Energy and Sustainability Challenge for Engineering Profession

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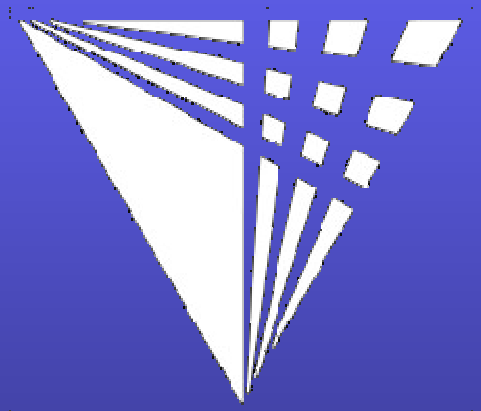


October, 2006

What is the Energy and Sustainability Concept?

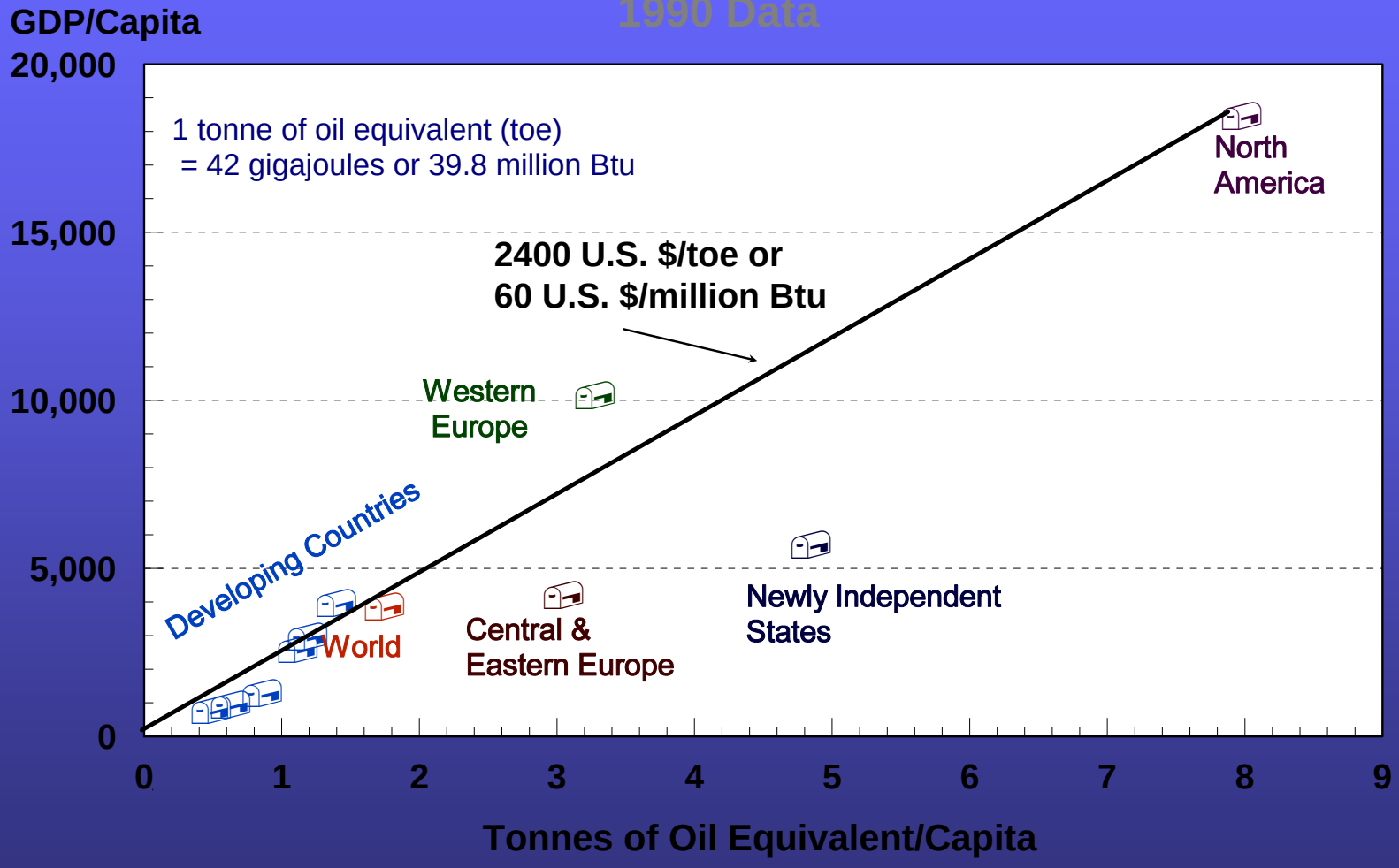
To continue to provide all of the useful energy services and materials required for constant improvement in human and economic well-being while preserving resources and the environment for future generations

