ALTERNATIVE ENERGY DEVELOPMENTS

[WITH EMPHASIS ON LOUISIANA]

Presentation to

Louisiana Section
Air & Waste Management Association
Fall Conference
Environmental Focus 2008

By
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LSU Center for Energy Studies

November 18, 2008

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ALTERNATIVE ENERGY DEVELOPMENTS

PRESENTATION OUTLINE

- Introduction
- Conventional Energy
- Electricity Generation
- Unconventional Energy
- Waste-to-Energy
- Renewable Energy
- Transportation
- Conclusions

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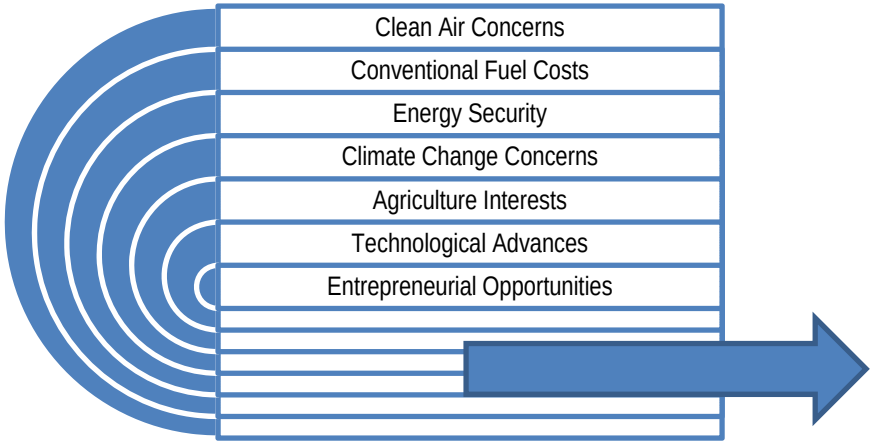
Introduction – Convergence of Factors



E85 85% Ethanol www.E85Fuel.com

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Energy Picture for Louisiana

Conventional Energy Sources:

- Oil
  - Louisiana ranks 4th in the nation in crude oil production behind TX, AK, and CA.
  - Louisiana state lands oil production (2007) = 54 million barrels
  - Louisiana state lands proved reserves (2007) = 458 million barrels
  - Louisiana OCS oil production (2007) = 372 million barrels
  - Louisiana OCS proved reserves (2007) = 3.32 billion barrels
  - Louisiana proved reserves (state lands and federal offshore) = 3.778 billion barrels or about 18% of U.S. total.
- Natural Gas
  - Including output from the OCS, Louisiana ranks 2nd in the nation in natural gas production
  - Louisiana state lands gas production (2007) = 1.257 trillion cubic feet (tcf) dry natural gas
  - Louisiana state lands proved reserves (2007) = 10.045 tcf dry natural gas
  - Louisiana OCS gas production (2007) = 2.066 tcf dry natural gas
  - Louisiana OCS gas reserves (2007) = 11.090 tcf dry natural gas
  - Louisiana proved reserves (state lands and federal offshore) = 21.135 tcf dry natural gas or about 9% of U.S. total with 831 million barrels of natural gas liquids.
- Coal (Lignite)
  - Louisiana has an estimated 1 billion tons of identified coal reserves consisting entirely of lignite.
  - Louisiana's two operating lignite mines have over 300 million tons of recoverable lignite.

Source: EIA (October, 2008)

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Conventional Energy : Natural Gas

USGS
science for a changing world

National Assessment of Oil and Gas Fact Sheet

Assessment of Undiscovered Gas Resources in the Upper Cretaceous Tuscaloosa and Woodbine Formations, Western Gulf Province of the Gulf Coast Region, Louisiana and Texas, 2007

Using a geology-based assessment methodology, the U.S. Geological Survey estimated a mean of 20.8 trillion cubic feet of undiscovered natural gas and a mean of 0.60 billion barrels of undiscovered natural gas liquids in the Western Gulf Province of the Gulf Coast Region, Louisiana and Texas.

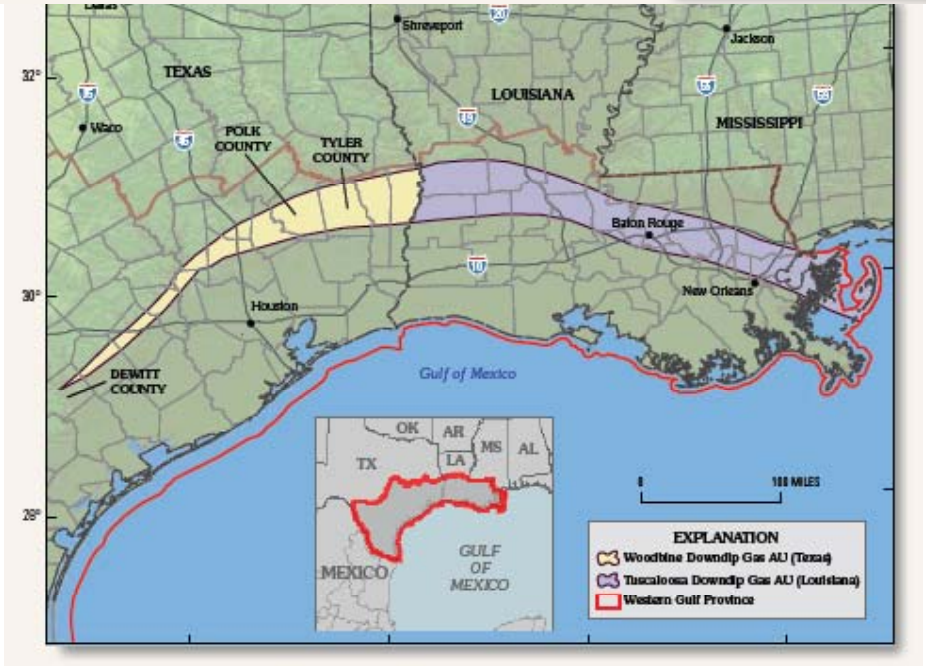

Figure 1. Map of the Western Gulf Province of the Gulf Coast region showing distribution of the Tuscaloosa Downdip Gas and Woodbine Downdip Gas Assessment Units (AU) in the Upper Cretaceous Tuscaloosa-Woodbine Total Petroleum System.

USGS estimates a mean of 20.8 tcf of undiscovered natural gas and a mean of 600 million barrels of undiscovered natural gas liquids.

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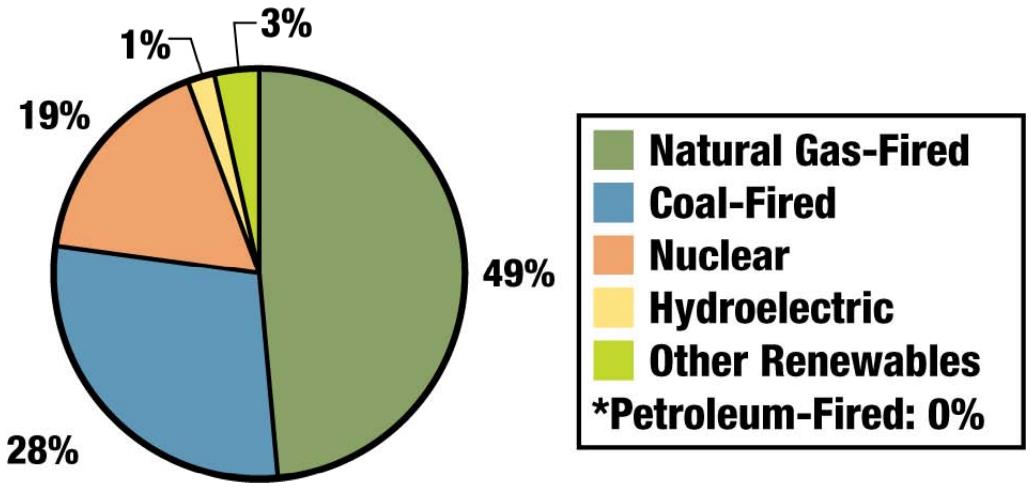
Louisiana Electricity Generation



- Net generating capacity of 92.6 million megawatthours (2005)
- In 2005, 58% of generating capacity came from electric utilities and 42% came from independent power producers (IPPs) and cogeneration.
- Louisiana is a marginal net importer of electricity.
- PSC/Entergy has a pilot green pricing program with a 2.5 cent/kWh premium.

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Energy Picture for Louisiana

Non-Conventional Energy Sources:

- **Heavy Oil** (Est. 2 billion barrels – new production techniques promising)
- **Potential CO2 Enhanced Oil Recovery** (Est. 9.4 billion barrels)
- **Petroleum Coke** (LA produces an est. 10 million tons annually)
- **Coal/Petroleum Coke Gasification** (Two recently announced major projects – ~340 bcf synthetic natural gas)
- **Shale Gas** (Haynesville play – estimated 34 tcf recoverable gas)
- **Coal Bed Methane** (Est. 1 trillion cu.ft. in Gulf Coast deposits)
- **Coal-Derived Liquids** (CTL costly ~$1 billion/10,000 bpd)

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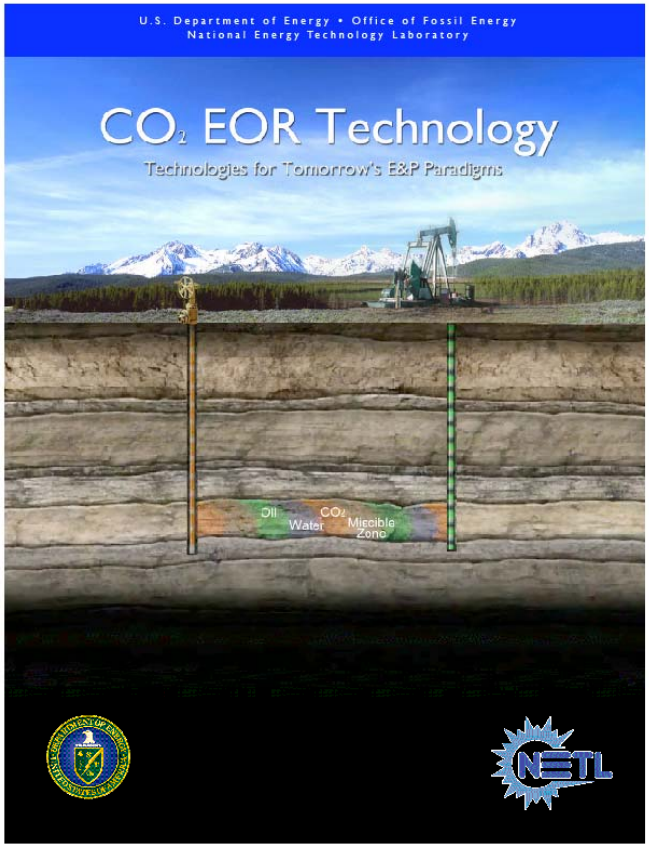
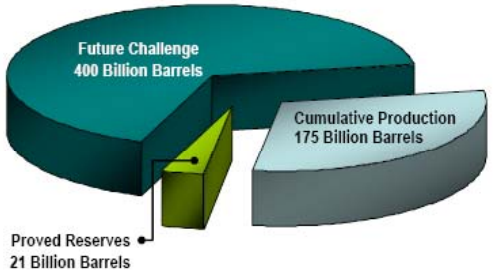
Unconventional Energy : CO_2-Enhanced Oil Recovery (CO_2-EOR)



Large Volumes Of Domestic Oil Remain "Stranded" After Traditional Primary/Secondary Oil Recovery

Original Oil In-Place: 596 B Barrels*

"Stranded" Oil In-Place: 400 B Barrels*

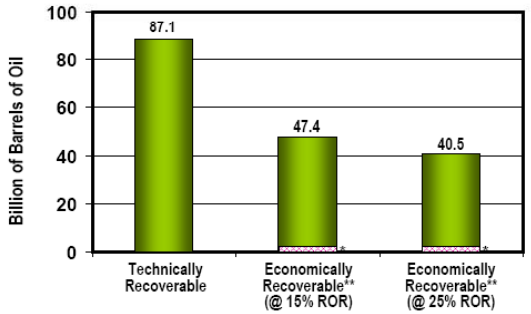


*Based on field-by-field assessment of over 2,011 large U.S. oil fields accounting for 74% of domestic oil production; excludes deep-water GOM.
Source: Advanced Resources International (2008)

May 6, 2008

Advanced Resources International

Domestic Oil Resources Technically and Economically Recoverable w/CO_2-EOR



*Already produced or place into proved reserves with CO2-EOR.
**Assuming oil price of $70/B (real); CO2 costs (delivered to field at pressure) of $45/metric ton ($2.38/Mcf); investment hurdle rate (15% and 25% ROR, real).

