WIndiana
Indiana Renewable Energy Conference

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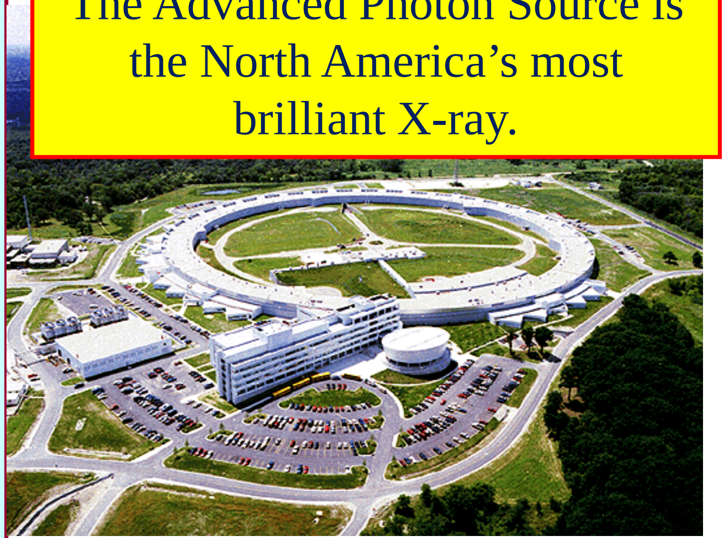
July 20 2011

Argonne National Laboratory

America's first national laboratory

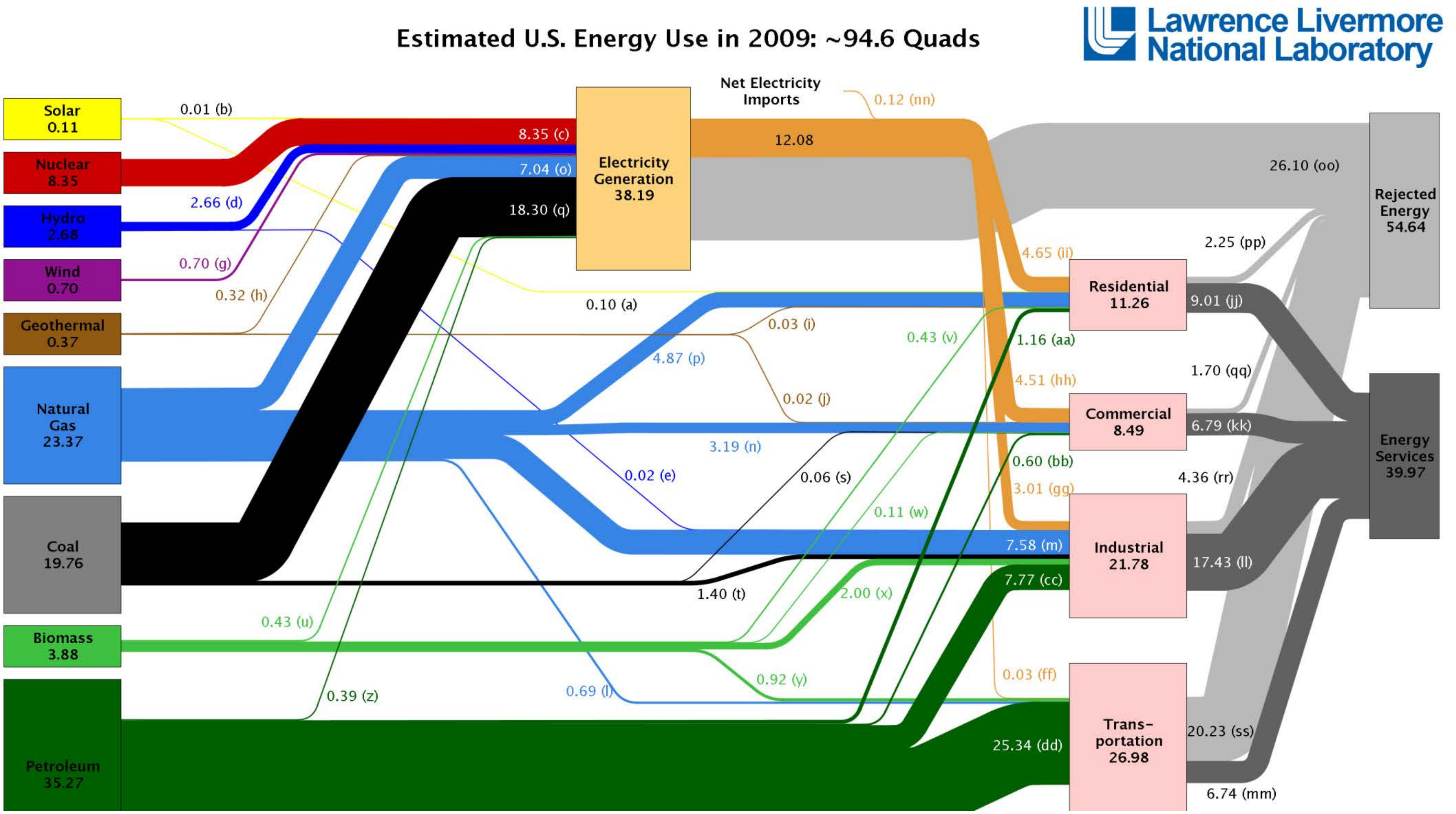
- Chartered in 1946 from Enrico Fermi's work on the Manhattan Project.
- Operating budget of $600+ million
- Center for Nanoscale Materials
- Energy Storage
- Operated by UChicago-Argonne LLC
- Science Council includes
  - Northwestern U and U of Illinois

The Advanced Photon Source is the North America's most brilliant X-ray.

