity. No special maintenance.	Operation falling under investment management activities of the airport. Investment with payback	Small airport property of AUTECO Srl in agro of Serdiana, Cagliari, Sardinia – Italy (see paragraph 2.4.3.e. of this text)	• Feasibility study for environmental impact assessment • 1 MWp
4	Re-use of degraded area used for military purposes through sustainable investment integrating it in the surrounding landscape without removing the original historical references.	Private initiative supported by a Fund.	Former ammunition deposit in Hemau, Bavarian Land – Germany (see paragraph 2.4.3.e. of this text)	• Even today the old bunkers still serve as housing for the inverters. For long time, the plant has been the biggest solar park in the world. • 4MWp

Table 14: *Buffer zone PVPP implementation models*

BUFFER ZONE MODELS				
N.	**Soil recovery and reuse model**	**Operative model**	**Best Practice**	**Remarks**
1	Re-use of a buffer zone near to linear infrastructures (junction point between 2 high speed roads) giving a function to an otherwise non disposable lot of terrain.	Private investment by private company, Tozzi Sud S.p.a.	Tozzi Sud, Foggia, Puglia – Italy (see paragraph 2.4.3.f. of this text)	• 650 kWp
2	Recovering marginal cemetery buffer zone by providing cemetery visitors with parking canopies.	The system is owned by the Municipality of Los Villares. When the PVPP was put into commission the feed-in tariff was set at 0.45 €. This feed-in tariff has been yearly updated according to the annual escalation rate of the retail price of conventional electricity. The system was partly funded by the Spanish Ministry of Science and Technology together with the Autonomous Government of Andalusia.	Local cemetery in Los Villares, Jaén – Spain (see paragraph 2.4.3.f. of this text)	• Built in 2006 • 95 kWp
3	Recovering marginal local slaughterhouse buffer zone by providing slaughterhouse employees with parking canopies.	The system is owned by the Municipality of Pozo Alcón, which partly supported its deployment. When the PVPP was put into commission, the feed-in tariff was set at 0.45 €. This feed-in tariff has been yearly updated according to the annual inflation rate. The system was also partly funded by the Autonomous Government of Andalusia.	Buffer zone close to the local slaughterhouse in Pozo Alcón, Jaén - Spain	• Built in 2007 • 61,2 kWp

2.4.3 Some models in details: description of some significant cases

a. Open quarries and mines

PVPP "I Corozi": an embedded richness in the woods over a former porphyry quarry

The plant of "I Corozi" – Municipality of Carano, Val di Fiemme (TN), Italy, is an example of successful landscape integration. The plant, covering 15,000 square meters, is embedded in a forest of trees and covers an area first interested by the extractive activity of a porphyry quarry. The plant was installed by a private company (CPL Concordia), which won the tender launched by the Municipality of Carano.

Figure 3 Source: http://www.cpl.it/casi_di_successo/energia/fonti_rinnovabili/fotovoltaico_a_carano_tn.

The choice of the place made it possible to exploit an already empty and historically characterized by an artificial landscape, and did not involve cutting of any tree. To further reduce the impact, efforts to contain the height of the panels, which do not exceed 165 cm, and, at the request of the Municipality, was planted a row of trees along the perimeter road. For building elements local stone materials were used left over in the porphyry quarry. In Carano, we are at 1,200 meters above sea level. This has led to the choice of a particular type of panel, with the possibility of adjusting manually the angle of inclination (the so-called "angle of tilt "). The angle of inclination is changed seasonally: in winter an acute angle (between 45 and 55 degrees) prevents the deposition of snow and makes it so the panels do not shadow each other, while in the summer the angle from the ground is reduced to 25 degrees in order to increase the incidence of sunlight. The previsions of CPL Concordia were winning, even in consideration of two design choices: the support structure of the panels (some of them are mobile) and the anti-theft system, the first alarm installation in Italy applied to photovoltaics. If a panel is detached from the structure, a signal is communicated to the system of supervision which forwards it to the company delegated to the monitoring and maintenance of the plant, and even to the police.

Figure 4 Source: http://www.cpl.it/casi_di_successo/energia/fonti_rinnovabili/fotovoltaico_a_carano_tn.

The PVPP is composed by 3000 solar panels (of which 90% fixed and 10% mobile), installed in 2007, and now the plant produces an average of 625,000 kilowatt hours a year (for 500 kWp of nominal power). The Municipality carried out the investment availing itself of a mortgage. The deal guarantees a return to the public administration of Carano of approximately 300,000 euro per year, net after maintenance costs. The return is guaranteed for 20 years by the Italian Electricity Services Management company, granting a feed-in tariff of 0,47 euro per kilowatt hour produced. The total investment amounted to 3.2 million euro, and will be amortized by the municipality in ten years. The 60% of the income produced (approximately 300,000 euro per year) is used to repay the mortgage, while the remaining 40% goes into the coffers of the municipality allowing it to supply free-of charge services to citizens and to carry out supplementary investments for the development of the local community.

<u>Solar power plant in Leipzig: one of the world's largest photovoltaic system takes the place of coal mining activity</u>

Around 30 kilometres south of Leipzig the is the area of Espenhain. Espenhain, where the sun radiance seems relatively intense, has become a symbol of a highly interesting example paradigm shift characterizing the new millennium: the "Leipziger Land Solar Park." The transition from a polluting power generation activity using fossil fuels to the production of renewable energy is particularly evident here, where coal mining has modified visibly all the surrounding environment. The Solar Park, composed by 33,264 solar modules on a 16 hectare area (over a landfill that was developed over one of the coal mines), was built by GEOSOL Solar Energy Society GmbH, Shell Solar GmbH and the Western Fund Real Estate Investment Company. The electricity is fed into the public grid and is enough to supply about 1,800 households with green electricity. The plant has been for some time one of the largest solar power plants in the world, with a capacity of 5 MWp, opening a new dimension to the production of solar electricity. With this and other planned instalments the state of Saxony gave a long-lasting contribution to the implementation of the Kyoto Protocol: the solar power plant of Leipzig alone, avoids the production every year of around 3,700 tonnes of greenhouse gases (CO_2).

Figure 5: Aerial view of Espenhain area (Source: http://www.solarserver.de/solarmagazin/anlageoktober2004.html).

Figure 6: Panels in Leipziger Land Solar Park (Source: http://www.solarserver.de/solarmagazin/anlageoktober2004.html).

Figure 7: Solar generator (Source: http://www.solarserver.de/solarmagazin/anlageoktober2004.html).

Figure 8: Assembling technique in Espenhain (Source: http://www.solarserver.de/solarmagazin/anlageoktober2004.html).

The reconversion of the coal mine area at Heusden-Zolder: from mining activity to RES Park

The mining area of Heusden-Zolder has been recovered through an articulated redevelopment program through projects and initiatives aimed at diversifying development paths.

In 1992, the coal mine site of Heusden-Zolder was closed, the last of all mines in the province of Limburg. The dramatic rise of unemployment figures made it urgent to proceed to a reconversion of the mining site. Hence, the local authorities decided to buy the entire site and to develop a new industrial area, with the aim of creating new employment focusing on innovation and sustainable development.

As in other mine areas in Limburg, the abandoned mine area of Zolder was converted into a modern industrial and service estate also with the support of different European programmes. The grounds were cleared and stabilised primarily through the RECHAR programme. Buildings with no future use were demolished. The grounds were then equipped with basic infrastructure such as roads, sewage lines and public lighting through ERDF - Objective Competitiveness and Employment funds. The total renovation of the area cost 5,827,852.82 euro, with a ERDF contribution of 1,748,355.85 euro.

The recovering program has developed a RES Park. The Park is composed of 3 parts:

A) PVPP over former coal pit

The first is a free standing PVPP over a former coal mine, which entered in function since 2009 and is currently the largest PV system in Benelux, with a peak output of 4,7 MWp. The system is composed by 23,500 modules, for a year estimated output of 3,000,000 kWh/year that will avoid the emission of 2,800 tonnes of CO_2. The plant covers 17 hectares. The PVPP was developed by the project developer NV Zonnecentrale Limburg, a subsidiary body of the provincial company Limburgse Reconversie Maatschappij, founded to facilitate the economic development after the suspension of mining activities in the province of Limburg. The contractor is Group Machiels together with the PV installer Izen.

Figure 9: Aerial view of the Heusden-Zolder RES Park – First part (Source: http://www.eesc.europa.eu/sections/ten/events/energy/2009-06-29-photovoltaic/visit_PV_Heusden_090629v3.pdf).

LRM was the owner of the coal pit in Heusden-Zolder. When coal was still being extracted, the mentioned pit was used as rubble and fly ash dump. The pit covered approximately 17 hectares and was decontaminated in the late '90s. Because it was decontaminated using a film coverage method, it was very difficult to find a suitable use for this site. LRM decided to transform the decontaminated land into a solar power plant – so transforming an otherwise unusable site to a new function. The project was put on the

market and Group Machiels was chosen as partner of the investment in mid-2008.
In August 2008 the two partners formed the project company 'Zonnecentrale Limburg'. LRM owns 24.9% of the shares; Group Machiels holds the other 75.1%.

An initial phase (approximately 250 kW peak of green power) was finished and connected to the electricity grid already at the end of 2008. The further development of the project continued throughout 2009 and the work was completed at the end of 2009.

B) Semitransparent BIPV system at CeDuBo Centre

The second part forming the RES Park of Heusden-Zolder is the semitransparent BIPV system at the CeDuBo Centre, one of the two centres created in the area within the framework of the reconversion program of the area. The two centres, the European Centre for Restoration Techniques (training centre) and the Centre for Durable Constructions - Centrum Duurzaam Bouwen" (or CeDuBo, knowledge centre for durable techniques in constructions), located over the mine's former pits area, were built in cooperation with various national and regional partners, and the Belgian Building Research Institute played an important role in the coordination of the project. The province of Limburg also contributed to the financing, together with the Flemish region which granted a subsidy for the PV plant.

The CeDuBo Centre opened on April 12th, 2002 and covers 10,000 square meters. The centre organises events for building professionals and the general public, and supplies technical advice to citizens and private investors an individual on sustainable constructions, based on a specific analysis of their building plant. Separate from the Centre's building, a PVPP has been installed as free standing surface, through a steel support structure that gives it the shape of a ramp. The PVPP project was started-up on the 15^{th} of January 2007, and the completion of the works occurred in May 2007. The total installed power is 350 kWp, with about 2000 polycrystalline PV-modules. The total panel surface is of 2,760 square meters, with a total ground covered of 2,780 square meters. The peculiar display of the PV plant, allowed to save a lot of surface, since the surface required for an equivalent output if the system had been installed over a flat roof or totally on the ground would have been of at least 8,000 square meters. The ramp has an inclination of 15 degrees, and the highest point is 18.5 meters. The expected annual output of this space-saving PVPP is approximately 300,000 kWh/year, with annual savings of CO2 emissions equal to 228 tonnes.

Figure 10: Second part of the Heusden-Zolder RES Park (Source: http://www.eesc.europa.eu/ sections/ten/events/energy/2009-06-29-photovoltaic/visit_PV_Heusden_090629v3.pdf).

C) PV roof Glas Caissons

The centre's energy demand is reduced by energy saving measures, e.g. optimal daylight, energy saving fluorescent lamps, ventilation with heat recovery and preheated air in the double building coverage, while energy consumption is provided both by the described PVPP and by an integrated PV system covering the roof of the building. It consists of 120 square meters of semitransparent PV modules, with a peak output of 13 kWp and an expected annual output of about 10.000 kWh/year.

b. Garbage Dumps – Landfills

New Energy Mountain in Wulmstorf: re-use of a landfill to generate electricity from renewable energy sources

Even at the beginning of the reclamation works, the goal for the former landfill site of Wulmstorf was that of finding an ecologically viable second use for the area. The landfill gas collection system had been foreseen already in the mid 90s, and was therefore included in the reclamation program. The following building of the CHP for the energetic use of landfill gas immediately after the completion of the terrain reclamation work was the first step towards the transformation of the area into an "energy mountain" scenery.

