PhoEf: Photovoltaics research for the creative community
By Bartaku / FoAM – Brussels (Be), 2007

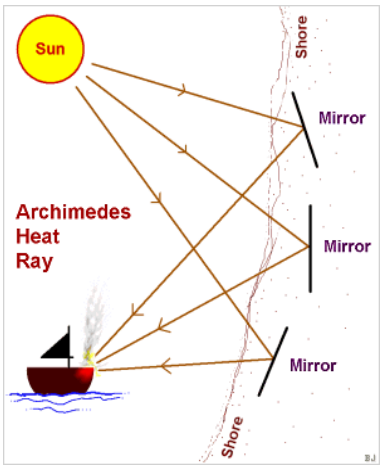
PhoEf's Assumed Origins
Deep respect and fascination for Andean Cosmovision, based on millenia of profound observation of the earth-constellation relation- coexists with that for the massive *bombardment* by the sun's particles that also appear to be waves...

Discovering new interesting and promising technologies probably made me undertake ***PhoEf***. With the support of FoAM, the interdisciplinary lab which I got to know due to their fascinating workshops (with okno and nadine) and gatherings. Also the dependence of the main supplies, the grid, with always-in-the-way- cables and converters and the omnipresent A, AA or AAA tiny chemical containers contributed highly to the eager of finding other ways to power what inevitably and ultimately has to be (low-)powered.

Luminous Green
The research had a kick off at the Luminous Green hands-on workshop where Marko Peljhan -based on his experience with his polar station- explained how to size a pv-system, calculate the energy requirements and how to set-up an of the grid system. A rather important observation was the presence of a (lead-acid) battery in the system. A back up that is needed in case electricity is required when there is not sufficient light. We experimented also with newer pv-technologies such as the Dye Sensitized Solar Cell, one of the newer technologies using plant matter as a semiconductor, based on the photosynthesis proces.

PhoEf > the photovoltaic effect
The subject of this research is generally indicated by either solar energy (solar products, solar cell, solar panel etc...) or Photovoltaic (PV) energy (and -product, -cell, -module etc...). This is a bit confusing as all energy sources depend or originate from the sun. Photovoltaics, the generation of electricity (volt) by the use of light (photons) is one solar energy technique using the energy available as sunlight. Other examples are active and passive thermal solar energy but strictly speaking other renewables like hydropower, wind energy, and biomass, are also forms of solar energy. Also, new technologies -although most are in the experimental low efficiency phase- appear to be able to capture spectra of the irradiation which do not require the presence of the sun, not at daytime nor at night. And finally, it is also possible to generate electricity using articificial light for PV-applications.
Conclusion, the best way to denominate the subject of this research is arguably *PhoEf,* the photovoltaic effect: the generation of a voltage and/or a current by absorption of light in some material or combination of materials.

PV-Origins
As is the case for most 'inventions', the invention of the solar cell is the result of a historical and continouing process involving a lot of people with diverse angles, paradigmas and backgrounds such as chemistry, physical sciences and quantum physics, physical electronics, optics, photonics, (advances) materials science and engineering, electric sciences, cosmology and astronomy. It is generally acclaimed that the photovoltaic effect was first discovered in 1839 by the French nature scientist Alexandre Edmond Becquerel. In 1883, the American inventor Charles Fritts produced the first selenium-solar cell with an efficiency of



only 0,1 %.

After making its commercial debut in solar-powered toys and games, solar energy was used to power satellites in the space program; the first time a PV-System was used in space was on the NASA Vanguard I satellite launched March 17th, 1958. Solar energy was a more functional and efficient source of energy than batteries that burned out within a week of orbit. Solar cells are since terrestrially used/integrated in a growing number of contexts and applications such as houses/buildings, water pumps, electronic hand held devices, naval navigation devices and many developing modes of transportation.