Motivation

- Energy consumption increase due to human productivity and well being
- World primary energy substitution
- Prevent situations such as recent blackouts

Primary Energy Productivity in U.S. 1985 $/Tonne of Oil Equivalent

1990 Data



Source: World Energy Council (1992)

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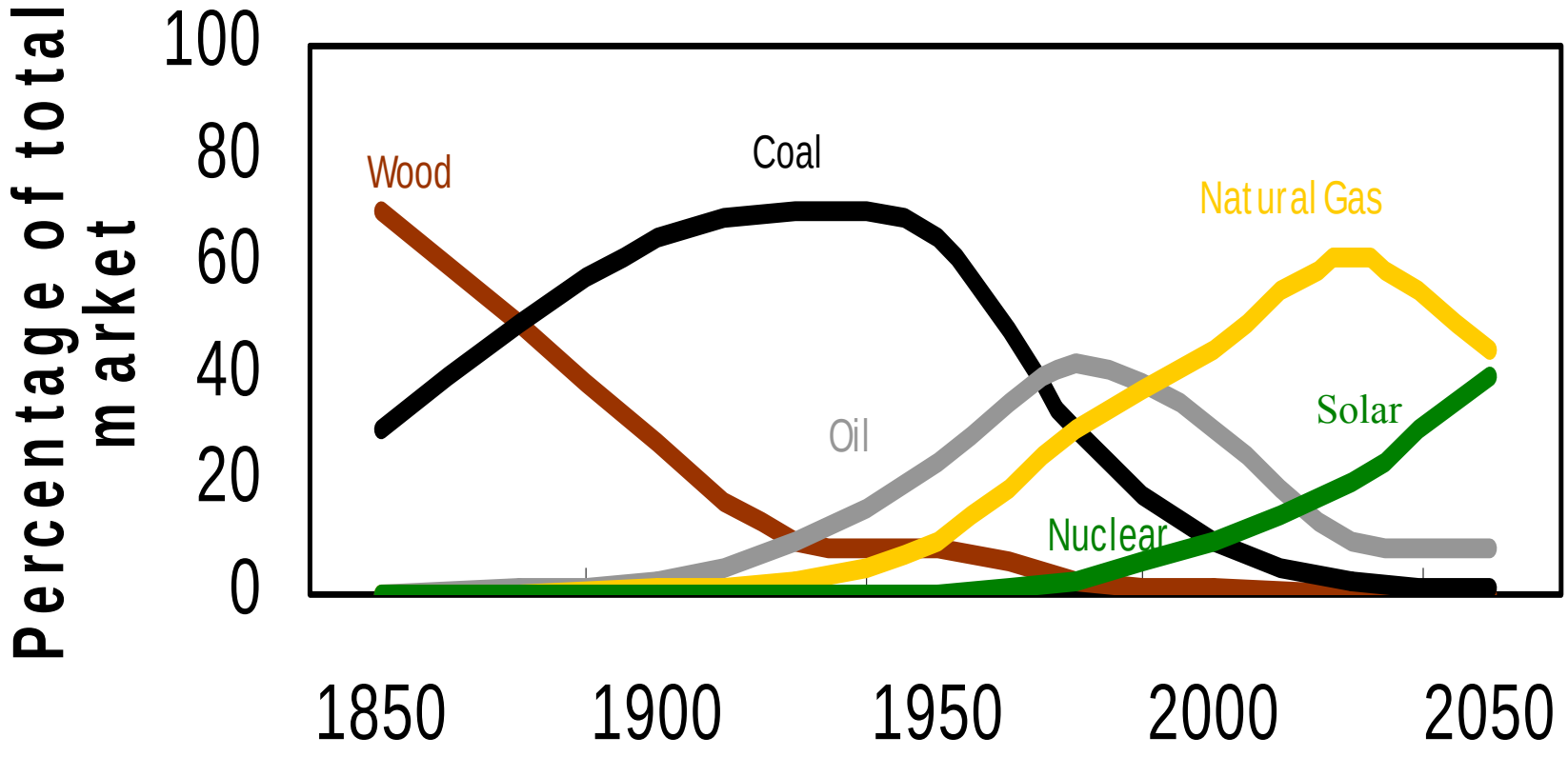
World Primary Energy Substitution



