Basic Research and the U.S. Energy Challenge

Fully Engaging U.S. Universities

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Clean Cheap Energy is the Greatest Challenge of the 21st Century

- Every aspect of our contemporary society is dependent upon the availability of clean, affordable, flexible, and sustainable energy sources.
- Cheap available energy is critical to our economy, where over 7% of GDP is spent on energy.
- Our current energy infrastructure is unsustainable.
- Our environment is seriously impacted by hydrocarbon energy sources.
- The security of our nation is threatened by our reliance on foreign energy imports.

Meeting the Challenge

- **Energy research should be a major focus at a leading public research university such as the University of Michigan, which has a strong responsibility to address the most urgent needs of our state, nation, and world.**
- **Currently, the UM and other leading U.S. research universities do not have the resources to carry out the basic research needed to address our pressing energy issues.**

U.S. universities need to be fully engaged in meeting the Nation's energy challenges.

FY04 FEDERAL FUNDING OF H2 / FUEL CELL RESEARCH[1]

• Energy[2]	$ 233.3 M[3] (8M for fundamental)
• Defense	$ 40.9 M
• Transportation	$ 1.6 M
• NSF	$ 10.4 M
• NASA	$ 8.5 M
• EPA	$ 1.6 M
• Commerce	
• State Department	
• USDA	$ 0.3 M
Total funding:	$ 296.6 M

[1] Source: Dr. Esin Gulari, NSF
[2] Agencies listed are part of Hydrogen Interagency Task Force
[3] Includes DOE demonstrations

University share of federally funded research is too little and too unfocused.

Ad Hoc Committee on Energy Initiatives

- UM VP for Research Ulaby asked a Group of UM faculty and industry experts to conduct a quick scan of various approaches to building a significant research program addressing alternative energy supplies.
- Initial charge involved assessing possible initiatives concerning roadmaps to a possible future "hydrogen economy", with an emphasis on the use of hydrogen as a transportation fuel.
- Committee broadened this discussion to include an array of alternative energy options characterized by zero- or low-hydrocarbon emissions.
- Three key criteria were considered in discussions:
  - achieving national energy independence
  - miminimizing impact on global climate
  - addressing the particular needs of the transportation industry

Committee Membership

- James J. Duderstadt, Science and Engineering, UM (Chair)
- Arvind Atreya, Mechanical Engineering, UM
- Francois Castaing, Chairman of the Board, New Detroit Science Center
- James Cook, Chief Technology Officer, Retired, CMS Energy
- James Croce, Chief Executive Officer, NextEnergy
- Robert Culver, USCAR Director, Retired, Ford
- Gregory Keoleian, School of Natural Resources & Environment, UM
- James MacBain, College of Engineering, UM
- William Powers, Vice President, Retired, Ford Motor Company
  - Take Powers off list? He hasn't participated.
- Johannes Schwank, Chemical Engineering, UM
- Levi Thompson, Jr., Chemical Engineering, UM
- John R. Wilson, TMG/ENERGY

- Lynn Cook, Support Staff, UM OVPR
- Lee Katterman, Support Staff, UM OVPR

Four Initiatives (Options) at the National, Regional, State, and University Level

- At the national level, a major DOE initiative to fund 8 to 10 "Energy Research Centers" on university campuses, organized much along the lines of the NSF Engineering Research Center program.
- At the regional level, a consortium of university energy research centers focused on the energy needs of the Great Lakes states (e.g., manufacturing and transportation).
- At the state level, the establishment of several major energy research centers with a focus on transportation fuels, along the lines of major initiatives in other states.
- At the University level, establishing a major Energy Research Institute, aimed at building the University's capacity and presence in a range of scientific, technological, and policy issues involving transportation energy resources.

