Consiglio Nazionale delle Ricerche

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EUROPEAN METTTES PROJECT

REGIONAL DEMAND PROFILE (RDP)

for

Latium Region - Italy

Renewable Energy for Latium: looking for innovative technologies in PV and solar thermal field

Sara Berselli and Stefania Giuffrida

Consiglio Nazionale delle Ricerche
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Regional Demand Profile

Renewable Energy for Latium: looking for innovative technologies in PV and solar thermal field

1. Definition of technical field: photovoltaic PV and solar thermal technologies

2. Definition of the region: Latium (Central-west region of Italy)

3. Short presentation of the region in question: area, population, summary of the significant economical activities:

Latium is a region of central Italy, bordered by Tuscany, Umbria, Abruzzo, Marche, Molise, Campania and the Tyrrhenian Sea. It comprises 5 provinces, Rome, Viterbo, Latina, Frosinone and Rieti, and 377 towns. The regional capital is Rome, which is also the national capital. The region's area covers 17.203 km². The population is about 5.304.778 millions of inhabitants for a density of about 300 inhab./km².

Latium population is younger compared to national average. Activity rate (the ratio between labour force and active population) is 63,6%, higher of one point compared to national average. Unemployment rate is improved by almost one point between 2003 (8,7%) and 2004 (7,9%).

Latium territory is characterized by its heterogeneity: 54% is covered by hills, 26,1% by mountains and the remaining area is flat. This part is almost concentrated near the coast. It's also the richest Italian region in rivers, for example Tevere (that runs through Rome), Liri, Aniene, Sacco, and lakes, a lot of whom have volcanic origin, like Bolsena, Bracciano, Vico and Nemi.

Latium is diversified also in local flora and fauna, with a large presence of natural parks and protected areas, that implies a big interest in environmental defence and represents a big touristic attraction. Tourism is one of the most important economical resources as we consider Rome, the coast, but also little towns and villages, rich of history and archeological sites.

Agricoltural products differ on the basis of the geographical area: in the area of Agro Pontino, cereals, vegetables and fruit represent the main crops; the area of "Roman Castles" is well known for the production of wine; Sabina is specialized in olive colture, providing an excellent oil. Breeding is concentrated on bovine and ovine; fishing is a resource of medium importance.

Latium is the second Italian region for the firms'number, 563.925 thousand, which represent about 9% of national amount. For the fourth consecutive year, Latium industry has increased more than national one and its growth was characterized by a constant improvement (the number of firms is risen of 1,7% in 2005).

This aspect denies the imaginary idea of Latium of 80's as a territory characterized by a "statal" economy, made of offices, bureaus and public services because of Rome's role, as capital and headquarters of government, ministries and public offices.

According to recent evaluations, Latium has made a contribution of about 40% to national growth.

The reason can be found in the productive structure: his economy strength relies upon advanced tertiary and in chemical-pharmaceutical industry, with an increase of 1,1% and a contribution to GDP (gross domestic product) of about 10%. The leading role represented by financial services, information technology and communications is the reason of the very recent Latium development and its excellent results. Very important are also manufacturing industries, with over 45.500 factories, and building firms.

In this scenario, tertiary sector (in particular trading, research and development, consultancy and services to firms) is the most important one (61,7%), although the high development of Latium's industry is also due to high technology and high added value activities, as mechanical machines, precision instruments, chemical-pharmaceutical products, energy, electro-mechanics and printed paper.

As further confirmation of Latium dynamism and innovation capability, we must add that ICT sector represents about 9% of the regional employment. This value is much higher than the national one that is about 4%. Although this is only a little component of the entire productive scenario, ICT sector is a direct measure of the productive and innovation capacity. Rome province seems to catalyze this sector expansion, with over 90% of ICT firms.

Latium presents also some industrial agglomerates that actually have a high value in the national panorama; some of them have been formally recognised by Regional Council such as Local Productive Systems or Industrial Districts, in application of Regional Law 36/01.

Between Rome and Latina (the so-called “pontino axis”, Rome-Pomezia-Aprilia-Latina) it’s localized the second industrial druggist pole in Italy, which is characterized by the presence of important production plants. In addition most important multinational enterprises of the field have in this area their research centres.

Latium is also famous for the aerospace industry, thanks to the presence of great enterprises and of innovative small and medium firms, located in Rome, Frosinone and Latina.

On the other hand, Rome represents a national pole in the sectors of audiovisual aid and telecommunications. This is due to the presence of Cinecittà Studios, of principal national broadcasters (RAI and Mediaset), many SME specialized in television and cinematographic productions and multimedial services connected to ICT development.

In Viterbo province it’s evidenced the industrial district of Civita Castellana, well known for ceramics and pottery production.

In Frosinone area, between Colleferro and Anagni, it’s concentrated chemical and electronic district; car industry is more active near Cassino, around FIAT plant.

The most important activities in Rieti territory are precision mechanics (between Cittaducale and Rieti) and electronic industry in Borgorose.

Agricoltural and food-row is very expanded in Tuscia land and in the Pontin plain, where there is the biggest commercial and logistic centre of South Italy of vegetables and fruits.

In conclusion, marble and stone extractive and transformation industry has great importance, in particular regarding to Tivoli-Guidonia compartment (roman travertine) and industrial district of Ausoni Mountains (pearly marble).

4. Interactions of the region with the neighbouring regions – Italian dependence from foreign countries for the supplying of energy

Italy is a net energy importer, and presently consumes more than six times the amount of energy it produces. Italy is dependent on outside sources for almost all of its crude oil, natural gas, and coal, and even imports a significant part of its electricity supply. Italy presently ranks as the world's twelfth-greatest energy consumer (and fourth-greatest in the European Union), accounting for about 1.9% of the world's annual energy consumption.

The Italian authorities often underline the singularity of Italy’s electricity mix, which has no nuclear power (apart from nuclear electricity imported from France). Difficulty to exploit domestic energy resources also explains the strong historical dependency on primary energy imports and the need to diversify energy supply to spread the security of supply risks.

Even if in 2004 renewable energy production grows (+16%) up to the 45% of national energy production, taking into account all the energy supply, including imported, only the 6.2% of total used energy is renewable energy, while 44% derives from petroleum, 34% from gas and the other from coal and from electricity imported by third countries (mainly produced in nuclear power plants).

Energy dependency by type of source

Petroleum

Petroleum is being imported mainly from the former Soviet Union, Libya, Saudi Arabia, and Iran. Italy currently ranks as the world's twelfth-greatest petroleum consumer (and third-greatest in the EU).

Natural gas

Italy is the world's ninth-greatest consumer of natural gas (and third-greatest in the EU), accounting for about 2.8% of the world's annual natural gas consumption. Consumption is far greater than production, and Italy is importing natural gas via international pipelines from Algeria, Russia, Norway, Netherlands, and Libya.

Coal

Italy has only relatively minor coal reserves and no longer produces coal, though coal still contributes about 6% to Italy's primary energy demand. Italy imports steam coal from a variety of countries including South Africa, Colombia, and the United States. Demand is increasing, mostly from additions to coal-fueled power generation capacity.

Electricity

Electricity demand has been steadily increasing in Italy, with consumption now nearly 30% higher than it was a decade ago. Italy presently ranks as the twelfth-greatest electricity consumer (and fourth-greatest in the EU). Most of Italy's electricity comes from fossil fuels, though a shift is occurring away from oil toward natural gas. Italy presently imports more than 17% of the electricity it consumes, with imports coming mostly from France and Switzerland.

Although there are four nuclear power plants in the country, none have been in use since 1987, when a public ballot referendum opted to discontinue all use of nuclear power. These four nuclear power plants are now being dismantled. Most new power-generating facilities, at least in the near future, will be fuelled by natural gas.

At the 1997 Kyoto conference, the EU as a whole agreed to limit its increase in greenhouse gas emissions to 8% below 1990 levels by the 2008-2012 timeframe. Italy currently is responsible for about 1.8% of the world's total fossil fuelled-based carbon dioxide (CO_2) emissions (ranking it 10th in the world and third in the EU in that regard), but has taken some steps to attempt to reduce its carbon emissions, including encouraging the use of natural gas for power generation and implementing a carbon tax (in 1999). Increased use of renewable energy is also a national priority; Italy now funds more than 25% of all PV research in the EU, and Italy already ranks 5th in the world in geothermal electricity generation.

5. Specification of the relevant regulations concerning the chosen technical field

5.1 European Regulation

Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market

The purpose of this Directive is to promote an increase in the contribution of renewable energy sources to electricity production in the internal market for electricity and to create a basis for a future Community framework thereof.

Targets can be summarized as follows:

1) To establish a framework to increase the share of green electricity from 14% to 22% of gross electricity consumption by 2010;
2) To help to double the share of renewable energy from 6% to 12% of gross energy consumption in Europe by 2010;
3) To further compliance with the commitments made by the EU under the 1997 Kyoto Protocol on reducing greenhouse gas emissions.

In Article 3 of the Directive some national targets are given. In particular Member States shall take appropriate steps to encourage greater consumption of electricity produced from renewable energy sources in conformity with the national indicative targets.

Not later than 27 October 2002 and every five years thereafter, Member States shall adopt and publish a report setting national indicative targets for future consumption of electricity produced from renewable energy sources in terms of a percentage of electricity consumption for the next 10 years. The report shall also outline the measures taken or planned, at national level, to achieve these national indicative targets. To set these targets until the year 2010, the Member States shall:

- take account of the reference values indicated in the Directive;

- ensure that the targets are compatible with any national commitments accepted in the context of the climate change commitments accepted by the Community pursuant to the Kyoto Protocol to the United Nations Framework Convention on Climate Change.