May 6, 2008

Advanced Resources International

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Unconventional Energy : CO_2-Enhanced Oil Recovery (CO_2-EOR)

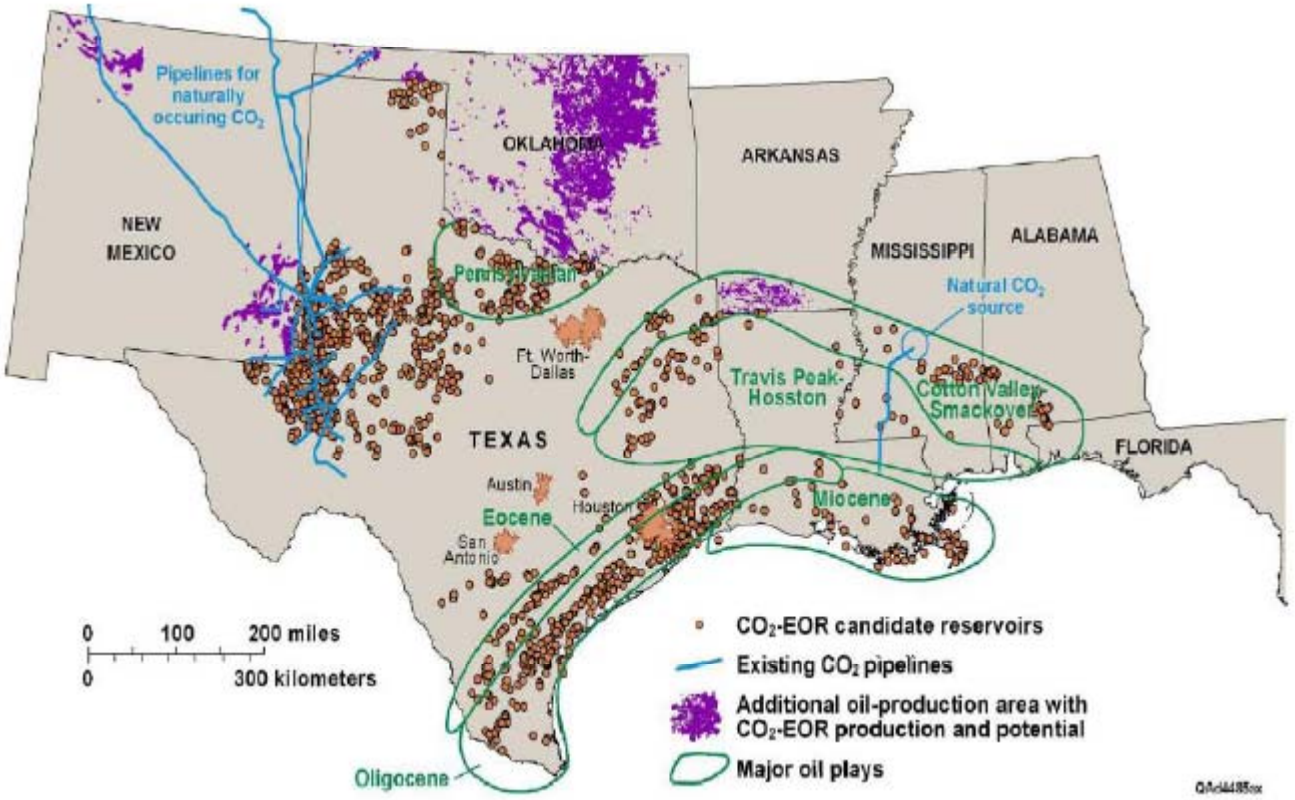

Figure 21 Areas with miscible CO_2 –EOR Potential [8]

Source: Pone & Kim (2006)

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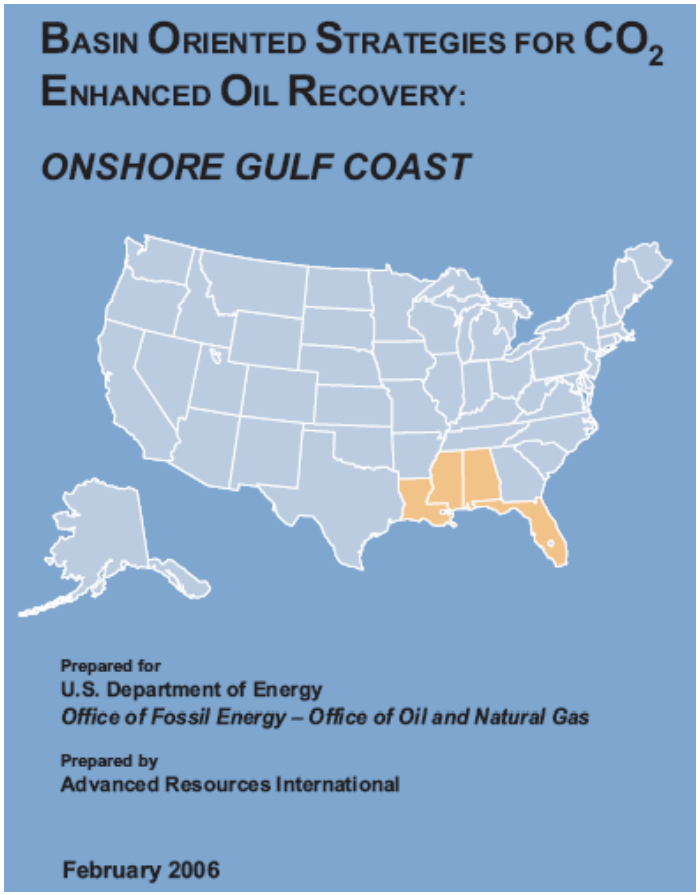
Unconventional Energy : CO_2-Enhanced Oil Recovery (CO_2-EOR)



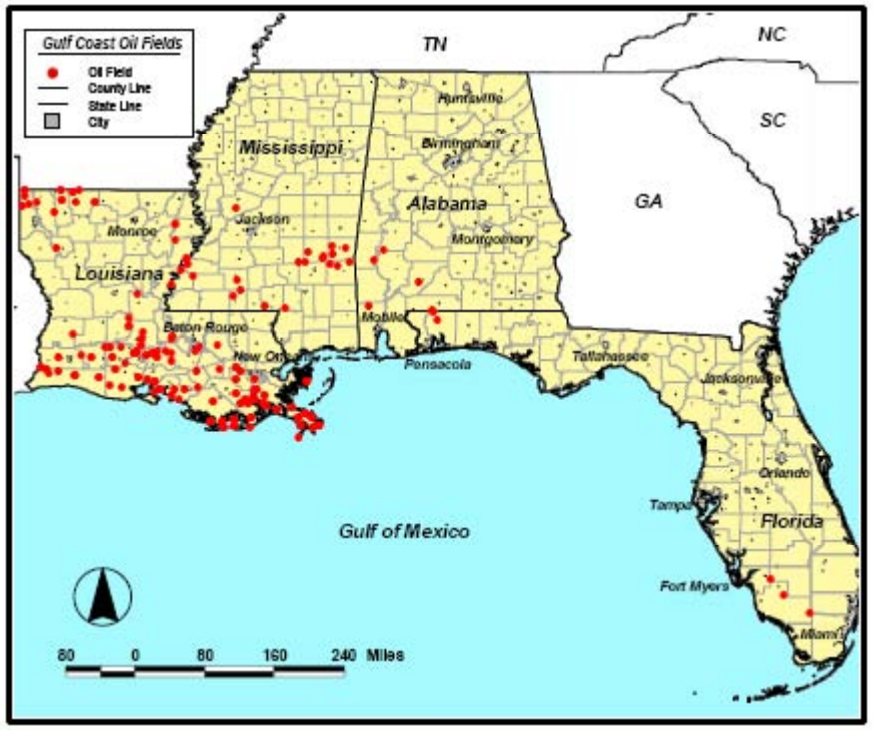


Table 2. The Gulf Coast Region's "Stranded Oil" Amenable to CO_2-EOR

Region	No. of Reservoirs	OOIP (Billion Bbls)	Cumulative Recovery/ Reserves (Billion Bbls)	ROIP (Billion Bbls)
Louisiana	128	16.1	6.7	9.4
Mississippi	20	1.9	0.7	1.2
Alabama	5	0.8	0.3	0.5
Florida	5	1.3	0.5	0.8
TOTAL	158	20.1	8.2	11.9

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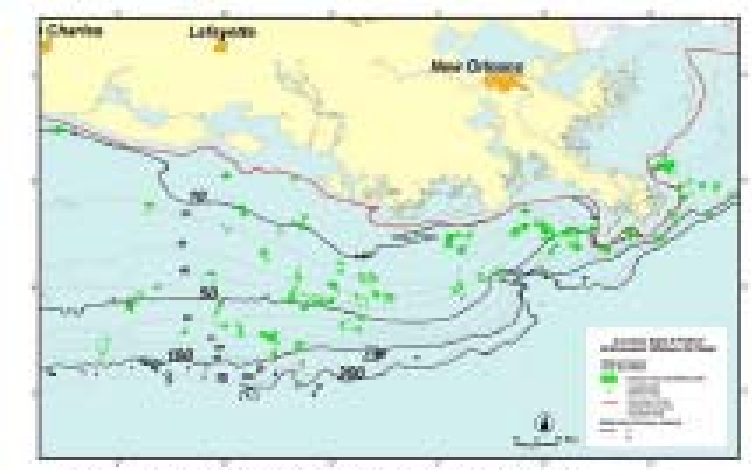
Unconventional Energy : CO_2-Enhanced Oil Recovery (CO_2-EOR)



Offshore Louisiana Fields with Future Incremental Oil Recovery Potential

Estimates of Technical Recoverable Oil Resources in the Louisiana Offshore

	No. of Fields	OOIP (MM Bbls)	Technically Recoverable (MM Bbls)
State Offshore	12	1,100	237
Federal Offshore	87	20,950	4,213
Total	99	22,050	4,450

Economic Benefits of Producing Incremental Oil from CO_2-EOR

Assuming that 3.6 billion barrels are developed over a 40-year time frame, by 2025 this would amount to:

- Incremental crude oil production of 200,000 to 250,000 barrels per day
- Over 8,000 jobs retained by the Louisiana oil and gas industry
- Increased economic activity in Louisiana amounting to over $500 million per year
- Increased state and federal revenues of over $250 million per year.

