

Making Ammonia Fuel From Alaska's Abundant Stranded Renewable Energy

Ammonia Fuel Conference

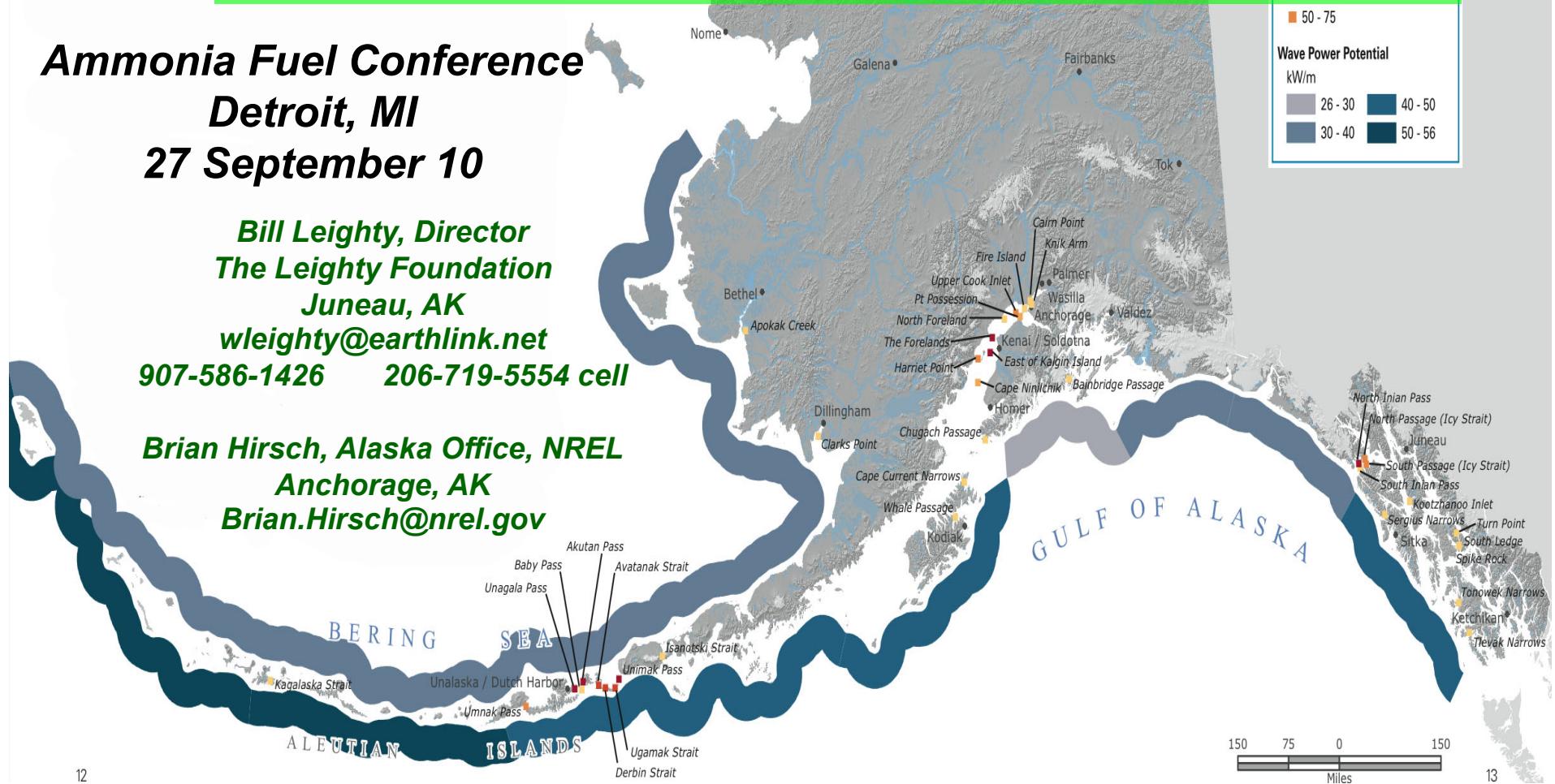
Detroit, MI

27 September 10

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MUST Run the World on Renewables – plus Nuclear ?



MUST Run the World on Renewables – plus Nuclear ?

- Climate Change
- Demand growth
- Depletion of Oil and Gas
- Only 200 years of Coal left
- Only Source of Income:
 - Sunshine
 - Tides
 - Meteors and dust
 - Spend our capital ?





**“ Americans can be
counted on to
always do the right
thing –

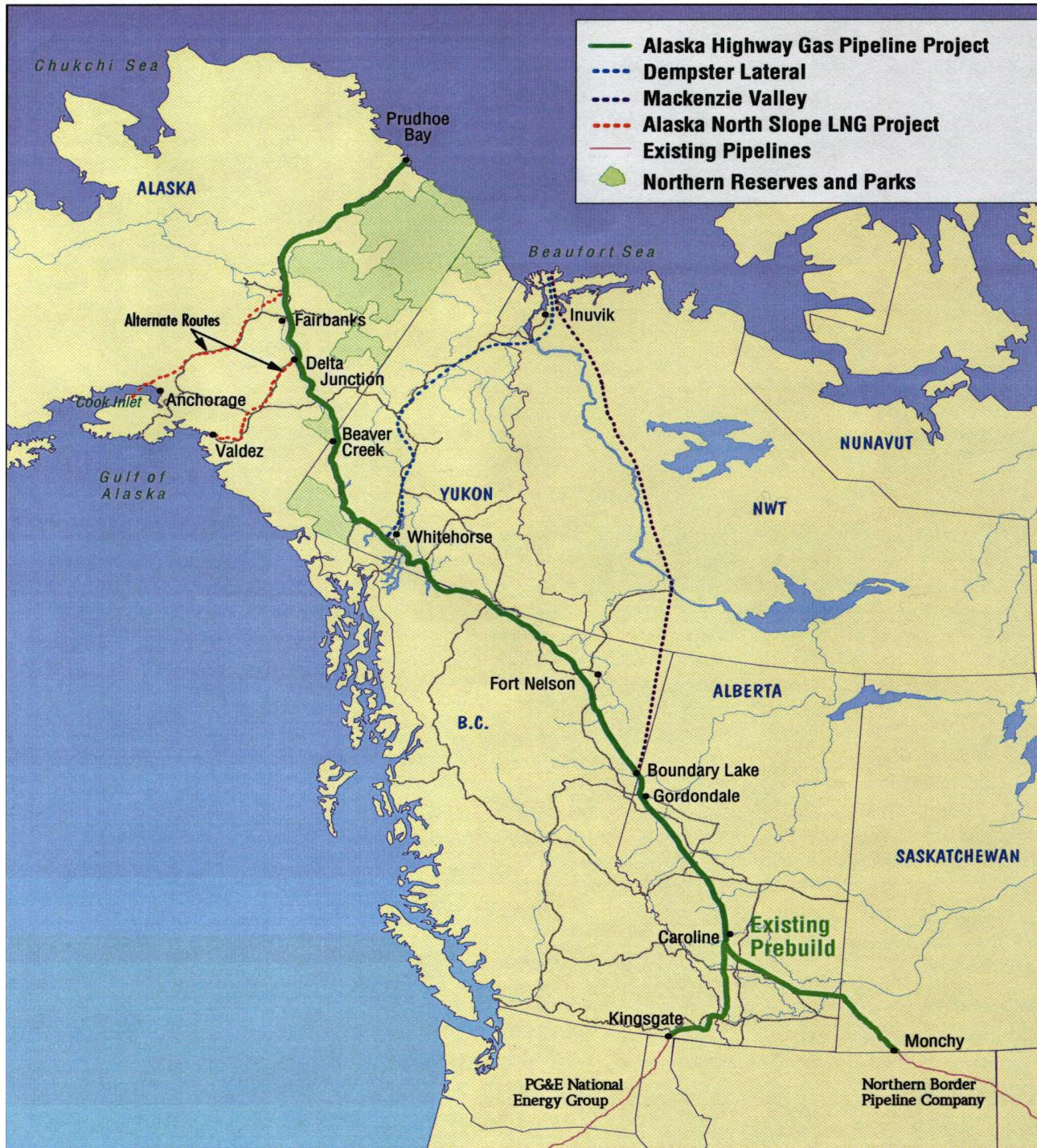
but only after they
have tried
everything else ”**

Winston Churchill

The dog caught the car.

