CONSOLFOOD 2020 − International Conference on Advances in Solar Thermal Food Processing
Faro-Portugal, 22-24 January, 2020

SOLABUNDANCE – AN AUTONOMOUS SMALL SOLAR POWER STATION FOR AROUND-THE-CLOCK COOKING, COOLING, HEATING, AND ELECTRICITY

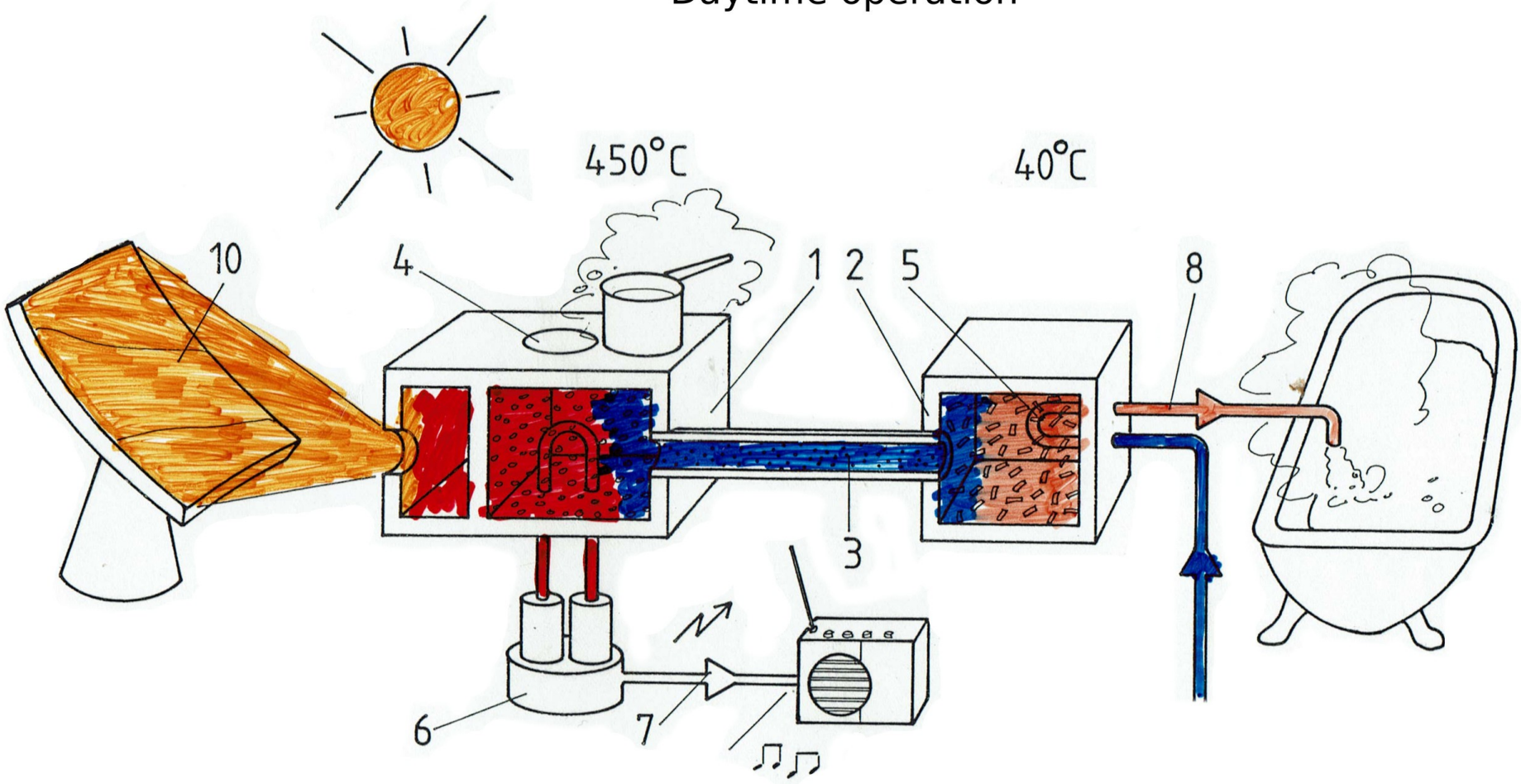
Jürgen Kleinwächter, Olivier Paccoud

SunOrbit (Germany), Luftstrom (USA) and Tamera Testfield, Portugal

Abstract: SOLABUNDANCE is a small, autonomous solar power station capable of providing power, heating and cooling (Illustration 1 – next page). During daytime it uses the stationary Focus (FIX Focus) of a membrane Fix Focus mirror (Concentron), to transport highly concentrated photonic energy into a combination of high and low temperature metal hydrides. The two hydrides are contained within two closed steel reactors and connected by a pipe allowing the hydrogen, which is discontinuously desorbed from the high temperature reactor (using the concentrated solar energy), and the low temperature reactor (extracting ambient heat), during night time or bad weather periods (Illustration 2 next pages). Solabundance works as a thermochemical heat pump. The process can be described as a sort of “ping pong game” pushing hydrogen between