National University-based Basic Research Initiative

Format	8-10 university centers addressing energy research, education, and training issues.
Focus	Broad portfolio of energy-related basic research topics. Each center focuses on a different aspect of energy challenge. At each center, carry out energy education programs at undergrad, grad levels, and industry-oriented continuing education program.
Organization	8-10 separate but coordinated university centers of excellence. Each center would be composed of a consortium of universities with one university as the lead. Emulate NSF Engineering Research Center structure.
Industry Liaison	Each university center emulates an NSF Engineering Research Center model. Each carries out an active industry/government liaison program. Each supports an active technology transfer program. Industry technology adoption is facilitated by an independent NIST ATP-like funded activity
Government Liaison	Each Center would engage federal/state agencies and organizations with interest in energy. Could include DOE, DOD, DOT, EPA, NSF, as well as relevant state organizations (e.g., NextEnergy).
K-12 Outreach	K-12 outreach addressed within each university research and education activity.
Annual Funding	Federal: $120-150M for university centers initiative Federal: $100M to leverage industry technology adoption projects Industry membership per center: $50K per company; $10K for SMEs State: Supplemental funding from participating university states
Duration	5-year base funding with 5-year renewal based upon performance
Oversight	Federal funding organization(s), each center Industry role on Executive Committee, each center

Regional Consortium of Energy Research Centers

Format	A Great Lakes consortium of universities addressing energy research and education issues. (Alternatively, a geographically distributed set of universities strategically chosen from around the country).
Focus	Basic research topics addressing both mobile and stationary energy issues with a focus on transportation, manufacturing, and agriculture. Carry out energy education programs at undergrad, grad levels, and industry-oriented continuing education program.
Organization	Single university lead. Other universities are consortium members. Emulate NSF Engineering Research Center structure.
Industry Liaison	Engage energy, transportation, manufacturing, agricultural community and their 1st- and 2nd-tier supplier as partners on research projects. Offer favorable terms on licenses and patents. Provide access to test facilities. Provide support for high tech spin offs. Charge nominal fee for participation. Hold annual technology review and liaison meeting.
Government Liaison	Include regionally relevant federal agencies such as DOE (Argonne), DOD (TACOM, WPAFB), NASA Glenn, and EPA as well as state-based energy organizations (e.g., NextEnergy).
K-12 Outreach	K-12 handled within each university research and education activity.
Annual Funding	Federal: $15M per participating state State: $10M from each participating state Industry: $50K per large company; $10K for SMEs
Duration	5-year base funding with 5-year renewal based upon performance
Oversight	Federal funding organization(s) Participating states Industry member role on Center Executive Committee

State of Michigan-based State Energy Research Program

Format	State of Michigan consortium of universities addressing energy research and education issues. (Include MSU, WSU, MTU and other Michigan schools addressing energy research and education issues.)
Focus	Basic research topics addressing both mobile and stationary energy issues with a focus on transportation, manufacturing, and agriculture. Carry out energy education programs at undergrad, grad levels, and industry-oriented continuing education program.
Organization	Led by the University of Michigan. Other universities are consortium members. Emulate NSF Engineering Research Center structure.
Industry Liaison	Engage energy, transportation, manufacturing, agricultural community and their 1st- and 2nd-tier supplier as partners on research projects. Offer favorable terms on licenses and patents. Provide access to test facilities. Provide support for high tech spin offs. Charge nominal fee for participation. Hold annual technology review and liaison meeting.
Government Liaison	Include relevant federal agencies such as DOE, DOD (TACOM), and EPA (Ann Arbor) as well as Michigan-based energy organizations (e.g., NextEnergy).
K-12 Outreach	K-12 handled within each university research and education activity.
Annual Funding	Federal: $15-20M Industry: $50K per large company; $10K for SMEs State of Michigan: $1M in supplemental funding
Duration	5-year base funding with 5-year renewal based upon performance
Oversight	Federal funding organization(s) State of Michigan Industry role on Executive Committee

