

5<sup>th</sup> ANNUAL AMMONIA  
FUEL CONFERENCE  
SEPTEMBER 29-30, 2008  
MINNEAPOLIS, MN

"NH<sub>3</sub> IS CARBON-FREE"

WILLIAM H. KUMM, P.E.  
PRESIDENT, ARCTIC ENERGIES LTD.



**AIChE**  
NATIONAL CAPITAL SECTION

The American Institute of Chemical Engineers  
National Capital Section

*extends its sincere appreciation to*

**WILLIAM H. KUMM, P.E.**

*for his presentation on the*

***SOLVING OUR ENERGY-WATER NEXUS CHALLENGES WITH NH<sub>3</sub>***

April 17, 2008



# TERMINOLOGY 1.

**NEXUS**      **A MEANS OF CONNECTION,  
A CONNECTED GROUP,  
EG: “THE ENERGY-WATER NEXUS”**

**ENERGY**      **VIGOR, OR POWER-IN-ACTION  
EG: GLOBAL ENERGY DEMAND,  
SUCH AS IN TERMS OF “MILLIONS OF BARRELS  
PER DAY OF OIL EQUIVALENT” (EXXONMOBIL)**

# TERMINOLOGY 2.

POWER

**THE RATE AT WHICH  
WORK IS DONE**

EG: “Electrical MegaWatt Hours”

“1 Horsepower = 746 Watts”

CARBON-  
FREE  
FUEL

**A FUEL THAT DOES  
NOT PRODUCE  
**CARBON DIOXIDE  
EXHAUST****



**CONSIDER  
OCEAN-  
SOURCED  
AMMONIA  
(NH<sub>3</sub>) AS A FUEL**

# IT MEETS FOUR GREEN OBJECTIVES

1.  $N_2$  From the Atmosphere
2.  $H_2$  From Water
3. No Resulting  $CO_2$
4. Balance-Of-Payments Neutrality

# THE BIGGEST PART OF THE EXPLODING US DEBT TO OTHER COUNTRIES IS DRIVEN BY FOSSIL FUELS, AND IT IS GOING TO INCREASE WITH LNG IMPORTS

*Lehman Brothers Kuhn Loeb*  
Incorporated  
One William Street  
New York, N.Y. 10004

PETER G. PETERSON  
CHAIRMAN OF THE BOARD

April 29, 1980

Mr. William H. Kumm  
President  
Arctic Enterprises Incorporated  
1120 L. Gendri Drive  
Annapolis, Maryland 21403

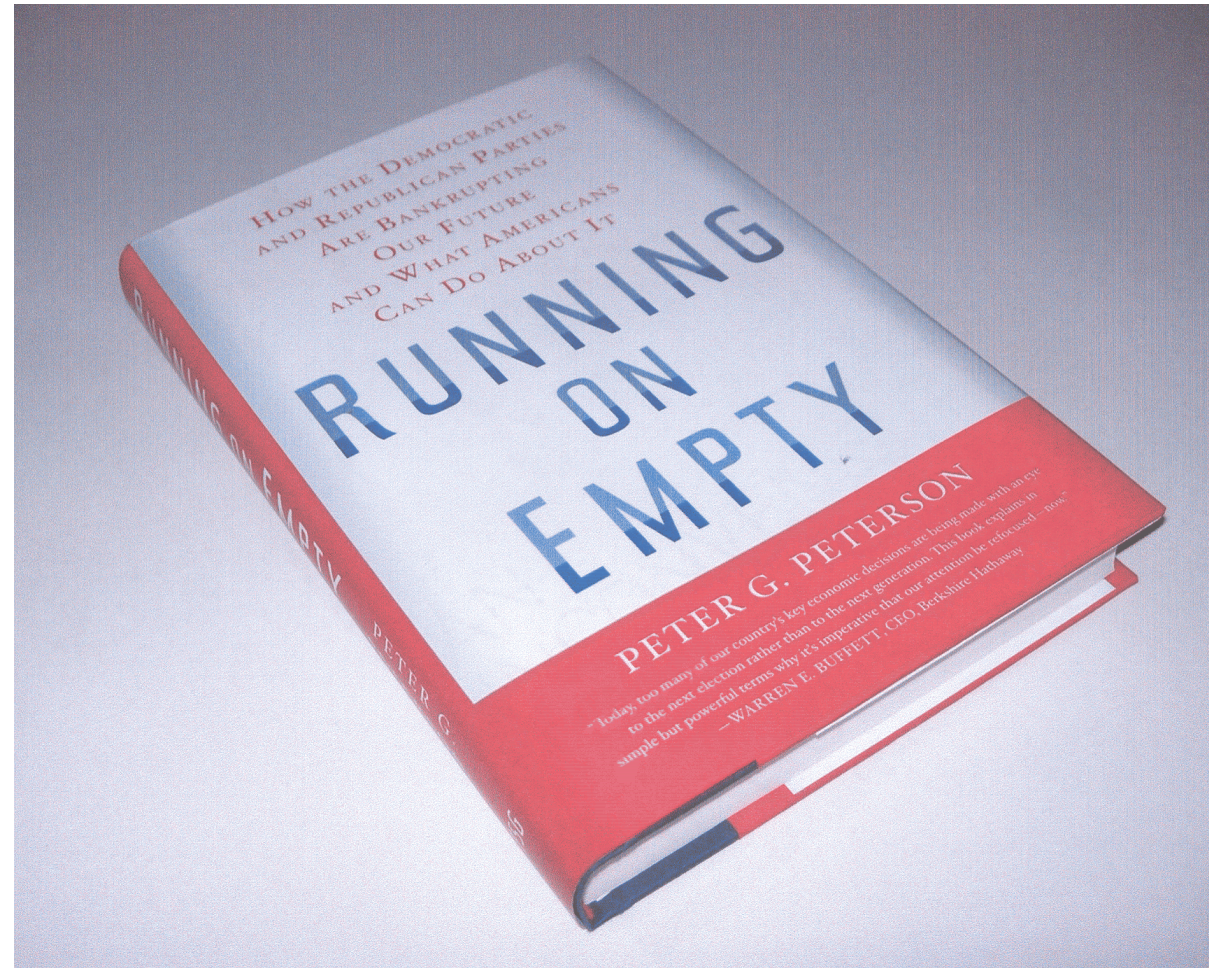
Dear Mr. Kumm:

Thank you for your letter of March 24th. We share your belief that Ocean Thermal Energy Conversion could eventually be the answer to energy needs in certain geographic areas of the world and have been actively involved in this field for the past two years.

Working with Fairchild Industries and two U.S. utilities, we provided financial analyses of alternative ways to bring about the commercialization of OTEC technology in Florida and Hawaii. This work was financed by the Department of Energy. The approaches we identified relied primarily on private initiative with U.S. Government financial backing.

A summary conclusion was that the current status of OTEC technology did not permit its exploitation on a purely private basis (and probably will not at least the mid 1990s). Relating this conclusion to your comments, we question if developing countries would be willing to commit their energy needs to OTEC facilities (at \$350-\$500 million minimum per commercial installation) until such a facility were commercially accepted in a more sophisticated location such as the U.S.

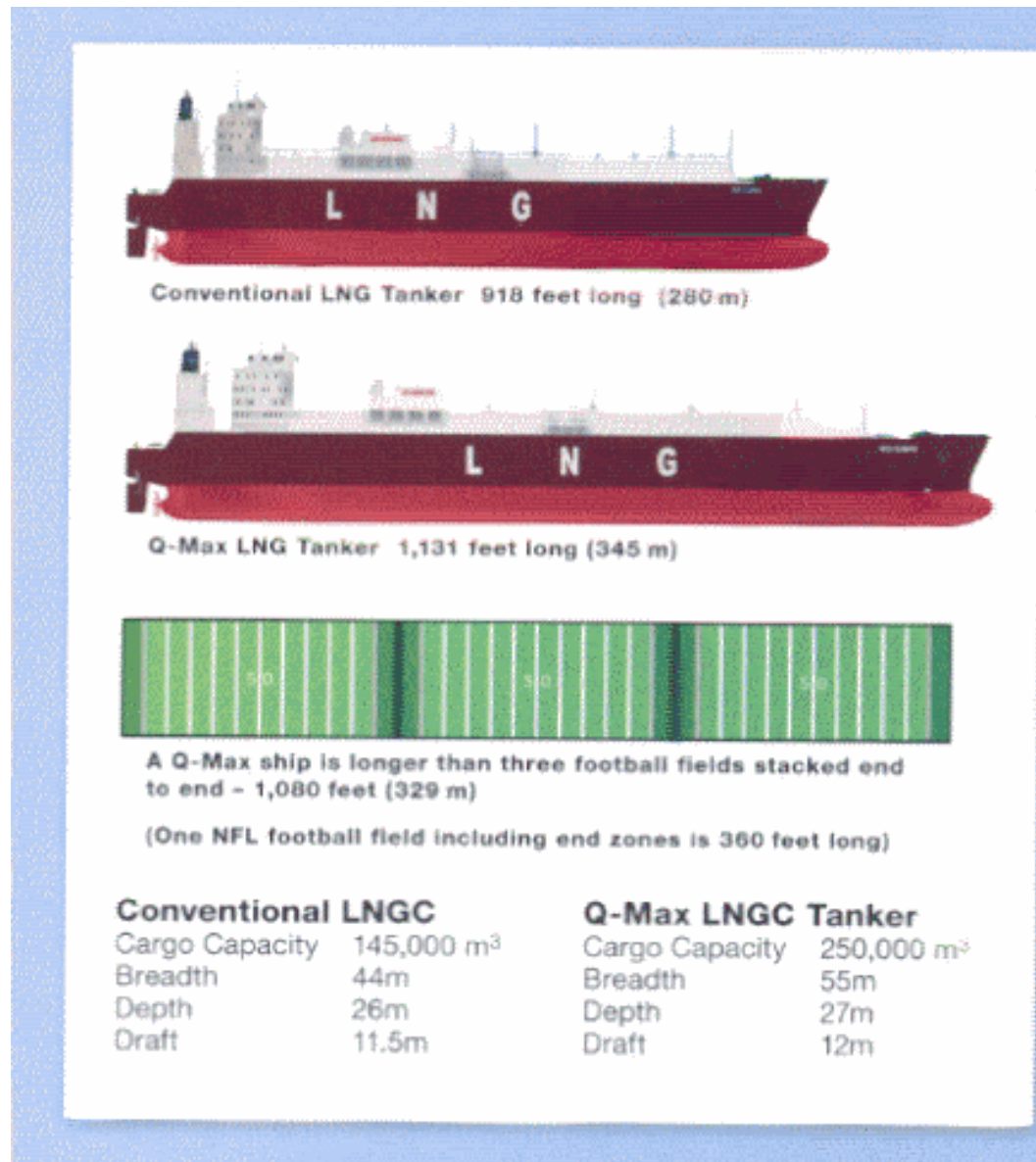
**A SUPPORTIVE  
APRIL 29, 1980  
LETTER FROM  
PETER G.  
PETERSON  
ON OTE**





# 45 of LNG “Q-Flex” and “Q-Max” are being built





Source: “The Lamp”, “ExxonMobil Taking on the World’s Toughest Energy Challenges”