Member States shall publish, for the first time not later than 27 October 2003 and thereafter every two years, a report which includes an analysis of success in meeting the national indicative targets taking account, in particular, of climatic factors likely to affect the achievement of those targets and which indicates to what extent the measures taken are consistent with the national climate change commitment.

Renewable energy sources are :

1) Wind energy;
2) Solar energy;
3) hydroelectric power;
4) Biomass energy;
5) landfill gas energy;
6) biogas and sewage treatment gas energy;
7) Geothermal energy;
8) Wave energy;
9) Tidal energy.

National law 2003/387 of 29th December 2003 implements the Directive 2001/77/CE and introduces some measures addressed to overcome problems connected to the market of different renewable sources of energy. The law is focused on some main aspects which are summarized in the following list:

1) renewable sources plants with a power up to 20 kW can be connected to the grid. This will allow the net metering, for example, for little wind power plants;
2) the introduction of an incentive policy for PV energy, similar to the one adopted in Germany. The system foreseen incentives for the production of electricity and its intake in the grid;
3) some incentives are foreseen for solar thermal energy;
4) authorization procedure has become easier;
5) the energy produced from renewable sources has been granted;
6) the obligation of an efficient information campaign has been introduced in order to promote renewable sources of energy and their uses;
7) a better definition of the kind of energy sources that can be considered as renewable and for this subjected to an incentive policy.

Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings

In order to ratify the *Kyoto Protocol*, EU has engaged to reduce the gas emission of 8% in the period 2008-2012 and has issued the *Directive on Building Energetic Performance* (Directive 2002/91/EC, published on January 4, 2003), with the aim to provide for an ambitious step-ahead to increase the energy performance of public, commercial and private buildings in all Member States. The objective of Directive 2002/91/EC is to promote the improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.

This Directive lays down requirements concerning:

- the general framework for a methodology of calculation of the integrated energy performance of buildings;
- energy certification of buildings;

❖ regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old.

In the Directive, some definitions are given:

❖ "**energy performance of a building**": the amount of energy actually consumed or estimated to meet the different needs associated with a standardised use of the building, which may include, inter alia, heating, hot water heating, cooling, ventilation and lighting. This amount shall be reflected in one or more numeric indicators which have been calculated, taking into account insulation, technical and installation characteristics, design and positioning in relation to climatic aspects, solar exposure and influence of neighbouring structures, own-energy generation and other factors, including indoor climate, that influence the energy demand;

❖ "**energy performance certificate of a building**": a certificate recognised by the Member State or a legal person designated by it, which includes the energy performance of a building calculated according to a methodology based on the general framework set out in the Directive;

Member States shall apply a methodology, at national or regional level, of calculation of the energy performance of buildings, which must be expressed in a transparent manner and may include a CO_2 emission indicator.

Italian Government has issued the Legislative Decree 192/2005 of August 19th, which entered into force on the 8th October 2005 in execution of the aforesaid European Directive.
Some contents of the decree were already part of the Italian normative patrimony, thanks to Law 10/1991, although their whole fulfillment depended on the establishment of decrees aimed to make them effective. However, during the transitory period, there wasn't legislative uncertainty because the Decree 192 previewed (articles 11 and 12) a transitory discipline, according to which the building energy performance would be calculated on the basis of "Law 10/1991, as it was modified by the Decree 192, by norms and by disposals of Annex I"; "thermal plants" might be regulated by "articles 7 and 9 of the Presidential Decree 412/1993, by the following changes and by disposals of Annex L"; the energetic certificate could be replaced by a qualification certificate written up by the building's planner.
On the 6th of October 2006 Italian Government has approved a scheme of a legislative decree which modifies Legislative Decree 192/2005, in order to better implement European Directive 2002/91/EC, with the aim of striking a balance of the first ten months in which the norms have been applied and of developing the National and Regional Energetic Policy in the civil field.
The law will allow to implement in a better way the European Directive and to improve the energy efficiency of buildings and also to promote the use of renewable sources of energy.
The law can be summarized as follows:

1) energy performance certificate of a building: new buildings and those, which are on sale, must be equipped with a certificate attesting the good energy performance. Most important effects are:

- The law is better integrated with European Directive 2002/91/EC and this could avoid economic sanctions, which European Justice Court could impose to Italy.
- A market driven towards the purchase of low energy consumption buildings;

- Reduction of taxes for families;
- Development of industries involved in construction sector, in services etc.;
- More employment.

2) Thermal dispersions of buildings will be avoided: more restrictive time to fulfill new level of thermal insulation.

More important effect is that the introduction of a new level of thermal insulation will allow to reduce thermal needs of more than 40% in a 3 years time with respect to values which were compulsory until 2005 and this thanks to new level of thermal insulation foreseen from 2010.

3) Solar energy for new houses: thermal solar energy for heating at least 50% of sanitary water and PV energy for the production of a portion of electricity.

More important effects will be the creation of a market of about 400-500.000 square meter of solar panels within 2009; energy consumption will be reduced; the increase of Italian industry involved in solar energy will be favored; solar panels will be better integrated with buildings architecture.

4) Boiler will be more efficient: simplified procedures for the substitution of old plants with more efficient ones colder areas.

More important effects are the reduction of energy consumption and the improvement of Italian industry.

5) New buildings will be screened in order to protect them from the sun.

More important effect is the reduction of air conditioner use and the improvement of a more sustainable energy design of buildings.

6) More environmental sustainable Regional and Municipal plans. This aspect will favor the protection of the environment.

The Legislative Decree was approved on December 29th 2006 (L.D. 311/2006) and it has corrected the L.D. 192/2005 according to its application's balance and some opinions expressed by the Unified Conference and 10th Productive Activities' Commission of the Chamber of Deputies.

Very important is the Energetic Certificate for buying and selling buildings, activated by degrees, first of all for buildings larger than 1000 square meters, after, by July 1st 2009, for each real estate; there are simplified procedures of Energetic Certificate for buildings in existence; the obligation of PV and solar thermal technologies is introduced; facilities for works of building energetic re-qualification are foreseen.

Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC

In the Directive 2006/32/CE the European Parliament and Council focus their attention on the need for the Community to improve the energy end-use efficiency, to manage the demand for energy and to promote the production of renewable energy.

The directive draw the attention on the relatively limited scope for any other influence on energy supply and distribution conditions in the short to medium term, either through the building of new capacity or through the improvement of transmission and distribution.

Improved energy end-use efficiency will contribute to the reduction of primary energy consumption, to the mitigation of CO_2 and other greenhouse gas emissions and thereby to the prevention of dangerous climate change. These emissions continue to increase, making it

more and more difficult to meet the Kyoto commitments. Human activities attributed to the energy sector cause as much as 78 % of the Community greenhouse gas emissions.
Energy efficiency improvement measures could realize these energy savings and thus help the Community reduce its dependence on energy imports. Furthermore, a move towards more energy-efficient technologies can boost the Community's innovativeness and competitiveness as underlined in the Lisbon strategy.

The purpose of the Directive 2006/32/CE is to enhance the cost-effective improvement of energy end-use efficiency in the Member States, by:

(a) providing the necessary indicative targets as well as mechanisms, incentives and institutional, financial and legal frameworks to remove existing market barriers and imperfections that impede the efficient end use of energy;

(b) creating the conditions for the development and promotion of a market for energy services and for the delivery of other energy efficiency improvement measures to final consumers.

The Directive shall apply to providers of energy efficiency improvement measures, energy distributors, distribution system operators, retail energy sales companies, final costumers and armed forces as described in art 2.

In accordance to Directive all Member States shall adopt and aim to achieve an overall national indicative energy savings target of 9% for the ninth year of application of 2006/32/CE, to be reached by way of energy services and other energy efficiency improvement measures. Member States shall take cost-effective, practicable and reasonable measures designed to contribute towards achieving this target. Each Member State shall establish an intermediate national indicative energy savings target for the third year of application of this Directive, and provide an overview of its strategy for the achievement of the intermediate and overall targets. This intermediate target shall be realistic and consistent with the overall national indicative energy savings target.

In order to achieve this purpose all Member States have to present to Commission three Energy Efficiency Action Plans (EEAP) (the first within June 30th 2007, the second within June 30th 2011, the third within June 30th 2014) containing all the energy efficiency improvement measures planned to reach the targets, as well as to comply with the provisions on the exemplary role of the public sector and provision of information and advice to final customers. In fact, Member States shall ensure that energy efficiency improvement measures are taken by the public sector, focussing on cost-effective measures which generate the largest energy savings in the shortest span of time. Such measures shall be taken at the appropriate national, regional and/or local level, and may consist of legislative initiatives and/or voluntary agreements.

The Commission shall give an opinion on whether the intermediate national indicative target appears realistic and consistent with the overall target.

5.2 European legislation on renewable sources of energy: actual choices for the next future

On January 10th 2007 European Commission presented some proposals for the improvement of energy supplying in Europe and, at the same time, for the resolution of climate changes and the promotion of European industries competitiveness. Among proposed strategies a higher use of renewable energy sources, as well as, an improvement of energy efficiency has been confirmed. The aim is to cut CO2 emissions by at least 20% by 2020, with the objective of limiting global climate change to 2°C. This cut should be increased to 30% if an international agreement is reached. The Commission also proposed to increase the share of renewable energy sources in the overall energy mix. It reaffirmed its commitment to improving the EU's energy efficiency by 20%. This would make Europe the most energy efficient region in the world. The Commission proposed to create a true Internal Energy Market with further action required to deliver these aims through a clearer separation of energy production from energy distribution.

