



Renewable energy

If our energy for the future only depended from the sun



How to produce electricity with solar energy?



SUMMARY

INTRODUCTION	3
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I) CURRENT SOLAR PHOTOVOLTAIC (PV) TECHNOLOGIES (*by Sui CHEN*)

a) <i>Preface</i>	4
b) <i>Solar energy map</i>	4
c) <i>The cell basic construction</i>	5
d) <i>Material of photovoltaic cell</i>	6
e) <i>Array design and sun tracking</i>	7

II) SOLAR PANEL FOR BUILDING (*by Rahul KAPADIA*)

a) <i>Preface</i>	9
b) <i>Overview</i>	9
c) <i>Why are solar panels important</i>	9
d) <i>Solar panel arrays</i>	10
e) <i>Account of daily producing power</i>	10
f) <i>Solar panel installation</i>	11
g) <i>Precautions</i>	11
h) <i>Battery system for solar panel</i>	11
i) <i>How many solar panels to recharge the battery</i>	12

III) APPLICATION OF SOLAR ELECTRICITY FOR COMMERCIAL BUILDING (*by Geeta PANDE*)

a) <i>Application of solar energy for rural electrification</i>	13
b) <i>Industrial application for solar electricity</i>	14

IV) SOLAR TOWERS: A NEW WAY FOR SOLAR USERS (*by Sébastien DANIERE*)

a) <i>Solar tower using a “single flow upwind system”</i>	17
b) <i>From the prototype of Manzanares to the Australian project</i>	22
c) <i>Solar tower using a “rotational flow whirling system”</i>	24

CONCLUSION	27
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BIBLIOGRAPHIE	28
----------------------------	----



INTRODUCTION

Our current industrial society works only with conventional energy sources like coal, oil, natural gases or uranium. Meanwhile, we will have two big problems with them:

- ❖ They produce several kinds of pollutions. If we do not care, atmospheric pollution, climate change or nuclear waste can endanger our living condition on the earth.
- ❖ After several years the limited energy source will become exhausted, which will not guarantee our energy supply in the future.

On the opposite side, the renewable energy sources use natural flows. These renewable energy sources only use a small part of the flow that is why they cannot damage natural surrounding.

One of these natural resources is solar power and there are several ways to use it. One of them is to produce electricity.

Firstly, we will explain how the photovoltaic technologies work, and then we will show implementation of buildings and commercial buildings and end up with solar towers.



I) CURRENT SOLAR PHOTOVOLTAIC (PV) TECHNOLOGIES

a) Preface

The term “Photovoltaic” or abbreviated “PV” is a combination of two words - “photo”, meaning light, and “voltaic”, meaning electricity. Thus, photovoltaic technology, the scientific term used to describe solar energy, involves the generation of electricity from light. More precisely, solar cells or solar photovoltaic arrays convert light from the sun directly into electricity.

In recent years, the capital and energy costs of photovoltaic (PV) parks reduced to 20 cents/kWh below. The goal of ongoing research programs funded by the U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) is to bring solar energy cost below 15 cents/kWh by 2010. The solar electricity becomes a sunrise industry. But it still has the big problem of itself. The cost of PV electricity is still high (Between 15 and 25 cents/kWh) compared to utility power just cost 10 to 15 cents/kWh. Because its high price, PV cannot economically compete directly with utility power as yet, except in remote markets where utility power is not available and the transmission cost too much. And that is where the most PV growth is taking place.

Although the cost is high, the PV industry still has \$7 billion in annual business. The installations grew at an average annual rate of 25% to 30% during the period from 2000 to 2004. The cumulative PV capacity was 2,030 MW by the end of 2004. The annual production of PV modules was 530MW in 2004 and is expected to reach 1,600MW by 2010. So PV system is expected to distribute more in the future power generation.

b) Solar Energy Map

The solar energy impinging on the surface of the earth is different in different regions. Before make deciding where the PV plant can be built, it is important to check where is suitable for that in the solar energy map as followed figure 1.

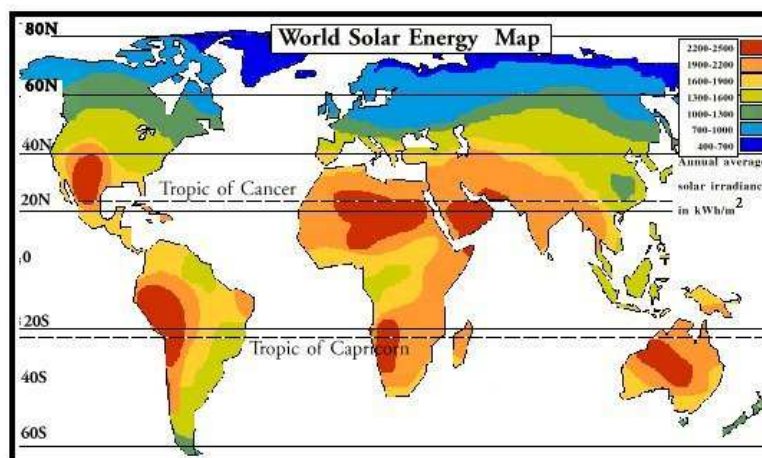


Figure 1: World Solar Energy Map (From: <http://www.rise.org.au/info/Applic/Solarpump/index.html>)



c) The Cell Basic Construction

HOW DOES IT WORK?

PV cells convert sunlight directly into electricity without creating any air or water pollution. PV cells are made of at least two layers of semiconductor material. One layer has a positive charge, the other negative. When light enters the cell, some of the photons from the light are absorbed by the semiconductor atoms, freeing electrons from the cell's negative layer to flow through an external circuit and back into the positive layer. This flow of electrons produces electric current.

Form the figure 2, it can be found that the physics of the PV cell is similar to that of the classical diode with a pn junction. The energy from the light is absorbed by the junction. The absorbed photons are transferred to the electron-proton by the silicon system. And then it comes to electron flow in the circuit which could be used in electric load.

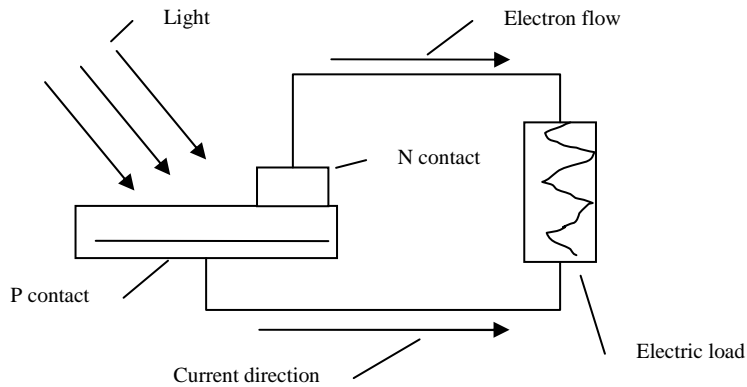


Figure 2 The basic circuit of PV effect converts the photon energy into voltage across the pn junction.

