Energy Seminar
Waterloo, Iowa, 11 Sept 06
Five Sullivans Center

Bill Leighty, Director
The Leighty Foundation
Juneau, AK
wleighty@earthlink.net
907-586-1426  206-719-5554 cell
USE OF THE OSCILLOSCOPE FOR MEASURING BROADBAND SIGNALS

9th grade, NE Iowa Science Fair, SCI
10th grade
NE Iowa
Science Fair
SCI
11th grade NE Iowa Science Fair SCI
12th grade
NE Iowa
Science Fair
SCI
Mary Sue Wilson Coleman
President
University of Michigan

NE Iowa Science Fair
SCI
“Best Paper” award
World Gas Conference
Tokyo
June ‘03
25 minutes: Energy

- Leighty Foundation research:
  - Renewables
  - “Hydrogen Economy”
- Energy scenarios
- Alaska:
  - Global warming “canary in coal mine”
  - ANS gasoline
  - Arctic National Wildlife Refuge (ANWR)
- Iowa, Waterloo opportunities
- Coal plants
Waterloo action

Inflicted coal plant controversy:

Gift?

Understand energy: broad context

How respond?

Find new community paths, strengths?
“America is addicted to oil.”


*Humanity is addicted to energy*
Energy Slaves
Lance Armstrong
2002

Peak  500 Watts
Average  250 Watts

3 kWh per day
( 12 hour day )
746 Watts = 1 hp
Energy Slaves

USA:
35 Lance Armstrongs per person

24 / 7
The Fossil Fuel Age: a “Blink of an Eye” between the First and Second Solar Civilizations
Earth’s only source of income: Solar radiation, dust
Titusville, PA
1859
First oil well in USA
One-fourth of the farm’s solar energy harvest goes to the draft animals.
The Second Solar Civilization

- Diverse
- Benign
- Renewable
  - Electricity
  - Hydrogen
"There's a better way to do it... Find it"
Repowering The Midwest:
The Clean Energy Development Plan for the Heartland
Business – as-usual

- New Renewables
- New Gas
- Existing Renewables
- Hydro
- Gas/Oil
- Nuclear
- Coal
New Clean Power Capacity (MW)

- CHP-Biomass
- District Energy
- Biomass Co-Fire
- CHP-Gas
- Wind

New Renewables - 2020

New Clean Power Capacity (MW) 4,474
The Great Plains Wind Resource
How shall we bring the large, stranded, Great Plains wind to market?
Total solar: $\sim 3 \times 10^{14}$ kg / yr

Total wind: $\sim 3 \times 10^{11}$ kg / yr

Rich, stranded Resources
The Great Plains Wind Resource

“Stranded”

- No transmission
- Electric lines are full
- No farm-to-market roads
Proposed ANS* Gas Pipeline

"ALCAN" Alaska Highway Route

Foothills Pipe Lines Ltd.
Canada

* Alaska North Slope
• Great Plains Wind: Huge, Stranded
• Big Market: Hydrogen Fuel, not Grid Electricity
• Accelerate Conversion
## Exporting From 12 Windiest Great Plains States

Number of GH2 pipelines or HVDC electric lines necessary to export total wind resource

Wind energy source: PNL-7789, 1991

* at 500 miles average length

<table>
<thead>
<tr>
<th>State</th>
<th>AEP, TWh</th>
<th>Wind Gen MW (nameplate) (40% CF)</th>
<th>6 GW 36” GH2 export pipelines</th>
<th>$ Billion Total Capital Cost *</th>
<th>3 GW export HVDC lines</th>
<th>$ Billion Total Capital Cost *</th>
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<tr>
<td>North Dakota</td>
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<td>206,906</td>
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<td>29</td>
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<td>Minnesota</td>
<td>657</td>
<td>187,500</td>
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<td>26</td>
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<td>Iowa</td>
<td>551</td>
<td>157,249</td>
<td>22</td>
<td>22</td>
<td>50</td>
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<td>Colorado</td>
<td>481</td>
<td>137,272</td>
<td>19</td>
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<td>New Mexico</td>
<td>435</td>
<td>124,144</td>
<td>17</td>
<td>17</td>
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<td>24</td>
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<td><strong>TOTALS</strong></td>
<td><strong>9,984</strong></td>
<td><strong>2,849,316</strong></td>
<td><strong>401</strong></td>
<td><strong>$ 401</strong></td>
<td><strong>890</strong></td>
<td><strong>$ 534</strong></td>
</tr>
</tbody>
</table>
Iowa Wind Potential

