Alternate Fuel Refuse and Recycling Trucks
Leading the Way to Energy Independence and a Cleaner Environment

Mack Trucks, Inc. History in Heavy Duty Natural Gas Engine Refuse Trucks
+ Scenarios for The Next Ten Years
- utilizing NG from conventional, non-renewable sources (gas wells)
  AND
  renewable, “non-conventional” sources of biomass/biogas
- in CA, NJ, PA, GA, MI, other US and international venues

Bruce M. Smackey, Ph.D.
Technology Commercialization
Mack Sales & Marketing and
Volvo Technology Transfer AB
bruce.smackey@macktrucks.com
610-390-8240
Rutgers University NJ
January 24, 2008

OUTLINE

1.0 What is the Going-Forward Goal of Today’s Conference
   - What Should WE Try to Make Happen?

2.0 History and Serendipity in the MSW and HD Refuse Truck Industries +
   “As the World Turns”

3.0 Harmony Among the 5 E’s
   [Economics, Energy, Engineering, Education and Environment]

4.0 The Total Solution for the Customer = Refuse Truck Hauler
   - Optimal Scenario for the US (at least) and the World
     = Cooperative Competition

5.0 Epilogue for Today’s Conference
   - Y2005 Energy Policy Act and Tax Credit Extensions for Conventional
     Sourced NG
     AND
     Municipal-Created Waste/Biogas [=Renewable Energy Source]
1.0 What is the Going-Forward Goal of Today's Conference
- What Should WE Try to Make Happen?


Perspective
- Energy Independence – NO; not likely BUT - YES
- Diversify sources of energy from a concentration in politically unstable regions that don’t exactly like the US
- WE need energy for several basic uses
  1. electric power
  2. residential and commercial heating and cooling
  3. industrial processes
  4. transportation

Our greatest vulnerability is in transportation and the importation and use of liquid fuels
- Alternate Fuel – can be beneficial for the environment but it should, most assuredly, help to diversify sources for transportation fuel

(1.0 continued)

Let's Do the Math

<table>
<thead>
<tr>
<th>140,000 Refuse Trucks (US Fleet – Class 8)</th>
<th>x10,000 Diesel gallons per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4 Billion diesel gallons per year</td>
<td></td>
</tr>
<tr>
<td>x 60% Conversion to LNG/CNG engines</td>
<td></td>
</tr>
<tr>
<td>0.84 Billion diesel gallons per year</td>
<td></td>
</tr>
<tr>
<td>X 2.0 [2 LNG gallons = 1 diesel gallon of energy]</td>
<td></td>
</tr>
<tr>
<td>1.68 Billion gallons of LNG</td>
<td></td>
</tr>
</tbody>
</table>

Questions
- How many LNG/CNG trucks have to be produced and bought?
- Who will supply the NG fuel?
- Who will build the infrastructure for delivery, storage and dispensing?
- How many in audience are within five years of signing-up for Medicare?
(1.0 continued)

**Sum of all the Questions =**

Need to infuse sizeable long-term capital investments into the market linkages for the supply, distribution and consumption of natural gas used as transportation fuel.

[There is no simple, painless way to displace imported crude oil and liquid fuels.]

How to Do it? [ more to follow]

---

2.0 History and Serendipity in the MSW and HD Refuse Truck Industries + “As the World Turns”

**Brief History of Mack’s Two Venture Capital Investments**

- Engineering Development, Market Introduction and Sale of 450 LNG/CNG E7G Engine Refuse Trucks
- Six Year Joint Venture Project/Licensing Agreement with Acrion Technologies, Inc.
- Recent Volvo Technology Transfer AB “Partnership” with Mack

**TIMELINE**

1995 – 1997  Mack investment in E7G natural gas engine and Washington PA project at WM landfill (7 trucks)
2000 – 2002  E7G product launch; 120 LNG truck order with WM/CA; NYC CNG order
2002  Acrion agreement signed with Mack [Diesel Gallon Price ~ $1.50]
2003 – 2006  Warranty claims surface; continued development on E7G to achieve 2010 emissions standards
2004 – 2005  Successful completion of NJ EcoComplex project - 10,000 gallons of LNG fuel from LFG; two LNG WM refuse trucks accumulate 600 hours each - no degradation of engines; no contaminants found in LFG/LNG fuel

