Biofuels

Derived from biomass

Four generations

- ➔ 1st generation = from edible plant parts
- ➔ 2nd generation = from inedible plant parts
- ➔ 3rd generation = from (macro/micro) algae
- ➔ 4rd generation = from genetically modified algae
    - ◆ For increased energy efficiency

Biofuels are a promising and realistic substitution fuel for transportation

- ➔ Combustion properties similar to those of fossil fuels
- ➔ Possibility of replacing fossil fuels in the transportation sector
- ➔ Minimal modifications in internal combustion engines
- ➔ Supplied by the same infrastructure

Biofuels are plagued by problems and conflicts

- ➔ Cultivation of feedstock and production of biofuels
    - ◆ Social, economic, and political impacts
- ➔ Conventional (1st and 2nd generation) biofuels
    - ◆ Food vs energy conflicts

Algal biofuels have the potential to be the fuel of the future

Biofuels are

- ➔ Liquid (or gaseous) energy sources derived from biomass
- ➔ A form of RES

Biofuels, unlike other forms of energy, require a source of feedstock!

Conventional biofuels = derived from terrestrial plant feedstock

- ➔ 1st generation = from edible plant parts
- ➔ 2nd generation = from inedible plant parts

3rd and 4th generation biofuels

- ➔ Rely on algae (φύκη, άλγες) and cyanobacteria (κυανοβακτήρια)

1st generation biofuels

- ➔ Sugar

- ➔ Beet (παντζάρι, κοκκινογούλι)
- ➔ Sugarcane (ζαχαροκάλαμο, ζαχαρότευτλο)
- ➔ Maize (καλαμπόκι, αραποσίτι)
- ➔ Oil palm
- ➔ Soybean (σόγια, γλυκίνη η αδρότριχος)
- ➔ Sweet sorghum (σόργο, ζαχαρόχορτο)

Characteristics of 1st generation biofuels

- ➔ 99.85% of biofuels produced globally
- ➔ Dominate markets
- ➔ Negative impacts on food and water

2nd generation biofuels

- ➔ Inedible feedstock
  - ◆ Lignocellulosic crop parts, e.g. stems, leaves, husks)
  - ◆ Waste products of vascular plants (e.g. sugarcane crop residues, firewood, switchgrass, forest and plantation residues, Jatropha [γιατρός] sp.)
- ➔ Promise of alleviating food vs energy conflict
- ➔ Developed more slowly due to
  - ◆ High capital costs of refining their feedstock
  - ◆ Dependence on subsidies and other economic incentives

3rg generation biofuels

- ➔ Do not compete with food or land (that could be used for food production)
- ➔ Can be fed with wastewater
- ➔ Only need water and sunlight to grow
- ➔ Are more efficient than photosynthesis
  - ◆ Can capture 3% of incoming sunlight, compared to 1% for photosynthesis.
- ➔ Slowest to develop
  - ◆ Their feedstock requires a lot of water, nitrogen, and phosphorus.
  - ◆ High costs to comply with current mandates

4th generation biofuels

- ➔ Particularly appealing solution
- ➔ Use genetically modified algae
  - ◆ Maximizes yield
  - ◆ Minimizes costs

Alternative names for biofuels

- ➔ Bioethanol
- ➔ Biodiesel
- ➔ Biogas
- ➔ Biomethanol
- ➔ Biokerosene
- ➔ Biohydrogen
- ➔ Syngas
- ➔ Bioethers

Major types of biofuels

- ➔ Made from 1st generation processes
- ➔ Bioethanol = gasoline substitute
  - ◆ Also called biopetrol
  - ◆ Made from carbohydrates (sugars)
  - ◆ Cellulosic ethanol production is now possible thanks to technological advancements
  - ◆ May also be produced from algal carbohydrates
- ➔ Biodiesel = diesel substitute
  - ◆ Made from lipids (fats)
    - India, China, Southwest Asia
  - ◆ May also be produced from algal oils

Technical, socioeconomic, environmental and political benefits of biofuels:

- ➔ Reduction in greenhouse gas emissions
- ➔ Improvement in air quality
- ➔ Job and wealth creation
- ➔ Rural development

- ➔ Fuel price stability

Biofuel challenges involve the environment, resources, society, and the economy

Biofuels are characterized by

- ➔ Technical barriers
- ➔ Debates
    - ◆ Economic
    - ◆ Social
    - ◆ Environmental
        - Deforestation
        - Loss of biodiversity
        - Haze pollution (also from forest fires)
        - Increase of carbon emissions
        - Water usage
        - Energy usage
        - Food vs fuel conflict
        - Rural poverty
        - Land use conflicts

Social acceptance issues of the 1st generation of biofuels prompted the development of the 2nd generation of biofuels

3rd generation biofuels have attracted investors

Issues of 1st generation of biofuels

- ➔ Lower net energy returns
- ➔ Overstated net carbon emission benefits
- ➔ Increased dependence on fossil fuels
    - ◆ Due to their high energy requirements
    - ◆ Instead of more energy independence
- ➔ Competition with food demand
    - ◆ Through crop and resource allocation