Annual energy production, TWh 550
Installed wind generation, MW 157,249

Export electric lines 50
Export electric lines cost $ 30 billion

Export hydrogen pipelines 20
Export hydrogen pipelines cost $ 20 billion
High Voltage Direct Current Transmission

**North Dakota**
wind needs
**115 new lines**
at **3,000 MW**
each

**Twelve Plains states**
wind needs
**890 new lines**
at **3,000 MW**
each

**SIEMENS**
**HVDC line**
+/- **500 kv**
Pilot-scale Hydrogen Pipeline System: Renewables

- Diverse
- Dispersed, diffuse
- Large-scale
- Stranded
  - Remote
  - No transmission
International Renewable Hydrogen Transmission Demonstration Facility (IRHTDF) Pilot plant

Global opportunity: IPHE project
IRHTDF
International Renewable Hydrogen Transmission Demonstration Facility

* Des Moines
* Ames

Iowa Energy Center
This map was generated from data collected by the Iowa Wind Energy Institute under Iowa Energy Center Grant No. 93-04-02. The map was created using a model developed by Brower & Company, Andover, MA.

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IRHTDF: generation, conversion, collection, storage corridor

Biomass, Wind, Other Catchment Areas, with Delivery Points to GH2 pipeline

GH2 geologic storage

O2 pipeline

*
Solar Hydrogen Energy System

Sunlight from local star

Electrolyzer

Fuel Cell

Electricity

Work

H₂

O₂

2H₂O → Energy → 2H₂ + O₂

2H₂ + O₃ → 2H₂O + Energy
Hydrogen-fueled, Fuel Cell Electric
Proposed Northeast Asia Natural Gas Pipeline
The NATURALHY approach

NATURALHY:
• Breaks “chicken-egg” dilemma
• Bridge to sustainable future

Prepared by
O. Florisson
Gasunie
The Leighty Foundation
co-authored research papers, posters
2000 - 06

• 15 papers, international conferences
  – World Energy Congress ’04
  – World Gas Conference ’03, ’06
  – World Hydrogen Energy Conference ’02, ’04, ’06
  – Windpower ‘01 – ’06 (AWEA)
  – National Hydrogen Association ’01 – ’06
  – International Pipeline Conference ’04, ‘06

• Transmission options: large, stranded renewables as hydrogen fuel in pipelines
Hydrogen is NOT a clean, abundant energy source

- **Never** an energy source, on Earth
- Energy carrier, storage medium: fuel
- Not a panacea nor *deus ex machina*
- Most abundant element in universe – Earth, no free hydrogen, H or H$_2$
  - H$_2$O, CH$_4$, NH$_3$, C$_8$H$_{18}$
- Only as clean and abundant as energy source from which it is made
- Many sources: fossil, renewables, nuclear
What Hydrogen Economy?

Hydrogen “sector” of a sustainable, benign, global energy economy
• Largest Leighty Foundation grant
• Great Plains expansion
• Des Moines office
  – ‘07 Farm Bill, Title IX, Energy
  – Local ownership of IA renewables
  – Global Warming: presidential race
Rush to Coal, Nuclear

- Coal abundant? Cheap? Indigenous

- Nuclear:
  - Safer plants?
  - Fed subsidies needed: insurance, PTC
  - Waste disposal
  - Proliferation
  - Plant capital cost
SPECIAL REPORT:
THE END OF CHEAP OIL
It’s Coming Fast.
But New Technologies Might Prevent an Energy Crisis
Estimated 2005 US energy use

Estimated Future U.S. Energy Requirements - 96.8 Quads

- Hydro 0.94
- Bio/Geo 3.81
- Wind 0.06
- Solar 0
- Nuclear 7.48
- Coal 20.83
- Gas 24.73
- Oil 38.96

Electricity Generation 33.91

- Residential 11.89
- Commercial 8.96
- Industrial 26.36
- Automotive 16.18
- Freight 9.19
- Airlines 2.8
- H2 Production 0

Useful Energy 44.76

Rejected Energy 52.06

Projection Year 2005
From Year 2005
Efficiency Year 2005
Energy Distribution Year 2005
US total crude oil production

- Lower 48 = 189 BBbls
- North Slope = 15.5 BBbls
- ANWR = 5.7, 10, 16 BBbls
Arctic National Wildlife Refuge (ANWR)