Dan Reicher



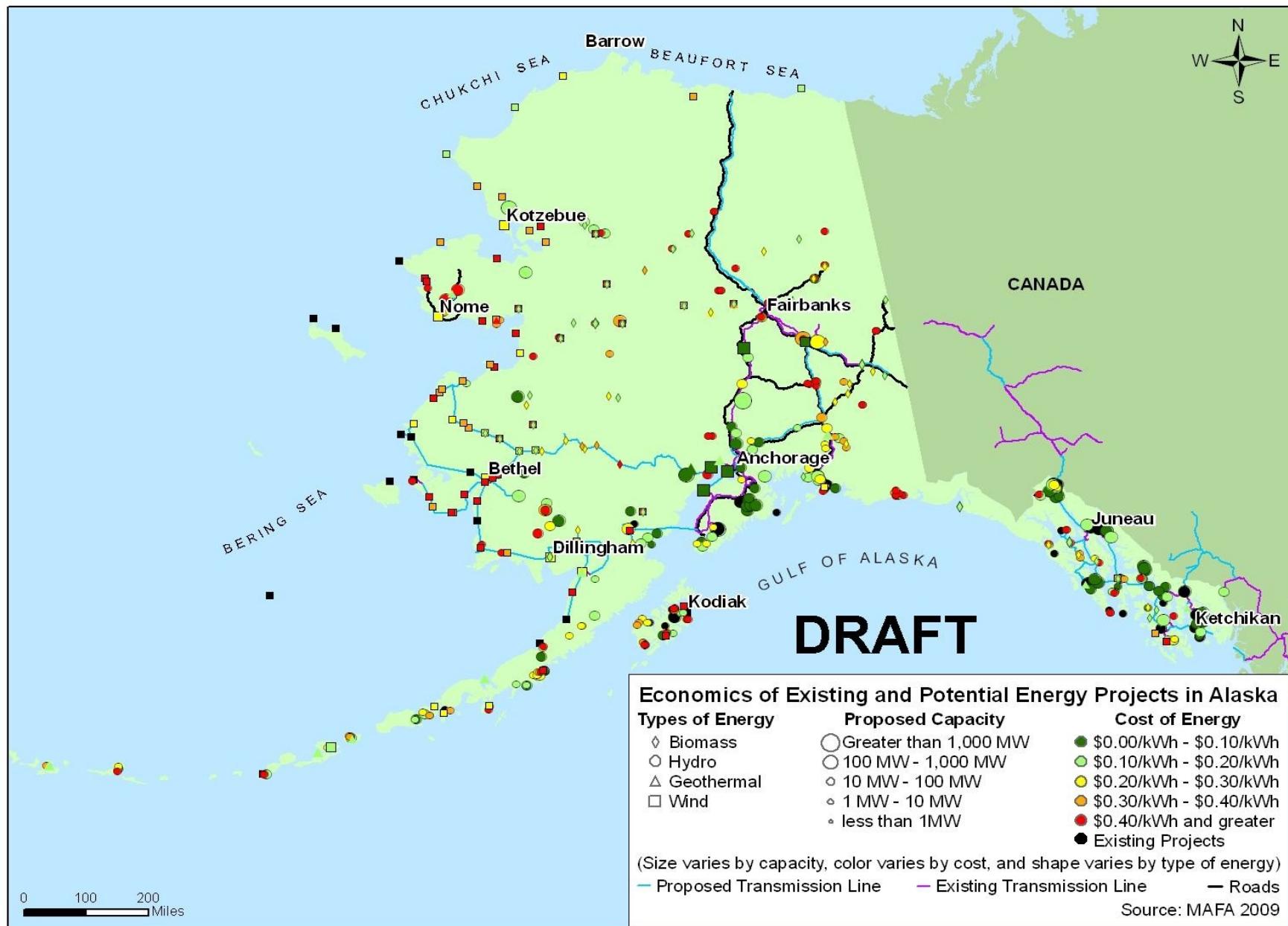


Proposed ANS* Gas Pipeline

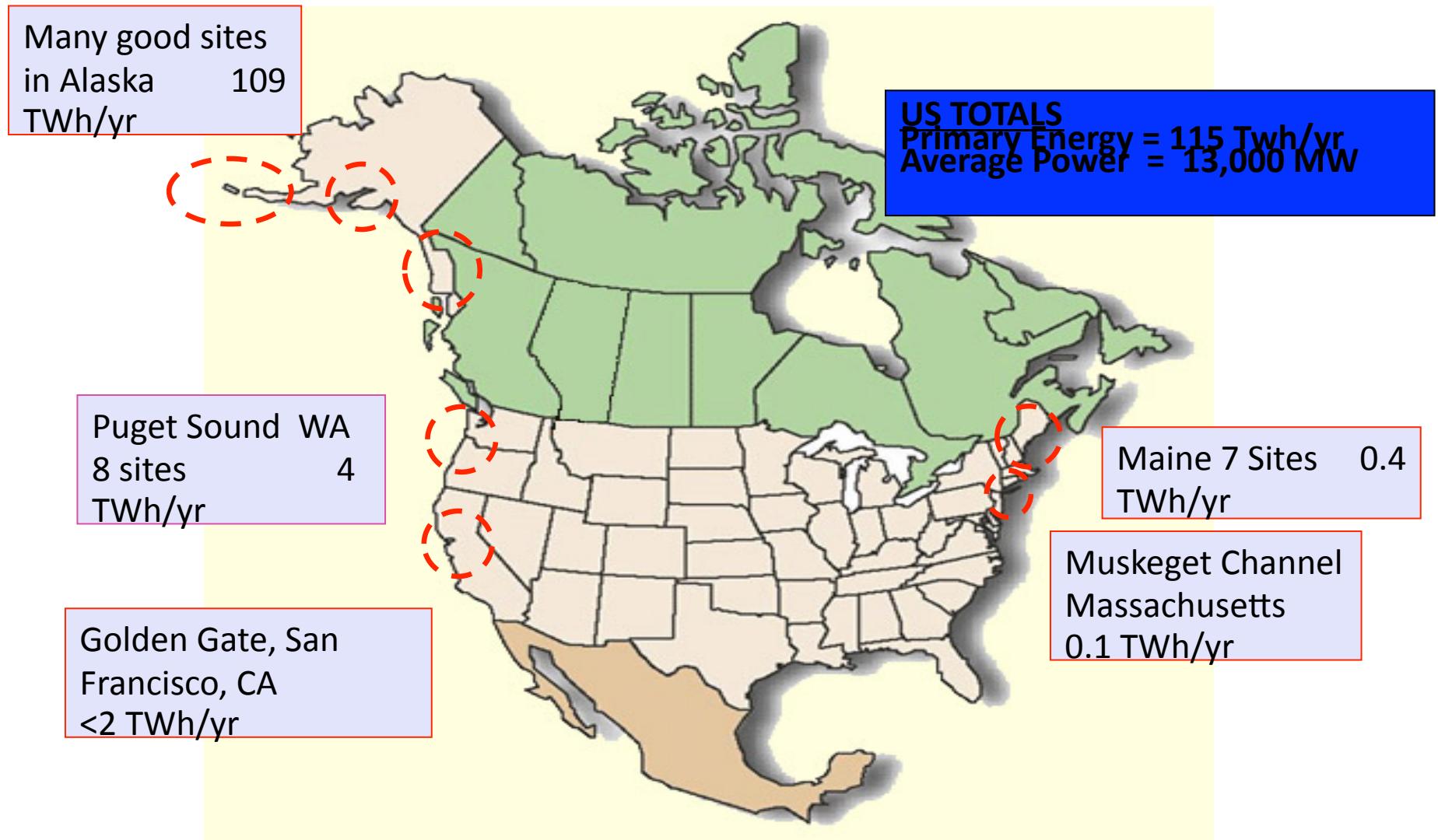
**"ALCAN" Alaska
Highway Route**

**TransCanada
Pipelines**

* Alaska North Slope



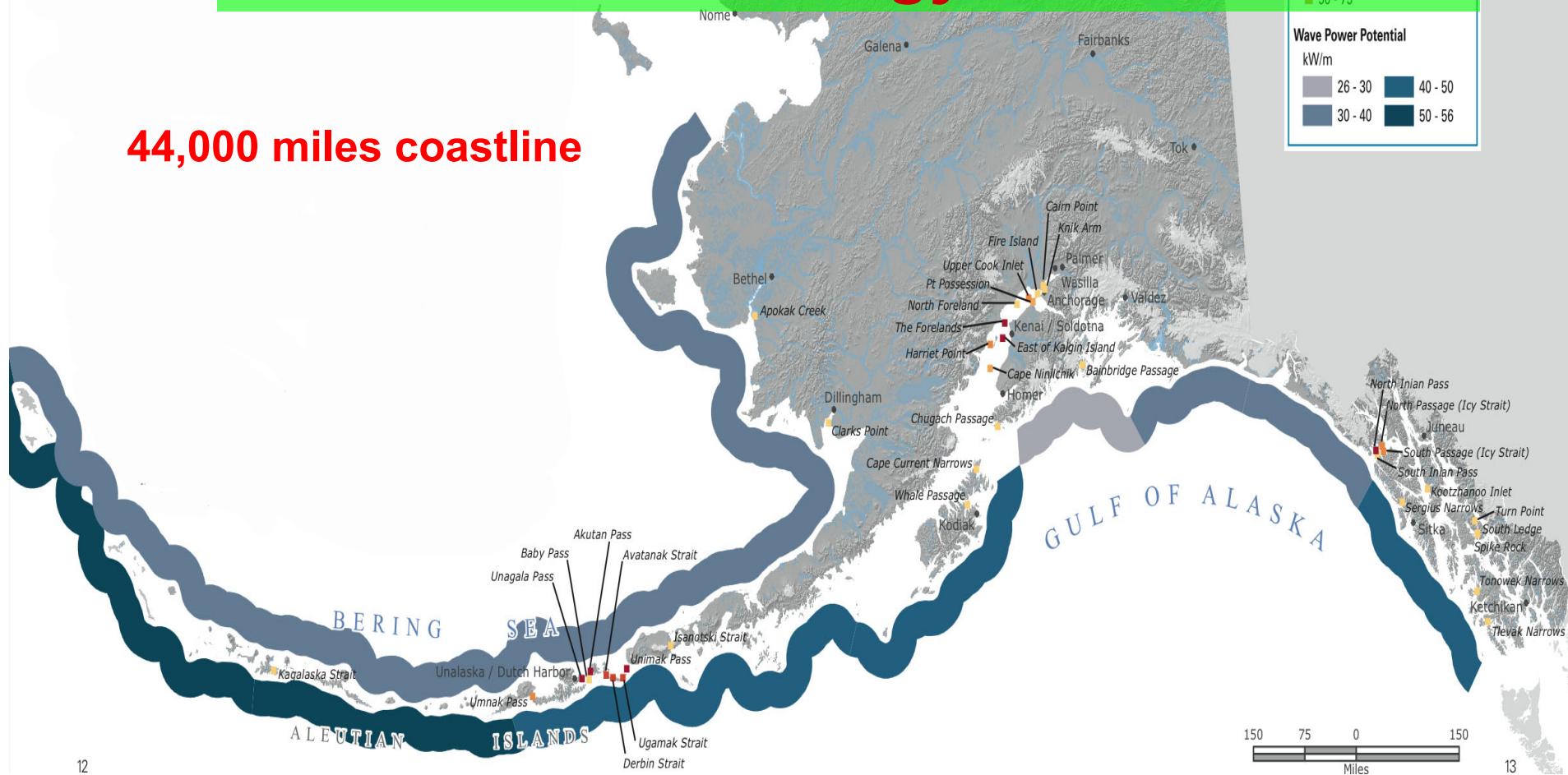
Tidal Current Energy



OCEAN

Making Ammonia Fuel From Alaska's Vast Stranded Renewable Energy Resources

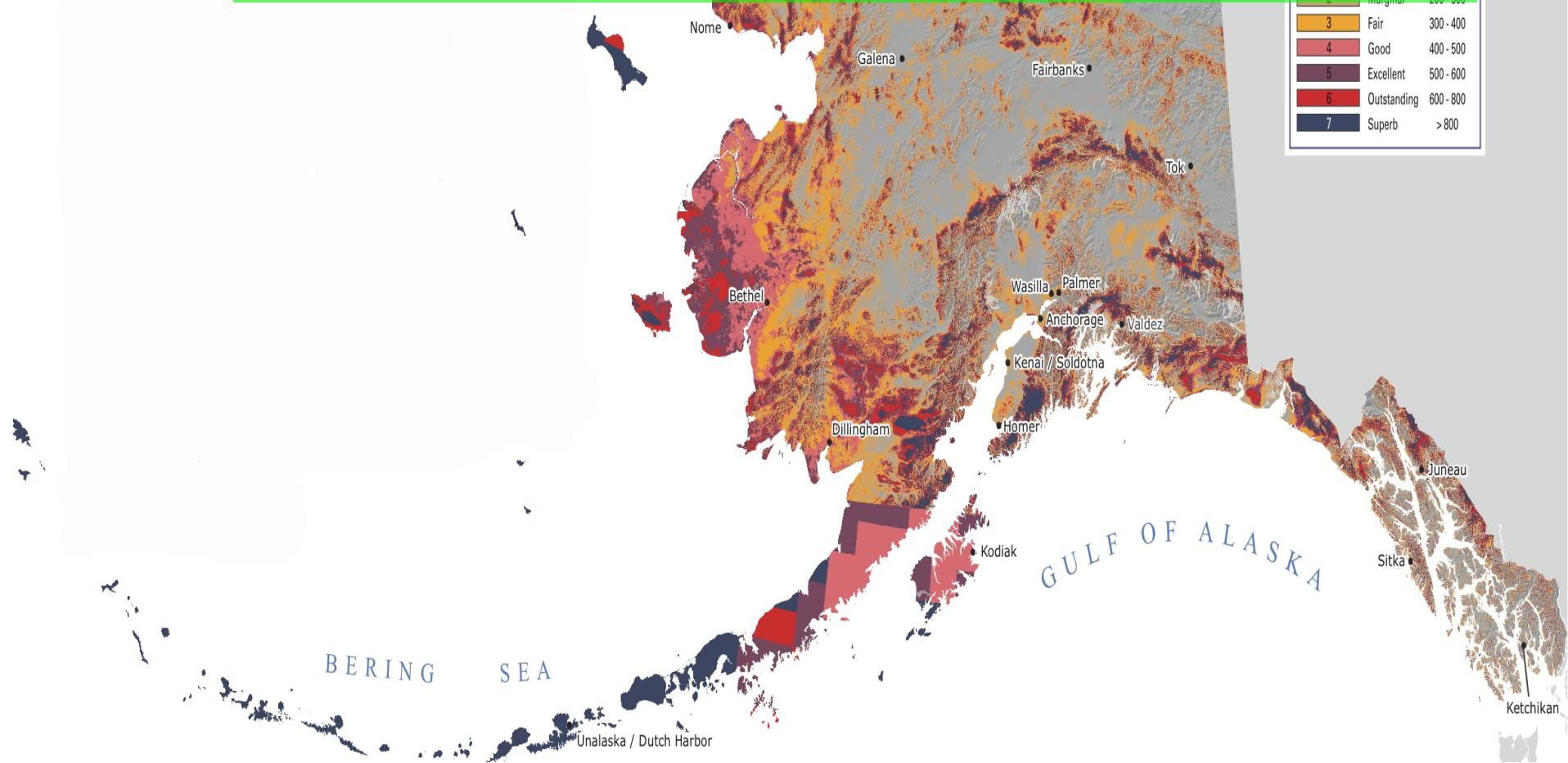
44,000 miles coastline



WIND

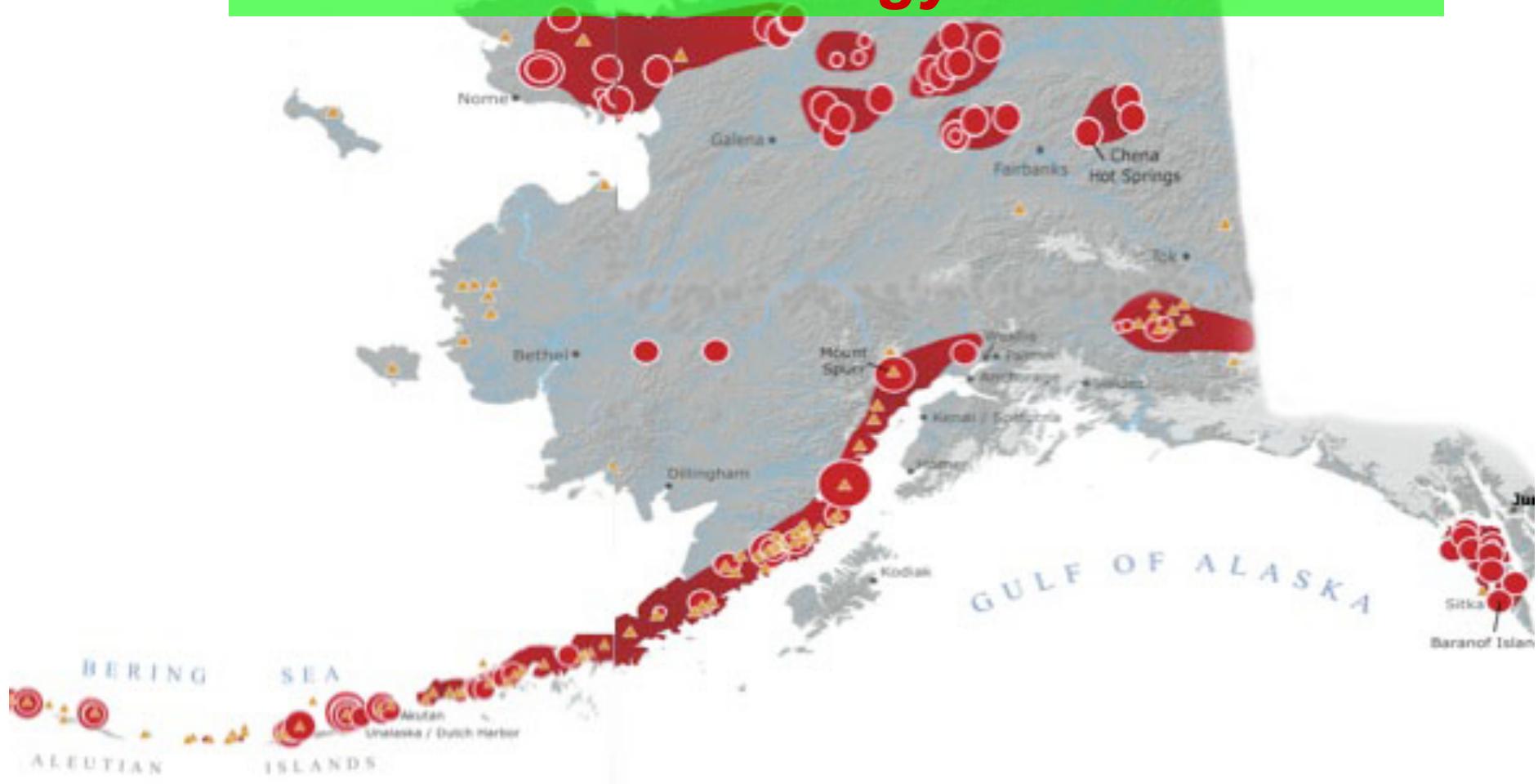
Making Ammonia Fuel From Alaska's Vast Stranded Renewable Energy Resources

