Biofuel and sustainable development

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- Biofuels have become a popular way to use renewable biomass energy and have emerged as a potentially major alterative to gasoline and diesel transportation fuels derived from petroleum. Interest has been growing in the large-scale application of biofuels to address the twin global challenges of global climate change, and shifting away from increasingly scarce and environmentally and politically risky petroleum supplies.
- At least in theory, biofuels can play a key role in solving these problems in many nations, as long as the biomass sources are grown, converted, and used sustainably. However, historically speaking, the biofuels industry has largely ignored sustainability criteria and consequently has been the source of considerable controversy in North America, Europe, and Southeast Asia.


BIOFUEL

- The future development of biofuels thus seems bright, but it will be important to develop and apply biofuels sustainability criteria as soon as possible and in a consistent way worldwide.
- This will require increased cooperation among a large range of stakeholders and governments who support sustainable development, and who share a common concern for tackling the global climate change and petroleum challenges facing the world in the 21st century. The Roundtable on Sustainable Biofuels shows great promise for meeting this challenge based on the recent release of its draft principles.

Sustainable development and biofuels

- Biofuels development to date has been uneconomical, energy-inefficient, and environmentally and socially harmful, whether developed in the United States, Brazil, Europe, South- east Asia, or elsewhere. Even so, production of biofuels, such as ethanol and biodiesel, has been rapidly expanding in recent years, a trend that is expected to continue given the global interest in low or no carbon fuels and alternatives to petroleum (although this will depend in part on future oil prices).
- Many nations are promoting advanced, “second- generation” biofuels, such as cellulosic ethanol, as are the United Nations and World Bank, as one possible solution to the climate problem, but with some significant startup risks. Thus, an integrated assessment of the sustainability of existing and future biofuels systems is timely in the context of ecological economics.

Are biofuels a sustainable solution?

First generation
(1G)

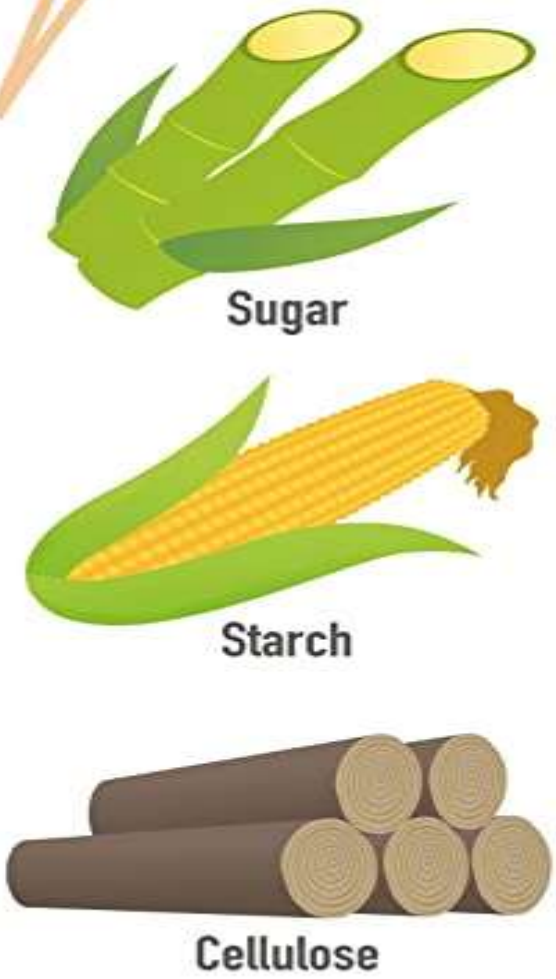
Second generation
(2G)

Third generation
(3G)

Fourth generation
(4G)