Current biofuel production systems

- ➔ Are mostly 1st generation
- ➔ Compete with agricultural land for the production of feedstock

2nd generation biofuels

- ➔ Are not derived from parts of plants grown for food
- ➔ Some, however, are derived from plants grown on agricultural land that could be used to grow food

The biomass left over after the production of biofuels may be used for the production of

- ➔ Supplements
- ➔ Animal feed
- ➔ Fertilizers

1st and 2nd generation biofuels cannot meet global energy demand sustainably

3rd generation biofuels are considered to play a crucial role

- ➔ They help achieve long-term climate policy objectives
    - ◆ Especially in regard to the energy demand of the transportation sector

Negative impacts of conventional biofuels

- ➔ Eliminate or degrade local jobs
- ➔ Decrease the income of households
- ➔ Increase food prices
- ➔ Lower the purchasing power of households

Areas most vulnerable to job security

- ➔ Impoverished regions
- ➔ In developing countries
    - ◆ Where agriculture is the pillar industry

Suggestions

- ➔ Reuse abandoned crops for the production of biofuels
    - ◆ Conforms to the recycling economy model
    - ◆ Improves the efficiency of resource utilization

Algal biofuels are likely to have positive impacts

- ➔ Better access to food

- ➔ More employment opportunities
- ➔ Stimulation of rural economies
- ➔ Less vulnerability to shocks in food prices

Other biofuel issues (that I will not be discussing much here, but you should read from my chapter)

- ➔ Costs and prices
- ➔ Gender and culture
- ➔ Public acceptance
    - ◆ Influences and factors
    - ◆ Public attitudes
    - ◆ Social norms
    - ◆ Social acceptance
    - ◆ Role of experts
    - ◆ Biofuel perceptions
    - ◆ Characteristics that may affect public opinion

Environmental aspects and sustainability of biofuels (also will not be discussing much)

- ➔ Atmosphere
- ➔ Greenhouse gas emissions
- ➔ Land
- ➔ Deforestation
- ➔ Ecosystems and biodiversity
- ➔ Water quantity and quality
- ➔ Wastes and recycling
- ➔ Energy
- ➔ Health and safety
- ➔ Aesthetics and sustainability
- ➔ Ethical aspects (very interesting in an IR context)
    - ◆ Environmental injustice
    - ◆ Policies and ethics

Policy and geopolitical aspects

Policy and geopolitical aspects relate to

- ➔ Country policies
- ➔ Security
  - ◆ Socioeconomic
  - ◆ Ecological
  - ◆ Food
  - ◆ Transportation
  - ◆ Energy
- ➔ Geopolitical considerations

Larger social context of biofuels

- ➔ Economics
- ➔ Public policies
- ➔ Structural matters associated with
  - ◆ Legislators
  - ◆ Regulators
  - ◆ Producers
  - ◆ Marketers
- ➔ Politics of support or opposition by
  - ◆ Political parties
  - ◆ Policy makers
  - ◆ NGOs

For algal biofuels in particular

- ➔ Long-term economic benefits
- ➔ May benefit from
  - ◆ Government support
  - ◆ Partnerships with universities and research institutions
- ➔ Should be supported with policies

Algal biofuels can help meet the energy demand of transportation

- ➔ This argument holds only as long as a positive energy balance is achieved during their production

- Chevron, BP, and ExxonMobil have made great investments

➔ The adoption of flex-fuel engines places consumers in the role of investors

- Purchasing more expensive flex-fuel engine vehicles so that they may enjoy the benefits of cheaper fuel in the long run

Conventional biofuels are a bit like wind and solar, in that they cannot guarantee a constant energy supply, because of uncertainties

➔ Regional climate

➔ Soil

➔ Water

➔ Other uncontrollable natural factors

Thanks to policy support, biofuels have infiltrated markets such as

➔ Corn-based ethanol (biopetrol) and soybean-based biodiesel in the US

➔ Sugarcane ethanol in Brazil

➔ Rapeseed (κραμβέλαιο, κανόλα) biodiesel in Europe

Aggressive government promotion of biofuels in the US and Europe has benefited corporations that invest in biofuel research

➔ Shell

➔ ExxonMobil

➔ Dow

➔ Monsanto

➔ DuPont

➔ Syngenta

Some researchers have suggested that related subsidy policies (instituted in the name of environmental protection) in the US and Europe

➔ Have been a guise for the transfer of wealth from taxpayers to agrifood and energy corporations

- Sustainability criteria for biofuels have not addressed the social and human rights impact
  - Such as the right to food!