Thanks to the feed-in tariffs for electricity from wind power granted in year 2000, also wind turbines became economically interesting. The landfill area was therefore enriched also with the maximum capacity of wind turbines.

Figure 11: Aerial view of the new landfill of Wulmstorf 1996 during the fitting out of the surface sealing (Source: http://www.climate2008.net/?a1=pap&cat=4&e=66).

After the amendment of the Renewable Energies Act (EEG) in 2004, solar power also became profitable, and a photovoltaic system was developed over the landfill. Such PVPP is considered one of the largest outdoor installations in Northern Germany, and the largest facility in the metropolitan region of Hamburg. Each kilowatt-hour, no matter whether generated by landfill gas, wind or solar energy, will be reimbursed by the German national authority for energy and gas for 20 years at a fixed price. The legally guaranteed feed-in tariff rates have strengthened the city of

Figure 12: Aerial view of the new landfill Wulmstorf. The image is accurately represented in the north-south orientation. The wind turbines and the rows of photovoltaic modules are easily recognizable (Source: http://maps.google.it/maps?hl=it&um=1&q=SunEnergy%20Europe%20GmbH%20wulmstorf&ndsp=20&ie=UTF-8&sa=N&tab=wl).

Hamburg in its efforts to expand the production of renewable energy.

The generated electricity amounts to five-six million kilowatt hours per year, making the average annual electricity consumption that can be covered equal to that of 2,000 households.

The example of Berg's New Energy Wulmstorf clearly shows that Hamburg can count on large amounts of energy that allows them to avoid waste combustion in incinerators, counting on environmentally friendly electricity production and a significant contribution to reducing the production of climate-damaging CO2 emissions.

Figure 13: General view of New Energy Mountain in Wulmsorf (Source: http://www.climate2008.net/?a1=pap& cat=4&e=66).

In Germany ground PV systems are subject to some license restrictions, and as in other countries ground systems are granted lower feed-in tariffs than integrated plants. Landfills, however, are commercial areas that need to be maintained even after the waste storage for decades and therefore are unsuitable for other uses (residential, leisure, etc.). Therefore, they are ideal for the installation of wind farms or photovoltaic systems.

The alignment of a long slope area to the south is clearly visible. The PVPP covering this area was built in 2005, composed by 3,132 polycrystalline modules (160 watts each), covers 4,100 square meters and produces up to 501 kWp at full exposure. The PVPP an output of about 450,000 kWh/year.

Energy Mountain Georgswerder: re-use of a landfill area to create a RES Park

The landfill area of Georgswerder has been recovered through the creation of a RES park composed by three parts: an Energy Mountain (wind, gas, PV, Hydrothermie), a panoramic view, and an exhibition site with an information pavilion (landfill history rehabilitation, aftercare, habitat, sustainable energy).

The area covers approximately 45 acres, and the area's height is 40 meters. The area was a deposit from 1948 to 1979, with about 7 million m³ of waste space for approximately 0.2 million tonnes of hazardous waste.

The rehabilitation period went from 1984 to 1995, and the total reclamation cost amounted to approximately 100 million euro.

The wind plant counts 2 x 2 MW of installed power for an output of 6 million kWh/year, while the PVPP has a power

Figure 14: Aerial view of the Energy Mountain Georgswerder (Source: http://www.isebiogeochemistry.com/ Documents/ ISEB2009Tagungsband_FieldTrips7.pdf).

of 500 kWp and some 400,000 kWh/year.

Currently there is also the possibility of adding inputs for a biogas plant and for the use of the thermal energy coming from the leachate and/or drainage water.

The RES Park is completed by some safety measures (a Park ranger, an alarm system, and video surveillance).

Figure 15: Aerial view of the Energy Mountain Georgswerder (Source: http://www.isebiogeochemistry.com/ Documents/ ISEB2009Tagungsband_FieldTrips7.pdf).

Below we offer several aerial views of the RES Park area before and after the reclamation program.

Figure 16: Aerial view of the Energy Mountain Georgswerder (Source: http://www.isebiogeochemistry.com/ Documents/ ISEB2009Tagungsband_FieldTrips7.pdf).

Figure 17: Aerial view of the Energy Mountain Georgswerder (Source: http://www.isebiogeochemistry.com/ Documents/ ISEB2009Tagungsband_FieldTrips7.pdf).

Landfill of Roncajette: solar shells floating over the urban waste of 23 municipalities

The project for recovering some areas of the MSW landfill of Roncajette, in the Province Padua, through the realization of a PVPP envisages a plant of about 1 MWp of ground solar panels installed on chlorine-free recycled polyethylene supports without penetrating the ground. These plastic structures are designed to float upon the surface of former allotments of the landfill in order to overcome possible downfalls of the cover due to waste settlements.

As part of the energy valorisation plan of the landfill of Roncajette in Ponte San Nicolò, area managed by the Ente Bacino Padova 2 (the Consortium of Muncipalities of the Padua area), this is a project of waste management involving two post-operative allotments, through the creation of a RES park (the PV plantation will be combined with the biogas energy recovery).

The environmental

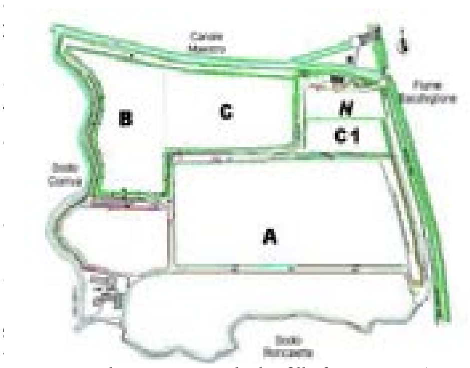

Figure 18: Plots composing the lanfill of Roncajette (Source: http://www.legambientepadova.it/files/Articolo_Tecnico_Roncajette.pdf).


Figure 19: Vision of how the floating tubs sustaining the solar modules will look like once deployed (Image courtesy of Ente Bacino Padova 2).

impact assessment authorization was granted in June 2009. (The Roncajette landfill interested by the PV project is composed of: Area B, Area C, a building and the front area (15 hectares).

The activity of the landfill started in 1989, the waste disposal ended in November 1999, and the final cover was certified in 2002 and since that time the landfill is in aftercare management.


Figure 20: Aerial view of the landfill area of Roncajette (Image courtesy of Ente Bacino Padova 2).

The PVPP is supposed to last 30 years with a decreasing production of energy, and 20 of those years will be privileged by a feed-in tariff (0.36€/kWh) officially recognized by the GSE (Electric services manager).

The photovoltaic generator will be connected to the Power distribution network where the total energy produced will be delivered to the grid.

The area will be used for the following purposes:

- Waste dump area which is available for environmental re-qualification (plots B, C, C1)
- Area dedicated to facilities linked to the waste dump (nearby area Casa Norbiato - plot N)
- River water run off area (a 50 meter wide strip near to the plots N and C1)
- Pre-park area (portion of plot N and C1).

Flexible thin film over the largest landfill of the Italian capital: Malagrotta in Rome

The new PV plantation realized in the former landfill area of Malagrotta (Rome) is the most significant example of recovering of a marginal area for the production of green energy currently available.

The main aim at the basis of the area's recovering was to enhance the waste recycling power (especially plastic and metallic waste) and to convert gasses deriving from waste's decomposition into electricity and fuel. Once reached the goal of becoming the main green energy supplier of the Region, the owners of the landfill (Colari Consorzo Laziale Rifiuti and Sorain Ceccini – public-private consortium) chose to add to the potential green energy production of the area the installation of PV system.

The PV plant was built by the Consorzio Laziale Rifiuti and Solare Integrated Technologies, which used UNI – SOLAR flexible thin film cells. The adopted technology allowed to create a structure perfectly integrated with the environment; the use of flexible PV has been advantageous also in terms of costs' saving: there's no need for costly supporting structures and no risk of breaking due to natural ground subsidence.

Moreover, the UNI – SOLAR cells produce a high quantity of energy, thanks to amorphous silicon modules' efficiency, which allows capturing energy for a larger light spectrum during the day.
Considering now some data, during the first year of activity, the system, covering an area of 21,300 m^2, produced 1,3550 MWh/year, avoiding CO_2 emissions equal to 1,250 tones.

Figure 21: View of the Malagrotta site in Roma (Source: http://nuke.rinnovambiente.it/Home/tabid/36/language/en-US/Default.aspx)..

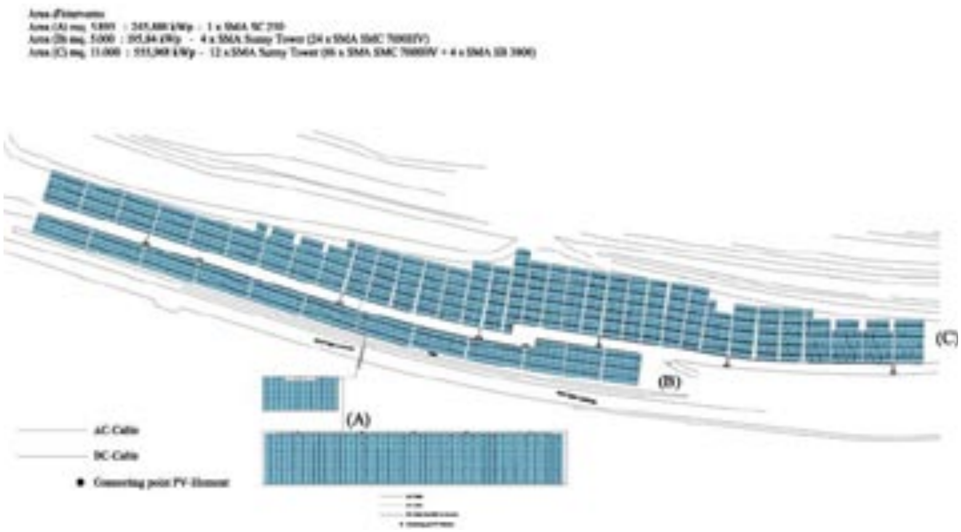

Figure 22: Parts composing the landfill of Malagrotta (Image courtesy of Enea- Ente per le Nuove Tecnologie l'Energia e l'Ambiente).

c. Industrial sites

Athena: thin film on the ground and roof of a manufacturing company

A grid-connected PVPP made of fixed PV panels on the ground and roof made of amorphous silicon thin film modules. Athena spa is a company manufacturing gasket, metal parts, molded rubber and other products.

The ground PVPP has a peak power of 274.05 kWp, made by 3,654 modules, while the roof PV system counts 588.6 kWp and is composed by 7,848 First Solar FS275 modules.

The thin film modules grant a good energy production in different climate conditions, maintaining standard energy yield also in cloudy days. The modules are connected to 2 tri-phase inverters.

Figure 23: Inauguration of the ground PVPP composing the plant (Source: www.ilgiornaledivicenza.it/galleries/ Fotogallery/ fotodelgiorno/62508/).

The ground PVPP is fixed on Conergy SolarLinea supports, planted directly into the terrain, without cement foundations, reducing the environmental impact and future costs of restoration of the area.

The total power of the plant is 862.65 kWp, and the plant will produce about 1 million kWh/year avoiding a considerable amount of CO2 emissions.

Figure 24: View of the roof section covering the factory (Source: www.clickutility.it/italian/news_energia.php?idnews=3702).

Jaen II: a former landfill transformed into a solar farm 'OLIVE TREE fields"

Nearly half the area where this PVPP was deployed was a landfill, while the other half was an olive tree plantation with low profit rates. The owner of this area was not satisfied either with the degraded condition of part of the area nor with the low profitability achieved producing olive oil. Consequently, he was happy to rent out his land plot to deploy a PVPP. The olive trees had to be pulled out and then the ground conditioned, together with that of the neighbouring garbage dump, in order to install the PV plant.

Figure 25: Jaen II Solar Farm (Image courtesy of University of Jaèn).

This 9.2 MWp PVPP was installed using monocrystalline silicon modules. Its design includes seventy two subplants of 121.4 kWp each, together with four more ones, of 105.6 kWp each, adding up to seventy six subplants. This scheme is commonly referred to as "Solar Farm" ("Huertos Fotovoltaicos").