* 1002 Area
Estimated 2050 energy use
(H₂ fleet using nuclear thermochemical)

Estimated Future U.S. Energy Requirements - 153 Quads

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<thead>
<tr>
<th>Energy Source</th>
<th>Estimated Use (%)</th>
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<tr>
<td>Bio/Geo</td>
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<tr>
<td>Wind</td>
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<tr>
<td>Solar</td>
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<tr>
<td>Nuclear</td>
<td>30.72</td>
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<tr>
<td>Coal</td>
<td>28.38</td>
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<tr>
<td>Gas</td>
<td>42.83</td>
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<tr>
<td>Oil</td>
<td>42.9</td>
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<table>
<thead>
<tr>
<th>Energy Distribution</th>
<th>Estimated Use (%)</th>
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</thead>
<tbody>
<tr>
<td>Residential</td>
<td>17.22</td>
</tr>
<tr>
<td>Commercial</td>
<td>16.91</td>
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<tr>
<td>Industrial</td>
<td>45.97</td>
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<tr>
<td>Automotive</td>
<td>10.71</td>
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<tr>
<td>Freight</td>
<td>18.45</td>
</tr>
<tr>
<td>Airlines</td>
<td>7.77</td>
</tr>
</tbody>
</table>
Estimated 2050 energy use
(H₂ fleet using wind electrolysis)
Big Mistakes

- 80’s – 90’s
- USDOE, EIA: gas $ 2 – 4 for decades
- Utilities buy many gas power plants
  - aeroderivative
  - low capital cost
  - modular
  - high-efficiency
  - turn-down capable
- Gas price UP, VOLATILE
- Gas supply uncertain: imports, LNG
Rush to Coal, Nuclear

• Coal abundant? Cheap? Indigenous

• Nuclear:
  – Safer plants?
  – Fed subsidies needed: insurance, PTC
  – Waste disposal
  – Proliferation
  – Plant capital cost
Svante Arrhenius

Sweden

1905
Nobel Prize Chemistry

Proved CO₂ is heat-trapping gas in 1896
The Greenhouse Effect

SUN

Some solar radiation is reflected by the Earth and the atmosphere.

Solar radiation passes through the clear atmosphere

ATMOSPHERE

Most radiation is absorbed by the Earth's surface and warms it.

EARTH

Infrared radiation is emitted from the Earth's surface.

Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Carbon Dioxide Concentrations

Source: Office of Science and Technology Policy, Oct 97
Climate Change over Next 100 Years

- CO₂ concentration in the atmosphere (Antarctic Ice Core)
- Temperature changes compared to the present temperature
How much will the Kyoto Protocol reduce emissions?

In past 50 years,

**Alaska:**
Temperatures have increased
- 4°F overall
  (National Assessment Synthesis Team)

**Worldwide:**
Temperatures have increased
- approx. 1°F
  (ACIA, 2004)
Melting Sea Ice

- An area twice the size of Texas has melted away since 1979.
- Ice 40% thinner.
- Arctic Ocean could be ice free in summer by 2100.
- Bering Sea Ice Sheet also retreating.
Glacial Retreat

- The rapid retreat of Alaska’s glaciers represents about 50% of the estimated mass loss by glaciers worldwide.

- Alaska’s glaciers are responsible for at least 9% of the global sea level rise in the past century. (ACIA, 2004)

- Loss of over 588 billion cubic yards between ’61 and ’98. (Climate Change 11/05)
Scientific American, Sept 06

- Beyond Carbon
- GW / GCC urgent action

Mendenhall Glacier
Juneau, Alaska 2005
Permafrost Thawing

Upper soil layers have warmed as much as 3°C in the last 20 years, causing permafrost to melt at an unprecedented rate.

Impacts in Alaska

1. Melting
   - Damage to infrastructure, lakes, rivers, and forests.
   - Rising sea levels.
   - Release of stored carbon (methane and CO2)

Consequences

- Damage to infrastructure, lakes, rivers, and forests.
- Rising sea levels.
- Release of stored carbon (methane and CO2)
Permafrost Thawing

Upper soil layers have warmed as much as 3°C in the last 20 years, causing permafrost to melt at an unprecedented rate.