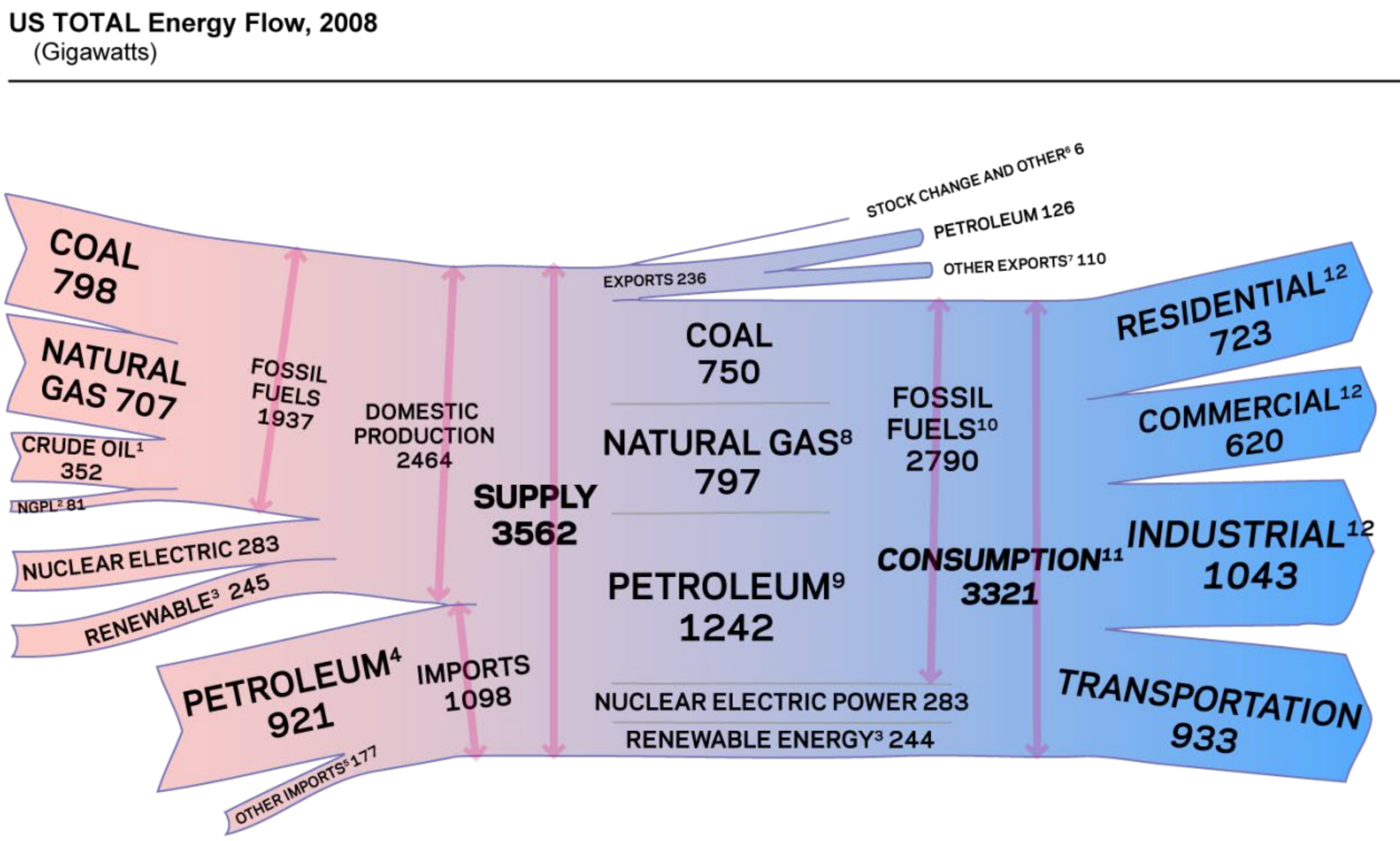


The white deer are native to Northern Africa and Europe and were a gift to Gustav Freund, the estate owner in the 1930's.