It is worth pointing out that a high power LV/HV transformer centre was very close to the area.

The 9.2 MWp Solar Farm named "Olive tree fields" Farm is privately multi-owned by seventy six limited liability companies. Each limited liability company owns one subplant. This large number of companies is due to the power limit of 100 kVA (nominal inverter power) below which an advantageous feed-in tariff is paid to the owner: 0.440 € ·kWh, according to the Spanish Royal Decree 661/2007. If this power threshold would have been exceeded by any subplant at the time of its commission (August 2008), the feed-in-tariff would have been decreased to 0.417 € ·kWh for that subplant.

Figure 26: Solar modules of Jaen II Solar Farm (Image courtesy of the University of Jàen).

<u>d. Brownfields - Dangerous industrial sites</u>

<u>The photovoltaic power plant near the Neurather See</u>

The Neurather See lies in the proximity of a former lignite extracting site near Grevenbroich, in the East part of Germany, South form Dusseldorf. The area is part of the region characterized by intense extractive activity during the past decades that is cut by an important linear infrastructure, the so-called "Energiestraße".

Figure 27: Aerial view of the Energie Strasse area (Source: http://maps.google.it/maps?hl=it&q=energie%20strasse&um=1&ie=UTF-8&sa=N&tab=wl).

The PVPP that has been installed contiguously to the Neurather See Overview, north of Neurath, lies between the "Energiestraße" and one of the many pits where coal/lignite was extracted from. The PVPP is composed by more than 3,700 PV modules which cover a surface of 3,500 square meters. In the Neurather See PVPP newly developed large PV modules have been used for the first time. These have a surface of almost 2-and-a-half square meter per piece. The PV-plant has a nominal peak power of 360 kWp and generates approximately 270,000 kWh/year. With this output, the electrical demand of approximately 70 German households can be covered.

Figure 28: Aerial view of the photovoltaic power plant around the Energie Strasse (Source: https://www.unido.org/fileadmin/media/documents/pdf/Energy_Environment/Moss_080520__5.pdf).

The PVPP has been installed in the framework of other green energy interventions, that include, on one of the surrounding hills, 14 wind turbines for the production of wind energy.

The images below show an aerial view of the region around the Energie Strasse and of the Neurather See PVPP.

Figure 29: Aerial view of the photovoltaic power plant around the Energie Strasse (Source: http://maps.google.it/maps?hl=it&q=energie%20strasse&um=1&ie=UTF-8&sa=N&tab=wl).

The PVPP of Maò, Menorca: the redevelopment of a contaminated land in the framework of a UNESCO Reserve island

This PVPP is situated in the Municipality of Maó, Menorca, on a decontaminated and redeveloped former industrial area.
Menorca is a small island large 702 square Km in the Balearic islands. Menorca is protected and the whole island was designated a Biosphere Reserve back in 1993. UNESCO defines a Biosphere Reserve as 'a place of important natural and cultural heritage where economic development is compatible with nature conservation'. Menorca is 1 of 411 places in 96 countries that has been designated a Biosphere Reserve. The attention reserved by UNESCO to the island is due to its landscape. This little island features a diverse range of Mediterranean landscapes and the presence of indigenous animals and plants. In the framework of this attention of international and local authorities for the local landscape and environment, the Municipality of Mao chose to invest on the recovering of a former industrial contaminated area.

Figure 30: Aerial view of the photovoltaic plant on Menorca Island (Source: http://usa.sanfrancisco.ahk. de/fileadmin/user_upload/Dokumente/2009-06_Solar_Day/4.3.1_SunEnergy_Europe_GmbH.pdf).

The PVPP was built in 2007, and is composed by 14,679 Sharp modules in polycrystalline silicon facing South with tilt angle of 30º, supported by metal structures, by the company Schletter Metallbau. Each metal structure is fixed on the ground by means of four poles. This PVPP is devoted to the production of electricity in a marginal terrain, with completely public ownership (municipality of Menorca). The

Figure 31: Aerial view of the photovoltaic plant on Menorca Island (Source: http://usa.sanfrancisco.ahk.de/fileadmin/user_upload/Dokumente/2009-06_Solar_Day/4.3.1_SunEnergy_Europe_GmbH.pdf).

total peak output is of 3,205 kWp, covering a 17,000 square meters area, for a total investment of 13.7 million euro plus VAT (16%). The system was also funded by the Spanish Ministry of Science and Technology together with the Insular Council of Menorca. All this, combined with a generous feed-in-tariff translated into some 8-year payback time. When the PVPP was commissioned in December 2007, the feed-in tariff was set to 0.43 €. The PVPP is owned by the Municipality of Menorca. The plant is supposed to be further enlarged to create a 3.2 MWp grid connected system.

Figure 32: Aerial view of the photovoltaic plant on Menorca Island (Source: http://usa.sanfrancisco.ahk.de/fileadmin/user_upload/Dokumente/2009-06_Solar_ Day/4.3.1_SunEnergy_Europe_GmbH.pdf).

<u>***Nordhackstedt: PV and wind for a brownfield reclamation***</u>

In Nordhackstedt, an industrial area near Hamburg, Germany, a 758 kWp PVPP was used for redeveloping a decontaminated area, with the support of the Municipality of Hamburg, though solar energy and wind energy devices.

The PVPP was implemented in 2007 by AEP Energie-Consult GmbH, and consists of 3,840 modules in polycrystalline silicon. The PVPP is grid-connected and produces 985,400 kWh/year covering an area of 15,000 square meters.

The modules face south with a tilt angle of 30°, and are fixed to the ground through metal Solartrak ST 2,000 supports.

Figure 33: PVPP modules in Nordhackstedt area (Source: http://usa.sanfrancisco.ahk.de/fileadmin/user_upload/Dokumente/2009-06_Solar_Day/4.3.1_SunEnergy_Europe_GmbH.pdf).

Each metal structure is fixed on the ground through Doma, a kind of flexible foundations. This PVPP is completely publicly owned by the municipality of Hamburg, and its maintenance is carried out by a public operating company.

The total investment amounted to 3.3 million euro plus VAT (16%), and its maintenance costs per year around 36,300 euro.

Figure 34: PVPP structures in Nordhackstedt area (Source: http://usa.sanfrancisco.ahk.de/fileadmin/user_upload/Dokumente/2009-06_Solar_Day/4.3.1_SunEnergy_Europe_GmbH.pdf).

Figure 35: (Source: http://usa.sanfrancisco.ahk.de/fileadmin/user_upload/Dokumente/2009-06_Solar_Day/4.3.1_SunEnergy_Europe_GmbH.pdf).

Figure 36: PVPP plant in Nordhackstedt area (Source: http://usa.sanfrancisco.ahk.de/fileadmin/user_upload/Dokumente/2009-06_Solar_Day/4.3.1_SunEnergy_Europe_GmbH.pdf).

e. Former military sites and airports

A sun airport: the PVPP of Saarbrücken

The Saarland's state capital of Saarbrücken is situated on the France-German border. According to the measured values of the German Weather Service (DWD) the regional long-term mean global radiation is 1080 kWh / m² per year.

Figure 37: Map of the Saarland's state, Germany (Source: http://www.mygermancity.com/saarland).

The Saarbrücken Airport rises in the suburb area of Ensheim, and in January 2004 the construction of a PVPP was completed, having a peak capacity of 1.4 MWp. The PVPP at the time was the first solar power station in Saarland. The Saarland Ministry for the Environment promoted the 6.5 million euro project at the time with a grant support.

With the amount of electricity produced annually (approximately 1.4 million kWh/year), that is equal to the demand of some 600 German households, approximately 1,100 tonnes of CO_2 emissions will be avoided each year. An interesting feature concerns the maintenance of the plant: sheep are used to graze the grass growing around the panels, keeping the PV system free from overgrowing plants.

Figure 38: Solar modules in Saarbrucken airport (Source: http://www.solarserver.de/solarmagazin/solar-report_0109_e.html).

The PVPP is composed by three separate sections: Saarbrucken 1, 2 and 3. Saarbrucken 1 covers 40,000 square meters and is owned by the company City Solar AG; the nominal power is around 1.4 MWp with 9,200 solar-modules (produced by Sharp) cover an area of 10,000 square meters.

The energy production, 1,372,000 kWh/year, should be sufficient to satisfy the need of almost 600 German families. In terms of CO2 emissions' savings the expectations are about 22,000 tonnes in 20 years (1,100 tonnes per year)

A second plant with peak capacity of 1.8 MWp and a third of 0,8 MWp lie on other areas of the airport grounds. Saarbrücken 2 covers 35,000 m2, and is owned by Voltwerk Hamburg AG; the nominal power is around 1,8 MWp with 10,360 solar-modules (produced by Sharp) cover an area of 13,572.55 square meters. The energy production, 1,782,360 kWh/year, should be sufficient to satisfy the need of almost 900 German families. In terms of CO2 emissions' savings the expectations are about 30,000 tonnes in 20 years (1,500 tonnes per year).

Figure 39: Aerial view of the Saarbrucken plant (Source: http://www.solarserver.de/solarmagazin/solar-report_0109_e.html).

Saarbrücken 3 covers 14.000 square meters and is also property of City Solar AG; the nominal power is around 0.8 MWp with 3,500 solar-modules (produced by City Solar AG, PQ 200) cover an area of 3,501.64 square meters. The energy production, 727,500 kWh/year, should be sufficient to satisfy the need of almost 400 German families. In terms of CO_2 emissions' savings the expectations are about 12,000 tonnes in 20 years (600 tonnes per year).

The Hemau Solar Park: transforming a former army ammunition deposit into one of the biggest Solar Parks of Bavaria

Solar power is getting bigger and better in Southern Germany. From the beginning of 2003, the Bavarian town of Hemau receives its entire electricity supply from the sun. A large solar-farm of over 32,000 photovoltaic panels has been built on a former army ammunition deposit near the city of Regensburg.
Some claim this is the largest farm of its type in the world.

The solar park was installed on the grounds of a former ammunition depot in Hemau. Today, the old bunkers serve as housing for the inverters of the 4 MWp PVPP.

Figure 40: Hemau Solar Park (Source: http://www.panoramio.com/photo/2503018).

The solar-farm in Hemau consists of 40 photovoltaic systems composed of 32,740 modules, and its power can satisfy the energy demand of the 4,600 residents of the town of Hemau. The plant was completed by 70 workmen in a construction time of only 12 weeks.

The solar project was financed by a closed fund, and the total cost of the project was equal to approximately 20 million euros and has been built by the Hamburg-based company .

Figure 41: Hemau Solar Park PVPP plantation (Source: http://www.epuron.de/en/desktopdefault. aspx/tabid-95/).

"Sun Technics - Solartechnik". SunTechnics estimates that its electricity production will be sufficient to cover the needs of all the 4,600 residents of Hemau.
It will also help avoid the emission of over 82,000 tonnes of carbon dioxide in the next 20 years.

The PVPP will increase Bavaria's solar energy production to over 72 MW per year, out of which 30 MW are fed into the public electricity grid.
This represents over 40% of the total German production of solar energy, which is estimated at some 173 MW.
In Bavaria currently 17,000 out of the 42,000 German photovoltaic facilities are operating.

Figure 42: Hemau Solar Park plantation (Source: http://www.epuron.de/en/ desktopdefault. aspx/tabid-95/).

Figure 43: Solar modules at Hemau (Source: http://climatex.org/articles/climate-change-info/ sunny-solar-farm/).

Figure 44: Solar modules at Hemau (Source: http://climatex.org/articles/climate-change-info/ sunny-solar-farm/).

“Su Sparau”: marrying the recovering of a degraded terrain with a new environment-friendly tourist activity

The project of creating a PVPP in the area of “Su Sparau” in the Province of Cagliari, Sardinia, Italy, envisages that a part of the produced energy will be used in loco, while the rest will be sold to the grid.

The PV panels will be fixed on the ground through aluminium and steel supports within the property of the company AUTECO Srl.

Different solutions have been evaluated for the upgrading of the area, all keeping in consideration the preservation of the environmental frame work, as well as the technical efficiency and the economic profitability.