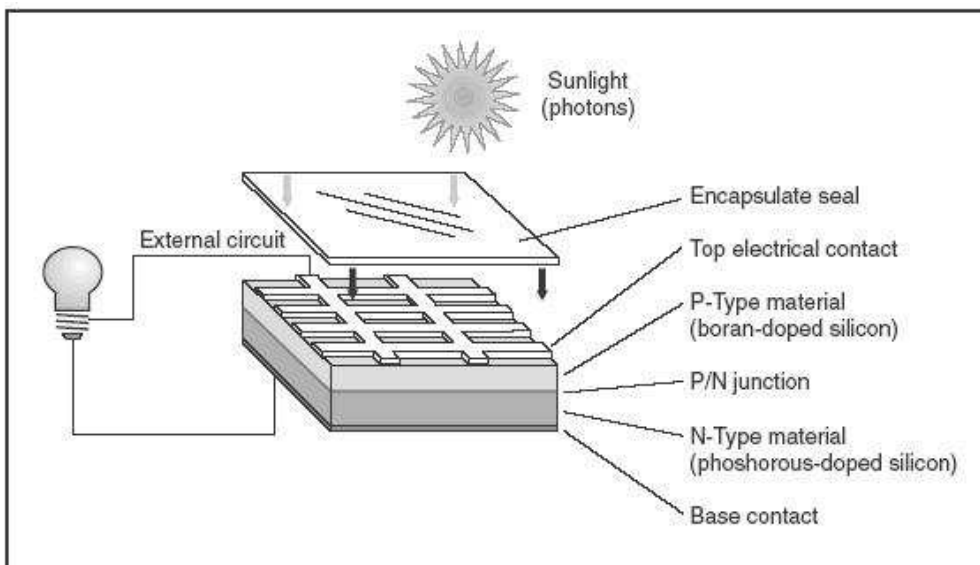


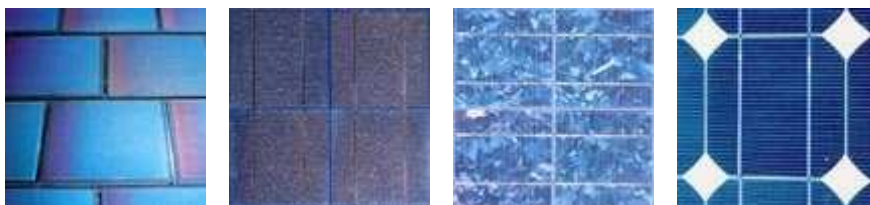
Figure 3 Basic construction of PV cell in the real application. (From: <http://www.ekotek-energija.com/Images/solar%20cell%20construction.jpg>)



d) Material of Photovoltaic Cell

The most important part of solar energy system is PV CELL which decides the capital cost per watt capacity and conversion efficiency of solar energy. In the solar energy system, the two parameters, which are talked above, indicate the economic competitiveness of the PV electricity. The major material types are: Single-Crystalline Silicon, Polycrystalline and Semi crystalline Silicon, Thin-Film Cell, Amorphous Silicon, Spherical Cell, Concentrator Cell and Multijunction Cell.

- 1) The Single-Crystalline Silicon is most widely available cell material and has been the workhorse of the industry. The efficiency range from 14% to 18% while as the price of per pound is \$20 to \$25.
- 2) The Polycrystalline and Semi crystalline Silicon is low-cost but the efficiency is also lower, and give a low cost per watt of power.
- 3) Thin-Film Cell is a new type of PV entering the market. Because of CuInSe₂(CIS), CdTe and GaAs joining makes it less in thickness, and also can be directly deposited on a glass, plastic, stainless steel, ceramic, or other compatible substrate material. This technology uses less material per cell so it is less expensive per watt of power generated. Researchers at NREL achieved a record thin-film solar cell efficiency of 18% for a CIS cell.
- 4) Amorphous Silicon is only 2- μ m-thick. Compare to crystalline silicon, this type cell uses about 1% of the material and its efficiency is approximately half that of crystalline silicon at present. So the cost per watt is significantly lower than it.
- 5) Spherical Cell is costing approximately \$1 per pound, and is 2 μ m thickness (less than 1% of 200-400 μ m of crystalline silicon) with 8%-10% efficiency. Then \$3-\$5 per watt cost is expected to fall rapidly to \$2 per watt due to substantial DOE funding to fully develop this new technology.
- 6) Concentrator Cell is focusing on small area with high-efficiency (37%) for its technology.
- 7) Multijunction Cell can converts red, infrared light and blue and also ultraviolet light which make the efficiency higher, so that it efficiently is reported a record 34% by NREL and Spectrolab under concentrated sunlight. But it cost much.



From the left to the right: amorphous, thin-film, polycrystalline and monocrystalline (From: <http://www.ekotek-energija.com/>).



e) Array Design and Sun Tracking

The major two factors influencing the electrical design of the solar array are as follows: The sun intensity; the sun angle. The two factors are discussed in the following subsections.

Sun Intensity

Under a full bright sun, the magnitude of the photocurrent is reach to maximum. At a lower sun intensity, the power shifts downward as follow Figure 4.

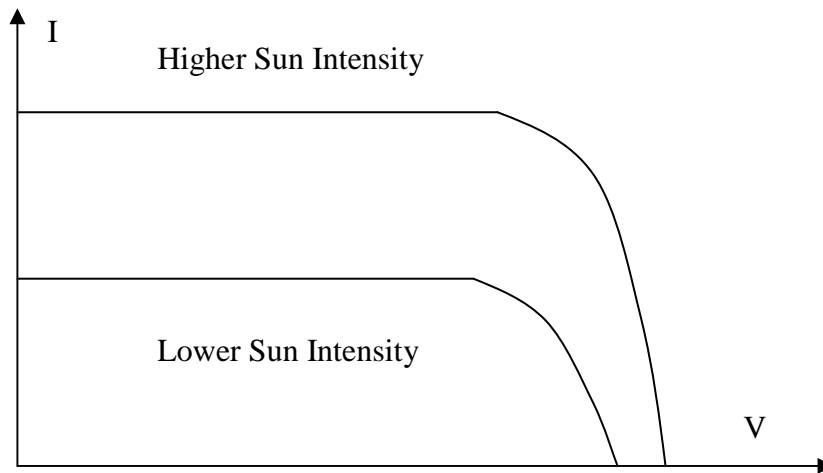
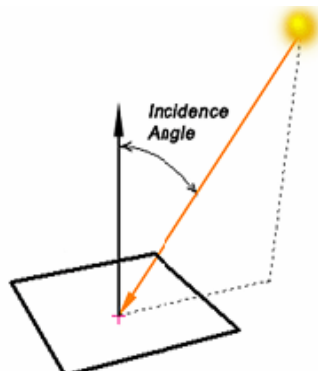


Figure 4 Power change in different sun intensity.

