Alternative Fuels

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Today’s agenda

- A short game
- Introduction
- Types of fuels
- Indicative value chains
- Alternative fuel usage
- Q+A
Before we start

• A short game!
• Let’s see where we need energy in the transport chain
• And then in the supply chain
• ???

• Is that all?
The Age of Cheap Energy is Nearly Over!

- “Hubbert’s Peak”
  - Did we reach a high point or have we already passed by that?
  - Indicates US oil production peaked about 1970
  - World peak might be 2007-9

- Oil prices are volatile
  - …but the long term trend is scaling up as extraction becomes more expensive

- Gasoline and diesel prices
  - Volatile too...
  - …and are increasing erratically in the long term!

- Natural gas prices are rising and massive hydrogen production will speed that trend

- Hydrogen will be made from natural gas first, then coal, then possibly through nuclear thermal conversion or electrolysis from wind or sun --- a matter of cost
Overview of Energy Sources

• Currently, energy primarily comes from combustion of fossil fuels or nuclear energy

• Electricity and hydrogen are energy *carriers*, not primary sources!

• In some areas of the World, wind energy is being significantly developed: Europe, United States, Denmark, Sweden, Germany, India, China are a few

• Energy sources are so critical to civilizations that many wars have been fought over these resources

• Lack of common local energy sources can hold back the development of a nation
## Energy Source Categories

<table>
<thead>
<tr>
<th>Conventional</th>
<th>Non renewable</th>
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<tbody>
<tr>
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<td></td>
<td></td>
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<tr>
<td>Nuclear</td>
<td></td>
<td></td>
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<tr>
<td>Fission</td>
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**Alternative**

## Energy Source Categories

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<td>Wind, Solar, Biomass, Wave/Tide, Ocean Current</td>
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Sustainable means using less than is renewed; if water is withdrawn from a dam faster than it is refilled, the level drops and hydro power is lessened, and finally fails.

Types of fuels

- **Natural Gas (CNG & LNG):** This is a clean-burning, readily available, competitively priced fuel alternative. Unfortunately, it produces methane, a much-worse greenhouse promoter than carbon dioxide.

- **Ethanol (E85):** Made from wheat, corn and barley, this alcohol-based fuel, mixed with gasoline, improves octane levels and emissions. Although it is a renewable resource, government incentives to produce it also drive up food prices.

- **Electricity and Fuel Cells:** Since hybrid vehicles are already popular, this is a viable alternative fuel. However, it may increase need for higher coal and natural gas-produced electricity production. In spite of its drawbacks, this option is probably one of the most practical.

- **Propane (LPG):** This is a byproduct of natural gas and crude oil refining; it is already used extensively (e.g., in heating). LPG, however, can also promote methane pollution.

- **Hydrogen:** This is useful for vehicles equipped with special combustion engines (e.g., those using a natural gas/hydrogen system). It has a clean emission. Unfortunately, this technology is still in its infancy stage.

- **Biodiesel:** Probably one of the most promising alternative fuels, biodiesel, which made from animal fat and/or vegetable oil waste combined with petroleum diesel, is affordable, safe and clean-burning. However, the technology still needs more development.

- **Methanol:** Blended with gasoline, this fuel may be useful for long-term future solutions. Right now, though, vehicles that might benefit aren’t being produced.

- **P-Series Fuel:** A blend of methyltetrahydrofuran (McTHF), natural gas and ethanol, this fuel raises octane levels when mixed with gasoline, if used in flexible-fuel vehicles (when they become available).
**Liquid fuel characteristics:**

<table>
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<tr>
<th>Fuel</th>
<th>Energy Content (BTU/gallon)</th>
<th>Other aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td>66,000</td>
<td>Toxic in direct contact</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Octane number 88.6 (gasoline 85)</td>
</tr>
<tr>
<td>DME</td>
<td>67,000</td>
<td>Gaseous Vapour pressure 5.1 bar at 20°C</td>
</tr>
<tr>
<td>Fischer-Tropsch gasoline</td>
<td>127,000</td>
<td>Very comparable to diesel and gasoline; zero sulfur, no aromates</td>
</tr>
<tr>
<td>Ethanol</td>
<td>84,000</td>
<td>Octane number 89.7 (gasoline 85)</td>
</tr>
<tr>
<td>Diesel from bio-oil/bio-crude</td>
<td>144,000</td>
<td>When fully de-oxygenated</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>133,000</td>
<td>Cetane number: 58 (diesel 47.5)</td>
</tr>
<tr>
<td>Gasoline</td>
<td>115,000</td>
<td>Depending on refining process, contains sulphur and aromates</td>
</tr>
<tr>
<td>Diesel</td>
<td>139,000</td>
<td>Depending on refining process, contains sulphur and aromates</td>
</tr>
</tbody>
</table>

Some indicative RE costs

<table>
<thead>
<tr>
<th>Technology</th>
<th>Range (minimum to average) of electricity generation cost (€/MWh)$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind onshore</td>
<td>50-80</td>
</tr>
<tr>
<td>Small-scale hydro</td>
<td>40-140</td>
</tr>
<tr>
<td>Biomass using forestry residues</td>
<td>40-80</td>
</tr>
<tr>
<td>Agricultural biogas</td>
<td>60-100</td>
</tr>
<tr>
<td>Photovoltaics</td>
<td>$&gt; 450$</td>
</tr>
</tbody>
</table>


$^b$The calculation of generation costs and feed in tariffs is further elaborated in module 8, annex I, “Methodology and examples on how to calculate the level of feed in tariffs”.
How energy flows?