Energy Flow Slide

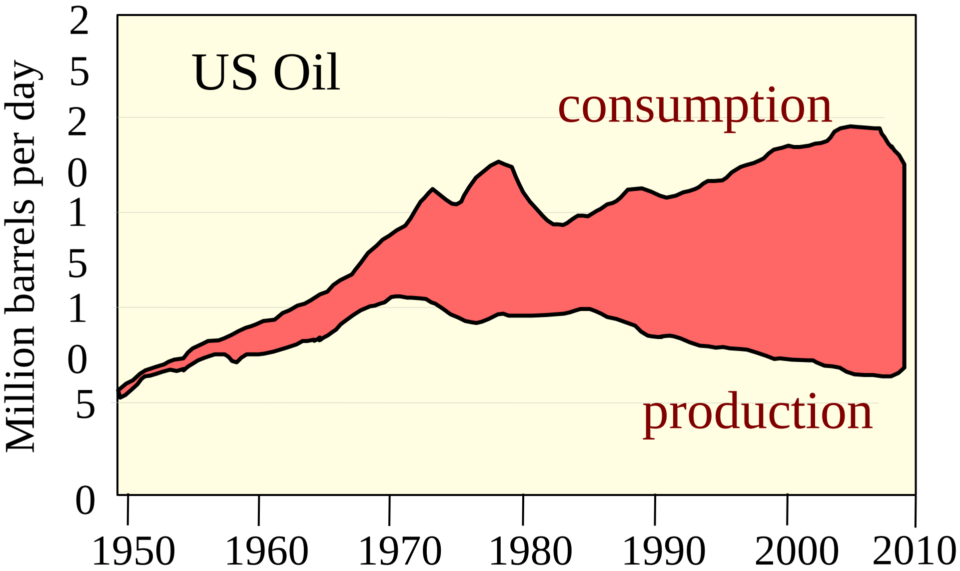


Energy Flow Slide



http://www.energyliteracy.com/ - from information from the EIA

Dependence on Imported Oil

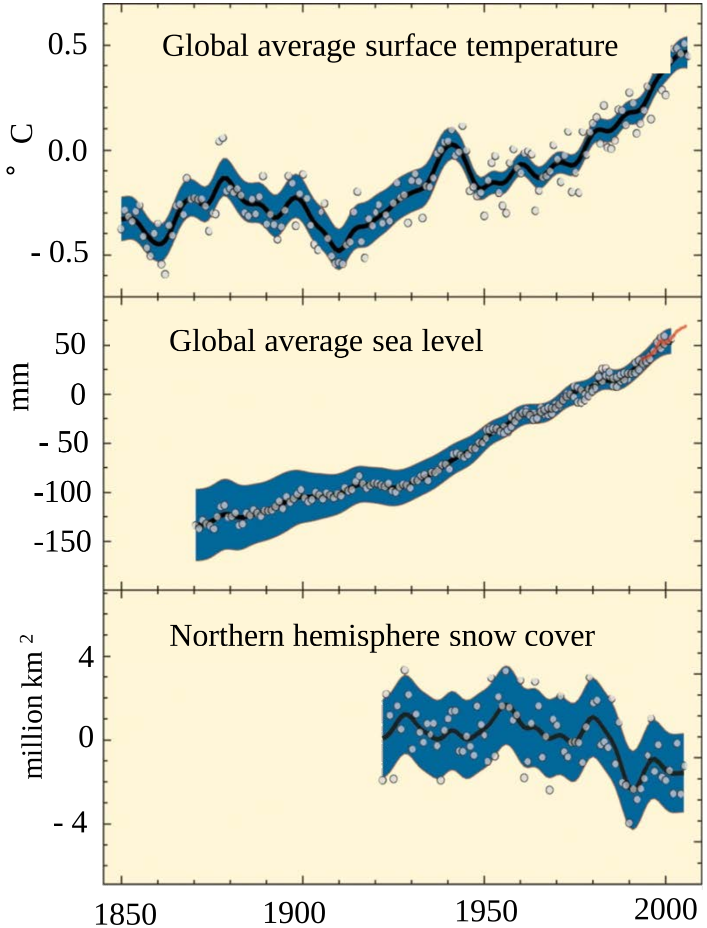


Source: EIA Annual Energy Review 2009
http://www.eia.doe.gov/aer/overview.html

- Cost to economy:
- ~$350 B/yr at current prices transferred to foreign oil producers
- Energy security ←→ Economic security ←→ National Security

http://tonto.eia.doe.gov/energy_in_brief/foreign_oil_dependence.cfm

Greenhouse Gases and Climate Change



IPCC Fourth Assessment 2007
http://www.ipcc.ch/graphics/gr-ar4-syr.htm SPM1

- 2/3 of carbon dioxide emissions come from power plants and autos
- Permanent changes in weather patterns, agricultural networks and coastal geography
- Cost of accommodation may be higher than preventive cost of reducing emissions

Current Biofuel Status

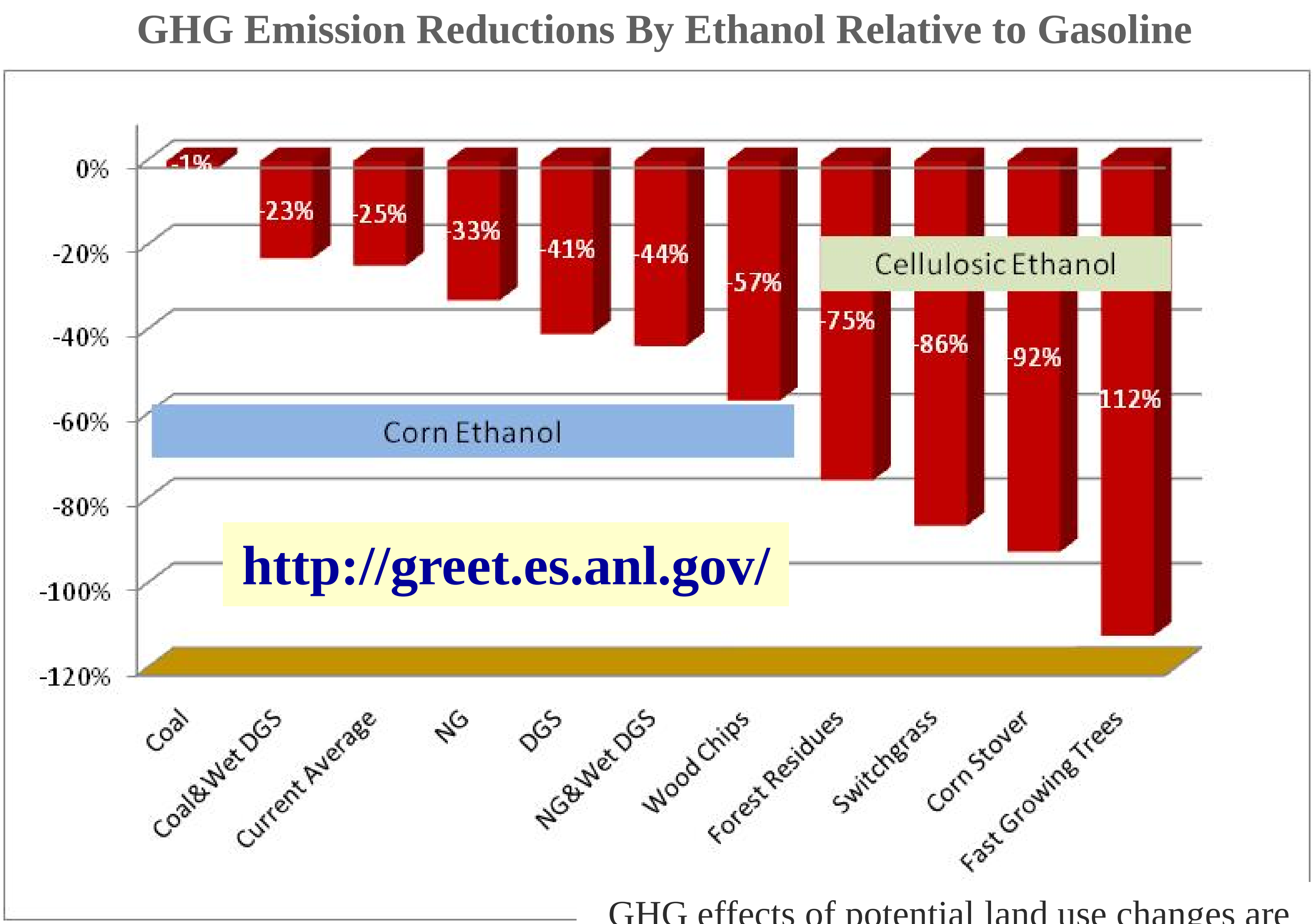
- **Current production: ~14 billion gallons/year**
  - Virtually all ethanol produced from corn
  - Essentially at the "10 % blend wall"
  - Third largest supply for US light duty vehicle fuel
  - The US is an ethanol exporter
- **45 cents/gallon tax credit**
  - Congress will likely reduce or eliminate
- **RFS2 under negotiation (EPA)**
  - Phase-in of cellulosic ethanol is be delayed
  - Pioneer plants are being commissioned
  - Blend wall was raised to 15 % for newer vehicles
- **>40 % of the corn supply is used to produce ethanol**
  - Distiller's Grains provide animal feed instead of whole corn
    - The US is a larger DDGS exporter
  - Increased corn yield is addressing the market

