ALTERNATIVE ENERGY DEVELOPMENTS

[WITH EMPHASIS ON LOUISIANA]

Presentation to

School of the Coast and Environment
Louisiana State University
Baton Rouge, LA

By
Mike D. McDaniel, Ph.D.
LSU Center for Energy Studies

February 19, 2010

ALTERNATIVE ENERGY DEVELOPMENTS

PRESENTATION OUTLINE

- Introduction
- Conventional Energy
- Electricity Generation
- Unconventional Energy
- Waste-to-Energy
- Renewable Energy
- Louisiana's Bioenergy Resources
- Conclusions

LSU CENTER FOR ENERGY STUDIES

Introduction – Convergence of Factors

- Clean Air Concerns
- Conventional Fuel Costs
- Energy Security
- Climate Change Concerns
- Agriculture Interests
- Technological Advances
- Entrepreneurial Opportunities

Energy Future

✓Domestic
✓Clean
✓Affordable
✓Renewable
✓Sustainable

LSU CENTER FOR ENERGY STUDIES

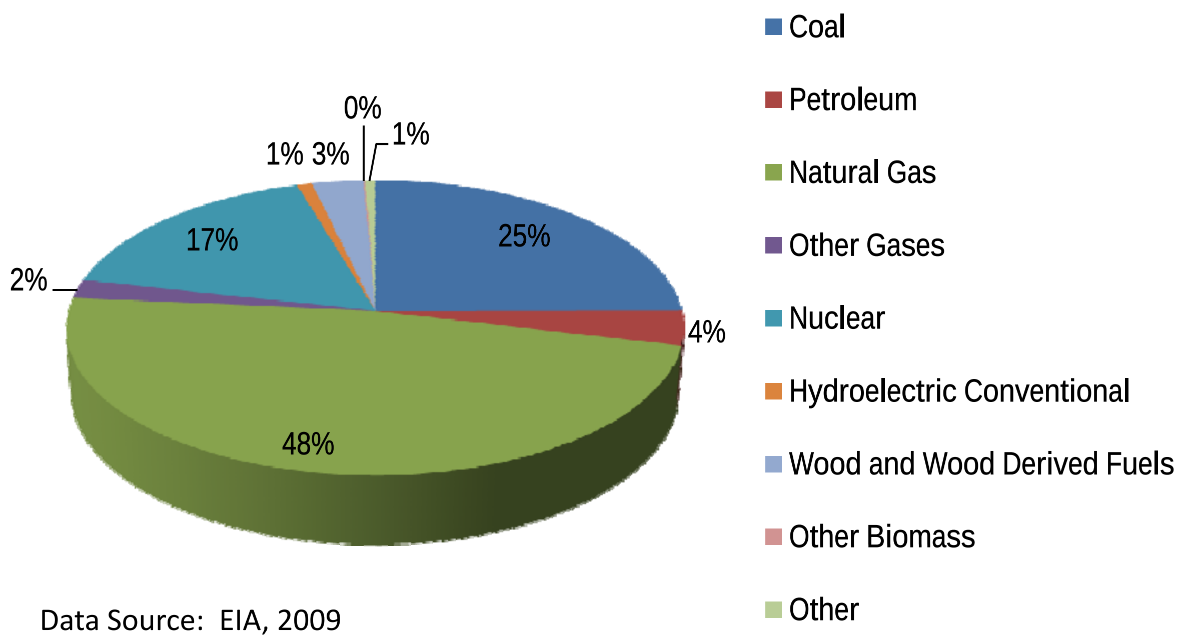
Louisiana's Conventional Energy Resources

- 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**.

LSU CENTER FOR ENERGY STUDIES

Source: EIA (October, 2008)

Louisiana's Electric Power Generation



Data Source: EIA, 2009

- 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.

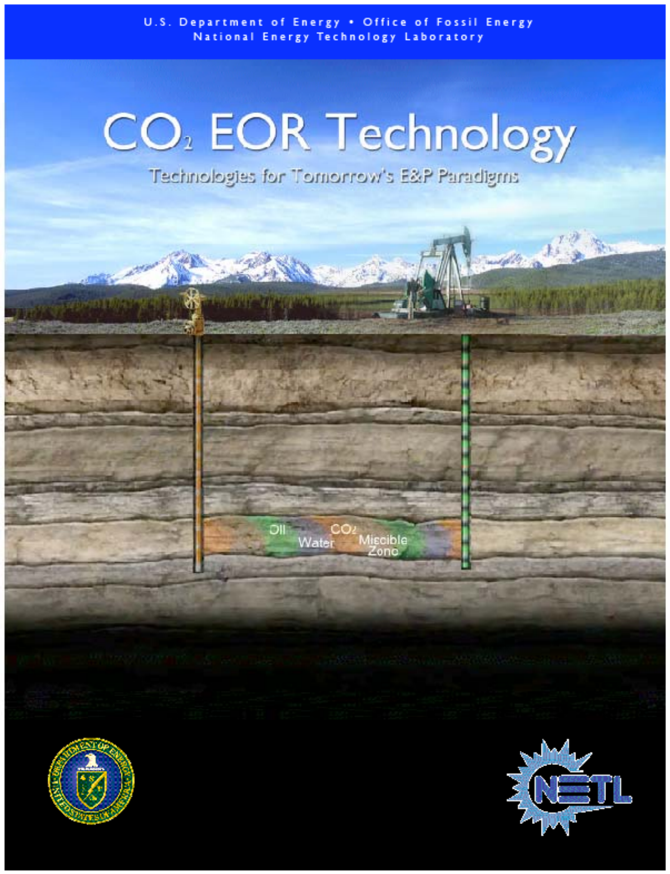
LSU CENTER FOR ENERGY STUDIES

Louisiana's Unconventional Energy Resources

- **Heavy Oil** (Est. 2 billion barrels – new production techniques promising)
- **Potential CO_2 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)
- **Coal Bed Methane** (Est. 1 trillion cu.ft. in Gulf Coast deposits)
- **Coal-Derived Liquids** (CTL costly ~$1 billion/10,000 bpd)
- **Hydrogen –** LA ranks 3rd in the nation in hydrogen production capacity and has one of the best hydrogen infrastructures in the country.

LSU CENTER FOR ENERGY STUDIES

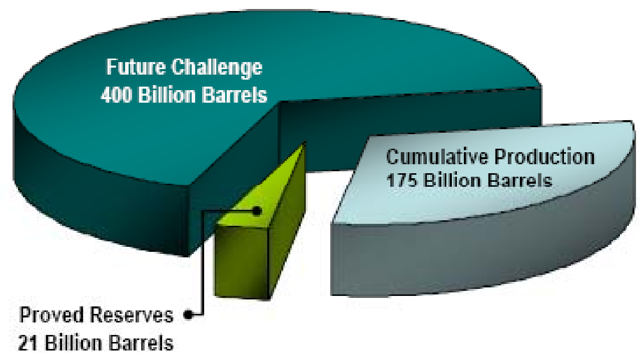
Unconventional Energy : CO_2-Enhanced Oil Recovery (CO_2-EOR)



