
Bartaku

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PhoEf > The Undisclosed Poésis of the Photovoltaic Effect

A research project exploring Photovoltaics at the interstices of arts, science and technology.

Photovoltaics (PV) is the direct conversion of light into electricity at the atomic level. The word refers both to the science and the technology, which are based on the photovoltaic effect: the generation of a voltage and/or a current by absorption of light in some material or a combination of materials. Electricity that can be used for immediate power or deferred with the help of storage technologies. In PV these elements are interconnected by various sciences: (quantum) physics, optics, (bio) chemistry, engineering, materials science and micro-electronics.

The photovoltaic effect is first observed in 1839 by A.E. Becquerel, a French physicist, but the first functional, purpose-built PV device is made by American inventor Charles Fritts in 1883 with an efficiency of 0.1 percent. The modern era of PV starts in 1954 when Bell Labs in the USA produces a 6 percent efficient solar cell using silicon as a semiconductor. Five years later the Sputnik 3 is the first satellite using solar arrays, followed by Vanguard I for powering a small radio transistor. A major visual proof for the world that the sun's energy can be harvested to generate electrical energy.

Light - a mysterious element that enables people to *command nature.*
Francis Bacon, *New Atlantis* (1627)

A second hallmark for PV arrives in 1973, when the global oil crises turns the noses of petrol-dependant states and energy companies towards renewable energy and especially PV: US president Carter puts PV panels on the roof of the White House.... Only to be removed by Ronald Reagan in the slipstream of the oil crisis. Furthermore, when PV-research and development faces scale-up problems, budgets are drastically cut or cancelled, and the culmination of years of dynamic brain power is lost. In the eighties and nineties, with the help of consumer devices like the solar-powered calculator, wrist watch, outdoor lighting and other novel consumer applications, Japanese, US and European companies continue to develop power modules, mainly for the building industries and for stand-alone systems in remote areas.

In the 21st century, supportive government policies in many European countries and in Japan – partly driven by the Kyoto Protocol, climate change and especially the steep rise of oil prices in 2007/08 – result in a substantial increase in production. Most of the big manufacturers are either divisions or subsidiaries of large companies with diverse manufacturing interests (Sharp/BP/Shell/Kyocera). Most of the research for advanced future technologies takes place in academic and privately owned research centers.
The role of PV power in the world's overall energy system is still negligible – less than 0.5 percent – with predictions by industries and environmental organisations that it could rise to 26 percent by 2040.

Photon Power for Art

The strong vibrations in the rapidly expanding field of photovoltaics are increasingly being picked up by the global arts community. Since the beginning of the 21st century more artists engage and experiment with different kinds of solar cells and panels. Partly due to the technology becoming more efficient and more readily available at affordable prices, partly due to the intrinsic qualities of the technology which when in use is silent, emission-free, portable, durable and functional as a power generator and/or a light sensing device.

The environmental impact of PV is probably lower than that of any other renewable or non-renewable electricity generating system.

–IMEC Research Center – Leuven, Belgium

New designs, materials, structures and shapes have especially augmented the interest of creatives. The "classic" rigid blue/grey/brown silicon-based cells are gradually joined by thin-rigid or thin-flexible organic PV cells of various colors and shapes. This means that integration with more materials is possible, opening the way to new functions and aesthetics. These recent innovations in PV technology are fused in particular with advances in nano-sciences, allowing PV to enter the realm of soft materials (SMPV) and thus bringing it closer to the body, into the realm of the intimate. The energy requirements of portable devices are now low enough that clothing-integrated solar cells are able to power most mobile electronics. Military textile designers are trying to overcome integration problems by developing PV fibers that can be used for producing woven PV textiles.

Nevertheless, the more versatile, aesthetically interesting cells like the polymer and dye-sensitized solar cells are still less efficient (max 10%) and durable (<3 years) than the classic silicon cells, which have efficiencies of over 16 percent and an expected life span of 20 years or more. Also, the integration of PV based on flexible polymer or other chemicals with electronic consumer goods, solarbots and textiles raises environmental concerns. These are limited life-span products that rapidly become a new widespread kind of e-waste, requiring new recycling schemes.

Appropriating PV

DIY-ing traditional silicon PV cells is reasonably feasible, with extensive documentation online and with the necessary tools and materials readily available. The materials involved require a lot of "heat, beat and treat," so it is worthwhile looking for used or recycled panels – a rapidly expanding market, since the first generation of PV panels is reaching the end of its life cycle (with the Si-cells still functioning). Or one can try to interconnect different parts of broken "scrap" cells, requiring especially steady hands and a patient tranquil mind.

