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The sand option: energy from silicon

Silicon and carbon have almost identical energy densities so that, for fuel purposes, a lump of silicon can be thought of as an emission-free lump of coal. From this follows the tantalising prospect of silicon serving as a coal substitute which could allow renewable energy to become a globalised commodity for base load power generation. Yet few will think of this potential when silicon is mentioned, as most associate it with highly refined materials for applications like computer chips and solar cells.

Very much like hydrogen, often thought of as the ideal alternative energy carrier, silicon is abundant in nature in its oxidized form, the silica that makes up the sand of beaches and desert dunes. And like hydrogen, silicon requires a primary energy source, ideally a renewable energy source, for its production but shows then compared to hydrogen superior properties as an energy vector for transporting renewable energy around the world.

Indeed, a global silicon energy economy can be envisaged as a very promising equivalent to a high-tech and complex hydrogen economy.It is particularly in the transportation and storage of energy where the hydrogen economy falters because expensive pressurised containers are required for the task. In addition, an intricate delivery infrastructure is needed to get the hydrogen to filling stations and hydrogen vehicles require on-board storage and robust fuel cells for conversion back to electricity.

By contrast, the much simpler silicon energy economy would be similar to exporting coal for power generation. The bulk silicon would be shipped in ocean freighters and then transported by rail to silicon-fired base load thermal power stations, avoiding long transmission lines. Because silicon fuel would be consumed as a fine powder, similar to coal, it should not be too difficult to retrofit coal power stations. A requirement here is that the silicon particles be small enough for complete oxidation at temperatures that are not so high that expensive special materials are required. There would also need to be efficient extraction of the copious volumes of fine silica fly ash. This could be either shipped back to source to complete the cycle or used locally for glass production or land fill.

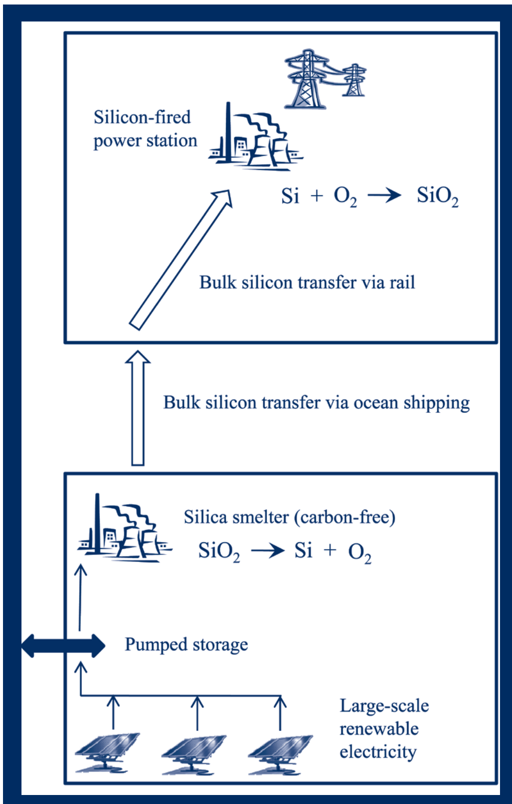
The final stage is supplying the silicon-derived electricity increment via existing national grids for uses such as electric cars and home heating.

It might be argued that shipping of silicon would itself add to carbon emissions. However, silicon is also an ideal fuel for a new era of steam-powered global shipping as oil diminishes. We have been here before with the coal steamers of old and silicon bunkering facilities would appear in optimal locations like Suez and Singapore.

Any energy vector system is inevitably inefficient and costly, and significant silicon production will have a high capital cost. However, zero-emissions aside, silicon has special strategic appeal in that it can be permanently stockpiled outdoors with no loss of fuel value. The recent gas supply disruption in Europe showed that multi-nation energy transmission is no substitute for maintaining security of supply from within one's own national borders.

This leaves, however, the sticking point, how can it be produced using renewable energy sources?

Indeed, the one significant technological breakthrough required is development of an efficient carbon-free process for industrial production of low-grade silicon. The current absence of such a process is not necessarily a reflection of inherent difficulty. Rather, there hasn't been any necessity because the small volumes of silicon needed for high-tech applications can be easily produced by the traditional dirty method using carbon. Consequently, there is a lack of electrolytic silicon research reflected by an important 1988 review paper having been cited just three times to date.*



Envisaged supply path for the supply of emission-free silicon fuel for power generation

One industrial-scale alternative might be electrolytic production of silicon along the lines of aluminium smelting, but avoiding carbon emission. It might seem unrealistic to expect that silicon production from something akin to a large aluminium smelter could be maintained by power from intermittent wind or solar sources. However, the necessary large energy storage buffers could be achieved using pumped storage schemes. Where major desert solar power systems are involved there will be little available fresh water and pumped storage might better utilize ocean water – already verified by a trial scheme on the Japanese island of Hokkaido.

In 2006, Auner and Holl** were the first to suggest silicon as a coal substitute and my own contribution was a 2008 paper expanding the idea into a global energy economy. Why hasn't this option been noticed before? The answer to this may lie in the particular attention hydrogen has received as an alternative energy carrier, dating more than hundred years back.

So is it possible that silicon could suddenly appear from left field as a world-saver? It is still early days for silicon and it would be desirable to establish a working group to quickly review the practicalities of all facets of silicon as a green solid fuel. The obvious beneficiaries of a global silicon trade would be Australia and the nations of the Middle East and North Africa with their large renewable energy resources. If the potential of silicon is confirmed then perhaps this grouping could set up a silicon energy association to fund the required technological developments so we can finally start using less coal.

**Elwell, D., Rao, G.M., 1988. Electrolytic production of silicon. Reviews of Applied Electrochemistry, v.18, p.15-22.*
***Auner, N., Holl, S., 2006. Silicon as energy carrier – facts and perspectives. Energy, v.31, p.1395-1402.*