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

LSU CENTER FOR ENERGY STUDIES

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

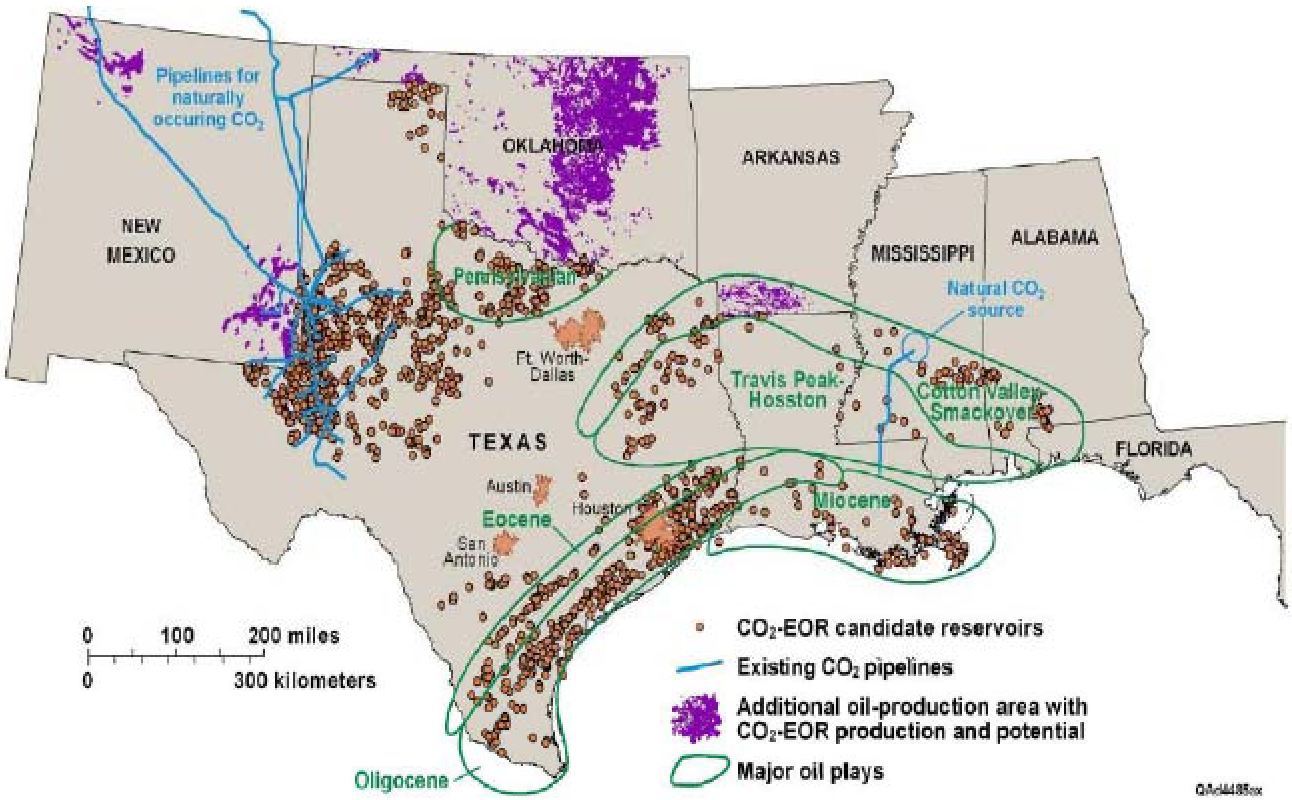
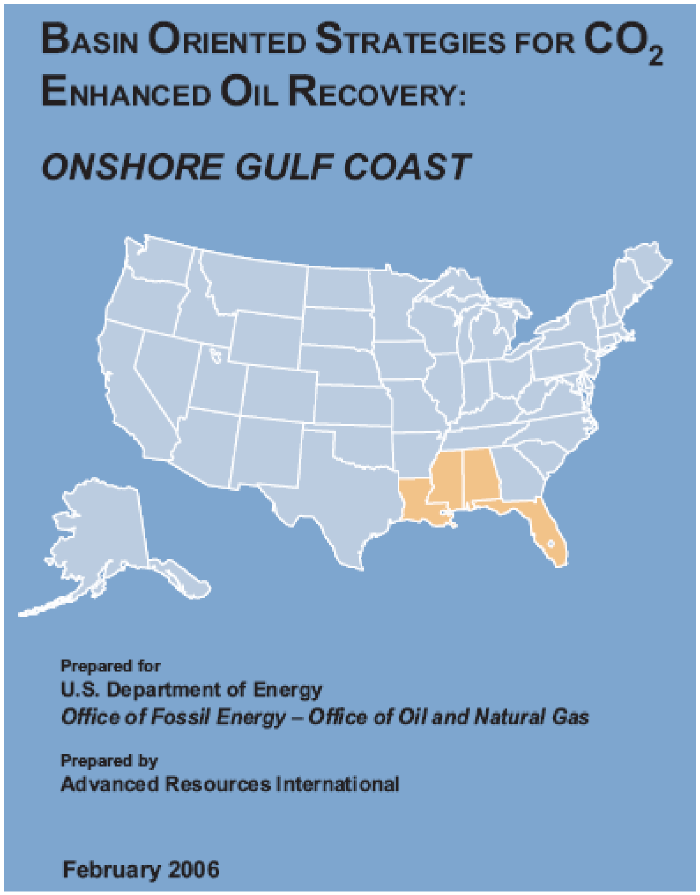


Figure 21 Areas with miscible CO_2 –EOR Potential [[8]]

Source: Pone & Kim (2006)

LSU CENTER FOR ENERGY STUDIES

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


BASIN ORIENTED STRATEGIES FOR CO_2 ENHANCED OIL RECOVERY:

ONSHORE GULF COAST

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

Prepared by
Advanced Resources International

February 2006

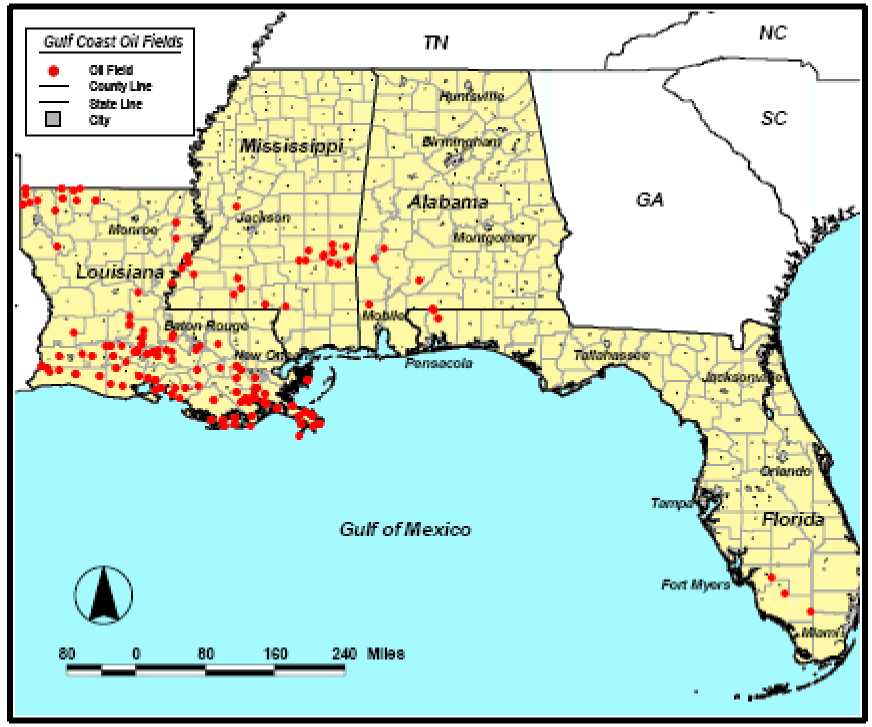
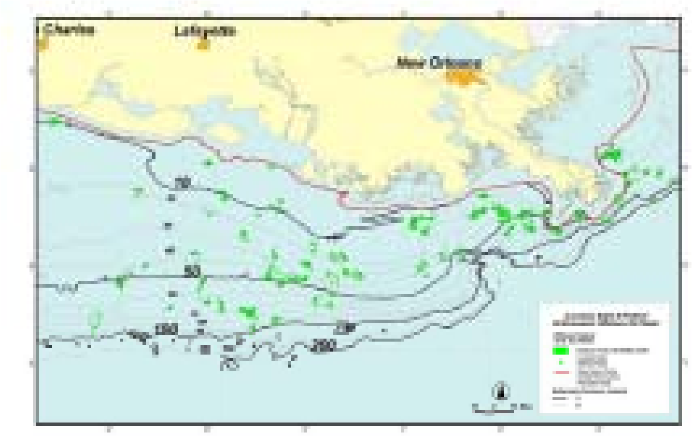


Table 2. The Gulf Coast Region's "Stranded Oil" Amenable to CO_2-EOR

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

LSU CENTER FOR ENERGY STUDIES

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	20,960	4,213
Total	99	22,060	4,450

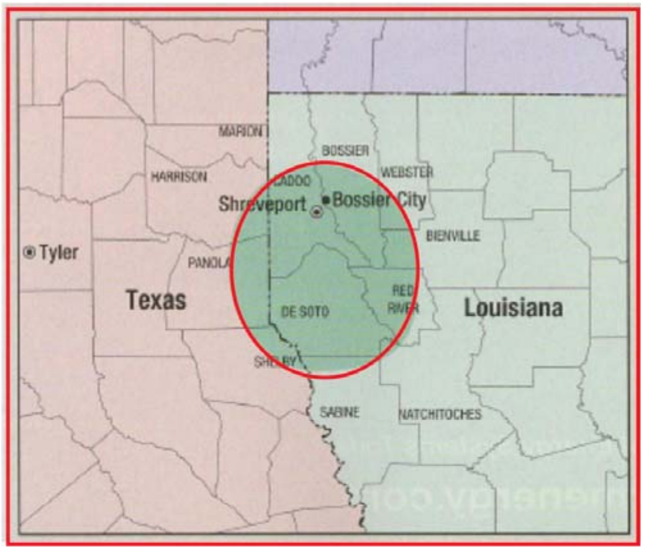
Economic Benefits of Producing Incremental Oil from CO_2-EOR

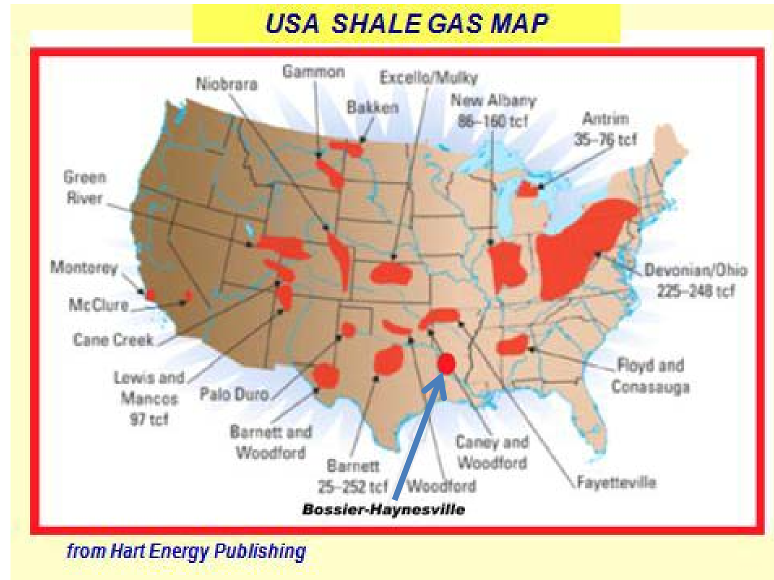
Assuming that 3.6 billion barrels are developed over a 40-year time frame, by 2025 this would amount to:

- Incremental crude oil production of 200,000 to 250,000 barrels per day
- Over 6,000 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.