# THE “Q-MAX” GLOBAL- REACH PROPULSION SYSTEM WILL MOVE A LOT OF OCEAN WATER BACKWARDS

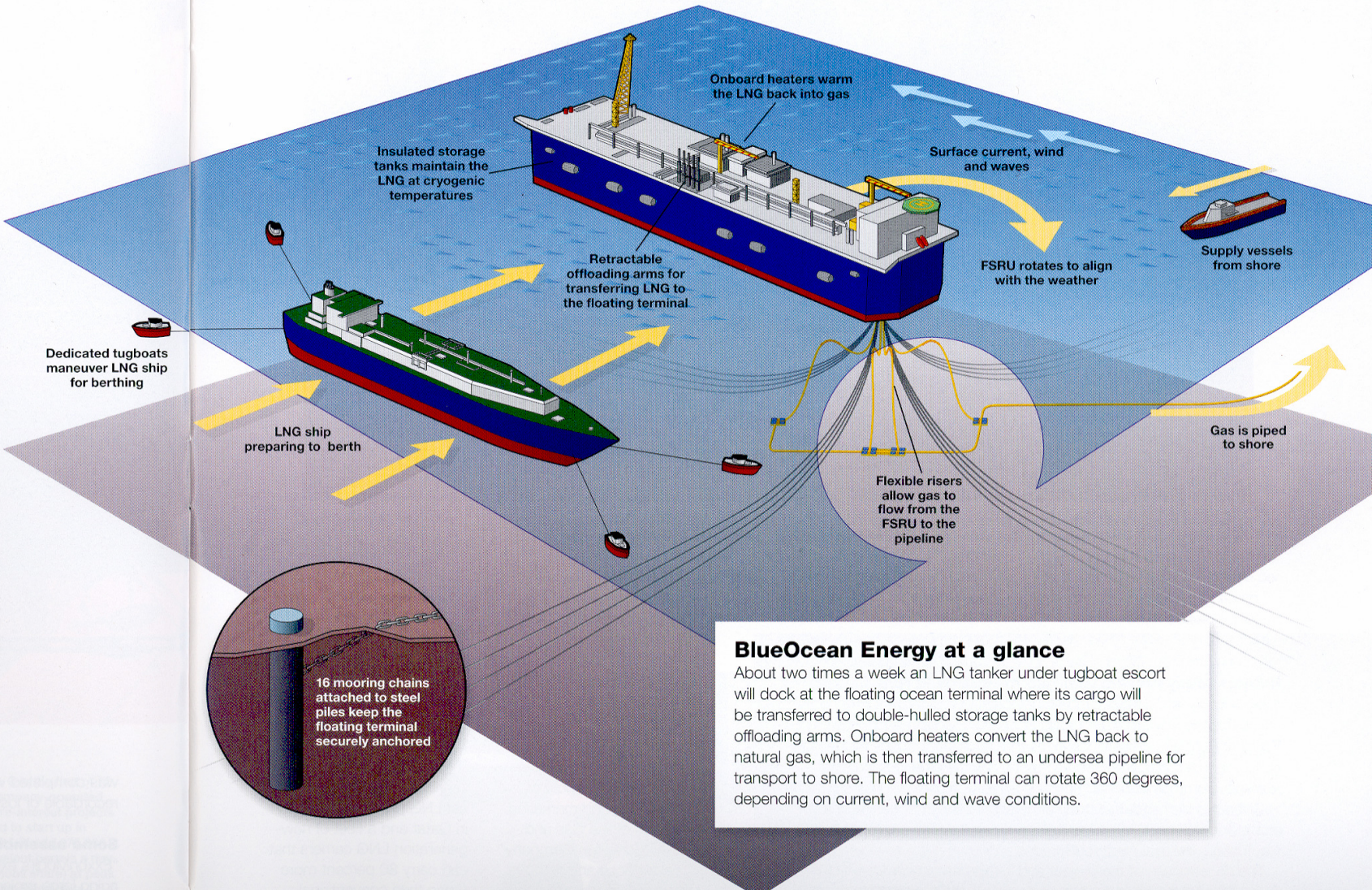


Each propeller on a Q-Flex ship is about 25 feet in diameter and weighs around 80,000 pounds. The ships are powered by twin engines that total 44,000 horsepower.

Photos courtesy of Qatargas



# EXXONMOBIL CONCEPT FOR OFFSHORE CARGO TRANSFER



**BlueOcean Energy at a glance**  
About two times a week an LNG tanker under tugboat escort will dock at the floating ocean terminal where its cargo will be transferred to double-hulled storage tanks by retractable offloading arms. Onboard heaters convert the LNG back to natural gas, which is then transferred to an undersea pipeline for transport to shore. The floating terminal can rotate 360 degrees, depending on current, wind and wave conditions.

