



The University of Texas at Austin

Center for Electromechanics

Cockrell School of Engineering

HYDROGEN – *Opportunity for Texas and the U.S.*

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Center for Electromechanics

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Global Enthusiasm

- Billions of dollars of industry and government investment globally
 - Europe
 - Middle East
 - North Africa
 - South America
 - Asia
- Benefits
 - Helps meet global emission standards
 - Increases efficiency
- Risk
 - Needs cost reduction



Efficiency Impacts Can Be Impressive

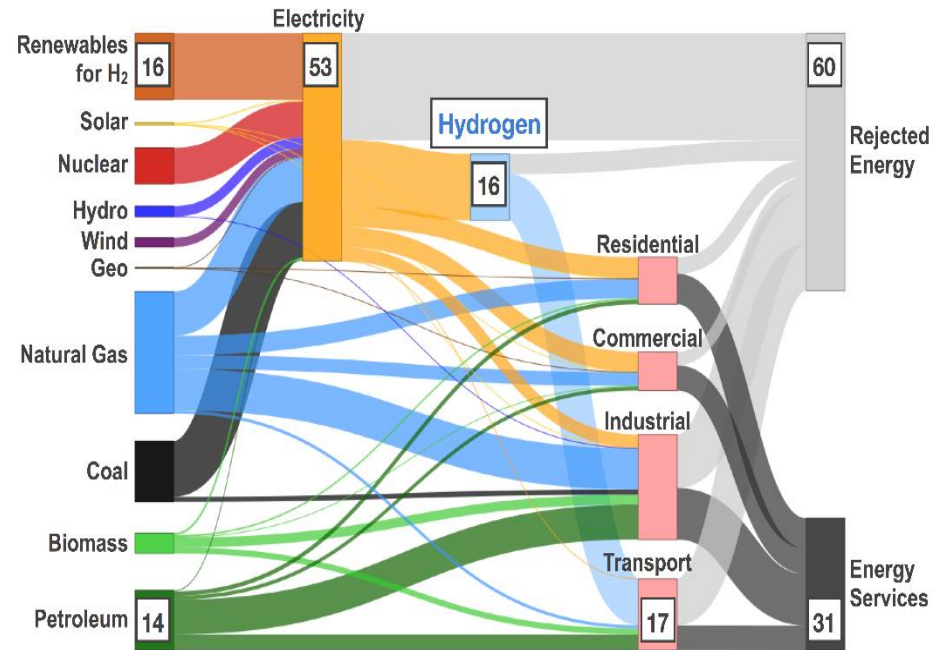
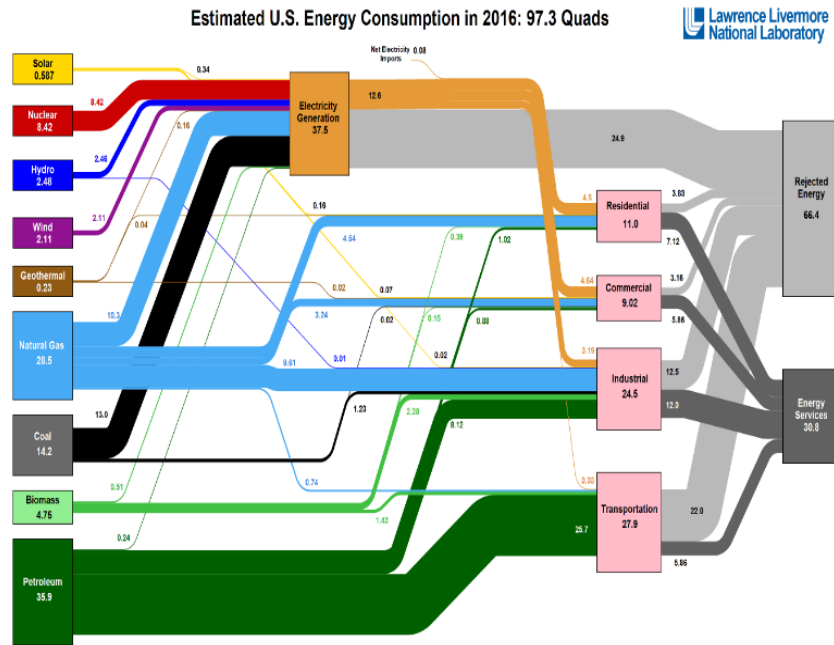
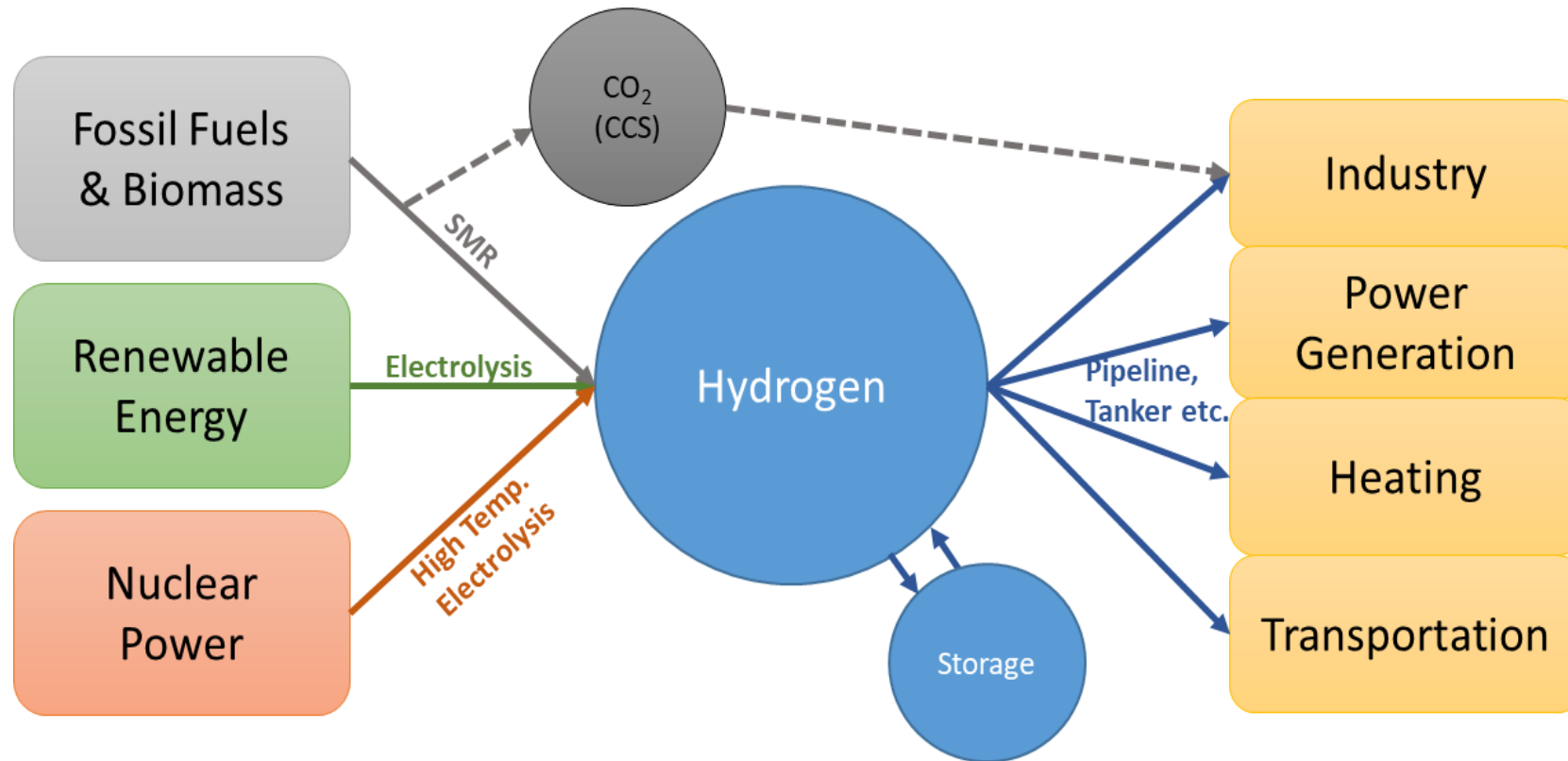


Figure 4. Energy Flows within the United States' economy in 2016 from sources (on the left-hand side) to end-uses (on the right-hand side), with values listed in Quads (quadrillion Btu).