Critical Barriers to the *Continued* Growth of Bioenergy

- ***Policy:*** EPACT 2005, **EISA 2007**, **RFS2**, RPS, Cap and trade
- ***Sustainability:*** What are the impacts of displacement of fossil resources with biobased resources including **greenhouse gas emissions**, water utilization, and **land use changes**? For example, the current interest in algae is directly attributable to concerns on land use impacts.
- ***Compatibility:*** Both ethanol and biodiesel have experienced resistance to increasing the blend wall. Neither are currently transported or refined in the existing fuel infrastructure. There are significant efforts to produce "**drop-in fuels**" that are either blended into the existing crude oil streams could be direct replacements for gasoline, diesel, or jet fuel.
- ***Economics:*** Petroleum refineries are large integrated operations that produce a suite of fuels, chemicals, and materials with significant economies of scale. **Biorefineries** do not offer the same economies of scale so the compete economically they require low cost feedstocks, efficient processing, and a suite of value added products.

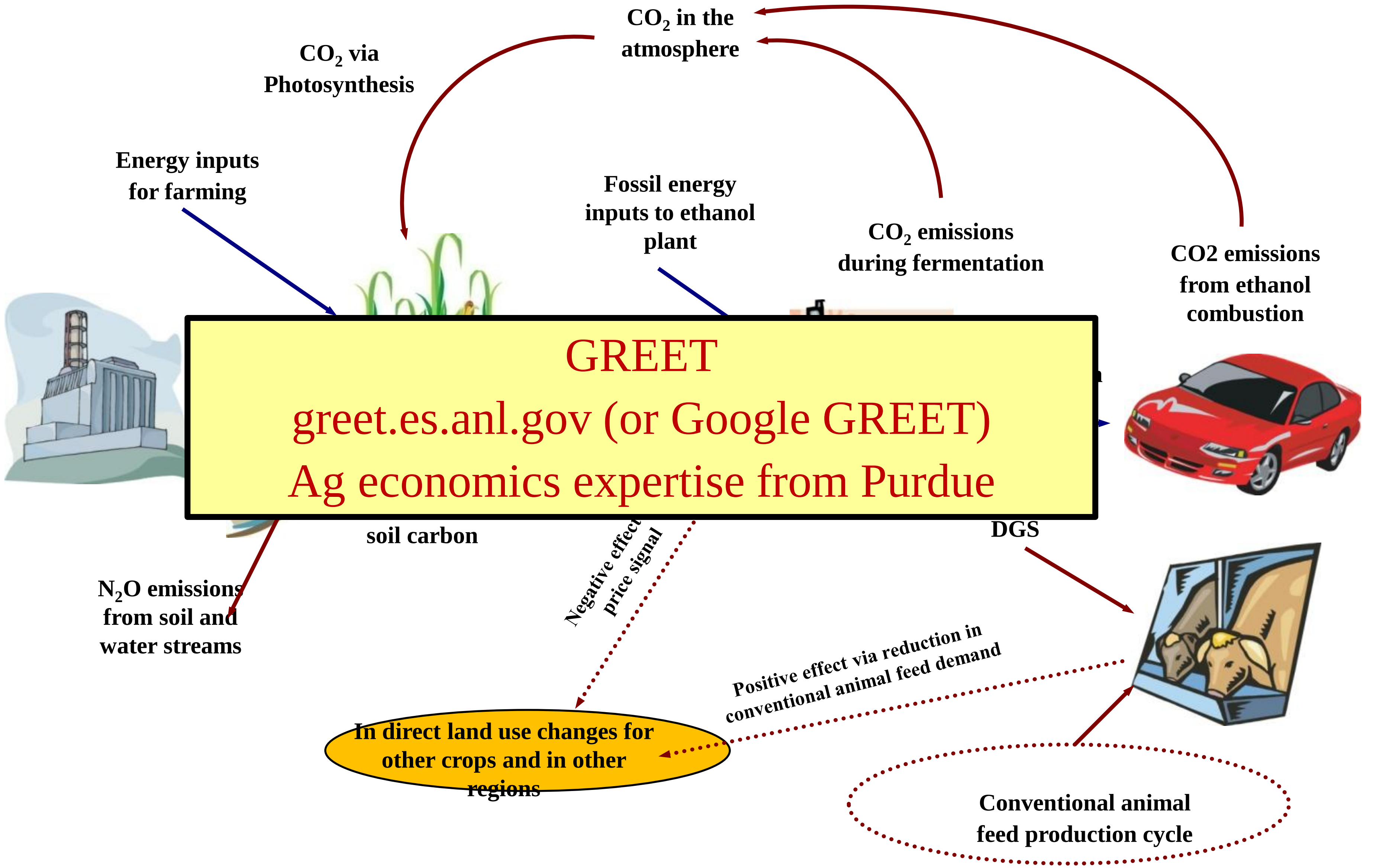
Sustainability

GHG Emissions of Corn Ethanol Vary Considerably Among Process Fuels in Plants



GHG effects of potential land use changes are not fully included in these results.