## MARITIME ENERGY SHIPPING ROUTE DISTANCES COMPARED

<u>SOURCE</u>	<u>DESTINATION</u>	<u>COMMODITY</u>	<u>N-MILE</u>
TRINIDAD	NEW ORLEANS, LA	AMMONIA	2,056
TRINIDAD	TAMPA, FL	AMMONIA	1,745
QATAR	GULF OR EAST COAST	LNG	12,325
QATAR	LOS ANGELES, CA	LNG	11,202
OTE Plantships			
SOUTHWEST OF SAN DIEGO	SAN DIEGO, CA	AMMONIA & DESALINATED WATER	700
OTE Plantships			
GULF OF MEXICO	GULF COAST PORTS	SAME CARGO	300

Source: Maritime Administration Data



“FROM THE DOE  
FREEDOM CAR”  
PROGRAM

## Potential Roles of Ammonia in a Hydrogen Economy

A Study of Issues Related to the Use Ammonia for On-Board Vehicular Hydrogen Storage

U.S. Department of Energy



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*“Although DOE is not currently funding conventional fuel processing of ammonia for on-board hydrogen storage, the potential use of **ammonia as an energy carrier**, particularly during the transition towards the hydrogen economy, is not disqualified.”*

*“Ammonia may be considered as a potential hydrogen carrier for hydrogen delivery and off-board storage, such as at refueling stations and for stationary power applications.”*