The need of cooperation between the European Union with both developed and developing countries and energy consumers and producers has been evidenced. In particular the European Union will develop solidarity mechanisms to deal with any energy supply crisis and actively develop a common external energy policy to increasingly "speak with one voice" with third countries. Energy research will be promoted in Europe with annual investiments.

José Manuel Barroso, President of the European Commission, said: "The challenges of climate change, increasing import dependence and higher energy prices are faced by all EU members" and also "A common European response is necessary to deliver sustainable, secure and competitive energy. "The three objectives – sustainability, competitiveness and security of supply – were set out in the Green Paper on Energy the Commission issued in March 2006

About this new European strategy some Association working for the promotion of renewable energy sources has expressed the need to establish different objectives for each different renewable source of energy. This could promote in a more efficient way the development of that type of industry.

5.3 General framework of next Italian policy in environmental field

European Commission has recently declared that Italy is late in the field of the renewable sources of energy. Although there was a big expansion of wind power, biogas and biodiesel, Italy is still very far from the objectives established at Euopean and National level. European Commission believes that this delay was determined by two factors. The first one is the lack of a clear and effective policy. The second one is due to the presence of too much administrative obligations which represent an obstacle for the installation of some plants. In addition some financial barriers represent a further obstacle, as for example, the high costs for the connection to the grid. The objective which was indicated for Italy is the production of 75 billion kWh/year of renewable energy against actual production which is about 50 billion. This means further 2000 MW from wind power plants, 500 MW of hydroelectric power plants, 2000 MW biomass and biogas power plants and 1000 MW from PV power plants.

In this framework, environment has become a crucial point of next Italian policy. In the next future attention will be focused on measures directed to the reduction and rationalization of energy consumption. The attention will be given to different topics concerning energy. In national Financial Program for 2007 (L.n. 296/2006) specific measures are foreseen for different aspect of daily life.

The main aspects concerning the present Regional Demand profile are here summarized:

Buildings and Energy efficiency of buildings. In order to reduce the energy consumption of buildings there is a tax deduction of 55% for the energy efficiency improvement interventions in existing buildings, for the installation of covering, floors and fixtures, for the installation of solar panels for the production of hot water, for the substitution of cooling and heating plants with plants provided with a condensation boiler and for the adaptation of the distribution grid. Tax deductions are subjected to the examination of a consultant, who is responsible for the declaration of the plant conformity to the law prescriptions. In addition, local authorities has to issue an "energy efficiency certificate". An amount corresponding to the 55% of the total cost will be given to whom will intervene on buildings with a volume of 10.000 m^3 begun within 31 December 2007 end ended within three years.

Renewable sources of energy. Financial Program for 2007 foresees state contributions for the production of energy only for renewable sources of energy, that are indicated in European Directive 2000/77.

Other aspects of the Financial Program are about refrigerators (tax deduction of 200 euros for the purchase of high efficiency refrigerators); fluorescent lamps (tax deduction of 36% for shopkeeper for the adoption of high efficiency illumination systems). Others measures are taken for cars in order to intensify the use of public transport, for industrial machines characterized by low energy consumption, for the promotion of environmental friendly fuels (this to line up Italian legislation to European directive 2003/30/CE) and the reduction of air emissions. Specific financial measures will be taken in order to promote actions dictated by Kyoto Protocol. These are some of the measures contained in national financial program for 2007, that will force industries, private and public companies and the every citizen to seriously consider the possibility to save energy in order to save money.

In order to make these tax deductions effective, the Government has approved in February 2007 a plan called "Climate, Energy Efficiency and Industrial Innovation". While the demand for environmental friendly and energy saving products is increasing there is the need for developing suitable offers through the innovation of Italian industry.

If we consider the demand of technology 6 actions are foreseen:

1) **Tax deductions foreseen by the Financial Plan 2007 will become effective** through the emanation of decrees concerning: **a)** buildings re-qualification; **b)** efficiency in industry: tax deduction of 20% for the purchase and the installation of electric motors with high efficiency (power between 5 and 90 kW) both for new installations and for the substitutions of old motors. Same tax deduction for the purchase and installation of speed variators for electric motors with power between 7,5 and 90 kW. This action is very important for reducing industrial energy consumption; **c)** sustainable mobility: tax reduction for GPL (-20%) and incentives for the creation of ecological cars for the reduction of pollution; **d)** Incentives to agro-energetic system: forced mixing of biofuels increasing within 2010. New instruments are aimed to the development of dedicated productive lines, from agricolture to industry of transformation; **e)** Kyoto Protocol promotion: 600 million euros are dedicated from 2007 to 2009 to the reduction of greenhouse gas emissions.

2) **PV Energy will be promoted.** A new decree for the promotion of PV energy is going to be taken. The most important innovative decision are about the fixation of 3000 MW of PV within 2016. Incentives for industrial plants of 0,36 €/kWh which become 0,49 €/kWh for domestic plants. Attention to plants built in schools, hospitals and small towns to whom a bigger contribution of 5% will be given.
3) **Promotion of energy saving among energy distribution companies** (White Certificates).
4) **Enhancement of incentives of renewable sources of energy** (based on Green Certificates).
5) **High Efficiency co-generation promotion.**
6) **Bio-building Industry promotion.**

6. Presenting the state of art in PV and solar thermal technology

6.1 Solar power energy main features

Solar power is the technology that allows to obtain usable energy from the light of the sun. *Solar energy* has come into widespread use where other power supplies are absent, such as in remote locations and in space.

Solar energy is nowadays used for different applications:

- Heat (hot water, building heat, cooking);
- Electricity generation (PV, heat engines);
- Desalination of seawater.

Its application is increasing thanks to its low environmental impact and to the limited supply of other energy sources such as fossil fuels.

Solar radiation reaches the Earth's upper atmosphere at a rate of 1366 watts per square meter (W/m^2). Solar energy varies in different latitudes. 6% of the incoming solar radiation is reflected and 16% is absorbed resulting in a peak irradiance at the equator of 1,020 W/m^2. Atmospheric conditions (clouds, pollutants and dust) reduce insolation by 20% through reflection and 3% through absorption.

Many technologies have been developed to make use of solar radiation. Some of these technologies make direct use of the solar energy (e.g. to provide light, heat, etc.), while others produce electricity. In the following section we will briefly describe PV cells and solar thermal collector.

6.2 PV technology

Developed at the end of 50’s in space programs field, where it was necessary to have a endless energy source, nowadays PV technology (PV) is going to spread very quickly, with application to buildings and to systems respectively “stand alone” and “grid connected”.

Solar cells are devices or banks of devices that use the PV effect of semiconductors to generate electricity directly from sunlight. Their use has been limited because of the high manufacturing costs. One cost effective use has been in very low-power devices such as calculators with LCDs. Another use has been in remote applications such as roadside emergency telephones, remote sensing, cathodic protection of pipe lines and limited "off grid" home power applications. A third use has been in powering orbiting satellites and other spacecraft.

The feature of this technology consist in using a semi-conductor material which can be fit to release electrons, the negatively charged particles which concern the basis of electricity. Generally silicon is the semi-conductor material used in PV cells because of its easy finding in the sand.

In each PV cell, silicon plate presents two faces, the upper positive and the lower negative. When the light irradiates the cell, it creates inside the material a movement of the electrons, which pass from the negative face to the positive one, generating direct current.

A PV system doesn't need bright sunlight to be operative: it can generate electricity also on cloudy days, producing an energy proportionally to the density of the clouds.

Because of the reflection of sunlight, in days with a few clouds it can yield more energy than in completely clear days.

Solar cells are connected in order to constitute a module. As above mentioned, among the employed materials, silicon is the most used and can provide a theoretical maximum efficiency of about 25%. If we only consider commercial products, more common technologies for their realization of modules are:

<u>Crystalline module:</u>

1. Mono-crystalline silicon: every single cell is made from a wafer, whose crystalline structure is homogeneous. These are the most efficient, but also the most expensive
2. Polycrystalline silicon: the above mentioned wafer is not structurally homogeneous, but is structured in locally organized granules. This is probably the most common type. Slightly less efficient than single crystal, but once set into a frame with 35 or so other cells, the actual difference in watts per square foot is not much

<u>Thin film modules:</u>

1. Amorphous silicon: here the silicon is spread directly on large plates, which are generally made of stainless steel. Cheaper to produce, but often much less efficient, which means larger panels for the same power.
2. Cadmium disulphite: monocrystalline (CdS) presents very low production cost because the technology doesn't require high temperatures, which are necessary for the fusion and purification of silicon. It can guarantee efficiency of about 18%;

3. Gallium arsenide (GaAs): it is a binary with semiconductive properties, able to ensure very high efficiency (27%). It is mostly employed in military or advanced scientific applications.

Other modules:

- microspherical silicon: polycrystalline silicon has a spherical shape with a diameter of about 0,75 mm. Spheres are connected to an aluminium cage.
- Heterojunction: it means that a junction between two different materials is realized. Crystalline silicon is commonly employed as sustaining layer for one or more amorphous or homogeneous layers, which are specific for a band of radiation.