Energy and Sustainability Connects Three Major Issues

- Economy (human productivity, economic well-being and quality of life)
- Environment (world primary energy substitution)
- Security (secure energy supply and delivery to consumers)

Trends

- Continued population growth
- Continued growth in energy consumption per capita
- Continued depletion of oil and gas resources
- Environmental goals beginning to play more significant role in energy choices

Desired Emerging Paradigms

- Zero-emissions plants and vehicles
- Perfect electricity
- Energy efficient buildings
- Full-life-cycle accounting

Transition Step

- Continuing electrification using
  - Clean coal technology
  - Natural gas
  - Nuclear energy
- Enhancing efficiency of energy conversion and energy and power distribution systems; and building reliable power distribution infrastructure

Transition Step (cont'd)

- Energy and power conservation
- Manufacturing of efficient energy and power utilization devices
- Enhancing efficiency of the transportation vehicles and gradually switch to non-fossil based fuel

Desired Outcome

- Electrification of most stationary energy sources using
  - –Renewable (e.g. photovoltaics, solar, wind) as the main sources of energy
  - –Clean coal, gas, and nuclear as the secondary source
- Hydrogen as the dominant transportation fuel

Desired Outcome (cont'd)

- Environmentally friendly materials
  - Recycle, reuse, or biologically degrade
- Comprehensive energy and environmental policy
- Sustainable built environment

Mission of the IIT Energy and Sustainability Institute

- To provide all energy needs while continuing to improve the social and economic well-being of our society without damaging the environment or depleting our essential resources

Goals of the IIT Energy and Sustainability Institute

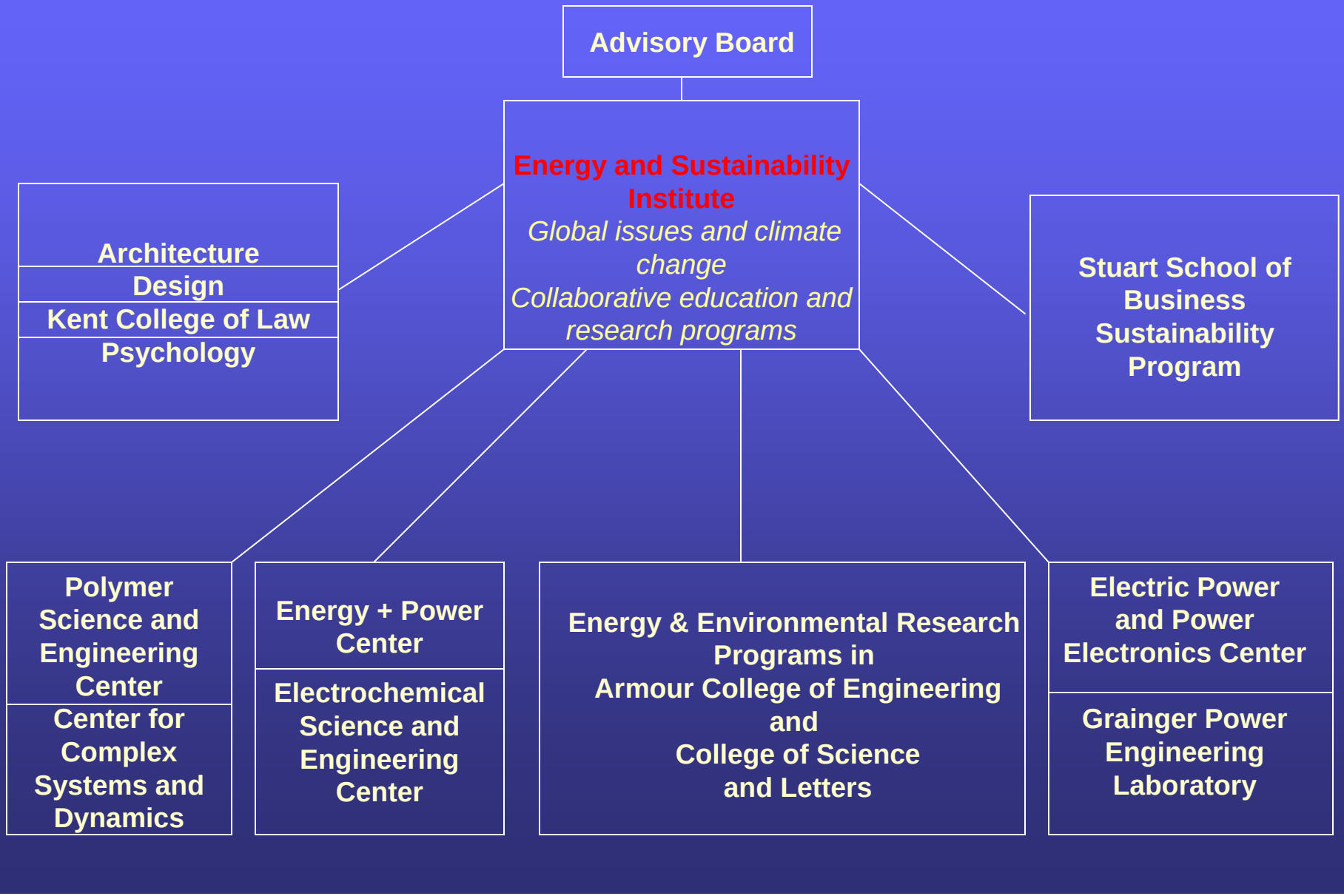
- Continue to develop research, education and demonstration programs in partnership with industry, national and research laboratories, and other universities
- Continue to develop state-of-the-art, interdisciplinary education and research programs and commercialize technologies in areas related to energy and sustainability
- Assume a leadership role in making key contributions to national energy policy