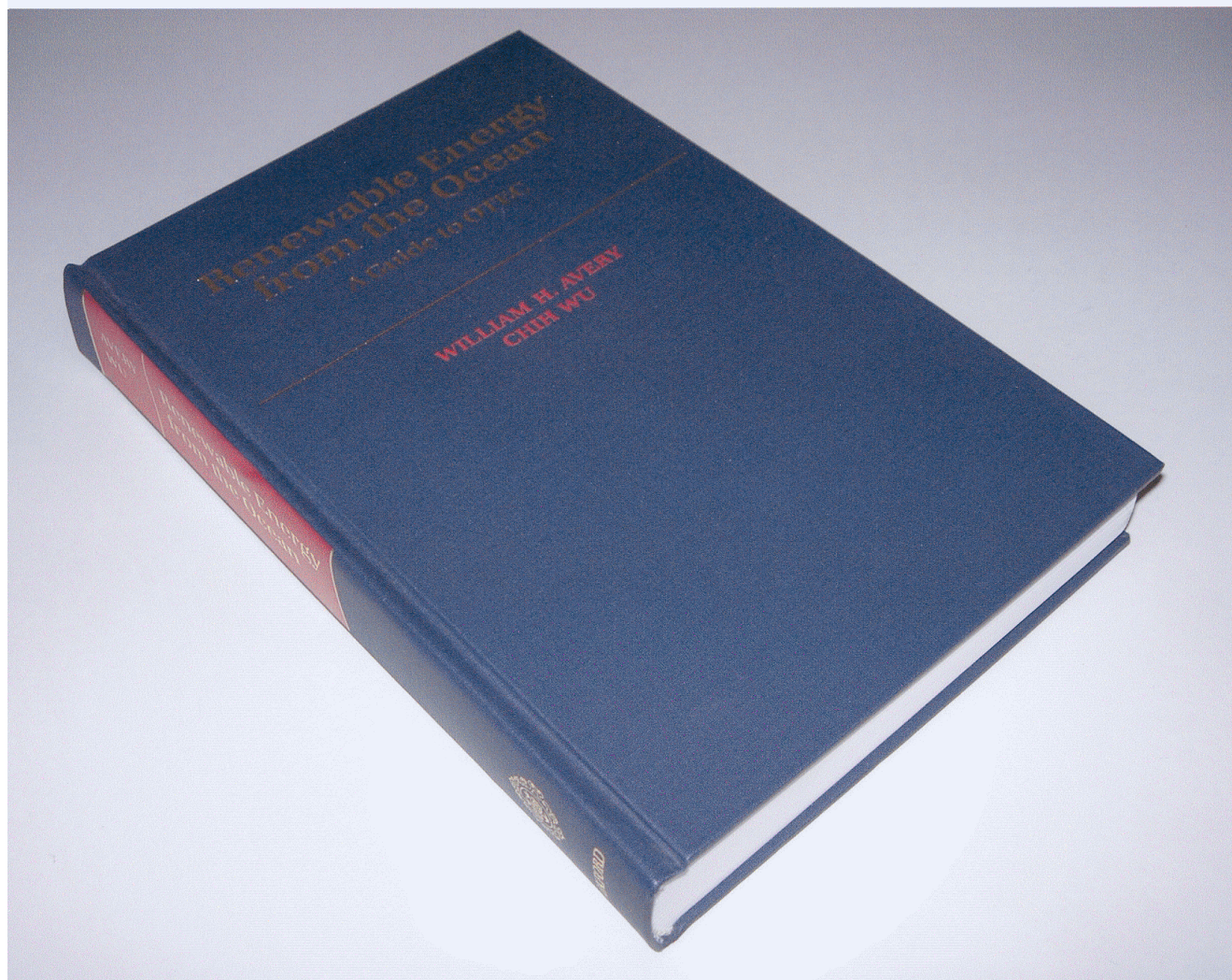


**September 11, 2007, WORKSHOP at The Degas Salon,  
L'Enfant Plaza Hotel, Washington D.C. , morning**

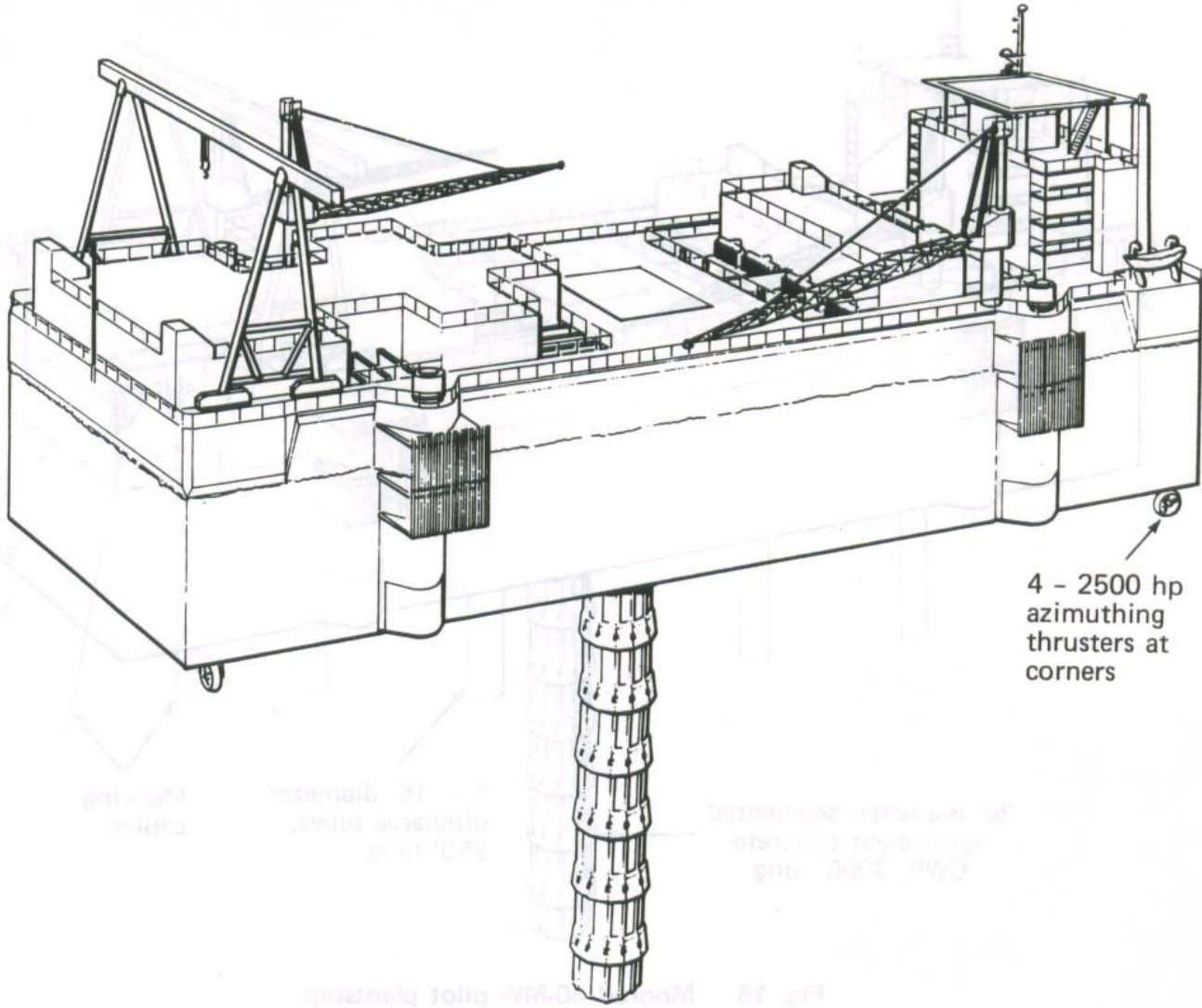
**OCEAN THERMAL ENERGY PLANTSHIPS**  
**FOR PRODUCTION OF AMMONIA AND DESALINATED WATER**

- |         |  |          |   |
|---------|--|----------|---|
| 8:30 AM | Sign Up For The Workshop                                       | 10:00 AM | Global Peak Oil And<br>Alternatives<br>Representative Roscoe<br>Bartlett (MD) |
| 9:00 AM | Welcome And Introduction<br>CB Panchal, Argonne                | 10:45 AM | Solid State Technology<br>For Ammonia Synthesis<br>Jason Ganley, Howard U.    |
| 9:15 AM | Recent Developments<br>Peter Pandolfini, JHU/APL               | 11:00 AM | Introductory Remarks<br>Mark Paster, Department<br>Of Energy                  |
| 9:30 AM | Historical Perspectives<br>Robert Cohen, Consultant            | 11:30 AM | Technical And Economic<br>Analysis Of Plantships<br>C. B. Panchal, Argonne    |
| 9:45 AM | OTE And The Energy-<br>Water Nexus Issues<br>William Kumm, AEL |          |   |