Land Use Change in The Context of Biofuel LCAs

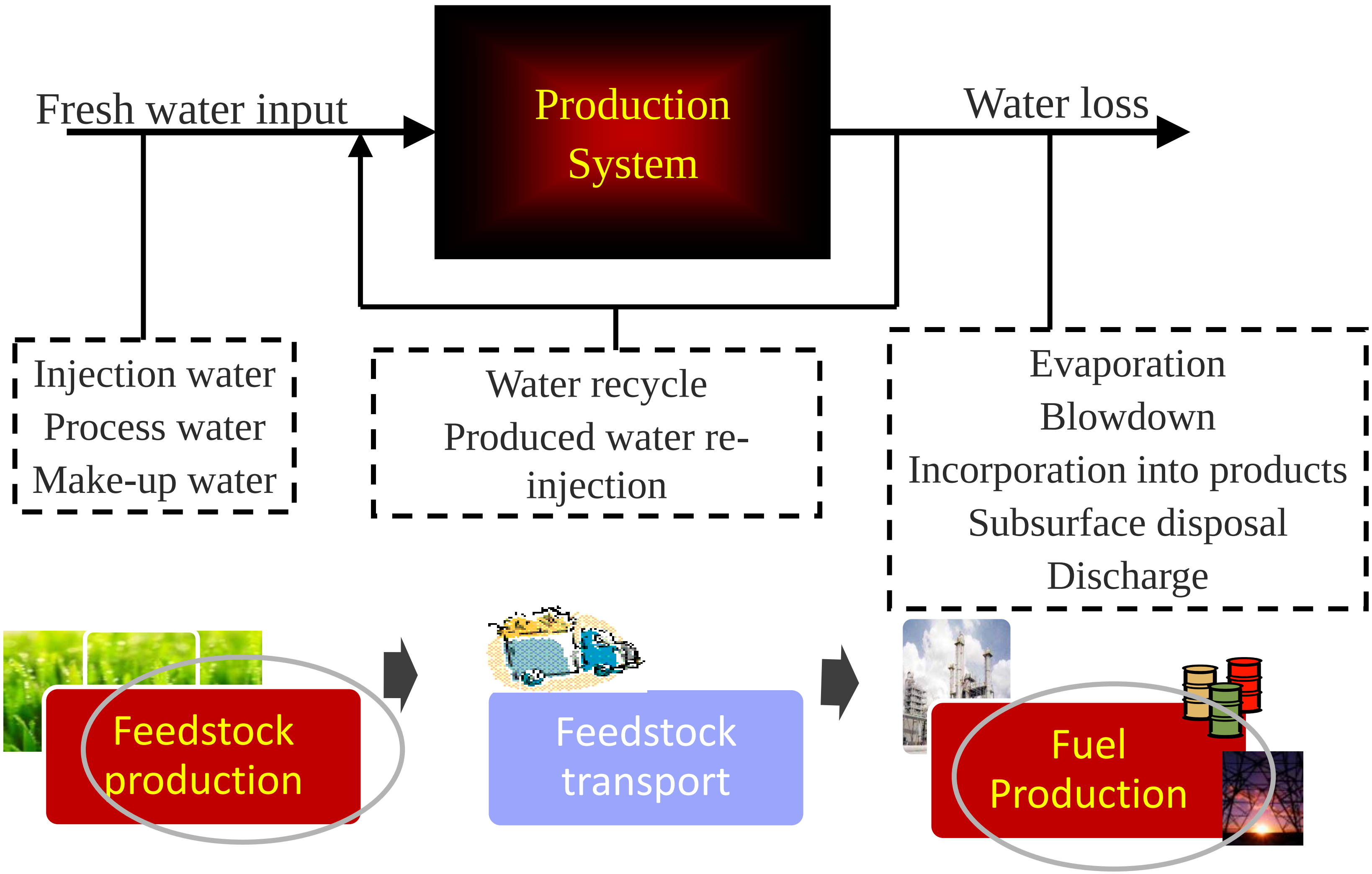


GREET

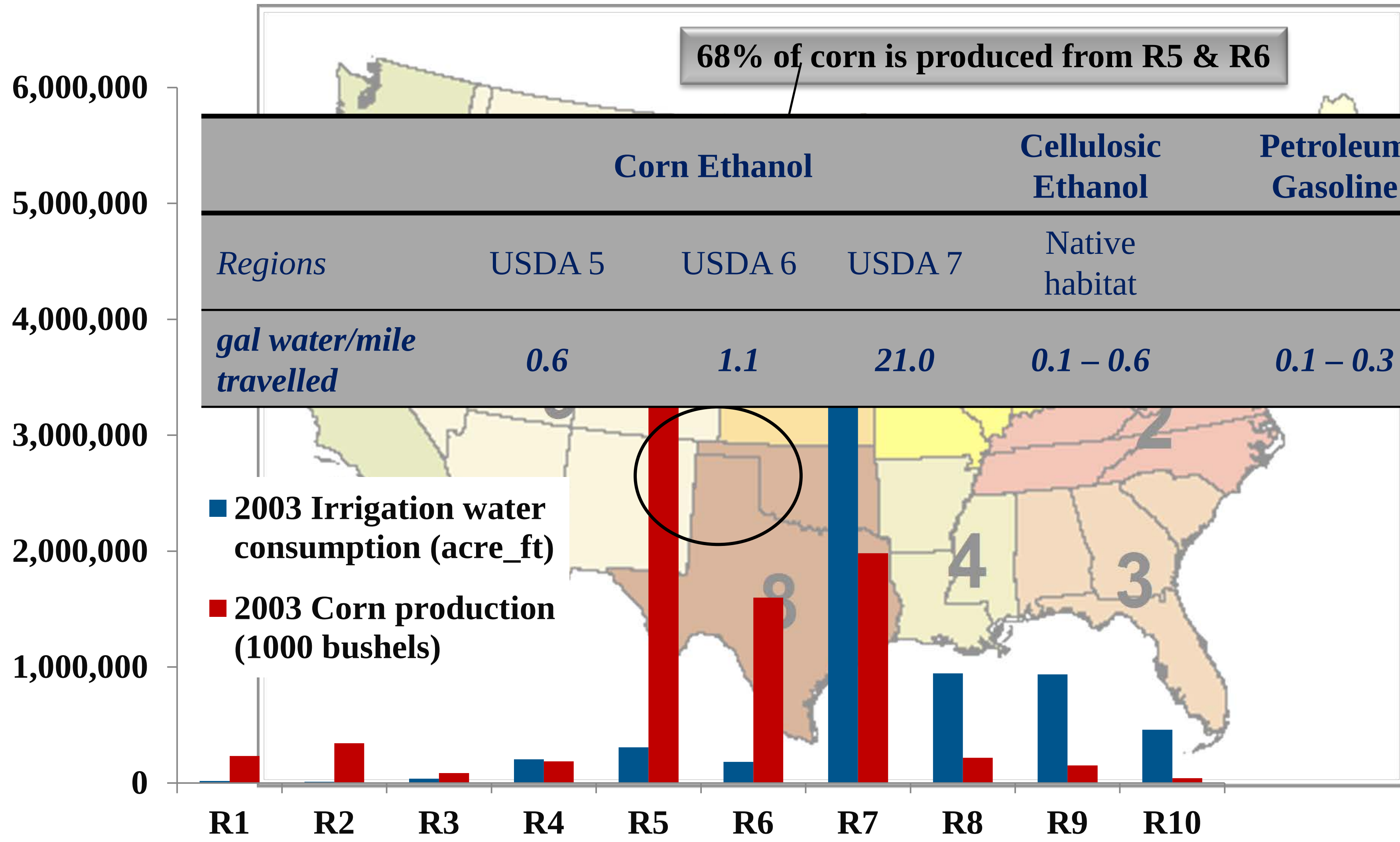
greet.es.anl.gov (or Google GREET)