BASIN ORIENTED STRATEGIES FOR CO_2 ENHANCED OIL RECOVERY:

OFFSHORE LOUISIANA

Prepared for:
U.S. Department of Energy
Office of Fossil Energy – Office of Oil and Natural Gas

Prepared by:
Advanced Resources International, Inc.

March 2005

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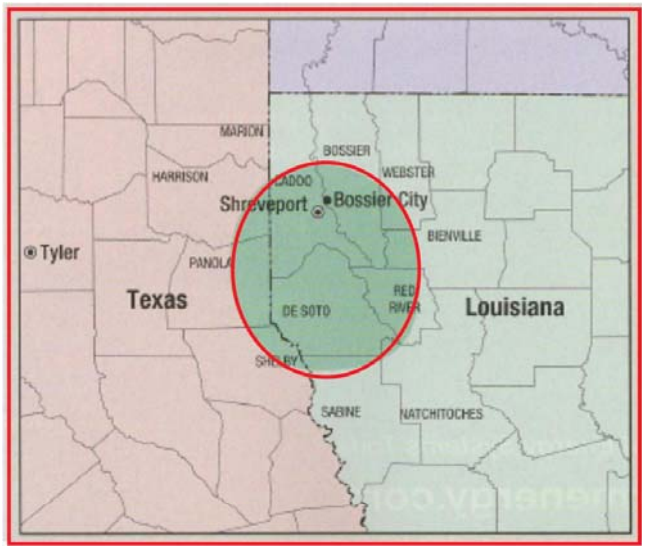
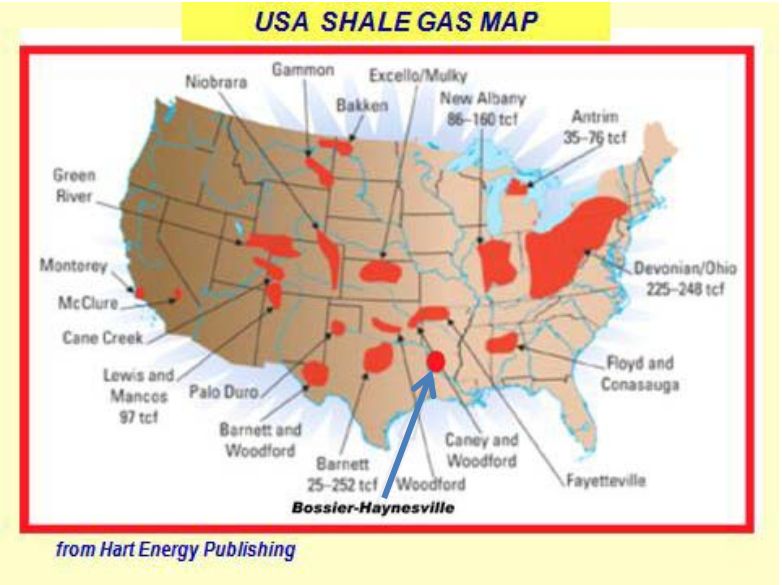
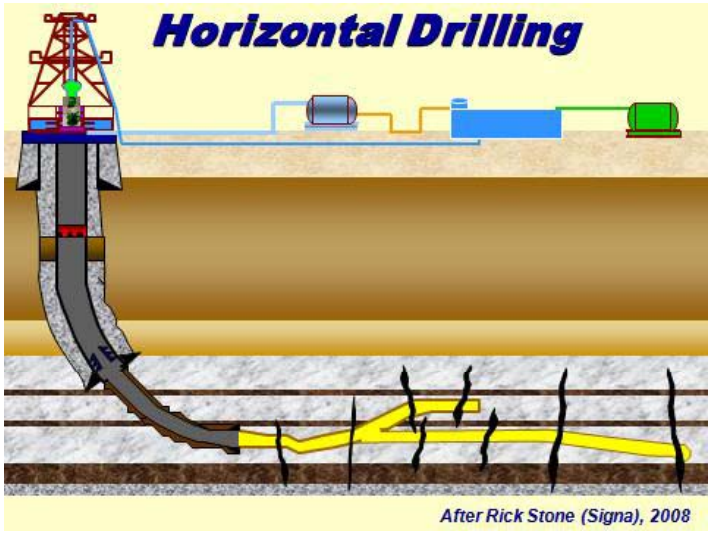
Unconventional Energy : Shale Gas





Bossier-Haynesville Drilling Activity

Gas in Place = 250 – 320 TCF
Estimated Recoverable Gas = 34 TCF



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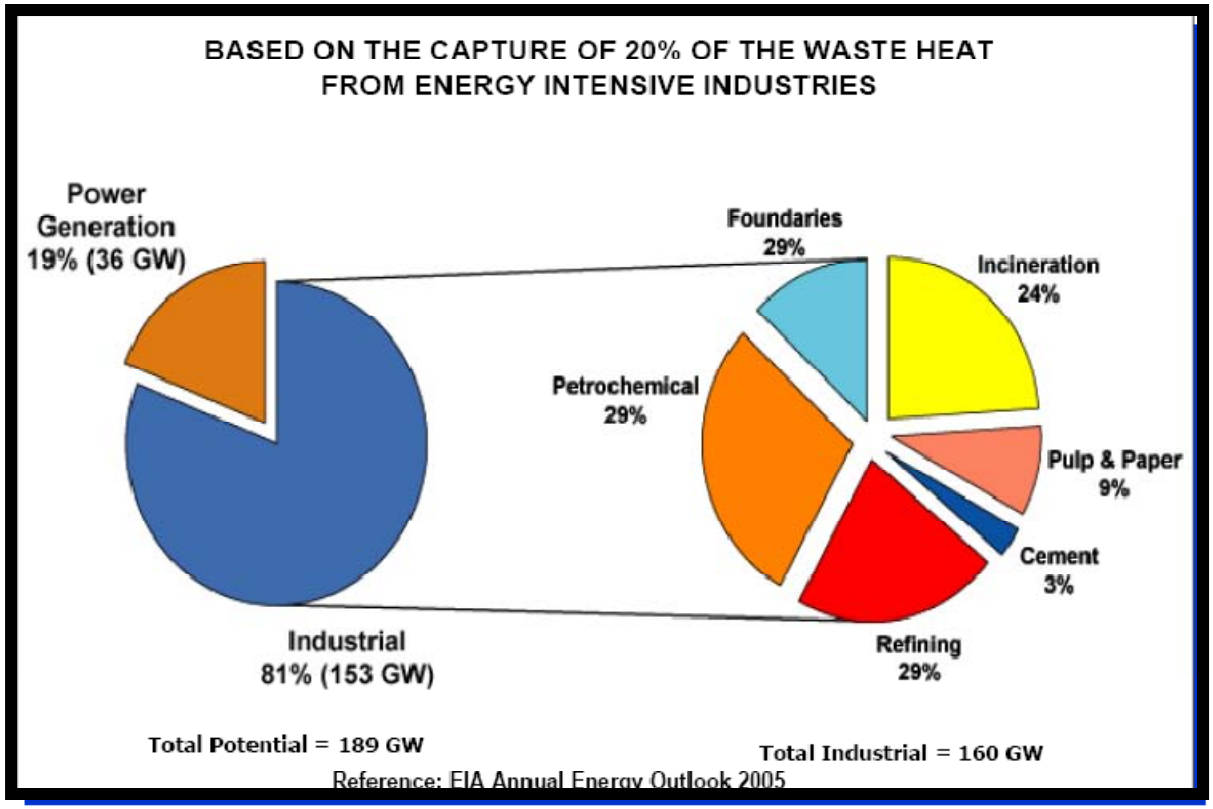
Waste-to-Energy: Waste Heat Recovery



With Louisiana's energy intensive industries, there should be good energy potential from waste heat recovery.

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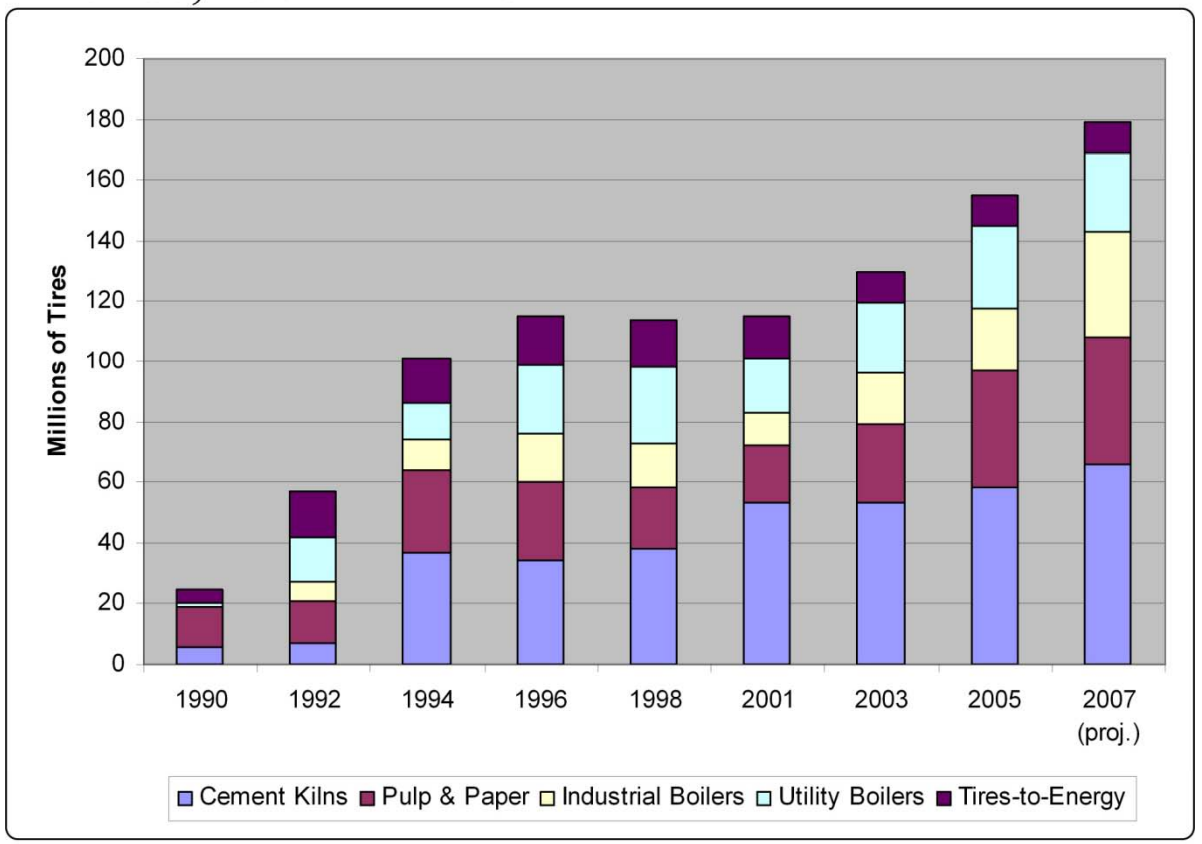
Waste-to-Energy: Tire-Derived Fuel