THE OTE “BIBLE” BY AVERY AND WU, 1994  
WITH FORWARD BY JOHN P. CRAVEN, IS ALL ABOUT AMMONIA

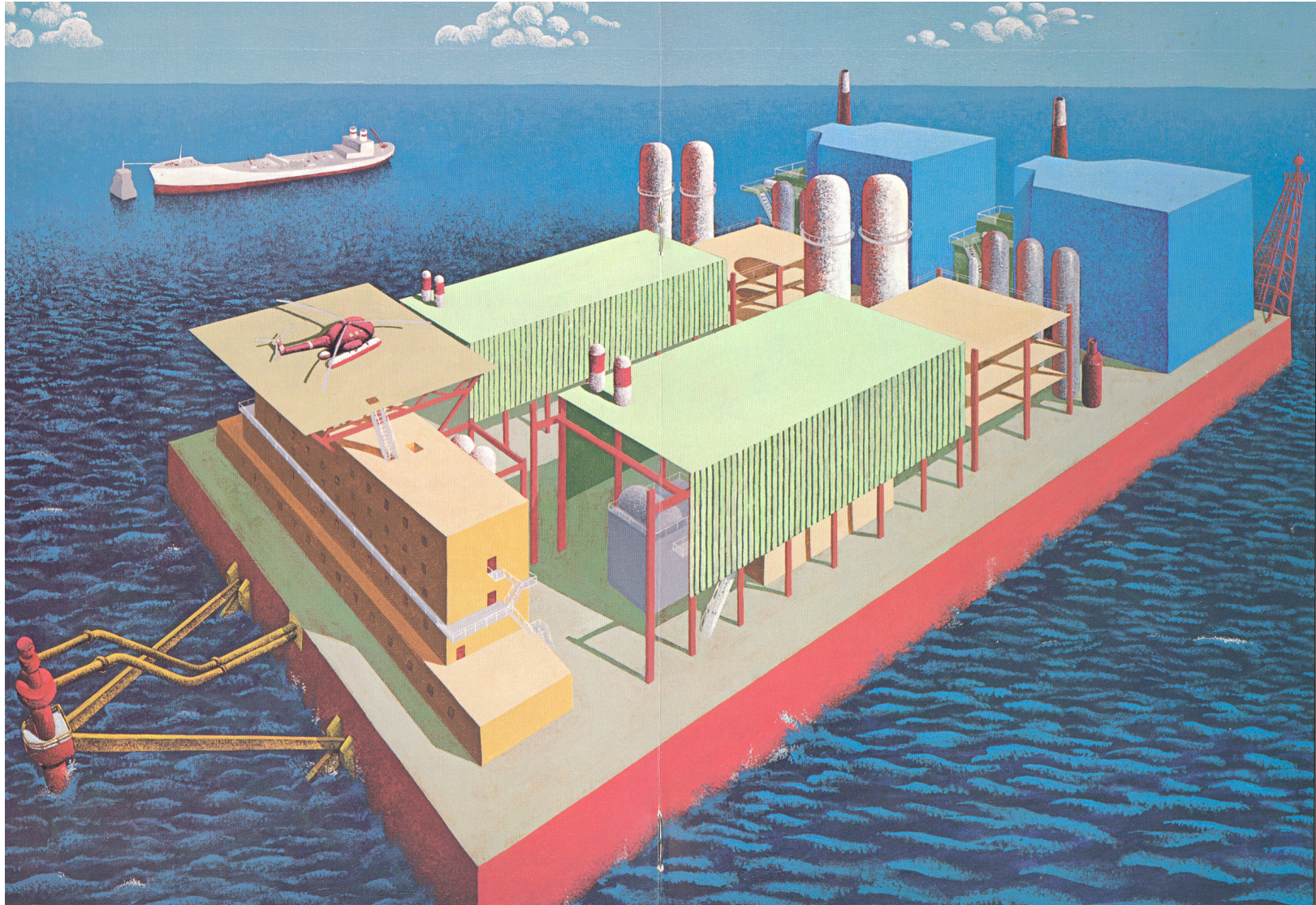


# AT-SEA OCEAN THERMAL PLANTSHIP



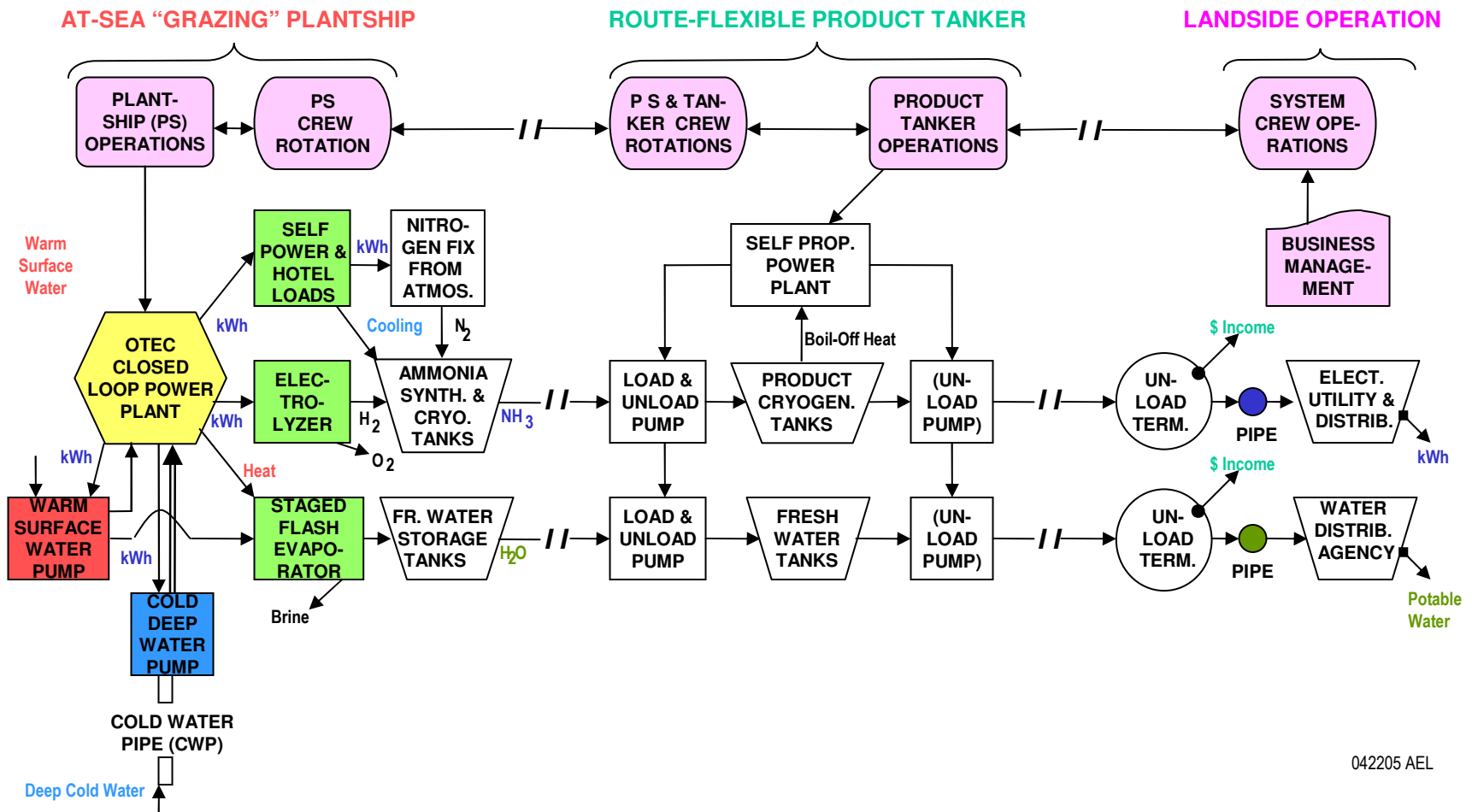


# OCEAN THERMAL PLANTSHIP CONCEPT





# SYSTEM BLOCK DIAGRAM



042205 AEL



CARGO OPTION:  $\text{NH}_3$  55,000 mt @  $-33^\circ\text{C}$



“CAPTAIN MARKOS NL” Bahamas Registry, 16 kn, 18,420 bhp





**A POSSIBLE AMMONIA FUELED SHIP**



**Also Remember:**

**AT-SEA  
OCEAN THERMAL ENERGY  
PLANTSHIP SYSTEMS  
UNIQUELY  
CAPTURES SOLAR ENERGY  
24 HOURS PER DAY**

**[ON-LAND PHOTOVOLTAIC CAPTURE IS  
ONLY 33% EFFICIENT (8/24 HOURS)]**

# THE ENERGY-WATER NEXUS SOLUTION

## **WORLD-SCALE OTE PLANT-SHIPS MEAN**

- ✓NO AIR POLLUTION IMPACT
- ✓NO ENERGY FUEL DEPLETION IMPACT
- ✓NO BALANCE-OF-PAYMENTS “River Of \$”
- ✓NO FOSSIL ENERGY REQUIRED



**OCEAN THERMAL PLANTSHIPS FOR PRODUCTION OF AMMONIA  
AS THE HYDROGEN CARRIER**

Report Prepared by

CB Panchal  
Argonne National Laboratory  
Argonne, IL 60439

Peter P Pandolfini  
The Johns Hopkins University/Applied Physics Laboratory  
Laurel, MD 20723

William H Kumm  
Arctic Energies, LTD  
Severna Park, MD 21146

Hydrogen Production and Delivery  
B&R No.: EB-4201

Task: Hydrogen Production by Ocean Thermal Energy Conversion (OTEC)

February 2008

**FEB. 2008  
REPORT  
TO  
DOE**



**Argonne**  
NATIONAL  
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*... for a brighter future*



U.S. Department  
of Energy

**UChicago** ▶  
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managed by UChicago Argonne, LLC

# ***Ocean Thermal Plantships for Production of Ammonia as the Hydrogen Carrier***

***C.B. Panchal***

***Argonne National Laboratory***

***June 11, 2008***

This presentation does not contain any proprietary, confidential, or otherwise restricted information

***PROJECT ID # PDP19***



# OVERVIEW

## Timeline

- Start – October 2005
- Finish - March 2008
- Final Report Submitted

## Budget

- Total Project Funding
  - DOE \$150K
- Funding Received in FY06
  - \$20K
- Funding Received in FY07
  - \$100K
- Funding Received in FY08
  - \$30K