the hot and cold sources of concentrated sun and the ambient air, forwards and backwards. It needs no external controls, as the hydrogen pressure 'senses' in which direction the gas should flow. During the 'round trip' of the system the overall energy produced (process heat, domestic heat, and cooling) exceeds the photonic energy brought in by the Concentron, because the heat pump process extracts extra energy from the environment. Very compact reactors are possible. The system is scalable from the kW range to MW Range. It is however predestined for small to medium sizes, as the SOLABUNDANCE system presented here, which would be useful for restaurants, canteens etc. The system described has already been developed, late last century, with all its components as a fully functioning prototype. The present partners are now dynamically developing SOLABUNDANCE technology to provide economic, serial production. The target? Proving that the most promising aspect of solar energy technology can be reached: local autonomy.

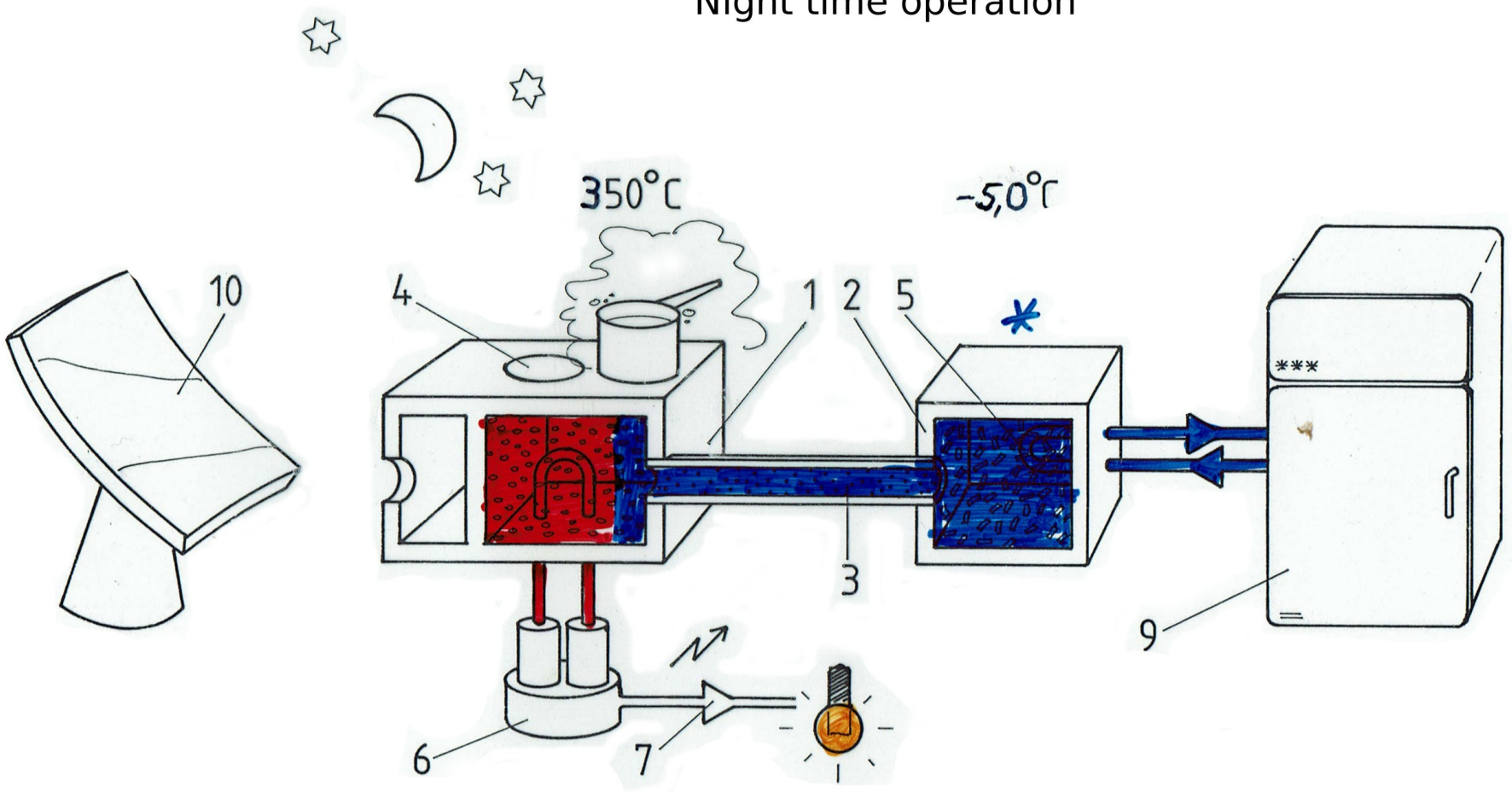
Keywords: Membrane Fix Focus Concentrator, Metal Hydrides, Reversible thermochemical reactions, Chemical Heat Pump, Seebeck Elements, Sunpulse Stirling.