Impacts in Alaska
1. Melting

-6°C -8°C -10°C

-6°C -8°C -10°C
Deadhorse West Dock

Consequences
- Damage to infrastructure, lakes, rivers, and forests.
- Rising sea levels.
- Release of stored carbon (methane and CO₂)

photo © Vladimir Romanovsky

Global Warming: The Greatest Threat © 2006 Deborah L. Williams
Polar Bears in Peril

- 87% on sea ice ('79-'91) vs. 33% on sea ice ('92-'04) (Monnett et al. 12/05)
- Numbers in western Hudson Bay have declined 22% in 17 years.
- Vulnerable to extinction.
Polar Bear Cannibalism

Photos courtesy of Steven Amstrup, USGS
Yukon Chinook Diseased

- Protozoan parasite *Icthyophonus* never found in Yukon salmon before 1985.
- Today, 45% of the Yukon’s Chinook salmon are infected.
- Infection is causing wastage, reduced returns to spawning grounds, and mortality.
Exotic Species Appearing

Juneau Empire Sep 25, 2005

“Squid, sharks, barracuda are among species newly arrived in Alaska waters.”

“Seiners and troll fishermen reported sardines, anchovies, jumbo squid, sharks, barracuda and large concentrations of brilliantly hued open-ocean fish such as pomfret and opah.”

2005 GOA water temperatures were 2-3°C higher than average.

Juneau Empire report, Sep 25, 2005
In 1950, critical temperature threshold crossed (16 deg C); since then, growth has declined.

Species could be eliminated from central Alaska by the end of this century (ACIA, 2004).
Forest Decline: Black Spruce

- The dominant tree in about 55% of Alaska’s boreal forest.
- Warming temperatures result in strongly reduced growth. Trees are also disrupted by thawing ground.
- By 2100, predicted temperature scenarios would not allow black spruce to survive in Fairbanks area (ACIA).
A dramatic decline has affected over 500,000 acres of yellow cedar in SE Alaska.

The suspected cause is spring freezing injury, due to:

- Warmer winters (premature dehardening in springtime).
- Reduced snow cover (less insulation).

Hennon/USFS, 2004; Schaberg & Hennon, 2005
Impacts in Alaska

3. Wetlands and Forests

Spruce Bark Beetle

The world’s largest outbreak of spruce bark beetle has infested approximately 4 million acres on the Kenai Peninsula. (ACIA, 2004)

Cause:
- Warmer summers
  One year life-cycles.
- Warmer winters
  No kill-off.

USFS photo

Columbia University photo http://www.columbia.edu/~jas194
Forest Fires

- 4.6 million acres burned in 2005
- 6.6 million acres burned in 2004

Alaska Acres Burned 1956-2005

Source: NOAA National Climate Data Center
Weather and Storms

September, 2005:
- Storm surges 9 ft, waves 15 ft.
- 34 communities affected.
- Unalakleet lost 10-20 feet of beach.
- Newtok lost 10 ft of beach and a 1000 gallon fuel tank.
- Golovin homes were flooded for an unprecedented third year in a row.

Golovin, September 23, 2005. photo courtesy of Toby Anungazuk, Jr.

Global Warming: The Greatest Threat © 2006 Deborah L. Williams
Weather and Storms

- Some shorelines have retreated more than 1500 feet over past few decades. (National Assessment Synthesis Team)
- Newtok lost 2-3 miles in 40 years.
- In a single storm in 1997, Shishmaref lost 125 feet of beach.
- Cost to move Shishmaref: $193M (Army Corps of Engineers estimate, 2006); Kivalina: $100 to $400 million.
- 184 communities are at risk from flooding and erosion (GAO estimate).

“Coastal villages are becoming more susceptible to flooding and erosion caused in part by rising temperature.” (GAO, 2004)
Global Warming, Global Climate Change

- Real, worsening, accelerating
- Cause: Anthropogenic greenhouse gases
- Alaska: canary in coal mine
- Emergency: large, urgent response
- “Wedges”
- Unite humanity: aliens, asteroid, epidemic
Global Warming, Global Climate Change

• *Scientific American*, September 06
  “Energy’s Future: Beyond Carbon”
• *Field Notes from a Catastrophe*
  Elizabeth Kolbert
• *The Resurgence in Coal*, August 06
  ConocoPhillips
Global Warming, Global Climate Change

Movie: “An Inconvenient Truth”

- Good overview of GW / GCC science
- Climate scientists agree: movie’s science 95% correct
- Global problem: our end of the boat
- Focus on science, not Al gore
YO! AMIGO!!