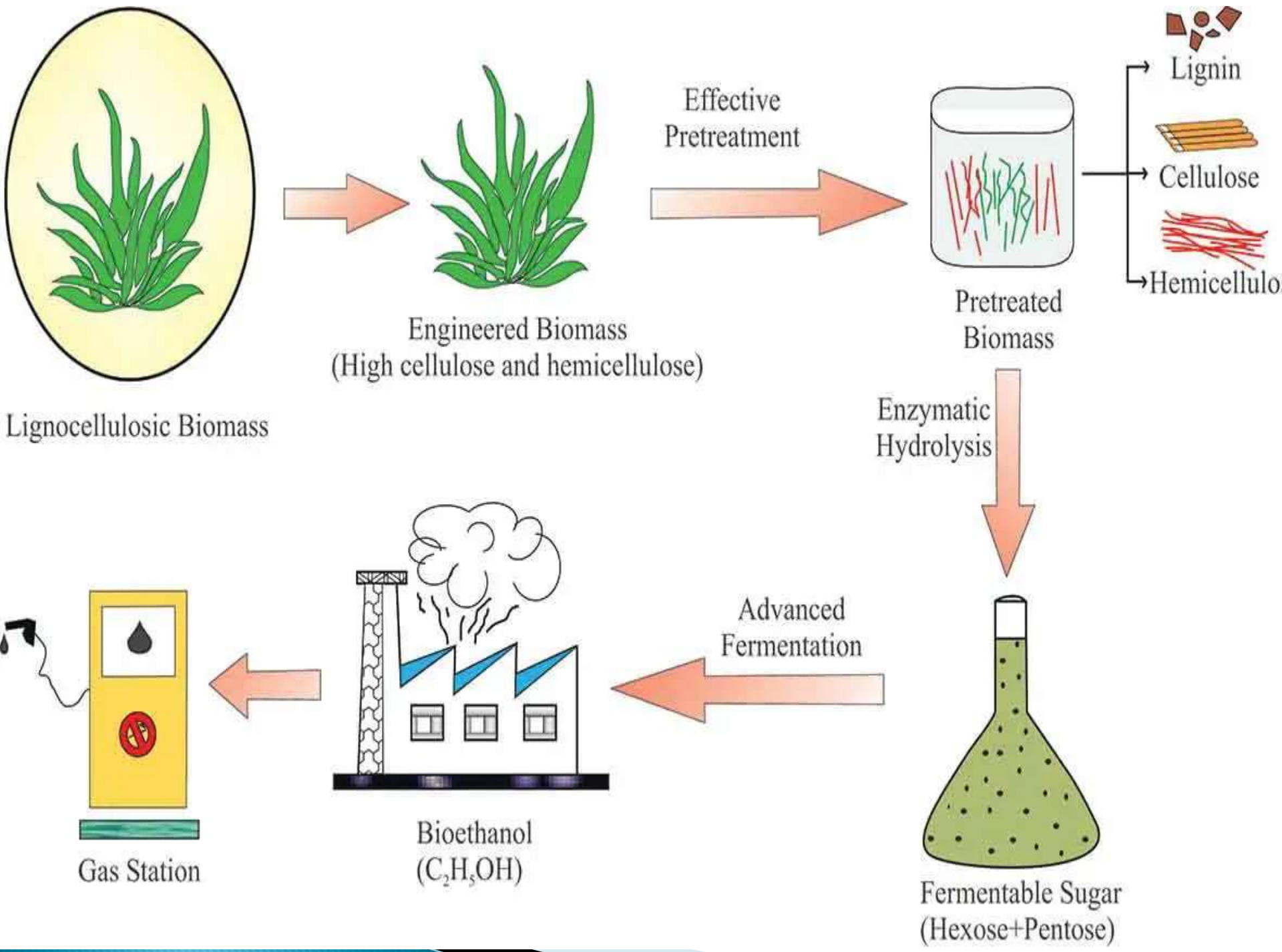
- Four principal fuels can be manufactured from biomass: ethanol, methanol, biodiesel, and hydrogen—although other fuels (e.g., biobutanol and dimethyl ether) can also be made from biomass.
- Among these fuels, the leading commercial options in recent years have been ethanol manufactured from cornstarch in the United States, ethanol made from sugarcane in Brazil, and biodiesel produced primarily from rape seed oil in Germany and France.
- Ethanol and biodiesel only, given their dominance in current transportation energy systems and corporate plans over the next decade. The production of ethanol from the cellulosic portion of biomass sources (or more aptly, and hereafter, referring to cellulose and hemicellulose), such as wood; grasses; and agricultural, forestry, and municipal wastes and residues, has been highly touted over the last few years but will require at least another decade to establish as a significant share of the bio- fuels mix.