Strategy

- **Use least-cost strategy to:**
  - provide reliable and affordable energy
  - improve energy efficiency
  - continue ongoing decarbonization path
  - minimize wastes and pollutants

- **Develop research and development collaboration, partnership, and alliance between industry, government, and academic institutions**

Organizational Structure of the IIT Energy and Sustainability Institute



Energy and Sustainability Institute Focus at IIT

- **Decarbonization approach to energy systems**
  (including renewable energy, hydrogen fuel cells, batteries, clean coal, small hydro, and nuclear energy)

- **Energy efficiency and conservation**
  (including energy saving approaches, hybrid systems, optimum energy conversion systems, and ”sustainably built” environment)

- **Power**
  (including reliability, security, and grid design)

Energy and Sustainability Research Teams

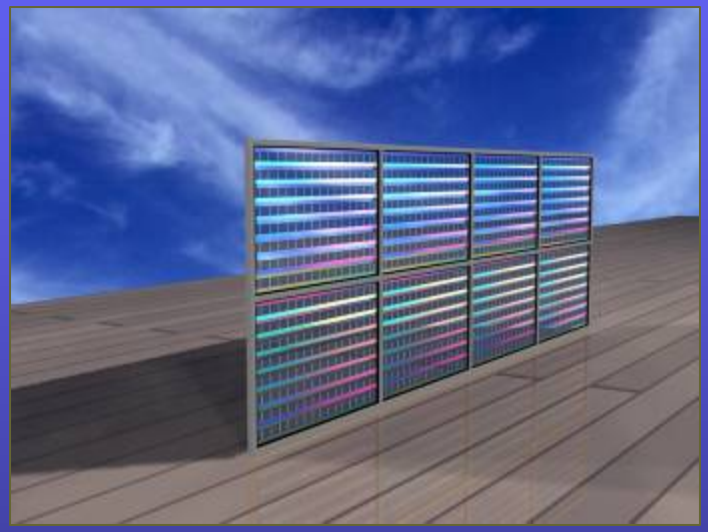
- Clean Energy Technology (including biofuels, clean coal technology, nuclear and methane hydrates)
- Solar Energy/Hydrogen Storage and Fuel Cells
- Environmental Systems and Sustainable Operations (including IIT's Campus Sustainability)
- Energy Efficiency and Conservation (including hybrid systems, optimum energy Conversion, and energy saving opportunities
- Educational Degrees and Certificate Programs
- House of the Future and Sustainable Buildings
- Small Hydropower Team
- Power and Power Distribution
- Recycling
- New Initiatives and Collaborative Opportunities

