

7th Annual Ammonia Fuel Conference

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Detroit, MI

Update on Maryland Ammonia Project

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ARCTIC ENERGIES LTD IS:

**A Maryland Professional Engineering Corporation
Focused on “Green Energy” for the last 28 years.**

**Successful in multiple, Federal Small Business
Innovation Research (SBIR) Contracts.**

**Phase III SBIR Sole-Source contracted technology-
developer for the USCG on “Green Ship” Powering.**

**Contractor to the DOE for Solar Energy Conversion
Technology Development.**

Holder of 7 US Patents and 2 Registered Trademarks.

Professional “Clean Energy” Conference Participant.

**Conversant and experienced in Interfacing with Staffs
of State and Federal Agencies and Members of Congress.**

America's Fuel Problems

- The U.S. depends on declining and polluting fossil fuels.
- Most development efforts are focused on existing carbonaceous fuels.
- These fuels add to the problem of global warming.
- 58% of oil products are now imported.

For the Future

- Fuel must not contain carbon
- Must not be imported from other countries where it could be a national security issue.
- Must be available in limitless supply.

Carbonaceous Fuels

In the U.S., use of carbonaceous fuels results in 5.66 billion metric tons of CO₂ being released into the atmosphere each year - a devastating amount of greenhouse gas. The following chart shows the various sources of CO₂: (EPA 2008)

Main CO₂ Generators in the U.S. (Annual)

Source	Quantity in Million Metric Tons
Power Plants	2,363
Transportation	1,785
Industrial	819
Residential	343
Commercial	219
Other	128
Total CO ₂	<u>5,657</u>
	(EPA and USDA 2008)

Comparison of Various Fuels and CO₂ Produced During Combustion (EPA)

Type of Fuel	Reference	Carbon Content	CO ₂ Produced CO ₂ /ton of Fuel
Diesel/Gas Oil	ISO 8217 Grades DMX through DMC	0.875	3.206 tons
Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.86	3.151 tons
Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.85	3.114 tons
Liquefied Petroleum Gas (LPG)	Propane	0.819	3.000 tons
	Butane	0.827	3.030 tons
Liquefied Natural Gas (LNG)	Methane	0.75	2.750 tons
Ammonia	Anhydrous Ammonia	0.00	0.00 tons

Minimizing CO₂ Emissions

- Sequester CO₂ at its source as is suggested for power plants.
- Phase out polluting power plants.
- Switch to non-polluting solar, wind and OTEC power.
- Plant more trees to absorb CO₂.
- Use non-carbonaceous fuels.

U.S. Forests' Contribution to Sequestering CO₂

- A square mile of forest absorbs about 621 metric tons of CO₂ per year. (USDA 2008)
- The U.S. produces 5657 million metric tons of CO₂ per year.
- We would need **9.1 million square miles** of forest to capture these CO₂ emissions.
- Total area of North, Central, and South America is only 9.5 million square miles.

Non-carbonaceous Fuels

- There are only two readily available non-carbonaceous fuels
- Hydrogen - hard to store and ship. Low energy per volume of gas, even at very high pressures
- Ammonia – easy to store and ship, stays liquid at only 125 psi pressure, a gallon contains nearly twice as much hydrogen as a gallon of liquid hydrogen, does not deteriorate during storage.

Change to Ammonia as a Fuel

- Use ammonia as primary fuel for energy storage, transportation, and power generation.
- Because of the uneven nature of wind and solar energy, wind turbines and solar panels sometimes produce more power than can be utilized on the “grid”. This excess energy could be used for generating ammonia.
- Ocean Thermal Energy Conversion (OTEC) is another excellent source for ammonia.

More Ammonia Advantages

- Ammonia can be produced in the U.S. or in surrounding waters.
- It is available in limitless supply.
- Price is determined by efficiency of production, not by who controls the source.
- Ammonia does not have to be pumped or dug out of the ground or sea
- It is environmentally friendly. No mountains have to be leveled or tar sands or shale dug up.