University of Michigan Energy Research Institute

Format	UM Energy Research Institute. Include following UM schools and colleges: Engineering, Natural Resources & Environment, LS&A and Business.
Focus	Basic research topics addressing both mobile and stationary energy issues with a focus on transportation and manufacturing. Carry out energy education programs at undergrad, grad levels, and industry-oriented continuing education program.
Organization	Led by Engineering. Emulate NSF Engineering Research Center structure.
Industry Liaison	Engage energy, transportation, manufacturing and their 1st- and 2nd-tier supplier as partners on research projects. Offer favorable terms on licenses and patents. Provide access to test facilities. Provide support for high tech spin offs. Charge nominal fee for participation. Hold annual technology review and liaison meeting.
Government Liaison	Include relevant federal agencies such as DOE, DOD (TACOM), and EPA (Ann Arbor) as well as Michigan-based energy organizations (e.g., NextEnergy).
K-12 Outreach	K-12 handled within each university research and education activity.
Annual Funding	Federal: $6-10M State of Michigan: $1M Industry: $50K per large company; $10K for SMEs
Duration	5-year base funding with 5-year renewal based upon performance
Oversight	Federal funding organization(s) State of Michigan Industry role on Executive Committee

Recommendations

- Conduct a comprehensive survey of existing energy research activities on our campus.
- Develop a plan to build and strengthen linkages with other state and federal initiatives such as NextEnergy, selected DOE offices and DOD.
- Create a University-wide organizational structure for such interdisciplinary energy research activities.
- Begin a series of investments in particular projects (see Committee report) while seeking external support from state, federal, and industrial sources.
- Commit itself to achieving leadership in energy research in areas of importance to the state (particularly transportation and manufacturing) within a five year period
- **Bottom-line Recommendation:** The University should move rapidly to pull together and augment existing energy research in areas designed to achieve greater impact and visibility, while building the credibility for leadership and attracting substantial external resources.

The University of Michigan has a Broad Range of Energy Expertise

- Energy source utilization
  - Coal, oil, gasoline, JP-8, natural gas, biomass, nuclear/thermochemical, solar, geothermal, wind, ocean wave
- Systems
  - Fuel processing reactors, fuel cells, micro-fuel cells, energy system integration, internal combustion engines (hydrocarbons fuels and H2), clean diesel, hybrid propulsion systems, electric propulsion
- Materials
  - Sulfur absorbents, catalysts for fuel processing, catalysts for fuel cells, photocatalysts for water splitting, hydrogen storage materials, sensor materials
- Processes
  - Fuel processing of hydrocarbons, biomass conversion, electrolysis
- Enabling technologies
  - High performance computing/simulation, information technology, low power electronics, manufacturing, sensors and controls, environmental analysis and monitoring, life cycle analysis, recycling technologies, energy efficiency audits, robotics, micromachining
- Energy policy, business and economics

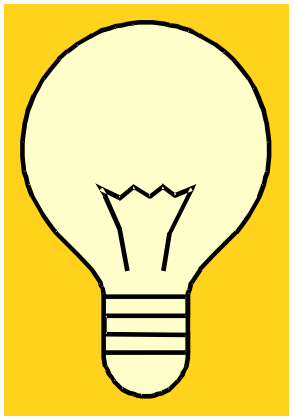
Regardless of the Size & Scale of Option Chosen, a University-based Program will:

- Engage the Nation's universities in a research and education program that addresses the many obstacles in moving to an energy future based on hydrogen.
- Enable objective investigation and assessment of the many options available to us as we move to a hydrogen economy.
- Educate the engineers and scientists needed in this critical area.
- Consider business/economic issues early in the R&D process.
- Engage industry and government as partners.

Assorted Back up Slides You May Find Useful.

Where Do We Go From Here?

