

The Hydrogen Defense against Climate Catastrophe

David Sanborn Scott's work interpreted and presented by Neil Alexander, Principal of Bucephalus Consulting and President of the Organization of CANDU Industries

David Sanborn Scott



Three decades of experience in energy system analysis

Chair of Mechanical Engineering at the University of Toronto

Founder of the University of Toronto's Advisory Group on Hydrogen Opportunities.

Jules Vernes Award for Outstanding contributions to Hydrogen Physics

Author of "Smelling Land"



The Hydrogen Defense Against Climate Catastrophe



Conservation, Confusion and Language



- Understand the problem
- Use language that drives
 the right behaviours

The first step to wisdom is getting things by their right names Chinese Proverb



- 1. CO₂ from fossil fuels <u>is</u> forcing climate destabilization which, if unabated, will become catastrophic.
- 2. To eliminate CO₂ emissions requires: <u>BOTH</u> non-C sources & non-C currencies.
- 3. Many Non-C *sources* available—or developable. (hydraulic, nuclear fission/fusion?, sunlight, wind...)





Not an energy source

No single currency for all services/transactions



Usually more difficult in one direction than the other

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Communication



Currency Evolution





Hydrogen-Carbon Ratios

Typical hydrogen/carbon ratios

- Most liquid fuels: H/C = 2.1/1 ~ 2.3/1
- Most conventional crudes:
- Athabasca (& Orinoco, Olenek):
- Most coals:

- **H/C** = 1.8/1 ~ 1.9/1
- H/C = 1.4/1 ~ 1.6/1
- **H/C** = 0.7/1 ~ 0.9/1





Time



$2H_2 + O_2 \rightarrow 2H_2O + Energy$ $2H_2O + Energy \rightarrow 2H_2 + O_2$



- H₂ and electricity can be manufactured from any source
- H₂ and electricity can be interchangeably converted
- H₂ and electricity are renewable

e⁻ H₂ Synergies

- H₂ can be stored in enormous quantities, electricity cannot.
- Electricity moves energy without material, H₂ cannot.
- Electricity can process & store information, H₂ cannot.
- H₂ wins for long-distance transport (on Earth)

Hydrogen's Two Pathways

Neat hydrogen (feeds service technologies)

- LH₂ aircraft.
- LH₂ automobiles, ships, locomotives.
- H₂ mobile phones, laptops.

Tether hydrogen (in harvesting technologies)

• Linking fossil/non-fossil sources.



Harvesting Technologies

WHIMSICALS: ~> "renewable" wind, sun, tidal . . .

- Harvesting rate must be less than replenishing rate
- Capped by large land area requirements
- Capped by intrusion on other renewables (forests, fish, water, wildlife)
- Requires storage or spinning reserves

Power in Sweden

Tue 10 Feb 200

The StarPhoenix (Saskatoon)

Nuclear energy vital to lessening carbon's impact

Streden has been the poster child of the anti-make

A Dorthern country with a social conscience, Sweden orusent county with a social considence, system [A80 decided to eschew inclust power and himtong ago decuted to eschew interest power and run. In efforts to renewable sources of energy. Thus it has bed the world in renewable nearer technology. It has its efforts to renewable sources of energy 1100 it has led the world in renewable power technology. It has commond the world turned the inverse and the cess. ted the world in renewative power recomplicity. It is a set of the captured the Wild, famed the rivers and the seas, increased insulation, stolen energy from the sin and aroun record the Forth for its thermal concer uncreased answardon, storen energy from the even tapped the Earth for its thermal power. But last week, the Swedish government conceded the formation on a drawn ion has week, the Sweensh government conceeed in fulfility of trying to run a modern nation on a dream it turned book a codicer cat out in 1000 to numy of trying to run a modern nation on a di If turned back a policy set out in 1980 to decommission all its nuclear power plants, and enhanked on a new are of the atom

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Captured the Wind

Tamed the Rivers and Seas

Daily Telegraph

FOUR leading environmentalists have abded FULCE leading on incomentalists barre abaudoned their opposition to success power and said Britain suss build more reactors to suce its climate chang arrent

Green campaigners back nuclear power

- Stolen Energy from the Sun
- Tapped the Earth for Thermal Power

"Conceded the futility of trying to run a modern nation on a dream"

At last the oil sands!



- Sasoline is a great way to tether Hydrogen and deliver it through an existing infrastructure to use for land transportation
- Oil sands oil could continue the trend to hydrogen if we upgrade the oil by adding Hydrogen rather than removing carbon and reduce carbon consumption during its production
- Better to change the process than to add clean up equipment to the wrong process

Clean(ish) Oil Sands Oil