LSU CENTER FOR ENERGY STUDIES

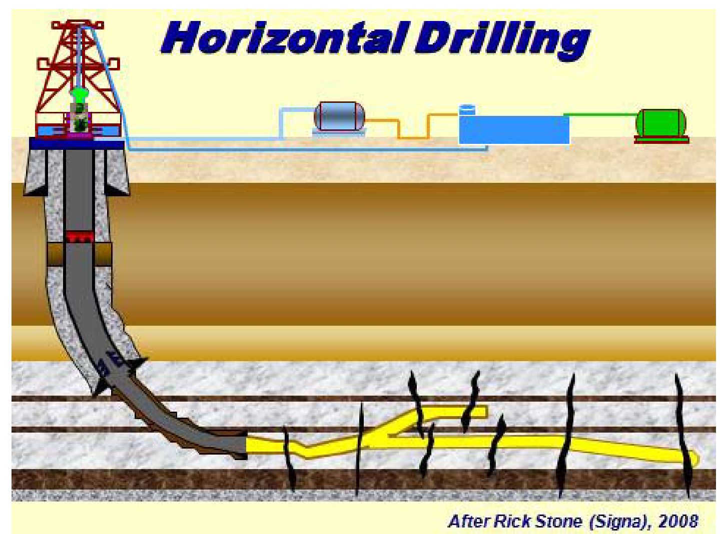
Unconventional Energy : Shale Gas





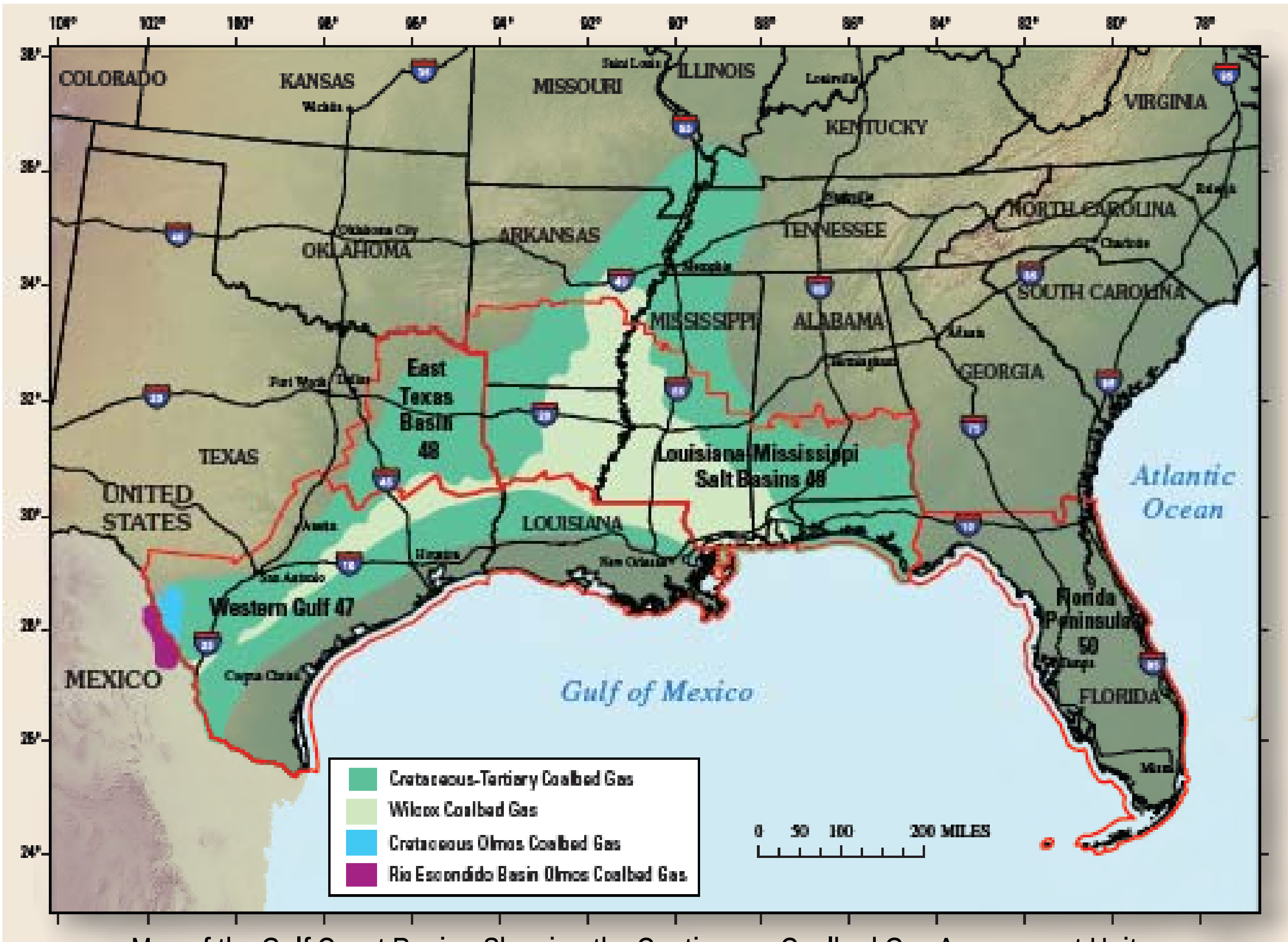
Bossier-Haynesville Drilling Activity

Gas in Place = 250 – 320 TCF
Estimated Recoverable Gas = 34 TCF
Chesapeake Energy Corp. estimate = 500 TCF



CENTER FOR
ENERGY STUDIES

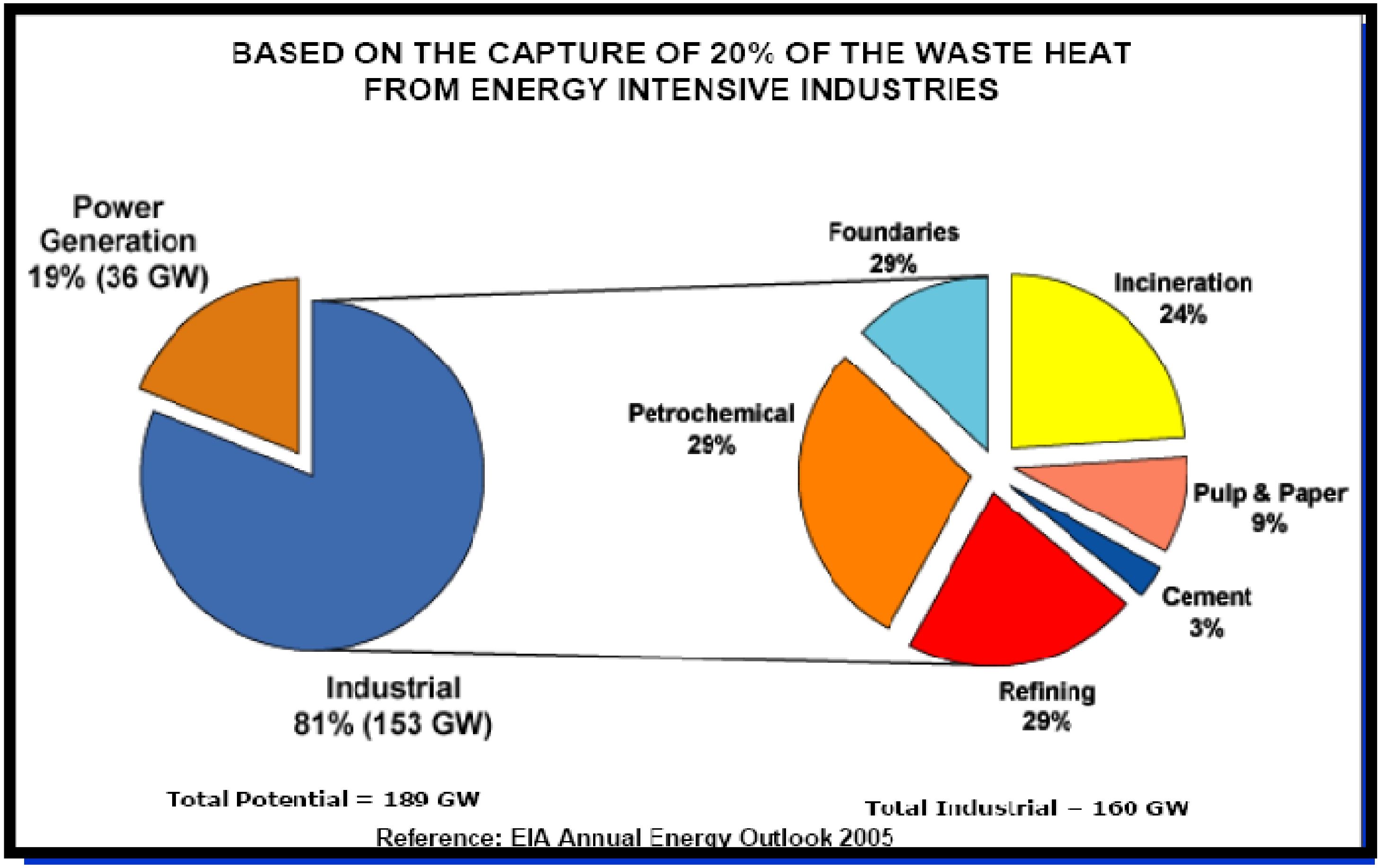
Unconventional Energy : Coalbed Gas



Map of the Gulf Coast Region Showing the Continuous Coalbed Gas Assessment Units.
Source: USGS, 2007.

