PHOTOVOLTAIC-PANELS ON GREENED ROOFS

Positive Interaction between Two Elements of Sustainable Architecture

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Definitions of Greened roofs:

The long tradition of greened roofs began with the „**HANGING GARDENS**" of Semiramis. Now we differentiate between:

INTENSIVELY GREENED: Roof Gardens such as the examples of *Burle Marx* in Rio de Janeiro (since 1940)

EXTENSIVELY GREENED: like Ufa-Fabrik: a thin layer of soil, low-maintenance, no additional water, plant species adapted to arid areas

Essential Advantages of Greened Roofs:

- Longer DURABILITY of the roof -construction,
- Low maintenance,
- Additional open space for city inhabitants
- New habitats for birds,
- Refuges for rare and specialized plant species.

ROOF-RESEARCH-AREA AT Ufa (BERLIN)

- Measurement of climate parameters, like temperature, air-speed, precipitation, radiation, run-off.
- Long-term-studies of the development of flora and fauna.

Water related aspects of greened roofs:

- 10 cm substrate means: EVAPORATION of 90% of summer precipitation
- 75% of the annual precipitation
- EVAPORATION lowers the surface temperature and improves the microclimate.
- Roof greening decreases the runoff during stormwater periodes.

Motonauta no Rio de Janeiro, 1.12.2000

Aspects of Hydrology and Energy

Actual situation:

- *Sealed surfaces of cities: a quick runoff in case of heavy rainfalls. –*

Proposal:

- *Greened roofs:* Reducing the run-off-quantity, and shifting the time of maximum peak.
- Evaporation of stored water in the *roof substrate* means an additional cooling (about: 250-360 kWh/m² *a in Germany and about 600 kWh/m² * a in Brazil)

Construction of the PV-Panel-system on the greened roof

- November 1998: the panels were installed
- Space between the slightly sloped roof and the PV-Panels:

  0,5 m.