The area, previously interested by extractive and manufacturing activities is currently part of a recovering programme composed by three actions: interventions for the levelling of the area’s surface, filling up the pits created through the extractive activity; maintenance of the track for the landing of small tourist airplanes; creation of a tourist structure functional to the small airport.

The project is currently being evaluated by the competent municipality office.

The installation of the PVPP, in the South-Eat area of the allotment, will be an important added-value in terms of energy self-sufficiency of the tourist infrastructure and of green image of the company.

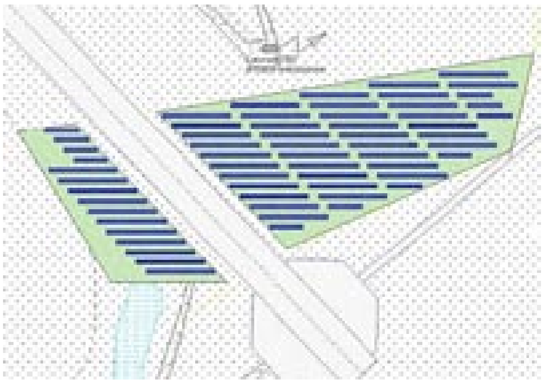

Figure 45: plan envisaged for the future PVPP (Source: http://www.sardegnaambiente.it/documenti/18_183_20081217104140.pdf).

The PVPP has been studied in order to be perfectly integrated in the surrounding landscape. The total area that will be covered by the plant will be of 18,300 square meters for a peak power of 999.00 kWp.

f. Buffer zones

Los Villares: green parking canopies for cemetery visitors

A formerly degraded terrain, the buffer zone close to the local cemetery in Los Villares, in the Province of Jaèn, Andalusia, Spain, has been recovered by means of a PVPP. Since the PV modules are fixed to galvanised steel frames with post foundations facing South with a fixed 35º tilt angle, the PVPP plays a two-fold role: solar electricity generation and providing parking canopies to cemetery visitors. This 95 kWp PVPP was installed using policrystalline silicon modules.

The system is owned by the Municipality of Los Villares. The PVPP was commissioned in 2006 and the feed-in tariff was set to 0.45 €. This feed-in tariff has been yearly updated according to the annual escalation rate of the retail price of conventional electricity. The system was partly funded by the Spanish Ministry of Science and Technology together with the Andalusia Autonomous Government.

Figure 46: PVPP in Los Villares (Image courtesy of University of Jaèn)

Tozzi Sud: turning lost space trapped between linear infrastructures into productive space

The grid-connected PVPP of Tozzi Sud, in the Incoronata area of the Province of Foggia, Puglia, Italy, is a private investment carried out by a company that chose to transform a buffer zone between two linear infrastructures (two high speed roads), with evidently no other possible function or possible use into a profitable PVPP. The owner of the plant, the company Tozzi Sud S.p.A., is an Italian company operating in the filed of electrical plant design and RES instalments. The 20,000 square meter triangular plot of land would have been abandoned and without any use if it were not converted into a PV plant. The panels have been settled in a way that avoids any problem concerning sun-beaming with reference to the nearby roads. Environmental impact is therefore extremely low (the kind of area is already compromised from the landscape point of view) and the passing cars do not have any problems with reflected sun-light.

The plant is made of manual mono-axial trackers and digital bi-axial trackers. The modules are composed by Sanyo HIP-205 – Monocrystalline cells, produced by an Italian company (Solon s.p.a.). The peak power is 650 kWp, composed by 450 kWp of removable panels in monocrystalline silicon and about 200 kW of panels installed on monocrystalline silicon solar biaxial followers. Those two different types of installations are called: Sestante and Elianto.

Sestante is meant to increase the efficiency of photovoltaic modules for fixed installations. The linear structure provides maximum flexibility related to the number and type of modules installed. Sestante uses tilting photovoltaic modules designed to follow the sun's cycle. This system is moved manually depending on the time of year – equinox and solstice. This method increases module productivity by approximately 6%.

Figure 47: PVPP of Tozzi Sud (Source: http://www.tre-energia.com/).

The twin-axis computerised tracking system makes Elianto one of the most evolved and reliable products when developing Solar Parks offering high-productivity at a low investment with low running costs.

Designed and produced entirely in Italy and covered by a European patent, Elianto has been chosen to develop Solar Parks as it results to be the most appropriate system for both satisfying environmental conditions and legislative requirements related to southern Europe.

The greater part of this system is pre-assembled in the factory with an obvious reduction of installation costs, and in economic terms, can be more viable than a fixed system of equivalent power. Elianto maintains the photovoltaic panels in a position perpendicular to the sun's rays throughout the entire day.

Compared to a fixed system of equivalent installed power, Elianto captures a greater quantity of sunlight resulting in a higher production of electricity. Positioned along the latitudes of Southern Europe greater productivity of a twin-axis system like this can be estimated depending on the climatic conditions of the microclimate typical of the installation location.

The photovoltaic panels are positioned horizontally maximising production even in conditions when there is little sunlight.

3. Innovation and technology trends

3.1 Technology development and solar innovation make investing on marginal areas even more attractive

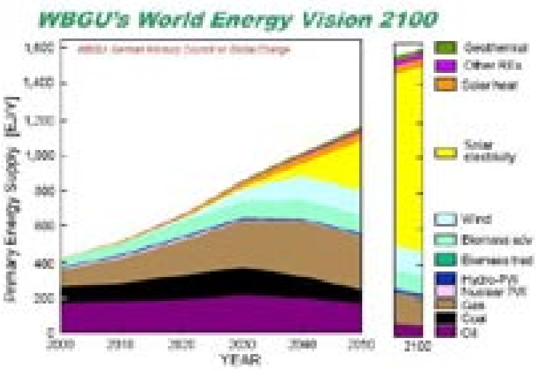

Figure 48: WBGU's World Energy Vision 2100 (Source: http://www.wbgu.de/wbgu_download_engl.html).

The present world energy scenario characterised by a combination of faltering fossil fuel reserves and an urgent need to reduce greenhouse gas emissions makes an ideal environment for the growth of Renewable Energy Sources. In particular, PV steps out as a reliable and durable alternative to conventionally-generated electricity, which will probably give a valuable contribution to the world energy supply[13] The PV industry has the potential of becoming a major electricity supplier in the twenty-first century and to constitute a powerful industry able to abate environmental stresses and to constitute an element of safety in the energy supply of developed countries.

According to the world leader in the development and application of PV technology – Germany - energy conversion based on PV technology will be, at the end of this century, the dominant technology of the world energy market .

However, the above mentioned ambitious goal requires basic R&D in photovoltaics, looking for breakthroughs if this technology in order to fulfil the goals that society requires. At the same time, subsidizing the existing market is leading to a cost reduction via the economy of scale allowed by

[13] For instance, PV met a still small but not negligible 4% of the electricity demand in Spain during August 2009.

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3. Innovation and technology trends

3.1 Technology development and solar innovation make investing on marginal areas even more attractive

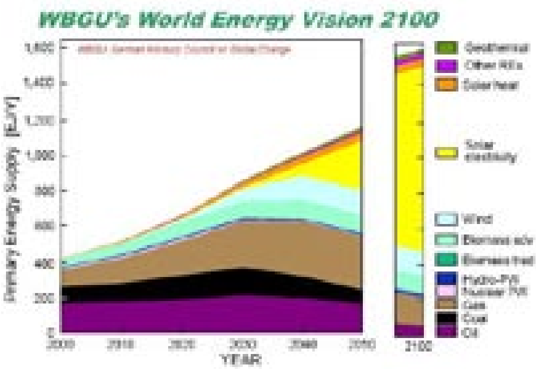

Figure 48: WBGU's World Energy Vision 2100 (Source: http://www.wbgu.de/wbgu_download_engl.html).

The present world energy scenario characterised by a combination of faltering fossil fuel reserves and an urgent need to reduce greenhouse gas emissions makes an ideal environment for the growth of Renewable Energy Sources. In particular, PV steps out as a reliable and durable alternative to conventionally-generated electricity, which will probably give a valuable contribution to the world energy supply[13] The PV industry has the potential of becoming a major electricity supplier in the twenty-first century and to constitute a powerful industry able to abate environmental stresses and to constitute an element of safety in the energy supply of developed countries.

According to the world leader in the development and application of PV technology – Germany - energy conversion based on PV technology will be, at the end of this century, the dominant technology of the world energy market .

However, the above mentioned ambitious goal requires basic R&D in photovoltaics, looking for breakthroughs if this technology in order to fulfil the goals that society requires. At the same time, subsidizing the existing market is leading to a cost reduction via the economy of scale allowed by

[13] For instance, PV met a still small but not negligible 4% of the electricity demand in Spain during August 2009.

the larger volume of production.

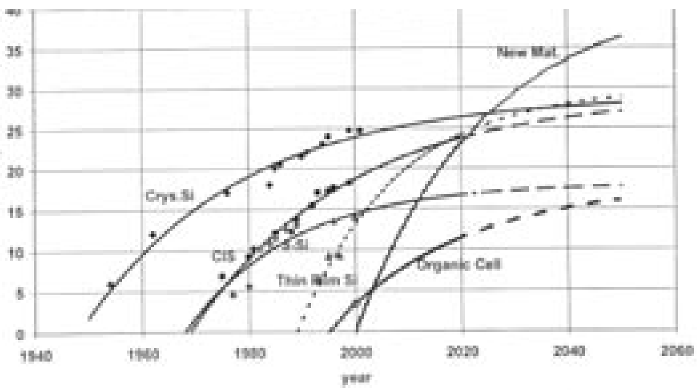

Figure 49: Trends in development of various techniques for photovoltaics (Source: J.B. Saulnier, New Path fot Photovoltaics, Materiały "Conference on the Future of Energy in Enlarged Europe: Perspectives for R&D cooperation", 7-8 October 2004, Warsaw, 20).

An important component of the cost of PV modules is the cost of material, used in photovoltaic converters. This cost depends both on the type of material (Si, CdTe, CIS itd), and the amount used in the construction of such a transmitter. Therefore, especially in the last decade with high development dynamics thin-film technology is emerging.

Already today, in connection with a large involvement in the energy field of the Asian tigers (especially China), the supply of raw materials (especially silicon) and PV modules has significantly increased. This has turned out in significantly lower prices per unit of power (1 Wp) also as revealed by the offers of the exhibitors at the recent international PV exhibition that took place in Hamburg (combined with the 24th PV Conference). PV modules from mc-Si are in fact available at prices much lower than 2 Euro/Wp, and thin-film modules are offered for about 1 Euro/Wp. Despite this significant reduction in the cost of PV modules, there are some economic and societal barriers that prevent the widespread application of PV technology.

As it has been reviewed in the previous sections of this document, the existing financial mechanisms aim at supporting PV through feed-in tariffs, rebates, low-interest loans, etc. These measures make investments attractive from a strictly economic point of view. However, these financial mechanisms will decrease their intensity over time as PV technology becomes more competitive, which at the end of the day means less costly.

The point where the costs of generating electricity through solar systems will equal the average price of generating electricity by means of conventional methods through fossil fuel, gas or other non-renewable resources is called grid parity. Reaching grid parity for a PV system means that this system is able to produce electricity as cheap as other conventional fuel-based systems, without government subsides. Once this point will be reached, investors will be more likely to bet on PVPP as a viable clean energy alternative to fossil fuelled technologies. It is important to point out that the prices compared refer to pool costs (the cost that energy companies pay) and not the retail price of electricity.

The above mentioned quest for achieving grid parity will be achieved by means of new technology developments and solar innovation, making investments on PVPP on marginal terrains even more attractive, as it will be detailed hereafter.