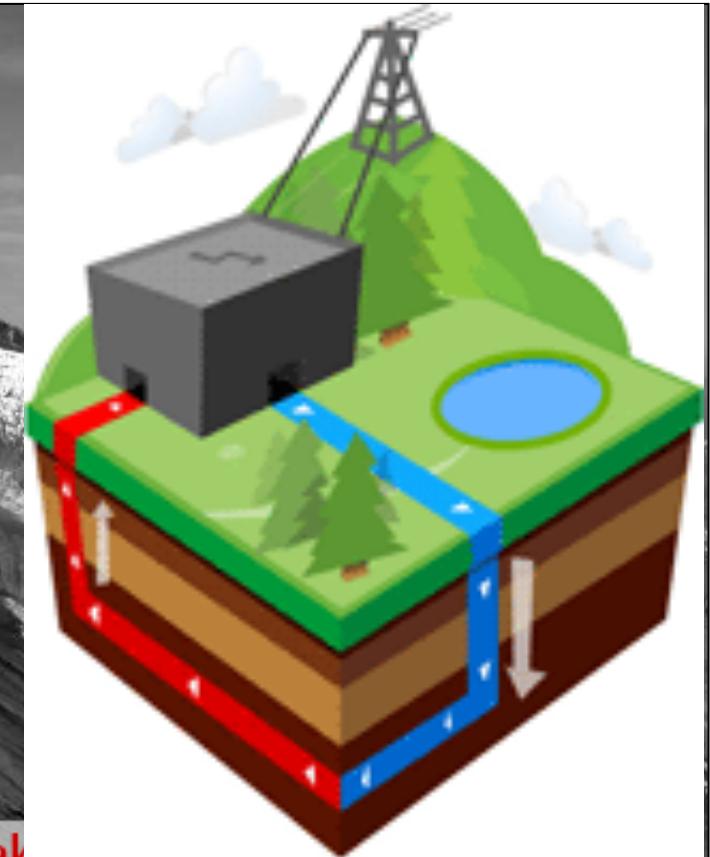
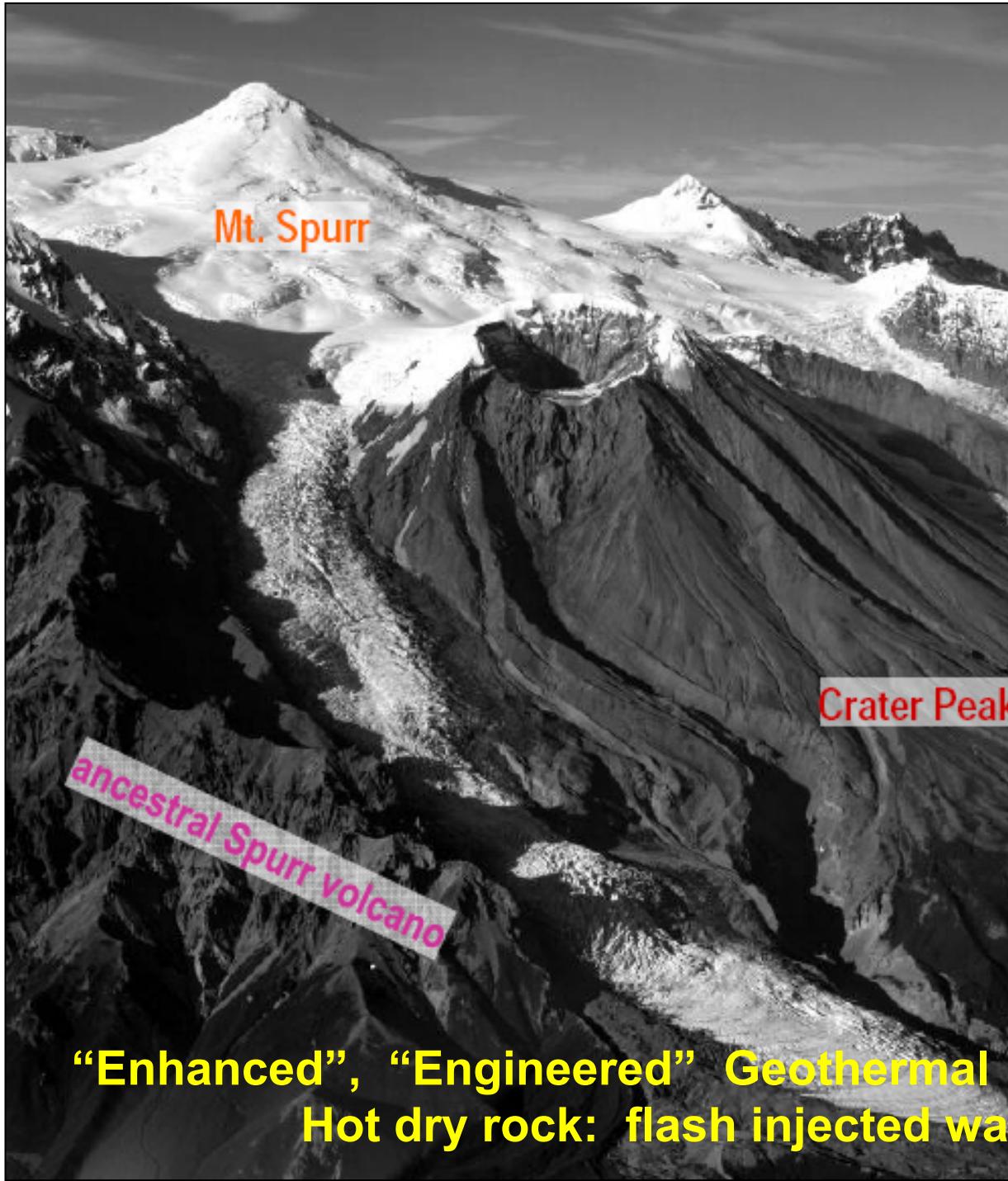
Wind Power Class	Resource Potential	Wind Power Density at 50m (Watts/m ²)
1	Poor	< 200
2	Marginal	200 - 300
3	Fair	300 - 400
4	Good	400 - 500
5	Excellent	500 - 600
6	Outstanding	600 - 800
7	Superb	> 800



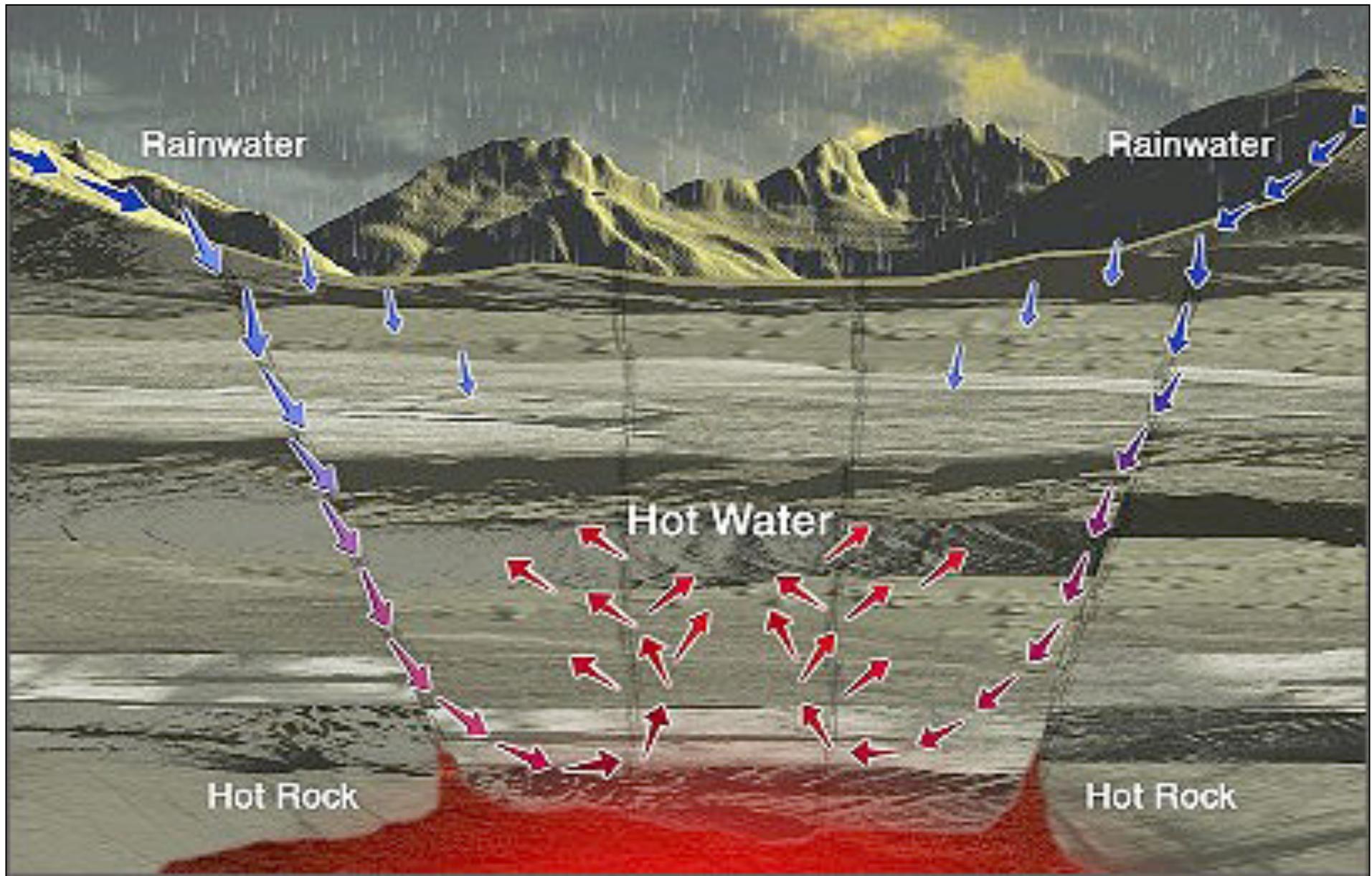
GEOTHERMAL

Making Ammonia Fuel From Alaska's Vast Stranded Renewable Energy Resources





“Enhanced”, “Engineered” Geothermal
Hot dry rock: flash injected water to steam



Geothermal: hot water, surface recharge

Alaska

- **650,000 pop**
- **Railbelt:**
 - **60% pop**
 - **Only “grid”**
- **200 “villages”**
- **100+ with good RE**
- **Energy islands**
- **44,000 miles coast > all other states**
- **Other Renewables Unknown:**
 - **Solar**
 - **Instream kinetic (rivers)**
 - **Biomass**



Alaska Business Opportunities: RE – NH3 “Green” Ammonia

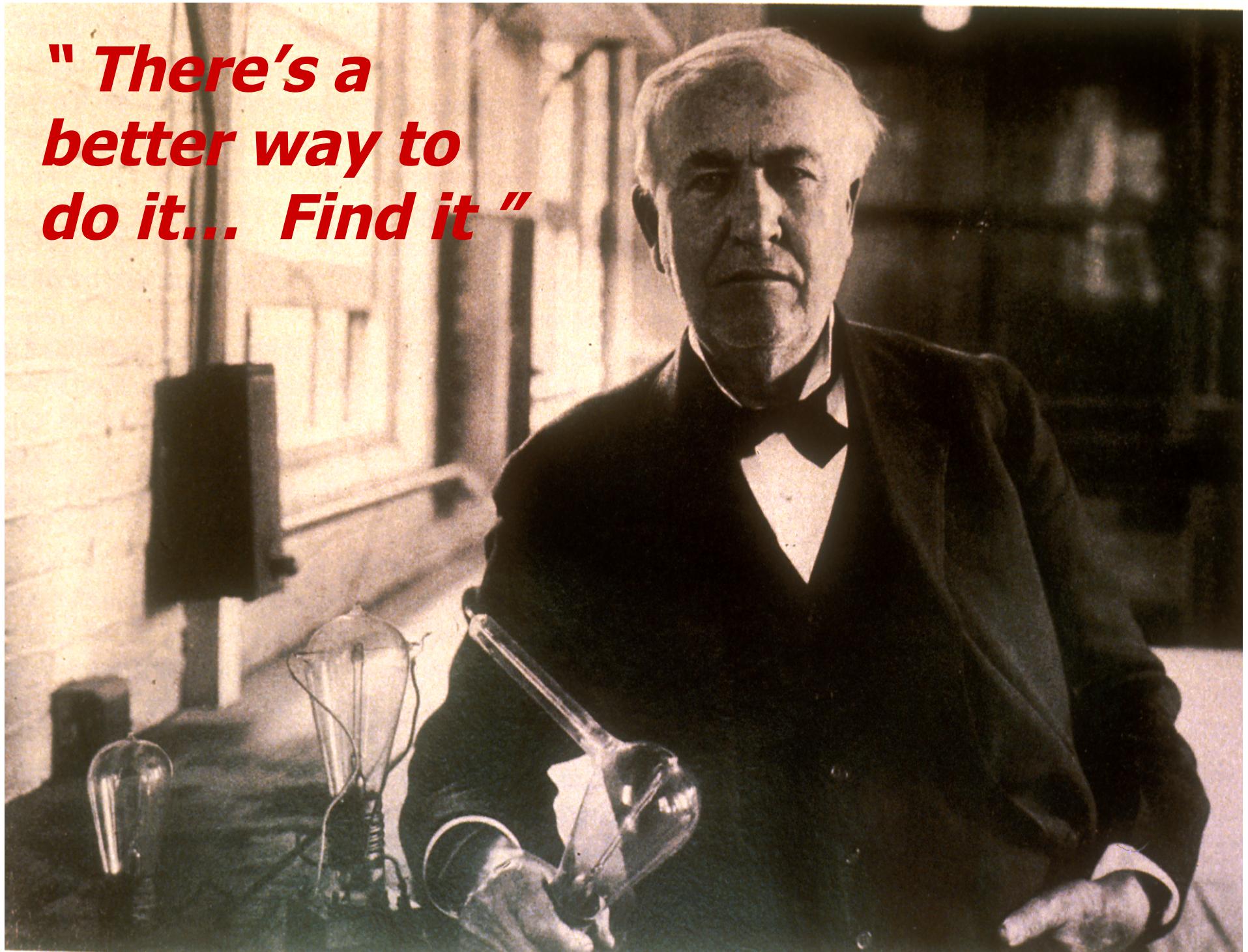
Monetizing Alaska's vast RE

1. Export from GW-scale RE: Increase cash **IN**
2. Village energy “independence”
 - Indigenous renewables; diverse
 - Seasonal, diurnal variability
 - Storage as NH3: pressurized tanks
 - Reduce cash **OUT**

Alaska Business Opportunities: Business is About Cash Flow

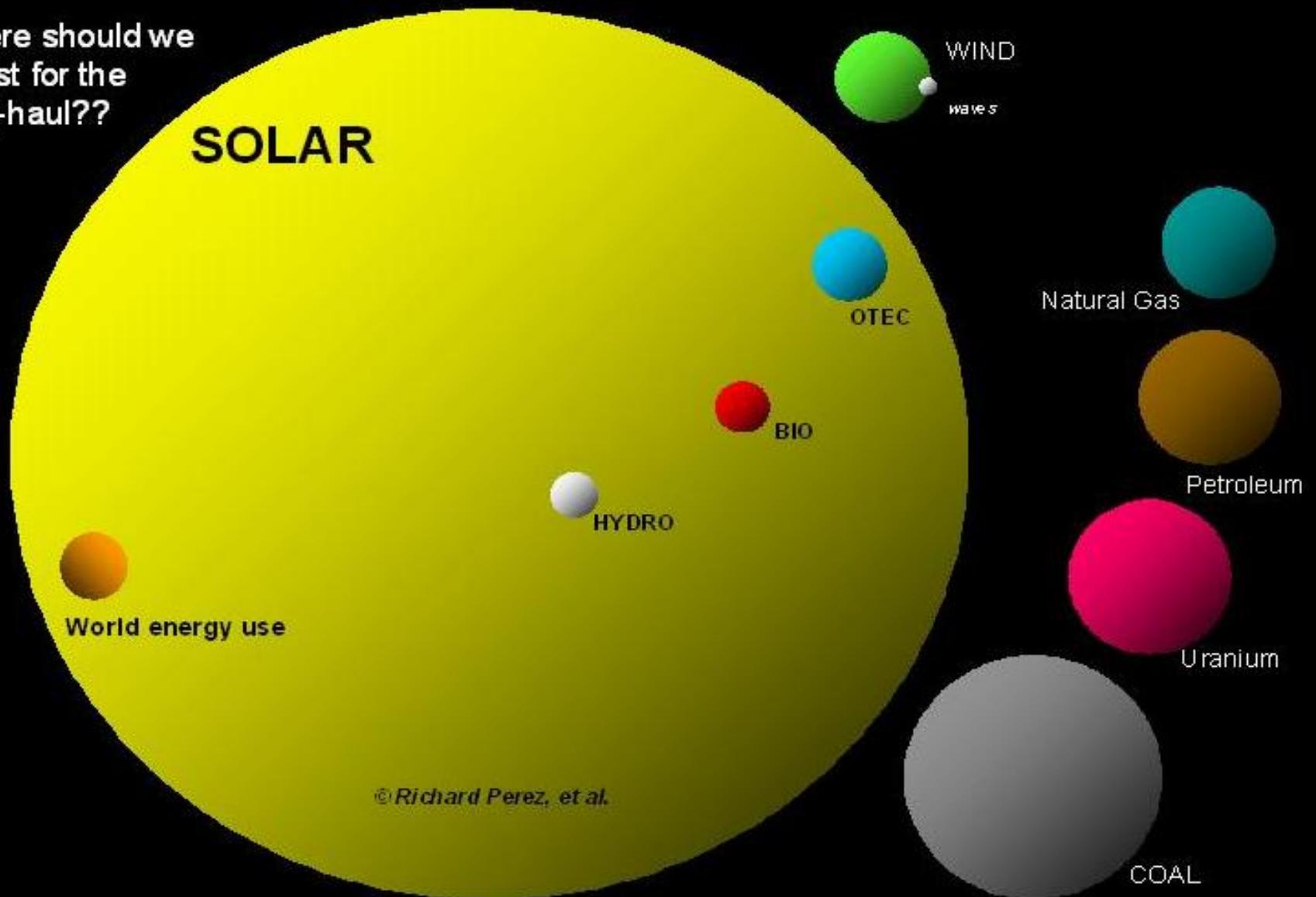
- Maximize cash **IN**
- Minimize cash **OUT**
- Short, long term NCF, IRR, NPV
- Enterprises:
 - State, Communities
 - People of Alaska
 - Capital Investors