SUSTAINABLE & CLEAN BURNING



C_2H_5OH

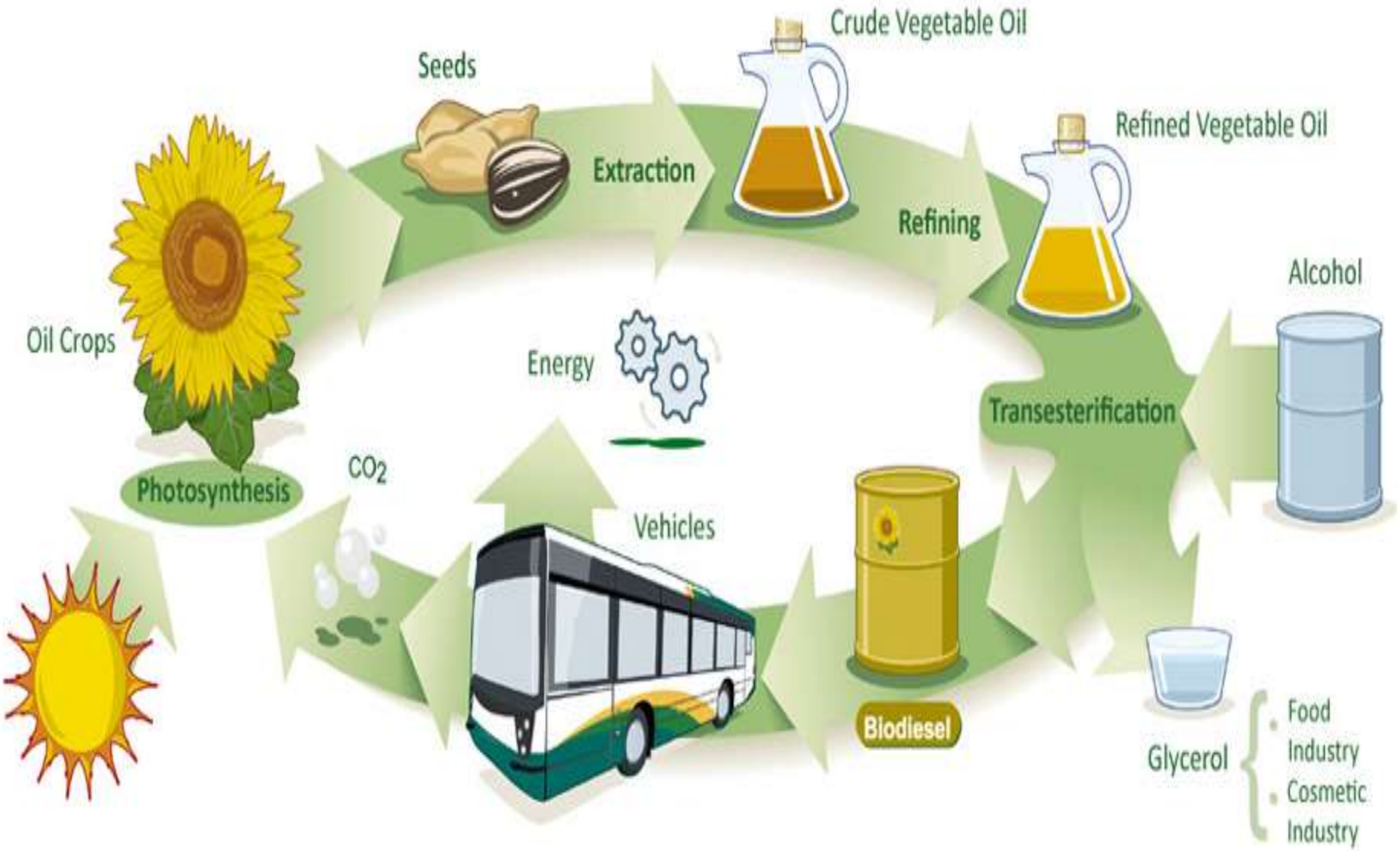
Bioethanol

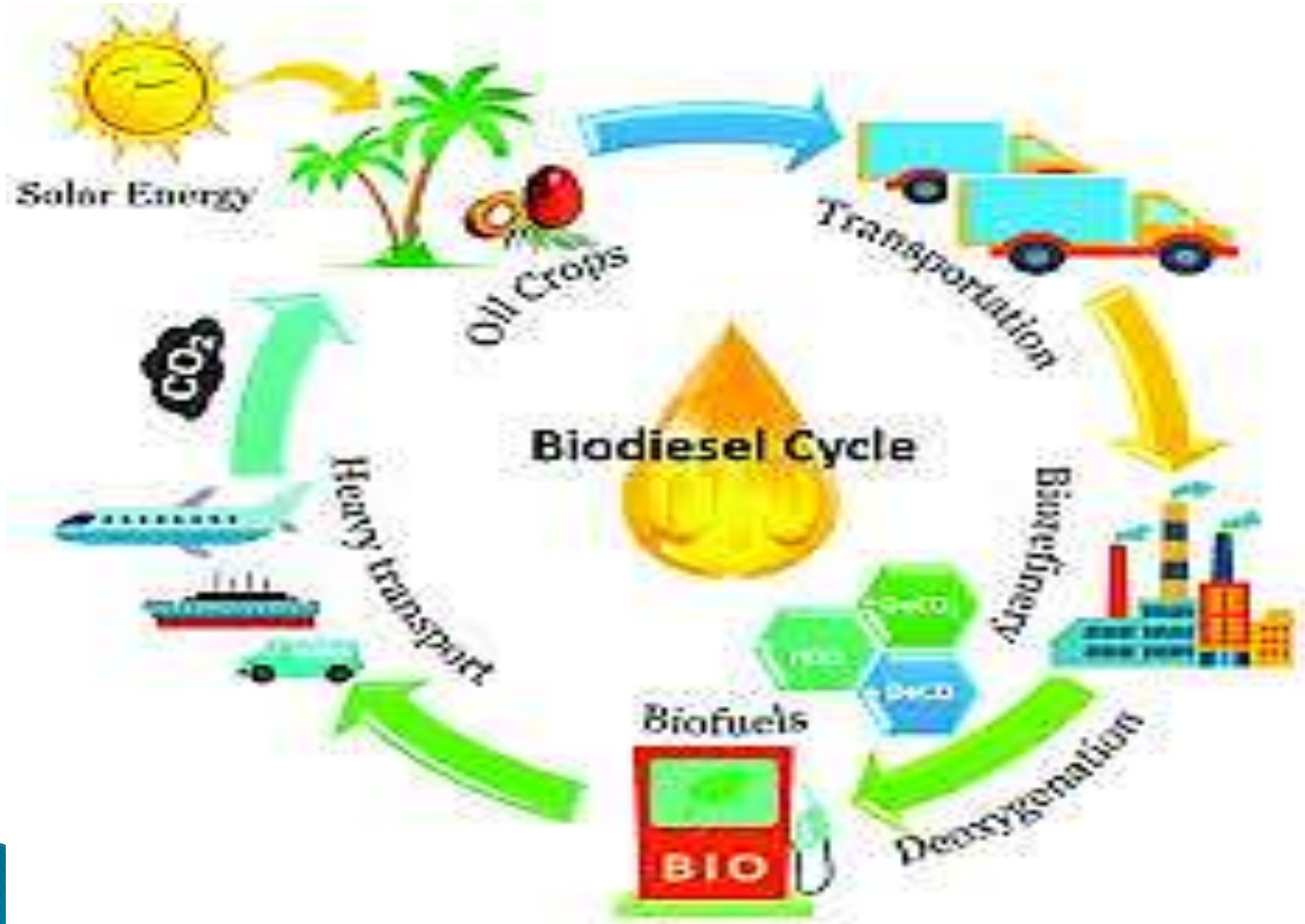

Lignocellulosic Biomass
Engineered Biomass
(High cellulose and hemicellulose)
Effective
Pretreatment
Lignin
Cellulose
Hemicellulo
Pretreated
Biomass
Enzymatic
Hydrolysis
Advanced
Fermentation
Fermentable Sugar
(Hexose+Pentose)
Bioethanol
(C_2H_5OH)
Gas Station

- Ethanol has been used in automobiles since the late 1800s, and initially a much larger role for it was envisioned before the domestic petroleum industry developed. It has an energy density of 24.0 MJ/liter, which is only around 68–75% the density of gasoline at 32–35 MJ/liter.
- Ethanol is currently used as a gasoline additive in most U.S. states. It has largely replaced methyl tertiary butyl ether (MTBE) in most states in the last 6 years as a gasoline additive and oxygenate to reduce air pollution. Although the energy density of ethanol is lower than gasoline, its octane rating is 35–40% higher and the fuel can improve thermal efficiency (and in theory engine performance) when compared with pure gasoline.
- However, since most automobile engines are not optimized to run on pure ethanol or high ethanol/gasoline blends, this potential advantage re- mains to be exploited.

- Biodiesel fuel production requires that alkyl esters first be extracted from a feedstock, such as animal fats or vegetable oils (soybean, rapeseed, sun- flower, palm, waste vegetable oil, etc.), and transesterified to produce fuel. The purpose of transes- terification is to lower the oil's viscosity.
- Biodeisel also has a long history, dating back to 1885 when Rudolf Diesel built the first diesel engine with the intention of running it on vegetative sources. This fuel is biodegradable and nontoxic, with an energy density of 33 MJ/liter.18,19 Because of the inherent high compression of diesel engines, this fuel can be operated with 20–30% higher efficiency than comparable gasoline engines.
- Biodiesel development advanced in the 1920s and 1930s through the testing of a variety of feedstocks in several countries. After decades of research, the first commercial plant opened in Austria in 1989. Production from rape- seed oil became popular in Europe in the 1990s, with Germany being the world's leading producer by far.