Daytime operation



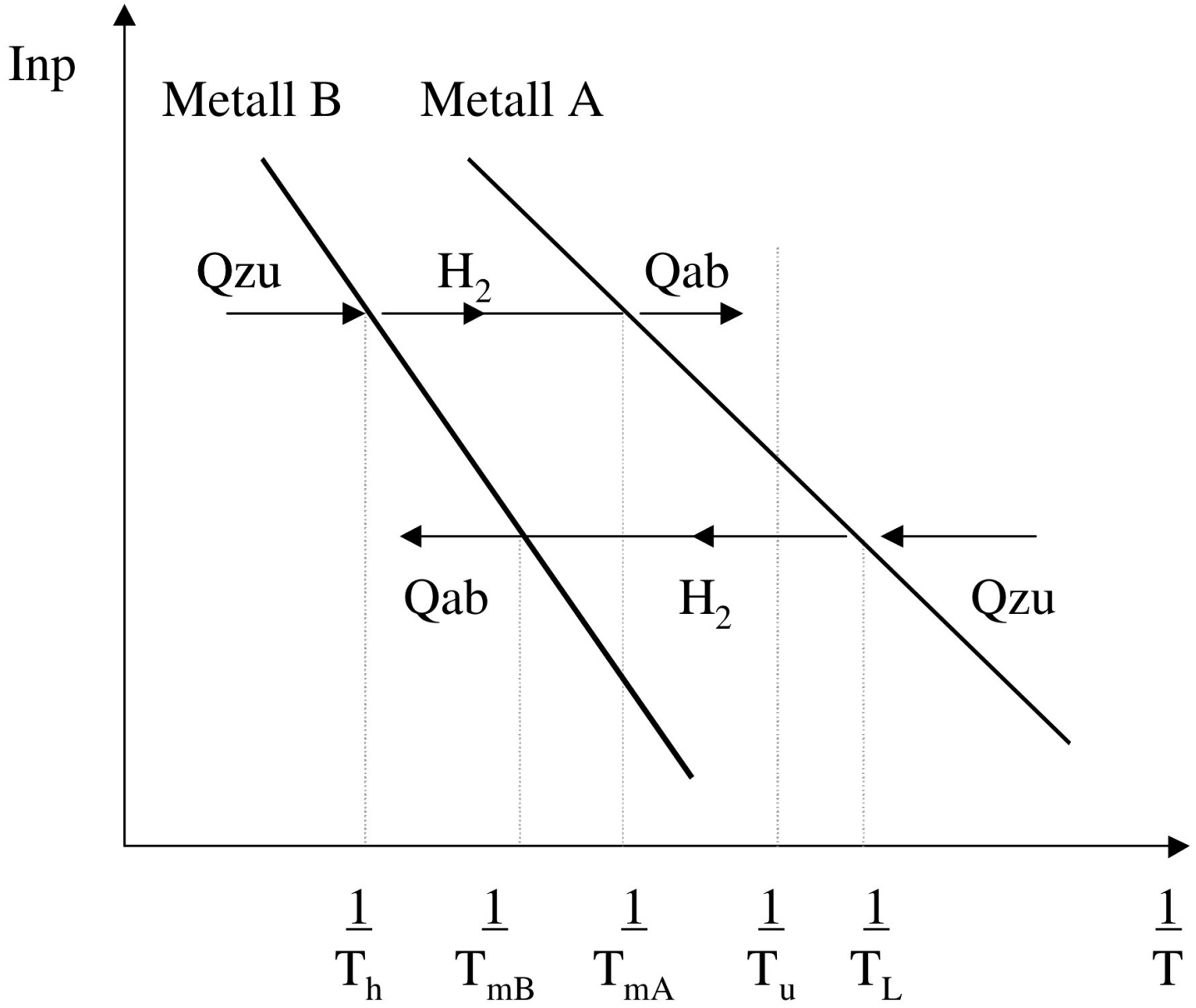
$MgH_2 + heat \Rightarrow Mg + H_2$

Night time operation

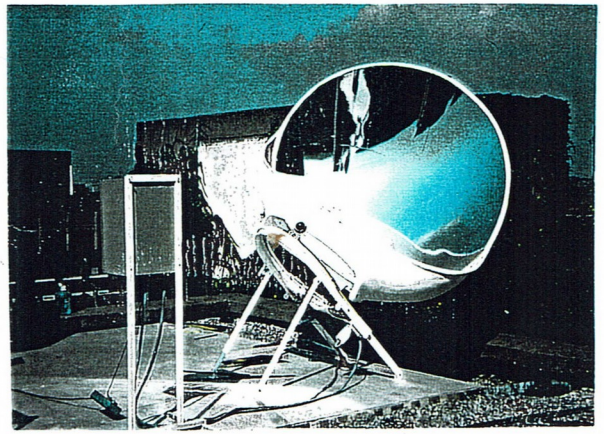


Mg + H2 => MgH2 + heat

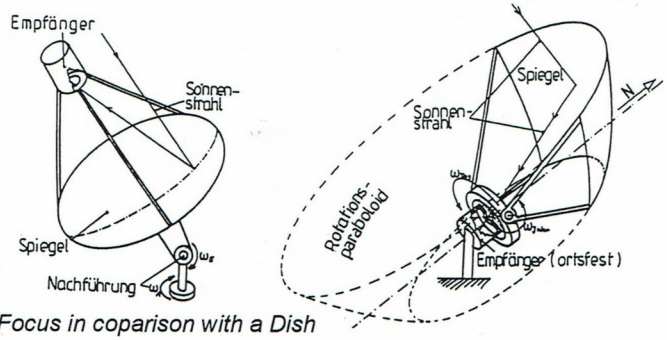
Thermochemical heat pump



FixFocus Concentrator



The **FixFocus concentrator** is a special designed **off-axis paraboilc** concentrator which generates a fixed, ground based focal spot.
The FixFocus concentrator is **polar tracked**. The reflecting shell follows the sun by revolving round an axis through the focal point which is parallel to the earth´s polar axis. The tracking of the declination is managed by tilting the shell round an axis perpendicular to the polar axis through the focal point.
The aperture level of a FixFocus receiver is placed always vertically to the polar axis.