Educational Programs

- Energy, Environment, and Economics (E^3) specialization and minor at both graduate and undergraduate levels for engineering and science majors
- Master's and PhD degrees in environmental engineering and master's degree in environmental management
- Elective courses in sustainability area for students in fields other than science and engineering

ESI Current Research Activities

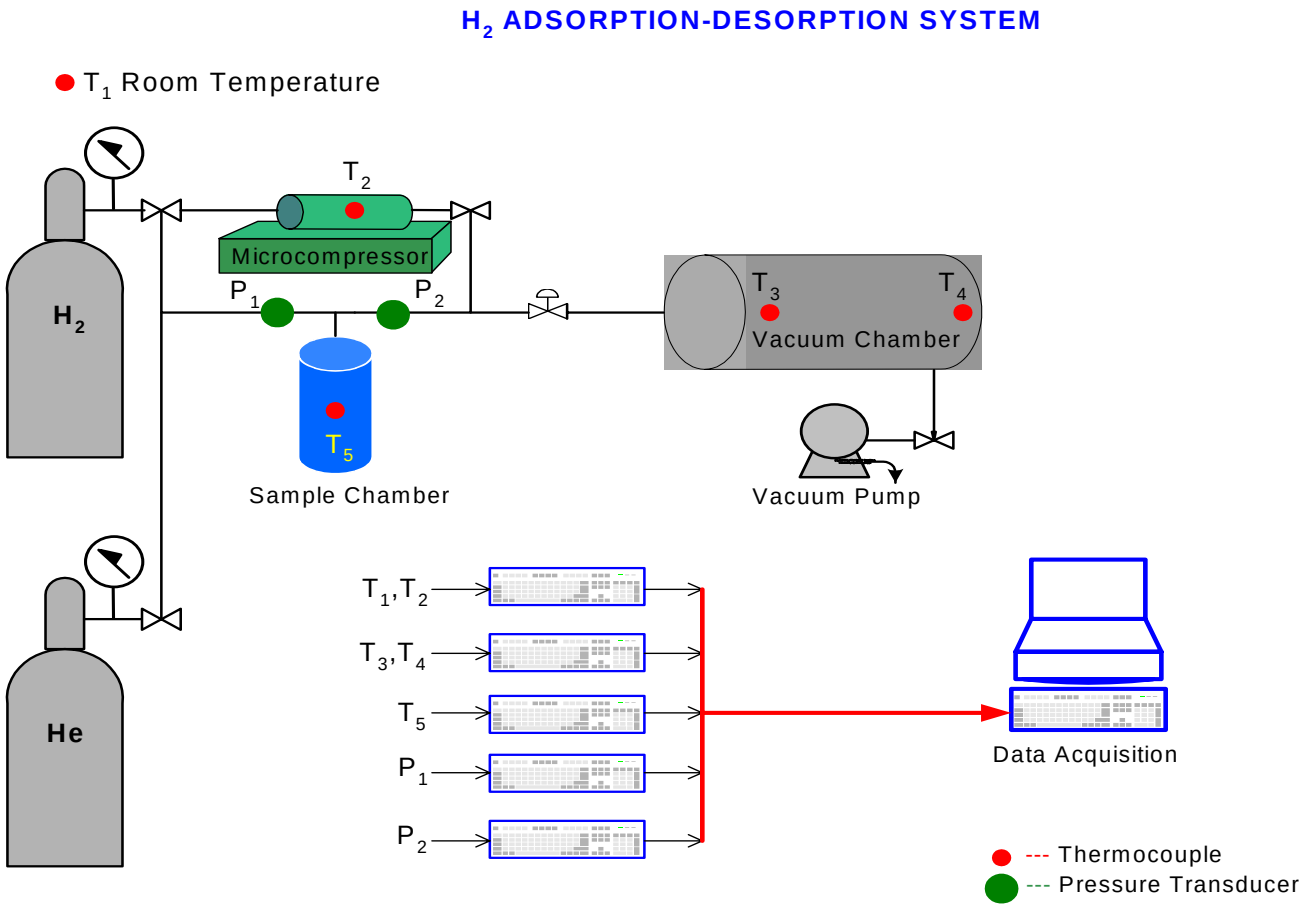
Solar Energy, Hydrogen Storage, and Fuel Cells



- During the past decade, IIT researchers have been involved in solar energy research and development using photovoltaic power (PV).