On a lower sun intensity day, the short-circuit current decreases a lot, but the open-circuit voltage changed is small. Although the power we get is changed by the different sun intensity, the efficiency is the same. Because of the lower solar energy impinging on the module, we get a lower power output.

Sun angle

The cell output current is given by $I = I_0 \cos \theta$, where I_0 is the current with vertical sun impinging, and θ is the angle to the vertical position. This cosine law holds well for sun angles ranging from 0 to 50 degree. Beyond 50 degrees, the relative current decrease significantly from the cosine law and the cell generates no power beyond 85 degree. It can be found from the Kelly cosine power-angle curve of the PV cell.



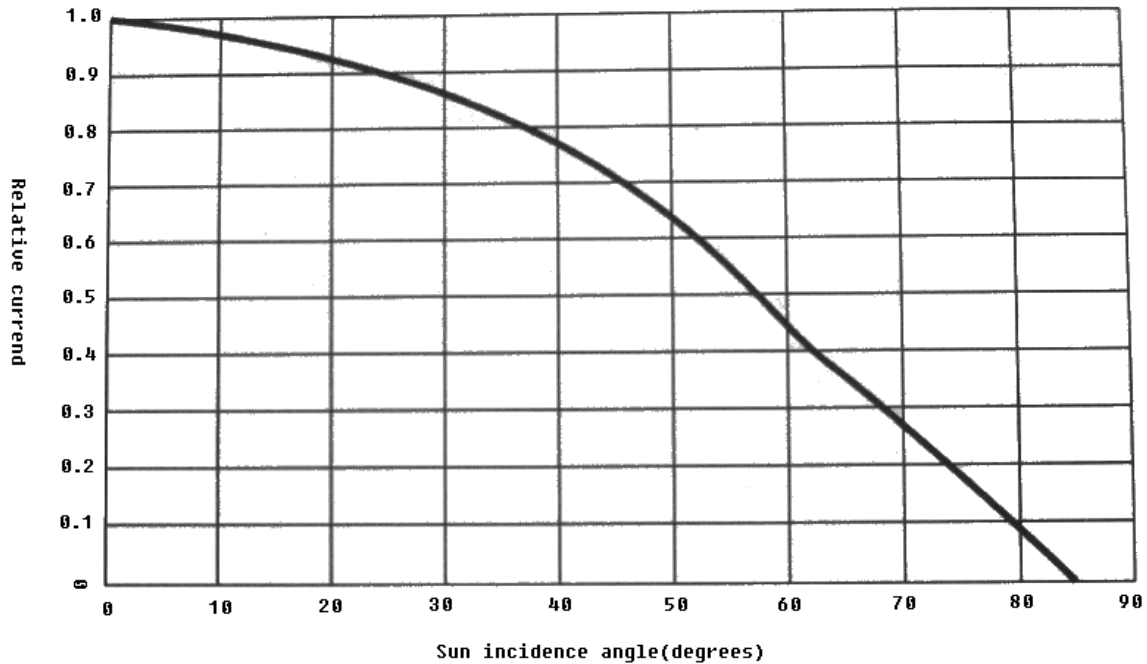


Figure 5 Kelly cosine curve for PV cell at sun angles form 0 to 90°and the Incidence angle.

Sun track

More energy is collected by the end of the day if the PV module is installed on a tracker with an actuator that follows the sun. There are two types of sun trackers:

- ❖ One-axis tracker, which follows the sun from east to west during a day.
- ❖ Two-axis tracker, which follows the sun from east to west during a day, and also from north to south during the seasons of a year.

A sun-tracking additional can increase the energy yield up to 40% over the year compared to the fixed design. During a day, it tracks the sun east to west, and at night it turns ease to position itself for the next morning' sun. By this design, the sun incidence angle could be fixed to meet the maximum power.



II) SOLAR PANEL FOR BUILDING

a) Preface:

Solar electric power is an alternative energy source that is cleaner, more reliable, longer lasting, and environmentally safer than nuclear and fossil fuels.

Solar electric power long lasting, we can use solar panels to produce electricity. We produce DC current with the help of the solar panel. Then we use converter to convert DC current into AC current. This current we directly use in home or industrial purposes.

b) Overview:

Nowadays buildings are the biggest users of energy. The majority of world's energy goes into keeping our buildings running and comfortable. We can save most of the energy with better planning.

Smarter planning, better insulation and solar panel are example of how to reduce energy usage in our buildings. More than two thirds of energy use in buildings is used for lighting, heating & cooling.

Here percentage is mentioned how much energy consumed by each instrument.

Heating: 34 %

Appliances and lighting: 34 %

Water heating: 13 %

Electric Air condition: 11 %

Refrigerator: 8 %

c) Why is solar panel important?

Solar panels convert the sun's energy into usable forms. Solar panels can be a certain kind of device that attracts the sun to use the sun to power machinery that can transfer the heat from the sun into whatever they need. We could use solar panels to convert the heat from the sun into the energy we need to power things that run. Solar panels are in hand held devices and they are in energy efficient appliances.



d) Solar panel arrays:

Serial and parallel interconnections in solar panels are called “Solar Panel Arrays”. Generally a series of solar panel arrays are configured to produce a specific voltage potential and collective power production capacity to meet the demand requirements of the project.



Figure 6: Solar Panel Store (www.solarpanelstore.com)

Solar panel arrays feature a series of interconnected positive (+) and negative (-) outputs of solar panel in a serial and parallel arrangement that provides a required DC voltage to inverter.