*" There's a
better way to
do it... Find it "*



Comparing the world's energy resources*

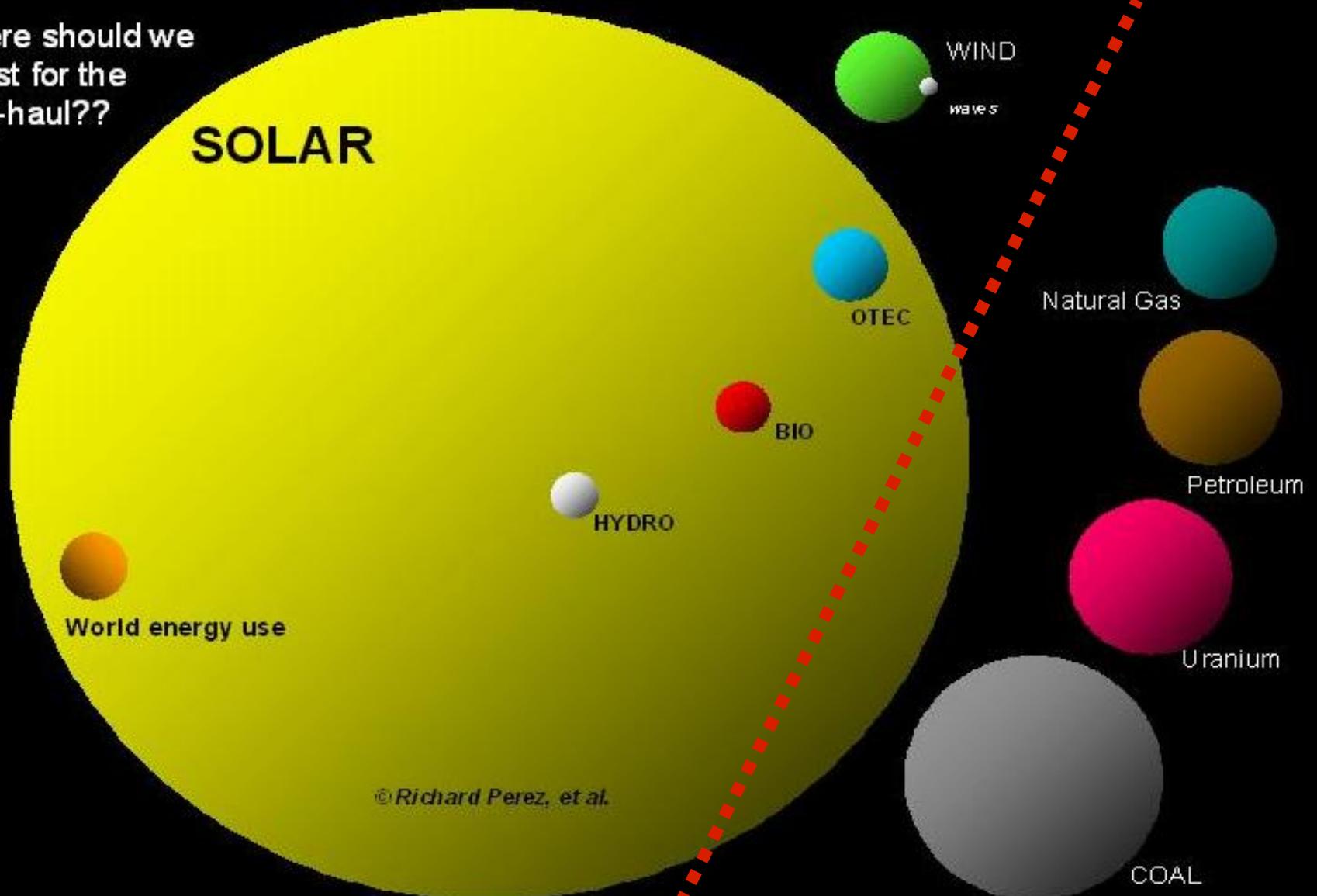
Where should we
invest for the
long-haul??



*yearly potential is shown for the renewable energies. Total reserves are shown for the fossil and nuclear "use-them, lose-them" resources. World energy use is annual.

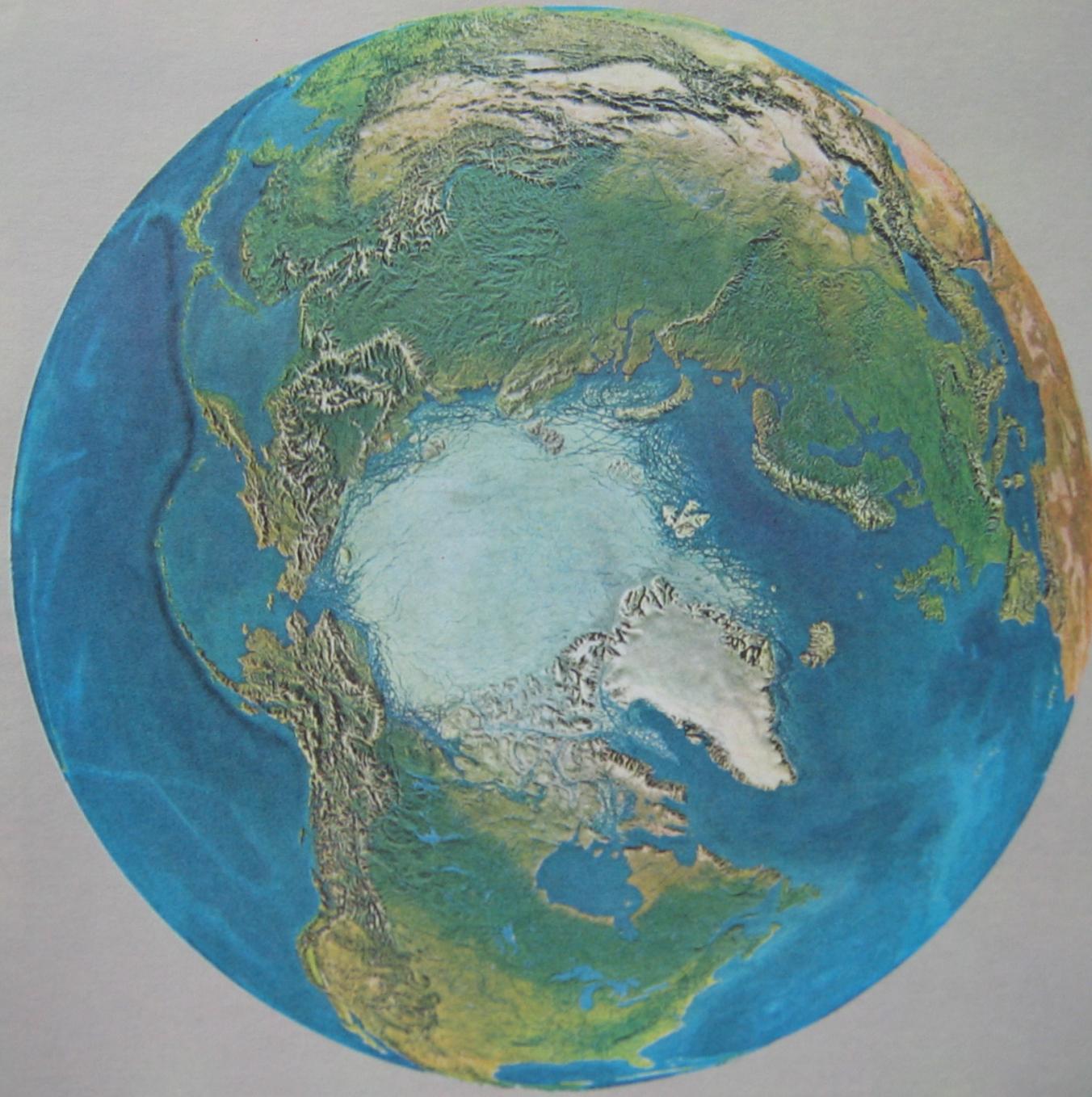
Comparing the world's energy resources*

Where should we
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*yearly potential is shown for the renewable energies. Total reserves are shown for the fossil and nuclear "use-them, lose-them" resources. World energy use is annual.

©Richard Perez, et al.





Our Spaceship Earth

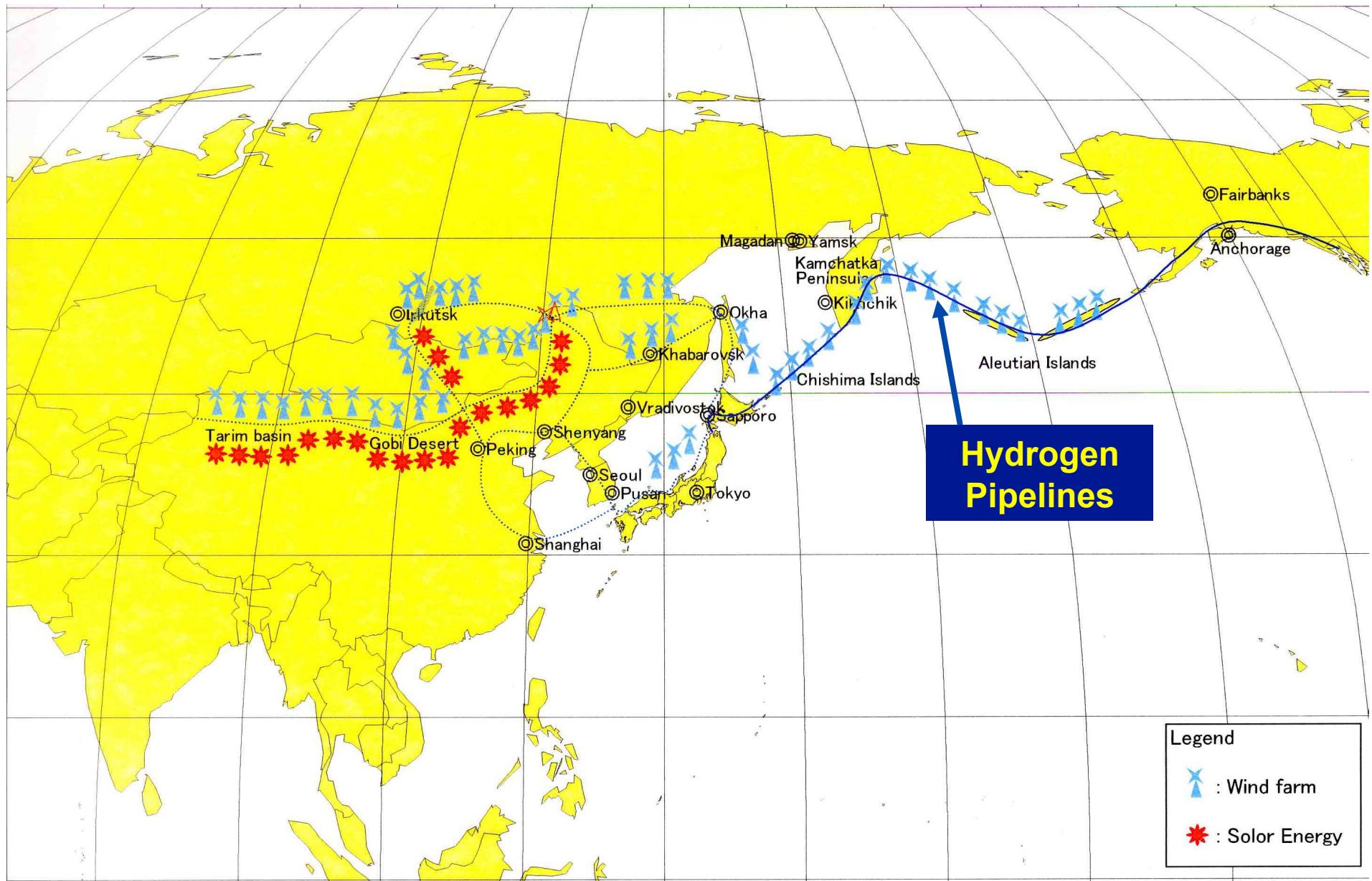
one island in one ocean ... from space

Learn all about the new *Star Trek* movie! [Read our review](#) and check out [J.J. Abrams' first trailer](#).