- **Fundamental research and breakthrough discoveries are needed for**
  - **Hydrogen generation methods**
    - From fossil fuels
    - From renewable sources
  - **Hydrogen storage**
  - **More durable materials for fuel cells.**



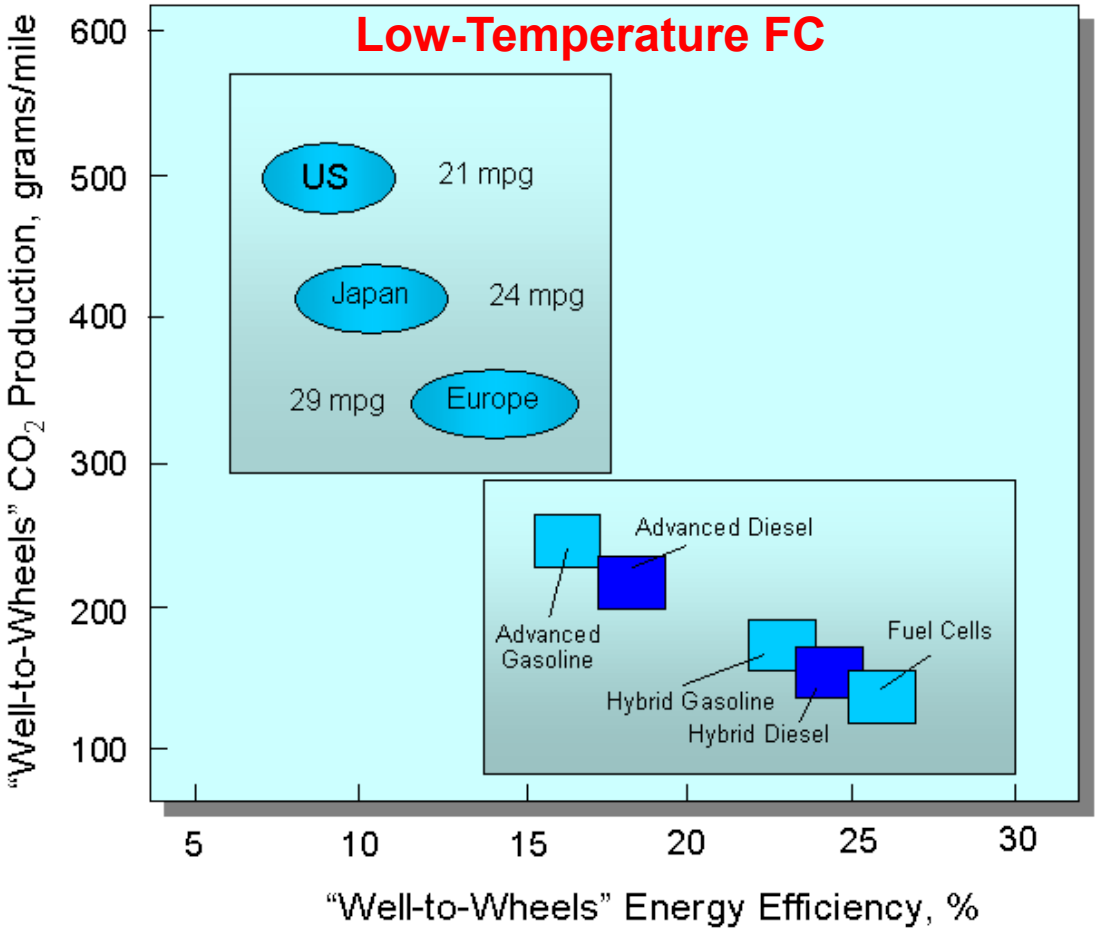
- ***Ultimately, we must figure out economically, technically, and environmentally sound ways to use water as source of hydrogen.***

Fuel Cells Promise Higher Efficiency

Higher efficiency means less fuel used, less greenhouse gases produced.