(Source: Lawrence Livermore National Laboratory, U.S. Department of Energy)

Using hydrogen for transportation reduces
“Rejected Energy” from 66.4% to 60%.

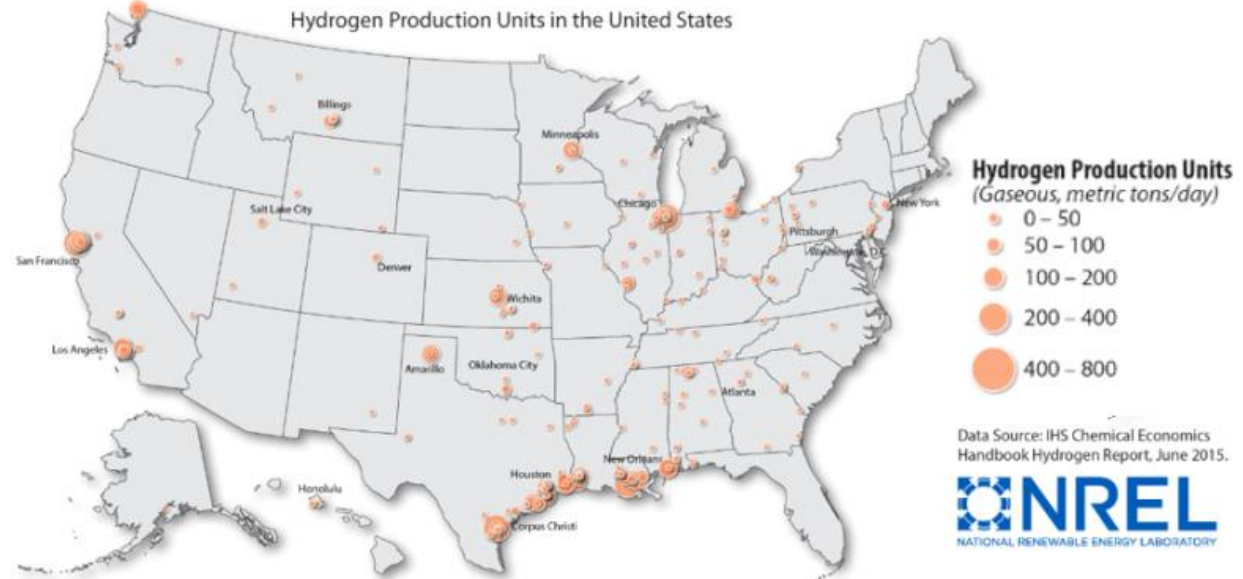
Hydrogen Serves as Storage/Carrier



The role of hydrogen highlights the Texas potential.

Texas is Positioned to Lead - I

- Existing hydrogen pipeline infrastructure
- Leading domestic producer of hydrogen
 - Experienced workforce
- Large presence of leading companies
 - Toyota, Shell, Air Liquide, for example
 - Corporate leadership
- Abundant renewables, natural gas and nuclear power
- Potential large-scale storage



Texas is Positioned to Lead - II

- Academic institutions with relevant programs:
 - University of Texas at Austin
 - Rice University
 - University of Houston
 - Texas A&M University
 - Texas Tech University
- Universities are important to
 - Provide R&D needed to drive down the cost of the technology
 - Educate the next generation of leaders in the hydrogen economy.