LSU CENTER FOR ENERGY STUDIES

Waste-to-Energy: Waste Heat Recovery



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

LSU CENTER FOR ENERGY STUDIES

Waste-to-Energy: Waste Heat Recovery

BROAD CHP

Fort Bragg Airforce Base, USA (Exhaust) Military Base

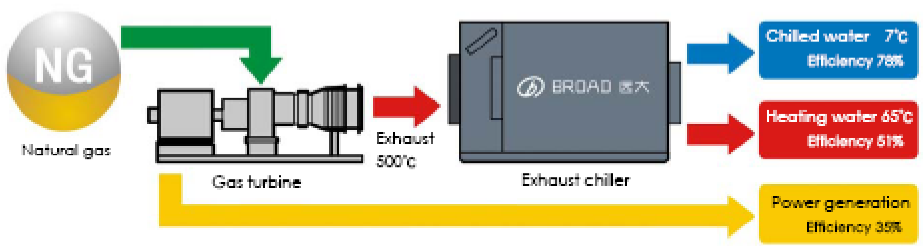
Power generator produces electricity and supplies to buildings or Power Grid, BROAD chiller recycles exhaust for cooling & heating, no fuel input.

Cooling capacity: 992 Rt/3.5 MW
Energy input: exhaust
Power generator: 5.2 MW
Energy efficiency: 113% (electricity + cooling)
Power generation efficiency: 35%

Yearly energy saving cost: USD 0.27 million
Payback period: 4 years
Yearly CO_2 cutting: 2,500 ton
Equivalent of planting 0.14 million trees

US military base of the 82nd Airborne Division

Mode 1: Exhaust type Energy efficiency: Electricity + cooling 113% Electricity + heating 86%



*Non-electric refrigeration

LSU CENTER FOR ENERGY STUDIES

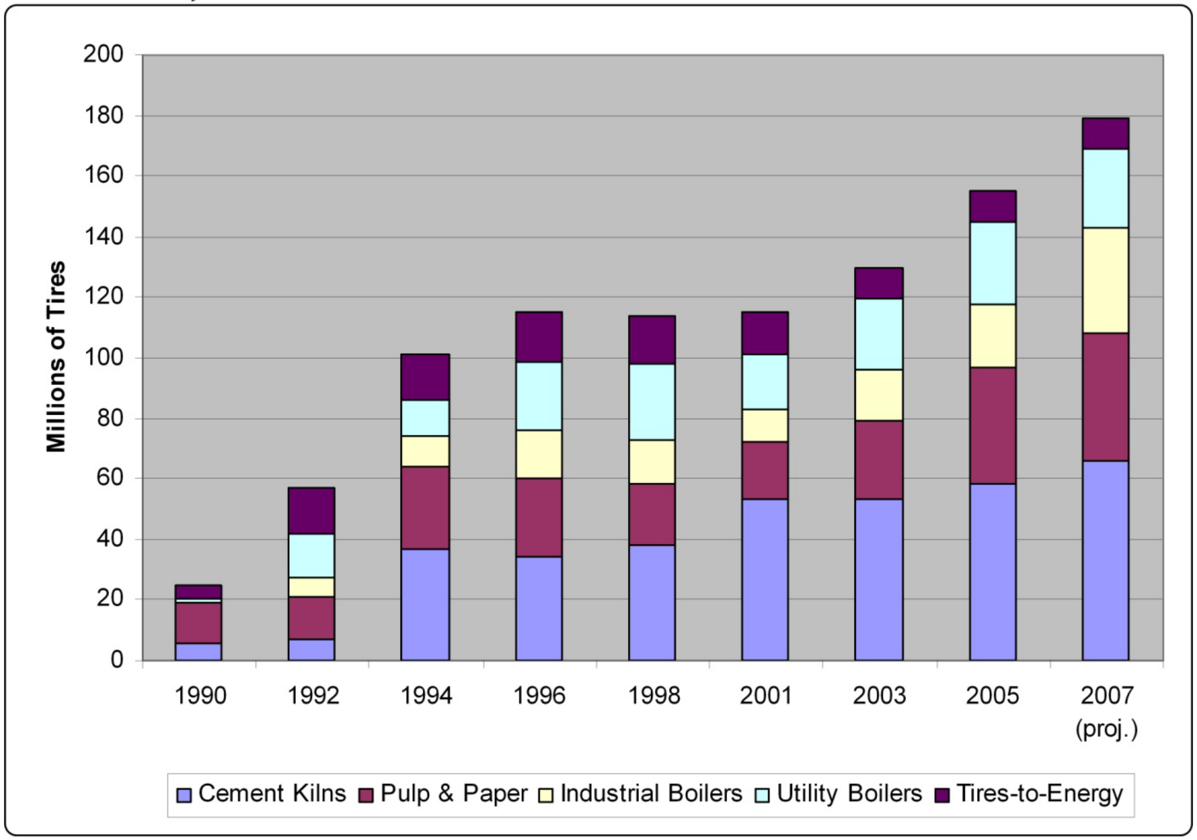
Waste-to-Energy: Waste Heat Recovery

- Commissioned December 2008
- Operating on jacket water of 8MW reciprocating engine ~ 200kW net
- Displaces expensive fuel costs
- Supports green initiative of customer

LSU CENTER FOR ENERGY STUDIES

Waste-to-Energy: Tire-Derived Fuel

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



LSU CENTER FOR ENERGY STUDIES

Renewable Energy Sources

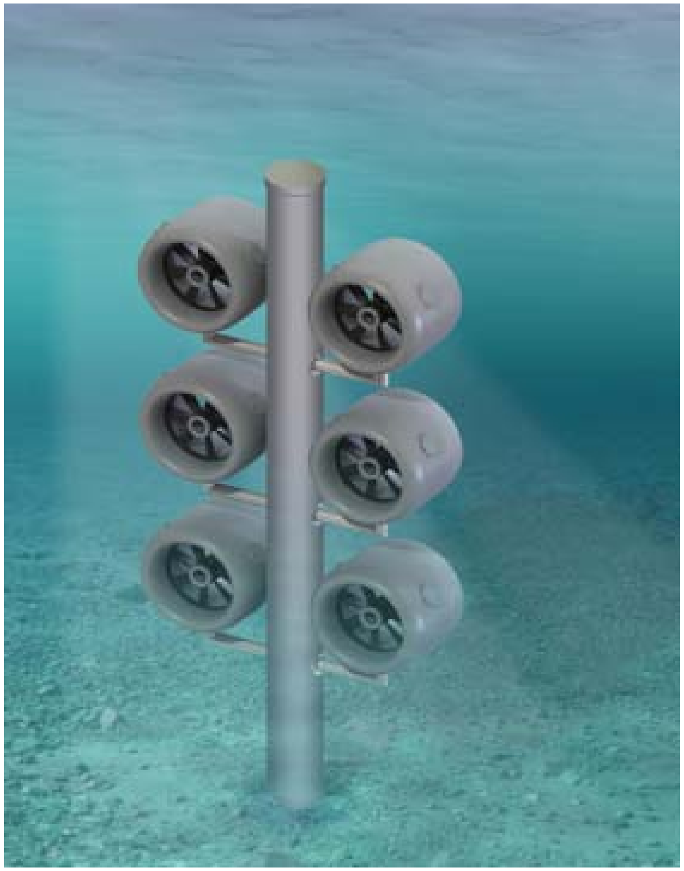
- **Hydroelectric** (Sabine River Authority, Louisiana Hydroelectric)
- **Hydrokinetic** (Mississippi River possibilities)
- Wave
- Tide
- **Ocean Thermal Energy Conversion (OTEC)** – Some GOM potential
- **Geothermal** – Some potential for direct heat along AR and TX borders
- **Geopressured-Geothermal** (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)

LSU CENTER FOR ENERGY STUDIES

Renewable Energy: Hydrokinetic

*Being considered for the Mississippi River

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

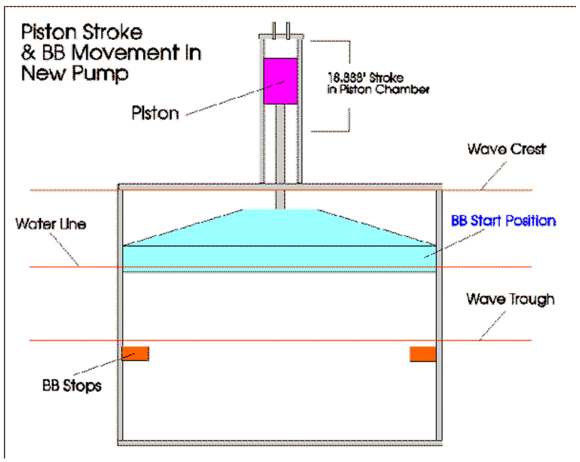


LSU CENTER FOR ENERGY STUDIES

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”



