# The SIELWAH Project

(**si**licon, **el**ectricity, **wa**ter, **h**ydrogen)

or

## From Sand and Sun to Electricity and Hydrogen

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The declining availability of fossil energy and the simultaneous need to sustainably reduce global warming by controlling and reducing $CO_2$ emissions have resulted in extensive search for alternative energy sources. Regenerative and inexhaustible sources of energy include solar, wind and waterpower, as well as biomass as energy suppliers, that are globally available. But these renewables are only accessible on a sufficient large scale in regions with poor infrastructure. Therefore, safe energy production, transport and efficient storage are particularly attractive, in addition to also providing local regional energy needs.
To solve the problem of the finiteness of fossil fuels, an infinitely available energy carrier has to be identified: Silicon (26.3%) is after oxygen the second most abundant element in the earth's crust (56.4% $SiO_2$), and as an energy carrier, solves the problem of limited resources. Whereas carbon-based energy processes always result in $CO_2$ emission, silicon-based electricity production by photovoltaic modules is $CO_2$-free, permanently delivering electric power by using only sunlight as an unlimited energy source!

The product line of the SIELWAH-Project consists of the following key steps:

- $CO_2$-neutral microwave assisted production of tetrachlorosilane ($SiCl_4$, STC) from sand and "bio-carbon" as reducing agent (carbohydrochlorination) or, alternatively, using STC, generated in multi-ton excess as cheap side product of the "Siemens Process", for the plasma assisted production of perchlorinated polysilanes, $Cl_3Si\text{-}(SiCl_2)_n\text{-}SiCl_3$ (PCS, n ~ 15). Hydrogenation of PCS results in the formation of an efficient hydrogen carrier, the hydridopolysilane, HPS, giving 20.3 wt% $H_2$ gas and "sand" upon hydrolysis. The "sand" formed is recycled back to STC by carbohydrochlorination.
- Thermolysis of this unique polymer (PCS) gives liquid oligosilanes $Si_nCl_{2n+2}$ (n=2–6) as starting materials for thin-film photovoltaics and coatings for e.g. semiconductor devices besides silicon subchlorides and amorphous and/or crystalline silicon. Reaction of the polymer with ether/HCl solutions yields trichlorosilane ($HSiCl_3$,TCS) and thus resembles a low energy STC/TCS conversion.
- Usage of the silicon subchlorides for blending processes with inexpensive technical grade silicon and its purification into solar grade quality.
- Amorphous, mono- and polycrystalline silicon are used as conventional materials for photovoltaic applications.

Moreover, in the near future perchlorinated polysilanes may serve as the link between solar energy and decentralized hydrogen generation: Silicon and hydrogenated oligosilanes $Si_nH_{2n+2}$ can be processed to wafers and modules for photovoltaics that will provide on-site electric energy, which is supplied to power grids and to solid and liquid materials, including PCS, that can be applied as permanent hydrogen storage media. Furthermore, the photovoltaically produced electric power may be used for water electrolysis to produce hydrogen which can be stored to provide a 24-hour energy supply. The additional hydrogenation of the polysilanes (PCS) leads to (solid) H-substituted permanent hydrogen carriers (HPS) that can safely be transported and stored. Base-induced hydrogen release can be used to produce electricity by either conventional combustion or by fuel cell technology, simultaneously delivering clean water as "byproduct".

**Summarizing, the SIELWAH-Project converts sand into electricity to secure energy supply, water electrolysis, and hydrogen technology**. Apart from that, it provides access to a variety of silicon based high-tech materials to create and secure high level living standards on a broad basis.