U.S. Tire-derived Fuel Market Distribution Trends, 1990 – 2007



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Energy Picture for Louisiana

Renewable Energy Sources:

- **Hydroelectric** (Sabine River Authority, Louisiana Hydroelectric)
- **Hydrokinetic** (Mississippi River possibilities)
- **Wave**
- **Tide**
- **Geothermal –** Some potential for direct heat along AR and TX borders
- **Geopressured-Geothermal** (Good potential LA and TX)
- **Solar –** some potential (2007 LA solar tax credit bill)
- **Wind –** some potential along coast (LA authorizes lease of state-owned lands for wind power production)
- **Biomass –** good potential (forest residues, mill residues, agricultural residues, urban wood wastes, e.g. bark, wood chips, bagasse, rice hulls)
- **Biogas –** anaerobic digestors.
- **Biofuels –** good potential (grain/sugar ethanol, biodiesel, cellulosic ethanol, green diesel and gasoline, butanol, diesel/jet fuel from algae, pyrolysis liquids, syngas liquids).

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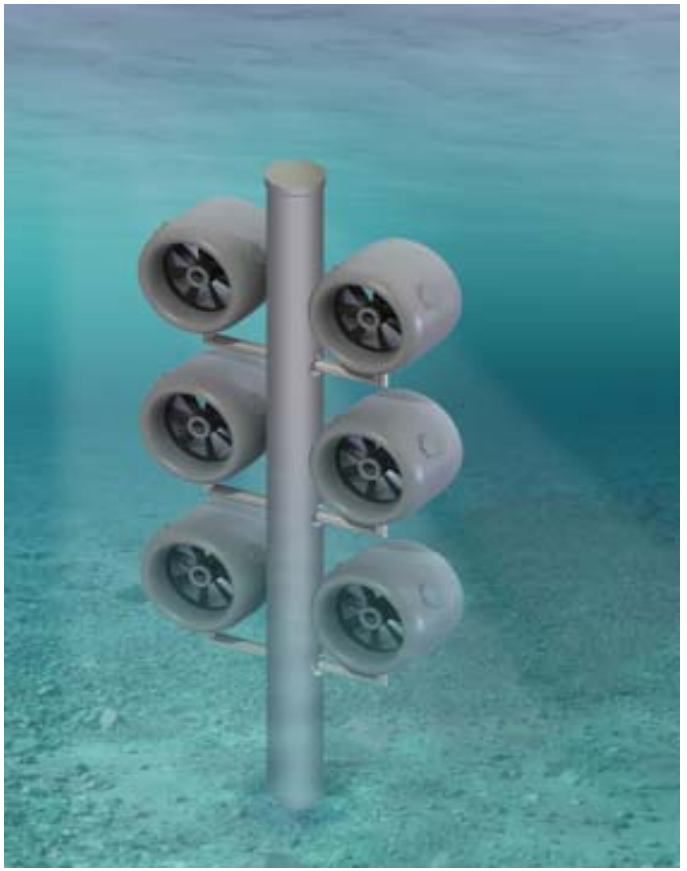
Renewable Energy : Hydrokinetic

*Being considered for the Mississippi River

- Typical installation includes six turbines
- Mounted on piling below shipping traffic



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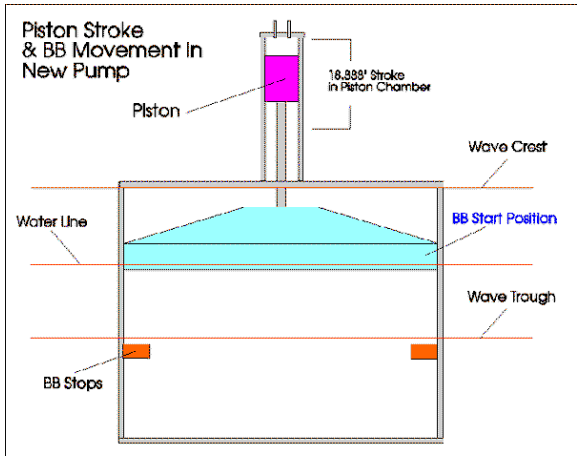
Renewable Energy : Wave

- Seadog pump (TX A&M GOM)
- Pelton turbine – AquaBuOY
- Oscillating wave system
- Seawave slot-cone generator
- Wave dragon
- Giant Sea-Snake generator

"European Ocean Energy Association"



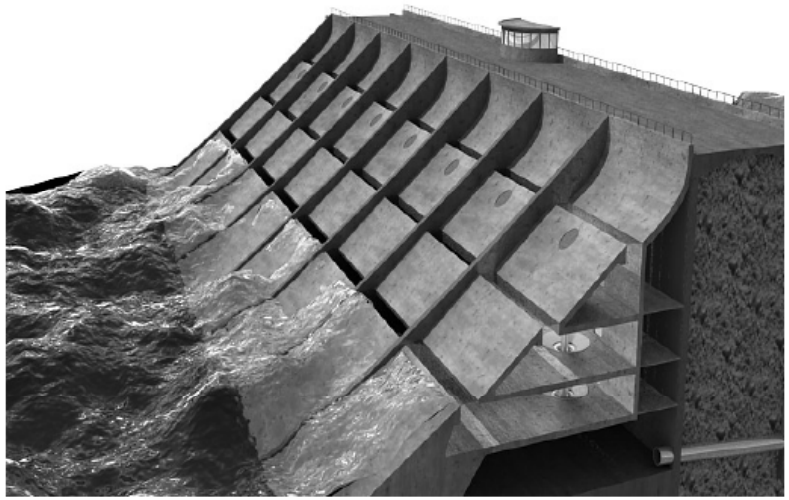


Figure 1. Cross Section of a SSG Wave Energy Converter.

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Renewable Energy : Tide

Rance Tidal Power Plant
Rance River, France

SeaGen, Northern Ireland

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Renewable Energy : Geopressured Geothermal

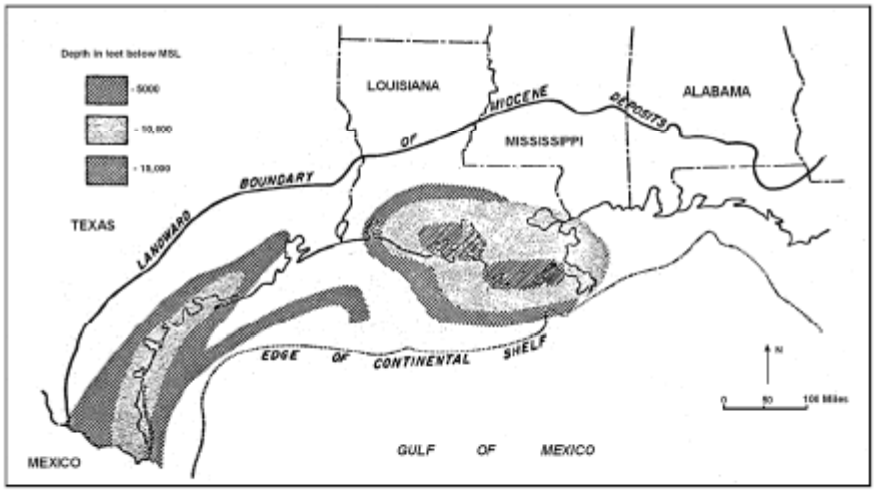

Figure 3: Geopressured zones in northern Gulf of Mexico Basin

Geopressured resources have three energy forms: thermal, kinetic and chemical energy. These three forms of energy can be converted to higher value forms of energy using available technologies. The thermal energy can be converted to electricity using a geothermal binary turbine. The kinetic energy can be converted to electricity with an hydraulic turbine. Dissolved methane gas (chemical energy) can be separated and sold, burned, compressed, liquefied, converted to methanol or to electricity by fueling a turbine. Flow rates can vary between 10,000 and 100,000 barrels per day (BPD), and temperature range from 100 to 250 degrees Celsius. Bottom hole pressures are 12,000 – 18,500 pounds per square inch absolute (psia). Salinity is present in the amount of 20,000 – 200,000 milligrams per liter (mg/l), and between 23-100 standard cubic feet (scf) of gas exist in each barrel of fluid.

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Renewable Energy : Geopressured Geothermal

Geological formations located in the northern Gulf of Mexico contain large reservoirs of hot, saline brine under abnormally high pressure and temperatures. This resource has been estimated by various researchers to contain from *150 - 5,000 TCF of recoverable methane and up to 11,000 quads of thermal energy* in sandstone pore fluids to a depth of 22,500 feet. *This is equivalent to many times more than the presently known conventional methane resources in the United States.* This resource *contains chemical energy in the form of methane dissolved in pressurized brine, thermal energy consisting of hot brines at high temperature (225°F+) which could be used for secondary hydrocarbon recovery or electricity generation, and mechanical energy generated through high brine flow rates (20,000+ barrels per day) which could be utilized to drive turbines to generate electricity.*

Estimates of the energy potential of this undeveloped resource range as high as 160,000 quadrillion BTUs (quads). The USGS has estimated that there are 5,700 quads of recoverable gas and11,000 quads of thermal energy in the onshore Gulf Coast reservoirs without regard to economics . The energy consumption of the United States is presently 100 quads per year*; this resource could conservatively provide a portion of the domestic energy supply for many centuries.*

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Renewable Energy :
Geopressured Geothermal

Table 1. Co-Produced Geothermal Fluids

Estimated equivalent geothermal power from processed water associated with existing hydrocarbon production, using 140°C (285°F) as a nominal fluid temperature.