You can find a historical overview of key people and inventions here

"That night the old woman went to the moon as a flying spark of light. She circled the moon three times before attending the meeting of other lights from all over the world. In the morning when she returned full of the energies and enlightenment the journey had given her -the life extension and the weight of future sight- she resumed the weaving of our narrative."
(Infinite Riches - Ben Okri)

PV & senses
A lot of new technologies are being developed, some building further on the well documented use of Silicon as a semi-conductor, others explore newer areas with other organic semi-conductors such as polymeres and Zinc-derivates New aesthetics
This leads to a present situation where -after 50 years of dominance of crystalline blue/grey- there is a lot more diversity though with a lot of developments still at an experimental or maybe prototyping stage. In general one of the most important influences on the rapid evolution of the photovoltaics impact on the senses comes from nanoscience leading to much tinier, thinner, either still solid, flexible or even printable and sprayable solutions. This facilitates integration with other materials including fabrics, which allows the PV-techology to enter the realm of the intimate.

Besides the variation in materials (components) and flexibility also the range of shapes -from flat to spherical- and colours is rapidly expanding. But -again in general- versatility and aesthetic freedom means a sacrifice of efficiency and durability.

An absolute advantage of using a photovoltaic system is it's silence. Unless you are using a pick-up coil, it does not produce audible sound frequencies.

Ecology
Photovoltaic energy is one of the most promising ways to contribute towards a greener planet, lowering carbon footprints and ensuring the earths balance remains intact. The generating component produces electricity silently and does not emit any harmful gases during operation. Environmental issues do exist ranging from CO^2-emission in the production process, scarcity of materials to the use of toxic materials in the fabrication of modules.

The basic photovoltaic material for most common Silicon modules made out of silicon is entirely benign, and is available in abundance. Si-based, second-generation, thin-film technologies and Third-generation approaches to photovoltaics use materials that are both nontoxic and not limited in abundance. This opposed to thin-film solar cells based on compound semiconductors like CdTe (toxic Cadmium) and chalcopyrite compounds CIS, CIGS (Cupper, Indium, Gallium and Selenium; not limited in abundance).

The technologies also need to have acceptable energy payback times, the time taken for a device to generate as much energy as was needed to fabricate the device. Crystalline and multicrystalline devices typically have energy payback times of 3–4 years and the thin-film technologies, 12–18 months.

The picture becomes a bit more complicated as soon as the PV-cells/panels/arrays are set up in a PV-system with the appearance of -depending on the system- some of the following parts: an array DC disconnect, a storage battery, a charge controller, an inverter a system meter and mounting and wiring systems.

The market

Solar energy is receiving worldwide attention due to the rising global warming awareness and in the 2nd half especially due to the oil prices breaking almost daily new records. The photovoltaics industry is rapidly expanding with manufacturing plants of increased capacity and implementations materializing. Scientists and engineers all over the world are exploring the potential for improved cell efficiencies and above all reduced production cost. Innovative processes and materials are being studied promising flexibility, printability and lower manufacturing, implementation and maintenance costs. Also other pv-related components such as mechanical support (including integration techniques), regulators, dc/ac inverters, batteries, etc. are improved.

BIPV is receiving much attention, as using photovoltaic cells in this way minimizes land use and offsets the high cost of manufacture by the cells (or panels of cells) acting as building materials. Although crystalline Si solar cells were the dominant cell type used through most of the latter half of the last century, the most successful technology at present is based on the use of multicrystalline Si. Recently other cell types have been developed that compete either in terms of reduced cost of production or in terms of improved efficiencies. The most successful technology at present is that based on the use of multicrystalline Si, which has expanded even faster.

The key aim of all the technologies is to reduce production costs to 1 $/peak Watt (1 $/Wp) to compete on cost with other forms of power generation. Cells based on the use of crystalline and multicrystalline Si cost more than four times this amount. It is generally accepted that this target is most likely to be reached using thin-film fabrication technologies when expanded for large scale production. Nanosolar claims to be the first company to have achieved this. The technologies also need to have acceptable energy payback times – this is the time taken for a device to generate as much energy as was needed to fabricate the device. Crystalline and multicrystalline devices typically have energy payback times of 3–4 years and the thin-film technologies, 12–18 months.