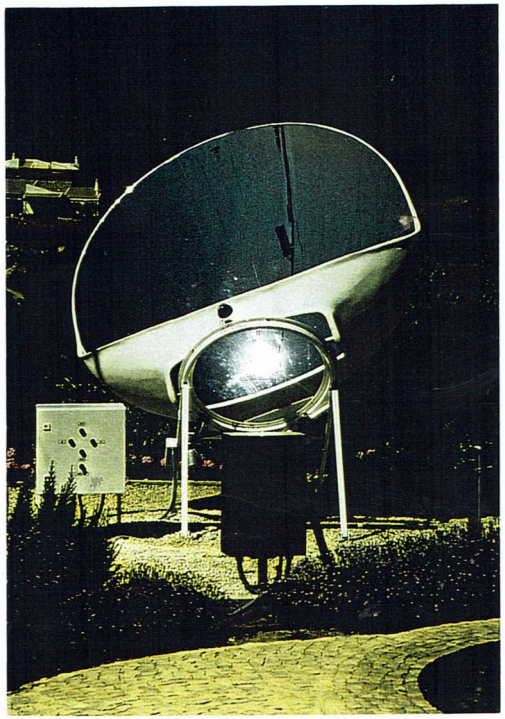
FixFocus in coparison with a Dish

The FixFocus concentrator enables the use of heavy and location sensitive receiver systems which are placed **stationary** on the ground, e.g.:

- chemical reactors with open cavity
- thermal storage systems, e.g.: MgH_2-storage systems
- fluidized bed receiver
- location sensitive, heavy machinery

The flux density in the focal plane varies by the declination. This saisonal variation in the peak flux does not harm the mean concentration of a FixFocus concentrator. The **mean concentration** is for an interception of 0.92 about **2000 suns** by definite receiver diameter all over the year.

FixFocus FF 3.5

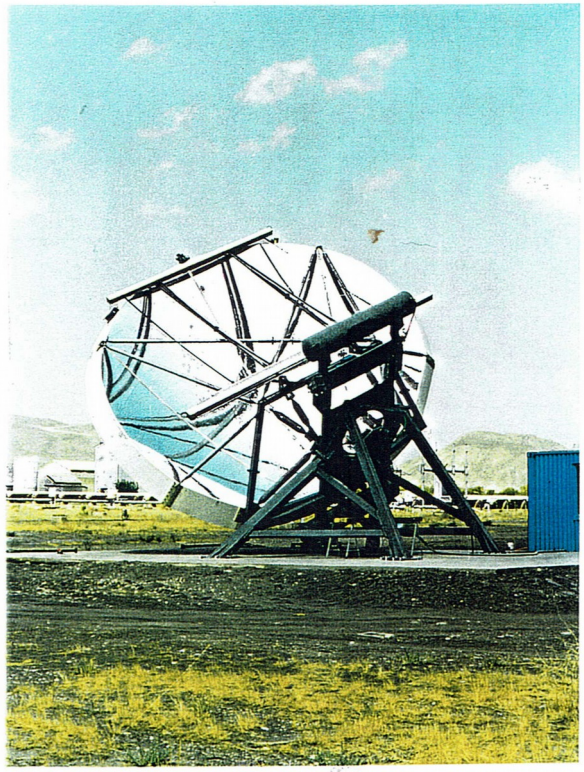


FF 3.5 at the Villa Solaris, Portugal

Technical Specification

	FF 3.5 m²
Focal Length	0.65 m
Total Reflective Area	3.68 m²
Aperture Area = Useable Reflector Area	2.66 m²
Rim Angel	between 19.5° and 79.6° (sagittal) max. 60.35° (tangential)
The reflector-shell is made of a monocoque construction, constituted by two layers of glass fibre laminat and distance laminat between these two layers.	
Nominal Slope Error (σ_{shape})	3 mrad
Reflective Film (silvered)	3M ECP305+
Reflectivity (initial)	94 %
also possible (depending on order)	
Reflective Film (aluminised)	3M SA85P
Reflectivity (initial)	85 %
Performance	
Peak Concentration	7,000 suns
Flux Distribution	see plot next page
Design	HTC Schwerte GmbH, Germany