State	Total Processed Water, 2004 (bbl)	Power, MW @ 140˚C (285)˚F)
Alabama	203,223,404	47
Arkansas	258,095,372	59
California	5,080,065,058	1169
Florida	160,412,148	37
Louisiana	2,136,572,640	492
Mississippi	592,517,602	136
Oklahoma	12,423,264,300	2860
Texas	12,097,990,120	2785
Total	32,952,140,644 bbl	7,585 MW

Courtesy: Dr. David Blackwell, Southern Methodist University

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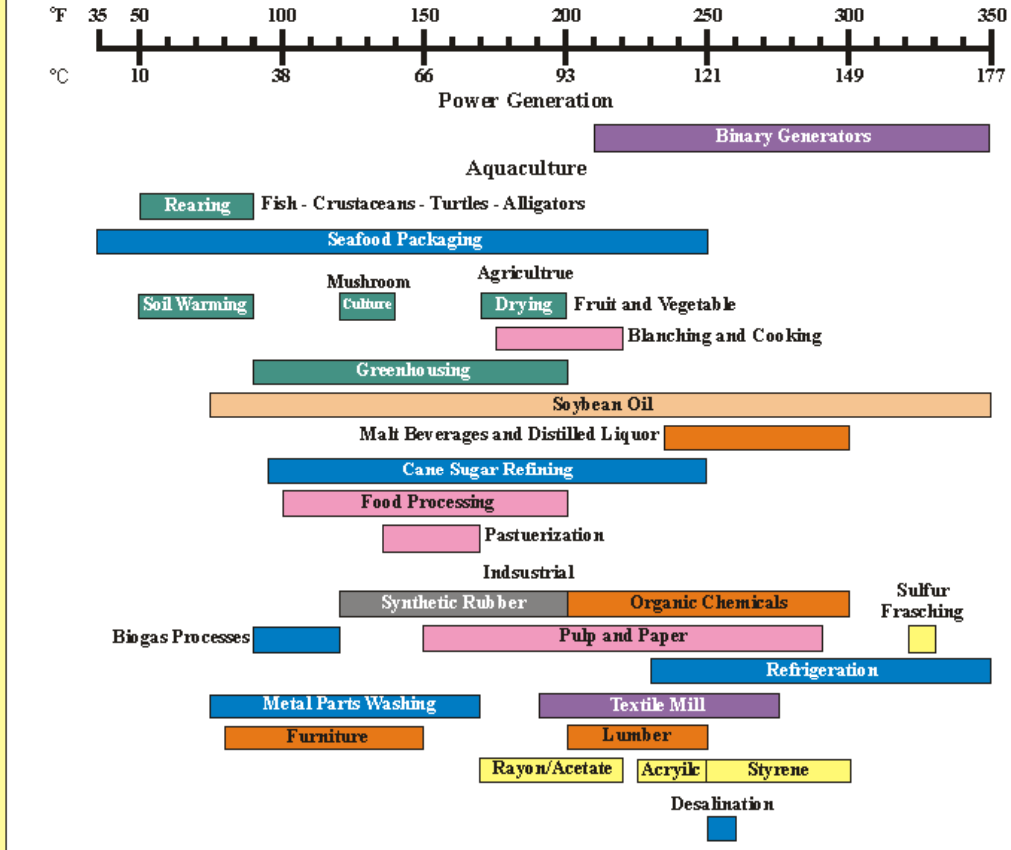
Renewable Energy : Geopressured Geothermal



Temperature requirements for potential applications of the geopressured-geothermal resource at a well site (from Lunis et.al., 1991).

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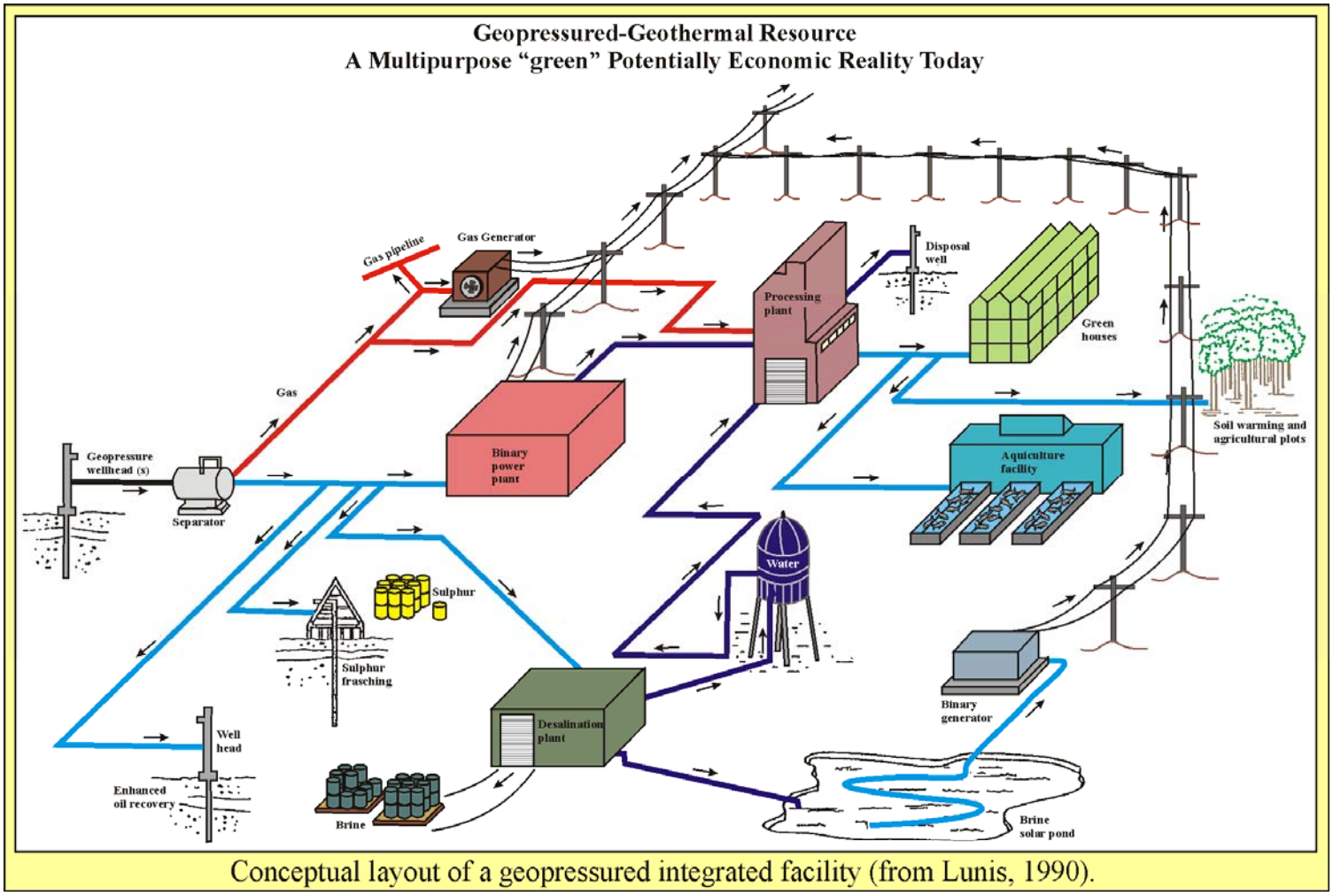
Renewable Energy : Geopressured Geothermal



Conceptual layout of a geopressured integrated facility (from Lunis, 1990).

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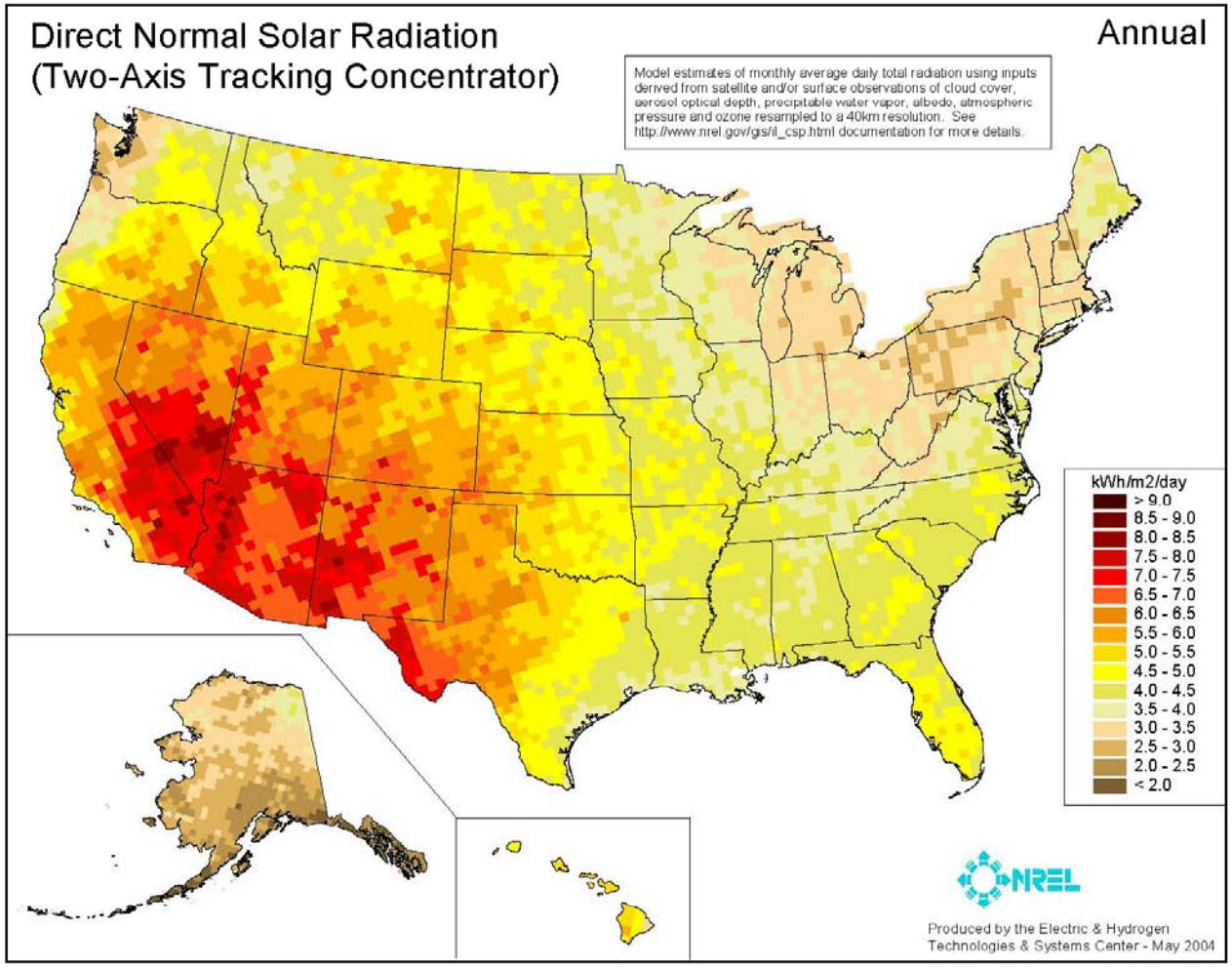
Renewable Energy : Solar



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2007 LA solar tax credit bill