In 2006, the largest production of PV-cells and modules took place in Japan, Germany the US and Spain. Prices per PV-module depend on the technology and the local market conditions and vary from 3-6EUR/Watt (USD 4-8; 2006).

"In this vision of the future, a thin film covered city

might drive the electrical grid itself,
essentially functioning as its own powerplant.
Increasingly you will see it everywhere, or,
you won't see it but it will be everywhere,
powering your life exactly the way you live it today."
Nanosolar's Vice President of Engineering - July 3, 2007 -
www.kqed.org/quest/television/fullscreen?id=399

Wanted right here right now

Coinciding with the high pressure to come up with the cheapest and most efficient technology is very high, a lot of Research centers, universities and companies show the awareness of the need for new ideas and experiments for further development of -the aesthetics and functions of- photovoltaic technologies.
Simultaneously there is a growing number of 'creatives' throwing out their first stones in the PV-stream wanting to take the first steps. So, if you have a somewhat crystallized project in mind and on paper, look for an appropriate PV-partner in the 'neighbourhood'; see the PV-overview as well as some things to think about before contacting them).

Laurie Anderson's Aimulet

An example of a fruitfull collaboration that has lead to a rather poetic result is the *Aimulet LA.* "It's is a device, "an electronic samurai's pillbox", slightly larger than a credit card, utilizing SphelarVoice technology enabling visitors to learn information about their environment. It delivers a low-volume audio signal to the user via an earphone speaker that is connected to a solar battery. One may simply point the Aimulet at an item of interest in an exhibition powered by SphelarVoice technology, and infrared light projected by Sphelar modules carries audio information that is decoded by the card." It is designed by Laurie Anderson in collaboration with the Japanese electronics company Kyosemi for the Aichi Expo in 2005. The AimuletLA is now mainly used in museums.

Methode, scope, time

After the first glances at pv-resources on print and screen, and being bombarded with news about this 'new world' by specialized newsletters, the first reality check took place at *InterSolar* . It's one of the most important if not the pv-annual event of the year, that in 2007 took place from June 21 -23 in the German 'solar city' of Freiburg. It seemed as if I had been blind before, not noticing how the whole world had gone 'photovoltaic'. It was rather comforting to see that the fair organizers had a similar shortcoming as they had to provide extra (emergency) pavilions.

Some other observations at Intersolar: the presence of huge, flashy stands with numerous rays of theater spots, not pv-powered: the impressive amounts of coca-cola can's and plastic goblets; the hyper-trained and tanned sales man, the materials used in some pv-applications (copper, plastics); the industrial pv-

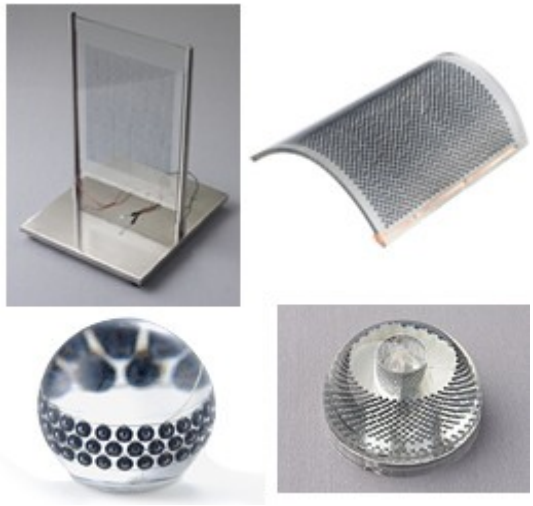
panel mounting robots; the omnipresence of 'storage batteries'; the glossy leaflets, brochures and magazines. I encountered one company only, Japanese, that used recycled paper with vegetable ink. I came out a little less naive, it's about business, big business. Nevertheless, I had to do serious rewriting of the first text drafts which exhaled the 'hallelujah buzz' sweeping through the Intersolar's premises and publications.