The PV industry and R&D Institutions are striving to lower the cost per PV-generated kWh, by means of developing more efficient solar devices. These agents are also paying an increasingly amount of attention to make their developments durable and reliable[14]

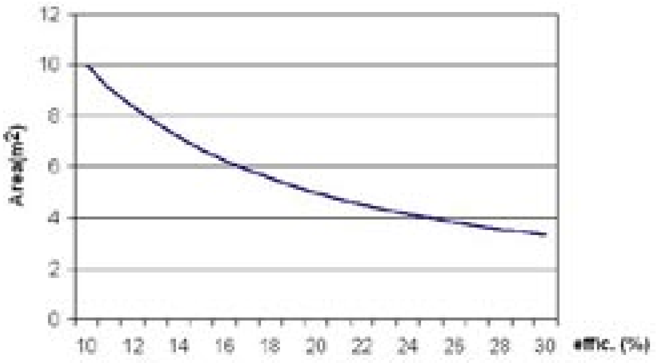

Figure 50: Area required by 1 kWp of PV versus Module Efficiency (Source: Jorge Aguilera, Gabino Almonacid, Leocadio Hontoria, Emilio Muñoz, Gustavo Nofuentes, Pedro J. Pérez, P.G. Vidal (in alphabetical order), (2009) "The CPV Challenge (Part I): Achieving Grid Parity", First Conferences Publishers, London, 100 pp

Let us see why increasing cell efficiency[15] is crucial. As the cost of the cell is related to its area, it becomes necessary to increase its efficiency to generate the same power with less surface –which implies the use of less semiconductor materials. The same consideration applies to PV modules. Figure 50 might help to achieve a better understanding of this issue: many common marketed c-Si PV modules at present have efficiencies lying within some 12%. Therefore, one kWp requires some 8 square meters of PV modules, as it can be seen from Figure 50. When this efficiency will be doubled in the coming years, only some 4 square meters of PV modules will be needed. Less surface means less PV modules cost and less Balance of the System (BOS) cost[16]. Consequently, smaller areas of marginal terrains will be required to deploy the same amount of PV power at a lower cost. Doubtlessly, all this will lure investors into installing PVPP in these degraded areas, since the profitability of the investments will rise and also smaller marginal areas (such as buffer zones, for example) will be addressable through the reclamation through a PVPP.

Reliability and durability are two crucial considerations in guaranteeing operational behaviour, safety and profitability in any PVPP. In other words: reliability and durability measure the extent to which a PVPP delivers the expected energy over their predicted useful life. R&D efforts intended to develop more reliable and durable PV devices will increase the confidence of public and private investors in PVPPs and possibly they will be willing to spend money on a profitable project based on reliable and durable elements, suited to be deployed on marginal areas.

Once grid parity is reached –some predictions say that this will take place during the first years of the coming decade, determining a downward trend of PV module cost – investments in solar electricity will increase and require terrains for hosting them. This will be a great opportunity for using degraded areas to deploy PVPPs, since land-related costs will thus represent a minor part of the PVPP budget.

[14] Reliability can be defined as the probability of failure in the system. The parameters that measure reliability are the Mean Time between Failures (MTBF) and also the time needed to repair a certain failure. On the other hand, durability is described as the lifetime of a system. It can be understood as a point of time beyond which, maintaining the operation of the system is not profitable in economical and energy terms.

[15] Cell (module) efficiency equals the ratio between the output PV power and the incident light power impinging on the cell (module).

[16] The term Balance of the System comprises all the elements of a PVPP other than PV modules. E.g: cabling, metal structures, inverters, etc.

During the successful uptake by the society of a newly developed solar technology, demonstration projects are essential. Public investors may find an opportunity to give back value to some marginal terrains by means of installing PVPP on them using the latest developments. This will help to gain on-field experience of new solar technologies and, additionally, citizens would be familiar with such new technologies.

It should be noted that industrial-scale thin-film technology based on silicon, with more than 10% efficiency of photo conversion is already being produced on large-scale (large modules). For example, the company SUNFABTM produces nearly 0.5 MWp of modules with an area of 5.7 square meters[17].

The following figures show the design and assembly of such modules.

Figure 51: Frameless glass-PVB-glass panels (Source: http://www.appliedmaterials.com/products/solar_sunfab_57m2_panels_3.html?menuID=9_5_2).

Of course, increasing the PV efficiency must be combined with a modification of the internal arrangement of the converter material. In addition, the offered solutions are characterized by high thermal stability (may therefore be preferentially used in countries with warmer climates). Another advantage of thin-film structure is that it is less sensitive to changes to the direction of solar radiation in comparison with the crystalline structures, which does not require tracking. Large format individual modules also have reduces PVPPs installation costs (up to 20%).

Government bodies should launch campaigns aimed at promoting environmental awareness about the benefits from installing PVPPs on marginal terrains, using emerging new solar technologies. This would be an exemplary way of recovering degraded areas that otherwise would remain as they are.

Private companies who are willing to show an energy and environmentally conscious image are good candidates to support solar innovation by means of creating Solar Parks in which emerging technologies are installed on environmentally degraded areas. PVPPs on such areas arise as unbeatable investments addressed to enhance the prestige of these companies.

Utilities have played a crucial role in the development of PVPP during the last two decades. Those utilities that were more reluctant to get involved in PV grid-connection projects and did not take full advantage of the benefits that PVPPs are conferring today in terms of image and prestige. This has been a lesson which has been well learnt, and many utilities and/or electricity distributors will likely be willing to launch projects to give back

[17] Source: http://www.appliedmaterials.com/.

value to degraded areas by means of PVPP using new reliable, durable and less costly solar developments.

Aesthetics must not be left aside in this brief summary of a prospective future panorama. Solar devices that combine aesthetics with efficiency at a reasonable cost –take the example of some flexible, semitransparent thin-film developments- support very well the environmental enhancement of marginal terrains, by means of the aesthetics asset. Such solar devices will be one of the most preferred by companies and utilities interested in showing a 'green' image.

4. Conclusions

4.1 Lessons learnt

The study concerning marginal areas carried out thanks to the PVs in BLOOM Project has revealed how many under-valorised or totally abandoned terrains actually exist that can be included within this macro-category. The majority of them are likely to remain for long time, and in some cases even forever, without any use or function, while other terrains are for various reasons included in local development plans or addressed by initiatives of private investors and therefore re-used and renovated through reclamation.

The sample analysis carried out in some regions and countries such as Italy, Spain and Slovakia show impressive numbers regarding the mass of terrains that currently are abandoned and the potential green revolution that could revolve around them.

A true green economy should turn its eyes on them, avoiding their destiny of unused resources in the general indifference.

Photovoltaics is a RES technology which is hungry for land; rehabilitating marginal areas for converting solar energy on a large scale is particularly suitable contributing to sustainable development.

More than 645 MWp of solar energy easily achievable from landfills in Italy, 393 MWp from contaminated soils in Slovakia and nearly 1,2 GWp easily achievable from landfills and mines in Spain, are remarkable figures that depict all the potential of including the PVs in BLOOM approach in the urban and landscape planning and of the public and private investment schemes of old and new European countries.

The production of electricity from photovoltaics on marginal areas, as well as reducing the environmental impact of PV plant deployment would also spare hectares and hectares of arable land.
The photovoltaic exploitation of marginal terrains allows transforming abandoned sites from "non-lieus" to "lieus", giving originally unproductive lands the power of generating long-term income.

The opportunity of exploiting some kinds of marginal lands (in particular landfills, open quarries, brownfields and former military areas) has been seized by some European and non European countries, yet in some cases without a clear reference within their strategic development policies.

In particular, according to the monitoring carried out through the PVs in BLOOM Project, it was noticed that the re-use of marginal terrains through RES investments, in particular photovoltaics, is currently practiced in the United States and Japan, while among European countries, the one with the most interesting programs and realizations is Germany. Also Italy can be quoted, but only with reference to some virtuous practices of some regions such as Sardinia, Piedmont, Lombardy, Veneto and Tuscany.

Even if they are not very many, the experiences of the above-mentioned countries are significant, and demonstrate for example how deploying PVPPs on landfills may bring benefits such as:

- *significant income for landfill owners and municipalities;*

• increased value of damaged terrains;
• safekeeping of potentially dangerous lands;
• aesthetic upgrading of the terrain and surrounding landscape;
• opportunities for further larger scale installations;
• energy independence and energy source diversification;
• matching solar energy production with periods of peak demand;
• avoiding carbon and other fossil-fuel air emissions;
• providing green jobs linked to the plant installation and maintenance.

Other cases demonstrate how airports can be a perfect showcase for a PV plant, when it is integrated on the airport's grounds and buildings. Finally, old military bases and old dismissed mines can be profitably converted to photovoltaic parks.

The lessons to be learned are the following:

• Municipalities, public organizations for the management of land resources, utility companies, energy producers and distributors, consortia for the management of industrial areas and Sate Land authorities are the organizations who own or manage the greatest number of marginal areas (usually the degraded ones or those that are subject to particular constraints that require limited uses);

• If these organizations were empowered to give the priority to the re-use of marginal lands when investing, the restoration of such areas through renewable energy and in particular photovoltaics would be a strong leverage for the public administration for enabling sustainable virtuous behaviours with tangible returns for local economies and indirectly for the State itself;

• Developing Photovoltaic Power Plants provides the opportunity of attracting environmentally conscious investors that are interested in supporting green investments or locating their premises in more environmentally-friendly industrial areas. For example, the location of a solar module manufacturer on a brownfield could provide a great opportunity for the creation of new jobs and for boosting the local solar market;

• PVPPs provide environmental benefits that are particularly attractive for urban areas with air quality concerns. With their zero emissions, solar energy systems can offset emissions from other energy sources particularly during peak hours when utilities often rely on older systems that pollute more heavily.

• Unfortunately, European countries, and even those where Photovoltaics have had a remarkable development, have not set up yet policies that specifically address the assessment of existing marginal areas and the planning of incentive measures and other support schemes giving the priority to the development of RES sources over such areas;

• Currently there are enough examples of good practices to allow any public or private organization wishing to promote this kind of initiative on one of its terrains to start from an advantaged point.

• Local, regional and national public administrations could develop policies that protect sowable land from speculation and promote real sustainable development through the introduction of RES marginal area reclamation into their territorial development policies and programmes.

• Applying the PVs in BLOOM approach, EU countries could avoid the

hard speculation that has characterized the development phase of the PV market in recent years, saving thousands of grain crops and other cultivations from destruction.

• Looking at PVs in BLOOM as a new way for approaching investments for real integrated and sustainable development represents an excellent chance for all European municipalities and citizens.

5. PVPP photo gallery

Figure 52: Kokkina Velestino (Prefecture of Magnesia) – PVPP implemented on marginal rural areas (Image Courtesy of Municipality of Milies).

Figure 53: Le Vigne Solar Park- Arezzo, San Sepolcro, Italy - Environmentally integrated PVPP in natural hill Landscape (Source: http://www.eurosatellite.com/notizie.php/26375).

Figure 54: Le Vigne Solar Park- Arezzo, San Sepolcro, Italy - Environmentally integrated PVPP in natural hill Landscape (Source: http://no-nuke-no-ogm.blogspot.com/2008/06/arezzo-parco-solare-le-vigne.html).

Figure 55: PVPP Double "S" snc – Brentonico TN - Less fertile mountain terrain (Source: http://www.doubles.it/?action=fotovoltaico).

Figure 56: Chilluévar in the Municipality of Chilluévar – Spain - Infertile hillside in the surroundings of Chilluévar (Source: http://www.solarjiennense.com/fotovoltaica/index.aspx)

Figure 57: Cárcheles in the Municipality of Cárcheles – Spain - Buffer zone close to a small industrial area (Image Courtesy: University of Jaén).

Figure 58: Municipality of Pozo Alcón - Buffer zone close to the local slaughterhouse. The workers employed there park their cars under the PV field (Source: http://www.solarjiennense.com/fotovoltaica/index.aspx).

Figure 59: "One Hectar of Sky" - Peccioli (Pisa) – Italy - Rural land, PVPP integrated in a eco-sustainable municipality programme with investment shared by citizens (Source: http://www.intoscana.it/intoscana2/opencms/intoscana/it)o-intoscana/Contenuti_intoscana/Canali/Ambiente/visualizza_asset.html?id=854744&pagename=704616).

Figure 60: "VILLACIDRO 2" - Municipality of Villacidro (VS) – Italy – industrial area (Source: http://sorgenia.wordpress.com/2009/12/09/fotovoltaico-low-cost-al-via-la-competizione-solar-for-all/).