Natural Dye-Sensitized Solar Cells

Often PV-tech is compared with the plant leaf's capacity for harvesting the sun's energy. But there is only one type of PV cell that mimics significantly the natural process of photosynthesis: the natural Dye Sensitized Solar Cell (nDSC). It is made of the dyes of anthocyanin or carotenoid-rich fruits like berries, currants, black beans etc., some titanium dioxide (cf. white paint, toothpaste), some graphite or carbon, and an electrolyte, all sandwiched between two tiny conductive (tin-oxide) glass plates. Easy to DIY in the kitchen with components available online, on the balcony, in the garden, the park and the street. Unsurprisingly, the plants that produce the energetic nDSC dyes are very popular amongst the bees.

It is the role of the artist to comment on the way society is dealing with Energy.
–Ai Wei Wei Architect/Curator

New Ways with Rays

Deciding to use PV cells for powering the electric devices of an artistic project has an impact on various levels: from the time and space of use, the choice of materials and components to the design and appearance, the relation with the user/audience and the budget. Working with PV most definitely puts the dimension of energy much higher on the project's list of priorities.

When and where is light

Unless one does not want to make use of the fabulous opportunity to be freed from the plug, a PV-arts project might be an indoor but mainly outdoor "autonomous" or "stand-alone" system.

The first issue in the latter case concerns the intermittent nature of the solar radiation, the ambient light intensity. Natural light is available only during the day – at varying angles according to the time of year – and is strongly reduced in overcast conditions. Consequently one has to decide when the energy is needed: 24 hours a day during a week in November? Or at noon only, for five minutes, every day in summer... Or maybe visiting hours have to coincide with the hours of direct sunlight.

This decision will strongly impact the choice of the system design: a direct PV-stand alone system, PV-Pur Sang, with PV cells providing electricity instantly to the Rotor, vibrator or LED-lights that respond immediately, demonstrating the flux of the qualities of light; or a stand-alone system including an energy storage system for the moments when energy is needed but not guaranteed by natural light. Obviously the geographic location of the project in itself determines the number of PV cells needed, since the solar radiation on the planet varies greatly.

Everything is relative.
The speed of light is not relative.
Albert Einstein

Some PV cells perform under artificial light conditions, so the work can be placed indoors, nearby some well-chosen lighting devices. The better the match between the PV cells and the lamps' spectrum and the more optimal the distance between them, the more power is generated and the fewer cells and lamps are needed for the same output.