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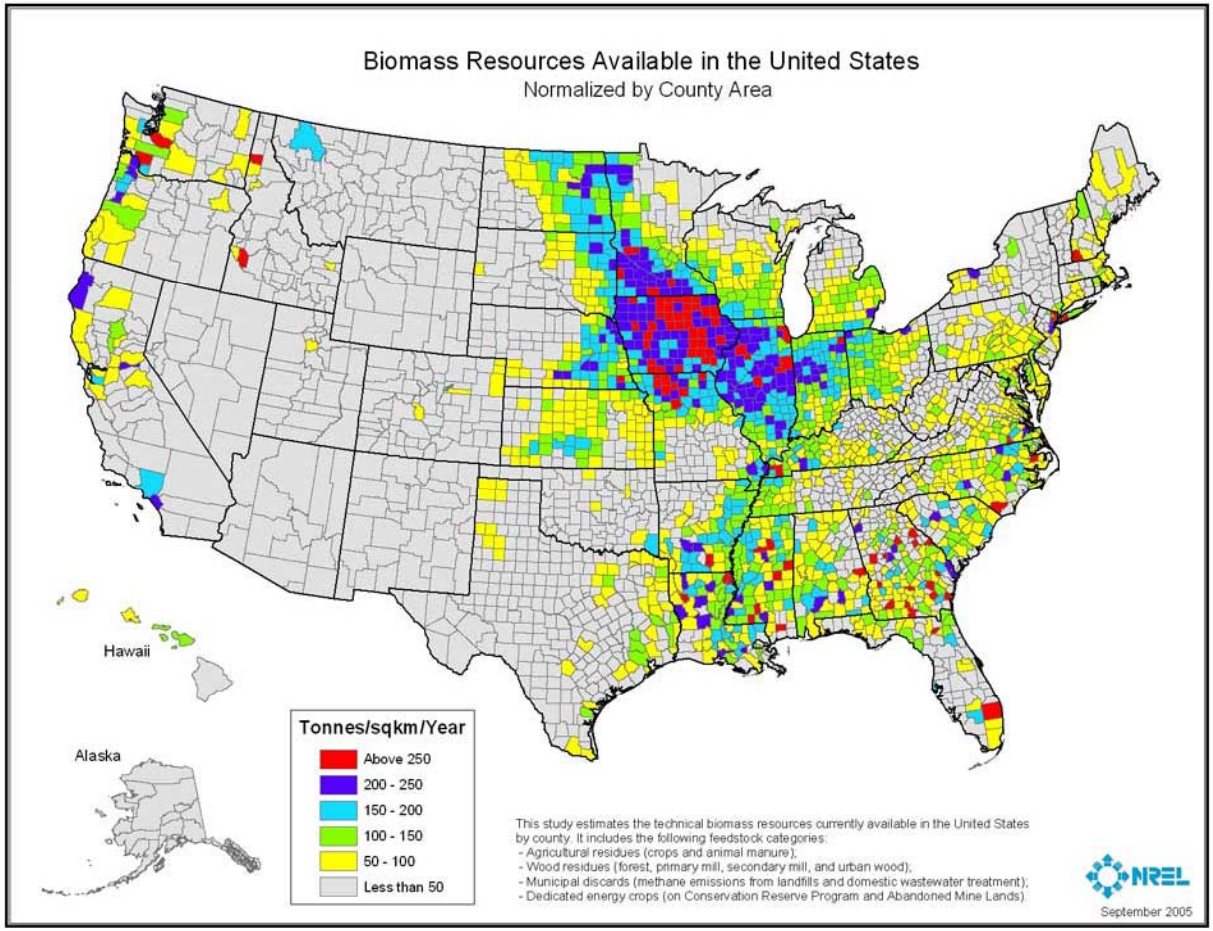
Renewable Energy : Biomass



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Renewable Energy : Biomass

- Annual wood and agricultural residue production in Louisiana are potentially available for biomass energy or other uses. Together, they could produce 6,620 million kWh and power 22% of Louisiana homes.
- Approximately 98% of the wood milling residues (bark, sawdust, etc.), 96% of the sugarcane bagasse, and 54% of the rice hulls are already being used for energy and other purposes and are not included in the numbers provided in the bullet above (source: LSU AgCenter, 2006).
- LDEQ lists 22 facilities with air permits that use biomass as an energy source.
- NREL (2005) listed Louisiana biomass resource availability as:
  - Forest residues ~3.384 million dry tons
  - Primary mill residues ~3.577 million dry tons
  - Secondary mill residues ~ 33 thousand dry tons
  - Urban wood residues ~ 474 thousand dry tons
  - Crop residues ~ 4.335 million dry tons

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Renewable Energy : Biogas

- Landfill Methane
- Anaerobic Digestion
- Methane from Manure Management (NREL estimates Louisiana resource availability of 6,000 tons methane per year)
- Methane from Domestic Wastewater (NREL estimates Louisiana resource availability of 7,000 tons methane per year)

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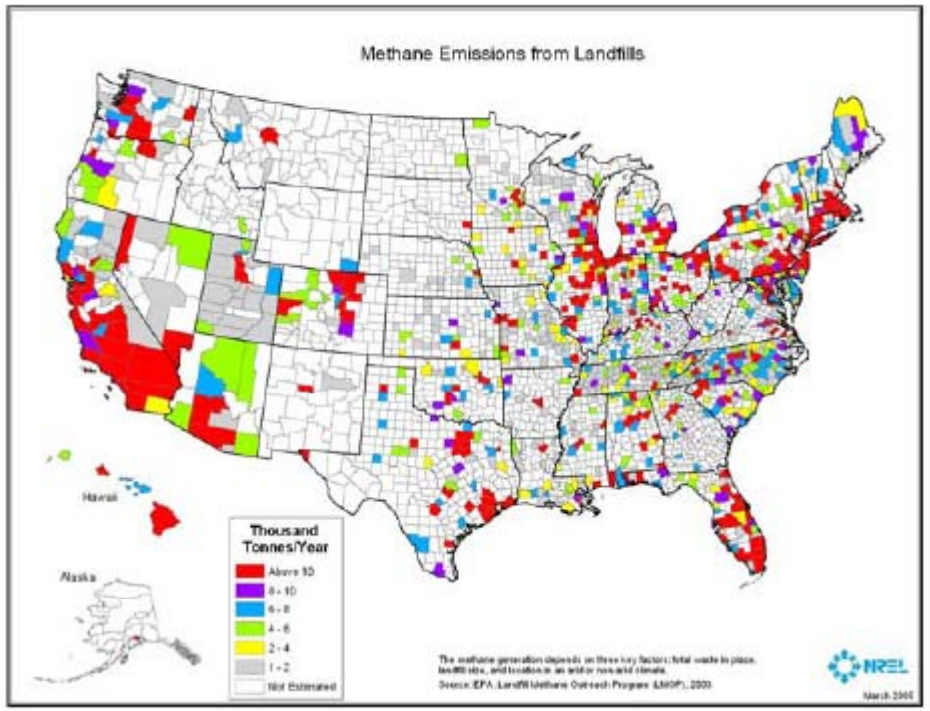
Renewable Energy : Biogas

Methane from Landfills



- Three active landfill methane projects in LA.
- Resource availability for Louisiana estimated at 166,000 tons methane per year (NREL, 2005)

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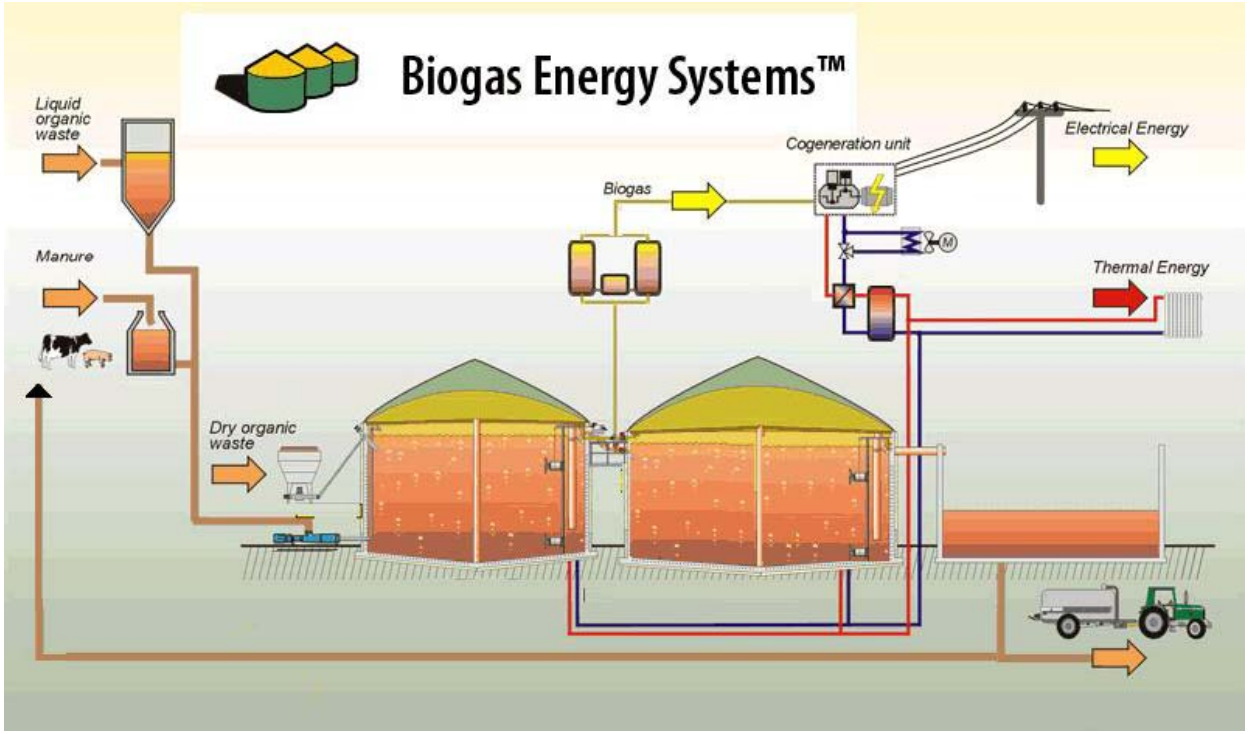
Renewable Energy : Biogas

Anaerobic Digestion



- DOE (1998) found that it is feasible to capture and use over a third of biogas potential from landfills, animal waste and sewage or about 1.25 quadrillion Btu (about 6% of all natural gas used in the U.S).
- In Sweden, biogas from organic wastes fuels city buses, garbage trucks, taxi cabs, even a train.
- Over 4,000 anaerobic digestors have been built in Germany
- A new generation of AD has been developed in the UK to help solve the problem of shortage of landfill sites.