- Total system consists of:
  - PV panels
  - hydrogen production (electrolyzer) and hydrogen storage (using carbon nano-particles)
  - a proton exchange membrane (PEM) fuel cell to convert the hydrogen into electricity

Hydrogen Storage



Wind Map for City of Chicago

- The goal of this project is to provide DOE with a wind resource map of the City of Chicago.

- The map will contain detailed wind power potential information that could later be used for specific wind energy projects in the city.

Clean Coal Technology

During the last 20 years, IIT has been involved in a series of research collaborations with Gas Technology Institute in different areas of clean coal technology, including:

- computational fluid dynamics (CFD) modeling of fluidized bed coal gasification processes
- hydrogen and methane production from coal
- CO_2 sequestration,
- hot gas cleaning
- SO_x and NO_x removal

Production of Natural Gas from New Reserves

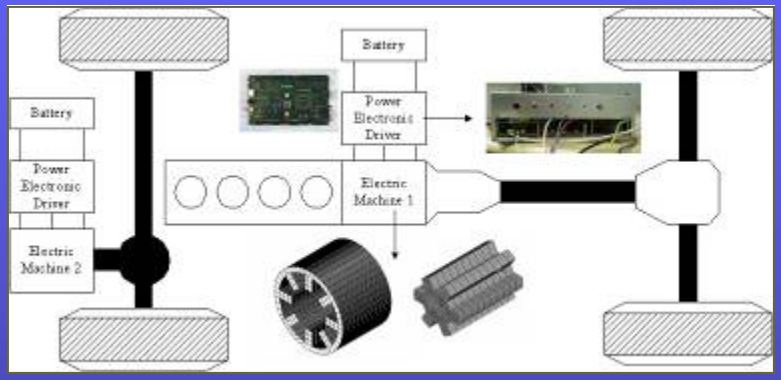
According to Department of Energy estimates: Gas entrapped in hydrates in United States: 320,000 (Tcf)

This means 1% of the methane entrapped is sufficient to provide 100 years of today's U.S. natural gas demand.

- IIT in collaboration with Gas Technology Institute is conducting research in the areas of natural gas production from hydrates and tight sand formations.

- IIT researchers have developed numerical simulators to predict production of methane from these unconventional sources.

Hybrid Electric and Ethanol-Fueled Vehicles



- To assist hybrid electric vehicle (HEV) designers, IIT researchers have developed a unique and comprehensive modeling tool for obtaining the optimal hybridization level.

- The IIT team also developed a highly efficient hybrid system that couples a DC motor with a 95% ethanol-fueled engine.

Electric Grid Modeling

IIT's *Grid Collapse Vulnerability Program* identifies the most significant grid collapse vulnerabilities as the first stage in a comprehensive risk reduction strategy developed for the critical electric power infrastructure.

Small Hydro Power

- Study of potential low head hydroelectric development using existing dams on the lower Fox River in northeast Illinois.

- If all 11 potential sites on the Fox River could be developed as hydroelectric plants, the total annual energy production would be about 31,000 MWh.

- A cash flow analysis based on conventional construction cost estimates suggests that the benefits would outweigh the costs at $0.11/kWh.

Tire Recycling

- IIT researchers developed a novel and economical rubber recycling technology.

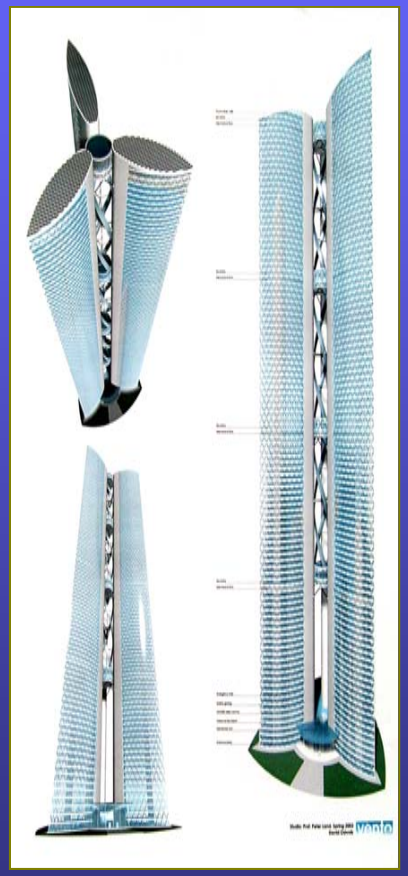
- This technology includes the *Solid State Shear Extrusion* pulverization process and a process to *change rubber particle surface properties*.