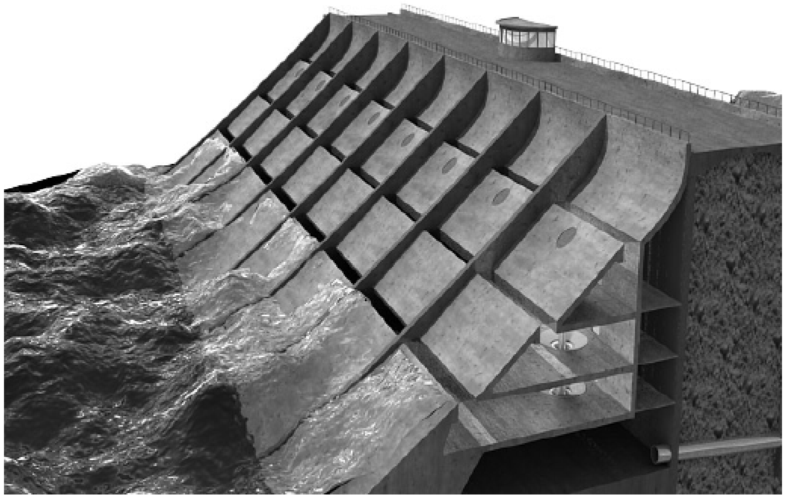
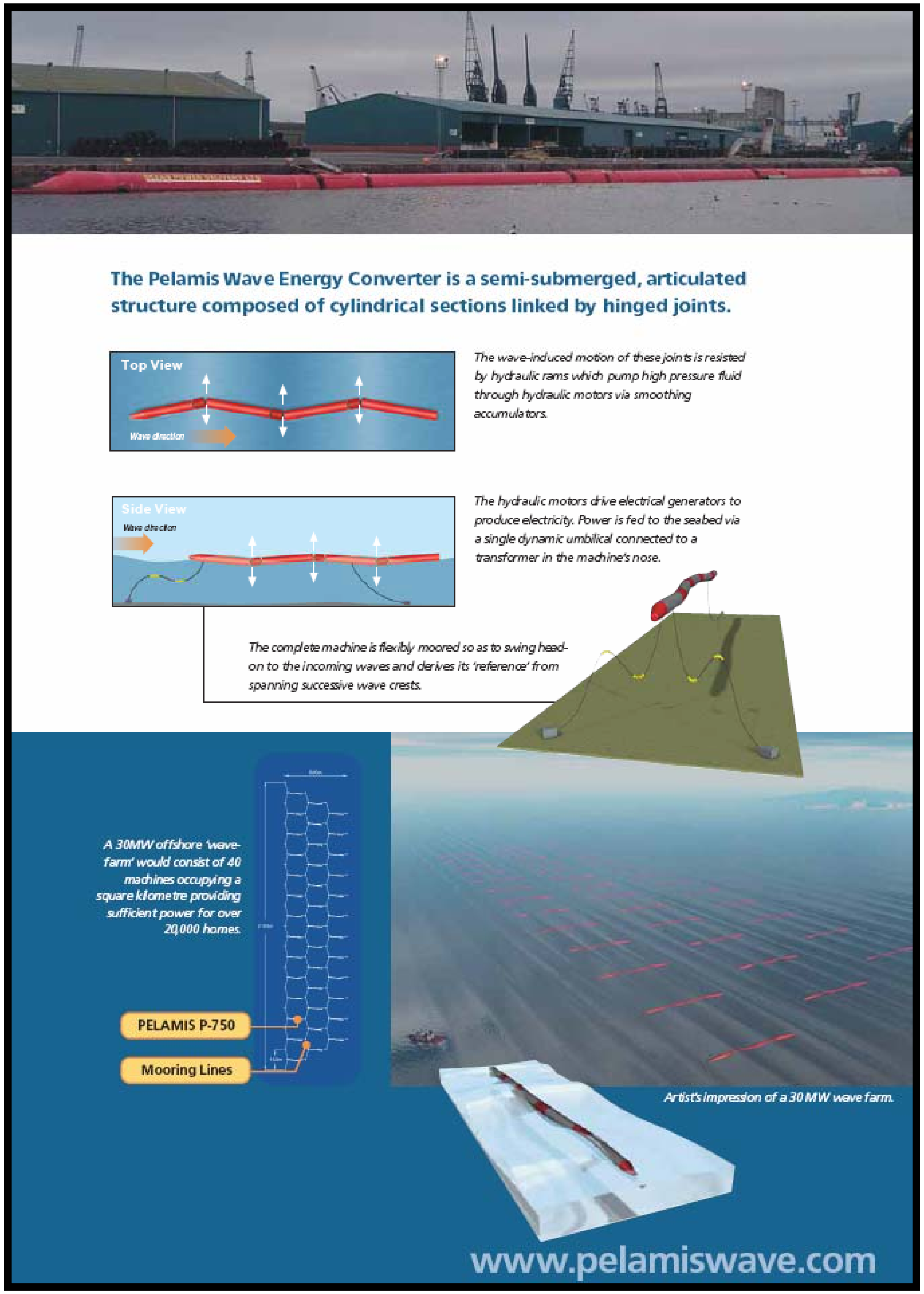


Figure 1. Cross Section of a SSG Wave Energy Converter.

CENTER FOR
ENERGY STUDIES

Renewable Energy: Wave

Giant Sea Snake Generator



LSU CENTER FOR ENERGY STUDIES

Renewable Energy: Tide

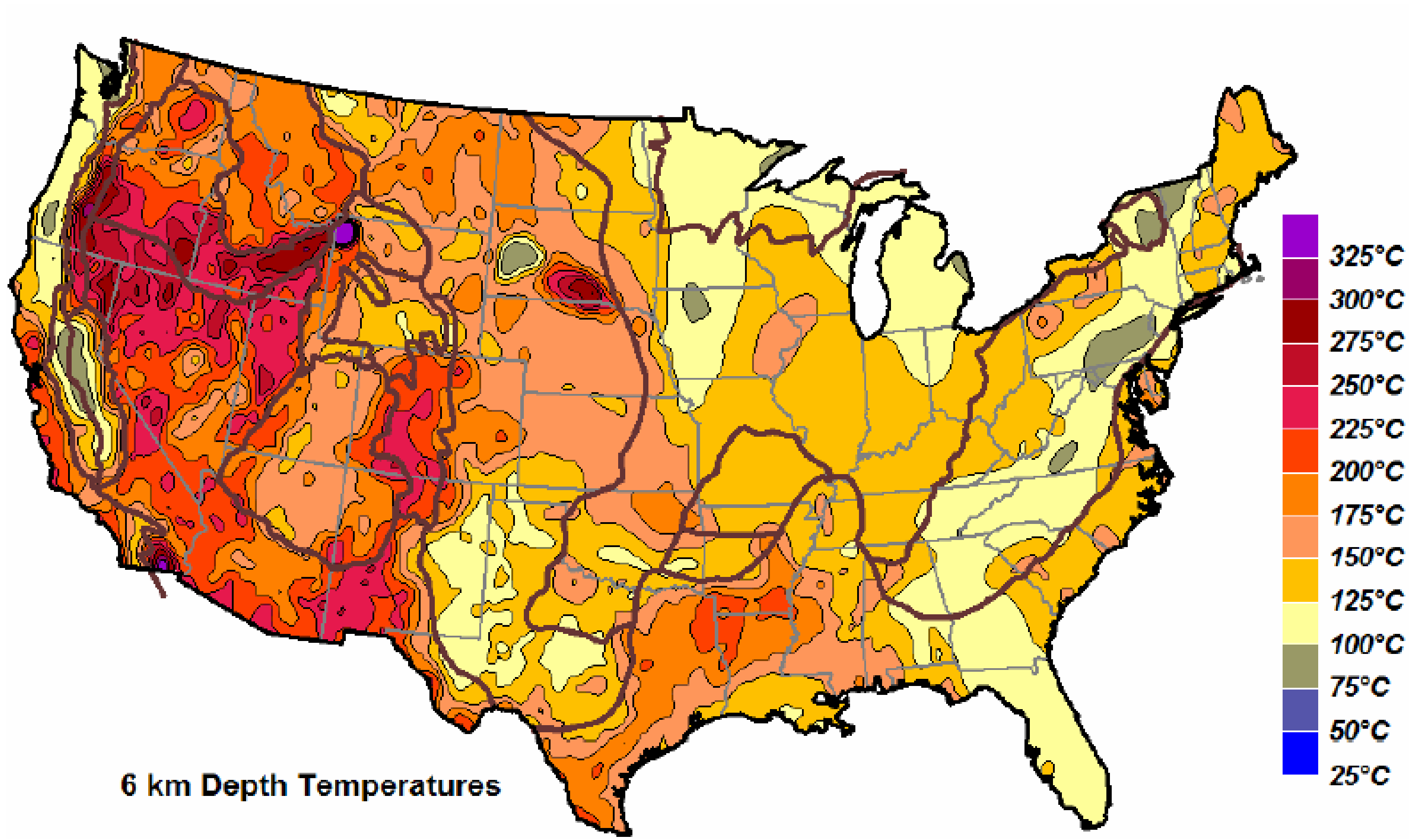
East River, NY

Rance Tidal Power Plant
Rance River, France

SeaGen, Northern Ireland

LSU CENTER FOR ENERGY STUDIES

Renewable Energy: Geopressured Geothermal



From Blackwell and Richards (June, 2007)

LSU CENTER FOR ENERGY STUDIES

Renewable Energy: Geopressured Geothermal

Geopressured geothermal 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 of produced fluids 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.

