Hydrogen Sulphide Power Plant by Sulfide-Driven Fuel Cell

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Problem: Greenhouse gas reduction?

Carbon-free energy/Renewable energy sources:

- **Wind energy**
- **Solar energy**
- **Hydrogen**
- **Biomass...**
- **What else?**

Opportunity: the enormous amount of hydrogen sulfide in the Black Sea waters

Hydrogen sulfide	Tonnes of oil equivalent (toe)	Electricity energy
4.587 Gt	2600 Mtoe (~2 x EU total annual energy consumption)	31500 TWh (10 x EU annual production)

Each year at least new 4.5 mlns tons hydrogen sulfide are formed (equivalent to 2.4% of the final total annual consumption in EU or to the whole gas import for Bulgaria)

Feasibility

Pros	Cons
Enormous renewable resource	Very dispersed, low concentrations, very large flow rates demanded
Environmental importance	Threat of disbalance
	Very big depths, large energy demands for pumping, off-shore processing

Traditional chemical technologies are helpless.
The only way is to apply electrochemistry.

We propose:

Direct energy production from hydrogen sulfide by sulfide-driven fuel cell (SDFC)

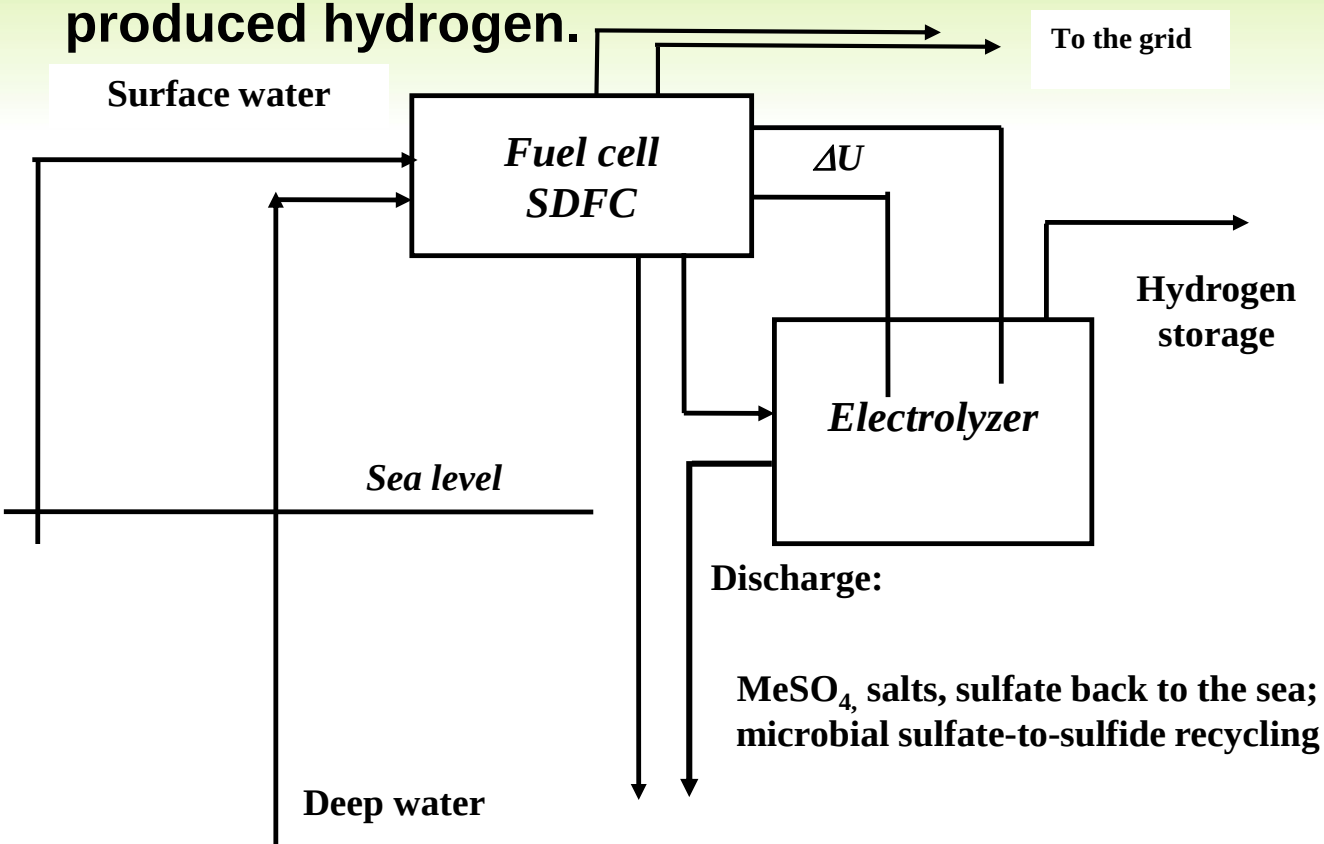
1 m^3 water/sec with 20 g/m^3 sulfide yields 300 kWh energy total (60% efficiency). The power consumption for pumping and operation is about 1% of the yield from SDFC.