## Barriers

- Barriers
  - Ocean thermal not viable for continent USA
  - Capital costs too high to be competitive to other technologies
  - No commercial or pilot plant operating
- Target
  - Short term: Displace petroleum liquid fuel for power generation
  - Intermediate: Displace natural gas for distributed power generation
  - Long term: Ammonia as hydrogen carrier for transportation

## Partners

- The Johns Hopkins University/Applied Physics Laboratory (JHU/APL)
- Arctic Energies, LTD (AEL)

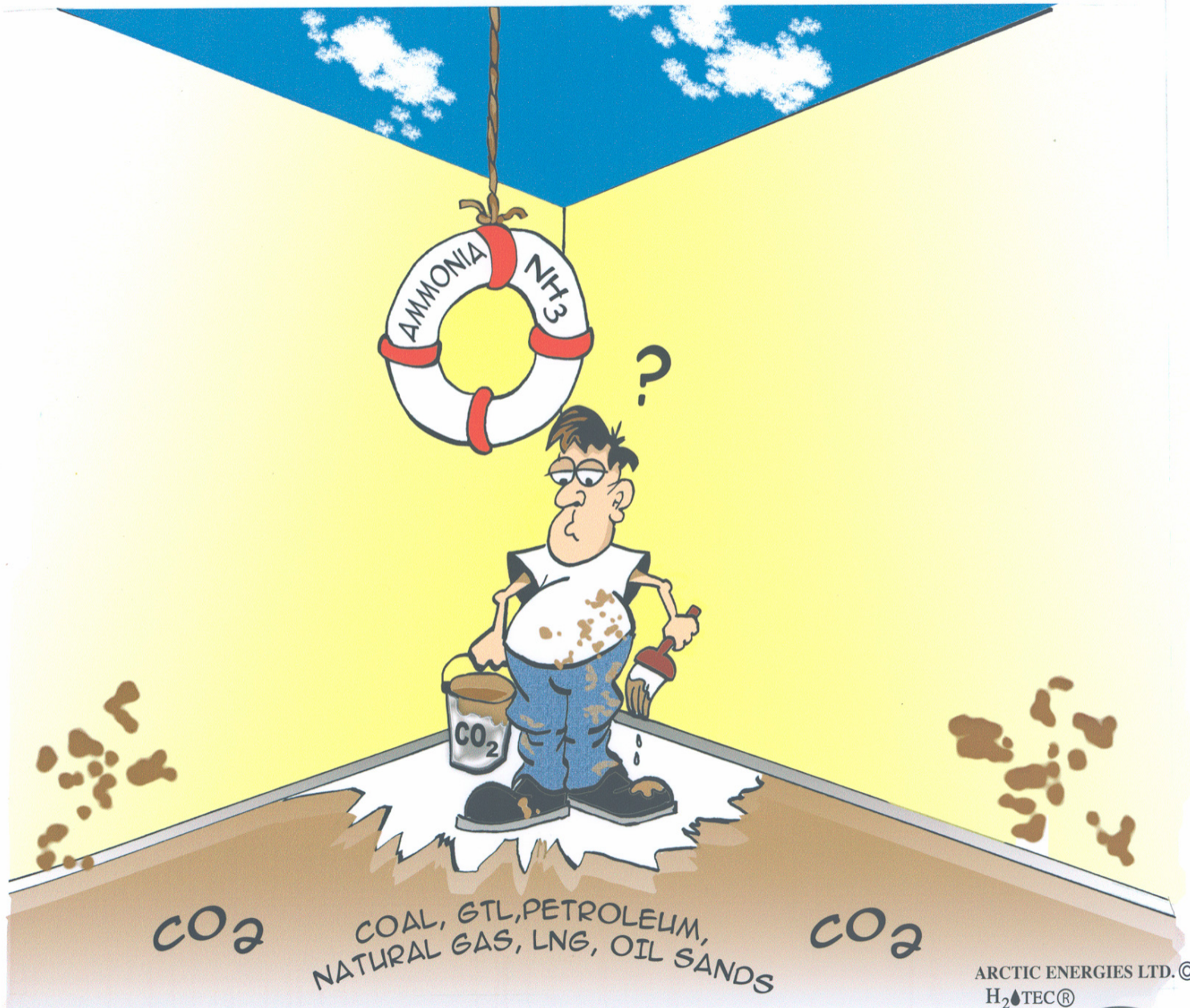
## **OBJECTIVE**

### **The Two Primary Objectives:**

- **To evaluate the technical and economic viability of at-sea ocean thermal plantships for production of ammonia as the hydrogen carrier to meet the HFCIT cost goal of \$2 to \$3/gge (delivered, untaxed, 2005\$ by 2015)**
- **To evaluate economic impact of co-production of desalinated water**



THE NON-CARBON FUEL WAY OUT



NEEDED: "THINKING OUTSIDE OF THE BOTTOM OF THE BOX"

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H<sub>2</sub>TEC®

ACKERMAN  
2007

**ARCTIC ENERGIES LTD.**

**WILLIAM H. KUMM  
PRESIDENT**

**511 HEAVYTREE LANE • SEVERNA PARK, MD 21146 • TEL: 410-987-5454  
FAX: 410-987-7549 • EMAIL: whkwhoswhoworld@aol.com**

**Q.  
E.  
D.**