Ag economics expertise from Purdue

Determine Water Consumption Factor

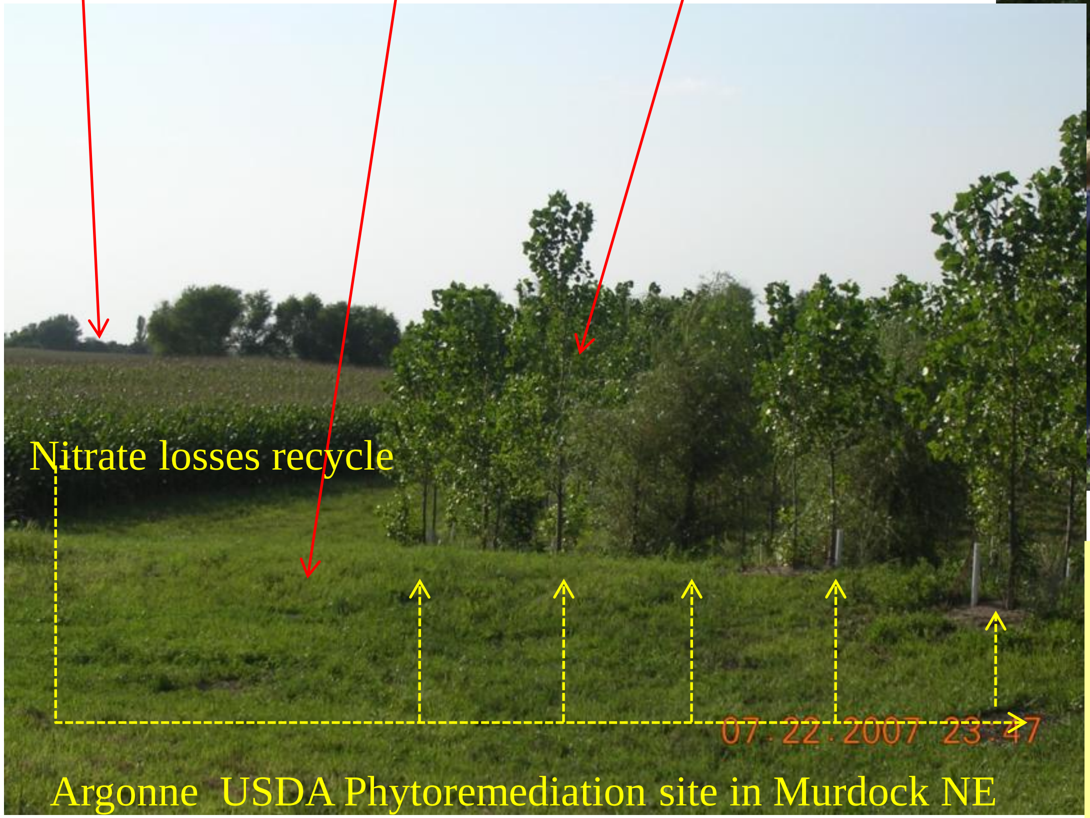


Substantial Variations In Corn Production and Irrigation Among The Ten Regions



	Corn Ethanol			Cellulosic Ethanol	Petroleum Gasoline
Regions	USDA 5	USDA 6	USDA 7	Native habitat	
gal water/mile travelled	***0.6***	***1.1***	***21.0***	***0.1 – 0.6***	***0.1 – 0.3***

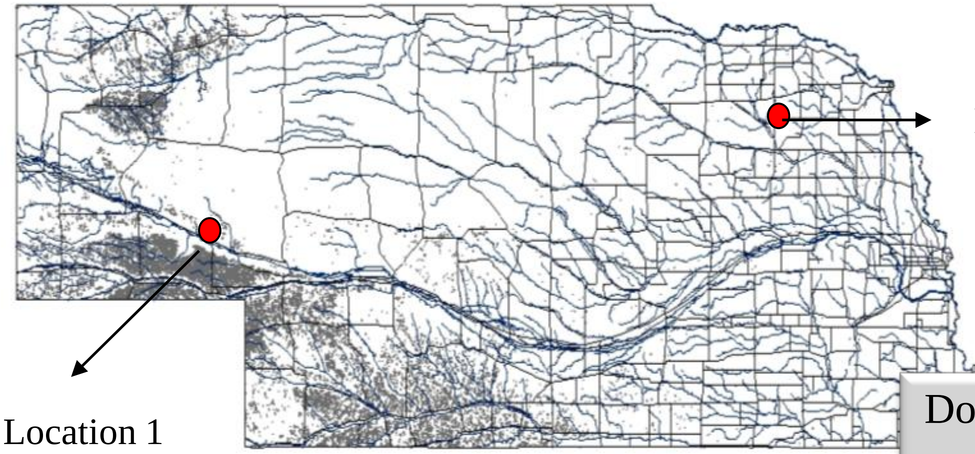
Enhanced productivity and better use of resources. - Murdock, Nebraska



- More than a riparian buffer:
  - An engineered, integrated biorefinery feedstock production model.