Land grabs

➔ Hasten the South's transition to large-scale, capital-intensive industrial agriculture

- ➔ Go against the spirit of small-scale sustainable agriculture
    - ◆ In food-insecure countries

Studies of algal production have been carried out in

- ➔ EU
- ➔ Sicily
- ➔ Iran
- ➔ US
- ➔ Australia
- ➔ Brazil
- ➔ Chile
- ➔ Mexico
- ➔ Colombia
- ➔ Ecuador
- ➔ Panama
- ➔ Venezuela

Governments that have engaged in research and testing of alternative feedstock and 2nd generation biofuels

- ➔ China
- ➔ India
- ➔ Japan
- ➔ Indonesia

Transportation logistics will continue to dictate the expansion of agroenergy production in Brazil, because of sprawling

- ➔ Settlement patterns
- ➔ Trade networks

Demand for arable land translated to deforestation

- ➔ Palm oil, South Asia
- ➔ Sugarcane and soybeans, Brazil

Comparing biofuel policies among China, India, Japan, and Indonesia

- ➔ China, India, and Indonesia = large rapidly developing countries
- ➔ Japan = developed country

- ➔ All four countries have emphasized rural development
- ➔ All four countries have recognized that overdependence on one (of few) feedstock(s) is undesirable
- ➔ Japan has placed more emphasis on reducing greenhouse gas emissions
- ➔ China, India, and Indonesia have prioritized energy security
- ➔ Indonesia aspires to become the Middle East of biofuels
    - ◆ But palm oil is too important for food
- ➔ India and Indonesia have backed off initial targets that were overambitious
    - ◆ Reflecting the concern of their governments about the food vs fuel conflict

Setting unrealistic targets for the development of biofuels would encourage

- ➔ Unsustainable production
- ➔ Deforestation
- ➔ Water shortages
- ➔ Food-fuel conflict
- ➔ Appropriation of land used by poor people

Malaysia

- ➔ Environmental protection groups have lobbied to boycott palm oil products
    - ◆ They consider them to be associated with
        - Forest clearings
        - Animal extinctions
- ➔ Malaysia's National Biomass Strategy 2020
    - ◆ Delivered a roadmap for the development of 2nd generation biofuels
        - Using residues front he palm oil industry
- ➔ A winter palm biodiesel has been invented
    - ◆ Able to operate in temperatures as low as −20°C
        - Without clogging diesel engines

Security and geopolitical aspects of biofuels (apologize for repetition)

- ➔ Socioeconomic security
- ➔ Ecological security
- ➔ Food security

- ➔ Transportation security
- ➔ Energy security
- ➔ Other considerations

Regarding the socioeconomic security of developing countries (like Brazil), biofuels offer

- ➔ Promise of employment
- ➔ Income
- ➔ Foreign investment
- ➔ Regional development
    - ◆ In depressed areas
- ➔ Tax and foreign exchange revenue
- ➔ Exporting technology and know-how
    - ◆ To areas like Africa

Potential negative impacts of biofuels on socioeconomic security

- ➔ Competition with food and other uses
- ➔ Impacts on ecosystems services
    - ◆ Deforestation
    - ◆ Water usage
- ➔ Social impacts
    - ◆ Tenure rights
        - Land of poor farmers taken over by large producers without fair compensation

What does the study of biofuels in China, India, and Indonesia show?

- ➔ Biofuels are unlikely to be miracle cures promoting rural development
- ➔ Growing nonfood crops in wastelands requires significant amounts of
    - ◆ Water
    - ◆ Fertilizers
- ➔ Wastelands
    - ◆ Provide ecosystem services
    - ◆ Are used by lower income people for economically viable purposes

In the global South, algal biofuels can act like a hedge against the price volatility of other fuels

- ➔ Especially in countries with high fuel imports

Turning to ecological security, the expansion of the cultivation of conventional biofuels to satisfy US and EU demand

- ➔ Impacts negatively the countries of the global south
  - ◆ Pollutes and depletes water supplies
  - ◆ Exacerbates deforestation, thus climate change

In Indonesia and Malaysia

- ➔ Tracts of tropical forest and peatland (βάλτη, έλη) have been converted to plantations

Middle-income countries like China, India, Brazil, and South Africa

- ➔ Have played a major role in the global land grab
  - ◆ Generating tensions among southern nations

On the the biofuels revolution

- ➔ It has granted Brazil (and other tropical countries) the role of agroenergy hegemon(s)
  - ◆ Land and labor are cheap
  - ◆ Climatic conditions favor photosynthesis all year round
- ➔ Transboundary issues have emerged
  - ◆ Forest fires in Indonesia
    - Intended to clear land for pulpwood (ξύλο χαρτοποιίας) and palm oil
    - Pollute neighboring countries like Singapore, Thailand, Malaysia, and the Philippines
    - In turn, Indonesia has blamed Singapore and Malaysia oil palm consortiums for haze pollution caused by forest fires

Ecological security benefits (and issues) of using algae for biofuels

- ➔ Less than 1% of the global terrestrial surface would be required to fulfill 30% of future domestic transport energy demand
- ➔ Lands with relatively low agricultural and biodiversity values would be required
  - ◆ With little dependence on freshwater resources

➔ Although high biodiversity areas would be spared, approximately one third of proposed algae production areas would overlap with

- Mixed forests
- Croplands
- Grasslands
- Natural vegetation mosaics
- Woody savannas

5.2.3. Food security