FixFocus FF 50



FF 50 at the PSA, Spain

Technical Specification

	FF 50 m²
Focal Length	2.4 m
Total Reflective Area	53 m²
Aperture Area	36 m²
Useable Reflector Area	31.5 m²
Rim Angel	between 19.5° and 79.6° (sagittal) max. 60.35° (tangential)

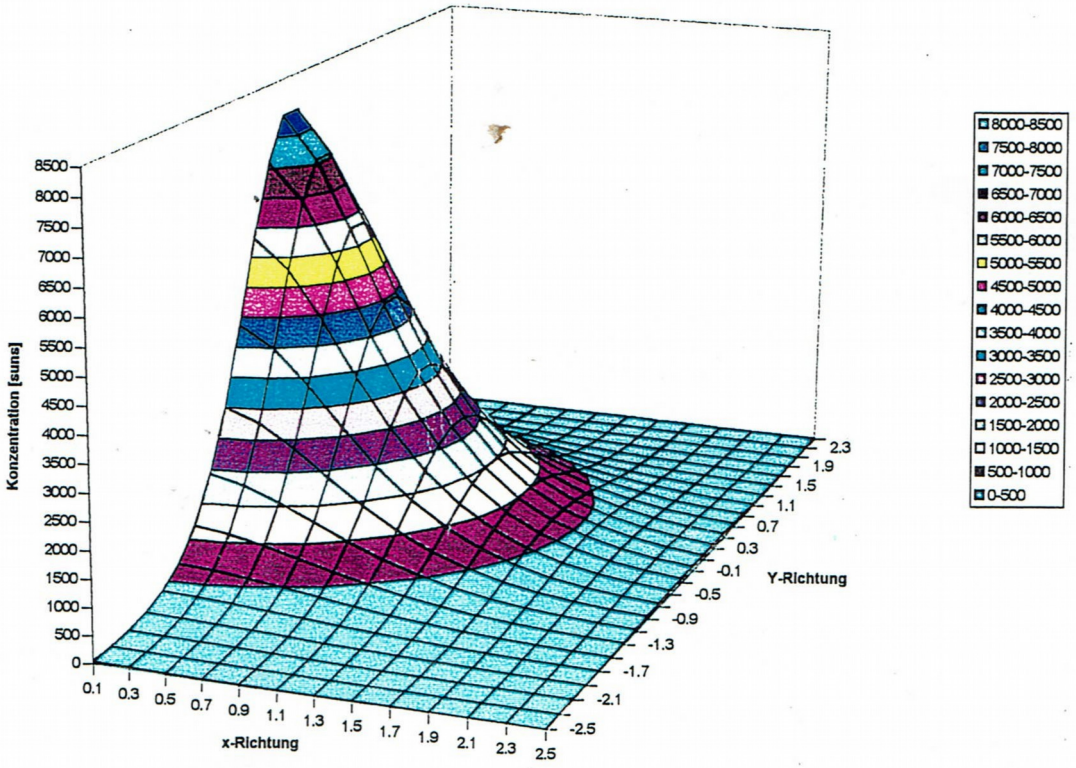
The reflector-shell is made of a monocoque sandwich construction, constituted by two layers of carbon fibre laminat and PU-foam between these two layers. The shell is stiffended by 600 mm high ribs on the rear side of the shell.

Nominal Slope Error (σ_{shape})	3 mrad
Reflective Film	3M ECP305+
Reflectivity (initial)	94 %