In commercial available systems the average efficiency is summerized in the following scheme:

MODULES	Average Efficiency
Heterojunction	16%
Monocrystalline Silicon	14%
Polycrystalline Silicon	13%
Microspherical Silicon	10%
Amorphous Silicon	6%

Among above mentioned technologies, only amorphous and microspherical silicon permit to have a module with a flexible structure. In the first case there is not the crystalline structure of the material as obstacle to movement while in the second case the cage is flexible.

Monocrystalline and polycrystalline modules represent the major part of the market. Both technologies are similar from the constructive point of view. Every cell is connected with a superficial grid made of conductive material, which canalizes electrons.

PV modules often have a sheet of glass on the front (sun up) side with a resin barrier behind, allowing light to pass while protecting the semiconductor wafers from the elements (rain, hail, etc.). Solar cells are also usually connected in series in modules, creating an additive voltage. Connecting cells in parallel will yield a higher amperage. This connection is made through a metallic ribbon. Modules are then interconnected, in series or parallel, or both, to create an array with the desired peak DC voltage and current.

The power output of a solar array is given in watts or kilowatts. In order to calculate the typical energy needs of the application, a measurement in kilowatt-hours (or kilowatt-hours per day) is often used, which accounts for changes in insolation.

6.2.1 Advantages and disadvantages of using solar PV panels

Main advantages of PV panels are the following:

- Solar electric generation has the highest power density (global mean of 170 W/m^2) among renewable energies;

- Solar power is pollution free during use. Production end wastes and emissions are manageable using existing pollution controls. End-of-use recycling technologies are under development;
- Facilities can operate with little maintenance after initial setup.
- Solar electric generation is economically competitive where grid connection is absent or where fuel transport is difficult, costly or impossible. Examples include satellites, island communities, remote locations;
- When grid connected, solar electric generation can displace the highest cost electricity during times of peak demand (in most climatic regions). It can reduce grid loading, and can eliminate the need for local battery power for use in times of darkness and high local demand;
- Grid connected solar electricity can be used locally thus minimizing transmission/distribution losses (approximately 7.2%);
- Once the initial capital cost of building a solar power plant has been spent, operating costs are low when compared to existing power technologies.

On the other hand, main disadvantages of PV panels can be summarized as follows:

- Solar cells are expensive and need a large initial capital investment;
- To get enough energy for larger applications, a large number of PV cells is needed. This increases the cost of the technology and requires a large areas;
- Like electricity from nuclear or fossil fuel plants, solar energy can be used for transport if only it can be stored (e.g. battery stored electricity or by electrolysing water to produce hydrogen);
- Solar cells produce direct current (DC), which must be converted to alternating current (AC) when used in distribution grids. This incurs an energy loss of 4-12%.

6.3 Commercial products

More common PV modules in crystalline silicon have variable dimension from 0,5 to 1,5 square meter. 2,5 square meter dimension are used for big plants. Anyway there is not the interest in building large panels because of the big loss of efficiency that occurs in case a single cell doesn't work. Common power is of about 150 Wp at 24 V, which can be achieved employing 72 cells. Power, expressed in Watt peak or Wp, is a measure of how much energy the solar panel can produce under optimal conditions. To determine and compare the nominal power of solar panels, the output is measured under standard test conditions (STC), that are: 1) an irradiance of 1,000 W/m^2; 2) solar reference spectrum AM 1.5 (this defines the type and colour of the light); 3) cell temperature of 25 °C (the efficiency of a solar panel drops when the cell temperature rises). The area occupied by commercial modules is about 7,5 mq/kWp. Cost for the client is about 4,00-6,00 €/Wp (January 2006), with annual increase of 10%. The reason for this increase is due to the high difference between demand and offer, which at the moment is at a ratio of 10:1. Since 2004 the demand of this technology increased rapidly worldwide because of uncertain sort of other form of energy and because of a promotion policy of governments. From June 2004 since June 2005 the increase of worldwide demand was about 200%, but silicon producers only increased their production of 60%. The main growth in the number of installed plants has been recorded in Japan, USA and Germany because of the National Financial Support Programs for installing PV plants.

In the absence of specific financial program for its promotion, diffusion of PV technology is limited by the high cost of commercial technology: mono-polycrystalline silicon. These represent about 90% of actual market. The technology is well developed and there will be few possibilities to further improve the existing performance. Nowadays the shortage of silicon for the pressing demand by electronic and PV industries has been the reason for the increase of PV modules cost and for the long time needed to receive the material. This is why there is the need to develop new technologies able to reduce the quantity of silicon needed. In the next future thin film and concentrating solar power technologies will be the most promising solutions.

Concentrating PV technology

In ordinary PV panels the area deputed to capture the sunlight is totally covered by solar cells, which represent about 40% of the total cost of the panel. In Concentrating Solar Power technology the sunlight is captured by lenses that concentrate the ray on solar cells characterized by reduced dimensions, which are placed in their optical focus. This permit a reduction of the silicon employed and also the use of very sophisticated devices, that now are employed in space technology. Although in the presence of high efficiency cells, the cost of the module will be lower. In the Concentrating Solar Power technology only direct component of sun ray is employed, the only lenses can focus. Lenses have to shut out the light orthogonally, thus modules have to be fixed on a high precision two axis heliostat. ENEA, an Italian Research Institute, has developed a low cost PV technology, modular and with low cost of maintenance which is suitable for application in places characterized by high direct sun light level, typical of southern Italy and Mediterranean Countries.

The Concentrating Solar Power can be employed:

- To produce heat usable in industrial processes;
- To move a thermodynamic cycle in order to produce electricity. In this case we talk about "thermodynamic solar technology".

Thermodynamic solar technology

Thermodynamic solar energy is a technique aimed at focusing light by parabolic or cylindrical/parabolic mirrors, to heat a heat transfer fluid which is then used for electricity production, refrigeration or desalination. The fluid can reach temperatures of about 400°C thus producing vapour for a conventional turbine. The system offers different advantages. First of all they can produce electricity during the night hanks to the hot fluid. If built near the see, these kind of plants can also be used to produce desalinated water usable for agriculture. Main disadvantages are connected to the big dimension needed by plants. For this reason they are more suitable for areas with low presence of population.

In Italy on 26 March 2007 ENEA (National Agency for new Technologies, Energy and the Environment) and ENEL SpA has signed an agreement for the realization of "Archimede", the first solar thermodynamic power plant in Italy and the first one in the world combined with a gas combined cycle station. The plant will rise in Priolo Gargallo (Siracusa) and the investment was of 40 million euros. Within 2009 the pilot plant (5 MW) is foreseen to be operative and able to provide energy to 4500 families saving about 2400 tep per year, corresponding to an emission reduction of about 7300 tons.

6.4 European Market

The necessity to contrast the environmental climatic crisis and the parallel increase of oil and gas costs has favoured the development of renewable energy technology.

Europe is the second major producer of PV modules with 27,4% of world production. Japan is the first producer with 44% of production and USA is the third producer with 22%. In the last decade an increase of 30% was annually recorded, bringing PV market at the second place of renewable sources of energy, after only the wind power in terms of investments.

European market has strongly increased only in 2005. 645 MWp were installed in 2005, with respect to 546 MWp in 2004, which means an increase of 18,2%. The major part of installation are essentially grid-connected applications (solar roofs and facades and PV power plants) with 94.4% of installed capacity. In particular the European Union PV market reached the limits of the sector's procurement capacity for the first time. PV industrialists would have been able to produce many more modules if it had not been for the current shortage of silicon, the principal raw material of solar cells.

If we want to examine the world scenario of silicon production we see that the critical sector, which is the obstacle for a large expansion of PV technology, is the one related to the production of "feedstock" or "poly silicon". The raw material is metallurgic silicon, which is used for the production of silicon ultra pure gases, then solidified in special reactors. The availability of metallurgic silicon represents the main problem. Nowadays the feedstock poly is used by both electronic and PV industry. In the 90's PV industry used to employ waste material from electronic industrial processes. A bigger and bigger portion of pure silicon has been employed by PV industry which consumes nowadays 50% of silicon. The shortage of poly is connected to the delay of that kind of industry to built new plants. This is principally due to three different reason. 1) the distrust on PV sector, which has always asked for low costs; 2) the evaluation of PV market as fragile; 3) the risk of installing plants that could become obsolete because of new technologies. The results are a sort of race to *grey gold* and a consistent level of speculation. In spite of technological improvements, the high cost of the raw material and the market unbalance have produced an increase of 10% in the PV systems' price in the last two years.

The introduction of new policies, as well as more efficient productive processes, could increase the solar silicon supply from 30.600 tons in 2007 to 42.800 tons in 2008,. The availability of silicon could be favoured through special agreements between producers involved in different production phases and through integrations between firms.

PV price has been reduced in the last ten years by countries as Germany (and Japan in Asia), where specific Government programs have favoured an excellent development of PV market. In 2004, the German government introduced the first large scale feed in tariff system, under a law known as the 'EEG' (Renewable Energy Sources Act), which resulted in explosive growth of PV installations in Germany. The principle behind the German system is a 20 year flat rate contract. The value of new contracts is programmed to decrease each year, in order to encourage the industry to pass on lower costs to the end users. Subsequently Spain, Italy, Greece and France introduced feed in tariffs.

In 2005, the German market has produced, according to the new German Solar Industry Association (BSW), 603 MWp installed and represents more than 80% of the total capacity installed in the European Union.

This great success has inspired other European countries to set up the conditions for promoting initiatives directed to the development of renewable sources, with the result of expanding solar PV technology. In particular, it has created regional, provincial and municipal agencies finalized to promote high energetic efficiency devices and technologies fed by renewable sources (in Italy, these agencies are more than 40).