WE NEED THAT TREE TO PROTECT US FROM THE GREENHOUSE EFFECT!
Why should Waterloo, Iowa care?

• Need your understanding, help
• Global, local effects:
  – weather
  – crops
  – disease
• Fairness:
  – grandchildren
  – fellow humans
  – fellow species
• Environmental refugees: sea level rise
• Carpe Diem: lost opportunities, bad choices
“There’s a better way to do it... find it”
beyond petroleum
BP, World Gas Conference
Amsterdam, June 06

- “… necessary shift to the low-carbon, high technology, industry of the future”

- “… we believe it is important that carbon is priced”

- “… power is a bigger emitter than transport, and it is probably easier to do something about the associated emissions”
Eight scientific academies of the G8, July 05:

“... sufficient evidence that human activity could affect the earth’s climate in a serious way to justify precautionary action ”
“… climate change is a risk we cannot ignore and that precautionary action is necessary, indeed essential.”

“ When academicians from every major country say that, I don’t believe any serious person can ignore them.”
BP, Lord Browne, CEO
Brookings Institution, 29 Nov 05

“... launching a new business.
BP alternative energy. ”

[ BP bought 10% of Clipper Windpower
(new CR wind generator manufacturing plant) plus 900, 2.5 MW wind generators ]
Rush to Coal, Nuclear

- Coal abundant? Cheap? Indigenous
- Nuclear:
  - Safer plants?
  - Fed subsidies needed: insurance, PTC
  - Waste disposal
  - Proliferation
  - Pant capital cost
“Decarbonization” of Fuels

CO₂

<table>
<thead>
<tr>
<th>Fuel</th>
<th>C/H Ratio</th>
<th>C/O Ratio</th>
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<tr>
<td>Coal</td>
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<tr>
<td>Crude Oil</td>
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<tr>
<td>Natural Gas</td>
<td>0.25</td>
<td>approx. 1.5</td>
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<tr>
<td>Hydrogen</td>
<td>0</td>
<td>approx. 1.0</td>
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</table>

Begin of Industrialization → Today → Future (Regenerative)
Coal Plants

• Combustion: burn coal in air $\rightarrow$ electricity
  – Steam
  – Pulverized coal (PC)

• Gasification: coal + oxygen $\rightarrow$ electricity
  – Syngas (hydrogen + CO2)
  – Gas turbine generator

• Chemical: gasification $\rightarrow$ syngas $\rightarrow$ fuels
  – Dakotas Gasification Company: methane
  – Germany WWII: gasoline, diesel
Coal Plant Types

NO carbon capture and sequestration (CCS)

- Combustion: burn coal in air $\rightarrow$ electricity
  - “Steam”
  - Pulverized coal (PC)

- Gasification: coal + oxygen $\rightarrow$ electricity
  - Syngas (hydrogen + CO2)
  - Gas turbine generator

- Chemical: gasification $\rightarrow$ syngas $\rightarrow$ fuels
  - Dakotas Gasification Company: methane
  - Germany WWII: gasoline, diesel
Coal Power Plants

• Pulverized coal (PC) power plants
  – “Combustion” burns coal in air
  – Proven technology
  – Large size, baseload
  – Modest capital cost
  – No CO2 emissions capture, control
  – No carbon taxes, CO2 caps, YET
  – Opportunity window closing
Coal Power Plants

• Integrated Gasification Combined Cycle (IGCC) power plants
  – “Gasification” in oxygen and steam
  – Proven, less-available technology
  – Large size, baseload
  – Higher capital cost than PC
  – Carbon Capture and Sequestration (CCS) capable
  – Near-zero CO2 emissions, with CCS
  – Opportunity window OPENING

• ConocoPhillips “Resurgence of Coal”
IGCC coal power plant with CCS*

1. Coal, water and oxygen are fed into a high-pressure gasifier in which the coal is partially oxidized and converted into syngas.
2. The syngas is reacted with steam to produce a gaseous mixture of mostly carbon dioxide and hydrogen (H₂) from which CO₂ is extracted for burial (yellow pathways at bottom).
3. Hydrogen-rich syngas is burned and the combustion products drive a gas turbine-generator.
4. The hot gas turbine exhaust passes to a heat-recovery steam generator, which converts water to steam that turns a steam turbine-generator.