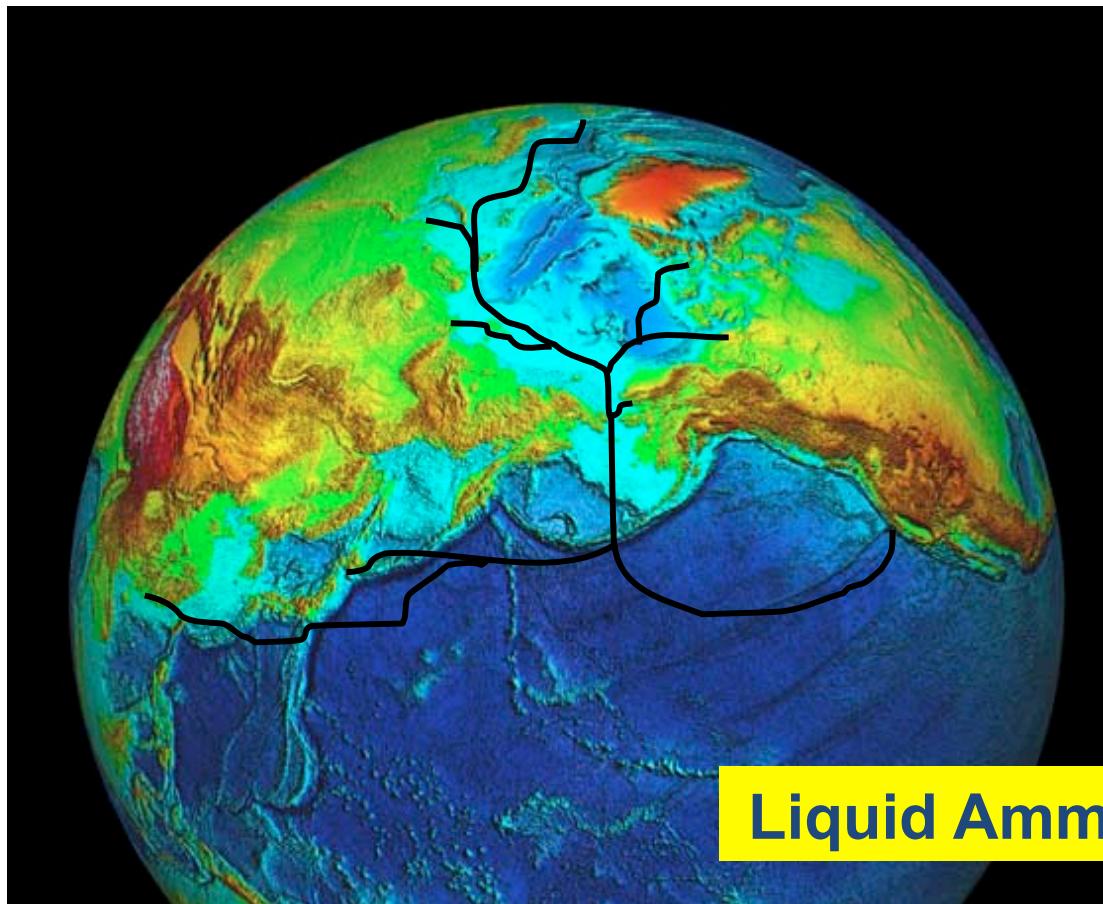
ANSWER

PHOTOGRAPH BY DAVID M. BROWN



Map by K. O'Hashi, Nippon Steel

Alaska in the future global energy economy



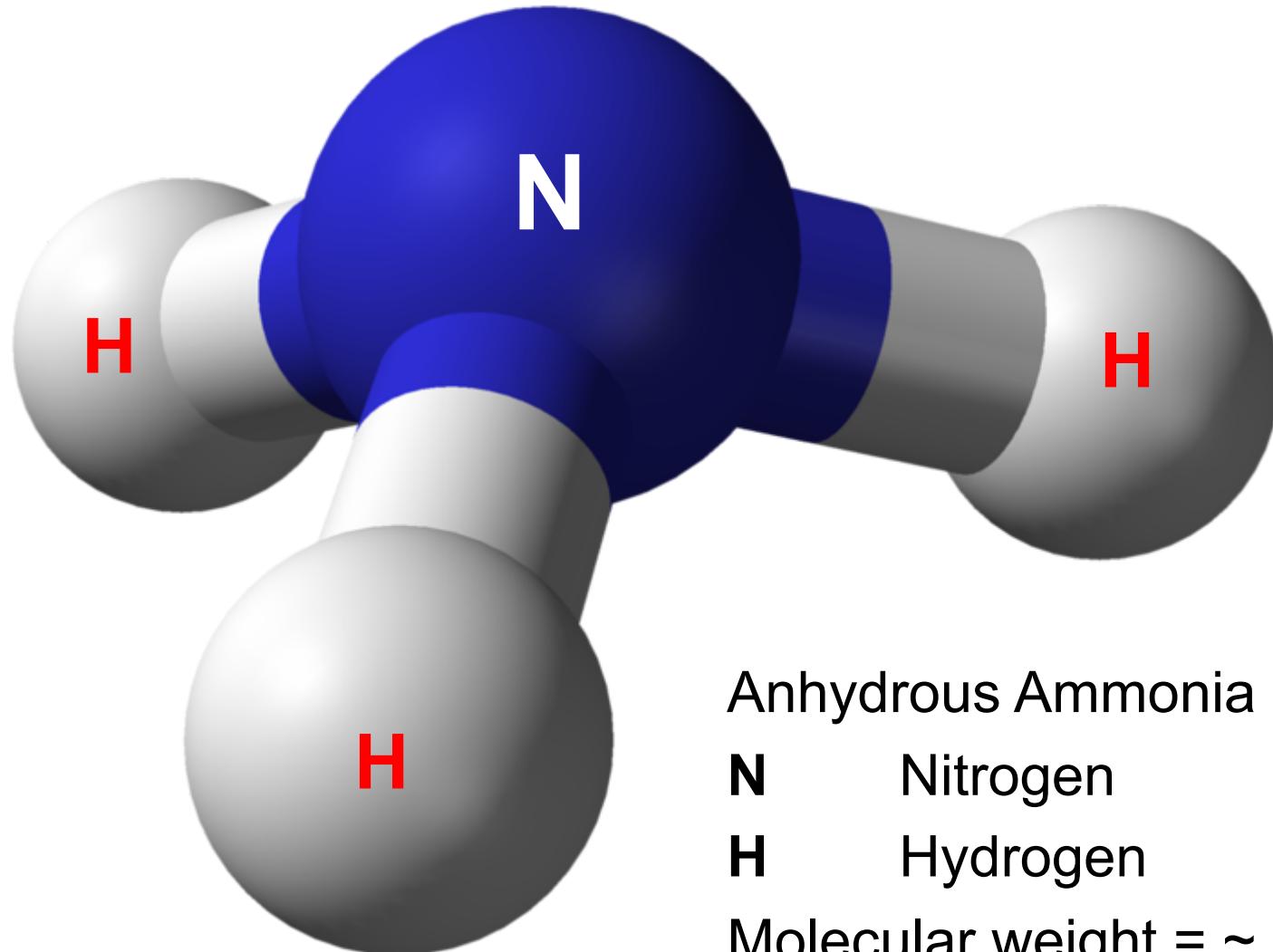
ACEP
Alaska Center for Energy and Power

Why Ammonia ?

Fertilizer and Fuel

Only liquid fuel embracing:

- Energy cycle inherently pollution free
 - Potentially all RE-source: elec + water + Nitrogen
 - Cost competitive with hydrocarbon fuels ?
- Carbon-free: clean burn or conversion; no CO₂
 - Excellent hydrogen carrier; easily “cracked” to H₂
 - Reasonably high energy density
- Decades of global use, infrastructure
 - Practical to handle, store, and transport
 - End-use in ICE, Combustion Turbine, fuel cell
 - Safety: self-odorizing; safety regs; hazard



Anhydrous Ammonia $\mathbf{NH_3}$

\mathbf{N} Nitrogen

\mathbf{H} Hydrogen

Molecular weight = ~ 17

18% \mathbf{H} by weight: “other hydrogen”





**Ammonia
534 kg H₂
EACH**

**Hydrogen gas
350 kg H₂**

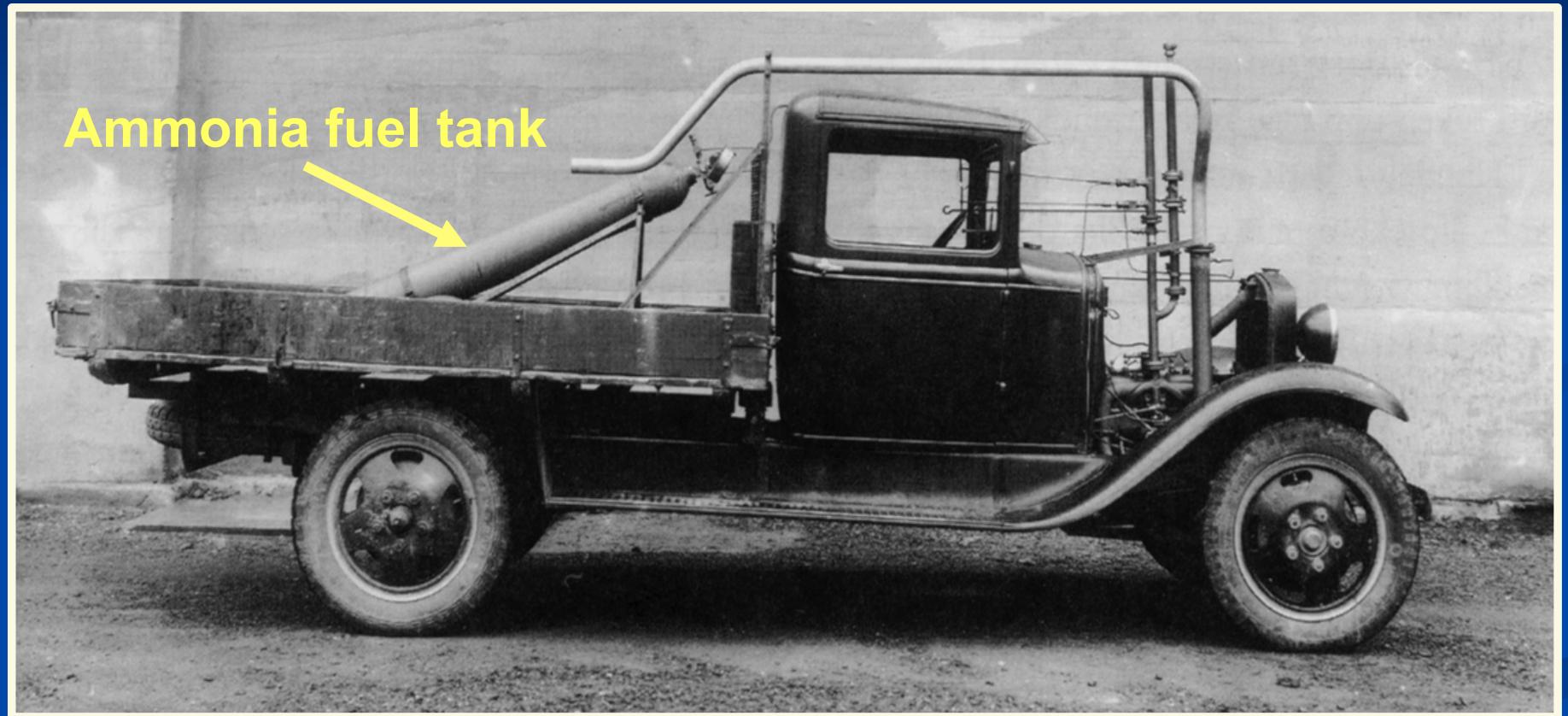


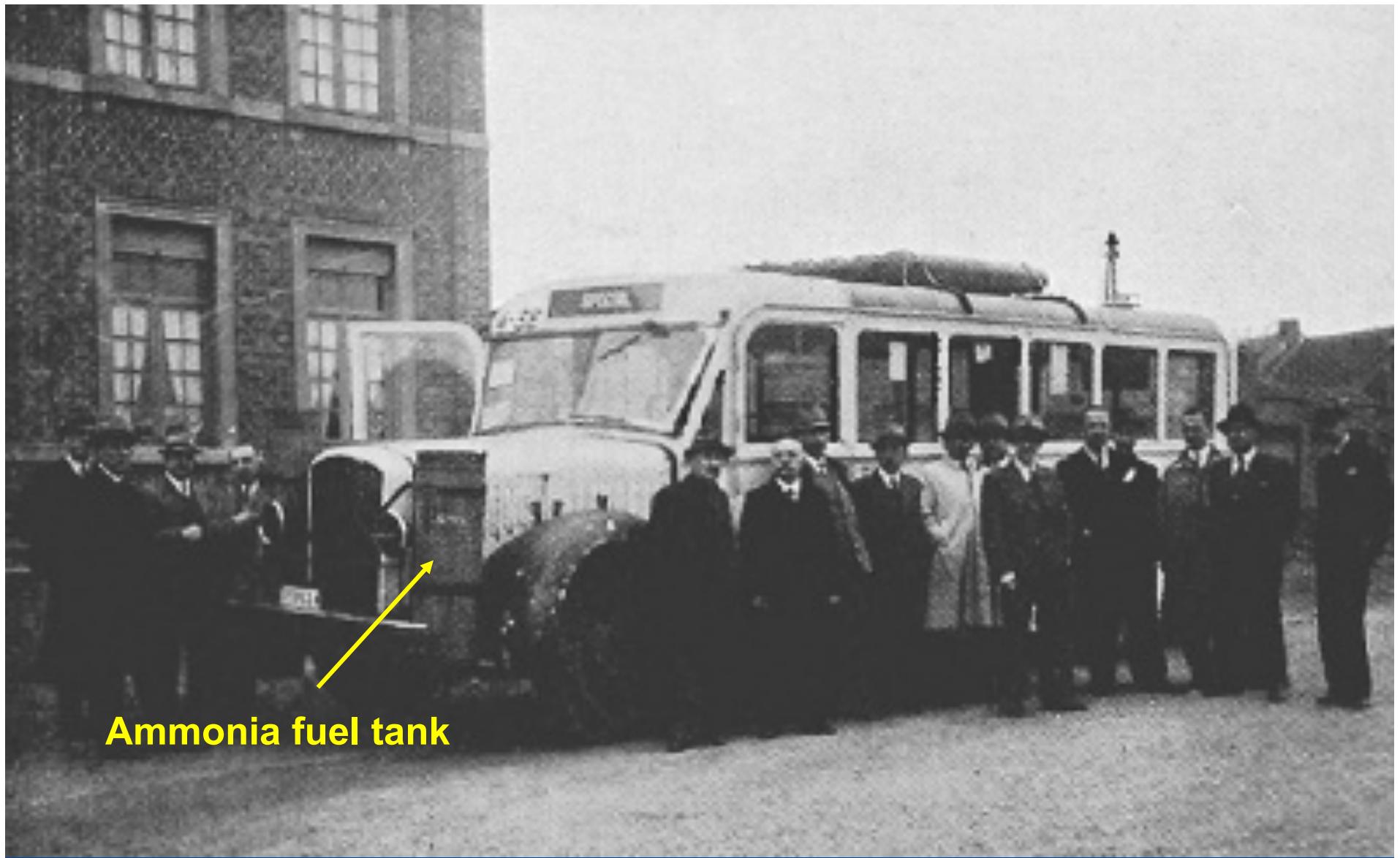


Streetcar
New Orleans
1871

“Ammoniacal
Gas
Engine”