The average daily output of solar power systems is entirely dependent on the amount of exposure of sunlight.

e) Account of Daily producing power:

In order to account daily solar exposure time, design engineers refer to the world sunlight exposure maps. Each area is assigned as “area exposure time factor”, which depending on the location may vary from 4 to 6 hours. A typical example for calculating daily watt hours for a solar panel array consisting of 10 modules with a power rating of 75 w in a area located with a multiplier of 5 will be $(10 \times 75\text{w}) \times 5 \text{ h} = 3750 \text{ wh}$ of average daily power.



f) Solar panel installation:



Solar panels are manufactured in rigid and flexible form. Cabling should be done properly to avoid voltage drop. A 15 amp cable is minimum size for 65 watt panels. We use only tinned copper marine cable. Most panels have weatherproof connection boxes and connection should be twisted and terminated on terminals. Manufactures also specify grounding of array or module metallic frames.

Figure 7: The Motorboat Electrical and Electronics Manual by John C. Payne

g) Precautions:

Concerns over vessels that have automatic bilge pump arrangements with a solar panel charging battery. If a pump cable has a fault. Once the battery is flat, a serious electrolytic corrosion problem may develop.

Always cover solar panels to prevent a voltage being generated during installation or removal so that accidental short circuiting of terminals and cables cannot occur. Each panel should be securely mounted and able to withstand mechanical loads.

Allow sufficient ventilation under the panel. Excessive heat levels will reduce output and damage cells.

h) Battery system for solar panel:

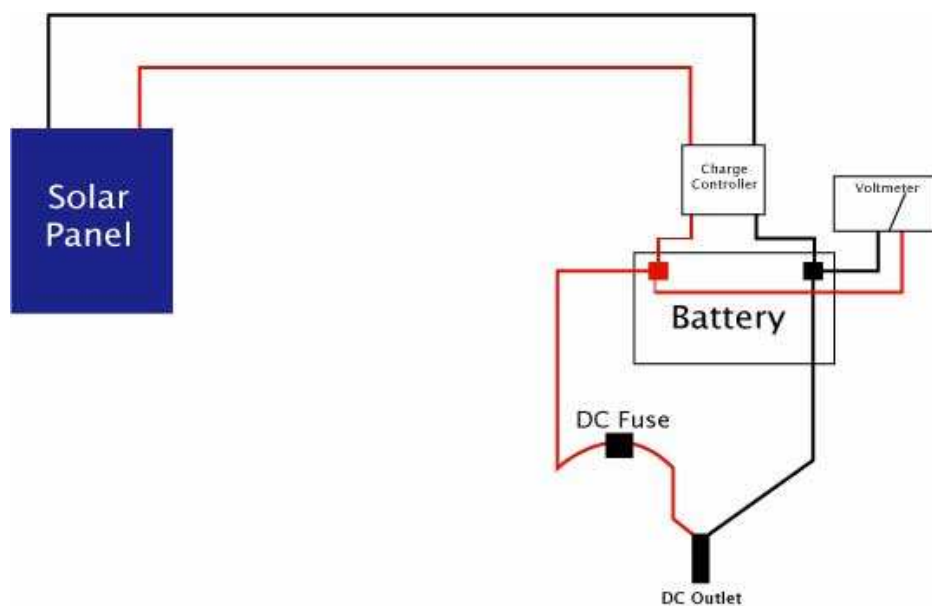


Figure 8: Simplest system of solar panel connected with Battery

Source: Vermont University



The solar panels produce same direct current that we cannot be used in household appliances. The solar panel system will power the load whenever sun is shining strongly enough and the system will stop when it is not.

In sunny weather solar panel supply so much electricity to the battery that it overcharges. When this happens, the acid and water mixture in the battery decomposes into hydrogen and oxygen. Reducing the acid level and eventually destroying the battery if not stopped.

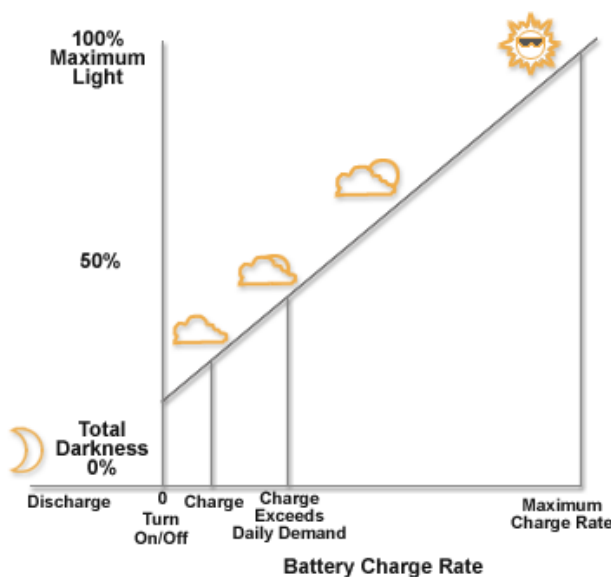
On the other hand if there is not much sun or we have been too ambitious for electricity, more will be drawn from the battery then the solar panel capable of replacing. This makes the battery go flat. The battery will no longer electricity supply until we will recharge. In simple system either overcharge or flatten the battery- both reduce the battery life.

To solve this problem, we add a package of electronics known as charge controller. This controller prevents the solar panel from overcharging the battery during the sunny weather as well as protecting the battery from going flat; it can protect the battery in this way by automatically disconnecting the load from the battery.

Systems as shown in above figure but including charge controller can work and have been used in many applications.

i) How much solar panels recharge the battery:

How quickly the solar panels will recharge the battery system is affected by:



1. How sunny it is outside (or the amount of overcast).
2. How much dirt or grime is covering the solar panels.
3. The outside temperature, as the battery systems and solar panels perform differently under various temperatures.

Figure 9: <http://www.solarairportlights.com>



III) APPLICATION OF SOLAR ELECTRICITY FOR COMMERCIAL BUILDINGS:

In the recent years solar electricity is considered as one of the options for electric supply. This is due to the rise in fuel prices, shortage of fuel supply, increase in concerns over pollution and resource depletion. Moreover it is easy to operate and maintain the solar cells. Considering these factors the photo-voltaic (PV) cells are used for rural electrification, professional applications, electric power generation in space and Grid connected systems. Generally, the applications of solar electricity can be classified into two categories. They are Residential applications and Commercial applications.

Some examples of commercial application are the uses of PV in rural electrification are water-pumping, domestic power supply, lighting and heating. Because of their high reliability the PV modules can be used for professional applications such as Ocean navigation aids, remote monitoring and control at weather stations, seismic recording stations, etc, and telecommunication systems. As it costs lot of money to carry even single kilogram of weight into the space orbit, the use photovoltaic modules is considered as cost efficient solution for generating power.