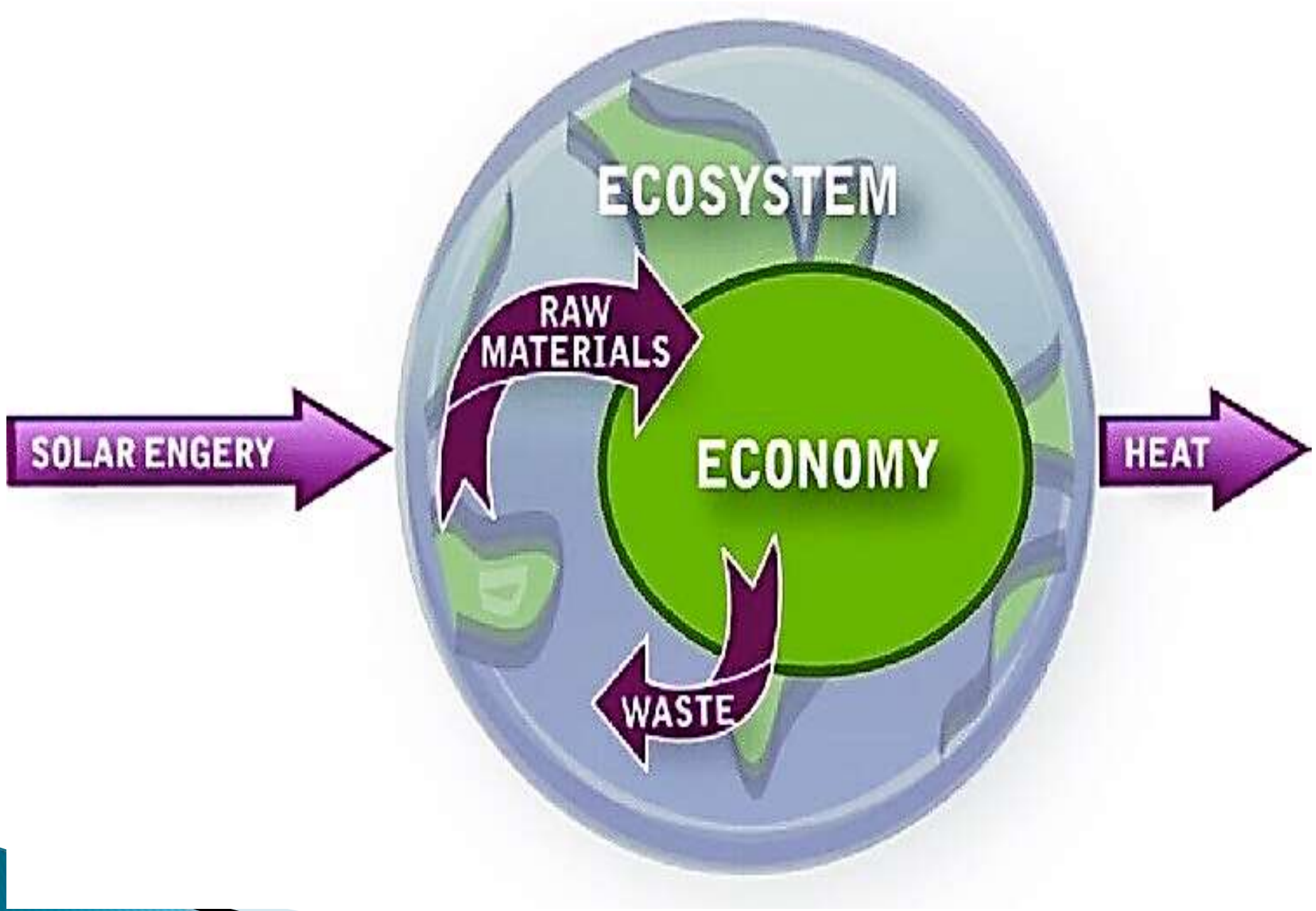
The Biodiesel Cycle




Solar Energy
Oil Crops
Transportation
Biodiesel Cycle
Biorefinery
Deoxygenation
Biofuels
BIO
Heavy transport
CO_2

Sustainability and ecological economics

- While there is continuing and lively debate about what differentiates ecological economics from other fields, there is a growing consensus that there are three foundational issues: the optimal or sustainable scale of the economy, economic efficiency, and equitable distribution of resources.
- Sustainable development and sustainability science, in turn, are usually thought of as some combination of the "triple bottom line" of economic development, social development, and environmental/resource sustainability.
- All of these issues, among others, are being addressed in the context of biofuels. Thus, this section will review the following dimensions for biofuels: optimal scale, efficiency, equitable distribution of biofuels, socio-economic issues, and environmental emissions and effects.


