BioEnergy: Considerations for Sustainable BioEnergy Strategies

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March 2008

ABSTRACT

The Heinz Center is currently working on understanding the ecological dimensions of bioenergy globally. This effort is part of a larger assessment, The Global Energy Assessment (GEA) seeks to examine: the major global challenges and their linkages to energy; the technologies and resources available for providing energy services; future energy systems that address the major challenges; and the policies and other measures to realize sustainable energy futures by assessing the social, economic, development, technological, environmental, security and other issues linked to energy.

The Heinz Center in collaboration with other groups is developing analysis to quantify the energy yields, greenhouse gas emission benefits, and other facets of socio-environmental aspects of BioEnergy development. We have initiated discussions various groups to support the Global Energy Assessment. These contacts have led to discussions with Global BioEnergy Programme and involvement of the Global Land Project to evaluate land use implications of bioenergy development. The current overall plan is define the ecological dimensions of bioenergy, efforts to determine best practice criteria, and to assess the various technologies which can define the role bioenergy can play in mitigating GHG emissions in the short- and long-term.

Introduction

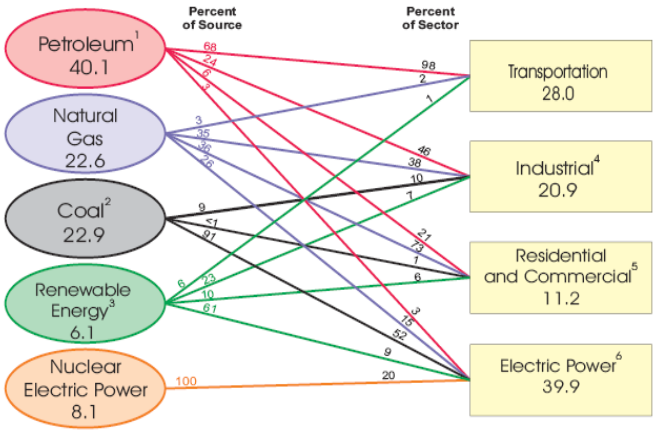
Energy services are essential for sustainable development, yet energy systems today face major challenges in relation to: security of supply; access to modern forms of energy; local, regional and global environmental impacts; and securing sufficient investment. Addressing these issues simultaneously to achieve the multiple objectives of sustainable development in both developing and industrialized countries requires detailed knowledge based on comprehensive and integrated analysis of energy challenges. However, existing authoritative studies on energy-related issues have generally failed to respond to this need, particularly in terms of integrating the range of potentially competing threats and possible responses, raising the risk that future energy-related decision-making and implementation by governments, investors, enterprises and intergovernmental organizations will be ineffective, and critical development needs will go unmet.

For these reasons, it is proposed to establish a Global Energy Assessment (GEA). The GEA will evaluate the social, economic, technological, environmental, security and other issues linked to energy, providing the basis upon which the challenges mentioned above can be addressed simultaneously. The GEA will identify options for the way forward—both on a global and regional level—and inform policymakers, the business and investment sector, and society at large, on the key opportunities and challenges facing the global energy system on the road to longer-term sustainable development—which represents a fundamental transition in our approach to energy. The GEA will target the needs of a range of stakeholders, providing policy-relevant analysis and capacity-enhancing guidance to national governments and intergovernmental organizations, decision-support material to the commercial sector (energy service companies, investors and others) and analysis relevant to academic institutions.

The GEA has been organized and structured around four major areas (clusters) of analysis:

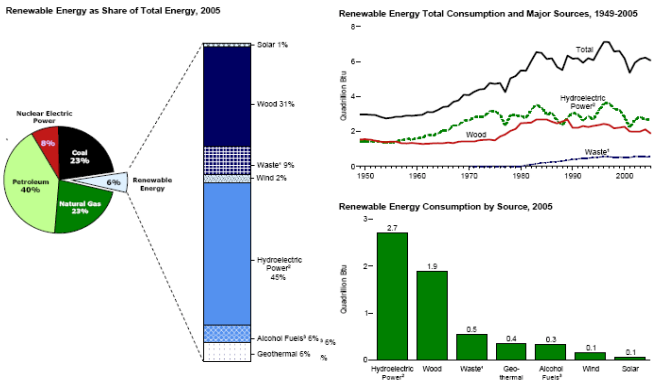
- **Major Global Issues and Energy:** assessing the challenges.
- **Energy Resources and Technological Options:** assessing of the components available to build future energy systems.
- **Describing Possible Sustainable Futures:** assessing of the composition of the systems that address the challenges.
- **Policies Advancing Energy for Sustainable Development:** assessing the policies options that address the challenges and provide options for future energy systems.

The Heinz Center has been designated as the United States GEA Science and Technical Support Office by the GEA. To meet the goals of the GEA, a sustainable strategy for bioenergy development is needed. The Heinz Center is actively involved in addressing the socio-environmental dimensions of bioenergy development and working in partnership with SCOPE and other Global Change Research communities.



US Energy Picture in 2005

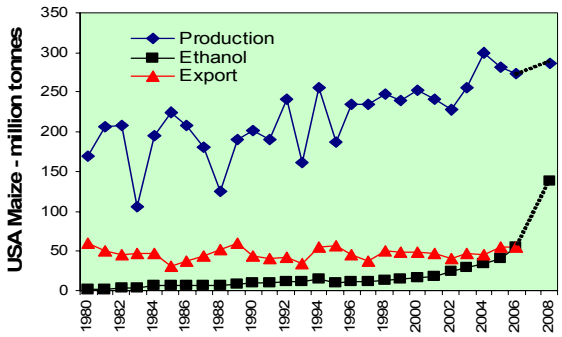
US energy use in 2005 was approximately 100 Quadrillion BTU; the proportional allocation of sources of energy consumed is depicted above. This energy was used in these 4 major sectors. As seen in the figure above, petroleum accounted for approximately 40% of the energy consumed with about 2/3 used in the transport sector. The transport sector currently utilizes only 1% of its needs from renewable energy where as currently, about 97% is derived from petroleum.



Source: http://www.eia.doe.gov/

Renewable Energy in the U.S

Ethanol currently constitute a small fraction of the current renewable energy production (~6%) or approximately 0.3 Quadrillion BTU's. DOE and the USDA is working to increase biofuel production in the next decade to reduce the petroleum use in the transportation sector. Current ethanol production systems have a number of economic and environmental constraints to meet the goals set by the US without new technological advances in use of alternative biofuel biomass sources.

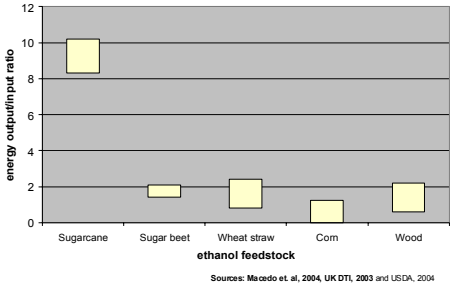


Earth Policy Institute, 2006

Ethanol Production

Total corn production in the US has increased during the past 5 years due to rising corn prices associate with the demand for corn-derived ethanol. This resulted in a decline in the export of maize and a competition for maize for a number of food related uses.

Figure 2A. Energy Balance By Feedstock



Sources: Macedo et. al, 2004, UK DTI, 2003 and USDA, 2004

GLOBAL BIOFUEL VIEW

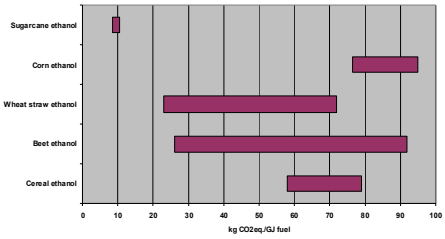
Not all feedstocks used today have the same economic-environmental properties. The properties of the sugarcane system developed in Brazil is evaluated as being highly beneficial from the both economic and environmental perspectives. Brazilian yields the highest energy ratio compared relative to inputs of fossil fuels (Figure 2A), the least amount GHG emissions (Figure 2B), and is the most cost effective in cost per liter (Figure 2C). In comparison to corn ethanol, current US corn-ethanol production evaluation falls far short in all these categories.