Ammonia fueled – Norway 1933





Ammonia fuel tank

Belgium, 1943

Ammonia Fueled Bus: Thousands of Problem-free Miles



X-15 rocket plane: NH3 + LOX fuel

Mach 6.7 on 3 Oct 67

199 missions between 1959 and 1968



University of Michigan

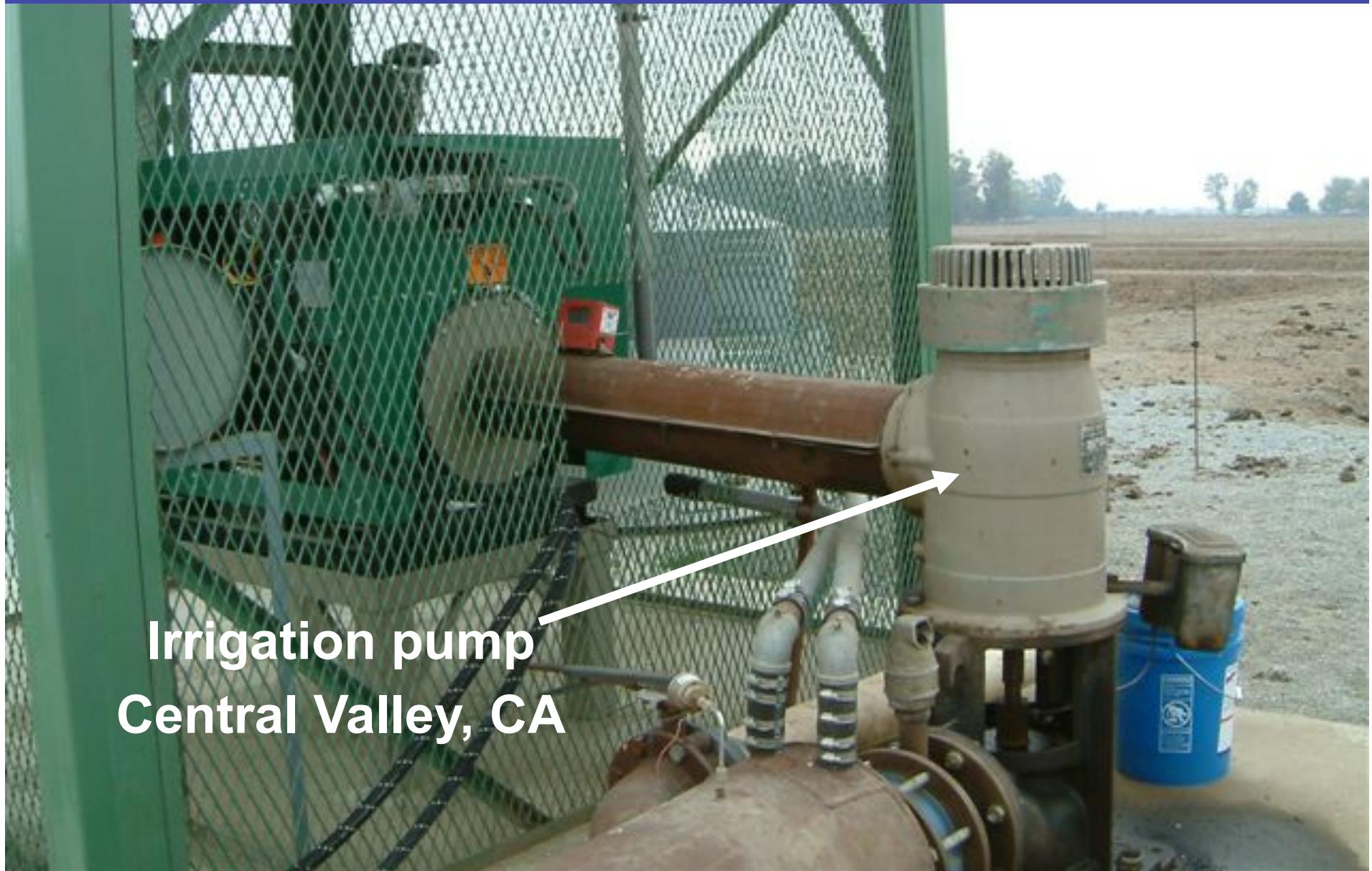
Ammonia + Gasoline Powered

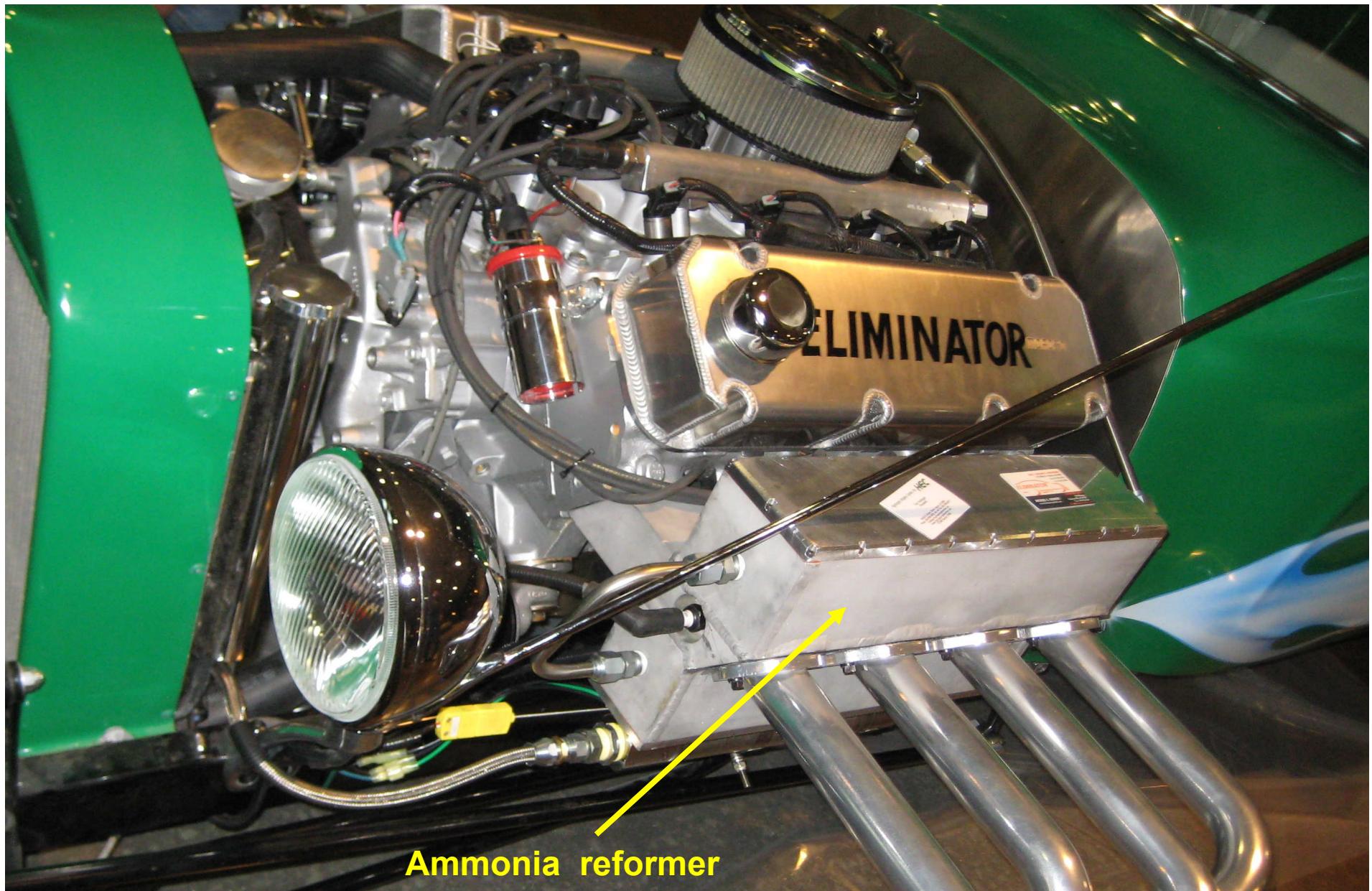
- Idle: gasoline
- Full power: 80% ammonia

Summer '07 Detroit → San Francisco

'08: 1,000 hours, ICE, 6 cyl, 100 hp

75% ammonia, 25% propane





Oct '09 Ammonia Fueled V-8 with Hydrogen Injection: Reformed from NH_3
Hydrogen Engine Center, Algona, IA

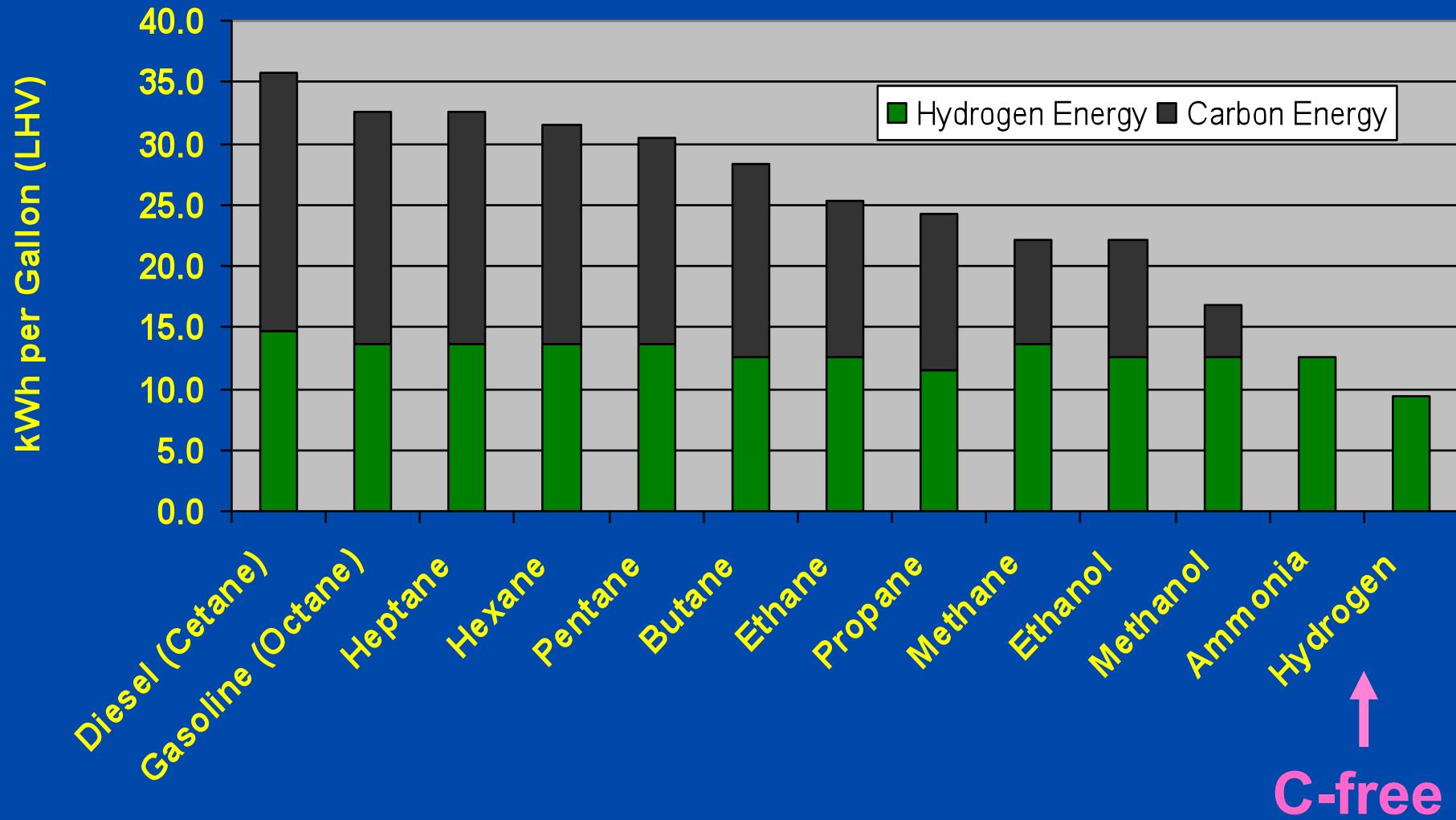
Ammonia Fuel Uses

- Internal Combustion Engine (ICE)
 - Diesel: NH₃ gas mixed with intake air
 - Spark-ignition: 70%+ NH₃ plus –
gasoline, ethanol, propane, NG, hydrogen
 - NOx ~ ¼ gasoline engines
- Combustion Turbines
- Direct Ammonia Fuel Cells:
 - Combined heat + power (CHP)
 - No NOx
- Reform (“crack”) to liberate hydrogen for fuel cells: $2\text{NH}_3 \rightarrow 3\text{H}_2 + \text{N}_2$

Ammonia Properties

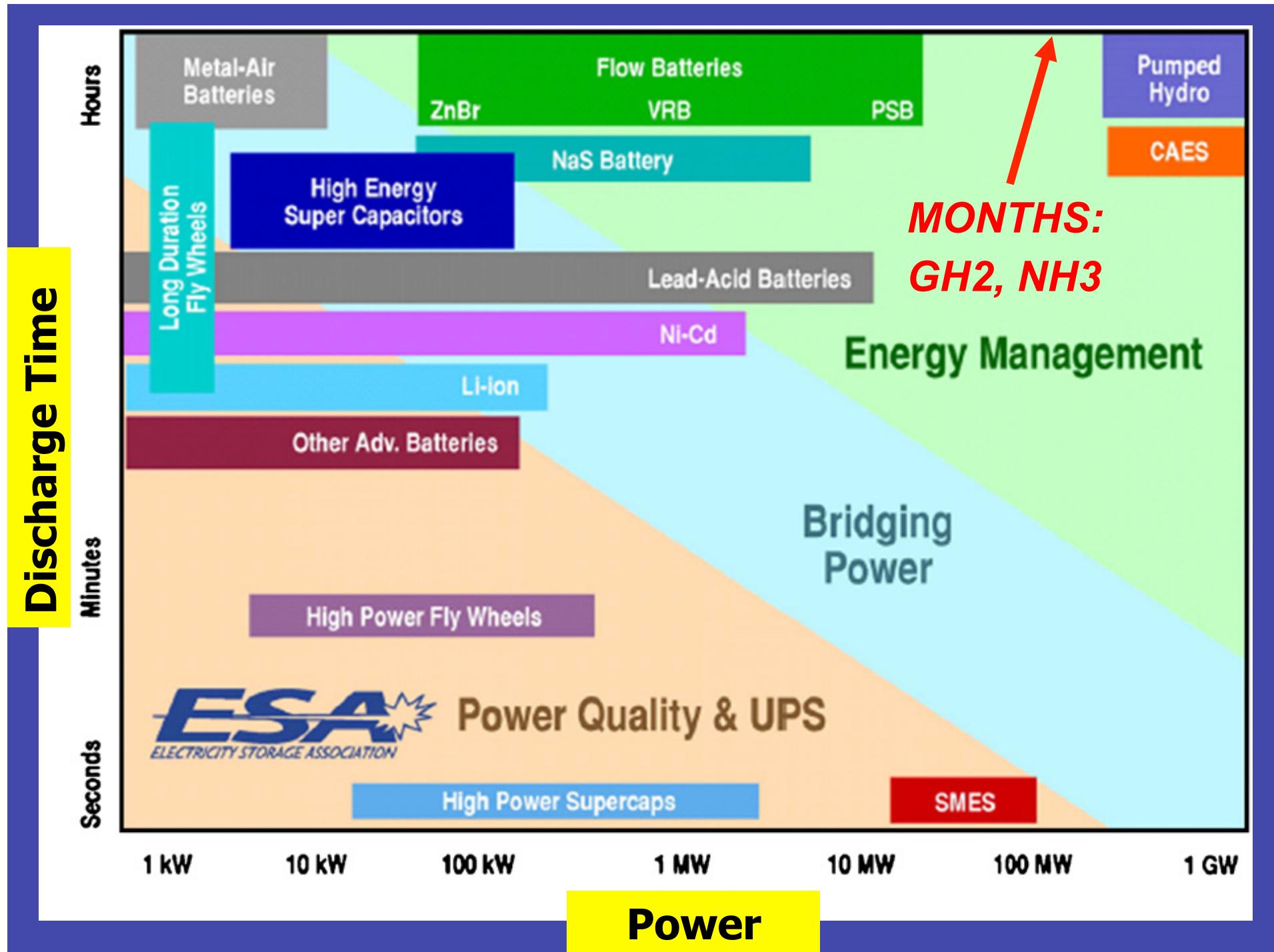
- C-free fuel: unique physical, chemical properties
- Carbon-free energy cycle, system
- # 2 global industrial chemical trade
- 95%+ from stranded natural gas
 - ~ \$1.00 / MMbtu
 - Trinidad, Australia, Quatar, Algeria, Russia
 - Other from coal gasification → hydrogen + Haber-Bosch
- Liquid at >125 psi at room temperature
- ~ Half energy density gasoline or diesel,
volume or weight
- Easily “cracked” to H₂ + N₂ at end-use
- Low flammability, flame spread