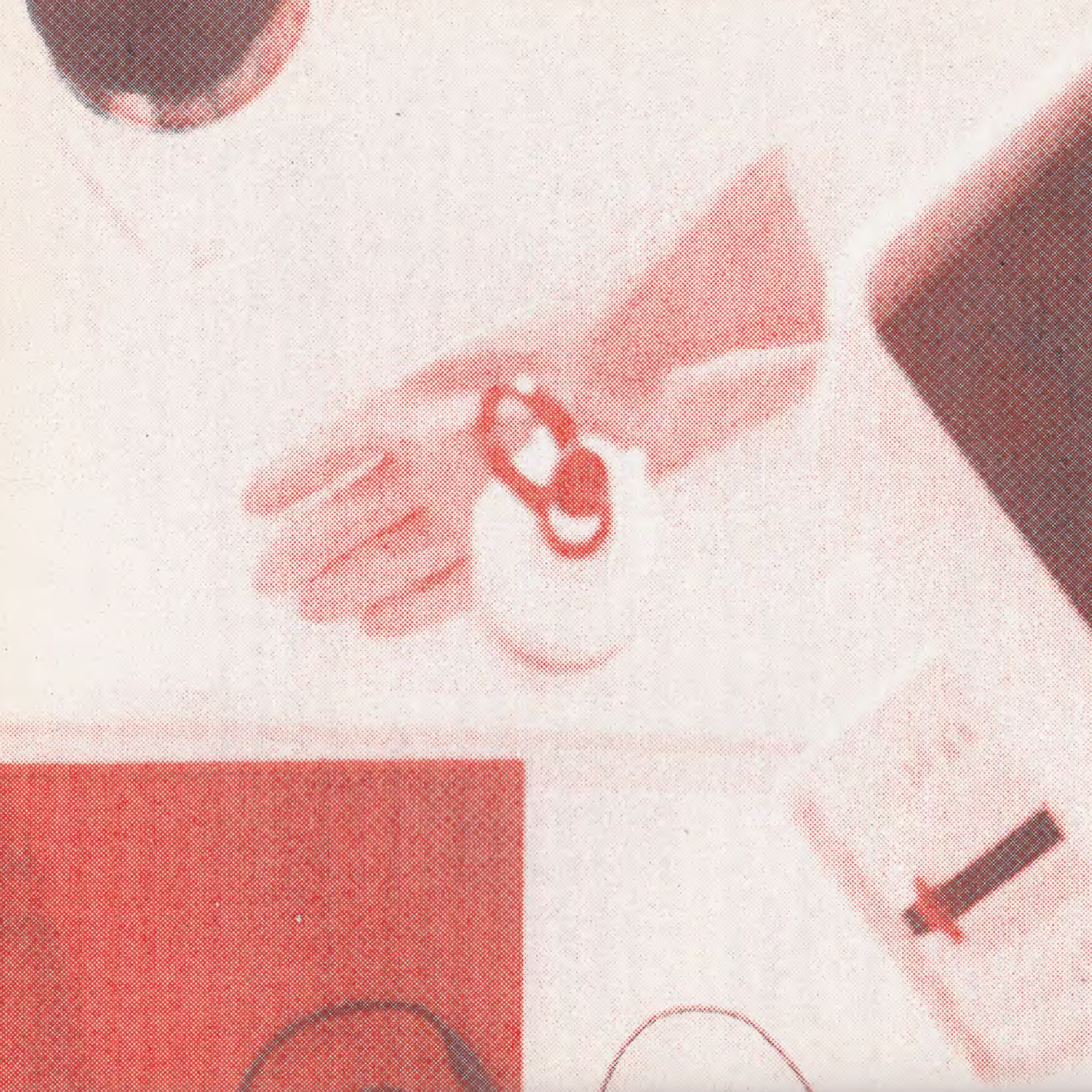
Optical tools and tricks

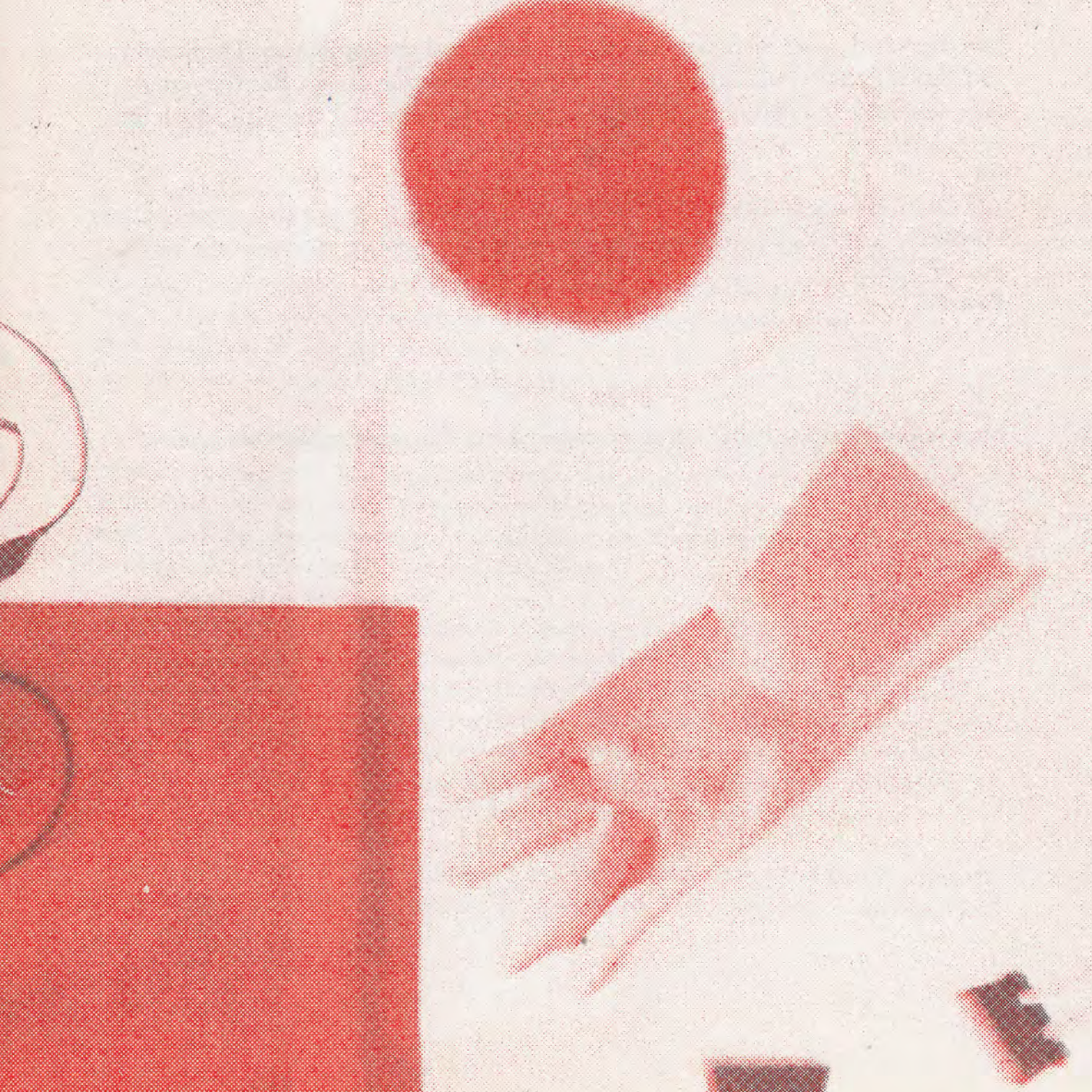
There are more tricks to make the process as efficient and and cost-effective as possible. One cell is connected to others to create a panel and interconnected panels constitute an array producing more volts or amps.