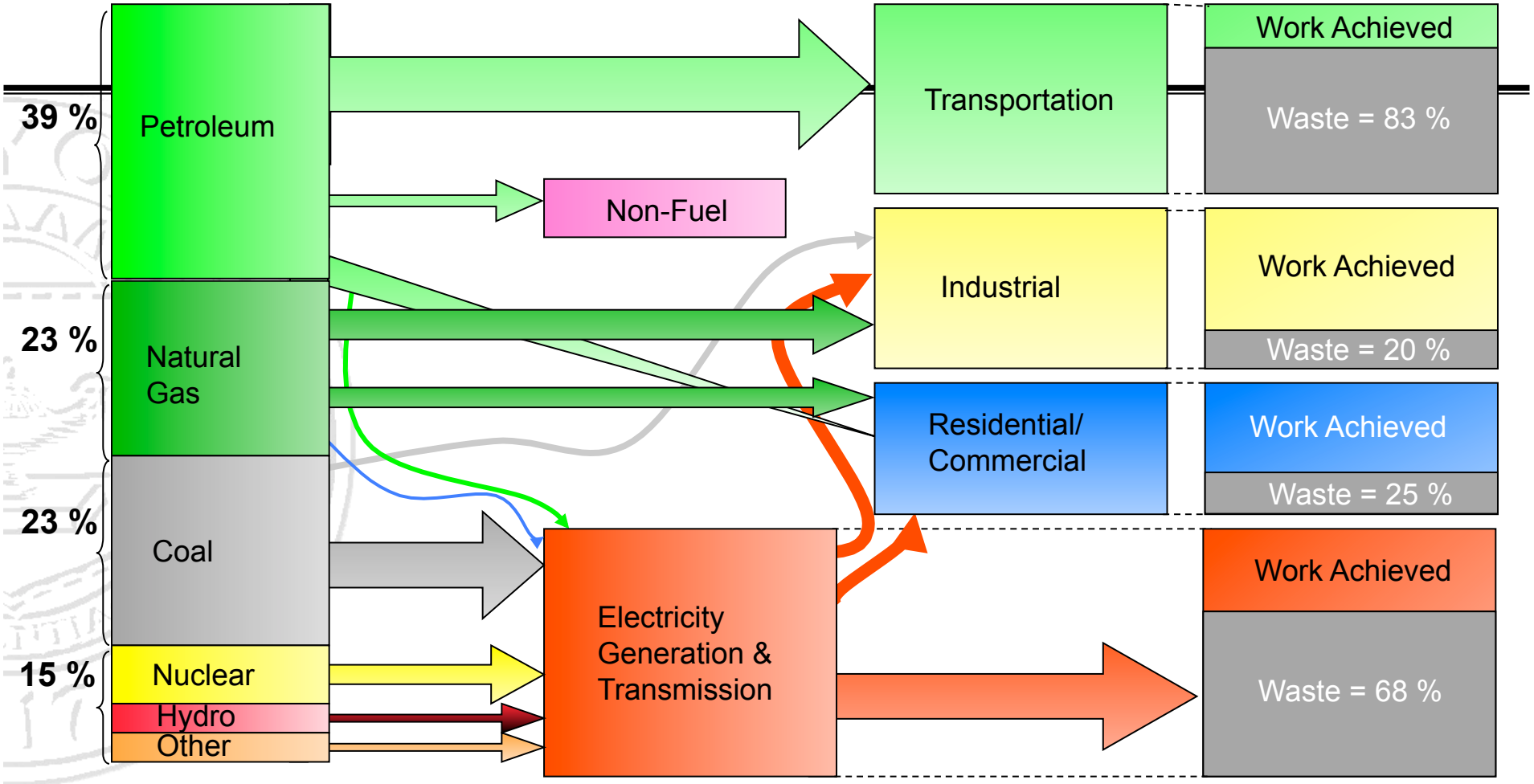
But, the jury is still out on which energy technology is best.

More research is needed!