ECOSYSTEM
RAW MATERIALS
SOLAR ENGERY
ECONOMY
HEAT
WASTE

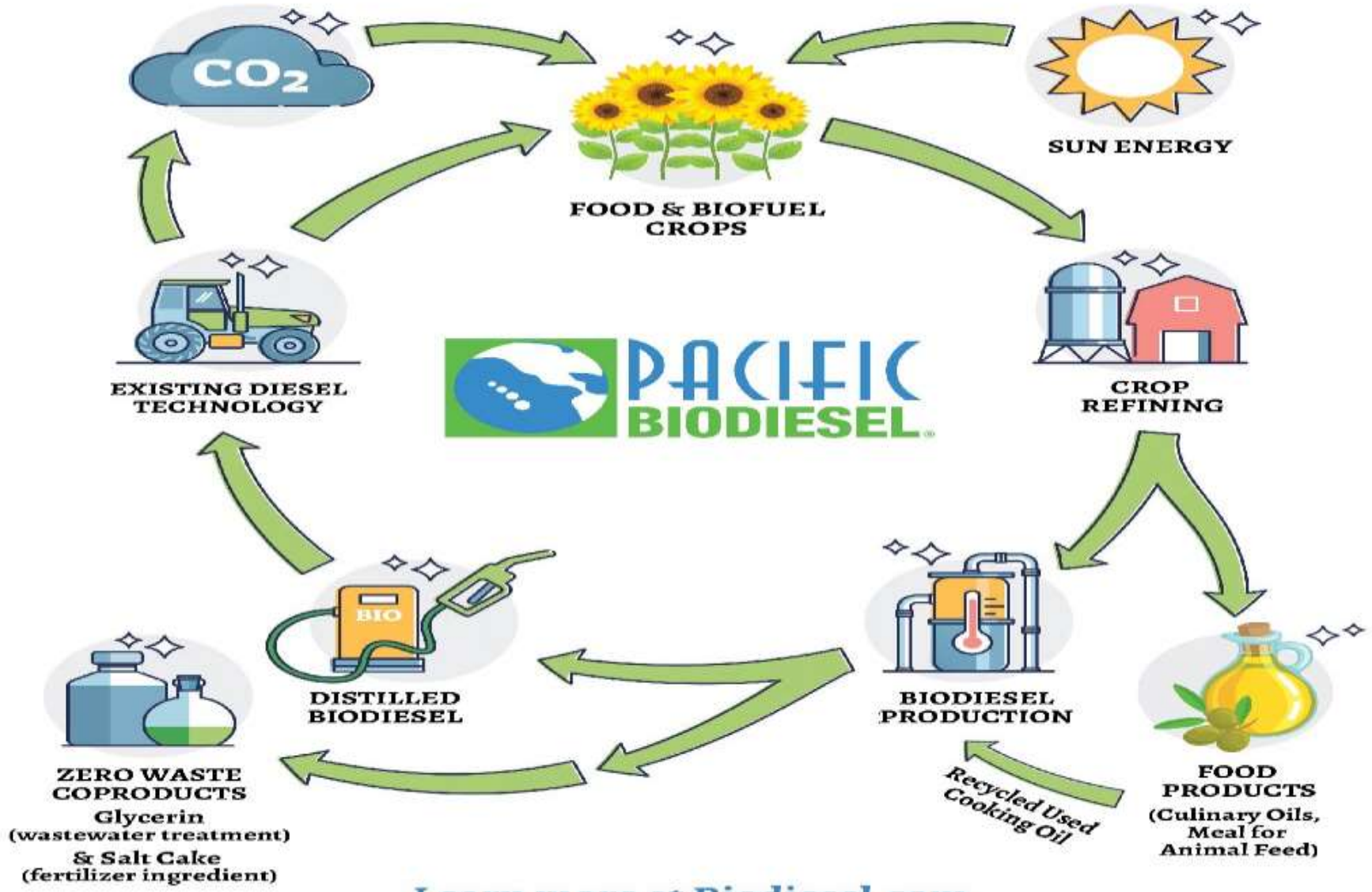
Efficiency: energy and economic

- Most of the literature on biofuels has characterized its efficiency in terms of the energy return on investment a concept pioneered by Charlie Hall in the 1980s. As noted by Hall et al., among many others, EROI is a ratio that measures the energy that one obtains from an activity compared to the energy it took to generate that activity.
- The numerator and denominator should be derived in the same units, although this has not always been done in practice. The reason why this issue has been hotly debated in the literature is because 75 years ago the EROI of petroleum in the United States was greater than 100:1
- while today it ranges from 11:1 to 20:1 at best. Consequently, alternatives to petroleum for transportation, such as biofuels, must compete against each other in this environment of decreasing EROI that places a premium on the efficiency of energy options.

A Carbon Negative, Zero-Waste

SUSTAINABLE AG & RENEWABLE ENERGY

Circular Economy Model for Hawaii



Learn more at Biodiesel.com

- The other major conventional route to produce ethanol is from sugarcane, as is dominant in Brazil and India. Ethanol production in tropical countries is more efficient because of better growing conditions and the need for fewer steps required for alcohol production in the refinery.
- Thus, the EROI is on the higher side and comparable to conservative estimates of the EROI for cellulosic ethanol. Two studies have estimated an EROI for sugarcane-based ethanol in the range of 3:1 to 10:1.
- In addition, the large-scale Brazilian ethanol program has been justified as economically efficient by reducing the amount of external debt and savings in hard currency from displaced oil imports.

Equitable distribution of biofuels and food resources

- The fair and appropriate use and distribution of biofuel resources has several dimensions. First, how are the existing biofuels industries distributed geographically.
- Second, how might this pattern change when, and if, cellulosic biofuels are commercialized? Third, are there important indirect effects of the development of the biofuels industries on other crucial resources? In this section, each of these issues will be addressed in turn.

- The existing biofuels industries (based on feed- stocks, such as cornstarch, sugarcane molasses, rape- seed oil, soybean oil, and palm oils) are highly concentrated. As shown in Table 2 for the case of global ethanol production, just two countries—the United States and Brazil—account for a significant percent- age of global output. In addition, the United States and China accounted for 40% and 6% of world corn production in 2006,

Table 2. Top ethanol-producing nations (in millions of liters per year)

Nation	2008
U.S.	34,069
Brazil	24,500
China	1,900
France	1,000
Canada	890
Germany	568
Thailand	348
Spain	317