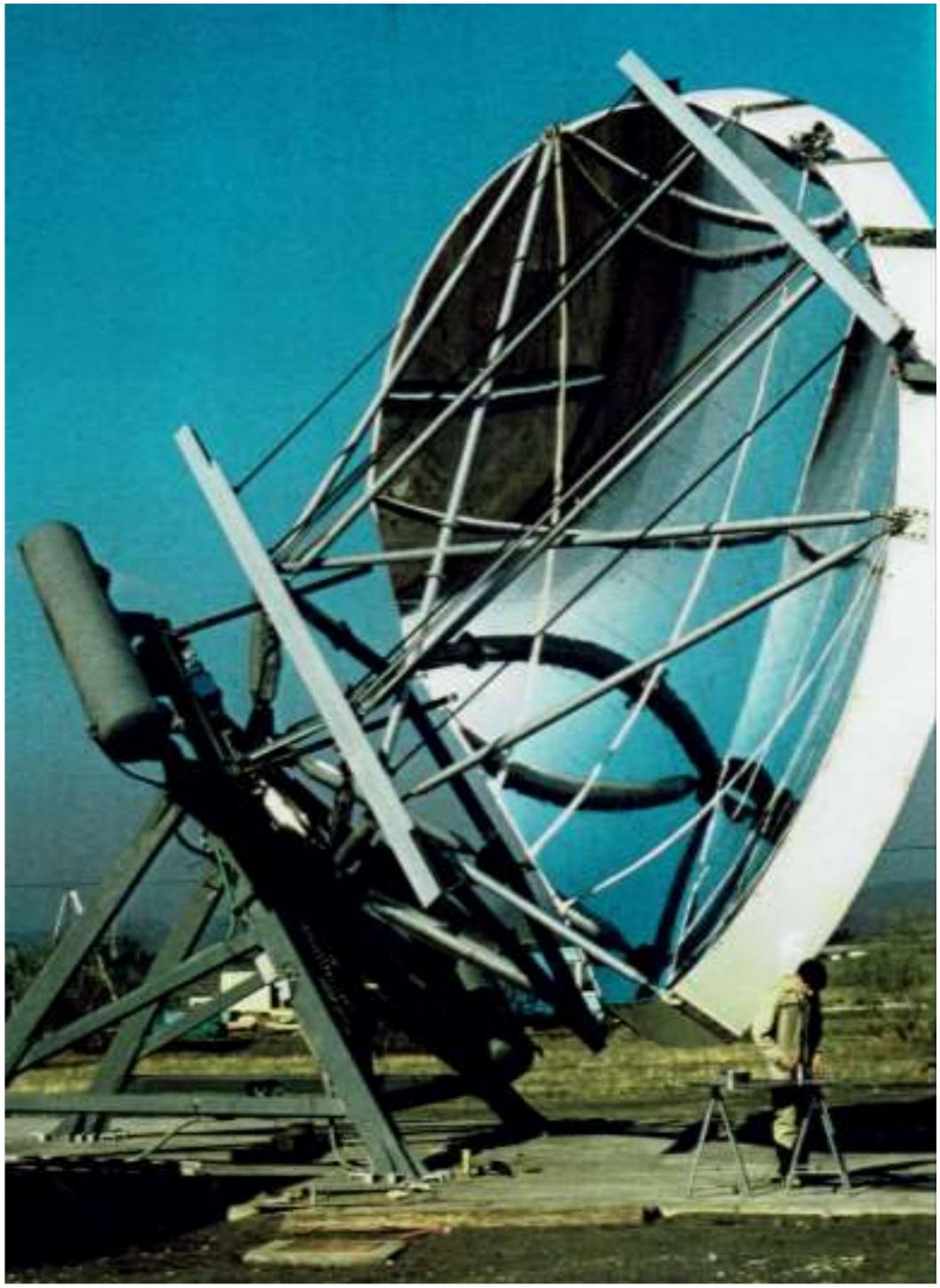
Performance

Output (thermal)	29 kW at 1000 W/m²
Optical efficiency (overall)	77 %
Peak Concentration	7,000 suns