* Carbon Capture and Sequestration
• BP, Mission Energy (SCE), proposed
• “Coke to Power” gasification plant
• 500 MWe to SCE grid
• Carson, CA refinery
• H2 - fired electricity generation, IGCC
• CCS for CO2 in old oil field
BP Miller Field, North Sea

Gas from North Sea fields is transported to shore to the UK gas grid.

The UK gas grid supplies gas to a new reformer located at the power station near Peterhead.

At the heart of the project is the natural gas reformer and carbon capture facility where natural gas is converted into Hydrogen and Carbon Dioxide (CO₂).

NG → H₂ + CO₂ → electricity + CO₂

with CCS* and enhanced oil recovery

* carbon capture and sequestration
Coal Plants

- Combustion: burn coal in air $\rightarrow$ electricity
  - Steam
  - Pulverized coal (PC)
- Gasification: coal + oxygen $\rightarrow$ electricity
  - Syngas (hydrogen + CO2)
  - Gas turbine generator
- Chemical: gasification $\rightarrow$ syngas $\rightarrow$ fuels
  - Dakotas Gasification Company: methane
  - Germany WWII: gasoline, diesel
Coal Gasification
Chemical, Fuel Plant

- Methane: substitute natural gas
- Hydrogen
- Ammonia
- Synthetic diesel, gasoline: Germany WW-II
- Other Fischer-Tropsch Liquids – FTL’s
The coal gasification process

Coal gasification involves dismantling the molecular structure of coal and reassembling the resultant hydrogen and carbon as methane.

The heart of the synfuels plant is a building containing 14 gasifiers. The gasifiers are cylindrical pressure vessels 40-feet high with an inside diameter of 13 feet.

Each day 16,000 tons of lignite are fed into the top of the gasifiers. Steam and oxygen are fed into the bottom of the coal beds causing intense combustion (2,200 degrees Fahrenheit). Resulting hot gases break down the molecular bonds of coal and steam, releasing compounds of carbon, hydrogen, sulfur, nitrogen and other substances to form a raw gas that exits the gasifiers. Ash is discharged from the bottom of the gasifiers.

The raw gas goes to the gas cooling area where the tar, oils, phenols, ammonia and water are condensed from the gas stream. These byproducts are sent on for purification and transportation. Other byproducts are stored for later use as boiler fuel for steam generation.

The gas is moved to a cleaning area where further impurities are removed. Some of these substances with additional refining could become valuable byproducts in the future.

Methanation is the next step. Methanation takes place by passing the cleaned gas over a nickel catalyst causing carbon monoxide and most remaining carbon dioxide to react with free hydrogen to form methane. Final cleanup removes traces of carbon monoxide.

The gas is then cooled, dried and compressed, entering the pipeline with a heating value of 975 Btu per cubic foot.

Dakotas Gasification Company
Beulah, ND
Coal Power Plant Questions

• Is Waterloo geology suitable for CCS from an IGCC coal plant?
• Who will propose an IGCC, rather than PC, power plant?
• Compare IGCC, PC plant econ benefits: payrolls (build; operate); capital cost
• How can Waterloo access the waste heat of a coal plant for district heating?
Coal Power Plant Questions

• What is amount of CO2 (carbon dioxide, principal greenhouse gas) emitted from PC, IGCC coal plants?
• What are local, global effects of CO2 emissions?
• How will future “carbon taxes” affect a PC plant?
• Is proposed PC coal plant “safe”?
  • From what?
  • For whom?
• How serious and urgent is GW / GCC? What is Waterloo’s responsibility, opportunities?
When we realize these as emergencies:

- Global Warming, Climate Change
- Energy Security and Cost
- Peak Oil and Natural Gas

We must quickly invest in:

- Energy conservation, efficiency
- Large, new energy supplies:
  - CO$_2$-emissions-free
  - Indigenous
  - Both Distributed, Centralized
Conservation and Efficiency: Best Investments

- KWh saved is a KWh earned (generated)
- Huge potential savings at cost below ANY new generation
- Labor-intensive AND capital-intensive
- Fast deployment
- Increases property value = tax base
- Many effective policies
Energy Seminar
Waterloo, Iowa, 11 Sept 06
Five Sullivans Center

QUESTIONS?

Bill Leighty, Director
The Leighty Foundation
Juneau, AK
wleighty@earthlink.net
907-586-1426       206-719-5554 cell
END of 11 Sept 06 live presentation at Five Sullivans, Waterloo, Iowa

The following slides were not presented nor discussed, because of time constraints.