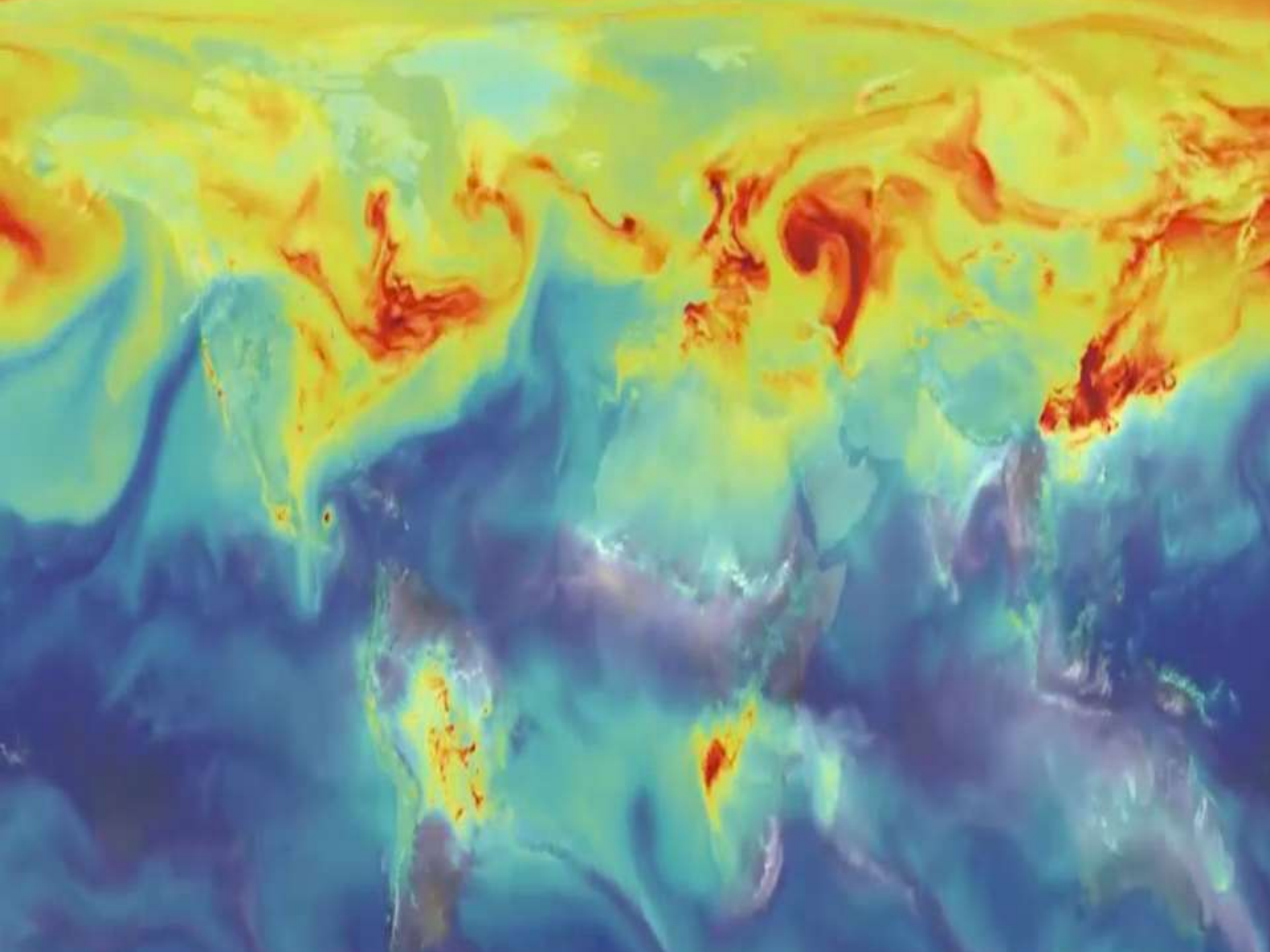
A similar geographic concentration exists for biodiesel production, with Europe accounting for around 75% of the total output (Table 3). However, these pat- terns may reflect the distribution of manufactured capital, choice of feedstock, overall transportation fuel consumption, and government policies more than geographic distribution of resources.

Table 3. Top 10 biodiesel-producing nations (in thousands of tonnes per year)

Nation	2008
Germany	2,819
U.S.	2,203
Malaysia	1,972
France	1,815
Italy	595
Belgium	277
Poland	275
Portugal	268
Austria	213
Spain	207