In this way, Spain has had a significant increase in its national market with, according to the Institute for Energy Savings and Diversification (Idae), an additional capacity of 14.5 MWp bringing Spain's total installed capacity up to 51.8 MWp.

In France, growth was essentially supported by the French overseas departments, which have a system of specific subventions. The objective, defined in the law of long-term programming of investments is to reach 120 MWp in 2010 (85 MWp for the French overseas departments and 35 MWp for metropolitan France).

The introduction of new technologies, as well as those in the process of development (as the creation of silicon slices of about 100 micron thick instead of 200 or cells guaranteeing efficiency higher than 20%), will allow to silicon slides to maintain its dominant position for many more years, while thin films will probably play an increasing role.

For both technologies the attainment of the midterm target (about 1euro/W as sale price of modules) is foreseen for 2020 and the full competitiveness is foreseen in 2030 and beyond. So it's important to adopt a wide strategy, which includes the reduction of costs, a more efficient use of the solar spectrum and most of all an increasing research and development activity able to sustain the cooperation between basis research and industry, also in cross-sectors as those of organic materials, LED and nanotechnologies.

6.5 Italian Market

During these last years, PV market expanded, moving from 1990's 45 MWp to 2000's 290 MWp. This great development has been possible thanks to two applications that are grown at the same rate: the "stand alone" plants, isolated and autonomous, and systems mounted on buildings and linked to electricity network ("grid connected").

In Italy , during the first mid-1990's, there was a great ferment, with installation of various PV stations by ENEL (the bigger is the station of Serre, in Salerno province, with 3,3 MWp); after that, PV market has slowed down, above all for the lack of aids and incentives to adopt these technologies.

According to experts, the Italian PV market is still at the beginning, but it is likely to grow rapidly from 2006 onwards. It has the potential to become one of the world's most important PV markets.

In July 2005, the national government launched the "Energy Count", a feed-in tariff for solar energy systems, with a 20 year payment guarantee (instead of the old system based on a capital account contribution). The attractive financial incentives (national and regional), the good climatic conditions and the availability of free land create excellent conditions for rapid growth. The "Energy Count" favours the set up of 100MW of PV plants with the national objective to reach an installed power of 300MW until to 2015.

The total installed power of PV systems in Italy by the end of 2005 was 36 MWp. Current estimates for 2006 are 30-53 MWp. The total budget of the government for the feed-in-tariff is 500MWp, 360 of which is available for PV systems with a capacity lower than 50kWp and 140MWp for PV systems with a capacity higher than 50kWp. However, the enormous over subscription of the feed-in tariff incentives during the early part of 2006, when the GRTN (the Italian body in charge of granting approval to applications) received almost 17,000 applications for a total capacity of more than 1,300 MWp, has made the situation almost chaotic. Currently the yearly limit of 85MWp (introduced by the Government in February 2006) is under discussion, since the procedures were complicating the realisation process too much.

The amount in 2007 will strongly depend on possible changes in the feed-in tariff system and the administrative and (local) permit application procedures as well as a further development of distribution channels.

The Government strategy, designed by Economic Development Minister in "2015 Industry Program", is to enforce PV integrated with building as main area of energetic efficiency and renewable sources; to create strong national industries that supplying these technologies after increasing PV request; to develop research activities being able to give to Italy strategic solutions for energetic future. To increase the spreading of PV technology, it's necessary to become almost self –sufficient in PV modules production to cut, or at least to reduce, costs from import.

6.6 Solar Thermal Energy

6.6.1 Presentation of the technology

Solar thermal is a technology that allows direct conversion of solar energy in thermal energy to produce hot water. We talk about "direct" when the heat is captured by an external disposal, while we use the word "passive" when part of the covering of the same building is assimilated to a collector. The basis of the plant is the *solar collector* or *panel*, a device that accumulates solar energy and stores it for a future application.

It's constituted by two elements, an absorbent black body in which it can flow a fluid, commonly water, or air (the purpose is to pick up energy from sun through the dark surface and transfer it as thermal energy to the fluid) and a transparent selective cover in the face exposed to sunlight (to limit energy dispersion because of radiation towards the external atmosphere); all this is enclosed, in its turn, in a container isolated in the sidewalls and in the wall opposite to that one which receives radiation.

Solar collectors are linked together in series and parallel, in order to produce a big quantity of warm water to a temperature comprised between 50°C and 160°C.

These systems represent a reliable and competitive technology, largely used for different aims:

- heating of the sanitary water for home, hotel, hospital, bathing establishments and camping use;
- heating of rooms;
- heating of water for low temperature processes;
- exsiccation of food processing products;
- spaces' cooling (still too expensive). In this case, the absorber machine works like a refrigerator: it uses hot water to compress a gas that, once expanded, will produce an endothermic reaction, which cools the air. The main problem currently is that the absorber machine works with liquid at 90 °C, a fairly high temperature to be reached with pumped solar panels with no auxiliary power supply.

6.6.2 Types of collectors, circuits and cost

The first difference of the collectors is represented by the use of water or warm air as thermovector.

Warm air solar collectors are used to heat air and to exsiccate food products in industrial plants. In air conditioning, the advantage of air collectors consists in the possibility to send heated air directly to the ambient, without intermediate heat exchangers. This system it's more efficient (if we think that to heat a room at 20-22°C , it must carry the water to 60-70°C) but it's necessary to withhold air longer in the collector in order to heat it.

Another collectors classification is based on fluid temperature of exercise; we can distinguish:

- low temperature solar thermal collectors, in which fluids are warmed up to a temperature under 100°C. Solar panels serve for using radiation to produce warm water or to heat buildings;
- medium temperature solar thermal collectors, a technology especially used for solar furnaces, devices that need solar energy to reach temperatures higher than 250°C;
- high temperature solar thermal collectors (also called "solar thermodynamic"), where heated fluid moves one turbine and produces electricity. The most employed technologies in this field are linear parabolic mirrors, solar power towers and systems provided by independent parabolic concentrators.

Under the constructive point of view , there are different solar panels/collectors:

- no glass (or unglazed or uncovered) flat panel;

- glass flat panel;
- glass non selective flat panel ;
- glass selective flat panel ;
- vacuum tubes panel.

No glass solar panels are favourable thanks to their low cost, simple installation and an excellent performance in optimal conditions of radiation, when external temperature is high (at least 20°C). However their efficiency is lower when radiation conditions get worse. As water flows in the panel's tubes and becomes immediately ready for use, it's commonly applied seasonally to produce sanitary hot water.

Uncovered panels are made of polyvinylchloride (PVC), neoprene, polypropylene; this last one material permits to realize solar panels able to sustain a water pressure until to 6 atmospheres.

Glass solar panels are composed of a panel and a tank to accumulate water. The heat absorber is protected from external air by a structure (made of a tempered glass, an insulating coat and a back body shell), in order to avoid heat dispersion and to grant more efficiency to the system. The glass is transparent to the sunlight but it's opaque to infrared rays. Therefore, sun rays reach internal part of the panel and the heat is withheld inside. These panels re able to produce warm water for sanitary use almost for all the year, because they can work also in radiation insufficient conditions. For this reason they're more expensive than unglazed panels but are more widespread in the traditional domestic field.

Evacuated (or vacuum) tubes panels show a technology more sophisticated, more expensive and fragile than glass ones but they're able to give high performances.

They're made of a series of modular tubes, mounted in parallel, whose number can be added to or reduced as hot water delivery needs change. This type of collector consists of rows of parallel transparent glass tubes, each of which contains an absorber tube (in place of the absorber plate to which metal tubes are attached in a flat-plate collector). The tubes are covered with a special light-modulating coating. In an evacuated tube collector, sunlight passing through an outer glass tube heats the absorber tube contained within it.

Two types of tube collectors are distinguished by their heat transfer method: the simplest pumps a heat transfer fluid (water or antifreeze) through a U-shaped copper tube placed in each of the glass collector tubes. The second type uses a sealed heat pipe that contains a liquid that vaporizes as it is heated. The vapor rises to a heat-transfer bulb that is positioned outside the collector tube in a pipe through which a second heat transfer liquid (the water or antifreeze) is pumped. For both types, the heated liquid then circulates through a heat exchanger and gives off its heat to water that is stored in a storage tank (which itself may be kept warm partially by sunlight). Evacuated tube collectors heat to higher temperatures, with some models providing considerably more solar yield per square meter than flat panels.

Warm water produced during daytime by solar collectors has to be accumulated in order to be used during the night. The connection between the solar collector and the storage tank is called "solar circuit". Each one can be "open", if the thermovector fluid that flows in the collectors is the same of that used in the circuit, or "closed" if the thermovector fluid (which circulates in the collectors) transfers heat to the utilization fluid through an exchanger. Moreover the circulation of thermovector fluid can be "natural" or "forced".

We talk about "natural circulation", when the fluid goes up to the storage tank taking advantage from convention process. It's quite cheap in operating costs but needs to put tanks at an higher level the panels; this increases the cost of the structures that sustain tanks. Moreover "natural circulation" is less efficient than "forced" one.

"Forced circulation" occurs through a pump which transfers the thermovector fluid (which presents an higher temperature than that of the accumulated water) from collectors to the tank, through sensors that compare temperature difference between fluid and stored up water ("thermocouple"). In those plants there are less restraints regards to position of storage tanks and the greater speed of the thermovector fluid allows a bigger thermal exchange; consequently the panel rendering is more efficient.