*Figure 10: The Georgetown university in Washington DC designed with PV roof
(Courtesy: Solar design associates, Inc.)*

The major industrial/commercial applications of solar electricity can be described as follows

a) **Application of Solar energy for rural electrification:**

The electrification of rural areas using solar energy is very economical compare to other forms of rural electricity supply such as diesel generators or grid extension. The rural electrification involves the power supply to remote houses or villages, electrification of the health care facilities, power supply for water supply treatment and irrigation.



Water pumping:

Solar pumps are used for two types of applications. They are 1) village water supply and 2) water for irrigation. Around 10,000 PV water pumps are operational across the world. As water supply is needed on a steady basis in villages, the solar water pumps are used for storing water in tanks and also for water treatment. For irrigation purpose the requirement of water depends on the type of crop and also the season of cultivation. Hence, this requirement is met by directly supplying water to the crops from bore wells rather than storing it.

Domestic power supply:

In developing countries and also in remote industrialized nations the domestic power supply requirement is met by using stand-alone PV systems. These PV systems are used to run electrical home appliances such as refrigerators, washing machines, television and also lighting the houses. The large PV systems may generate up to 5 kW while small systems may generate from 20-200 W.

Lighting of Houses and Streets:

Lighting is presently the biggest application of photovoltaic cells. Lighting using PVs is used for domestic purpose and also for commercial purpose such as street lighting, traffic signals, lighting in tunnels and security lighting. Generally, tens of thousands of PV units are installed worldwide for the purpose of lighting.

Medical applications:

The protection of vaccine and other sensitive medical supplies from excessive temperature is crucial for improving the health of the rural people. As it is very difficult and expensive to support refrigeration systems with diesel generated or grid-generated electricity, the solar powered systems are earning recognition from organizations such as WHO and UNICEF.

b) Industrial applications of Solar Electricity

Because of their high reliability and cost efficiency, the remote industrial applications make use of solar electricity. Some of these applications are:

- ❖ **Ocean Navigation** : Solar energy is frequently used for transportation signaling such as offshore navigation, buoys, lighthouses, aircraft warning lights ,etc



- ❖ **Telecommunication systems:** The radio transceivers on mountain tops or telephone boxes are often powered by solar PV cells. They are also use to power repeater stations for microwave, TV, radio telemetry and radio telephones.



Figure 11: Use of solar power for Telecom System (Coutesy: Kyocera Solar. Inc.)

- ❖ **Oil and Gas applications:** The automation equipment in oil and gas industry makes use of photovoltaic power systems. This set up consists of high-efficiency gas flow computers, data acquisition equipment for supervision and control and remote telemetry units. The power requirement for this set up is low and hence a single remote sitting PV system may be the most cost efficient source of power. The schematic representation of the application is shown in figure 12.



Figure 12: Use of PV for automation set-up for Oil and gas (Coutesy: Kyocera Solar. Inc.)

This set up is also used for cathodic protection, seismic monitoring, data recording and flow monitoring.



- ❖ **Traffic Applications:** The traffic signal systems range from school zone flashers and speed awareness displays to 24-hour flashers and changeable message displays. All these systems make use of photovoltaic for generating the power as shown in figure 13.



Figure 13: Use of PV unit for traffic signaling (Coutesy: Kyocera Solar, Inc.)

- ❖ **Solar Power for Space applications:** Photovoltaic cells are considered to be the most reliable and cost efficient source of electricity for satellites in space. In the beginning the requirement of power for satellites was few Watts but now it went up by several kilowatts. Generally arrays of PV cells are mounted on the solar panels of the satellites and these arrays are designed in such a way that they have high power to weight ratio due to economic reasons.

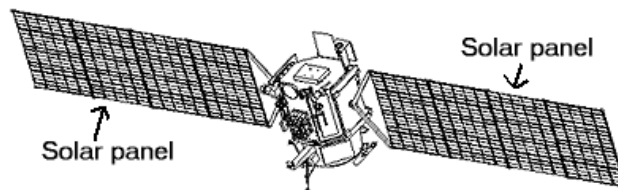


Figure 14: Use of Solar power for satellites in space (Ref:<http://nmp.jpl.nasa.gov/ds1/>)



IV) SOLAR TOWERS: A NEW WAY FOR SOLAR USERS

The main problem with a P.V. plant is that the system can not work twenty-four hours a day.

Another solution would be to find another process, more efficient to produce electricity day and night. This process already exists. It is called SOLAR TOWER or SOLAR CHIMNEY and now we will present you how does it work and its advantages.

a) Solar tower using a “single flow upwind system”

This kind of tower is the most popular because a prototype has already been built in 1982 in Manzanares in SPAIN.

This kind of tower uses a very simple principle, the natural convection.

The objective of this plant is to produce an artificial upward flow and to use this flow to generate electricity.

The P.V. plants use directly the solar rays to generate electricity. For the solar tower it is different. It does not use directly the rays directly, but the heat they produce on the ground by heat transfer.

Meteorological reminder:

The sun emits radiation on earth. A part of these radiations is absorbed by the ground, these radiations bring to the soil energy as heat. The temperature of the ground increases and it emits in its turn infrared rays. This infrared radiation is absorbed by atoms in the air increasing its temperature.

Yet a landscape has several types of surfaces and each one of them does not absorb solar rays in the same way. Thereby each surface will not receive the same quantity of heat energy and will consequently emit more or less solar rays and heat more or less ambient air.

For example if the landscape is a forest and, that in the middle of this forest is located a glade. The glade will absorb more solar rays and the temperature will be more important over the glade than over the forest so air will be more heated over the glade than over the forest.