When the sun is shining but not reaching the PV cell, Archimedes' "heat ray" demonstrates that mirrors can transport light for more and bigger suns. More power is also obtained by placing a fresnel concentrating lens between the light source and a PV cell. Or one can follow the sun's path with the help of a solar tracker: PV cell and panels mounted on rotating "feet," thereby imitating the movement of heliotropic plants. In Western Europe 30° is generally the best angle for the PV cell's best photon-catch.

Energy storage and AC/DC

In case there is no or insufficient natural light, one may consider creating a hybrid system, for example using a PV panel and a wind turbine in wind-rich areas. Still, it might be necessary to integrate an energy backup system consisting of a storage device like a battery or super capacitor, a charge controller, a DC-DC or DC-AC





inverter which is set up in between the PV panel and the appliances. The battery can also store electrical energy in case there is production excess. But the system becomes more complex, more vulnerable, more expensive and above all, much less sustainable.

It is disclosed that photovoltaics is most poetic when it uses the fruits of photosynthesis to convert the sun's energy directly into another kind of energy. A brief movement of a subtle mass of electrons.
Bartaku

More information: see PhoEf's digital compost: http://libarynth.org/luminous/phoef

The following excerpts are reflections for the interdisciplinary debate "Crosstalks - Navigating the Complex Nature Of Energy Efficiency - The Atomium Session" on 14 May 2009 in Brussels

[...] "In investigating the roots of our current environmental dilemma and its connections to science, technology and the economy, we must re-examine the formation of a world view and a science which, by reconceptualizing reality as a machine rather than a living organism, sanctioned the domination of both nature and women. The contribution of such founding 'fathers' of modern science as Francis Bacon, William Harvey, René Descartes, Thomas Hobbes and Isaac Newton must be reevaluated."
Carolyn Merchant in The Death of Nature, 1980

In 1903, E. Richardson of Ontario (US) introduces the lightweight electric iron. A boat-shaped, electrically heated piece of pointy metal, pressed by the housewife onto the husband's intimate cloth, flowing around buttonholes whilst creating soft smooth topologies. Soon after the toaster, the dust cleaner and other time-saving appliances invite the housewife to prove herself on other work floors.

These domestic appliances were designed to function on alternating current (AC), an invention of Nikola Tesla. AC became the main standard for the transport of electrical power after Tesla won "The War of the Currents" from his former employer Thomas Edison whose company promoted direct current (DC). Edison failed despite his attempts to disparage the AC system by electrocuting unwanted stray cats and dogs, horses and Topsy the circus elephant. In an ultimate attempt, he ordered the design of an electric chair. It was unintentionally the model for the ultimate anti-human machine.

In the second half of the 20th century, personal electronic devices that respond intimately to the movements of body and fingertips are introduced. The solar-powered calculator and

wrist watch demonstrate the advantages of on-site, stand-alone, clean and safe (low-power) DC energy production.