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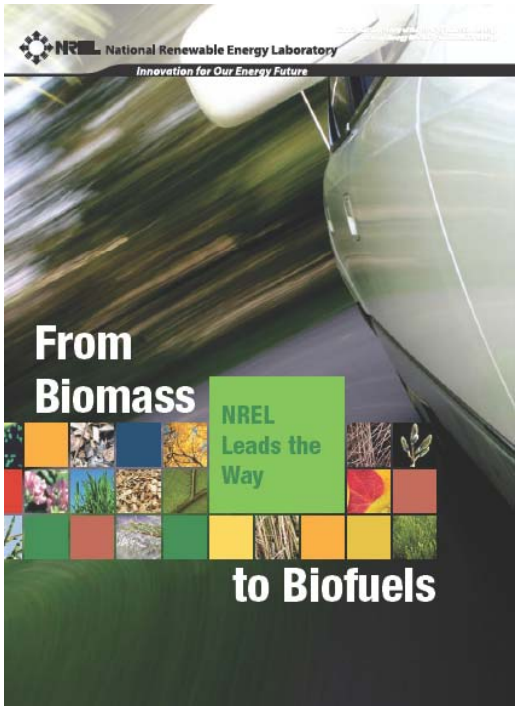
Renewable Energy : Biofuels



Fuel	Source	Benefits	Maturity
Grain/Sugar Ethanol	Corn, sorghum, and sugarcane	• Produces a high-octane fuel for gasoline blends • Made from a widely available renewable resource	Commercially proven fuel technology
Biodiesel	Vegetable oils, fats, and greases	• Reduces emissions • Increases diesel fuel lubricity	Commercially proven fuel technology
Green Diesel and Gasoline	Oils and fats, blended with crude oil	• Offer a superior feedstock for refineries • Are low-sulfur fuels	Commercial trials under way in Europe and Brazil for fuel
Cellulosic Ethanol	Grasses, wood chips, and agricultural residues	• Produces a high-octane fuel for gasoline blends • Is the only viable scenario to replace 30% of U.S. petroleum use	DOE program is focused on commercial demonstration by 2012
Butanol	Corn, sorghum, wheat, and sugarcane	• Offers a low-volatility, high energy-density, water-tolerant alternate fuel	BP and DuPont plan to introduce butanol fuel in 2007
Pyrolysis Liquids	Any lignocellulosic biomass	• Offer refinery feedstocks, fuel oils, and a future source of aromatics or phenols	Several commercial facilities produce energy and chemicals
Syngas Liquids	Various biomass as well as fossil fuel sources	• Can integrate biomass sources with fossil fuel sources • Produce high-quality diesel or gasoline	Demonstrated on a large scale with fossil feedstocks, commercial biomass projects under consideration
Diesel/Jet Fuel From Algae	Microalgae grown in aquaculture systems	• Offer a high yield per acre and an aquaculture source of biofuels • Could be employed for CO_2 capture and reuse	Demonstrated at pilot scale in 1990s
Hydrocarbons From Biomass	Biomass carbohydrates	• Could generate synthetic gasoline, diesel fuel, and other petroleum products	Laboratory-scale research in academic laboratories

Most Mature

Least Mature

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ALTERNATIVE ENERGY DEVELOPMENTS

Renewable Energy : Biofuels

Competitive yields of a range of crops!

- Mild climate
- Hi solar radiation
- Plentiful rainfall
- Fertile soils
- Strong ag infrastructure

rce: Gary Breitenbech LSU AgCenter

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Renewable Energy : Biofuels

Louisiana Crops with potential for energy production (Traditional Crops)

Biodiesel crops	Ethanol crops
Soybean	Corn
Cotton	Grain Sorghum
	Wheat/Oats
	Sugarcane
	Sweetpotato

Crops with potential for energy production in Louisiana (Non-traditional Crops)

Biodiesel crops	Ethanol crops
Peanut	Sweet sorghum
Sunflower	Industrial Sweetpotato
Canola	Biomass
	Miscanthus
	Switchgrass
	Other species

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Non- Traditional Crops for Biodiesel

- Canola -- 170
- Sunflower – 140
- Peanuts -- 125 (the original diesel)
- Chinese Tallow -- 1000
- Jatropha -- 220
- Tung Oil -- 120
- Oil Palm -- 700

Potential annual biofuel production from Louisiana resources estimated at 880 million gallons ethanol and 64 million gallons of biodiesel (McGee, LDNR, 2007). Assumes entire crop production is utilized for energy crop production, one-half of the Conservation Reserve Program is utilized for energy crop production, and all of the cellulosic component of MSW is converted to ethanol.

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ALTERNATIVE ENERGY DEVELOPMENTS

Renewable Energy : Biofuels

Environmental Concerns for Biofuels

Fragione, J. 2008. Land Clearing and the Biofuel Carbon Debt., *Science* online version. Planting corn on former cropland that has been idled through the Agriculture Department's Conservation Reserve Program causes a 48-year "carbon debt", while land conversions in Brazil, Indonesia, and Malaysia result in increased emissions that take from 17 to 423 years to work off through ethanol emissions savings.

Continuously-grown corn leads to heavy use of fertilizers, early return of land in conservation programs to production, and the conversion of marginal lands to high-intensity cropping. All of these bring with them well-known environmental problems associated with intensive farming: persistent pest insects and weeds, pollution of groundwater, greater irrigation demands, less wildlife diversity, and the release of more carbon dioxide. Carbon dioxide is a greenhouse gas that contributes to global climate change. Ironically, one of the touted benefits of biofuels is to help alleviate global climate change, a benefit that is considerably diluted under a high-intensity agriculture scenario. (Position statement - Ecological Society of America).

According to a recent study, increasing production of corn-based ethanol to meet alternative fuel goals may worsen the "dead zone" that plagues the Gulf of Mexico.

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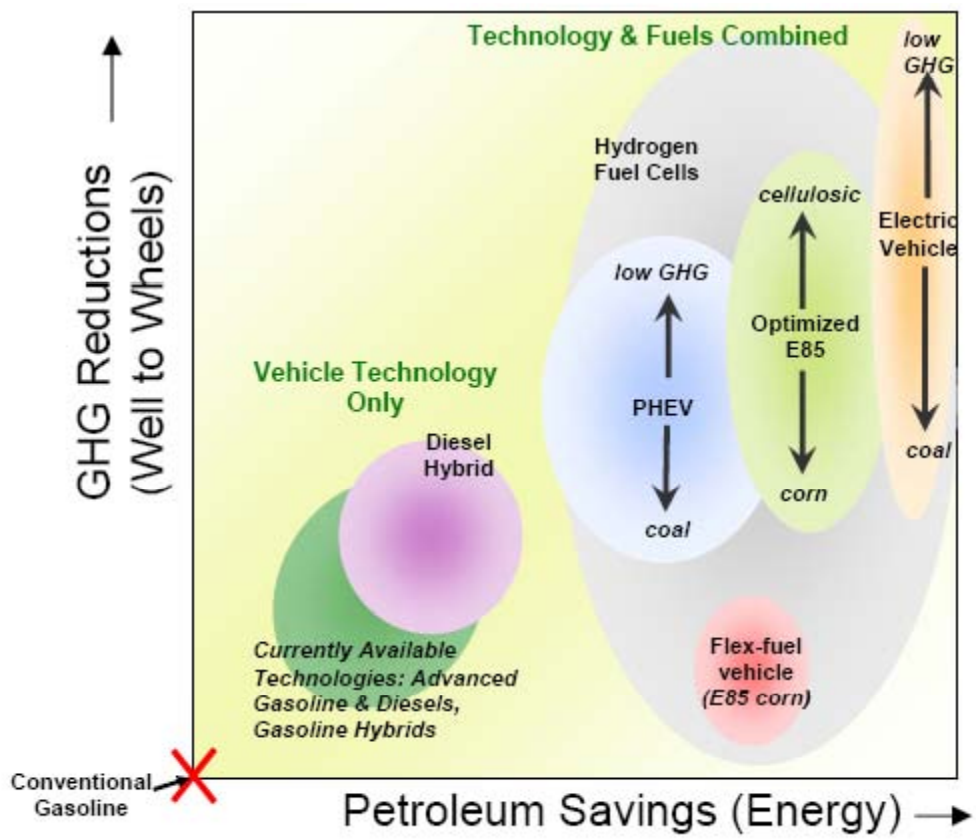
ALTERNATIVE ENERGY DEVELOPMENTS

Transportation: Alternative Fuels/Vehicle Technologies



Project Better Place
Denmark

Illustrative example of GHG reductions and petroleum savings for (1) various technology-only approaches and (2) combinations of vehicle technologies with alternative fuels. The reductions relative to today's conventional gasoline vehicle are shown. Note that the size and position of the bubbles are illustrative and assumptions-driven. Source: EPA

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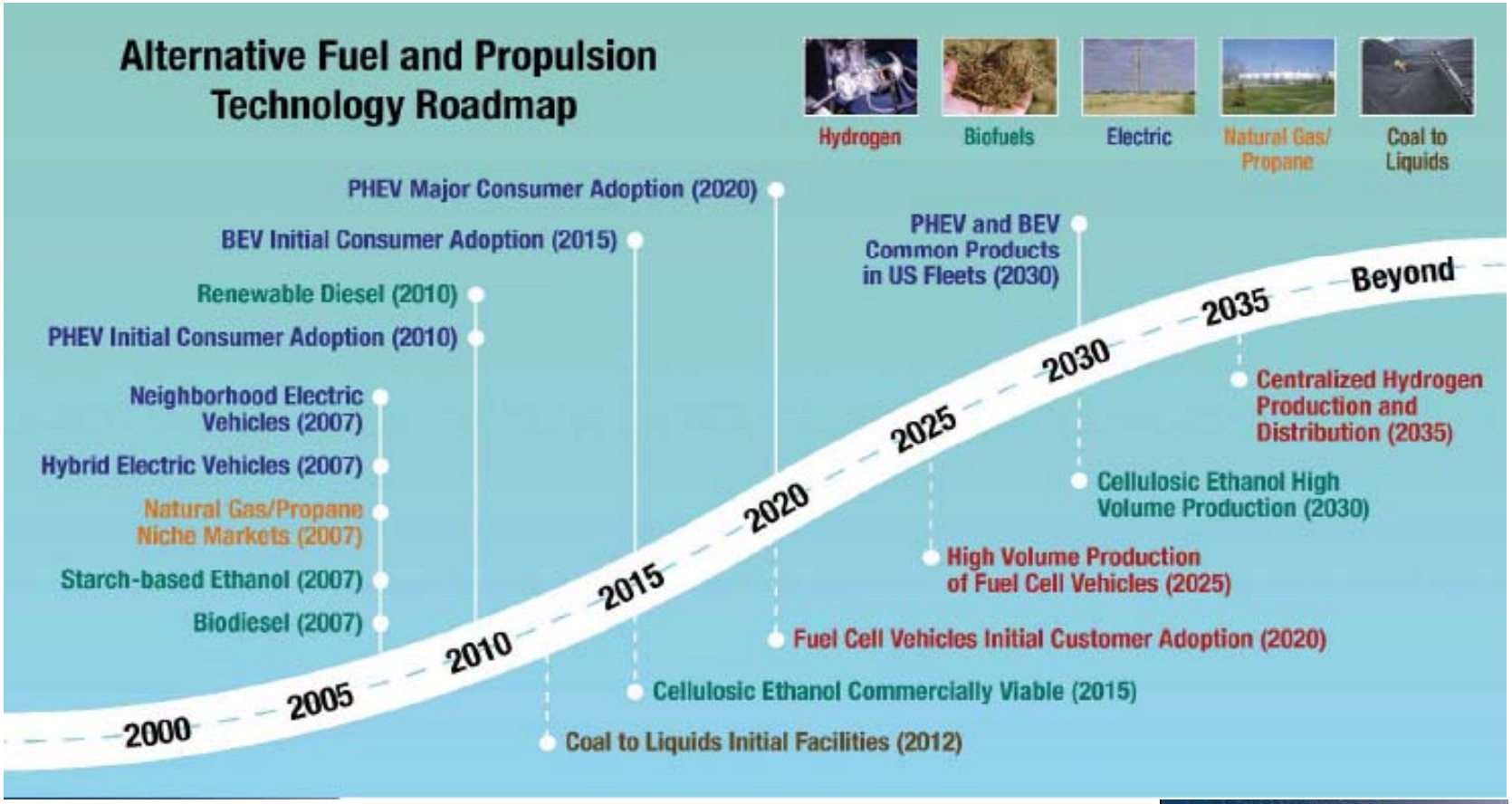
ALTERNATIVE ENERGY DEVELOPMENTS

Transportation: Alternative Fuels/Vehicle Technologies



Source: National Renewable Energy Laboratory

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ALTERNATIVE ENERGY DEVELOPMENTS

Transportation: Alternative Fuels/Vehicle Technologies

Louisiana has one of the best hydrogen infrastructures in the nation (behind only California and Texas). Dozens of hydrogen-producing and hydrogen-using facilities are linked by hydrogen pipelines stretching for hundreds of miles with connections in both Mississippi and Texas. Total production is estimated to be about 735 million cubic feet/day. Louisiana is well positioned for a future hydrogen (fuel cell) economy.