Due to the unexpected dimension and speedy growth of the global activity in photovoltaics I had to rethink the scope of the project. A difficult task when you end up in brand new or echoing playgrounds involving a range of natural sciences (having a Communication Sciences past myself). Therefore, besides the desk research and the Intersolar-experience of major importance was the encounter with several pv-experts of research centers and companies. They guided me through the expanding PV-landscape.

Two findings are worth mentioning here: Relatively few artists / arts projects are exploring photovoltaics and consequently there is not much practical context specific information available. More in general, there is little data available on the irradiance indoors as a result of artificial lighting or natural light that enters through windows.

Focus Limits
It is easy to indicate which applications are not the main interest of the research: PV-technology for space applications and the grid-connected systems (distributed or centralized (power plant) systems connected to the utility electricity network). Also, it is not possible to cover the possibilities of a hybrid system, like a pv-module/wind turbine set up.

Rather, focus is on terrestrial off-grid systems that can provide electricity for low power loads,, the latest technologies that are more versatile and that have different looks and feels compared to the first generation crystalline silicon-based ones. So-called 3rd Generation technologies and applications often based on nanoscale components allowing easier integration with other materials. Some of them are becoming readily available now, like the Dye Sensitized Solar Cells (DSSC) but a lot of these technologies are still at the experimental stage and according to some PV-experts most of them will need at least 5 years before being able to appear on the consumer market. Especially these newer 'inventions' -like printable and sprayable pv-cells based on bioplastics- are very promising in terms of versatility of use and aesthetics.



Shit, a Battery?!
Clean storage of renewable energy is at present problematic. One of the major drawbacks to storing PV-generated electricity is that we store the electricity in chemical storage batteries, relying on the electrical energy to produce a chemical change, which is later reversible. Things like cadmium, lead and sulphuric acid come to mind and -although to some extent recycling is possible- suddenly the grid suddenly pops up again as a cleaner alternative, especially when it functions on... PV-, wind-, tidal- or another renewable power.

So, at some point you will have to decide if a **storage battery** is needed or not in

your power design. You will not need them if you wish to use the PV-cells' response to changes in irradiation to determine if your electric devices are working or not. Mind you that some devices like cameras do not switch on automatically after they went off due to a lack of electricity. On the other hand, if your installation has to be up and running under -at some point- (too) poor natural or artificial light conditions, then you will need a battery back up that takes over when your PV-cells are pretty unable to absorb the bouncing photons.

Ever since childhood the junkie metaphor installed itself in my relationship towards batteries. Feeling bad whilst purchaising them-or 'borrowing'- knowing that their shot of energy would not last for long. Right after the short high, on feels awfull due to deprivation and guilt feelings. Tiny as it is, it would stay at eye-sight for a long time. Or, when it did stay out of sight, it destroyed the inner core of those beloved toys. Together with plastic bags, they must be the most widespread junk on Earth.
Bartaku, September 2007

If you DO decide to work with a storage battery, you better do your homework as they behave differently and require special care and caution. You can find an overview with the strong and weak points of the most common and most recent types as well as install precautions here.

PV-General Overview
A core component of the research project consists of a pv-overview. It's a spreadsheet (a database if you wish) consisting of research centers, companies, institutions and artists (projects), DIY-projects, pv-events and educational offers, and pv-media. It is not an exhaustive overview, but merely an inventory of virtual and reel encounters on the research path.