Source: Laurent Raspaud, « Sustainable energy and the fight against poverty », *Field Actions Science Reports* http://factsreports.revues.org/1931
An indicative Liquid fuel value chain

Feedstocks are the source materials used for producing biofuels.

Conversion technologies transform feedstock into "green crude" which is similar to crude oil.

Refining
End fuel

Process of upgrading "green crude" into a refined fuel using equipment similar to that found in a conventional refinery. Some types of green crude require more processing than others.

Refined fuel ready to be distributed to end users.

Source: L.E.K. research, interviews and analysis
Value chains? What about different RES Value chains?

Existing and new infrastructure components for producing and delivering liquid fuels, gaseous fuels, and electricity

CNG = compressed natural gas; E85 = ethanol/gasoline blend with 85% ethanol by volume; FAME = fatty acid methyl esters; FT = Fischer-Tropsch; G/L = gaseous/liquid; LNG = liquid natural gas
Existing and new infrastructure components for producing and delivering liquid fuels, gaseous fuels, and electricity.
Why Use Alternative Fuels?

• Petroleum Displacement
• Energy Diversity
• Air Quality Improvement
• Greenhouse Gas Emission Reductions
• Domestic Economic Development

Alternative Transportation Fuels

- Electricity
- Ethanol
- Hydrogen
- Methanol
- Natural Gas
  - Compressed
  - Liquefied
- Propane
- 100% Biodiesel
- P-Series
Alternative Fuel Vehicles Available Now

• Electric
• Ethanol
• Natural Gas
• Propane
Electric Vehicles

- Low Emissions
- Quiet
- At least 4% of new vehicles sold in California starting in 2003 must be EVs

- Expensive
- Limited Range

Ford Ranger

Toyota RAV4

Ethanol Vehicles

- Low GHGs
- Less Reactive

- Subsidy Required to be Cost Competitive
- Few Refueling Stations but Numbers Increasing

Ford Taurus
Ford Ranger
Chrysler Minivan

Natural Gas Vehicles

- Very Low Emissions
- Good Performance
- Lower Cost Fuel

- Limited Range, but Adequate for Most Applications
- Few Refueling Stations
- Higher Cost Vehicle

Honda Civic

New Flyer D40 LF Bus

Propane Vehicles

- Low Emissions
- Good Performance
- Cost Similar to Gasoline

- Few Typical Refueling Stations, Many Potential Places to Refuel
- Higher Vehicle Cost

Ford F-150

Ford Club Wagon

Is that all? Other vehicles?
Alternative Fuel Vehicle R&D Challenges

- EV Batteries
- Ethanol Production from Cellulose
- Reduce Natural Gas and Propane Vehicle Cost
- Expand Refueling Infrastructure
- Hydrogen Production (for Fuel Cell Vehicles)
- Availability of fueling stations
Coverage of transport modes and travel range by the main alternative fuels

Liquid biofuels are currently the most important type of alternative fuels:
• High energy density
• Applicability in all transport modes
• Existing infrastructure and vehicles.

There will be no single fuel solution for the future mobility – a consistent long-term strategy on alternative fuels has to meet the energy needs of the different transport modes.

So, what to use?

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Mode of Transport (Passenger and Goods)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car: Urban</td>
</tr>
<tr>
<td>Today / Future</td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>✔</td>
</tr>
<tr>
<td>Diesel / Kerosene</td>
<td>✔</td>
</tr>
<tr>
<td>CNG</td>
<td>✔</td>
</tr>
<tr>
<td>LPG</td>
<td>✔</td>
</tr>
<tr>
<td>LNG</td>
<td></td>
</tr>
<tr>
<td>Biodiesel (FAME)</td>
<td>✔</td>
</tr>
<tr>
<td>XtL</td>
<td>✔</td>
</tr>
<tr>
<td>Advanced gasoline (cell ethanol, butanol...)</td>
<td>✔</td>
</tr>
<tr>
<td>Advanced diesel/kerosene (BtL, HVO, sugar-to-diesel...)</td>
<td>✔</td>
</tr>
<tr>
<td>Hydrogen</td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>✔</td>
</tr>
</tbody>
</table>
Deployment Strategies

• Understand the market
• Develop and provide unbiased information
• Offer technical and financial assistance
• Develop, issue, and enforce regulations
• Find and support partners
• Conduct mission advocacy
End of Session

Thank you for your attention!

Q&A