Imported Ammonia is not Helpful

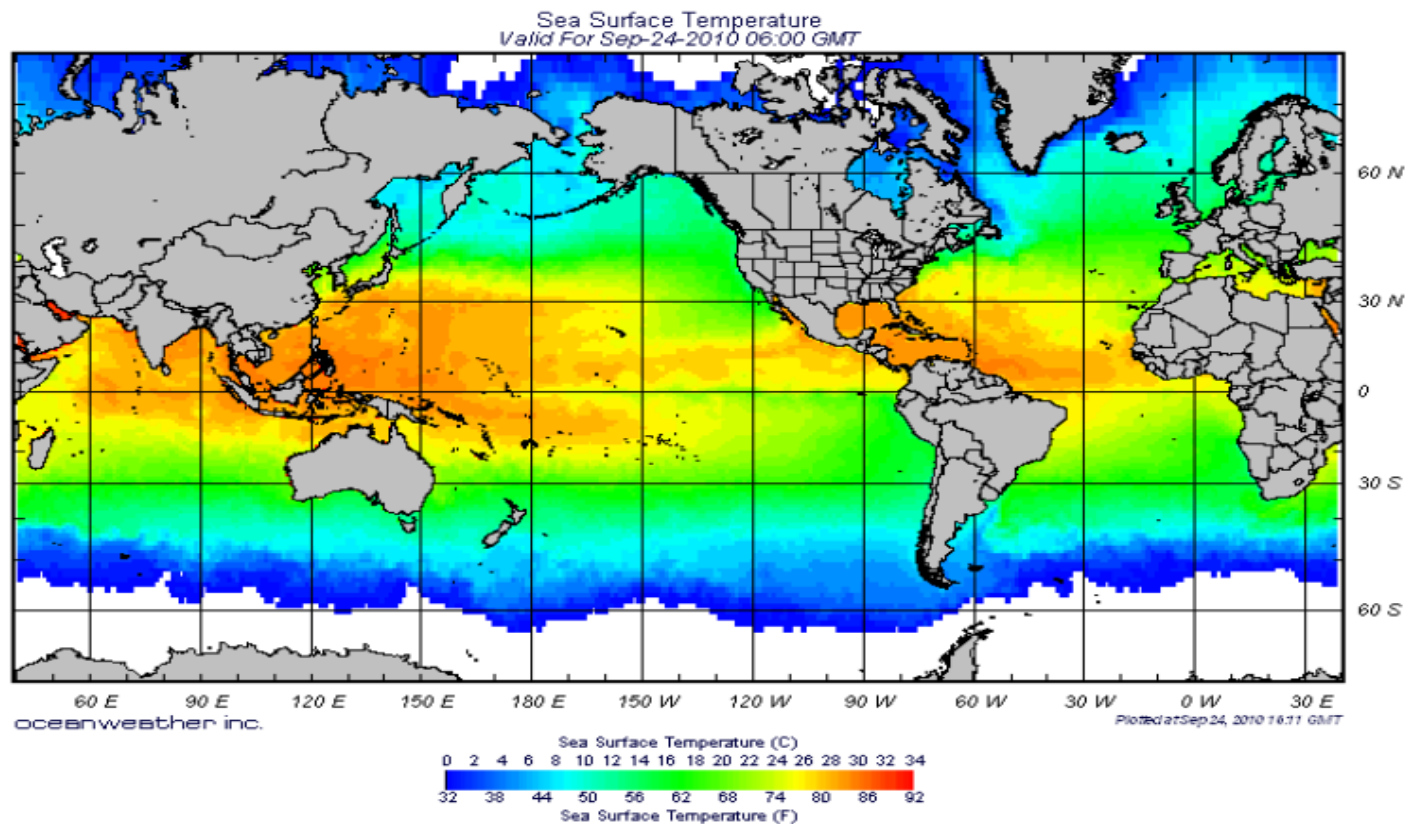
- Most of the NH_3 used in the U.S. is foreign-source produced from carbonaceous fuels.
- It is transported to the U.S. in ships burning carbonaceous fuel.
- Reliance on foreign fuel is a national security issue.
- Importation results in outflow of U.S. dollars and more CO_2 pollution.

Ocean Thermal Energy Conversion

- The largest heat storage in the world is in the equatorial oceans.
- The energy is free. All that is needed are OTEC plant ships to extract the never-ending solar heat and convert it to NH_3 fuel and fresh water.
- The NH_3 and fresh water can be taken ashore by tankers.
- U.S. “Jones Act” and other ships can “bunker” NH_3 fuel at sea.
- A study done in 2009 by Argonne National Laboratory (ANL/ESD/09-6) shows that using ocean thermal energy to make ammonia and pure water is economically very feasible and produces a fuel quite competitive with hydrocarbon fuels.
- AEL participated in this study.