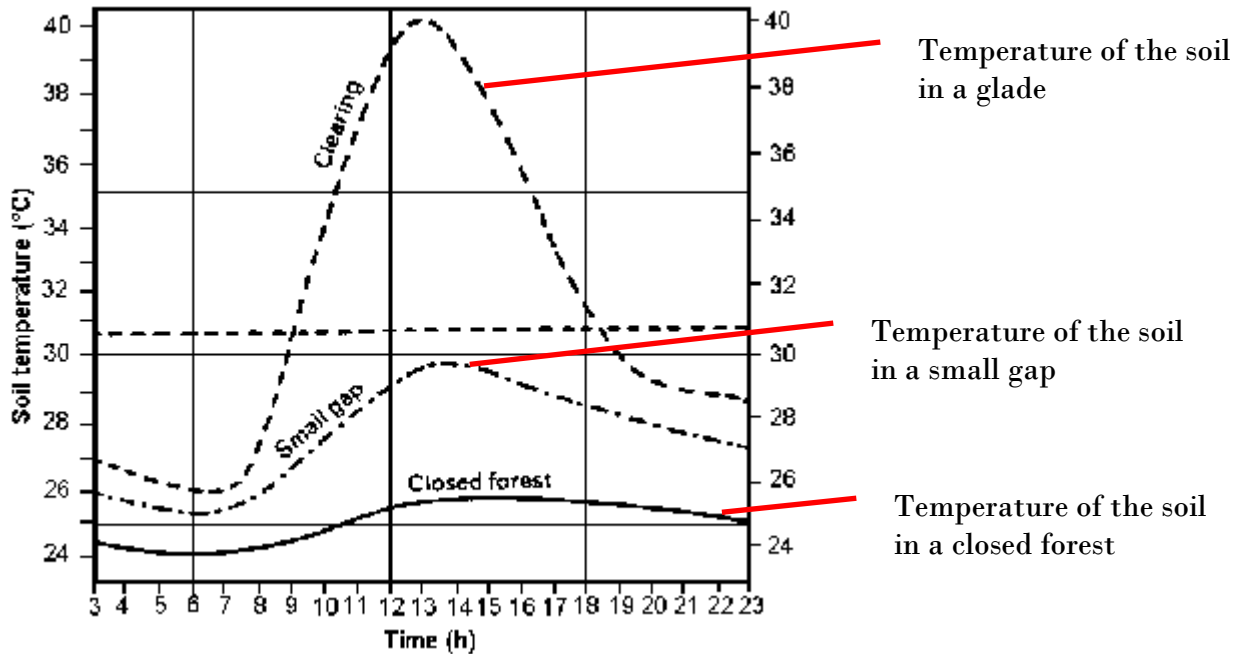
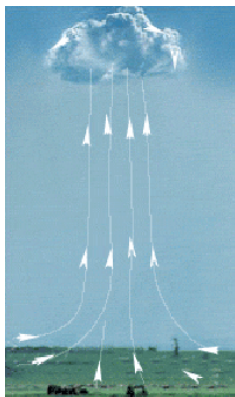


Figure 15: Change in temperature of the soil in a forest in Surinam

Source: European parliament (http://www.europarl.europa.eu/workingpapers/agri/s3-2-1_fr.htm)

In a system, when the temperature of a little quantity of fluid changes, this little quantity of fluid will vertically moves in the system because of the Archimedes' thrust. Indeed the change of temperature for a fluid modifies its density.

$$\rho_{cold\ air} > \rho_{hot\ air}$$



When the air heats up, its density decreases, that's why in a system, the little quantity of fluid which has been heated will lift. This movement is called movement of convection.

For the previous example of forest, air over the glade will be more heated than surrounding air which will generate a thermal lift.

The objective of the solar tower will be to create an artificial thermal lift and to canalize the air flow to use energy to generate electricity

Figure 16: Natural upward flow

Source: Gliding club of Saint Florentin – Cheu (<http://www.planeur-stflo.net/pages/vavvol/thermique.php>)



Collector

To create an upward flow we will first have to find a special material able to heat air more than all the other element of the landscape.

The best way for this is to use an immense greenhouse.

This collector will so be made of plastic and glass. The more important is to have a translucent material able to let the solar rays enter.



Figure 17: Roof of the collector in Manzanares (Spain)

Source: (<http://www.ecosources.info/Centrale-solaire-tour-cheminee>)

The ground receives the same solar radiation inside and outside the collector. So, its temperature will increase inside and outside and it will heat the air. But the air inside the collector will benefit of the greenhouse effect. The infrared radiation emitted by the ground will be refracted by the collector's roof and will return to the ground. That is why the ground inside will be hotter than the one outside, making the air inside the collector even hotter.

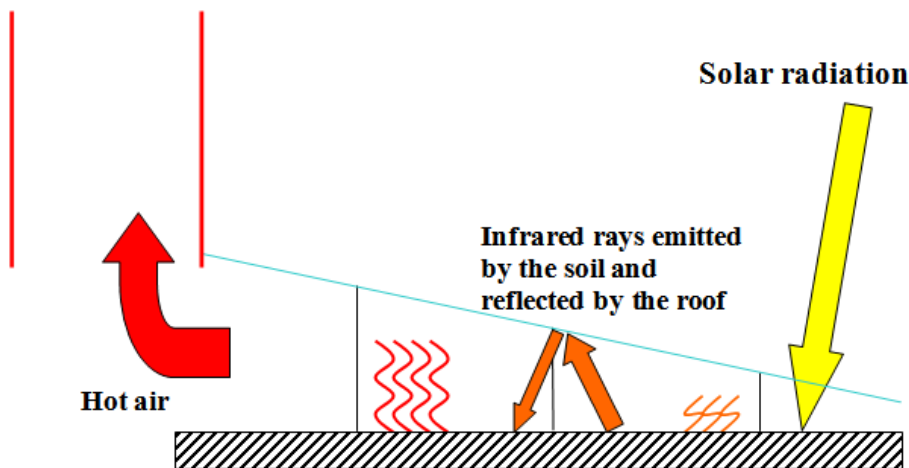


Figure 18: Greenhouse effect

This difference of temperatures will create an air movement which will be possible to canalize by the shape of the collector. The height of the roof increases adjacent to the tower base. Yet hot air naturally rises to the highest point that's why it directly goes to the foot of the chimney, where the turbines are located.



The tower tube

The tower will have to canalize and convert the airflow created by the updraft. This flow is in fact the sum of kinetic energy and potential energy.

The tower will in fact connect the surrounding atmosphere inside the collector with the top of the tower. Yet, because of the density difference, the column of air will lift in the chimney, but it will rise as a single flow, without rotation.

More, the pressure drop at the turbine. We consequently have a pressure difference between the tower foot and the ambient. This low pressure inside the chimney is a problem for the building because the material used will have to be rigid to resist.

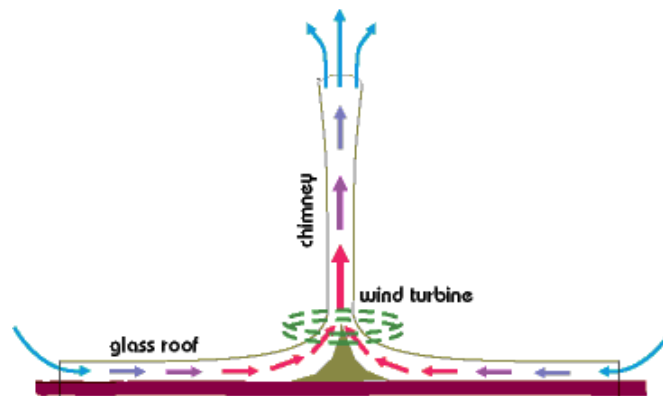


Figure 19: Principle of a Solar Chimney (Schlaich and Robinson, 1995)
 Source: (<ftp://ftp.ecn.nl/pub/www/library/report/2002/c02062.pdf>)

The turbine

The turbine will have to convert the air current in the tower in a form of rotational energy. Turbines in the solar tower don't exactly work like the wind energy plants.