Intensification of feedstock supply to biorefineries

assuming a 25 mile radius supply area, for a 80 MGY ethanol plant



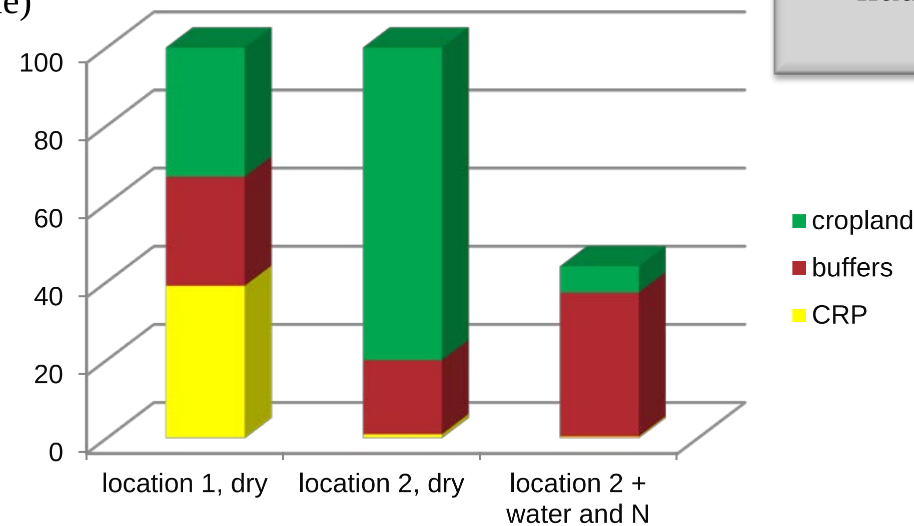
Location 2 (little CRP land)

Hypothetical locations of biorefineries

Location 1 (CRP land available)

Doubling yields of cellulosic feedstock are possible through the use of nutrients and water from N-rich, degraded water resources

Acreage required (thousand acres) to supply a 80 MGY ethanol plant



Fairbury IL Partnerships & Monitoring

Enabling the present and future work, Outreach and sounding board

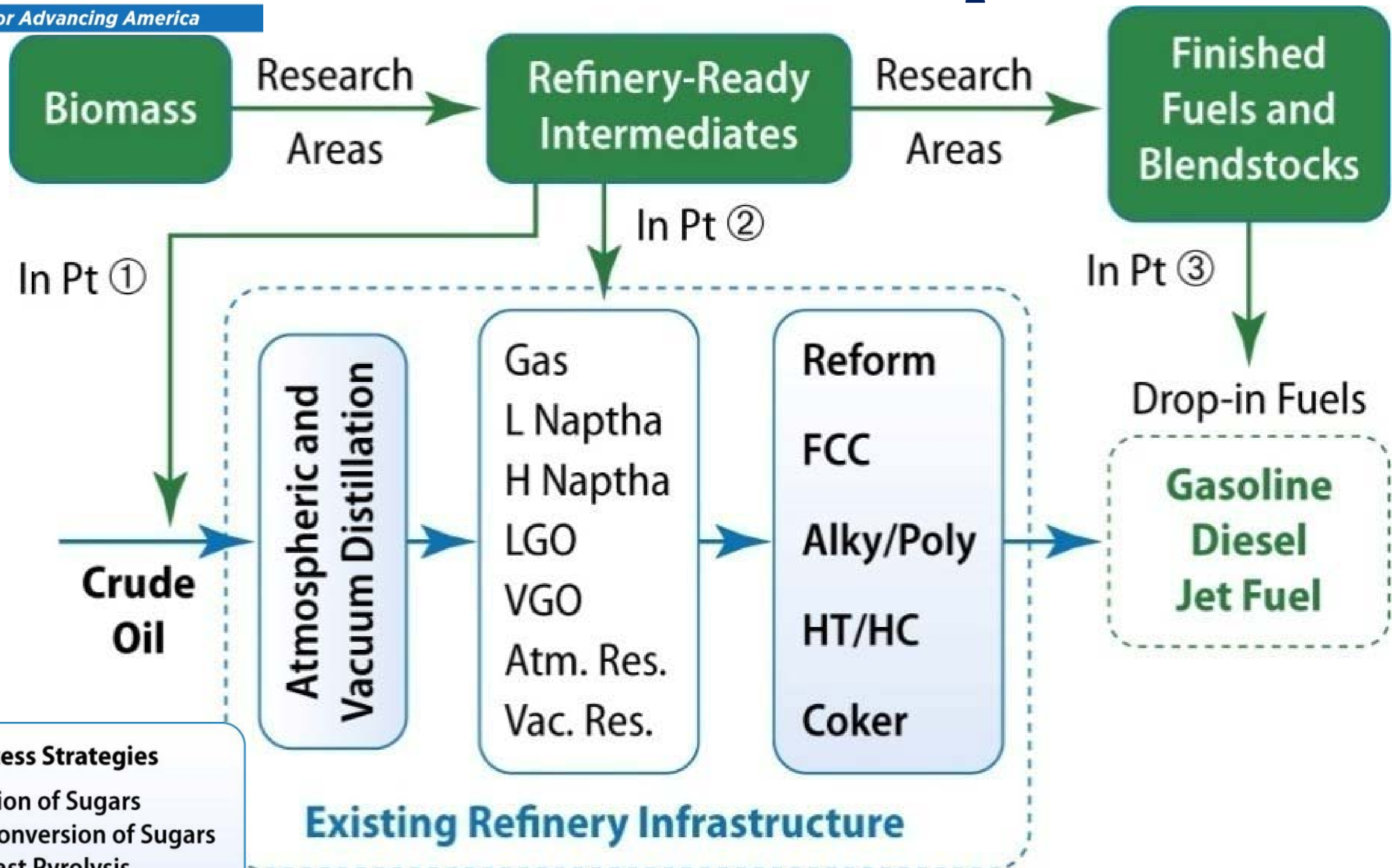
Demonstrate at the field scale GHG emissions, water quality and productivity of riparian biomass compared to usual practices; provide data to transition to watershed-scale studies and models.