The Best Locations for OTEC

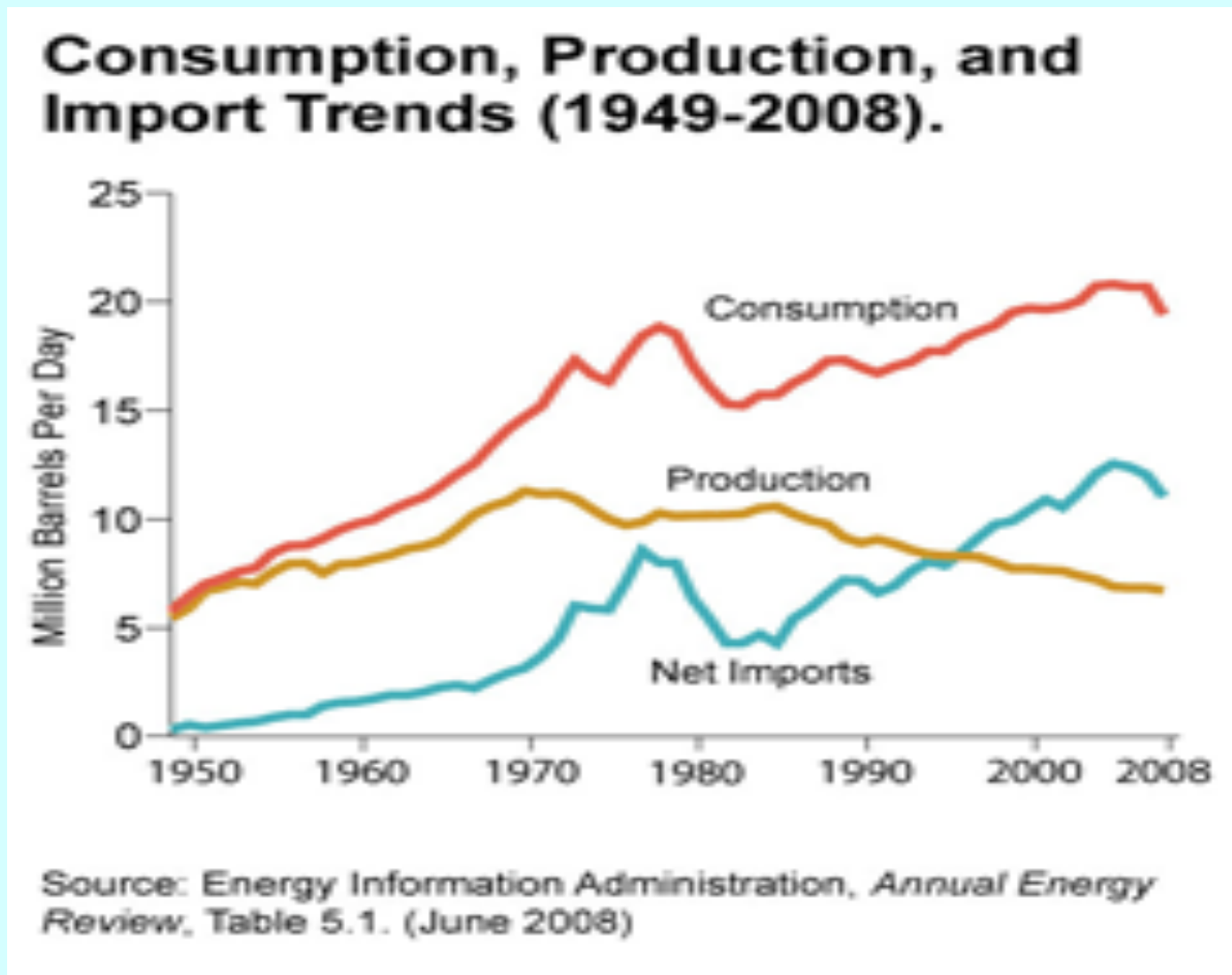
The dark orange areas are ideal with 28° to 30°C surface temperatures.



Equatorial Ocean Energy

- 23 million square miles of 77°F to 86°F water from 30° north to 20° south of the equator.
- Solar energy absorption in this region per day is equal to burning 170 billion barrels of oil.
- The Gulf of Mexico and Caribbean have excellent conditions for OTEC.