In fact, a wind energy converter is unable to convert an important part of the wind energy because of the lack of blades, and blades area. But a wind converter works with staged velocity so if the area is increased, the opposition to the wind will be too much important and the wind will avoid the turbine.

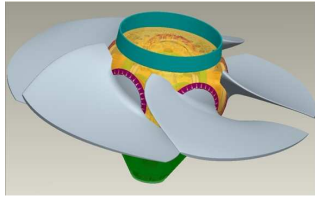


Figure 20: Wind turbine.
 Source: *Specialty Bar Products Company.*
 (<http://www.specialty-bar.com/power-generation/wind-turbine-parts.html>)

In the solar tower the turbine used will about be the same that in a hydroelectric plant. It is called shrouded pressure-stayed wind turbo generators. These turbines are very similar to Kaplan type turbine.



The Kaplan is of the propeller types, similar to an aeroplane propeller. The Kaplan's blades are adjustable and will handle a great variation of flow very efficiently.



Unlike all other propeller turbines, the Kaplan turbine runner's blades were movable. The guide vanes could also be turned and were automatically adjusted to any angle suitable to that of the blades by a combiner, so the turbine is efficient at different work loads. The optimum angle depends of pressure losses.

*Figure 21: Source: Alstom power
(http://lamh.gmc.ulaval.ca/turbines_en_bref/turbine_kaplan/)*

The heat storage

And the last point for the presentation of this power plant is that it can work during the night. In fact the ground heated during the day, stores heat and radiates during the day and during the night as much as he loses its heat. This radiation heats the air under the collector during a part of the night. But the natural soil was not so efficient. Something better would have to be found to store more thermal energy.

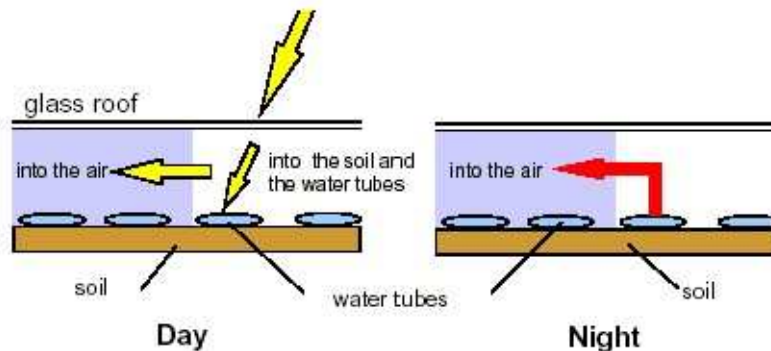


Figure 22: Source: Wikipedia Nederland

The solution found was to lay down tubes of water side by side in the ground under the collector. The tubes of water are closed that's why there is no evaporation. The water will be heated during the day; it will store the thermal energy. During the night this hot water will permit to the ground to stay hot for a longer time because the heat capacity of the water is about five times higher than that of the soil. Thus the ground will radiate and heat the air under the collector during a longer part of the night and the process will so become more efficient.



b) From the prototype of Manzanares to the Australian project

The power plant which is described in this project already exists in Manzanares in Spain. It was built in 1982 with funds provided by the German ministry of research and technology.

This solar tower was in fact just a prototype to obtain data on the efficiency of the process, to compare the measures and the calculations based on theory and to compare the influence of each component of the plant.



Figure 23 : Source : Enviromission
(www.rega.com.au/Documents/2002%20Forum/RDavey%20Enviromission.pdf)

That's why this tower and its output were so small. It was 195 meter height and 5 meter of radius. The collector roof was made of 6000 m² of glass and 40 000 m²² of plastic to try to reduce the price. The collector increases the temperature of the air to about 20°K. There was only one turbine which produced 50 kW, just enough to supply 50 housing.

This prototype showed different things:

- The agreement between theoretic and measured values was very good as we can see on this diagram showing the output calculated and measured.
That means that the engineer well understands the process and that they are now ready to build a bigger solar tower for a real application.
- That the output of the plant depends on the height of the tower, of the intensity of the solar radiation and of the size of the collector. In fact it shows one thing, it is that the output only depends of the difference of temperature between the top and the foot of the tower.



$$P_{tot} = \frac{1}{2} m V_{tower\ max}^2 \quad \text{With} \quad V_{tower\ max} = \sqrt{2gH_{tower} \frac{\Delta T}{T_0}}$$

T_0 is the temperature at the foot of the chimney. It only depends on the size of the collector (the bigger it is, the hotter will be the air).

$\Delta T = T_{foot} - T_{top}$ and T_{top} depends on the height of the tower because the more you lift in the atmosphere and the more the temperature decreases.

It finally permits to establish a relation between the energy output and the size of the plant.

Capacity	MW	5	30	100	200
tower height	m	550	750	1000	1000
tower diameter	m	45	70	110	120
collector diameter	m	1250	2900	4300	7000
electricity output ^A	GWh/a	14	99	320	680
^A at a site with an annual global solar radiation of 2300 kWh/(m ² a)					

Figure 24: Source: Schlaich Bergermann und Partner

Thanks to these results, economic calculations have been done to preview the price of this kind of installation for several outputs.

Thanks to these data, it was easier to preview a useful project.

Thus, the 30th of august 2002, the Australian ministry of industry published its project for a solar tower of 1000 meters height.

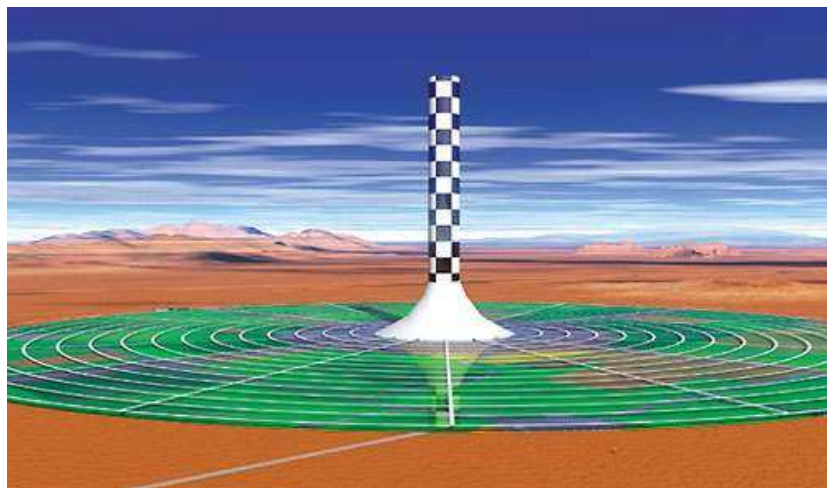


Figure 25: Source: Equity green (<http://equitygreen.typepad.com/blog/2007/07/enviromission-p.html>)

The engineer of Enviromission, in charge of the project, proposed a collector of 7 kilometres of diameter which will rise the temperature of the air to 30°K in comparison with the ambient air.