Compatibility

NABC National Advanced Biofuels Consortium

Biofuels for Advancing America

National Advanced Biofuels Consortium - Drop-in Fuels



Six Process Strategies

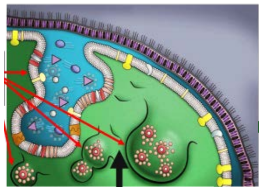
1) Fermentation of Sugars
2) Catalytic Conversion of Sugars
3) Catalytic Fast Pyrolysis
4) Hydropyrolysis
5) Hydrothermal Liquefaction
6) Syngas to Distillates

$35 M ARRA funding

NREL, PNNL, etc

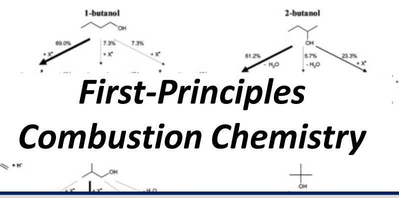
Integrated Biofuel / Engine Design

Approach: a system-level, iterative feedback loop – new feedstocks, processing, combustion science, modeling, real-world testing, optimization, and life-cycle analysis.

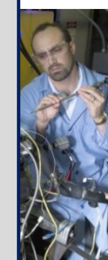


Feedstock Opti...

Bio-based Feedstock Selection



First-Principles Combustion Chemistry



- Classical approach has been to make biofuel mimic petroleum based fuel
- Engine/vehicle flexibility has made this approach archaic
- This project focuses on an integrated process for biofuel creation, production, and utilization.

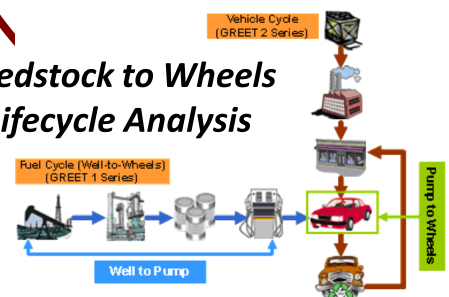
Catalyst Design and Synthesis

Chemical Processes

in situ Testing and Characterization

Production

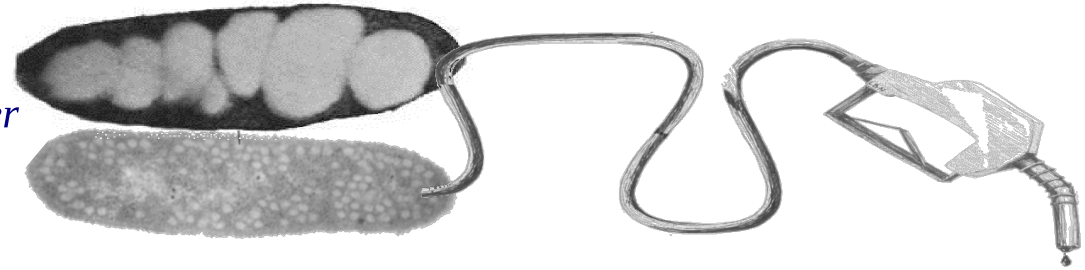
Feedstock to Wheels Lifecycle Analysis



Vehicle Integration

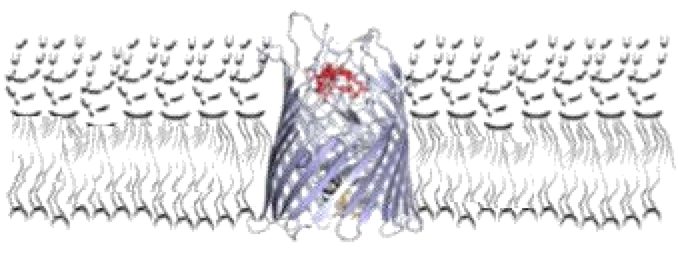
Next Generation Biofuels & Bioproducts

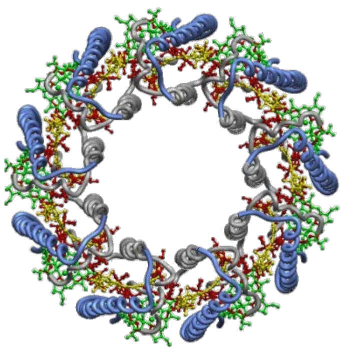
Rhodobacter



biofuel
spigot

Direct designer fuel production using photosynthetic bacteria





Phytol

Isoprenol

Shorter chain terpenes and isoprenoids

Precursors for plastic synthesis

Designer hydrocarbons

Novel lipids

Nutraceuticals

Acknowledgements

These R&D projects are financially supported by DOE EERE Office of the Biomass Program and EERE Assistant Secretary Technology Commercialization Fund. RW-EDI technology developments were supported by DOE Industrial Technologies Program and the Office of Fossil Energy & LDRD

Life cycle analysis **-** Michael Wang, May Wu, Jennifer Dunn, Ignasi Palou-Rivera, Ed Frank

Trees **-** M. Cristina Negri, Gayathri Gopalakrishnan, Paul Benda

Catalysis – Drop-in Biofuels Jeff Miller, Joe Libera, Ted Krause, Jeff Elam, Anil Mane, Angel Yanguas-Gil

Integrated Biofuel/Engine Design – Doug Longman, Mike Davis, Steve Klippenstein, Som Sibendu, Lisa LaRocco, Phil Laible

Bioprocessing **-** YuPo Lin, Mike Henry, Saurav Datta, Ed St. Martin, Cindy Millard, Dimple Kundiyana, Sabeen Ahmad, Tony Fracaro

- ***Sustainability***
  - GHG, Land, Water, Feedstocks
  - Algae
- ***Compatibility***
  - Drop-ins, Products, Production, Distribution, Utilization
- ***Economics***
  - Feedstocks, Production, Efficiency, Co-products
  - Biogas
- ***Policy***
  - Blend wall, GHG reduction, tax credits