Environmental impact:

The fuel cell product is sulfate, used by the deep water thiobacteria as electron acceptor instead of oxygen. The reduced sulfate yields sulfide, pumped as a fuel for the fuel cell, over and over.

Production steps

- Pumping from big depths (energy consumption);
- Energy production in SDFC (sulfide driven fuel cell);
- DC/AC transformation and supply to the grid, and/or
- Splitting water by electrolysis and storage of the produced hydrogen.



Customers/Market:

- Governments of the coastal countries;
- Big companies with interests in energy production and distribution wherever this resource is available (Black Sea; Caspian Sea; Baltic Sea, mineral water springs,etc.)

Competitors

- Oil, gas and coal production and distribution companies;
- Power stations based on fossil fuels;
- Producers of energy based on solar and wind resources;
- Nuclear power stations.

SDFC and other fuels – investments costs

Indicator/ Fuel	Gas turbines	Coal	Wind	Nuclear	Solar	Hydrogen sulfide/ electricity (60% efficiency)
Price, US $/kW	680-1350	500-5000	1880	5950	2600	500

SDFC and other fuels – comparison of power production costs; with emission trading in green,23Eur/t CO2

Indicator/ Fuel	Gas turbines	Coal	Wind	Nuclear	Solar	Hydrogen sulfide/ electricity (60% efficiency)
Price, Eur/ MWh	16,2/59,2	45,7/64,4	52,9/52,9	35/35	~45/45	<10
Carbon free	No	No	Yes	Yes?No!	Yes	Yes
Env. friendly	No	No	No!	No!	No!	Yes
Waste	No	Yes	No	Yes	No	No

SDFC and other fuels - comparison

Energy source	Features
Fossil fuels (thermal power stations) (oil, gas, coal)	Carbon emissions; expensive production; heavy operation; long switch on/off process; waste handling.
SDFC	**Carbon free; less operational costs; easy switch-on/off; no waste.**
Nuclear fuel	Expensive fuel production; heavy operation; long switch on/off process; hazardous operation and waste storage.
SDFC	**Less operational costs; easy switch-on/off; no hazards, no waste.**
Wind	Weather and season dependent; impact on environment (bird migration).
SDFC	**Independent**
Solar	Weather and season dependent; impact on soil and biodiversity
SDFC	**Independent, environmental benefits**

Fuel cell prototype- tested *in situ* on a ship in the Black Sea

Implementation steps

- **Built pilot-scale prototype of 30 kW: ~$16000 (12 months duration)**
- **In situ experiments on a boat or rig: ~$10000**
- **(1 month duration)**
- **Full-size equipment of 20 MW on a rig/ship: $10 mln**

THANK YOU FOR YOUR ATTENTION!