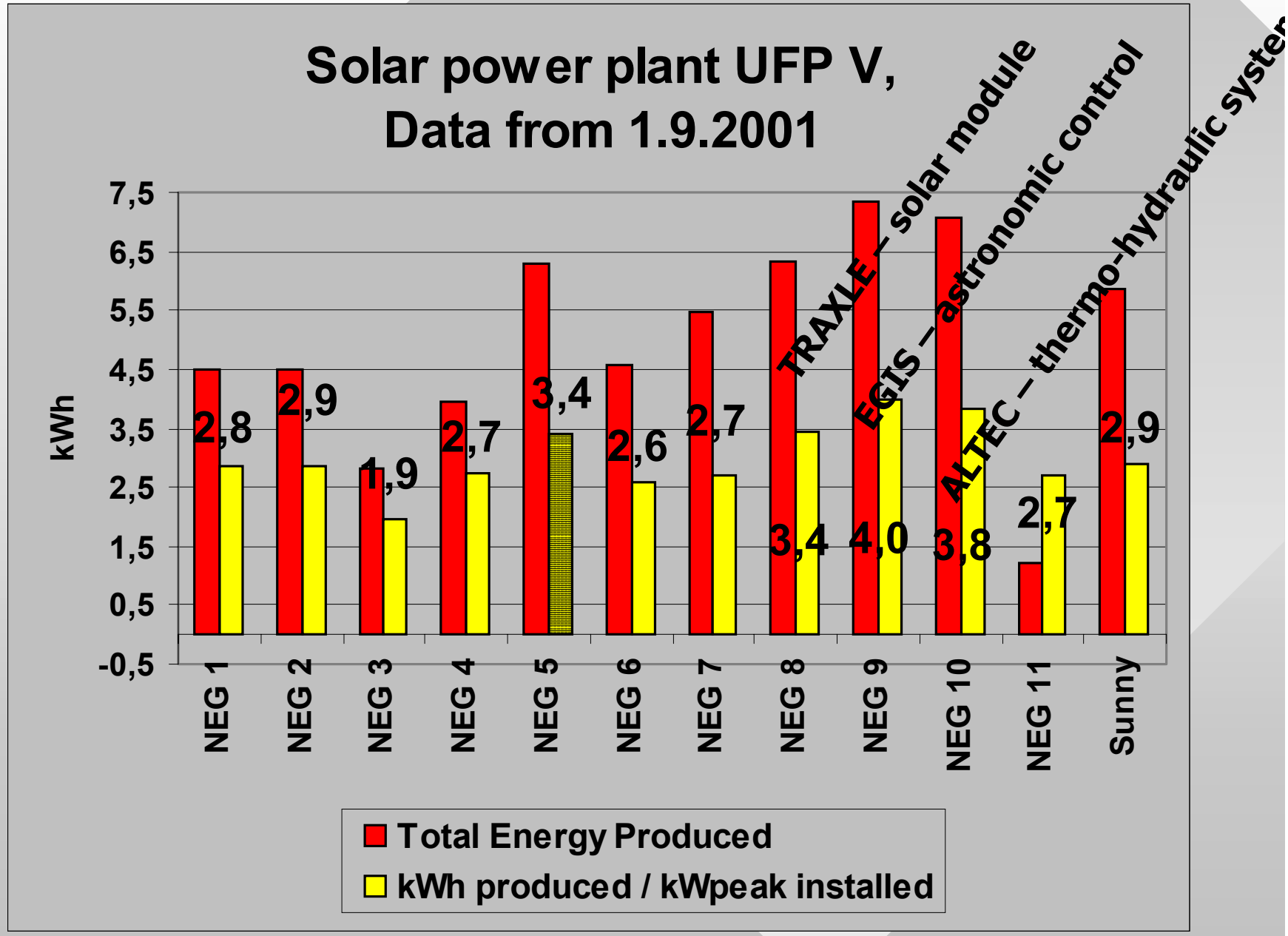
The PV-RESEARCH FIELD:

- Conventional bitumen roof sealing
- Greened roof monitored since 1992
- Different PV-panel-systems

- Detail: PV-Systems shade the roof top vegetation

The shade of the PVs benefits the vegetation: more plant species; higher plants

	Before PV-Installation (1992-1999)	Northern Part without PV (1999-2001)	Southern Part with PV (1999–2001)
Av. number of species	41	41	43
Av. cover in %	89	85	97
Max. plant height /Av. height (cm)	65/22	110/15	118/38
No. of species benefited by shade			7


Solar power plant UFP V,
Data from 1.9.2001
TRAXLE – solar module
EGIS – astronomic control
ALTEC – thermo-hydraulic system
kWh
7,5
6,5
5,5
4,5
3,5
2,5
1,5
0,5
-0,5
2,8
2,9
1,9
2,7
3,4
2,6
2,7
3,4
4,0
3,8
2,7
2,9
NEG 1
NEG 2
NEG 3
NEG 4
NEG 5
NEG 6
NEG 7
NEG 8
NEG 9
NEG 10
NEG 11
Sunny
Total Energy Produced
kWh produced / kWpeak installed

Traxle PV-Power plant

- Self-tracking array is 10% more efficient than fixed units.
- Quantifying the efficiency of PV-on greened-/ non greened roofs is the next step in our work.

Interaction between PV and the Greened Roof

PHOTOVOLTAIC PANELS	GREENED ROOFS
Cooling	Shading
Reduction of IR-emissions from the roof onto the PV-modules	Reducing surface air temperature
Reduction of reflection of solar radiation from roof onto the PV-modules	Protection of roof surface

Outlook

- This example of PV-panels integrated in green roofs points out a possibility of sustainable urban design, combining high-tech elements with natural elements
- Further research will be carried out to obtain specific numbers about the cooling effect on PV-elements by green roofs, for temperate climate as well as for the Tropics