Figure 61: Photovoltaic plant Ostrožská Lhota- Ostrožská Lhota - (Zlín region) - Czech Republic – Low fertile area (Source: http://www.hitechsolar.com/fotogalerie.php?kategorie=1150&sekce=1096&PHPSESSID=64d06b2c5e9e885735d851ef04e0923e).

Figure 62: El Batán - Municipality of Jaén -Infertile plot of land in the surroundings of an abandoned leisure centre (Source: http://www.solarjiennense.com/fotovoltaica/index.aspx).

Figure 63: Industrial Area "Parque Railla", Municipality of Sinarcas (Valencia) – Spain - PVPP on low-profitable agricultural field (Source: http://cms.krannich-solar.com/es/espanol/noticias/227-instalacion-laboratorio.html).

Figure 64: Industrial Area "Parque Railla", Municipality of Sinarcas (Valencia) –Spain - PVPP on low-profitable agricultural field (Image Courtesy: Chamber of Commerce of Valencia).

Figure 65: Municipality of Úbeda –Spain- Infertile plot of land in the surroundings of an olive tree field, close to a farmhouse named "Guadiana" (Source: http://www.solarjiennense.com/fotovoltaica/index.aspx).

Figure 66: Enerpoint PV Park of GROTTAGLIE – (TA) Puglia – Italy - Scarcely fertile terrain cultivated with olive trees (Source: http://agri-point.it/fr/photovoltaic-park.php).

Figure 67: Former site of Ca' Lino - Chioggia (Venezia) – Italy - Low fertile agricultural terrain (Source: http://www.ecquologia.it/sito/energie/municpalfeb07.pdf).

Figure 68: Neurather See area (Energiestrasse) - Germany (Source: https://www.unido.org/fileadmin/media/documents/pdf/Energy_Environment/Moss_080520__5.pdf).

Figure 69: Saarbruecken Airport – Germany (Source: http://www.solarserver.de/solarmagazin/solar-report_0109_e.html).

Figure 70: Nordhackstedt , Municipality of Hamburg - PVPP implemented on an decontaminated and redeveloped area (Source: http://www.sunenergy-gmbh.de/downloads/referenzen/see_references_openspace.pdf).

Figure 71: Tozzi electrical equipment S.p.A.- Incoronata, Foggia (Italy) - Buffer zone around linear infrastructure (road) (Source: http://www.tre-energia.com/).

Figure 72: "I Corozi" – Municipality of Carano, Val di Fiemme (TN), Italy - Dismissed porphyry quarry (Image Courtesy: Unioncamere del Veneto).

Figure 73: "I Corozi" – Municipality of Carano, Val di Fiemme (TN), Italy - Dismissed porphyry quarry (Image Courtesy: Unioncamere del Veneto).

Figure 74: Göttelborn Solar Park, Germany (Source: http://www.solarserver.de/solarmagazin/newsa2007m06.html).

Figure 75: Second part of the Heusden-Zolder RES Park (Source: http://www.eesc.europa.eu/ sections/ten/events/energy/2009-06-29-photovoltaic/visit_PV_Heusden_090629v3.pdf).

Figure 76: Sole a Carbonia, Former site of Serra Scirieddus (CA) – Italy - Garbage dump buffer zone (Source: http://www.itiomar.it/public/blog/wp-content/uploads/2007/05/presentazione%20fotovoltaico%20Renergies.pdf).

Figure 77: Sole a Carbonia, Former site of Serra Scirieddus (CA) – Italy - Garbage dump buffer zone (Source: http://www.itiomar.it/public/blog/wp-content/uploads/2007/05/presentazione%20fotovoltaico%20Renergies.pdf).

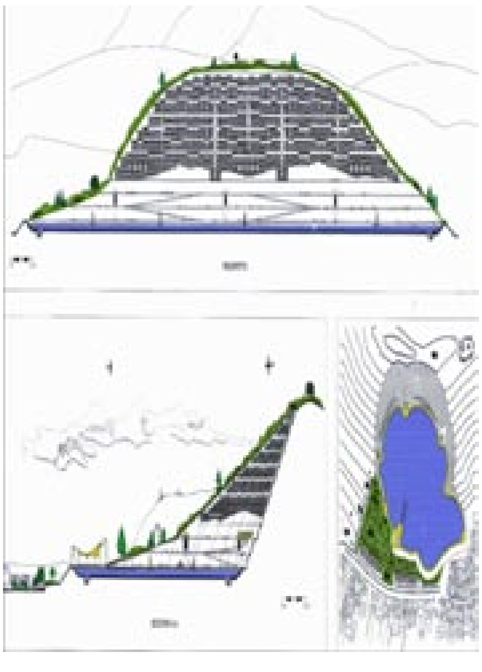

Figure 78: Project description of Vigna D'Albore, Municipality of Vitulazio (CE), Italy – Idle quarry (Source: http://www.ingegneriameccanica.com/download/INTEGRAZIONE%20FOTOVOLTAICA%20NEL%20TERRITORIO.pdf).

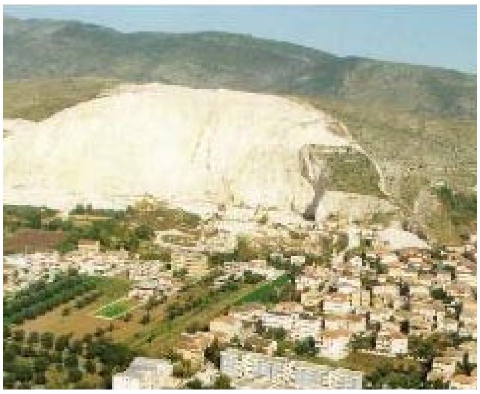

Figure 79: State of the art of the PVPP of Vigna D'Albore, Municipality of Vitulazio (CE), Italy – Idle quarry (Source: http://www.ingegneriameccanica.com/download/INTEGRAZIONE%20FOTOVOLTAICA%20NEL%20TERRITORIO.pdf).

Figure 80: State of the art of the PVPP of Vigna D'Albore, Municipality of Vitulazio (CE), Italy – Idle quarry (Source: http://www.ingegneriameccanica.com/download/INTEGRAZIONE%20FOTOVOLTAICA%20NEL%20TERRITORIO.pdf).

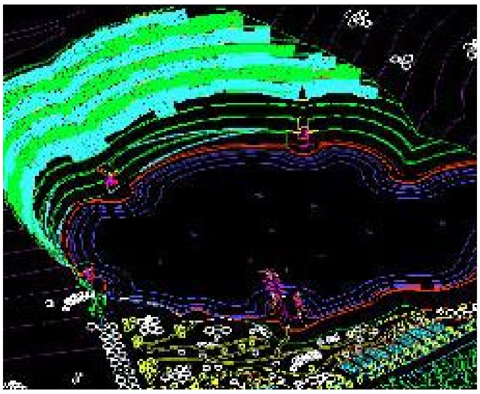

Figure 81: Project of the PVPP of Vigna D'Albore, Municipality of Vitulazio (CE), Italy – Idle quarry (Source: http://www.ingegneriameccanica.com/download/INTEGRAZIONE%20FOTOVOLTAICA%20NEL%20TERRITORIO.pdf).

Figure 82: Solar power collection on former landfill at Atzenhof, Germany (Source: http://www.breakingthetape.com/runningwithjack/images/Fuerth_2009_muellberg.jpg).

Figure 83: Site of Roncajette (PD) – Italy- Garbage dump (Image Courtesy of Ente Bacino Padova 2).

Figure 84: General view of New Energy Mountain in Wulmsorf (Source: http://www.climate2008.net/?a1=pap& cat=4&e=66).

Figure 85: Aerial view of the new landfill of Wulmstorf 1996 during the fitting out of the surface sealing (Source: http://www.climate2008.net/?a1=pap&cat=4&e=66).

Figure 86: Aerial view of the Energy Mountain Georgswerder (Source: http://www.isebiogeochemistry.com/ Documents/ ISEB2009Tagungsband_FieldTrips7.pdf).

Figure 87: Aerial view of the Energy Mountain Georgswerder (Source: http://www.isebiogeochemistry.com/ Documents/ ISEB2009Tagungsband_FieldTrips7.pdf).

Figure 88: photorealistic visualisation of the MEGALOPOLIS: 50MW (Source: http://www.ppcr.gr/index_en.php?page=activities&subpage=our_activities&node=23).

Figure 89: Loto PVPP, Solarolo –Italy (Source: http://www.settesere.it/public/parser_download/save/numero.ss.2008.48.Pag15.ambiente.pdf).

Figure 90: Malagrotta (Rome) - Italy – Former landfill area (Making Use of Unusable Space, The first PV installation on a working landfillSolar Integrated Technologies –Andrea Bodenhagen Conferenza dell' Industria Solare–Italia 2009. Source: www.solarintegrated.com).

Figure 91: Malagrotta PV installation (Rome) - Italy – Former landfill area (Making Use of Unusable Space, The first PV installation on a working landfillSolar Integrated Technologies –Andrea Bodenhagen Conferenza dell' Industria Solare–Italia 2009. Source: www.solarintegrated.com).

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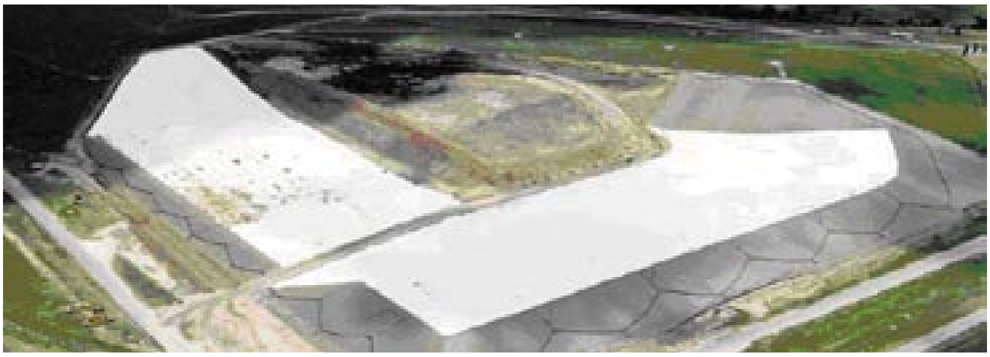

Figure 93: Exposed Geomembrane Caps - Tessman Road Landfill Solar Energy Cover (Innovative Landfill Cover Systems and Energy Recovery Systems Presentation, May 2009 - Republic services inc., Source: http://www.coloradoswana.org/presentations/2009_Annual_Meeting/Landfill_Solar-Energy-Cover-System_Jeff-Young.pdf).

Figure 94: Tessman Road Landfill Solar Energy Cover Anchor Trench Installation (Innovative Landfill Cover Systems and Energy Recovery Systems Presentation, May 2009 - Republic services inc. Source: http://www.coloradoswana.org/presentations/2009_Annual_Meeting/Landfill_Solar-Energy-Cover-System_Jeff-Young.pdf).

Figure 95: Tessman Road Landfill Solar Energy Cover Anchor Trench Installation (Innovative Landfill Cover Systems and Energy Recovery Systems Presentation, May 2009 - Republic services inc. Source: http://www.coloradoswana.org/presentations/2009_Annual_Meeting/Landfill_Solar-Energy-Cover-System_Jeff-Young.pdf).

Figure 96: Tessman Road Landfill Solar Energy Cover (Innovative Landfill Cover Systems and Energy Recovery Systems Presentation, May 2009 - Republic services inc. Source: http://www.coloradoswana.org/presentations/2009_Annual_Meeting/Landfill_Solar-Energy-Cover-).

Appendix

a. Summary of the Best Practices censed during the first phase of the PVS in BLOOM project

Table 15 reports the Best Practices censed during the first phase of the PVs in BLOOM Project are listed and subdivided according to the different marginal area they refer to.