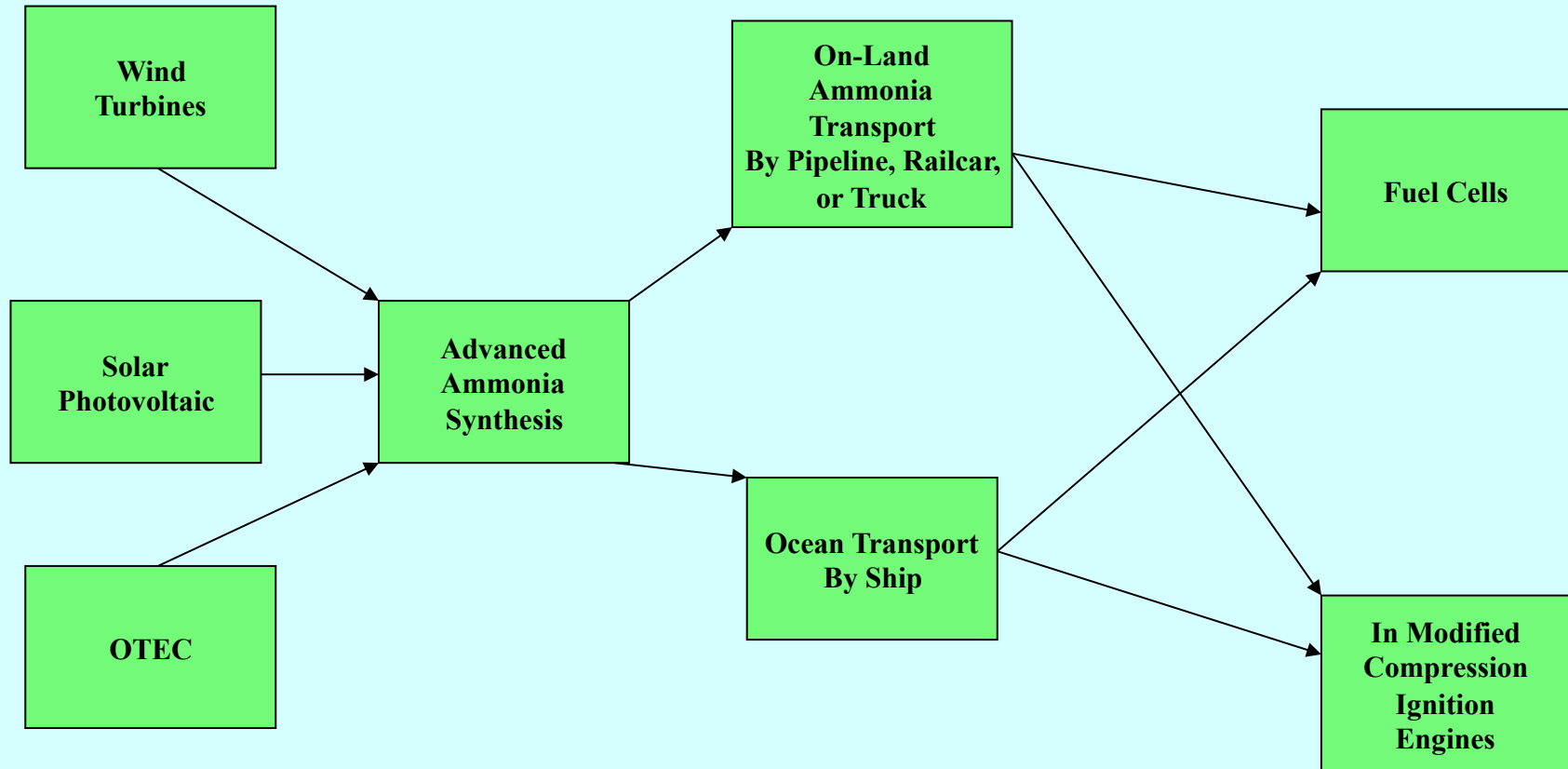
U.S. Carbonaceous Fuel Statistics



The Hidden Added Cost of Oil

A 2009 Rand Corp. study showed that the cost to the U.S. military for each barrel of imported oil is \$20 meaning that if oil is priced at \$80 a barrel, it really costs us \$100.

NH₃ (AMMONIA) PRODUCTION AND USAGE SYSTEM



This “Green” Approach Completely Eliminates the need for Carbonaceous or Sulfurous Fuels.

