SMELLING LAND

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”
SMELLING LAND

The Hydrogen Defense
Against Climate Catastrophe

David Sanborn Scott
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
The Issue

1. CO$_2$ from fossil fuels is forcing climate destabilization which, if unabated, will become catastrophic.

2. To eliminate CO$_2$ emissions requires: \textit{BOTH} non-C \textit{sources} \& non-C \textit{currencies}.

3. Many Non-C \textit{sources} available—or developable. (hydraulic, nuclear fission/fusion?, sunlight, wind... )
The Energy System
Currency?

Not an energy source

No single currency for all services/transactions

Inter-currency conversion always < 100%

Usually more difficult in one direction than the other
Examples

Services
- keeping warm/cool
- communication
- transportation
- facilitating trade/commerce
- food preparation
- illumination
- health care

Service Technologies
- telephones
- automobiles
- aircraft & airports
- lightbulbs
- heat pumps & refrigerators
- microwave ovens
- CAT-scans & X-rays
- computers & television sets

Currencies
- Jet A
- gasoline
- methanol
- electricity
- hydrogen
- diesel

Harvesting Technologies
- drilling rigs & oil refineries
- dams & hydraulic generators
- uranium mines & nuclear generating stations
- photovoltaic arrays
- wind turbines

Sources
- coal
- sunlight
- crude oil
- geothermal
- waterpower
- natural gas
- uranium
- wind
- tides

©David Sanborn Scott
Currency Evolution

~1770
- Horse
- Hay
- Agriculture
- Sunlight

~1840
- Land Transportation
- Steam Locomotive
- Wood
- Forestry
- Sunlight

~1910
- Land Transportation
- Steam Locomotive
- Coal
- Coal mine
- Coal fields

~1980
- Land Transportation
- Internal Combustion Automobile
- Gasoline
- Oil refinery

~2050
- Fuel Cell Vehicles
- Hydrogen
- Steam methane reforming
- Electrolysis
- Natural gas
- Sunlight
- Wind
- Uranium
Hydrogen-Carbon Ratios

Typical hydrogen/carbon ratios

Most liquid fuels: \( H/C = 2.1/1 \sim 2.3/1 \)

Most conventional crudes: \( H/C = 1.8/1 \sim 1.9/1 \)

Athabasca (& Orinoco, Olenek): \( H/C = 1.4/1 \sim 1.6/1 \)

Most coals: \( H/C = 0.7/1 \sim 0.9/1 \)
The Trend

The proportion of energy from various sources over time. The trend shows an increasing proportion of energy from hydrogen ($H_2$) compared to other fossil fuels such as coal, oil, and natural gas.
2H₂ + O₂ → 2H₂O + Energy

2H₂O + Energy → 2H₂ + O₂
H₂ and electricity can be manufactured from any source

H₂ and electricity can be interchangeably converted

H₂ and electricity are renewable
• \( \text{H}_2 \) can be stored in enormous quantities, electricity cannot.

• \textbf{Electricity moves energy without material, H}_2 \textbf{ cannot.}

• \textbf{Electricity can process & store information, H}_2 \textbf{ cannot.}

• \( \text{H}_2 \) \textbf{ wins for long-distance transport (on Earth)}
Hydrogen’s Two Pathways

**Neat hydrogen** *(feeds service technologies)*
- $\text{LH}_2$ aircraft.
- $\text{LH}_2$ automobiles, ships, locomotives.
- $\text{H}_2$ mobile phones, laptops.

**Tether hydrogen** *(in harvesting technologies)*
- Linking fossil/non-fossil sources.
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

The StarPhoenix (Saskatoon)
Nuclear energy vital to lessening carbon's impact

A northern country with a social conscience, Sweden has been the power child of the anti-nuke faction for more than two decades. Sweden has been the power child of the anti-nuke faction for more than two decades.

A northern country with a social conscience, Sweden has over the past two decades made nuclear power and renewables its prime sources of energy. It has led the world in renewable energy technology. It has captured the wind, tamed the rivers, and the sun, and it has even tapped the Earth for its thermal power.

But last week, the Swedish government conceded the futility of trying to run a modern nation on a dream. It turned back a policy set out in 1990 to decommission all its nuclear power plants and embarked on a new age of the atom.

Captured the Wind
Tamed the Rivers and Seas
Stolen Energy from the Sun
Tapped the Earth for Thermal Power

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

©David Sanborn Scott
At last the oil sands!
Observations

😊 Gasoline 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

Steam flows through a reactor to condense. Heated bitumen flows to a well.

Hydrogen
Atomic Number: 1
Atomic Mass: 1.00797

©David Sanborn Scott