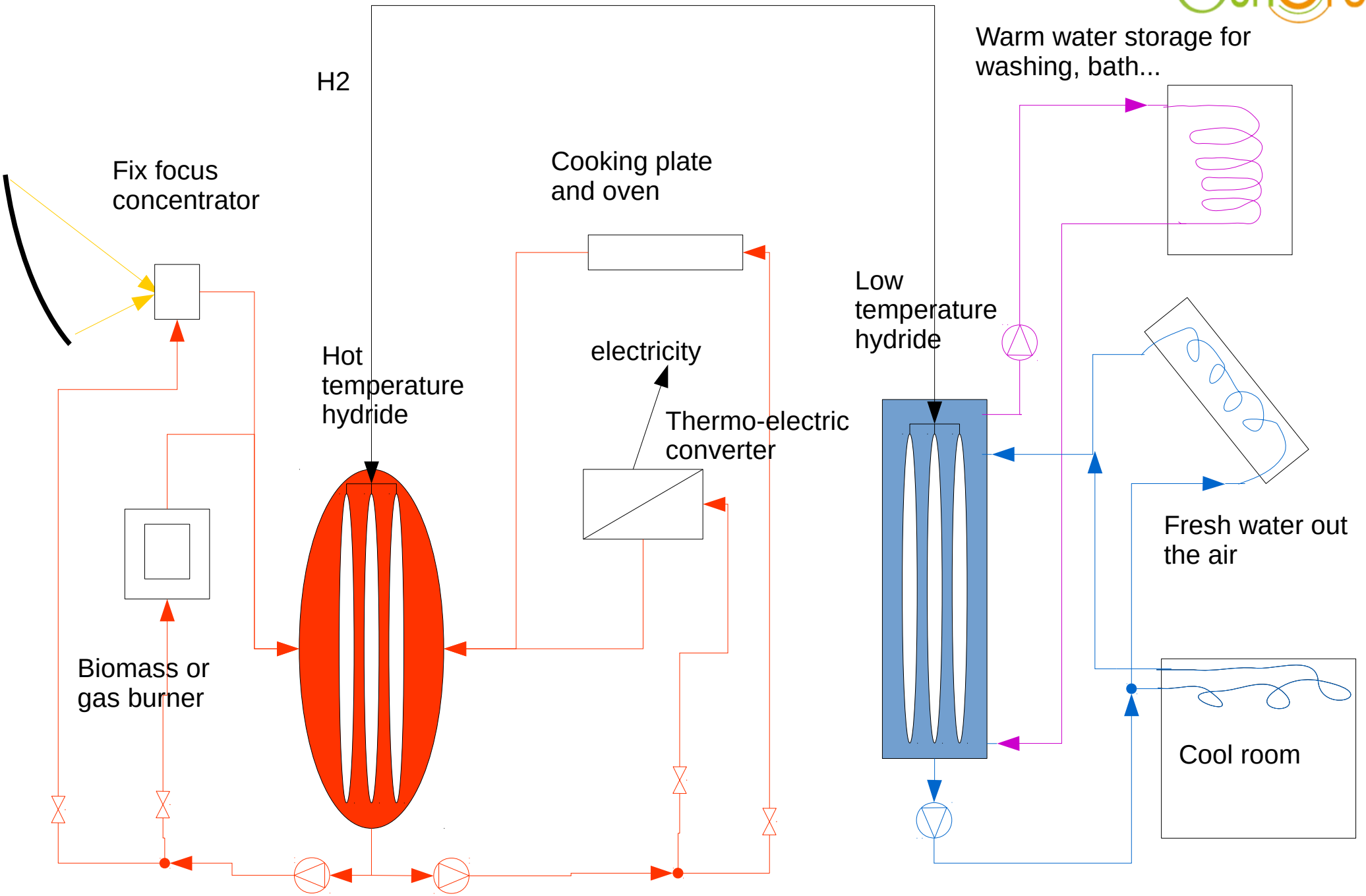
Design	HTC Schwerte GmbH, Germany
Manufacture	Speedwave, Jettingen, Germany



Flux distribution of a FF 3.5 m² with SA85P
Äquinox (Dec = 0°) 5mrad



Schematic diagram of the solabundance system



Data for of the System with Fix Focus 3,5		
Description	Value	Unit
Aperture area of the mirror	2,4	m^2
Mass of magnesium	21	kg
Mass of low temperature hydride material	105	kg
Incoming daily energy at 400°C (fix focus or burner)	12,1	kWh
Thermal energy in storage	10,4	kWh
Energy for cooking	6	kWh
Energy for thermo electric generator	4,4	kWh
Electricity	0,44	kWh
Energy for hot water at 60°C	7,28	kWh
Cooling energy near 0°C	3,84	kWh
Total effective energies	17,56	kWh
efficiency of the system (effective energies / incoming energy)	145,1	%

Light and matter, origins of life

Thank you for your attention