Thank you.

Bill Leighty
Denmark’s energy from windpower

- Prof Bent Sorensen, Roskilde Univ, DK
- WHEC, Montreal, June 02
- ALL Denmark’s energy from wind –
  - Elec, oil, gas
  - Transport, space heat-cool, industry
  - IF convert ~ 15% to H2, store in extant salt caverns
  - Can USA do same?
  - Start with transport fuel?
Conservation and Efficiency are our best investments!
Waterloo action:

- Opportunity: rebuild world’s largest industry, energy
- New farm-to-market “road” system for renewable energy products
- World’s best farm ground, sun, rainfall
Waterloo action:

• GW / GCC: *
  – study, prepare for decisions
  – assess magnitude, urgency
  – decide responsibility; response
  – appoint scientists advisory board
• Continue the debate: share results
• Learn coal plant options
• Learn “Energy’s Future” options (Sept ’06 Scientific American); appoint advisory committee
• Discuss video “The Zero Emissions City of the Future”
• Become world capital of cellulosic biofuels:
  – ethanol
  – other

* Global Warming / Global Climate Change
Waterloo action:

• “We have to act now… what can business do?”
  BP, CEO Lord Browne, DTI / DEFRA, 6 Oct 05

• Center: Cellulosic fuels and chemicals

• Corn–source ethanol limits:
  – total USA corn crop = 12% USA gasoline
  – water quantity, quality; competition in Iowa

• Soybean–source diesel limit:
  – total USA bean crop = 6% USA diesel
Waterloo action:

- **AB32:** California Global Warming Solutions Act (2006)
- IL Gov. Blagojevich new task forces:
  1. Vehicles & Conservation
  2. Biofuels
  3. IGCC coal plants
- Join USA Mayors’ Global Warming Group
- Presidential caucus focus: GW / GCC
Waterloo action:

• Energy efficiency building codes, lending practices (LEED)
• GHP (geothermal heat pump), renewable-source electricity
• “Smart Growth”, “Walkable Cities”, many templates
• Urban growth boundary; inner city rebuild
Waterloo action:

Where from here?

- need your help, understanding: invest, study, learn, decide
- disadvantage: poor science education in USA
- continue discussion: big, complex topic
- coal plant gift, catalyst, wakeup call, democracy messy
- community energy strategy
- “Zero Emissions Community of the Future”?
- propose alternatives
There are two spiritual dangers in not owning a farm:

One is supposing that breakfast comes from the grocery;

The other is supposing that heat comes from the furnace.

Aldo Leopold, “A Sand County Almanac”
You cannot have peace without justice
End of 11 Sept 06 presentation
Energy Seminar
Waterloo, IA

Following slides are supplemental
Hydrogen’s principal value

• NOT fuel cell cars
• Gather, transmit, store:
  – Large-scale, diverse, stranded renewables
  – FIRM time-varying-output renewables
    • Pipeline transmission, storage
    • Geologic storage
• Benign, if from renewables
• Global opportunity
• Hydrogen “sector”, not “economy”
  – Transportation fuel: ground, air
  – DG electricity, CHP, retail value
Hydrogen, Fuel Cell       Running on water ?
Denmark’s energy from windpower

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  - Transport, space heat-cool, industry
  - IF convert ~ 15% to H2, store in extant salt caverns
  - Can USA do same?
  - Start with transport fuel?
Total solar: $\sim 3 \times 10^{14} \text{ kg / yr}$

Total wind: $\sim 3 \times 10^{11} \text{ kg / yr}$

Rich, stranded Resources
How shall we bring the large, stranded, Great Plains renewables to market?
GW-scale Transmission Options: Stranded Renewables

- Electricity:
  - Overhead: HVAC, HVDC
  - Underground: HVDC
- Gaseous Hydrogen (GH2) pipeline
  - 100% GH2; purity
  - “Hythane”; “NaturalHY”, EC, Gasunie Research NL
- Liquid Hydrogen (LH2) pipeline, truck, rail car, ship
- Ammonia (NH3) gas, liquid: pipeline, truck, rail car, ship
- Liquid synthetic HC’s – zero net C
  - SNG, “synthane” CH4
  - FTL’s: Fischer – Tropsch liquids
  - CH3OH (methanol); DME (dimethyl ether)
  - Cyclohexane – benzene (2 pipelines)
  - Silanes: Si_{10}H_{22}
- “Energy Pipeline”: EPRI
  - SC, LVDC: ~ 100 GW
  - LH2: ~ 100 GW
- Al – Ga ← → Alumina
• Pilot plant: Every new industrial process
• Renewables-hydrogen system
  ▪ Generation
  ▪ Conversion
  ▪ Collection
  ▪ Transmission
  ▪ Storage
  ▪ Distribution, end users
  ▪ Synergy: $O_2$, seasonal
Hydrogen-fueled 2005 Prius ICE Hybrid

www.qtww.com
Chicken or Egg?