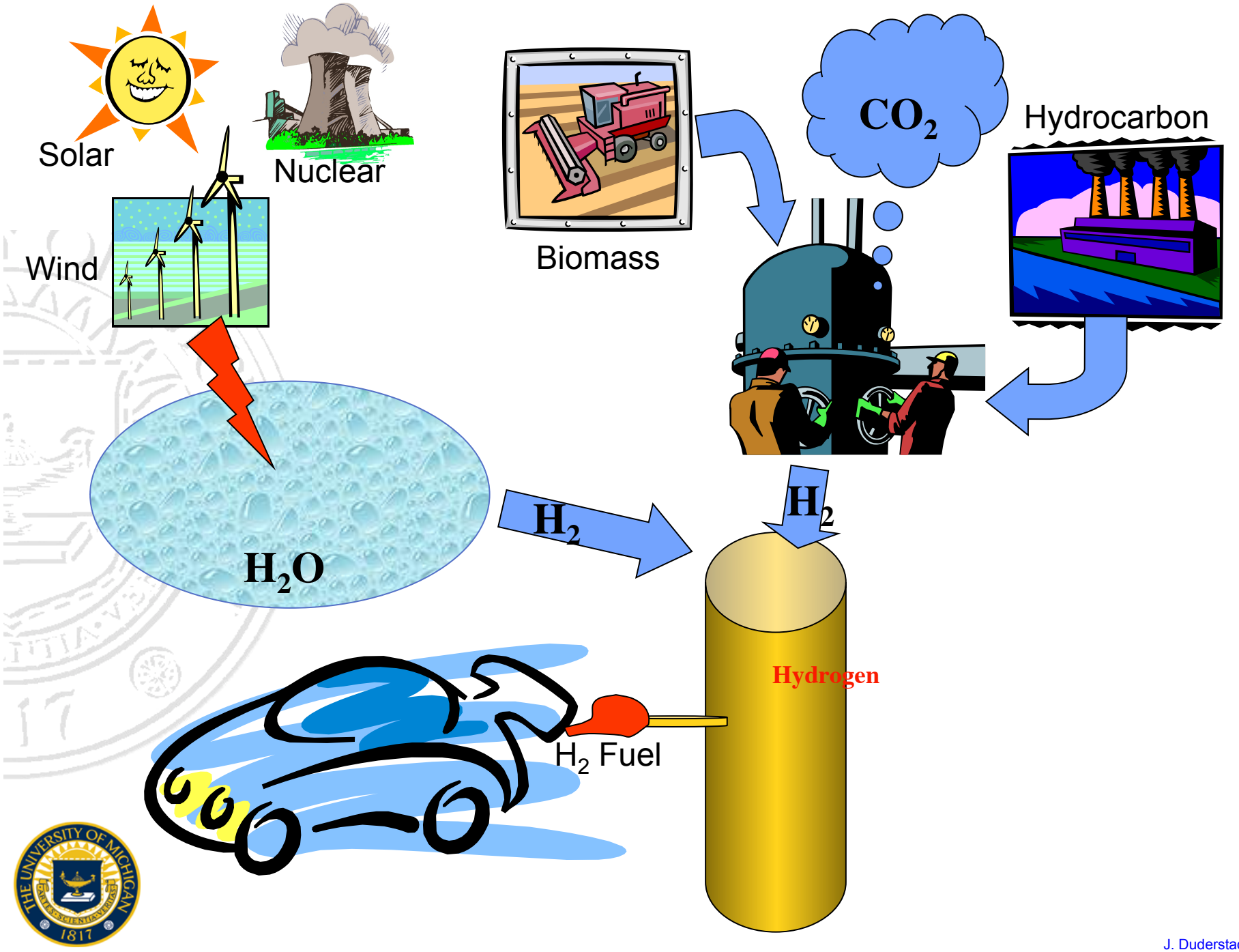
Source: ExxonMobil report

CURRENT U.S. ENERGY FLOW



- **Overall energy efficiency for U.S. is only 45%**
- **Transportation and power generation have greatest opportunities for improvement**

Sources: LLNL/DOE & Stanford GCEP


Solar
Nuclear
Wind
Biomass
CO_2
Hydrocarbon
H_2O
H_2
H_2
Hydrogen
H_2 Fuel