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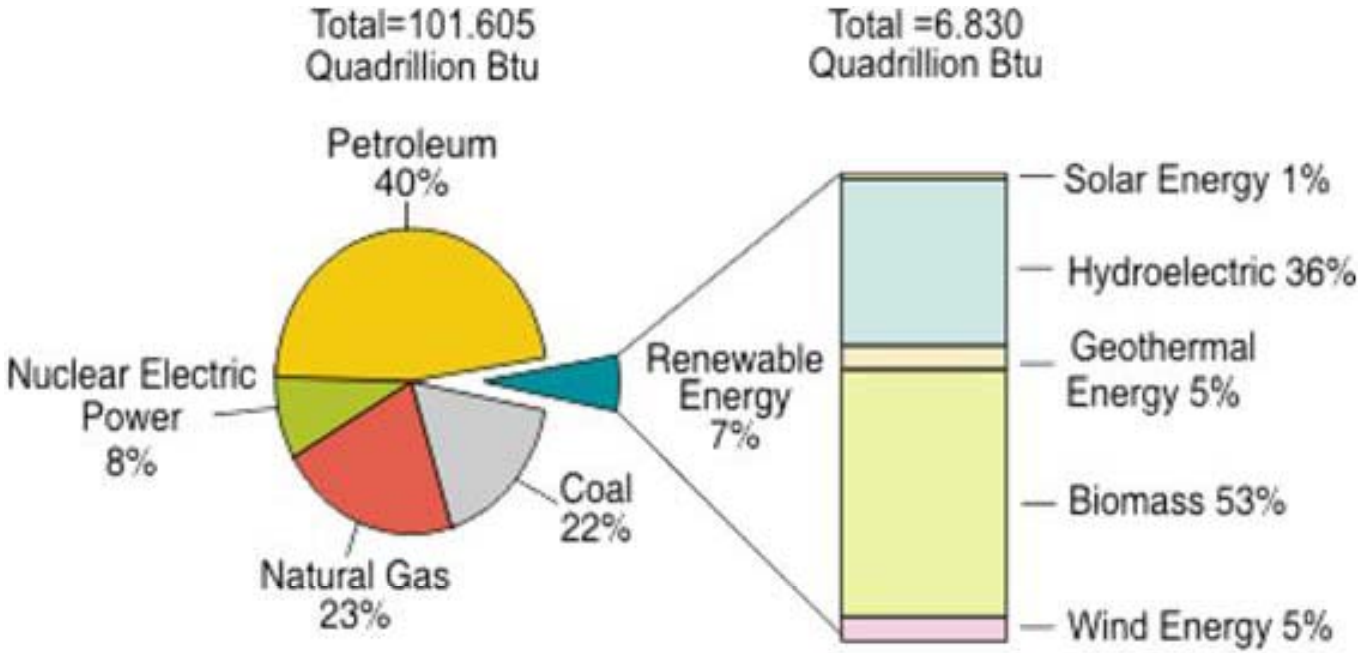
ALTERNATIVE ENERGY DEVELOPMENTS

Renewable Energy

Energy Consumption by Energy Source 2003-2007



Note: Sum of components may not equal 100 percent due to independent rounding.
Source: EIA, *Renewable Energy Consumption and Electricity Preliminary 2007 Statistics*, Table 1: U.S. Energy Consumption by Energy Source, 2003-2007 (May 2008).

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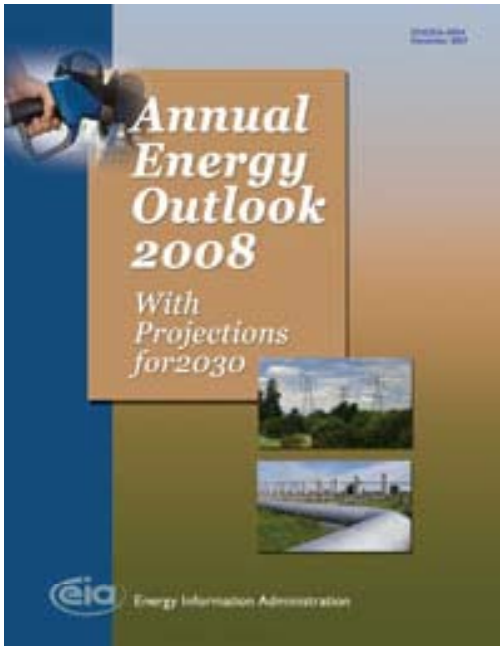
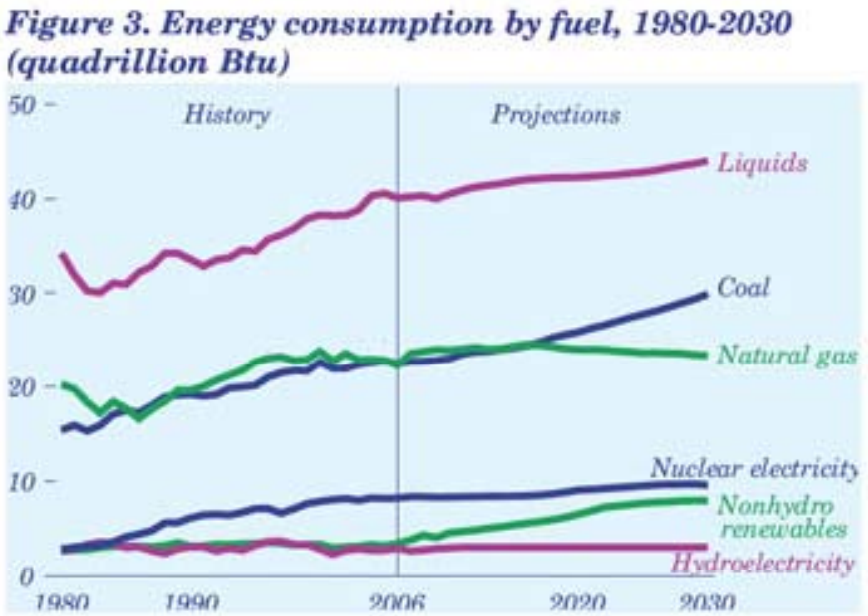
ALTERNATIVE ENERGY DEVELOPMENTS

All Sources of Energy Will be Needed





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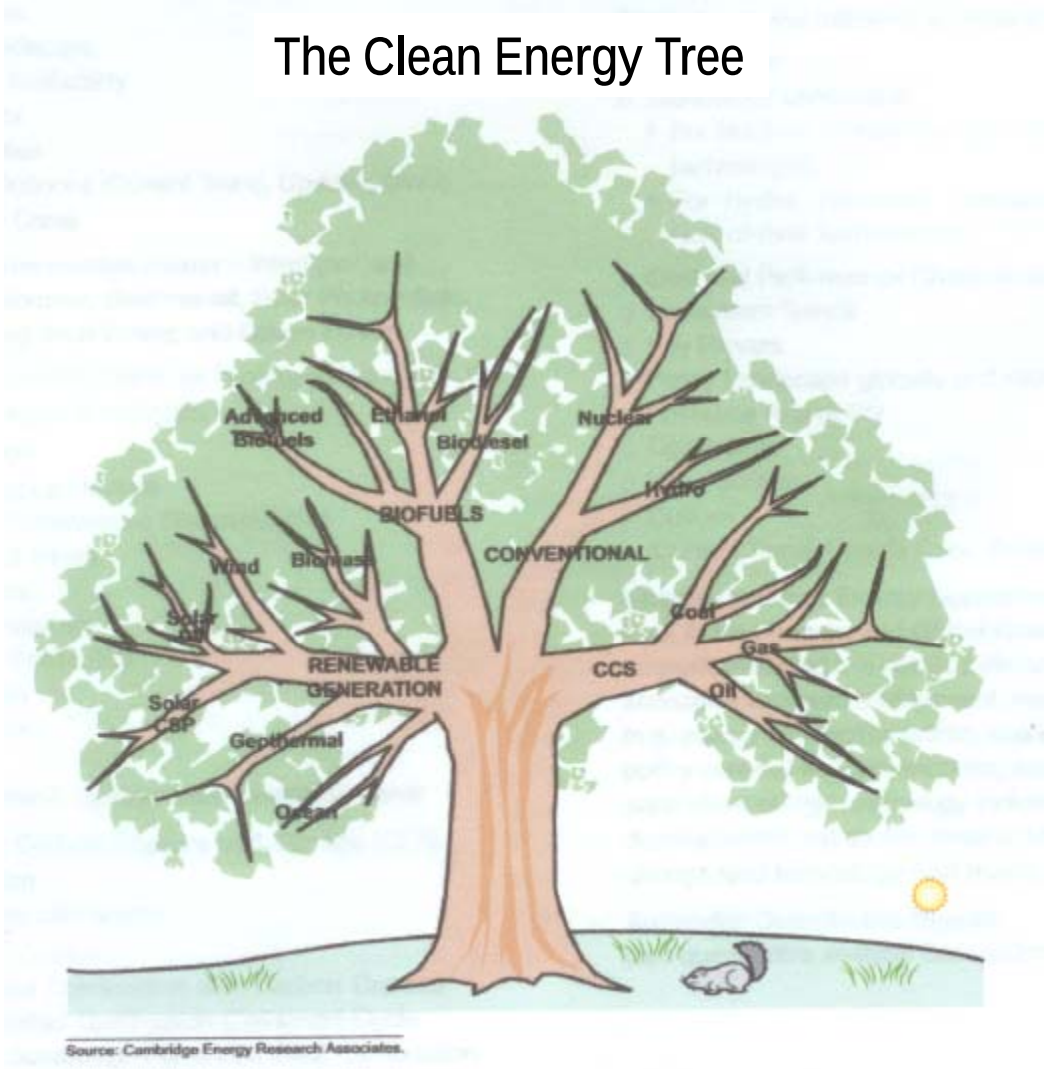
ALTERNATIVE ENERGY DEVELOPMENTS



Source: Cambridge Energy Research Associates, The Future of Clean Energy

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