2005 – 2007  Feasibility studies with LF customers – very favorable

2005 – 2007  Uncertainty in decision RE natural gas engine for Mack refuse truck market

2007  Cummins-Westport LNG engines ordered by Mack

2006 - 2007  Discussions with VTT AB result in working relationship between Mack and VTT to exploit opportunity to sell Mack LNG/C-W engine refuse trucks and LFG/LNG fuel facilities to customers under two separate agreements
- Initial projects pursued in US and Sweden

2008  Generation of orders for trucks and full-scale LFG/LNG transportation fuel facilities [Diesel Gallon Price ~ $3.50-4.00]

2008+  What will prices and availability of all fuels be in the next 10 years?
3.0 Harmony Among the 5 E’s
[Economics, Energy, Engineering, Education and Environment]

• Conflicts and Cooperation Among Vested/Entrenched Interests and Entrepreneur/Intra-Preneur Marriages
• Domination by One or Several (But Not All) of the Interests Stops the Realistic Evolution toward

Conflict Examples:

**Economics** – Whose “Bottom Line?”
1. Customer (generator of refuse) – You and Me as individuals
2. Landfill Operator/Owner/Governing Boards/Shareholders
3. Hauler
4. Capital Equipment infrastructure providers
5. Mack Trucks/Acron/Volvo Group
6. Other

**Energy** – “Just Right” Price of Natural Gas from Conventional Sources
Too Low – Recovery of LFG not economical
Too High – Sell the LFG to LNG product (don’t use for LNG refuse trucks)

**Engineering** – “Right-Sized” LFG to LNG liquefaction modules may have to be
designed versus re-design of BIG-BIG chemical and oil refinery liquefaction
designs

**Education** – Who is latest “In-Charge” voice in Washington – EPA, DOE?
- Does the public want to become knowledgeable and change individual behavior?

**Environment** – Within the Harmony Quest let’s try to
Maximize Benefits to the Environment
  Reduced LFG Greenhouse Emissions: CH₄, CO₂
  Reduced Vehicle Emissions: NOX, CO₂
  Reduced Use of (New) Fossil Fuel by Recovery of BTUs
4.0 The Total Solution for the Customer = Refuse Truck Hauler
   - Optimal Scenario for the US (at least) and the World
   = Cooperative Competition

Some More Math

Realistic Target = Displace 60% of diesel fuel used by Refuse Trucks
                 = 16.8 Billion gallons of LNG Annually

Q: What can Mack/Acrion/VTT AB do for the refuse truck hauler?

Landfill Gas (LFG) to Purified & Liquefied Natural Gas (LNG) Transportation Fuel
   [Proposed Project]

Customer
  LFO + Refuse Hauler

(A) + (B) = Total Solution

(LNG/CNG Refuse Trucks)

LFG/LNG Transportation Fuel

VTT AB
  Mack
  Acrion

Buses,
Day Cab and
Other Vehicles

Mack
More Math/Reality Check
One good size LF = 10,000 gpd LNG = 3.5 million LNG GP year
1.68 Billion Gallons LNG = 480 installations
3.5 Million Gallons LNG per LFG/LNG Facility

Good Target/Next 5 Years = 10% x 480 = 48
~ $0.7 Billion in Capital Investment!

So?

Three Scenarios

Q: What Do You Think About The Scenarios?

**Scenario I** – Plain Old US Competition -
[Texas Hold-Um; Keep Your Cards Close to the Chest]
+ Lots of Trouble; World Economy; HD Engine Technology

**Scenario II** – Similar to I

**Scenario III** – Cooperative Competition
The US needs an integration of interests to have—
A. HD Engine Market Embrace the Strategy to have (some) NG Vehicles in their Fleets [Refuse Trucks, Day Cab, Buses]
   AND
B. Acceptable Legal/Regulatory/Competitor Cooperation among Natural Gas Suppliers (Conventional and Non-Conventional Sources) to build a unique US LNG Supply Infra-structure
5.0 Epilogue for Today’s Conference


We need to be PROACTIVE at the state and federal level – it won’t happen without the E = Education!