Reducing Pollution on the Great Lakes

- AEL has discussed initiating a study concerning fueling ships on the Great Lakes with ammonia to eliminate most of the ship-generated pollution in the area.
- The agencies contacted were the American Bureau of Shipping and the Dept. of Transportation

**Other Organizations with Whom AEL'S
Totally Green Approach to Maritime Ship
Fueling has been Discussed are:**

The Department of Energy

The Navy

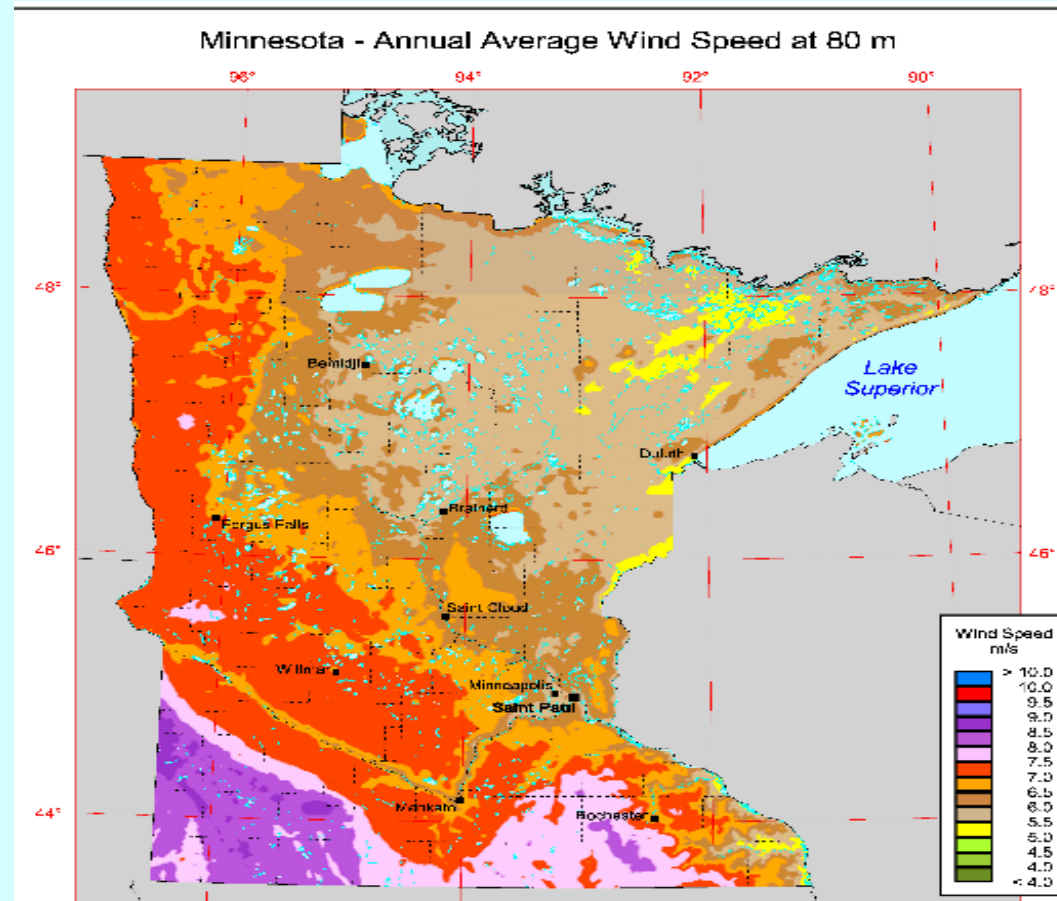
The Coast Guard

The EPA

The Maritime Administration

**Congressional Staff and
Committee Chair Persons**

Wind Resource Map of Minnesota



Shows Large Area of 10 m/sec (Red) Average Wind Speed.

Wind Farm Energy for Ship Fuel

- Minnesota and Wisconsin have wonderful wind resources.
- Some of this energy could be used to produce NH_3 for fueling ships on the Great Lakes.

Location of Future Wind and Solar Power on Maryland Eastern Shore



FAIRFIELD FARMS, LLC

2600 LUTHY ROAD CAMBRIDGE, MD 21613

What's Available Now

- Economical modification of internal combustion engines to run on NH_3 is available from a Canadian company that has converted engines for cars, trucks, farm tractors and locomotives.
- Solid state, low temperature fuel cells have been developed with efficiencies of about 80% by a Florida company.

What is Needed

- A high-efficiency ammonia synthesizer is needed to replace the Haber-Bosch process.

The Biggest Producer of Greenhouse Gases

- We have a large population
- That population likes to eat meat
- Cows, sheep and goats produce very large amounts of methane.
- Methane is over 23 times as effective as CO₂ for collecting heat from the sun.
- Methane has a half life of 7 years in the atmosphere.
- 1.5 billion cows on the Earth produce 142 billion metric tons of methane a year.

