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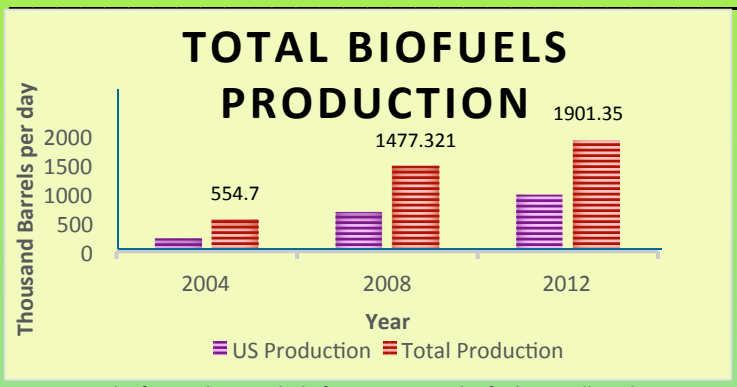
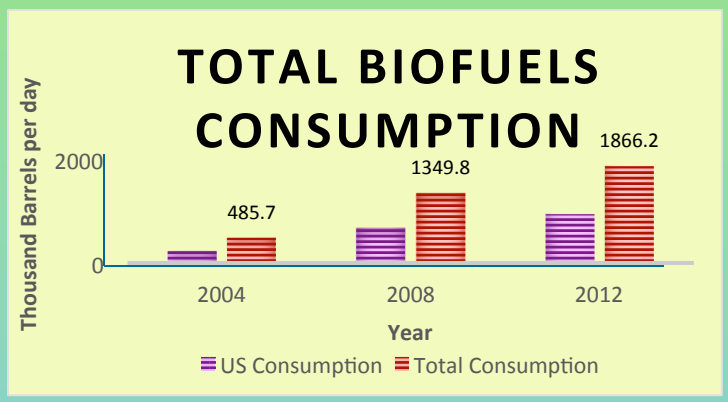
Second-Generation Biofuels



Note: The figure above include first generation biofuels as well, and thus offer a more general glance into this topic



Note: The figure above also includes information pertinent to first generation biofuels. See top right for distinguishing features.

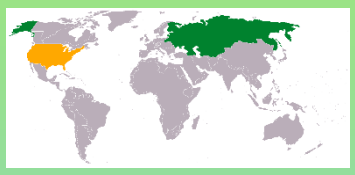
RELEVANT DRAWBACKS

- Can require anywhere from 2 through 84 times the water needed to produce an equivalent amount of energy by way of fossil fuels (Energy-Water Nexus, revisited)
- Although free of sulfur, second generation biofuels do often emit nitrates, which contribute to such phenomena as acid rain
- Generally contributes to an end product (e.g. biodiesel) with lower energy content than fossil fuels.
  - Biodiesel has roughly 90% the energy content of petroleum diesel
  - Ethanol has roughly 50% the energy content compared to gasoline

SECOND-GENERATION BIOFUELS: THE BASICS

- 2nd generation biofuels differ from the 1st generation in that they consist of *nonfood* sources and thus avoid competition with food products
- Common examples of 2nd G. materials include the following**:** short rotation forestry items (willow, poplar, etc.), perennial grasses, wood and agricultural industry residue, algae, Jatropha curcas seeds, etc.
- In contrast again to 1st generation sources, this type of fuel source is made of lignocellulose biomass (i.e. wood-like material), making extraction more complex.

MAJOR CONCERN: LAND USE

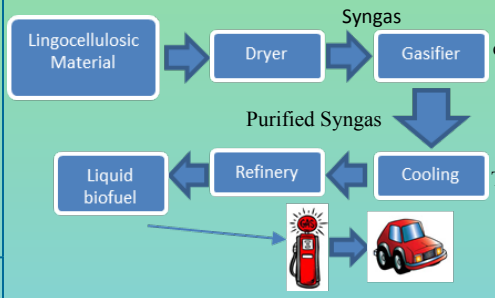


- Of large concern is the land-area needed to generate enough power through biofuel.

- For instance: Jatropha, a promising oil-seed crop, would require over 27 million square kilometers to supply the world's energy demand. This area is larger than the U.S. and Russia combined.

The gargantuan level of forest clearing necessary to meet this special requirement would almost certainly set carbon emission combatting back a period measurable in centuries.

PRODUCTION TECHNOLOGIES



I. This flow diagram illustrates one of three major processes through which carbon-rich residues are converted to synthetic gas: gasification. At its core, gasification lets heat in largely the absence of oxygen to create syngas.