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 and 11,000 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, *thus this resource could conservatively provide a portion of the domestic energy supply for many centuries.*

ALTERNATIVE ENERGY DEVELOPMENTS

Renewable Energy :
Geopressured Geothermal

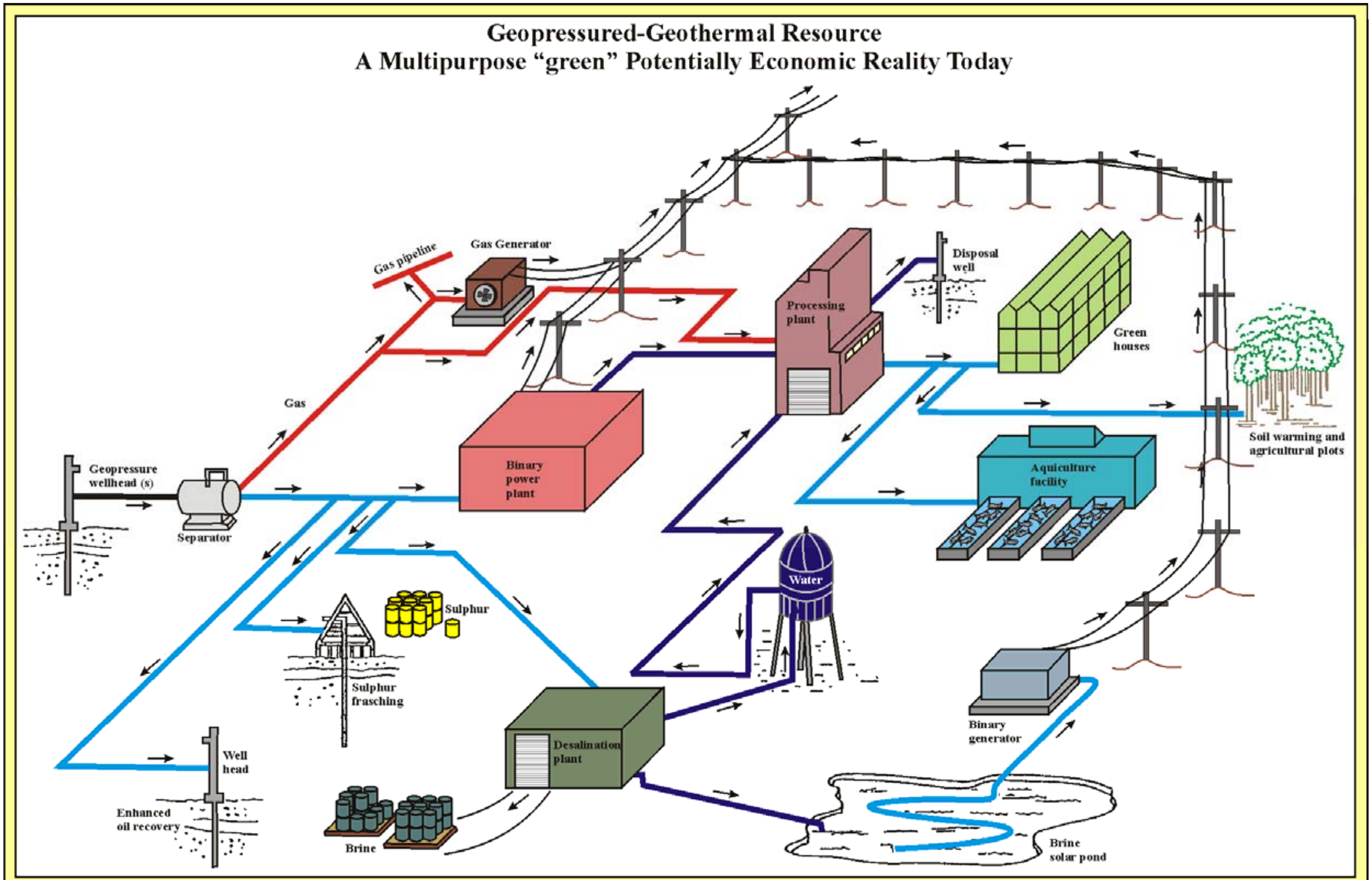
Table 1. Co-Produced Geothermal Fluids
Estimated equivalent geothermal power from processed water associated with existing hydrocarbon production, using 140°C (285°F) as a nominal fluid temperature.

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

LSU CENTER FO ENERGY ST

Renewable Energy : Geopressured Geothermal



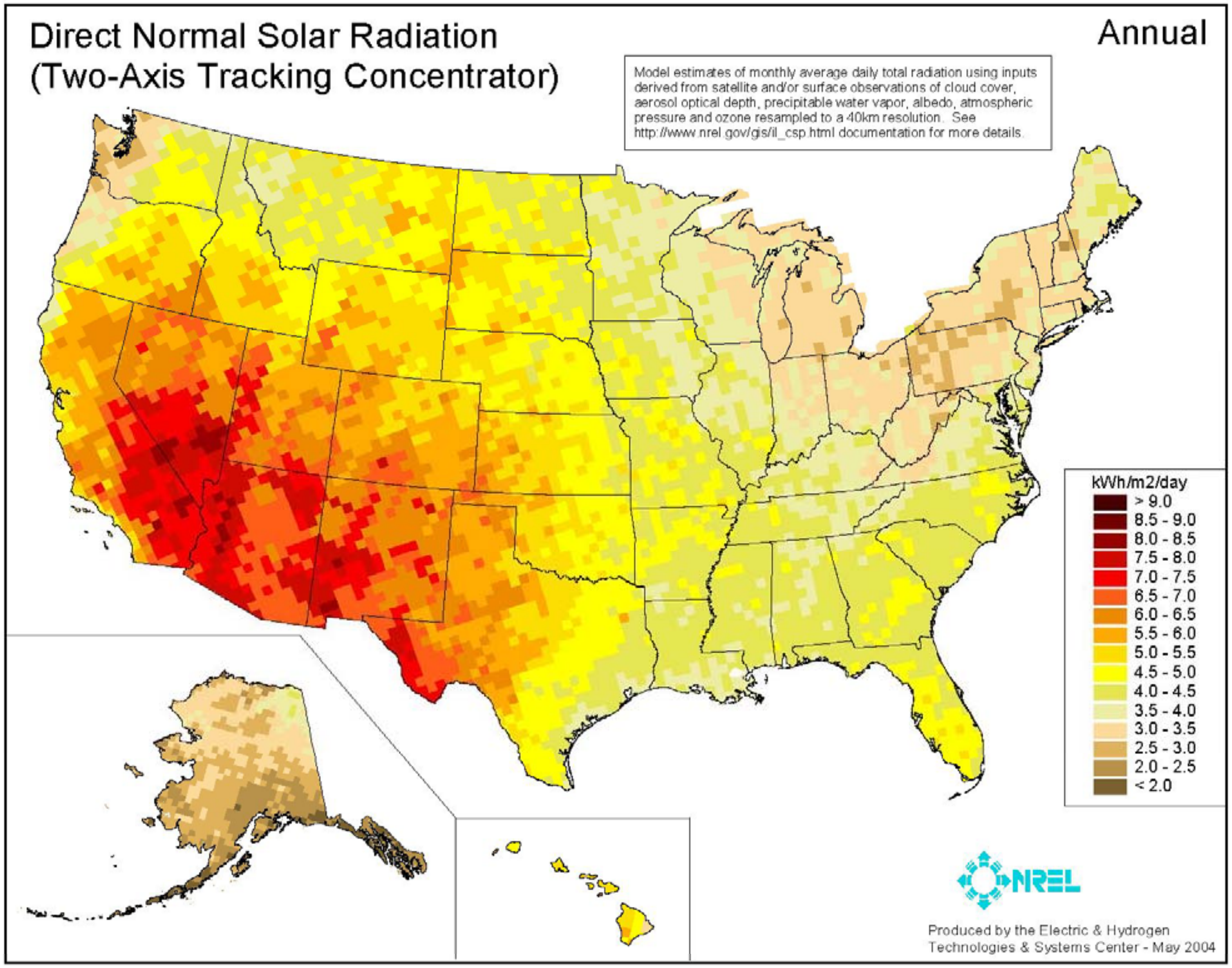
Conceptual layout of a geopressured integrated facility (from Lunis, 1990).