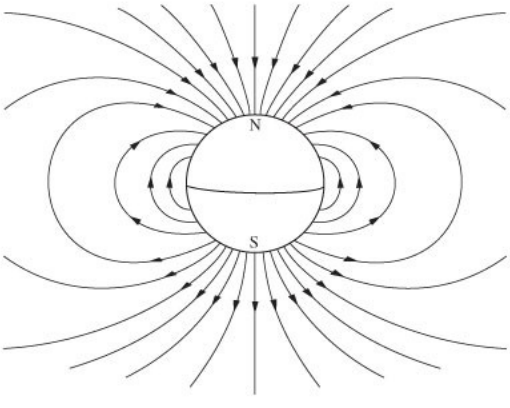
In brief:

- Autonomous: as in not connected to the main grid; stand-alone;
- Versatile and flexible; combinable with other materials in different contexts;
- Battery storage: is storage needed and what are the consequences of the Yes/No;
- PV-overview with the following categories:

1. Research Centers
2. Companies
3. Institutions
4. Artists / Creatives
5. DIY
6. Events / Education
7. Media

Time & Space
The publishing of the own research findings will start from the end of 2007 and will continue throughout January. After that the evolution will become mostly dependent of the contribution of the creative community. Findings will be published on http://luminousgreen.org

The sun's destiny is ours
If mankind survives the end of the 4th Sun on the increasingly becoming mythical December 21nd of 2012, one will more than ever be aware of the fact that the future of the planet is closely tied to that



of the Sun. The ancient Maya-calendar 'states' the sun is approaching the end of it's 4th Period, on the 21st December 2012. The birth of the 5th Sun means according to some "A shift of the ages". www.shiftingages.com/synopsis.html. Others tend to believe that the poles will switch because of the massive amount of solar irradiation and that this would cause mass-destruction on Earth.

Scientists predict that as a result of the steady accumulation of helium ash at the Sun's core, as part of its solar lifespan,the star's total luminosity will slowly increase by 10 percent over the next 1.1 billion years (1.1 Gyr), and by 40% over the next 3.5 Gyr. Climate models indicate that the rise in radiation reaching the Earth is likely to have dire consequences: the orbit of the Earth may have expanded to about 1.7 AUs because of the diminished mass of the Sun and so the planet might escape envelopment by the expanded Sun's sparse outer atmosphere. But most (if not all) existing life will have been destroyed by the Sun's proximity to the Earth including the possible loss of the planet's oceans.

Limited PhoEf
In this highly vibrating and rapidly expanding environment where weekly new products and actors pop up- I explored the horizontal and vertical dimensions within the limits of time and space. I apologize for not having covered what I might should and could have. I tried to present the findings in a multi-layered way, with links to supporting AV-material hoping to address the diversity, the differences in experience and expertise of the audience. And needless to point at the use and choice of words in the texts: English with a Dutch accent.

Invitation
Nevertheless I hope that this research contains sufficient elements and energy to motivate you to engage in the use of light for powering your inventions and creations. Especially, as the information will be out of date due to the rapid evolution in pv-land, hopefully you will find the time to participate in keeping what exists up-to-date and add new discoveries and findings. So, this is an open invitation to become an active participant, a knowledge node in this ongoing networked collaborative research project. Make it a usefull tool for yourself and the creative community; Http://luminousgreen.org is awaiting you.

Special thanks to FoAM for making this research possible and to the pv-professionals that have shared their inspiring insights with me.

For specific questions feel free to contact me at bartaku[at]yahoo.co.uk

References
See: resources

About

FoAM vzw
FoAM is a laboratory for re-integration of human knowledge, from science to arts, from technology to culture. As a hybrid between a research center and an artistic studio, FoAM works toward transdisciplinary models of creative expression and knowledge production. Our works include mixing virtual and physical realities; raising intellectual and emotional understanding of science; creating temporary responsive

environments; using environmentally and socially sustainable design and eco-technology practice. FoAM is based in Brussels with subsidiaries in Amsterdam, Berlin and soon Singapore.

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