H2 Experts at UT



Dr. Joan Brennecke



Dr. Dongmei Chen



Dr. Hugh Daigle



Dr. Thomas Deetjen



Dr. Mojdeh Delshad



Dr. Peter Eichhubl



Dr. Paulo Ferreira



Dr. Shadi Goodarzi



Dr. Graeme Henkelman



Dr. Gyeong Hwang



Mr. Mike Lewis



Dr. Ning Lin



Dr. Michael Baldea

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Dr. Bob Hebner

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Dr. Guihua Ya

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Dr. Vaibhav Bahadur

College of Natural Sciences



Dr. Alan Lloyd

Energy Institute



Dr. Michael Webber



Dr. Yuanyue Liu



Dr. Arumugam Manthiram



Dr. Delia Milliron



Dr. C. Buddie Mullins



Dr. Jean-Philippe Nicot



Dr. Ryosuke Okuno



Dr. Varun Rai



Dr. Joaquin Resasco



Dr. Michael Rose



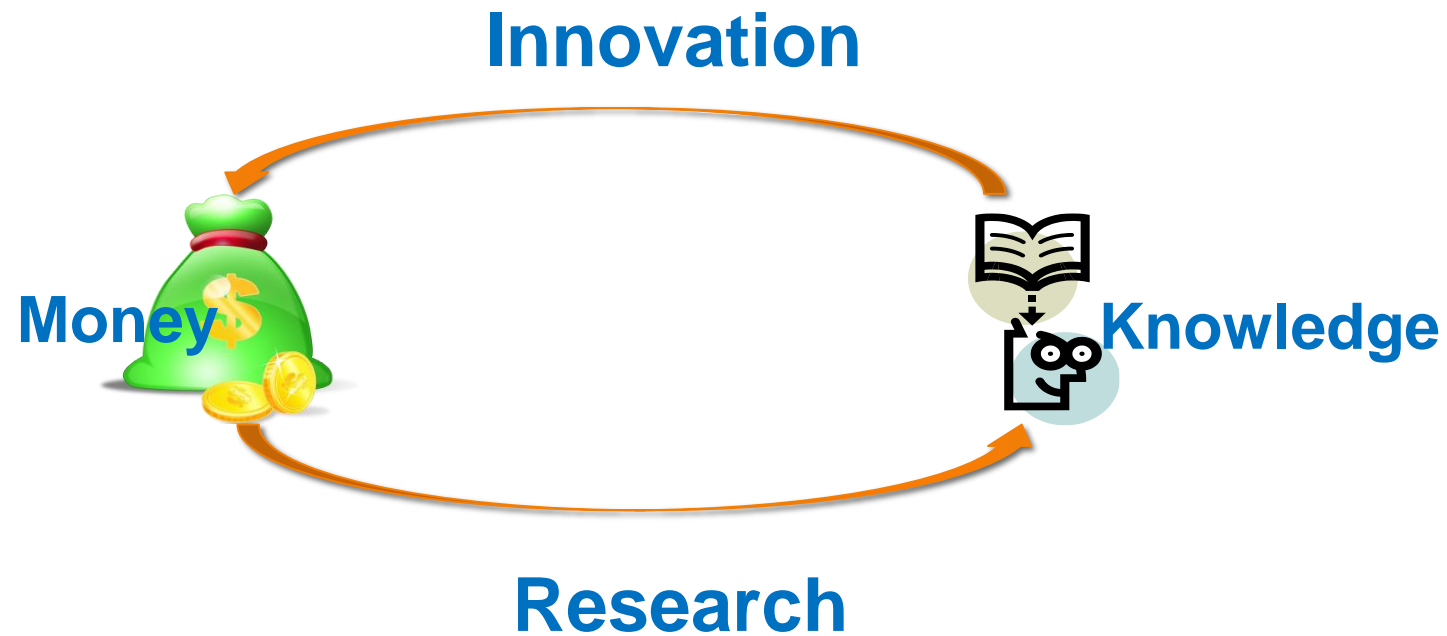
Dr. Kemy Sepehrnoori



Dr. Jamie Warner

Need the High-Tech Economy of Scale

- Most famous example is Moore's Law in the semiconductor industry



Most Promising Killer App - Trucks

- Commitments have been made:
 - China is investing more than \$7B in hydrogen truck development
 - Toyota announced a new hydrogen truck development
 - Cummins is developing hydrogen drive trains
 - UPS and FedEx have hydrogen delivery vans on the road.
- Key advantages
 - Fuel cell and battery drive train are smaller and lighter than battery alone
 - Greater range than battery alone
 - Short refueling times.
- A truck is a relatively low cost investment, so large quantities can be sold.
- Drives down supporting technology cost.

Takeaways

- Cost limits hydrogen growth today.
- Huge upside potential to improve efficiency and reduce greenhouse emissions.
 - Governments and industry globally are investing in reducing cost.
 - Economy of scale
 - Research and development
 - Materials
 - Controls
 - Storage
 - Techno-economic optimizations
- Texas has the economic and academic base on which to be a world leader in hydrogen.
- With effective leadership, hydrogen economy can be a huge economic benefit for Texas.