LSU CENTER FOR ENERGY STUDIES

The Case for Geothermal Energy

Levelized Cost of Electricity Analysis (Source: Credit Suisse 1-19-2009)	***High Case***	***Base Case***	***Low Case***	***Minimum***
Solar Photovoltaic (crystalline)	$201	$153	$119	$119
Solar Photovoltaic (Thin Film)	$180	$140	$110	$110
Fuel Cell	$117	$90	$72	$72
Solar Thermal	$126	$90	$69	$69
Coal	$66	$55	$46	$46
Natural Gas (CCGT)	$64	$52	$40	$40
Nuclear	$64	$62	$35	$35
Wind	$61	$43	$29	$29
Geothermal	**$59**	**$36**	**$22**	**$22**
Conservation/Efficiency	$30	$15	$0	$0
(figures in dollars per MWhr)				

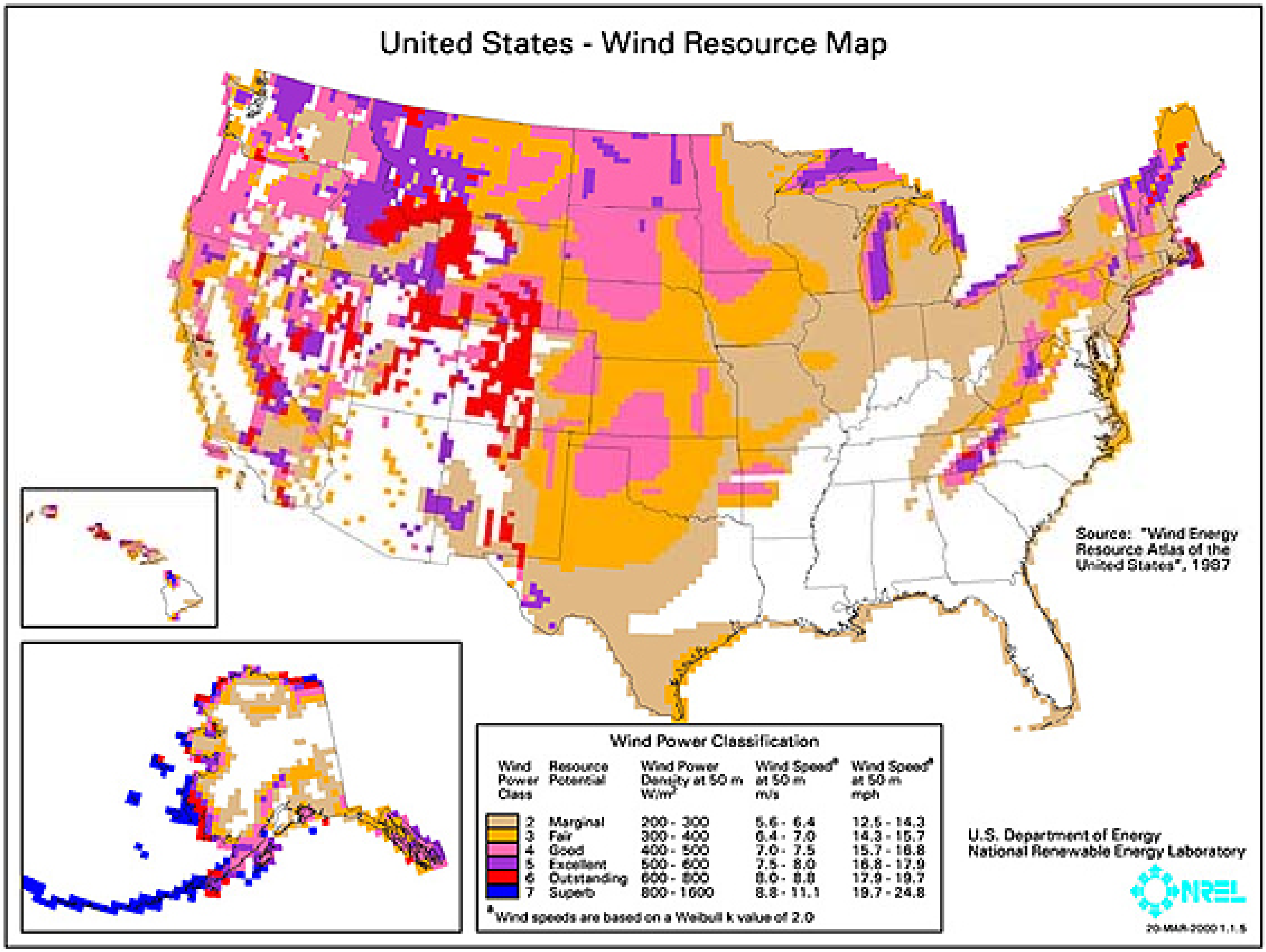
Renewable Energy : Solar



LSU CENTER FOR ENERGY STUDIES

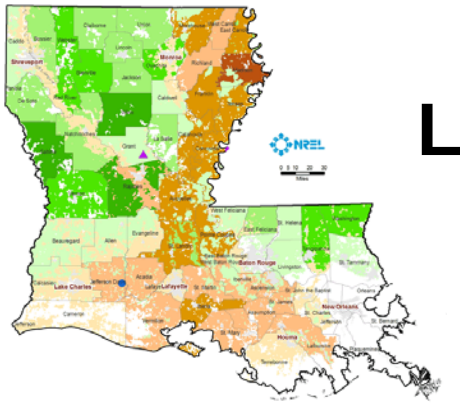
2007 LA solar tax credit bill

Renewable Energy : Wind



Louisiana’s Bioenergy Resources

LSU CENTER FOR ENERGY STUDIES



Louisiana's Bioenergy Advantages

- Mild climate – extended growing season
- Fertile soils
- Good solar radiation
- Plentiful rainfall
- Strong agricultural heritage/infrastructure
- Chemical manufacturing prowess
- Energy/fuels experience and distribution infrastructure

LSU CENTER FOR ENERGY STUDIES

Louisiana's Bioenergy Resources

	WET TONS	NET MILLION Btu	MILLION kWh
BIOMASS SOURCE			
Residue Wood			
Sawdust, trimmings, bark	134,323	1,244,665	73
Logging slash	8,432,792	71,678,733	4,216
Soybeans			
Straw	1,501,071	8,916,364	524
Sugarcane			
Bagasse (dry wt.)	122,702	895,725	53
Rice			
Hulls (dry wt.)	85,100	766,751	45
Straw	2,180,694	11,928,397	702
Sweet Potatoes			
Vines	60,288	253,000	15
Corn			
Stalks, roots, husks	350,043	1,470,000	86
Wheat			
Straw	320,064	2,010,000	118
Grain Sorghum (milo)			
Residue	52,544	221,000	13
Cotton			
Gin trash	57,553	327,000	19
Peanuts			
Vines	1,435	6,700	0.39
Oats			
Straw	267,670	1,670,000	98
Animal Wastes			
Cattle manure/biogas	9,881,919,000 cf	5,930,000	395
Poultry manure	944,150	4,437,505	261
TOTAL		111,755,839	6,620

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 these numbers.

LSU CENTER FOR ENERGY STUDIES

Data source:
LSU AgCenter, 2006

Louisiana's Bioenergy Resources

Louisiana Biofuel Production Potential (McGee and Crouch, 2007)
Using 2005 production data, McGee and Crouch estimated the amount of biofuel that could be produced from crops and waste products currently being produced in the state.

- They estimated that a little over *367 million gallons of ethanol* could be produced annually from sugarcane and grains (corn, grain sorghum, oats, and wheat) assuming the entire resource was used for biofuel production.

- Their estimate for *ethanol production* from biomass other than sugarcane and grains (e.g. forest residues, urban wood wastes, energy crops such as switch grass, bagasse, municipal wastes) was about *513 million gallons/year.*

- They estimated a production potential of around *64 million gallons/year of biodiesel* from oil crops and waste cooking oil/grease.

- Based on these estimates and some feedstock utilization assumptions, they concluded that *Louisiana could produce 18.7% of its transportation energy needs*.

LSU CENTER FOR ENERGY STUDIES

Louisiana's Bioenergy Future

Near-Term

Given current circumstances both nationally and locally, the near-term outlook does not look promising for bioenergy production in Louisiana, especially for 1st generation biofuels such as corn ethanol and soy biodiesel.

Intermediate to Longer-Term

Efforts made now to research, promote, and establish capabilities for production of 2nd generation and/or advanced biofuels could substantially benefit the state's long-term economic development. Some examples of promising 2nd generation/advanced biofuels are:

- Cellulosic Biofuels
- Bio-based Biodiesel
- Woody Biomass Fuels
- Biogas – Anaerobic Digestion
- Thermochemical Conversion Technologies

LSU CENTER FOR ENERGY STUDIES

Louisiana's Bioenergy Future

Cellulosic Biofuels

Biofuels derived from cellulosic feedstock offer many advantages over those derived from cultivated food crops such as corn and soybeans:

- Louisiana has substantial feedstock resources in wood and agricultural residuals.
- The state has good potential for producing specific energy crops such as high-fiber sugarcane, sweet sorghum, switchgrass and miscanthus.
- Louisiana's extended growing season allows for the possibility of producing a much wider variety of feedstock crops.
- Life-cycle greenhouse gas emissions are much lower than conventional fossil fuels and corn-based ethanol and easily qualify for meeting EPA renewable fuel standards.
- Not as susceptible to food-versus-fuel controversy.