So there are four main categories of solar circuits:

- natural circulation open circuit. This system is generally used to heat sanitary water in seasonal plants (bathing establishments, camping) or in domestic yearly use;
- natural circulation closed circuit. Usually this type of solar circuit is usually applied in plants for heating sanitary water for yearly domestic use;
- forced circulation open circuit. It's used in central heating plant to produce hot water for seasonal utilization or to heat water in uncovered swimming pools;
- forced circulation closed circuit. This system is generally utilized in central heating plant to produce hot water for yearly utilization; to heat water in uncovered or discoverable swimming pools; to heat spaces; to heat at the same time sanitary water and uncovered swimming pools' water.

In Italy it's possible to amortize a solar thermal plant, according to its location and utilization, during a 8-12 years period. As the minimal endurance is about of 15-20 years, it represents a medium term good investment; eventual tax rebate or other shapes of facilities can make the amortization faster.

Regarding to solar collectors, the square meter cost is little indicative: the real cost has to be calculated according to the quantity of hot water produced during one year.

The number of collectors necessary to satisfy the need of a four components' family (with a daily water consumption of about 200 litres) changes in order to geographic site, to solar energy availability; approximately, requested surface fluctuates from 0.5 and 1.2 square metres per person passing from South to North Italy.

Costs present remarkable differences according to the types of collectors installed (*flat* or *vacuum tubes*) and to the complexity of the circuit. However, estimated cost for one *standard plant* is about 3500-4500 euros.

6.7 European Market

Development conditions of solar thermal field are evolving very quickly; in fact the continuous increasing in the energy prices, associated to support programmes established by lots of Governments, are allowing the consolidation of the whole solar thermal sector.

The market dynamism is heightened by the insight that solar thermal technology will play a much more important role in the fight against climate change and against the dependency on fossil fuels.

The European solar thermal market has become more and more dynamic during the last few years.

During 2005, the European market has recorded 2.073.391 square metres of new solar panels installed (equivalent to 1451.4 MWth), 26% more than in the previous year.

Glass flat solar panels represent the essential part of the market (with a market share of 89.4%), followed by vacuum tubes collectors (6.4%).Unglazed collectors are a technology difficult to statistically monitor because of it isn't always subsidized and there isn't a systematic account by the producers.

A very interesting and positive development is the growing market share of combined systems that produce not only domestic hot water but also support space heating and therefore lead to higher energy savings. This system type is typically used in Northern and Central Europe.

Most government support solar thermal energy through direct financial incentives, building regulation, awareness raising campaigns.

The dominance of the German, Austrian and Greek markets is becoming more and more consolidated. However, some of the high-potential markets are slowly catching up, as France and Spain that show very interesting development perspectives (also sustained by government and legislative choices). Italy is trying to bridge the gap, increasing the use of solar thermal technology also with legislative rules and incentives.

6.8 Italian Market

Italian solar thermal market is a little far from objectives defined in the White Paper (the action plan of EC to favourite expansion of renewable energies). However, some indicators make to think that renewable technology are living an important period, with a growth of 2-3 % per year, favoured by the price increase of the gas that is the main competitor of solar thermal.

Another demonstration of a growth trend is from national production of solar collectors: after a maintenance on 55 thousand of m^2 installed in 2004, Italian market shows an increment of 30.9%, with 72 thousand of surface installed in 2005, equivalent to 50.4 MWth, excluding unglazed collectors (about 2.5 thousand of m^2).

The market might be almost settled: it estimates about 70-80 thousand m^2 installed within 2006.

Although a positive increase, the Italian market is still too limited, if it takes in account the potentialities of the country. It's reasonable to think that incentives' system is one of the causes of this situation: in the private sector, it's possible to deduct 41% of investment costs from income tax declaration (spreading the deduction in five years); in the public sector, on the contrary, the solar thermal incentives are based on national and regional specific programmes, that provide, according to promoting solar associations, limited funds.

Other problem is the increase of some raw materials, as branch and stainless steel, that are doubled during a period of two years; moreover some important components of the collectors are imported, in particular the absorbers and the same glass, whose costs depends on external producers.

By January 1st 2005, Italy has tried to develop his market through a national system of incentives about energetic saving called "White Certificates". This system, provided until to 2009, it shall allow to energy distribution's companies and to services societies to carry out measures of energetic saving through different actions defined by Minister of Economic Development.

Anyway, solar thermal collectors' installation is one of the most important and possible measures to achieve objectives of energetic saving. The aim fixed for the Country is to obtain a saving of 2.9 Mtep in 2009, going on step by step (0.2 Mtep in 2005, 0.4 in 2006, etc).

In order to increase solar thermal demand, 2007 Financial Act provides a deduction of 55% in three years, Italian Municipalities have settled new building regulations that provide the obligation of applying solar thermal technology in new buildings and in those subject to extraordinary restructure.

7. Presenting inadequacies – regarding the actual and also the future regulation. Where are insufficiencies?

We interviewed enterprises which work in PV and solar thermal energy field in Latium and asked what kind of difficulties they have in promoting and develop these technologies.

First of all in Italy available solar technologies don't guarantee to operators to be competitive at European level. This is due to the small dimension of the Italian market which doesn't give reason for making investments in order to improve technological level. The major part of Italian enterprises import and install foreign products. In general they also can easily stock up with materials for building solar thermal panels, but for PV panels the problem is the supplying of silicon. In fact the production of PV panels is affected at world level by the lack of silicon: there are very few producers, which prefer to sell high quality silicon to semiconductor producers than a low quality silicon to PV industry. Italian enterprises believe that the low development of this technology in Italy can be attributed to different causes. From the technological point of view enterprises expressed the need of more investments in the research field. Their small-medium size is often a barrier for a dynamic and intense research activity, as well as the difficulty to participate to European funds. If we consider legislation, Italian enterprises complain the lack of a serious and clear incentive policy which could finance the installation of new power plants.

At the end people working for this sector sustain that citizens are not well informed about the potentiality of renewable sources of energy.

8. Is there any development plan specifically for the region and for the selected technical field?

Latium Regional Administration has planned an innovative strategy for the development and the promotion of renewable sources of energy and Kyoto Protocol in the territory. The strategy is focused on different aspects of the problem and is articulated in four points: two points for the promotion of the research and two for the development at urban level of renewable energy. In the research framework, Latium Administration has financed the development of organic PV cells and of the production of hydrogen, cooperating with two Universities of Rome.
In order to facilitate the access to renewable sources of energy, the Regional Administration has modified The Regional Law 14/99 “Functions and task of Provinces” concerning the authorization to install and to use power plants based on renewable sources. This was also foreseen from art. 12 of the national Legislative Decree 387/03.
Beside this act the Region has signed an agreement with all Provinces for the realization and installation of renewable sources in schools and in public buildings. The amount of money which has been allocated for this purpose is of 10 million euros (this amount was divided in this way: Rome – 3.009.529; Latina – 2.163.075; Frosinone: 2.765.392; Viterbo: 1.722.246; Rieti: 339.758).
This action will allow the diffusion of PV and solar thermal energy and will be a for example for the population of the advantages of clean energy.

9. What kind of financial resources are or may be available for the development

9.1 Financial resources by EU to the solar technologies R&D

One of the ten high level themes proposed in European Seventh Framework Programme (2007-2013) for research and technological development (FP7 - http://cordis.europa.eu/fp7/) is Energy.

The objective of energy research under FP7 is to adapt the current energy system into a more sustainable, competitive and secure one. It should also depend less on imported fuels and use a diverse mix of energy sources, in particular renewables, energy carriers and non polluting sources.

The following activities will be funded:

- **Hydrogen and fuel cells** - supporting EU fuel cell and hydrogen industries, for stationary, portable and transport applications.

- **Renewable electricity generation** - technologies to increase overall conversion efficiency, cost efficiency and reliability, driving down the cost of electricity production.
- **Renewable fuel production** - fuel production systems and conversion technologies. Renewables for heating and cooling - technologies for cheaper, more efficient active and passive heating and cooling from renewable energy sources.
- **Renewables for heating and cooling** - technologies to increase the potential of active and passive heating and cooling from renewable energy sources to contribute to sustainable energy.
- **CO2 capture and storage technologies for zero emission power generation** - technologies reducing the environmental impact of fossil fuel use by capturing CO2.
- **Clean coal technologies** - technologies to improve plant efficiency, reliability and cost of coal and other solid hydrocarbon conversion technologies producing also secondary energy carriers (including hydrogen) and liquid or gaseous fuels.
- **Smart energy networks** - increasing the efficiency, safety, reliability and quality of the European electricity and gas systems and networks in the context of a more integrated European energy market.
- **Energy efficiency and savings** - technologies to improve energy efficiency and to enable final and primary energy consumption savings, over their life-cycle, for buildings (including lighting), transport, services and industry.
- **Knowledge for energy policy making** - tools, methods and models to assess the economic and social issues related to energy technologies and to provide quantifiable targets and scenarios for medium and long term horizons.

Among the activities that will be founded three of them are connected with solar technologies: "*Renewable electricity generation*" (Activity Energy.2), "*Renewables for heating and cooling*" (Activity energy.4) and "*Energy efficiency and savings*" (Activity energy.8).

1. <u>Renewable electricity generation</u>

Research should increase overall conversion efficiency, cost efficiency, significantly drive down the cost of electricity production from indigenous renewable energy resources including biodegradable fraction of waste, enhance process reliability and further reduce the environmental impact and eliminate existing obstacles. Emphasis will be on PVs, wind and biomass including CHP.