In direct comparison of the energy efficiency of Brazilian sugarcane ethanol to US corn ethanol (Figure 2D), it is seen that in both the crop production and in conversion of biomass to ethanol sugarcane does far better.

The development of US biofuels strategy will need to look beyond corn ethanol and to the potential of cellulosic pathways of utilizing biomass from wood sources, perennial grasses such as switchgrass, additional sources such as algal lipid conversion to hydrocarbons.

These current and near term developments will also need further analysis related to sustainability considerations in order to reduce inadvertent socio-environmental problems associated with biofuel developments.

Figure 2B. Greenhouse gas emission by feedstock



Sources: Macedo et. al, 2004, UK DTI, 2003 and USDA, 2004

Figure 2C. Ethanol Production Cost from Different Systems

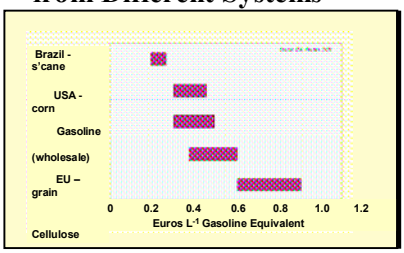
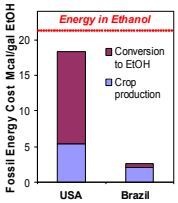


Figure 2D. Energy Balance for EtOH - USA & Brazil



- Sugarcane is a carbon crop
- Associative N fixation in cane reduces N input
- Cane has 4 ratoon crops reducing planting cost
- Bagasse is used to generate energy for cane conversion to ethanol

Sugarcane ethanol is 6x more energy efficient compared to corn ethanol

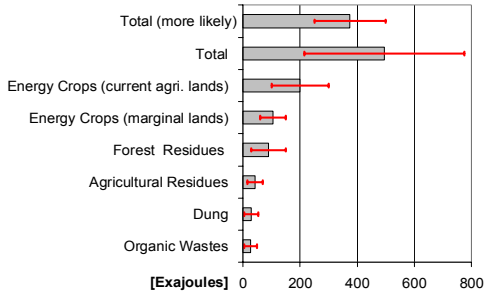


Figure 2E. Bioenergy Potential by feedstock

FUTURE BIOFUEL VIEW

The future outlook for use of biofuels has a relatively aggressive projection of the capability of its role in providing the needed energy, especially for transportation in the future. Recent analysis by Faaij 2006 and FAO Brief 2006 (Figure 2E) suggest that with second generation bioenergy prodcution may be as much as 400 EJ per year. These estimates depend greatly on incorporation of new lands for the biomass production. Land constraints (Figure 2F) will be a challenge for the bioenergy industry as increased competition for land and concerns of sustainable land management grow.

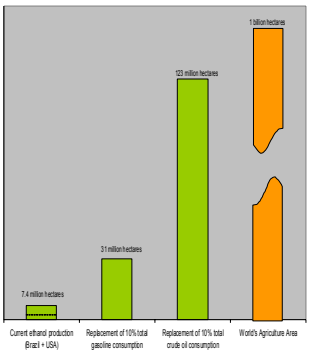


Figure 2F. Land Use Considerations for Ethanol Production

CONSIDERATIONS FOR ASSESSING SUSTAINABLE BIOENERGY DEVELOPMENT STRATEGIES

FULL LIFE-CYCLE OF BIOFUEL PRODUCTION

Land use
Energy use
GHG emissions
Energy resource depletion associated with production and utilization
Water consumption
Eutrophication
Biodiversity/ Invasive Species
Air pollution

SOCIO-ECONOMIC IMPACTS

Economic impacts
Job creation
Wealth distribution
Food versus fuel

Social impacts
Social responsibility
Social equity

Source: Sustainable biofuel systems: opportunities and threats. Royal Society, 2007