Table 15: *Best Practices divided by marginal area*

Marginal areas	State/ Region	Landfill/ Dump	Quarry/ Mine	Industry	Degraded/ Contaminated	Bound/ Access limited	Military/ Former military	Non fertile terrain	Other
Roncajette	I-Ve	X			X				
Grottaglie	I-Ve							X	
Cà Lino	I-Ve							X	
Le Vigne	I-Ve								X
Cagliari	I-Sa			X					
Marrubbiu	I-Sa			X					
Villacidro 1	I-Sa			X					
Villacidro 2	I-Sa			X					
Villacidro ASI A	I-Sa			X					
Villacidro ASI B	I-Sa			X					
Villacidro ASI C	I-Sa			X					
Menorca	ES- Ba	X			X				
Nordhackstedt	DE-Sch		X						
Sinarcas Nuevo	ES- Va							X	
Sinarcas Actual	ES- Va							X	
Ostrožská Lhota	CZ- Zl							X	
Campus of WUT	Pl-Ma								X
Divčice	CZ-Boe								X
Lukavice	CZ - Boe								X
Sole a Carbonia	I -Sa	X			X				
Sole a Oleggio	I -Pi	X			X				
Mattie	I- Pi	X			X				
Belvedere	I- To	X			X				
Chilluèvar	ES- And							X	
Carcheles	ES-And			X					
Dehesilla de Rus	ES- And							X	
El Batán	ES- And							X	
El Cerrejón	ES- And								X
Pozo Alcón	ES- And								X
Guadiana	ES- And							X	
Heusden Zolder	BE - Fi		X		X				
Wulmstorf	DE - Ha	X			X				
Malagrotta	IT - La	X			X				
Tozzi Sud	IT -					X			
Saarbrucken	DE - Sa			X			X		
La Vialla	IT - To							X	
Pomarance	IT -To							X	
I Corozi	IT - Tr		X						
Stockstadt	DE - Fr	X			X				
Waldpolenz	DE - Le						X		
Velestino 1	GR – Ma							X	
Velestino 2	GR - Ma							X	
Castelleone	IT - Pi								
Castelleone	IT - Pi	X			X				
Le Conche Montopoli	IT - To	X			X				
Fontino	IT - To							X	
Heliantide	IT - Ca							X	
Stockstadt	DE - Fr	X			X				
Waldpolenz	DE - Le						X		
Velestino 1	GR – Ma							X	
Velestino 2	GR - Ma							X	
Castelleone	IT - Pi								
Castelleone	IT - Pi	X			X				
Le Conche Montopoli	IT - To	X			X				

b. Detailed overview of censed marginal terrains (Veneto – Jaén)

Table 16 gives a detailed overview of the landfills considered suitable for installing a PVPP in Veneto, estimating for each site the potential installable power considering an average of 1,600 square meters for 50 kWp plant (using monocrystalline silicon, the most diffused technology on the market).

Table 16 part 1: *Veneto – The potential solar power capacity of Veneto landfills in detail*

	PROVINCE	MUNICIPALITY	LOCATION	COMPANY	SITE ID	STATUS	ESTIMATED SURFACE (square meters)	ESTIMATED POWER (kWp)
1	Treviso	Riese Pio X	Via Schiavonesca	Geo Nova Spa	5903	post-mortem	**51500**	**1609**
2	Treviso	Ponzano Veneto	Via Postumia 105	VENETA ROADS	5121	post-mortem	**51200**	**1598**
3	Verona	Verona	Ca' Nova	Amia	5880	post-mortem	**50000**	**1562**
4	Vicenza	Zermeghedo	Via Oltrechiampo	Consorzio Medio Chiampo	3820	exausted	**50000**	**1562.5**
5	Treviso	Roncade			12771	post-mortem	**47700**	**1489.5**
6	Treviso	Casale sul Sile				post-mortem	**46300**	**1448.5**
7	Treviso	Paese	loc. Borgo Economia	Ecoidrojet	15713	exausted	**45300**	**1415.5**
8	Verona	Mozzecane	Loc. Corte Pisana	Corme S.r.l.	6882	Expired	**44200**	**1380**
9	Verona	San Bonifacio	Tombole	Calcestruzzi Danese	5797	expired	**43700**	**1365.5**
10	Verona	Verona	Soriane	Cava Lessinia	2541	post-mortem	**43700**	**1365.5**
11	Treviso	Roncade				exausted	**43100**	**1345.5**
12	Treviso	Castelfranco Veneto	S. Floriano	Geo Nova Spa	5971	exausted	**38000**	**1187.5**
13	Venezia	Mirano	Loc. Cà Perale, via Taglio sinistro	A.C.M. Azienda Consorzio del Mirese S.p.A.	9609	exausted	**37500**	**1173.5**
14	Verona	Verona	Vignal	Fonderie Sime	5886	post-mortem	**33400**	**1044**
15	Treviso	Roncade				exausted	**32800**	**1025**
16	Treviso	Paese	S. Lucia "La Fossa"	Priula TV2	5631	post-mortem	**31900**	**997.5**
17	Verona	Valeggio sul Mincio	Ca' Baldassarre	Rede	5972	post-mortem	**30400**	**950**
18	Treviso	Mogliano Veneto	loc. Crocicchio Bianchi	Ex cava Bovo		post-mortem	**29800**	**930.5**
19	Belluno	Ponte nelle Alpi	Loc. Cadola	Comune di Ponte nelle Alpi	15686	expired	**29200**	**913.5**
20	Treviso	Morgano	loc. Colombera	Geo Nova Spa		exausted	**28400**	**888.5**
21	Venezia	Venezia	Loc. Malcontenta Marghera	Syndial S.p.A.	5742	expired	**27600**	**861.5**
22	Venezia	Spinea	Olmo	Ecoveneta		exausted	**27500**	**860**
23	Verona	Verona	Ca' di David	Cartiera di Ca' di David	5882	post-mortem	**26000**	**812.5**
24	Treviso	Mogliano Veneto	loc. Crocicchio Bianchi	Consorzio Intercomunale Priula	6869	exausted	**25800**	**805**
25	Rovigo	Porto Tolle	Magenta	SIEMEC Spa	4334	post-mortem	**25600**	**800**
26	Treviso	Cordignano	Loc. Campardo Quattro strade	Consorzio C.I.T. Consorzio dei Servizi per l'igiene del Territorio	14840	expired	**25600**	**799.5**
27	Rovigo	Giacciano con Baruchella	Via Roma - Loc. Zelo	Crivellari & Zerbini	3170	exausted	**24500**	**766.5**
28	Verona	Cerea	Asparetto	Merlin Giuseppe	4332	expired	**24500**	**765.5**
29	Vicenza	Sandrigo	Via Meucci	Comune di Sandrigo	3824	post-mortem	**23300**	**729**
30	Treviso	San Vendemiano	loc. Fossamerlo	Clara Ecologica	5901	post-mortem	**22000**	**689**

Table 16 part 2: *Veneto – The potential solar power capacity of Veneto landfills in detail*

	PROVINCE	MUNICIPALITY	LOCATION	COMPANY	SITE ID	STATUS	ESTIMATED SURFACE (square meters)	ESTIMATED POWER (kWp)
31	Verona	Verona	San Massimo	As.Ma.Ve.	5893	exausted	**21900**	**984.5**
32	Treviso	Sernaglia della Battaglia	Via Cal Zattera Falzè	Triveneta Asfalti. Gestore Girotto F.lli. S.r.l.	10541	expired	**20000**	**625**
33	Padova	Padova	Vai Vasco De Gama	Azienda Padova Servizi	3959	exausted	**19100**	**597**
34	Vicenza	Montecchio Maggiore	Via De Nicola	G.M. Srl	3830	post-mortem	**18700**	**583**
35	Treviso	Zero Branco	Via Tiveron, 3 Scandolara	CAZZARO S.P.A.	4381	expired	**16100**	**501.5**
36	Treviso	Paese	Via Oston	Vaston S.R.L.	6936	post-mortem	**15700**	**490.5**
37	Vicenza	Malo	Casette di Pisa	Comune di Malo	5734	expired	**15400**	**481**
38	Verona	Verona	Pestrino	Ecovalpantena	5846	post-mortem	**13200**	**413**
39	Rovigo	Adria	Via Risorgimento 66	SOCEIC di Carlo Valle e C. S.a.S.	6180	expired	**12000**	**375**
40	Treviso	Loria	S. Pancrazio	GEA Srl Ex Cava Marchetti	7058	exausted	**11900**	**372**
41	Verona	Verona	Falcona	Segala Luciano	2669	post-mortem	**11800**	**370**
42	Treviso	Quinto di Treviso	Via San Cassiano	Dal Zilio Inerti S.r.l.	3982	expired	**11100**	**345.5**
43	Verona	Verona	Forte Azzano	Comune di Verona	5823	post-mortem	**11000**	**344**
44	Treviso	Castelfranco Veneto	Circonvallazione Est Cava 'Cavalcavia' - San Floriano	Menini S.r.l.	10529	expired	**10700**	**333**
45	Padova	Cittadella	Via Cavin De Carli		5975	exausted	**9600**	**300**
46	Vicenza	Isola Vicentina	Bassanese	Comune di Isola Vicentina	5733	expired	**9300**	**290**
47	Belluno	Sospirolo	Loc. Masiere di Gron	Roni Angelo S.p.A	15697	expired	**9300**	**289**
48	Treviso	Paese	Loc. Colmello	Vaston S.r.l.	5902	expired	**8800**	**276**
49	Treviso	San Biagio di Callalta	Loc. Sant'Andrea di Barbarana	Artigiana Scavi dei F.lli Girotto S.n.c.	9633	exausted	**8800**	**275.5**
50	Vicenza	Sandrigo	via Masona	CISAT	3825	post-mortem	**8600**	**269**
51	Treviso	Ponzano Veneto	Via Morganella ovest 55	Biasuzzi cave S.p.A. ex GRUPPO BIASUZZI S.p.A	121	expired	**8000**	**250**
52	Treviso	Sernaglia della Battaglia	Loc. Masarole	Comune di Sernaglia della Battaglia	12773	expired	**8000**	**250**
53	Treviso	Vedelago	Via Tredase	Centro Riciclo Vedelago S.r.l.	6495	expired	**6500**	**203**
54	Belluno	Limana	Via degli Alpini	Costan Spa	4416	exausted	**5800**	**181.5**
55	Verona	San Bonifacio	Lioncello	Ferroli Spa	15968	exausted	**5700**	**177**
56	Treviso	San Biagio di Callalta	Loc. Fagarè	De Vido Ferruccio	10539	expired	**3800**	**117.5**
57	Belluno	Domegge di Cadore	Ciare di Ronda	Comune di Domegge di Cadore	14127	expired	**3500**	**109.5**
58	Treviso	Ponzano Veneto	Via Feltrina 76	Calcestruzzi S.p.A.	12767	expired	**2200**	**68.5**
59	Belluno	Arsiè	Loc. La Menor	Comune di Arsiè	10569	expired	**1500**	**47**
Totale							**1368500**	**43058.5**

Table 17 gives a detailed overview of the surface of mines and landfills in each municipality of the province of Jaén.