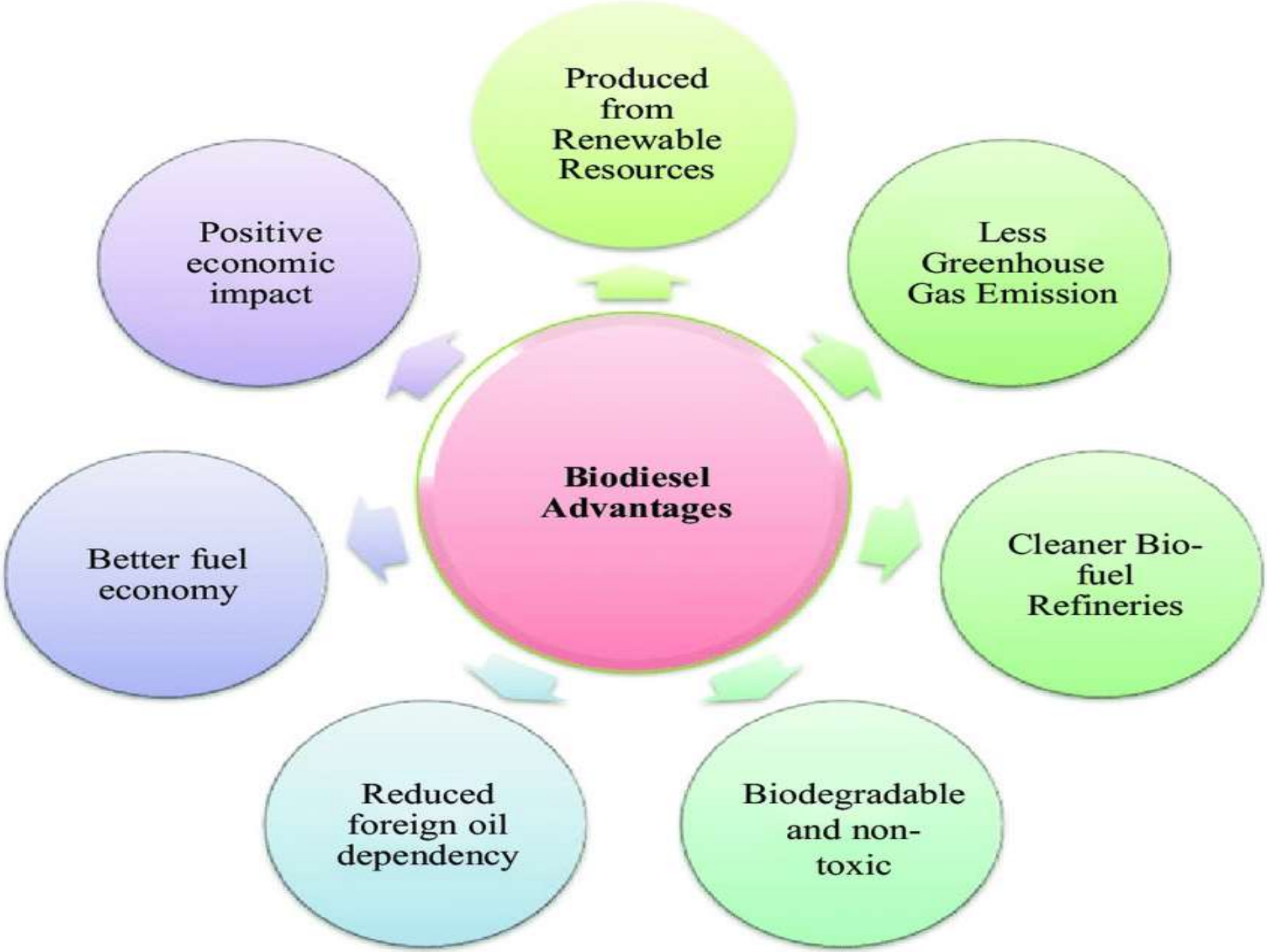
Socio-economic issues

- Related to the issues of biofuels, food security, and food prices, an expanded biofuels sector raises sustainable development challenges for rural economies. Since almost all the feedstock is located in rural areas, with the exception of municipal solid wastes, the influence of biomass energy programs on rural development is promising.
- Many such areas, especially small farms, welcome nonagri- cultural income, such as from energy resource development. Existing biofuels industries have been a major boon to rural economies and small farmers in several countries.
- Since expanded biofuels development does not guarantee benefits to small- scale producers, certification systems could help.80 In addition, liquid biofuels, such as vegetable oils and biodiesel, offer development opportunities for small- and medium-sized electric grids at the com- munity and village level



Environmental emissions and effects

- Given the predominance of gasoline and diesel fuels in transportation, most analyses of biofuels compare their emissions and environmental effects to the continued reliance on the former.
- Many researchers documented the most important environmental issues.
- Most studies have focused on environmental problems caused or exacerbated by grain-based cropping systems—especially corn- based—which include potential carbon debt,
- Greater soil erosion, nitrate and phosphorus nutrient losses, decreased ground and surface water quality, mixed effects on air quality, large water demand, and biodiversity loss. Most of these problems can be decreased by better agricultural practices and technologies, e.g., the use of no-till farming, advanced fertilizers, riparian plantings, and water conservation


Biodiesel Advantages
Produced from Renewable Resources
Less Greenhouse Gas Emission
Cleaner Bio-fuel Refineries
Biodegradable and non-toxic
Reduced foreign oil dependency
Better fuel economy
Positive economic impact

Sustainable biofuels criteria

- Given the major environmental concerns raised by large-scale biofuels development (food versus fuel, deforestation, water pollution, water scarcity, etc.), as well as the socio-economic considerations, over the last decade there has been a growing recognition of the need for development of sustainability criteria and certification standards for biofuels production and trade.
- Many Researchers existing environmental certification systems for their applicability to the growing bioenergy trade.
- The application showed how a participatory and more comprehensive approach to assessing sustainability could improve its validity, reliability, and efficiency over current approaches. In the second paper, Groom et al. made 12 timely policy recommendations to support biofuels certification standards.
- These proposals can be summarized by three general principles: promote sustainable and low-impact feedstocks with a small ecological foot- print, maintain native and essential food crop habitats, and require net carbon neutral biofuels.

Thank you