This explosive increase of mobile electronics and other DC devices, the "natural" DC output of renewable energies like solar and wind, as well as new developments in long distance DC transportation amplify the question of whether Edison hasn't won after all: DC/AC. With humankind facing upcoming water wars, the "flagship" of the "DC-movement" will be the solar water pump due to its life-saving and peace-keeping qualities.

Electronic apparatus require seemingly exotic resources to be dug up from the rich, dark earth in the heart of Africa. A region where – after decades of digging – the interaction between men, women and children, gorillas, and the soil's microherds is fundamentally disturbed, with after-effects that echo loud and clear through distant futures.

On a day's walk, westbound, women dig with their hands in the darkest of dark soils. They mix it with water and transform it, with the help of the sun's radiation and a sculptress from the capital, into flower pots, tiles, cutlery. "Vulnerable" they are called. They are symbolically protected by armed men with blue helmets that reside in the adjacent compound. With the help of the rich black soil, well-intentioned foreign powers hope to restore some of the intimacy and reintegrate the women into the family and the local community.

But after dusk the diesel generators malfunction, again. On the wings of the silent darkness the armed men do their thing, again. With their pointy metal objects, they transform radically the topology of the most sensible body parts. To the extent that only one man – due to a lifelong built up unique vertical specialization – might be capable of restoring some fragments.

In the capital K., a man connects an electrical wire to the AC grid, originating from colonial times. It will provide electrical power to some families, until the next downpour floods

the sprawled urban jungle. Then the end section, lying on the ground, will transform the controlled energy in the wire into an extended electrocution field, silently and invisibly awaiting the bare foot pedestrians that are trying to wade back home in the heart of darkness.

Homo homini lupus est (T. Hobbes)

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Bartaku Briefly

Bartaku's works emerge through the interweaving of different media, methods and technologies with a fascination for scientific tropes and "hyper-winded" systems, patterns, structures of man and matter. They echo former praxis as a drummer, academic and aimless wanderer, especially in the Andean Worlds. In 2007 – with the support of interdisciplinary lab FoAM – Bartaku started the research project "PhoEf: The Undisclosed Poésis of the Photovoltaic Effect." At the interstices of arts, science, technology and ecology, it explores the micro and macro realms of photovoltaics: the conversion of light into electrical energy. Since 2008 PhoEf fuses lectures, workshops and micro-interventions.

Bartaku is supported by the Flemish Community Commission (Brussels, BE)
Bartaku is affiliated with interdisciplinary lab FoAM (Brussels, BE; http://fo.am)

Although the "guild for Reality integrators and generators" may have been active for centuries, since November 2006 six cultural organisations have begun to open the doors of the guild. The current gRig members share a mutual purpose; to mix separate realities, as well as bring whole new realities into existence. They are committed to research and create situations in hybrid (or mixed) reality, where digital media and physical materials, objects and spaces are increasingly intertwined. It is on these fuzzy edges that experimental technology and contemporary culture amplify each other's potentials. We have found these edges to be the most fertile ground for innovative social and cultural advances, in which the Guild for Reality Integrators and Generators can be best called into service.
gRig sites 2006-2009

FoAM (Belgium) is a transdisciplinary laboratory committed openness, resilience and a holistic approach to life. FoAM seeks out and connects people in the interstitial spaces between professional and cultural boundaries, encouraging them to mix realities of art and science, digital and physical, nature and technology, adopting the motto - "grow your own worlds". *http://fo.am.be*

nadine (Belgium) is an arts laboratory aimed at developing research focusing on transdisciplinary experiments in the fields of new media and live arts. *nadine* is a flexible and evolving project that doesn't shy away from questioning itself to be able to stay on top of the constantly changing needs of artists. *http://www.nadine.be*

Time's Up (Austria) is a research institute using experimental situations as a means of investigating the behavior of the public individual in everyday and nearly everyday situations. *http://www.timesup.org*

Performing Pictures (Sweden) works in the area of moving images and new technologies for media delivery as part of the Interactive Institute – a Swedish experimental IT-research institute that combines expertise in art, design and information technology. In their artistic practice Performing Pictures explore and develop responsive film art. *http://performingpictures.se*

KIBLA (Slovenia), a multimedia artcentre, is focused on the new (contemporary) educational, cultural and artistic praxis, connecting education and research, culture and technology, arts and sciences, emancipating and demystifying media as a creative tool in education and new forms of art. *http://kibla.si*

InterMedia (Norway) investigates the intersections between design, communication and learning in digital environments. Their approach is multidisciplinary and involves critical research, development and experiments. *http://intermedia.uio.no*

Culture 2000

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