The 32 turbines of 6,25 MW each describe a circle at the foot of the chimney. They will generate an output energy 17 000 times more important than the prototype of Manzanares for a total output of 200 MW, enough to supply 200 000 housing.

The cost of this project would be about 400 M € so it is less than what the studies of Manzanares predicted. The investment cost will be about 2 €/W. We can compare it with other renewable energy sources:

- The price of the Watt is 3 times more expensive for a photovoltaic panels installation.
- The price of the Watt is 1,6 times more expensive for the recent solar thermodynamic power plant PS10.

In fact the price of the Watt is about the same that for a wind energy power plant.

But this solar power plant has its limits. It produces 7 times less energy than a nuclear power plant and the price of the kWh will still be 5 times more expensive than the electricity produced with coal, and currently, 95% of the Australian electricity is produced with coal.

This process is maybe not the best. Another project using the updraft air current is currently developing, but this one is really more efficient.

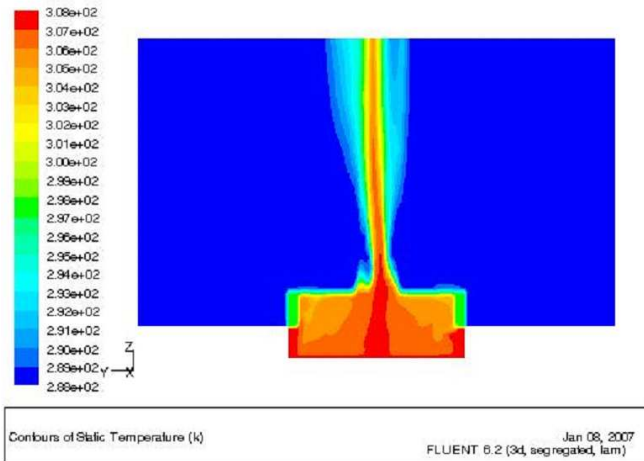
c) Solar tower using a “rotational flow whirling system”.

The “vortex” solar tower is currently the only power plant able to produce the same quantity of energy that current electric power plants.

If this installation can reach the announced performances, we could abandon all the current pollutant process to generate electricity.

In unstable atmospheric condition, the air mass acquires a rotational movement which will be slow at the beginning but which will accelerate if it is associated with an upward movement. This double movement where the rotation dominates will create a vortex of low pressure into a very long cone of high pressure. This cone where is located the vortex is called TUBA.

This is a characteristic of the whirlwind which is increased by the Coriolis forces (because of the earth rotation).



The tuba works like a chimney. It prevents all the heat exchanges between the air of the vortex and the ambient air. That is why a vortex can reach very high altitude.

Figure 26: The insulating properties of the tuba.

Source: Atmospheric Vortex Engine (http://vortexengine.ca/misc/Thermo_Pres.pdf)

The objective is so to recreate an artificial cyclone. The solar tower has to have the form of a vertical Venturi with a convergent-divergent. The most important thing is that the collar permits the through to an important air flow.

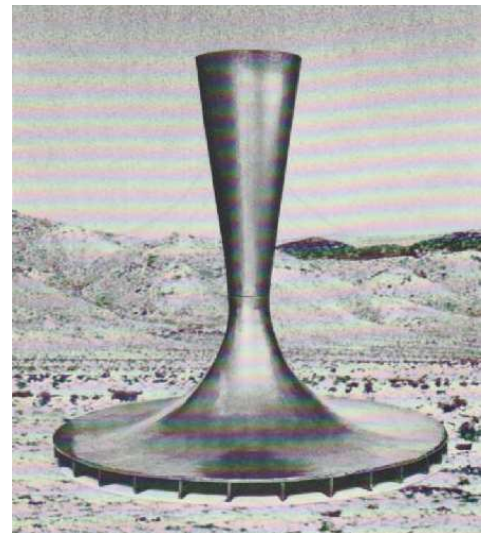


Figure 27: The solar tower of the professor NAZARE

Source: L'Ere nouvelle n° 52 July 1985

The convergent part is equipped with deflectors which permit to accelerate the rotation of the air mass in the same way that the Coriolis forces. The rotation movement of the air creates a vortex inside the tower at the collar level, where the diameter is the smallest.

This depression is accompanied with an increase of the pressure around the vortex and the ambient counterbalance each other.

The studies of the professor Nazare shows that a vortex can appear with a ΔT of 15°K and a rate of humidity of 40% and that it can rise up until 3000 to 6000 meters.



We said before that the output depend on the difference of temperature between the top of the chimney and the ground. Yet here, the top of the chimney is in fact the top of the vortex so it is more than 3000 meters high.

More, a 3 kilometres of diameter collector will be installed. That means that the ΔT will be about 50° to 60° so everybody can imagine the output energy.

The turbines would be installed at the collar level.



Currently one prototype of 6 meters high has been built in Chambéry in the centre of France by the private company Sumatel and a new one of 60 meters high would have to build in Guadeloupe by the same company.

Figure 28: The prototype of vortex tower of Sumatel

Source: Sumatel (<http://quanthomme.free.fr/energieencore/carnet14.htm>)



CONCLUSION

For our future, it is now essential to diversify our energy sources.

If we do not react now and stop or decrease our dependency on fossil fuels the future is in danger. When oil and coal resources will be exhausted, there will probably have tensions between the countries, maybe war or economic crisis will increase.

We have lost too much time, we have to react, the solar project of the professor Nazare already exist for 40 years, but neither private company nor European Union accept to give money to develop this project.

But now we think that the things will change because a lot of companies understood that the renewable energies market can be prosperous. Greed has always been the best engine for human race, but if it works...

Solar power plants are currently the mere process which can be used in all the poor developing countries. So we think that if researchers continue to work hard to improve all the processes, in several years, solar energy will be the first renewable energy source.

“We don't inherit the earth from our parents; we borrow it from our children.”

Antoine de Saint-Exupéry



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