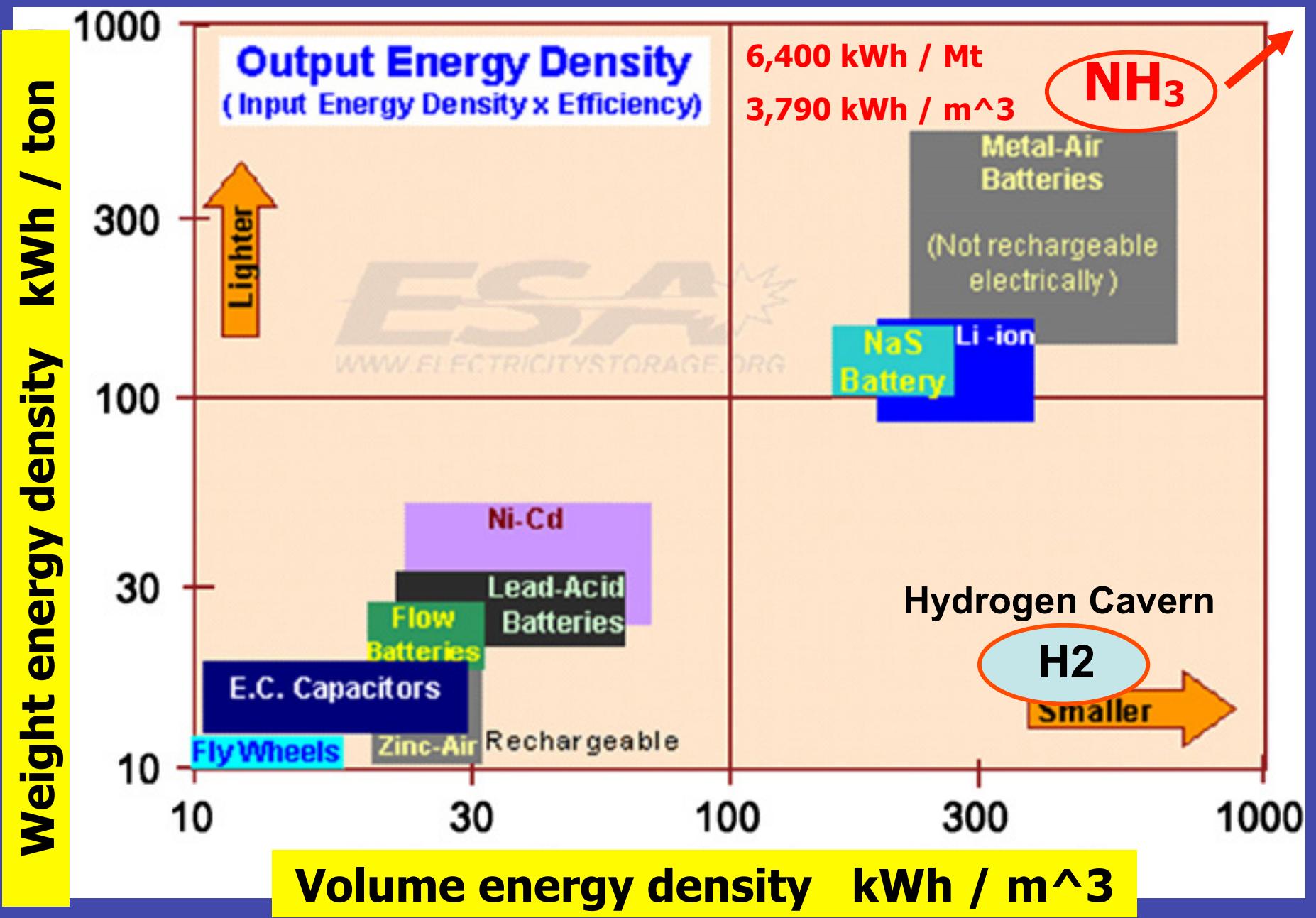
Volumetric Energy Density of Fuels (Fuels in their Liquid State)

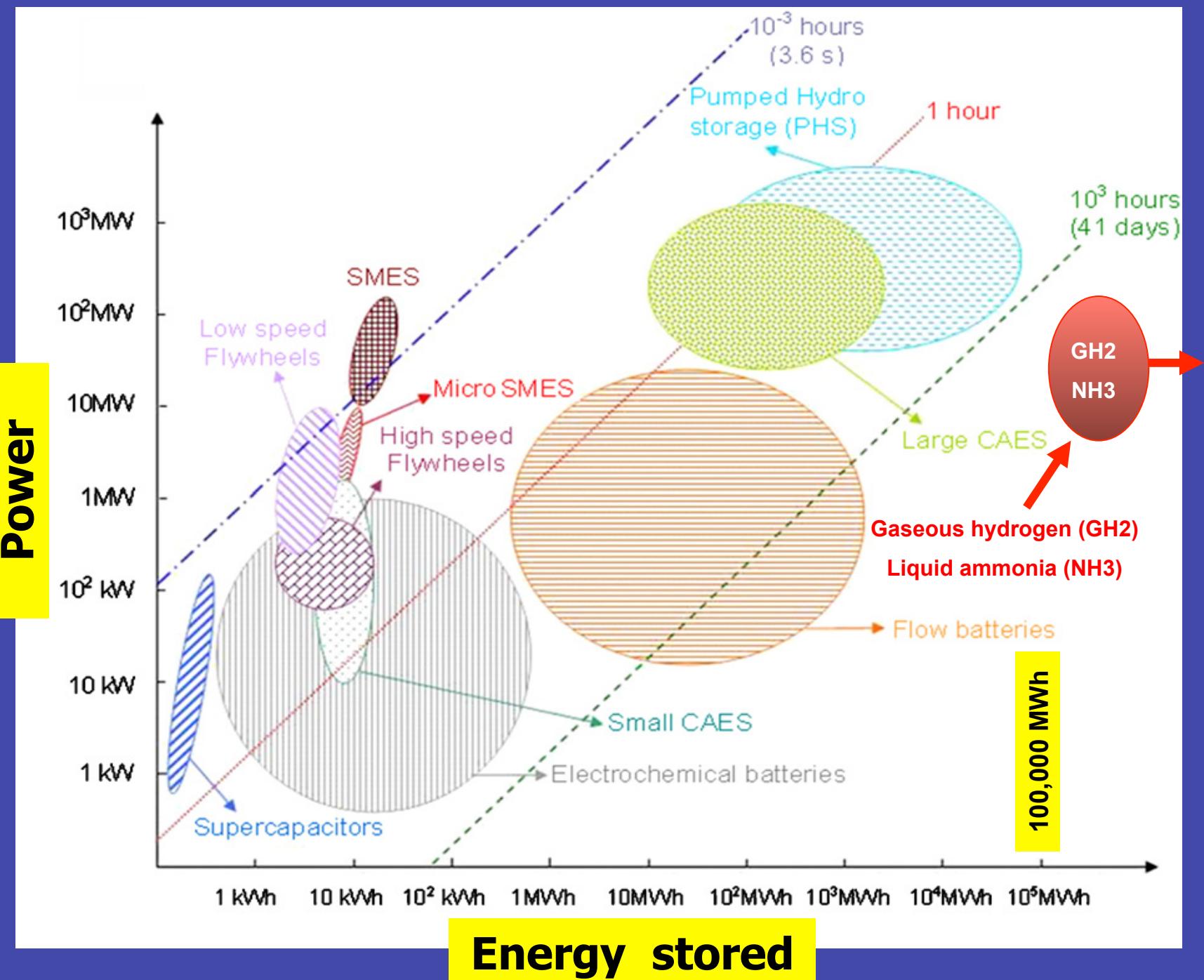


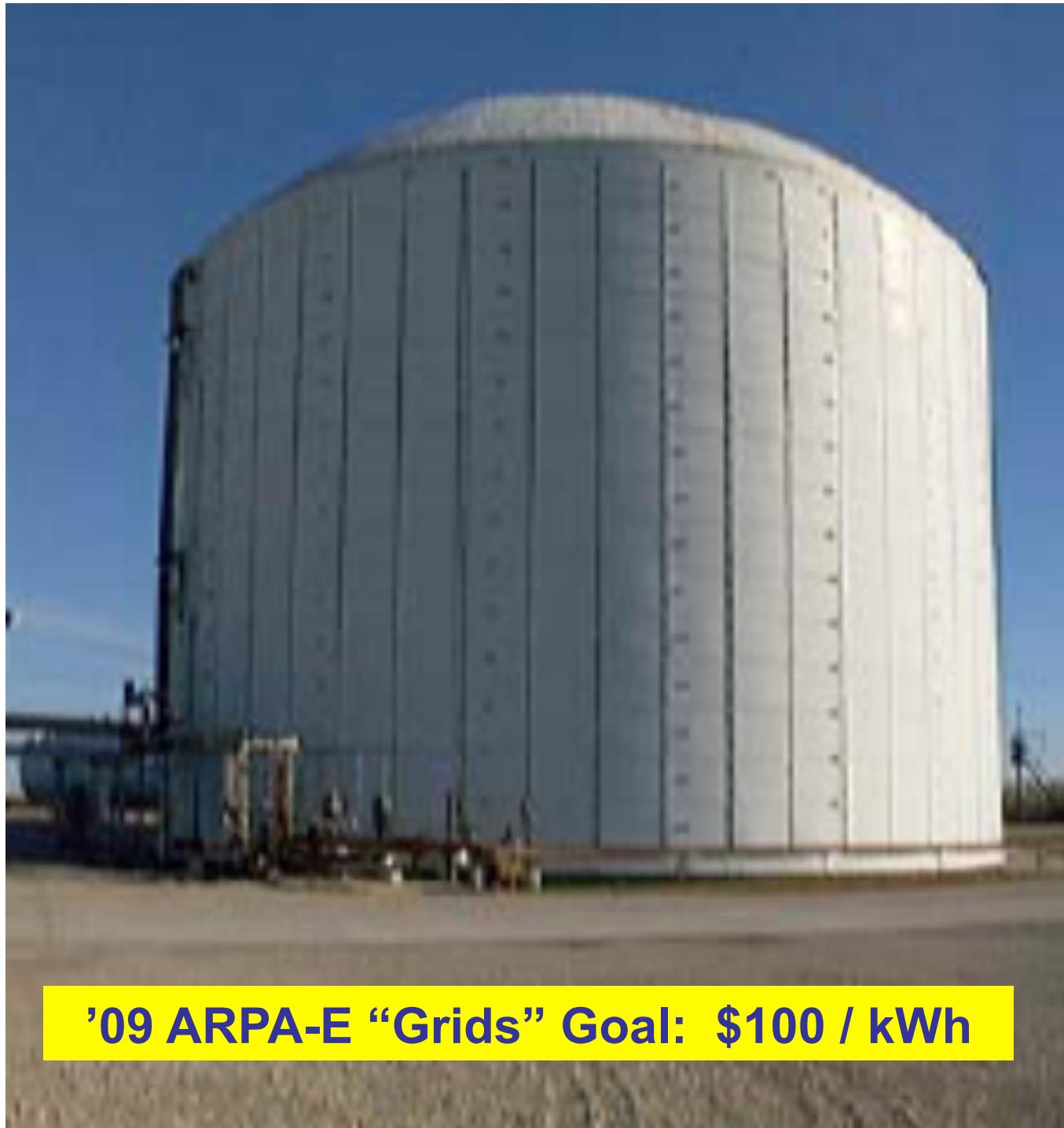
Ammonia Properties

- Forms:
 - “Anhydrous” NH₃ : useful as fuel
 - Urea: (2) NH₃ + CO₂
 - Ammonium nitrate: NH₄NO₃
 - UAN: aqueous urea + ammonium nitrate
- Decades infrastructure + safety record
 - ~14 MMt / year in USA, mostly fertilizer
 - Inhalation hazard; detected @ 5 ppm
 - OSHA, NIOSH regs + exposure limits
 - Toxic to aquatic life