- PC hardware, software
- Cell phones, cell towers
- Hydrogen cars, fuel, stations
Hydrogen is NOT a clean, abundant energy source

- *Never* an energy source, on Earth
- Most abundant element in universe – Earth, no free hydrogen, H or H₂
  - H₂O, CH₄, NH₃, C₈H₁₈
- Only as clean and abundant as energy source from which it is made
IT WASN'T HIS DRIVING
THAT CAUSED THE
ALASKAN OIL SPILL.
IT WAS YOURS.

We can shelve Bush's plan
to lease the continental shelf to
offshore drillers. We can put
pressure on Washington to
tighten auto efficiency standards
and restore the funding for
renewable energy sources
Reagan took away.

And we can convince U.S.
automakers to stop pushing large
cars and muscle cars, and get
back to marketing more fuel
efficient automobiles.

Support Greenpeace.

Because it's time we put the
brakes on our nation's oil
dependency.

GREENPEACE
The gas is only $1.39. The aircraft carrier is $470, the tank is $125, the stealth fighter is $330, the gas mask is $45 and the gun adds $30 a gallon.
Continental Supergrid – EPRI concept “Energy Pipeline”

- **Thermal Insulation**
- **Vacuum**
- **Electrical Insulation**
- **SC**: MgB$_2$ magnesium diboride superconductor
- **LH2**: liquid hydrogen coolant, energy transmit

* * SC: MgB$_2$ magnesium diboride superconductor
** LH2: liquid hydrogen coolant, energy transmit

Continental Supergrid – EPRI concept “Energy Pipeline”
“Zero Emissions” Coal Synergy

- ND, MT, WY are wind and coal states
- Oxygen byproduct of electrolysis to “zero emissions” coal gasification plants
- 4,000 MW windplant produces –
  - ~ 3.1 million tons O2 per year
  - value ~ $ 19.17 / ton at coal plant
  - $ 59 million per year delivered O2
- Share transmission; CF improve ?
- Is “zero emissions” coal “clean” ?
- Will CO2 sequestration work ?
Alaska Applied Sciences, Inc.

560 kW windplant

Palm Springs, CA
<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Net Oil Imports (million Bbl/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>12.1</td>
</tr>
<tr>
<td>2</td>
<td>Japan</td>
<td>5.3</td>
</tr>
<tr>
<td>3</td>
<td>China</td>
<td>2.9</td>
</tr>
<tr>
<td>4</td>
<td>Germany</td>
<td>2.4</td>
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<tr>
<td>5</td>
<td>South Korea</td>
<td>2.2</td>
</tr>
<tr>
<td>6</td>
<td>France</td>
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<td>India</td>
<td>1.5</td>
</tr>
<tr>
<td>10</td>
<td>Taiwan</td>
<td>1.0</td>
</tr>
</tbody>
</table>
“There’s a better way to do it... Find it”
Alliance Pipeline:
- Natural gas
- Canada-USA
- $US 3.5 billion (’97-00)
  1 Dec 00 startup
- 2,988 km (1857 miles)
  36”, 1740 psi (115 bar)
- 1.5 Bcf/d (16 GW)
- Compression = 407 MW
  - 14 stations
  - ~ 7% input energy
  - ~ 30% capital cost

$H_2$ not $CH_4$
gas properties different
Papers, national conferences

- Windpower ‘01 – ’06 (AWEA)
- National Hydrogen Association ’01 – ’06
- International Pipeline Conference ’04, ’06
- American Society of Materials ’05
- Power-Gen Renewable Energy ‘06
World Energy: A Global Growth Business

- World demand
- Required new production
- Existing field decline ~4-6%
- Existing production

- World energy investment, 2001-2030
  - $530 billion / year
  - $16 Trillion

- Electricity 60%
- Gas 19%
- Oil 19%
- Coal 2%

(Source: IEA)