Two other methods towards producing second generation biofuels proceed as follows: thermodynamic technologies and enzymatic technology.

II. Enzymatic Technology

THE CHALLENGE: this technique targets forest and agricultural residues, which by their very nature "imprison" usable sugars within the woody material

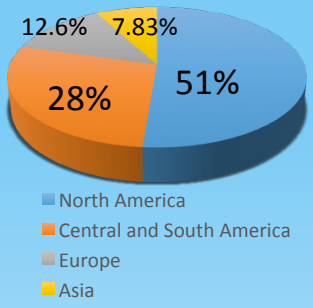
THE SOLUTION: biologically engineer specific enzymes to break through plant material

III. Thermochemical Technologies

THE CHALLENGE: this technique seeks to convert heterogeneous biomass material into usable energy, and specific enzymes thus cannot apply

THE SOLUTION: Rely on heat and cooling to purify and convert carbon-abundant materials into an end product

Geographic Comparison: Total Biofuel Production

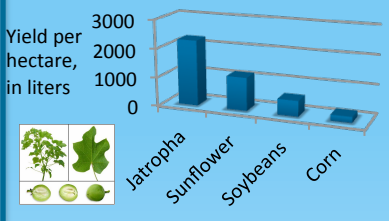


Conclusion: The majority of biofuel, including second-generation, comes from the Americas.

RELEVANT BENEFITS

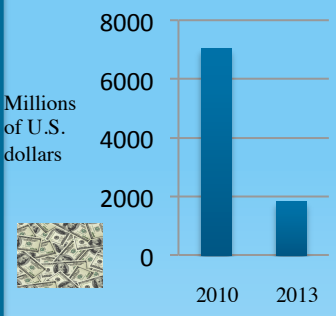
- Availability to grow on marginally-used lands
- Lower GHG contribution compared to all fossil fuels
- Status as a renewable resource
- Usability in standard internal combustion engines
- Potential to decrease domestic energy dependence on foreign regimes
- Consumed mainly for transportation, a growing sector
- *Reiteration*: No direct competition with food

COMPARISON: FIRST AND SECOND-GENERATION YIELDS



The two crops on the left constitute second-generation feedstock, and tower in comparison to the first-generation varieties on the right. Though still highly in the research and development stage, the yield of second-generation innovation remains promising

FEDERAL EXPENDITURES ON BIOFUELS



Though the U.S. government provides a variety of incentives to use biofuels, total expenditures declined dramatically (74%) from 2010 and 2013. Seeing as the second-generation is largely dependent on research and development, this is highly problematic.

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Total Production and Consumption Visuals: [7], [2]

Second-Generation: The Basics: [1], [4], [6]

Land Use Issues: [4], [6]

Production Technologies: [3], [5], [8]

Key Drawbacks: [6], [4]

Geographic Comparison: [7]

Key Benefits: [6], [4], [8]

Yield Comparisons: [4]

Federal Policy/ Funding: [7], [2]

[1] Kumar, Pawan. "Second Generation Biofuels Market Is Expected to Reach $23.9 Billion Globally by 2020." WhaTech. JD Energy, 27 Mar. 2015. Web. 14 Apr. 2015.
[2] "Monthly Biodiesel Production Report." *U.S. Energy Information Administration*. EIA, 30 Mar. 2015. Web. 14 Apr. 2015.
[3] Naaik, S.N., Vaibhav V. Goub, Prasant K. Rout, and Ajay K. Dalai. "Production of First and Second Generation Biofuels: A Comprehensive Review." *Renewable and Sustainable Energy Reviews* 14 (2010): 578-97. Web. 14 Apr. 2015.
[4] Patterson, Bob. "Competing Global Resources: Food vs. Fuel." North Carolina State University. PDF. Nov. 2011.
[5] Sabarsky, Martin. "Second-Generation Biofuels from Multi-Product Biorefineries Combine Economic Sustainability with Environmental Sustainability." N.p.: Cellana Inc., 30 July 2014. PPT.
[6] "Second Generation Biofuels." *Biofuels* -. N.p., n.d. Web. 16 Apr. 2015.
[7] "Total Biofuels Production and Consumption." *International Energy Statistics – EIA*. N.p., n.d. Web. 16 Apr. 2015.
[8] Labrie, Marie-Helen. "Gasification Technologies: Making Second-Generation Biofuels a Reality."*Biomass Magazine*. BBI International, 2015. Web. 20 Apr. 2015.