Policy context: this activity would facilitate the actual implementation of the "Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market (2001/77/EC, O.J. L283, 27/10/2001)" as well as its revision and medium-term application.

Fundable areas (linked with solar technologies):

<u>*AREA ENERGY.2.1: PVS*</u>

PVs is the most capital-intensive renewable source of electricity. Currently, the generation costs of grid-connected PV electricity in Europe range from 0.25 €/kWh to 0.65 €/kWh, depending on both local solar irradiation and market conditions. The work will include the development and demonstration of new processes for PV equipment manufacturing, standardized and tested building components and the demonstration of the multiple additional benefits of PV electricity.

Expected impact:

Through technological improvements and economies of scale, the cost of grid-connected PV electricity in Europe is expected to be lowered to a figure in the range of 0.10-0.25 €/kWh by 2020. Research and development should lead to reduced material consumption, higher efficiencies and improved manufacturing processes based on environmentally sound processes and cycles.

Topics to be opened in 2007:

- Photoltaics (PV);
- Intermediate band (IB) materials and cells for PV;
- Dye-sensitised PV solar cells;
- Concentrating PVs: cells, optics, modules;
- Research for binary thin-film PVs;
- Environmental aspects of PVs;
- Alternative approaches for crystalline silicon PV;
- Secure, reliable and affordable supply of feedstock for the PV industry;
- Improved production equipment and cost reduction;
- Innovative/improved PV manufacturing processes;
- Development and demonstration of standardized building components;
- Multiple benefits of PV systems.

AREA ENERGY.2.5: CONCENTRATED SOLAR POWER (CSP)

Concentrated solar power (CSP) has much scope for improvements in the optical and thermal efficiency of the solar components, power generation efficiency (including hybridisation with other fuel), and operational reliability. Current electricity generation costs for concentrating solar thermal are in the range of 0.16-0.20 €/kWh for the most southern regions of Europe.

Expected impact:

Reductions in cost through the up-scaling of units, volume production and technological innovation should lead to an electricity cost of around 0.05 €/kWh in 2020 for areas with high irradiation levels.

Topics to be opened in 2007:

- Key components for CSP
- Using CSP for water desalination
- Low cost, high efficiency daily storage systems

- Improve the environmental profile of the CSP installations
- CSP: Innovative heat transfer concepts
- Intermediate size, lower concentration ratio CSP systems

2. Renewables for heating and cooling

The aim of this activity is to achieve substantial cost reductions, increase efficiencies, further reduce environmental impacts and optimise the use of technologies in different regional conditions where sufficient economic and technical potential can be identified. Research and demonstration should include new systems and components for industrial applications (incl. thermal seawater desalination), district and/or dedicated space heating and cooling, building integration and energy storage.

AREA ENERGY.4.1: LOW/MEDIUM TEMPERATURE SOLAR THERMAL ENERGY

Expected impact:

Higher efficiency, and lower cost solar systems with high performing collectors (e.g. using plastic materials with high thermal and optical performances small scale, high performing, low price, solar thermal cooling systems to meet the increasing demand from the tertiary and household sectors; large scale solar thermal systems for industrial applications and solar heating and cooling as well as for sea water desalination.

Topics to be opened in 2007:

- Collector design and components
- Small scale thermal cooling units
- Small distributed systems for seawater desalination
- Large scale systems for industrial heat processes

3. Energy efficiency and savings

The vast potential for final and primary energy consumption savings and improvements in energy efficiency need to be harnessed through the research into, optimisation, validation and demonstration of new concepts, optimisation of proved and new concepts and technologies for buildings, transport, services, and industry. This incorporates the combination of sustainable strategies and technologies for increased energy efficiency, the use of renewable energy and co- and poly-generation and the integration of demand management measures and devices at large scale in cities and communities, and the demonstration of minimum climate impact buildings (eco-buildings).

AREA ENERGY.8.3: LARGE-SCALE INTEGRATION OF RENEWABLE ENERGY SUPPLY AND ENERGY EFFICIENCY IN BUILDINGS: ECO-BUILDINGS

Innovative integration of external energy supply with large self-supply from renewable energies and radical approaches for energy efficiency measures suited to different building types, in different climate zones and under different regional conditions will be supported.

This should included design and planning, followed by the construction phase of the building and the integration of energy efficient technologies such as co-generation/tri-generation.

For this Area, no topics are open in calls published in 2007.

Budget

The amended FP7 proposals from the European Commission, following the budget agreement between the European Council and European Parliament amount to a total of EUR 50,521 million for all the FP Programme, partitioned among the specific programmes as follows:

- Cooperation EUR 32,413 million
- Ideas EUR 7,510 million
- People EUR 4,750 million
- Capacities EUR 4,097 million
- JRC (non-nuclear) EUR 1,751 million
- Euratom (to 2011) EUR 2,751 million

Cooperation It supports all types of research activities carried out by different research bodies in trans-national cooperation and aims to gain or consolidate leadership in key scientific and technology areas. The Cooperation program is sub-divided into ten distinct themes.	**Ideas** It aims to enhance dynamism, creativity and excellence in European research at the frontier of knowledge by supporting 'frontier research' projects across all fields by individual teams competing at a European level.
People Based on the long and successful experience of the Marie Curie actions, this program will cover all stages of a researcher's professional life, from initial research training to life long learning and career development.	**Capacities** It supports the coherent development of policies; contributes to EU policies and initiatives to improve the coherence and impact of Member States policies; finds synergies with regional and cohesion policies, the Structural Funds, education and training programs and the *Competitiveness and Innovation Program (CIP).*
EURATOM Euratom research activities differ from those in other programmes in that they are carried out under a separate treaty. It legislates for a number of specific tasks for the management of nuclear resources and research activities	**JRC** The Joint Research Centre (JRC) provides customer-driven scientific and technical support to the conception, development, implementation and monitoring of EU policies. JRC is a reference centre for science and technology issues that serves the interests of the Member States while at the same time remaining independent of special interests.

The European Commission will fund Energy research by selecting project proposals submitted following the publication of a 'Call for proposals'. The budget for Energy theme over the duration of FP7 is **€ 2.3 billion.**

9.2 National financial resources allocated for the development

The Ministry for the Environment has published on the Official Gazette n. 22 of January 16th 2007 an announcement for small and medium enterprises, which foresees the payment of contribution in capital account for the promotion of renewable sources of energy in order to produce heat or electricity. The Ministry for the Environment has appropriated an amount of 25.822.844,95 euros to finance enterprises.

Companies that want to be financed have to respect some dimensional parameters which are indicated in the decree of September 18th 1997 of Ministry for the Industry, Commerce and Handicraft.

Only projects that foresee the installation of plants for the production of energy and heat from renewable sources and in possess of specific technical parameters will be admitted to the financing. These parameters are summarized in the following scheme:

- PV plants which are connected to grid and present a nominal power between **20** and **50 kWp** (nominal power is intended as the sum of nominal power of each single plant). One PV plant divided in two more plants must have just one point of connection. Only plants which are part of constructive elements of building structures or are installed on building structures are admitted to the financing. Plants where PV modules are installed on the ground level are not admitted;

- Wind power plant which is connected to the grid and present a nominal power between **20** and **100 kWp** (nominal power is intended as sum of nominal power of each single plant). One wind power plant which is constituted by more than one generator must have only one point of connection. The minimum size of every single generator must be equal or bigger than 10 kW;

- Solar thermal power plant for the production of sanitary hot water, for the heating and cooling of rooms, for the supply of heat at low temperature and for the heating of swimming pools. Plants which are equipped with glass flat collectors, no glass collectors and vacuum tubes collectors, with a total area ranging between 50 and 500 square meters, equivalent to 35 and 350 kW, are promoted through incentives;

- Thermal plant using wood chips and biomass pellets for the production of heat with a nominal power in the range of 150-1000 kW.

Operations related to the installation of PV plants will be financed at the maximum percentage of 50% of the total admissible cost for small and medium enterprises, at the maximum percentage of 55% of the total admissible cost for small and medium enterprises located in economic areas, where such aid does not adversely affect trading conditions to an extent contrary to the common interest; at the and the financing reaches the percentage of 60% of the total admissible cost for small and medium enterprises located in areas where the standard of living is abnormally low or where there is serious under-employment.

Operations related to the installation of wind power plants will be financed through the payment in capital account for a maximum percentage of 30% of the admissible cost.

Operations related to the installation of solar thermal plants for the production of low temperature heat will be financed through the payment in capital account for a maximum percentage of 30% of admissible cost.

Operations related to the installation of thermal biomass plants will be financed through the payment in capital account for a maximum percentage of 30% of the admissible cost.

For admissible cost, on the basis of which the contribution will be calculated, the announcement intends documented costs, VAT (value added tax) free, about the realizations of the plants, foreseen by the project, in particular to the interventions made for:
- realization of energetic diagnoses and feasibility studies, strictly necessary to plan the intervention (these costs are recognized for a maximum percentage of 5% of the intervention’s total value);
- intervention’s planning;
- supply of materials and parts necessary to carry out the intervention and components of specific consumption;
- installation and setting of the aforesaid components;
- eventual building works strictly necessary to carry out the intervention.

The intervention must be realized within and no longer the following 180 days, calculated from the date in which it has received the official communication of the facility entrance from the Minister.