Table 17 part 1: *Surface of mines and landfills in the municipalities of Jaén, 2008, Consejería de Medio Ambiente de la Junta de Andalucía, 2008*

SURFACE OF MINES AND LANDFILLS IN THE MUNICIPALITIES OF JAÉN, 2008	HA	% (MUNICIPALITIES)
ALCALA LA REAL	19.55	0.08
ALCAUDETE	12.16	0.05
ANDUJAR	69.33	0.07
ARJONA	8.62	0.05
ARJONILLA	9.74	0.23
ARQUILLOS	1.29	0.02
BAEZA	62.64	0.32
BAILEN	275.57	2.34
BAÑOS DE LA ENCINA	35.84	0.09
BEAS DE SEGURA	54.46	0.25
BEDMAR Y GARCIEZ	1.35	0.01
BELMEZ DE LA MORALEDA	8.96	0.18
BENATAE	2.06	0.05
CAMPILLO DE ARENAS	9.09	0.08
CANENA	1.34	0.09
CARBONEROS	4.28	0.07
CARCHELES	1.89	0.04
CAROLINA (LA)	17.91	0.09
CASTELLAR	34.6	0.22
CASTILLO DE LOCUBIN	6.4	0.06
CHICLANA DE SEGURA	1.47	0.01
CHILLUEVAR	4.65	0.12
ESCAÑUELA	0.25	0.02
FRAILES	1.29	0.03
FUERTE DEL REY	3.22	0.09
GUARDIA DE JAEN (LA)	37.61	0.98
GUARROMAN	63.69	0.67
HIGUERA DE CALATRAVA	2.03	0.05
HORNOS	0.66	0.01
HUELMA	27.23	0.11
HUESA	12.01	0.09
IBROS	8.11	0.15
IZNATORAF	4.35	0.05
JABALQUINTO	27.58	0.38
JAEN	244.1	0.57
JAMILENA	27.36	3.08
JODAR	31.77	0.21

SURFACE OF MINES AND LANDFILLS IN THE MUNICIPALITIES OF JAÉN, 2008	HA	% (MUNICIPALITIES)
LAHIGUERA	28.76	0.65
LINARES	309.97	1.57
MANCHA REAL	35.37	0.36
MARMOLEJO	19.49	0.11
MARTOS	46	0.18
MENGIBAR	31.54	0.51
MONTIZON	0.91	0
NAVAS DE SAN JUAN	18.67	0.11
ORCERA	15.52	0.12
PEAL DE BECERRO	37.16	0.25
PEGALAJAR	11.33	0.14
PORCUNA	21.42	0.12
PUENTE DE GENAVE	11.96	0.31
PUERTA DE SEGURA (LA)	7.31	0.07
QUESADA	6.78	0.02
RUS	1.98	0.04
SABIOTE	18.65	0.17
SANTA ELENA	5.55	0.04
SANTIAGO DE CALATRAVA	1.11	0.02
SANTIAGO-PONTONES	3.76	0.01
SANTISTEBAN DEL PUERTO	12.45	0.03
SEGURA DE LA SIERRA	5.86	0.03
SILES	14.59	0.08
SORIHUELA DEL GUADALIMAR	9.78	0.18
TORRE DEL CAMPO	55.08	0.3
TORREBLASCOPEDRO	5.92	0.1
TORREDONJIMENO	13.71	0.09
TORRES	2.71	0.03
TORRES DE ALBANCHEZ	1.37	0.02
UBEDA	109.2	0.27
VALDEPEÑAS DE JAEN	18.69	0.1
VILCHES	39.81	0.15
VILLACARRILLO	64.47	0.27
VILLANUEVA DE LA REINA	34.35	0.16
VILLANUEVA DEL ARZOBISPO	77.26	0.43
VILLARDOMPARDO	0.32	0.02
VILLARES (LOS)	11.96	0.14
VILLATORRES	18.41	0.25
Total (Ha)	**2263.64**	

Table 17 part 2: *Surface of mines and landfills in the municipalities of Jaén, 2008, Consejería de Medio Ambiente de la Junta de Andalucía, 2008*

c. Short profitability remarks

In the following section, we report three cases analyzing the economic return of a PVPP investment in broad terms, independently from the typology of terrain on which the plant is implemented.
The cases are useful to gain an idea of the scale of the potential return on investments. Outcomes that are even more positive can be foreseen when considering the direct and indirect advantages of installing the plant on a marginal area.

From a strictly economic viewpoint, the purchase of a PVPP means an expenditure of capital resources at a given time with the expectation of benefits in the form of solar electricity yield to be paid/saved to/by the user over the useful life of the system.

As commented in other sections of this document, many financial mechanisms are available in the European countries intended to promote PV plants. However, for the sake of simplicity, only buy-down incentives, soft loans for the whole remaining initial cost after the buy-down subsidy to be repaid in equal annual instalments, and enhanced feed-in tariffs are considered in a first approach for three specific PVPP investment cases (cases A, B and C, from now on) analyzed below, leaving aside the effects of taxation. However, as ignoring completely the tax influence may lead to unrealistic results, a brief analysis concerning the impact of taxation in these three cases completes this profitability review.

A review of two profitability indexes

The simple payback time (SPBT) of an investment project is the required number of years for the inflows to equal the outflows of this project. Despite being easily understandable, this profitability index does not take into account the moment over the life of the project when these inflows and outflows take place, so it is a rather unrealistic index (e.g.: a 3,000-Euro income in 2009 is worth more than a 3,000-Euro income in 2019). In this sense, it is preferred to deal with the discounted payback time (DPBT), stated as the required number of years for the present worth of the inflows to equal the present worth of the outflows (the present worth implies using an annual discount rate and taking into account the annual inflation rate). Evidently, profitability means that the discounted payback time should not exceed the serviceable life of the system. Although it is also easily understandable and straightforward, this parameter does not consider the cash flows that are produced after the DPBT. Hence, it may hide sound financial opportunities for those deciding to invest on a PV systems[18].

The internal rate of return (IRR) of an investment project equals the actual interest rate at which the project initial investment should be lent during its useful life to achieve the same profitability[19]. From an economic point of view, the PV system should be considered viable if the IRR exceeds a profitability threshold fixed by the future owner. In this sense, this parameter is very important for the investor since it provides a meaningful estimation of the return of their investment.

[18] Perez R, Burtis L, Hoff T, Swanson S, Herig C. Quantifying residential PV economics in the US-payback vs cash flow determination of fair energy value. Solar Energy 2004;77:363-366.

[19] Chabot B. From cost to prices: economic analysis of photovoltaic energy and services. Progress in Photovoltaics: Research and Applications 1998;6:55-68.

Three examples

Giving a tutorial on how to calculate the *IRR* lies out of the scope of this document, despite the method to do this is easy to find in literature [20,21]. Nevertheless, providing some figures for this profitability index in three specific cases treated below may enlighten a potential PVPP owner in his decision making. In this sense, some factors are involved in the calculation of the *IRR* and -as it can easily be anticipated- these are mainly related to costs, incentives, electricity yields and the annual increase rate of the PV electricity price. The figures that configure each one of the three cases mentioned earlier which refer to costs, incentives and electricity yields are commonly normalized-per-kWp.

Some values that characterize each one of the cases are supplied below, together with the corresponding figure for the *IRR*:[22]

Case A:

- The normalized annual PV electricity yield ([EPV]kWp) is assumed equal to 1200 kWh kWp-1 year-1 .
- The normalized initial investment in the PVPP ([PVIN]kWp) is assumed equal to 6000 € kWp-1 .
- The corresponding price per kWh for PV-generated electricity sold to the grid (pu), is fixed by law in different countries. It is assumed equal to 0.35 € kWh-1
- The annual increase rate of the PV electricity price (εpu) is assumed equal to 2%.
- The normalized initial investment subsidy ([PVIS]kWp) is assumed equal to 10% of [PVIN]kWp therefore [PVIS]kWp is assumed equal to 600 € ·kWp-1. It is worth mentioning some countries provide capital subsidies ranging from 10 to 50 percent [23,24].
- Consequently, the remaining sum [PVIN]kWp–[PVIS]kWp is to be paid by the owner. This amount is assumed to be borrowed at an annual loan interest il= 5% while the loan term Nl is assumed equal to 10 years.

IRR in case A equals a very attractive 8.6%

Case B:

- [EPV]kWp is assumed equal to 1400 kWh kWp-1 year-1.
- [PVIN]kWp is assumed equal to 6000 € kWp-1.
- The corresponding price per kWh for PV-generated electricity paid/saved to/by the owner (pu) is assumed equal to 0.20 € kWh-1.
- εpu is assumed equal to 2.5% .
- [PVIS]kWp is assumed equal to 2500 € kWp-1.
- Consequently, the remaining sum [PVIN]kWp–[PVIS]kWp is to be paid by the owner. This amount is assumed to be borrowed at an annual loan interest il= 7.5%, while the loan term Nl is assumed equal to 10 years.

IRR in case B equals an attractive 6.6%

[20] Talavera DL, Nofuentes G, Aguilera J, Fuentes M. Tables for the estimation of the internal rate of return of photovoltaic grid-connected systems. Renewable & Sustainable Energy Reviews 2007; 11:447-466.
[21] Nofuentes G, Aguilera J. and Muñoz FJ. Tools for the Profitability Analysis of Grid-Connected Photovoltaics. Progress in Photovoltaics: Research and Applications, 2002;10:555-570.
[22] A useful life of 25 years has been assumed in the three cases, together with an annual operation and maintenance cost that equals 1% of the normalized initial investment
[23] Martinot E. Renewable: Global status report. REN21 Renewable Energy Policy Network by The Worldwatch Institute, 2005. Available at: http://www.martinot.info/RE2005_Global_Status_Report.pdf(accessed November 2006).
[24] Martinot E. Renewable: Global status report, Update. REN21 Renewable Energy Policy Network, 2006. Available at: http://www.ren21.net/globalstatusreport/download/RE_GSR_2006_Update.pdf (accessed September 2007).

Case C:

- [EPV]kWp is considered equal to
- 1100 kWh kWp-1 year-1 .
- [PVIN]kWp is assumed equal to 5000 € kWp-1 .
- The corresponding price per kWh for PV-generated electricity paid/saved to/by the owner (pu) is assumed equal to 0.20 € kWh-1 .
- εpu is assumed equal to 1%.
- [PVIS]kWp is assumed equal to 26% of [PVIN]kWp, therefore [PVIS]kWp is assumed equal to 1300 € kWp-1 [7,9].
- Consequently, the remaining sum [PVIN]kWp–[PVIS]kWp is to be paid by the owner. This amount is assumed to be borrowed at annual interest rate il= 2% over a term equal to Nl= 20 years.

IRR in case C equals a fairly good 3.8%

Taxation Impact

As commented previously, the above cases have ignored the tax influence. However, some basic issues concerning this influence will shortly be dealt with below to help achieve an approach that tries not to conceal the effect of taxation. Anyway, it should be kept in mind that the general assumptions that follow are reasonable, but taxation differs considerably from country to country. However, tax exemptions have been left aside, due to the wide differences concerning this issue again from country to country.

In general, most existing tax laws, consider that every owner of a PVPP must pay an amount per annum, mostly attributable to the gains of the previous year. This amount depends on the law defined tax coefficient, investment revenue, the annual operation and maintenance cost, the debt repayment method, the asset amortization, etc.

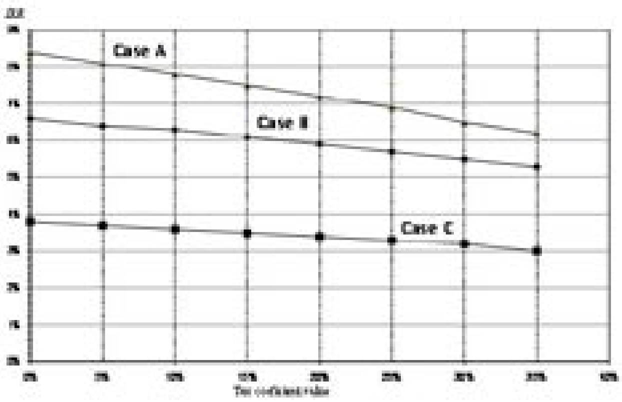

Figure 97: IRR (%) as a function of the percentage tax coefficient values for cases A, B and C (Image courtesy: University of Jaén)

The diversity of taxation systems according to each country makes it complex to encompass this issue in our analysis. Anyway, several tax coefficient values - ranging from 0% up to 35%- have been considered.[25] In this subsection, an analysis of the *IRR* has been made by taking in account a tax coefficient for the three considered cases. In order to estimate the taxes, this coefficient has been applied to the cash inflow from the PVPP, once the asset amortization, the interest payments of the loan, and the operation and maintenance cost of the PVPP have been deducted. The asset amortization has been considered lineal over the life cycle of the PVPP (25 years) and it has been excluded from taxation.

The results of the analysis in the base cases for scenarios A, B and C

[25]Kaldellis JK, Vlachou DS, Korbakis G. Techno-economic evaluation of small hydro power plants in Greece: a complete sensitivity analysis. Energy Policy 2005;33:1969-1985.

are shown in figure 97. In this figure, the internal rate of return is depicted vs the percentage tax coefficient. The *IRR* experiences a smooth and almost linear decrease as the taxation coefficient increases. More specifically, when the latter rises to 35%, the former is only decreased by 2.2% for case A, 1.3% for case B and 0.8% for case C.

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