

Reimagining Liquid Transportation Fuels: Sunshine to Petrol

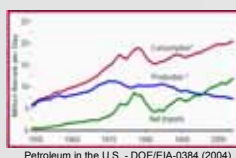
Sandia National Laboratories

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Problem

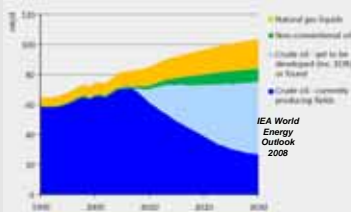
Enhancing Energy Security in an Age of Climate Change

U.S. Petroleum imports are roughly equivalent to that consumed by the transportation sector.



Costs include:
• economic and strategic vulnerability
• transfer of wealth
• loss of opportunity

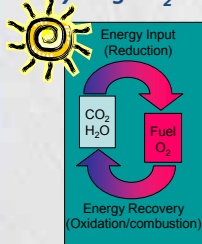
Significant resources will be expended even if we choose only to maintain the petroleum economy



Accounting for growth, about 14 TW of carbon-neutral energy will need to be brought online by 2050 to "stabilize" CO₂ levels.
Lewis and Nocera, PNAS 103(43): 15729 (2006).

Approach

Recycling CO₂ into Fuel



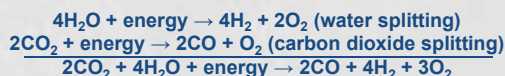
Incorporating CO₂ recycle into the Hydrogen Economy offers the benefits of the both the Hydrogen and Hydrocarbon Economies.

Applying solar energy directly to "re-energize" CO₂ and H₂O back into hydrocarbon form is analogous to photosynthetic processes, but potentially more efficient.

Capitalize on decades of Synfuel technology.

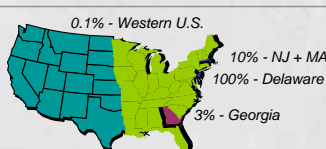


Focus on the critical energy intensive conversions:

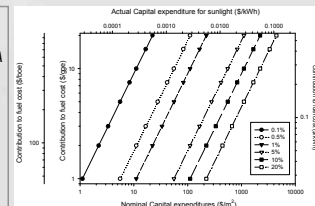


And integrating these into an efficient system powered by a diffuse energy source.

The magnitude of fuel consumption and the diffuse nature of the solar resource mandates high efficiency.

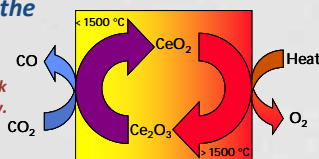


Nominal Equivalent Land Area Required to Produce 20 mbpd at a given efficiency. Sunlight to fuel efficiency assuming solar resource equivalent to Albuquerque ~ 2600 kWh/m²/yr. U.S. Petroleum consumption ~ 20 million bbls/day



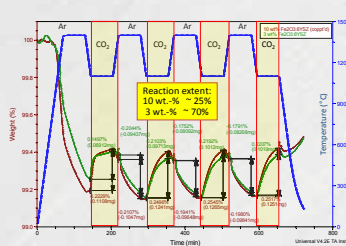
Thermochemical Conversion is the Heart of the S2P concept

Conversion of heat directly into chemical work without intermediate conversion to electricity. Energy management is crucial to high efficiencies.



Results

Materials are the heart ...



ThermoGravimetric Analysis (TGA) of Fe₃O₄/8YSZ: Thermal reduction under Ar; re-oxidation under CO₂

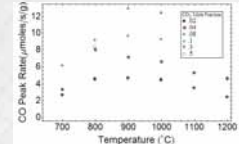
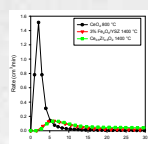
Characterize, Understand, Model, Improve

Fe/Zirconia Composites:

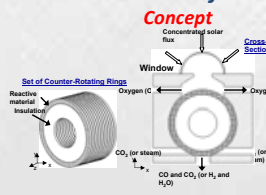
- Fe is highly mobile and soluble under reaction conditions
 - Reactions of dissolved Fe predominate in gas splitting
- $$\text{Fe}^{3+} \leftrightarrow \text{Fe}^{2+}$$



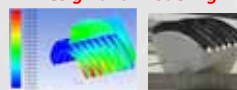
Ceria has better kinetics at more favorable conditions



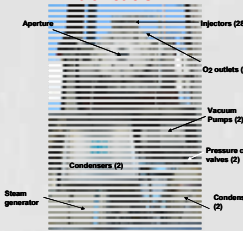
... of the Comprehensive Effort



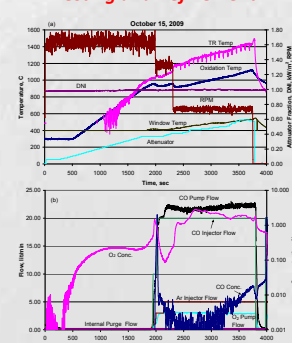
Design and Modeling



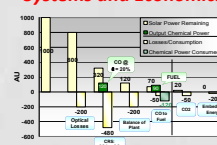
Fabrication



Testing and Refinement



Systems and Economics



Significance

Energy security and climate change are defining issues for the nation, and the global community. Competition for energy resources is increasing and will continue to do so. The availability and price of transportation fuels is closely linked to our economic and national security. Creating a breakthrough technology for the production of carbon-neutral transportation fuels is a challenge that must be met.

All of the growth in oil demand comes from non-OECD, with China contributing 43%, the Middle East & India each about 20% & other emerging Asian economies most of the rest