- The product partially devulcanized and structured rubber particles can replace paint as a coating or mixed with soil to significantly reduce water consumption for irrigation.

Energy Policy

For the last two decades, IIT has maintained its leadership role in energy policy analysis and forecasting by focusing on issues involving *decarbonization of energy systems* and *developing a national strategy for carbon-free energy.*

Sustainable Buildings

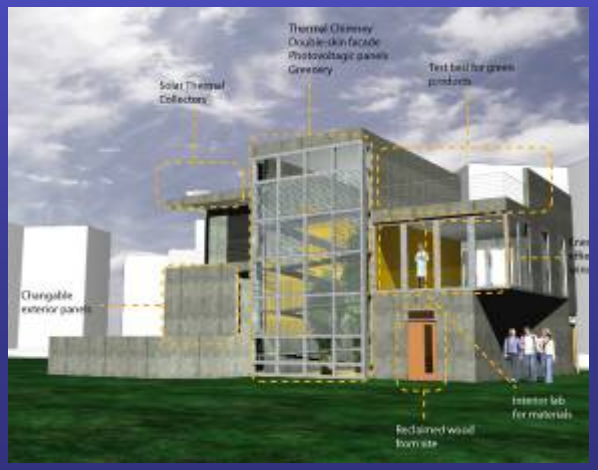


- IIT team has developed unique high-rise and wide-span structures equipped with wind turbines and photovoltaic arrays to produce electric power.

- Energy is generated at the point of actual use —reducing transmission infrastructure costs/losses through transmission.

- These concepts are currently being further developed with CFD analysis, energy production and cost effectiveness.

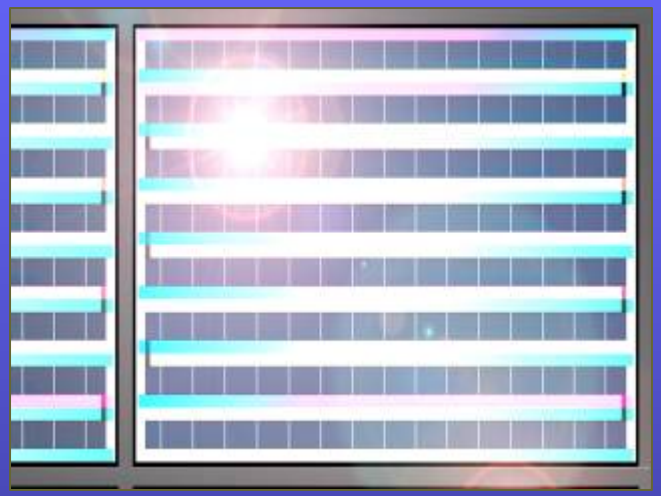
Sustainable Village/House of the Future



- Started in January 2005 to establish a benchmark of sustainability at IIT and define a 20-year road map to make the campus a Sustainable Village.

- Included the conceptual design of the *House of the Future* and the *Hydrogen Fueling Station* to be built on campus as demonstration projects of the IIT sustainability efforts.

Solar Feasibility Study for CPS



- A feasibility study for renewable resources potential on more than 600 public schools – almost 700 buildings – owned by the Chicago Public School (CPS) in the City of Chicago.

- The goal is to provide CPS with a comprehensive inventory of potential renewable resources in CPS properties, which will eventually lead to buildings improvements such as solar panels, wind turbines, and biomass.

Green Buildings Performance Study

- In 2005, a team at IIT was given the task through the City of Chicago Department of Construction and Permits (DCAP) to perform quantitative case studies on two Chicago Police District Stations.
- The two buildings studied were both based on the same design but one received the LEED® certification for green buildings.
- The results of this study will be made available to the public to document the impact of green building projects in the City of Chicago.

Summary and Conclusions

- A route to sustainability includes decarbonization of energy utilization and conversion
- The approach should be based on the least-cost strategy
- Hydrogen will be the primary fuel of the future, and natural gas Nuclear as transitional Energy

Summary and Conclusions (cont'd)

- electrification of most stationary energy sources using primarily non-fossil, including safe nuclear energy

- Increase in Energy Efficiency based on the Advances in Engineering and Science