The Minister verifies the regular carrying out of the works, their conformity to the presented project, the observance of times previewed for the start and the end of each work and the respect of every detail necessary to give contribution. For this aim, can be executed investigating and technical controls in whatever phase of the plant’s realization.

The Minister can consider, and in his judgement approve, proposals of variants provided they’re undersigned, motivated and integrated by suitable justificatory documents.

If the work is not completed within 180 days from the date in which it has received the official communication of the facility entrance from the Minister or within the date following the approval of an eventual variant/respite, the right to benefit of the facility will be annulled.
The Minister can revoke the facility put up by legal interests in the following cases:
- no respect of law fulfilments and of every regulation provided by this announcement and by facilities law referring to it;
- deep difference between presented project and realized work;
- business discontinuance of the beneficiary enterprise;
- failure, administrative forced liquidation of the enterprise or its subduing to another competition procedure;
- contributions granted on the basis of data, information or statements inexact or reticent;
- if the goods acquired thanks to facility participation should be alienated, yielded or misappropriated before that all foreseen by the project would be completed.

Any further information concerning this announcement is contained in the website of the Ministry of the Environment www.minambiente.it

10. Summary of the developments needed, concrete TRs

1) *Photovoltaic panels and Aeolic generators*
2) *High-transparency domes*
3) *Solar energy for studying high temperature materials and chemical processes*
4) *Encapsulation techniques and printing technologies for hybrid organic solar cell*
5) *Innovative method for the production of solar cells*
6) *Concentrating solar power systems and wind power generators (20 kWp)*

11. Contact persons at RDP and TR level

Sara Berselli and Stefania Giuffrida
National Council for the Research
Piazzale Aldo Moro 7,
00185 Rome (Italy).
mettes@cnr.it

12. Organisation of partnering events

The brokerage event will be organized by the National Council for the Research and will be held on 15th November 2007 in Rome in the framework of the 20th World Energy Congress.

13. References

http://www.minaambiente.it
http://www.sviluppoeconomico.gov.it
http://ec.europa.eu/environment/index_en.htm
http://cordis.europa.eu/fp7/
http://www.regione.lazio.it
http://www.iea.org
http://www.legambiente.com
http://www.qualenergia.it
http://www.ilsolea360gradi.it
http://www.isesitalia.it
http://en.wikipedia.org/wiki/Main_Page

ANNEX I

Technology Requests

More Efficient Transnational Technology Transfer in the Environmental Sector

METTTES Technology Request Profile TR 1

Title:
Photovoltaic panels and Aeolic generators

Abstract:
A firm located in Rome specialised in research, design and implementation of electrical energy generation systems by a renewable source, is looking for innovative photovoltaic panels and wind generators. A commercial agreement is sought.

Description:
A firm located in Rome specialised in research, planning and implementation of electrical energy generation systems fuelled by a renewable source, is looking for innovative photovoltaic panels and Aeolic generators in order to improve their systems' performances in terms of duration of the working life, weight, size, management, maintenance and cost.
Any other innovative aspect not listed before will be taken into consideration.

Technical Requirements:
Photovoltaic panels and wind generators must supply an accumulation system for the differentiated
production of electrical energy with powers varying from a few tens to 3.500 Watt (and even more).

METTTES Technology Request Profile TR 2

Title:
High-transparency domes

Abstract:
A firm located in Rome is specialised in research, design and implementation of electrical energy generation systems by a renewable source. The firm is looking for domes made in translucent material (glass) with high transparency. A commercial agreement is sought.

Description:
A firm located in Rome is specialised in research, design and implementation of electrical energy generation systems by a renewable source. The firm is looking for domes made in translucent material (glass) with high transparency.

Technical Requirements:
The main feature sought for the domes' material is the high transparency. Also good techanical features and flexibility are sought in order to obtain different shapes and sizes.

METTTES Technology Request Profile TR 3

Title:
Solar energy for studying high temperature materials and chemical processes

Abstract:
A University Research group is interested in getting in contact with foreign companies or research groups to carry out joint research project regarding high temperature materials and chemical processes using concentrated solar energy as primary high temperature source.

Description:
An Italian research team is interested in both the fundamental aspects of high temperature science and applications in the field of high temperature chemical processes and materials. In particular the interest have been recently focused on the study of innovative thermochemical cycles at high temperature to produce gaseous hydrogen by using concentrated solar radiation.
The laboratory is equipped by different devices such as for example a solar concentrated radiation furnace, which is employed to investigate materials and processes at high temperatures (500-1300°C obtained by direct solar radiation). The group is provided by a high temperature (800-2500°C) mass spectrometers in high vacuum (10^{-10} bar) for investigation in material thermal stability and gas phase process.
The high temperature (800-2500°C) mass spectrometers in high vacuum (10^{-10} bar) is coupled with a gas inlet system to study materials thermal stability, gas phase process, solid-gas interactions, high temperature corrosion and material reactivity by transport phenomena via gas-phase. In addition the group works with a high temperature electric furnaces (400-1500°C) used for various purposes (material synthesis, annealing, catalysis studies, aging studies).
Materials can be characterized by XRD, LOM, SEM and EDS techniques. Also the use of computational material modelling techniques, such as thermodynamic modelling and electronic structure calculations, to investigate materials and processes are available.

Technical Requirements:
The Italian research group is interested in finding technological partners to carry out the setting up of innovative high temperature solar reactors to be used in thermochemical processes in the solar furnace in the field of hydrogen production. Moreover the research team is interested in finding technological partners interested in the characterization of innovative materials for solar or space application.

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METTTES Technology Request Profile TR 4

Title:
Encapsulation techniques and printing technologies for hybrid organic solar cell

Abstract:
An Italian research group, involved in the development of both organic and hybrid (organic/inorganic) photovoltaic cells, looks for technological partners in order to realize a new method for the production of solar cells, reducing costs of energy per m^2
and making the process and the cells itself more environmental friendly. The technology request is about the encapsulation materials/techniques and layer deposition for both rigid and flexible for dye sensitized and organic solar cells.

Description:
The Italian research group cures out research and development on dye sensitized and organic solar cells. They are especially interested in encapsulation materials and techniques for both rigid and flexible cells. The request technology should be compatible with thin film or solution processed fabrications. The group is also looking for efficient, large area, thin film, printing and scribing techniques for deposition and pattering of cell layers.

Technical Requirements:
Thin film technology is the technology requirement

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METTTES Technology Request Profile TR5

Title:
Innovative method for the production of solar cells.

Abstract:
An Italian company looks for industrial partners, which could cooperate to development of an innovative process for the production of solar cells. The process should use architectural substrates as tile-like ceramic, covered by a thin layer of pure metal. The company looks for a partner who can manage the technology of CVD (Chemical Vapour Deposition) or plasma deposition to grow silicon and build the P/N junction over the metal layer. Technical cooperation is sought.

Description:
Generation of photo-voltaic (PV) energy is affected by architectural considerations and by high cost of silicon cells, mainly because of shortage of silicon slices.
A possible alternative is to build the P/N junction over a ceramic substrate. Some experiments show that it is possible to grow silicon over a Al_2O_3 (alumina) substrate. Unfortunately, the cost of alumina is quite high, and commercial grade ceramics are not pure enough to allow a delicate process like silicon deposition in diffusion chambers. The obstacle are the impurities into the ceramic material, which could easily pollute the diffusion oven, with dramatic effect on the global process. The Italian company solved the problem of impurities into the substrate trapping them under a layer of pure metal.
The company looks for foreign industries producing solar cells that could provide the technologies necessary to perform the productive process of growing the silicon and build the P/N junction over the metal layer.
After the metal deposition, it is possible to grow silicon and build the P/N junction using the standard methods of silicon process, the election technology for high volume and low cost in mass production is the use of high pressure plasma vapour deposition (HP-PVD).
Further steps could be selective etching of layers to obtain more than one cell on the same substrate, connecting them with further conductive oxide (ITO – Indium Tin Oxide) and metal, and protecting the cells with an hard transparent layer, e.g. made by silicon nitride (Si_3N_4).
All the needed technologies to do the above process are well known by people skilled in the respective fields, at the moment apparently no one set a process to make solar cells with it.

Technical Requirements:
The Italian company is looking for industrial partners in order to realize an innovative method to make solar modules in shapes and dimensions suited for architectural integration into new and existing buildings. The process is described above in detail. Although the technologies, that constitute the process, are well known, no one has set this process for the production of solar cells.

More Efficient Transnational Technology Transfer in the Environmental Sector

METTTES Technology Request Profile TR6

Title:
Innovative concentration solar systems and wind generators (20 kWp)

Abstract:
An Italian company involved in photovoltaic field is looking for partners providing innovative photovoltaic systems based on the concentration of sun light. The Italian company is also interested in wind power generators of 20 kWp. Technological, manufacturing and commercial agreement with technical assistance are sought.

Description:
Despite of traditional photovoltaic modules, photovoltaic concentration technology is based on separating the collection of solar light and its conversion into electricity. In the concentration systems, light is collected through various optical means – such as lenses and mirrors – and all the collected light is focused on the light-to-energy converters, which are photovoltaic solar cells of a very high output. When they receive a large amount of luminous energy they produce more electricity than traditional ones.

Technical Requirements:
The Italian company is interested in getting in contact with foreign industries involved in the production of concentrating solar power systems in order to establish a manufacturing and commercial agreement with technical assistance.
The Italian company is also interested in contacting companies in order to establish commercial agreement with technical assistance for the commercialization of wind power generators (maximum 20 kWp)