LSU CENTER FOR ENERGY STUDIES

Louisiana's Bioenergy Future

Bio-based Biodiesel

While the soybean-based biodiesel industry is currently struggling because of economic factors, the potential for biodiesel produced from other feedstocks such as animal fats, non-traditional crops, and algae looks promising for our state. As examples:

KEMA

Algae-to-energy opportunities in Louisiana

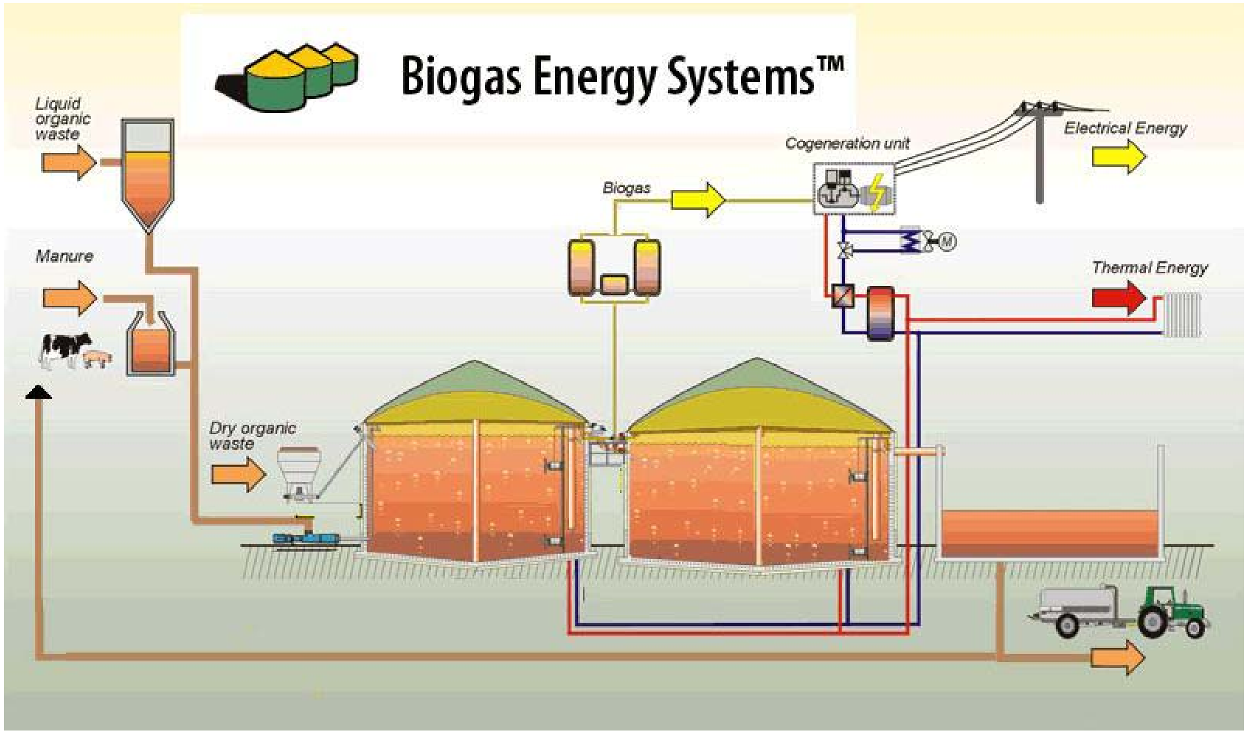
A Market potential report

- Dynamic Fuels, a joint venture of Tyson Foods and Syntroleum Corporation, is building a new facility in Geismar that will convert animal fats and greases provided by Tyson into ultraclean renewable diesel and jet fuel.
- A recent report commissioned by Louisiana Economic Development concludes that high yield potential and low impact on existing agriculture make algae a strong candidate for renewable fuel production.
- There is considerable interest in bio-based biodiesel in the aviation industry. Recent test results show that a jatropha and algae oil biofuel blend used in a Continental Airlines January 7 biofuel demonstration flight proved approximately 1.1% more efficient that traditional jet fuel and reduced life cycle GHG emissions by an estimated 60-80%. The Defense Advanced Research Projects Agency (DARPA) is funding research to accelerate the development of surrogates for military-grade jet fuel (JP-8), of which DOD consumes nearly 3 billion gal/yr.
- On July 14th, ExxonMobil announced plans for a $600 million investment in producing liquid transportation fuels from algae.

LSU CENTER FOR ENERGY STUDIES

Louisiana's Bioenergy Future

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 digesters 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.

Biogas offers a number of advantages as a bioenergy resource:

- It relies on mature technologies.
- It is a renewable energy source with low lifecycle GHG emissions.
- It can be distributed through existing natural gas infrastructure.
- It can reduce the amount of organic wastes going to landfills.
- Residuals can be used to enrich soils.
- Used for treating livestock wastes on farms, it can reduce water pollution.

LSU CENTER FOR ENERGY STUDIES

Louisiana's Bioenergy Future

Woody Biomass Fuels – Fuel Pellets

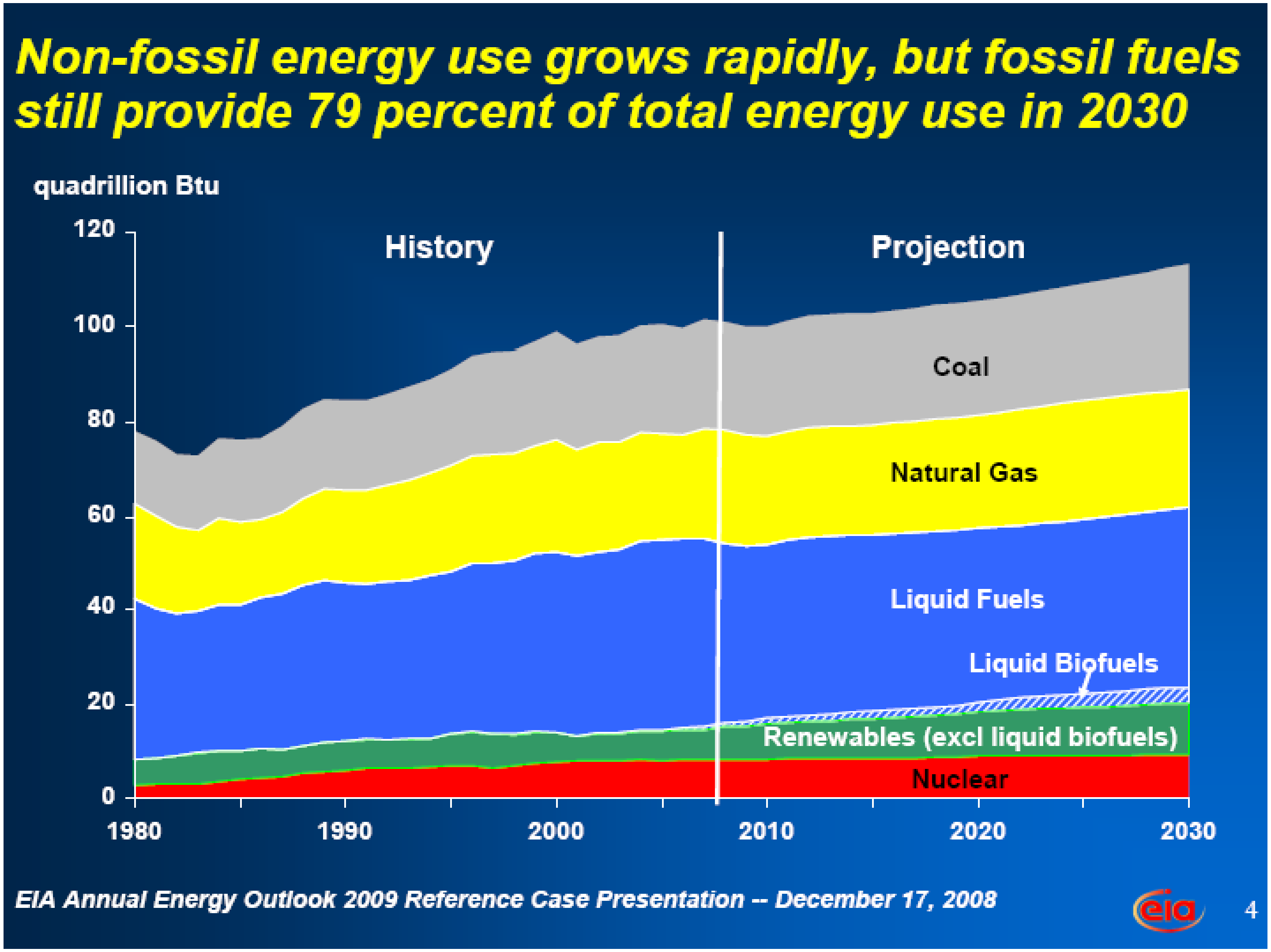
CENTER FOR
ENERGY STUDIES

Louisiana's Bioenergy Future

Woody Biomass Fuels – Fuel Pellets

- Wood pellets as a heating fuel actually originated in the U.S. in the 70's in response to high energy prices and is now an increasingly popular co-fire and stand-alone feedstock for commercial and utility renewable energy applications, especially in Europe.
- The EU requires member countries to generate 20% of their electricity from renewable resources by 2020. Although wood pellets are a bit pricier than coal, burning them is a less-expensive way to generate electricity than using wind or solar energy. Europe imported about $93 million of pellets and other wood-based fuels in the first three months of 2009, up 62% from the same period a year ago. Europe presently consumes about 8 million tons of wood pellets annually.
- Until recently, there were about 40 pellet factories in the U.S., which produced about 900,000 tons per year, mostly for heating homes in the Northeast and Northwest. Since May, 2008 there have been a number of large capacity (500,000 tons/yr) plants opened or announced (e.g. Cottondale, FL; Selma, AL; Camden, AR; Corinth ME).
- In March, 2009 plans to build a $100 million wood pellet-making plant at the Port of Greater Baton Rouge were announced, with the pellets to be sold as fuel overseas.
- There are currently several high-profile bills in the U.S. Congress that would require a renewable energy standard (RES) for electrical generation similar to that in Europe, and it appears likely there will be a federal RES within the next year or two. This will greatly increase interest in wood pellets in the U.S.
- American Electric has conducted biomass co-firing tests at several of its U.S. plants.
- Electric utilities in Georgia and Texas have recently announced they will build several biomass-fueled generating plants by 2015.

National Prognosis for Renewable Energy



LSU CENTER FOR ENERGY STUDIES