'09 ARPA-E "Grids" Goal: \$100 / kWh

***"Atmospheric"
Liquid
Ammonia
Storage Tank
(corn belt)***

30,000 Tons

190 GWh

\$ 15M turnkey

\$ 80 / MWh

\$ 0.08 / kWh

-33 C

1 Atm

“Firm” Energy Essential

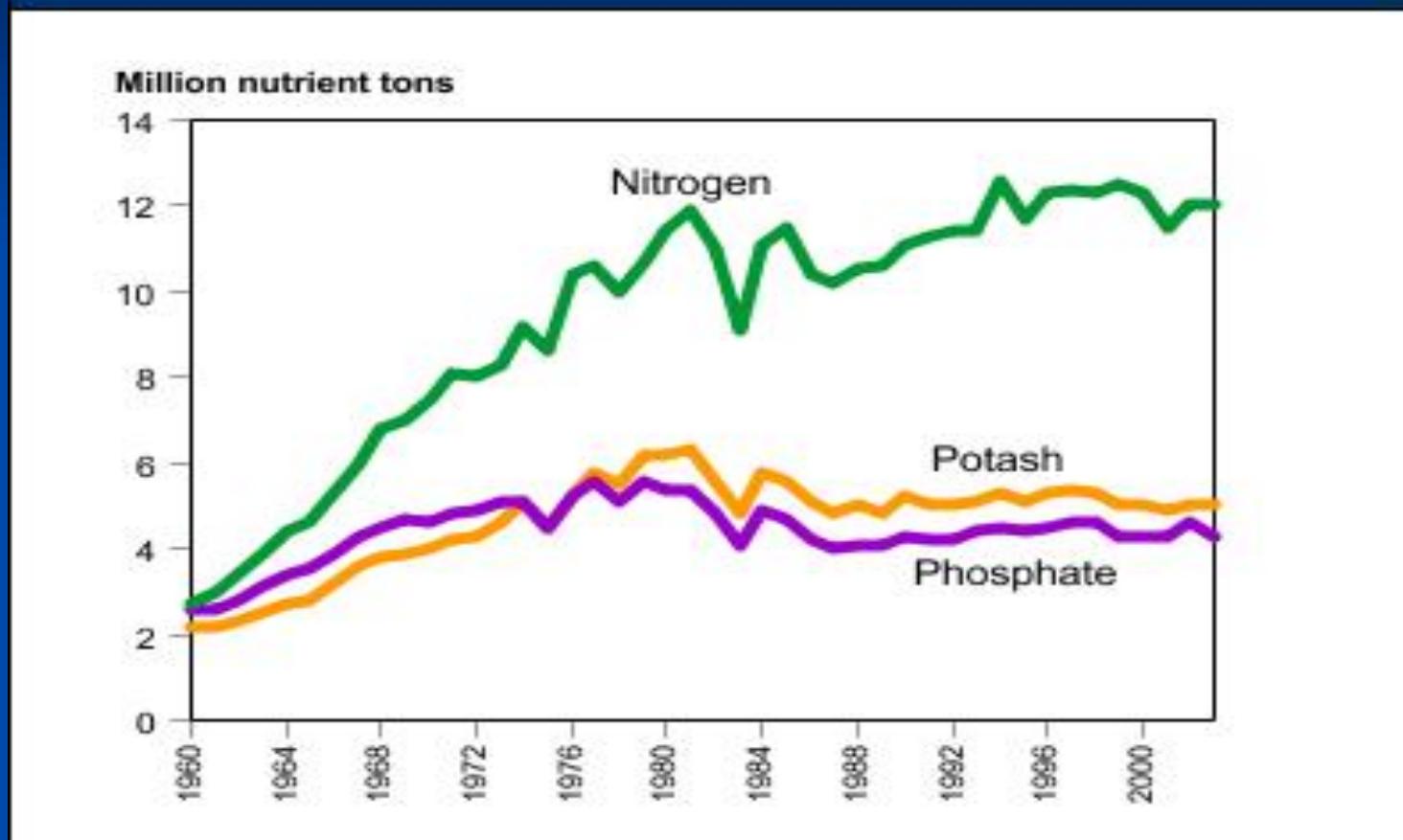
- Rural Alaska, Islands, Humanity
- Every hour, every year
- Dispatchable
- Strategically: indigenous, secure
- Market price: worth more
- Bankable large projects
- Risk avoidance:
 - Rapid climate change
 - Death

Alaska Business Opportunities: $RE - NH_3 = \text{“Green” Ammonia}$

1. Export GW-scale RE: Increase cash **IN**
2. Energy “independence”: Reduce cash **OUT**
 - Villages, communities
 - Indigenous renewables; diverse
 - Seasonal, diurnal variability
 - Storage as NH₃ in pressurized tanks
 - “Firm” energy

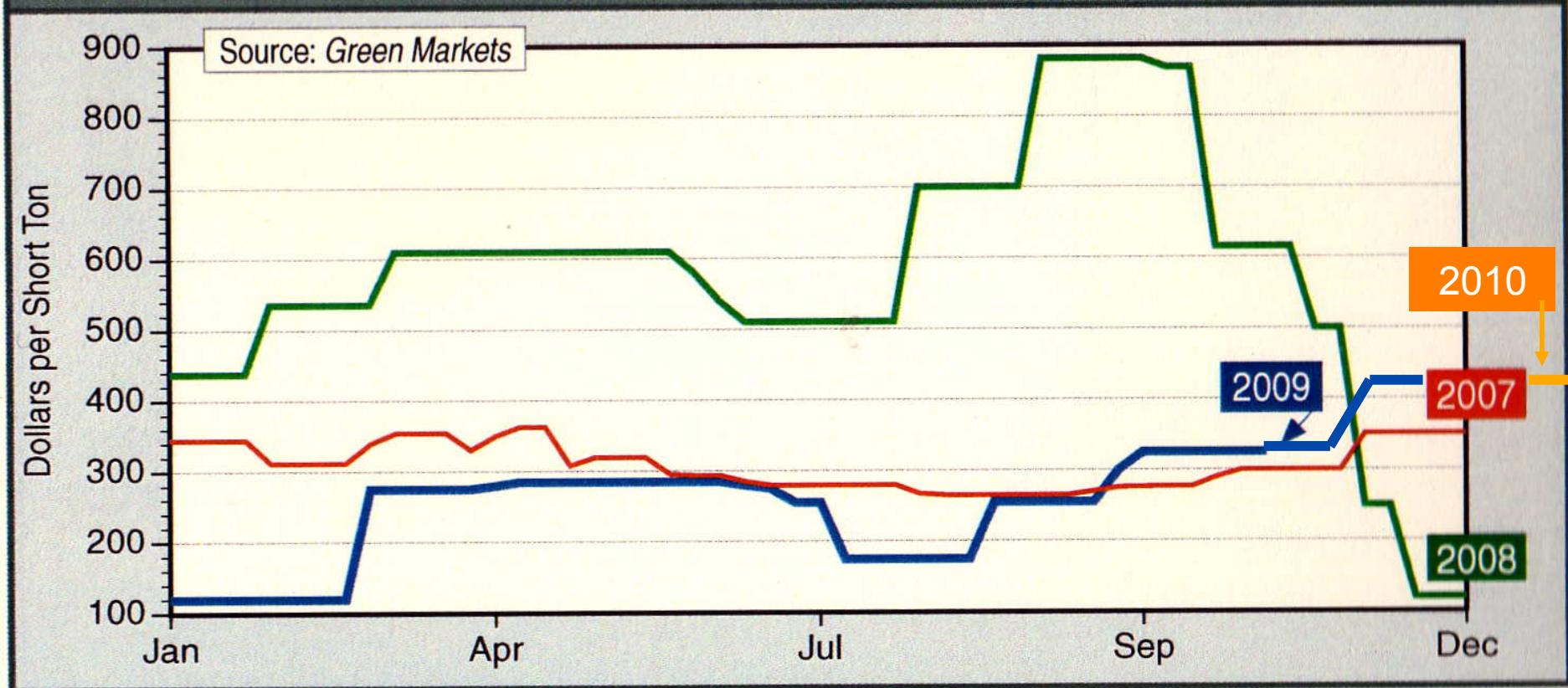
Expect N-Fertilizer Consumption to Rise: World Food Supply

Figure 4.4.2--Consumption of primary plant nutrients, 1960-2003



**40% of humanity requires Haber-Bosch
synthetic N-fertilizers**

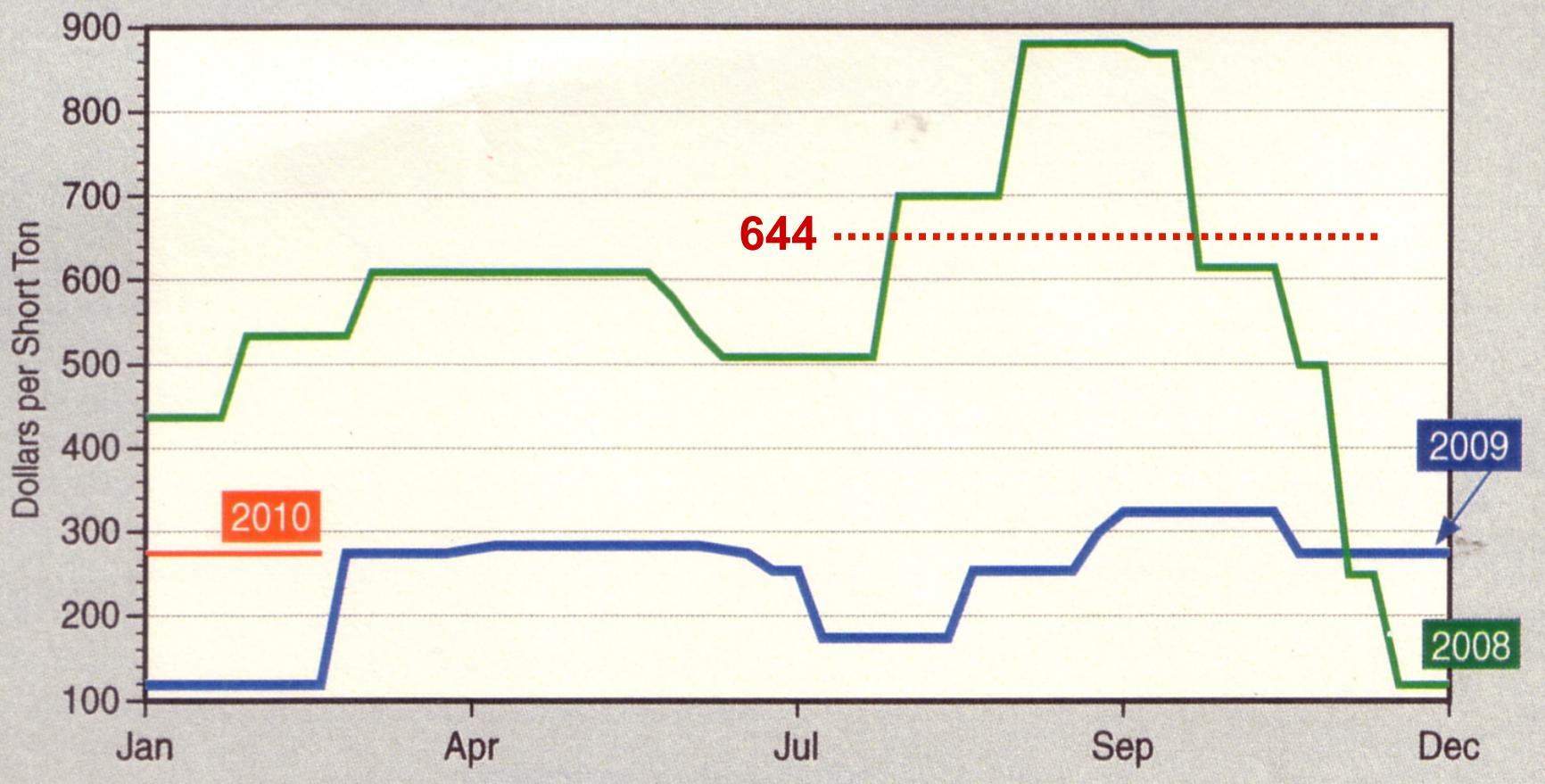


Figure V**Ammonia Prices (Average, New Orleans)**

Anhydrous Ammonia (NH₃) wholesale price,
NOLA (New Orleans, LA)

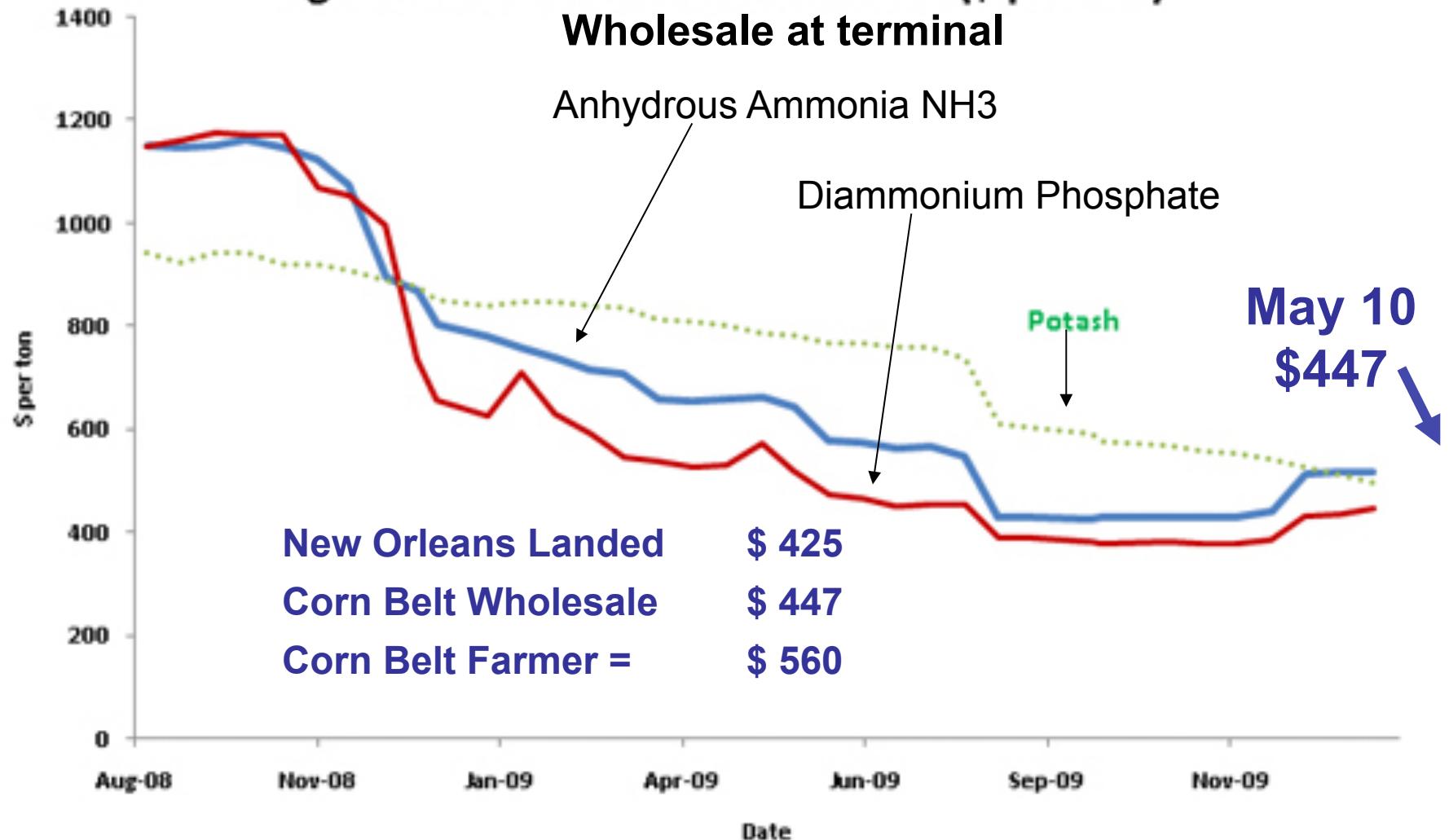
Figure III

Ammonia Prices
(Average, New Orleans)



**Anhydrous Ammonia (NH₃) wholesale price,
NOLA (New Orleans, LA)**

Figure 1. Fertilizer Prices in Illinois (\$ per ton)
Wholesale at terminal



Source: Agricultural Marketing Services, U.S.D.A.



*95% Global
Ammonia*

*Synthesis
Plant
Natural Gas
1 – 3,000 tpd*

*Haber-Bosch
process*



Fritz Haber



Haber-Bosch Process

1909 – 1913 BASF

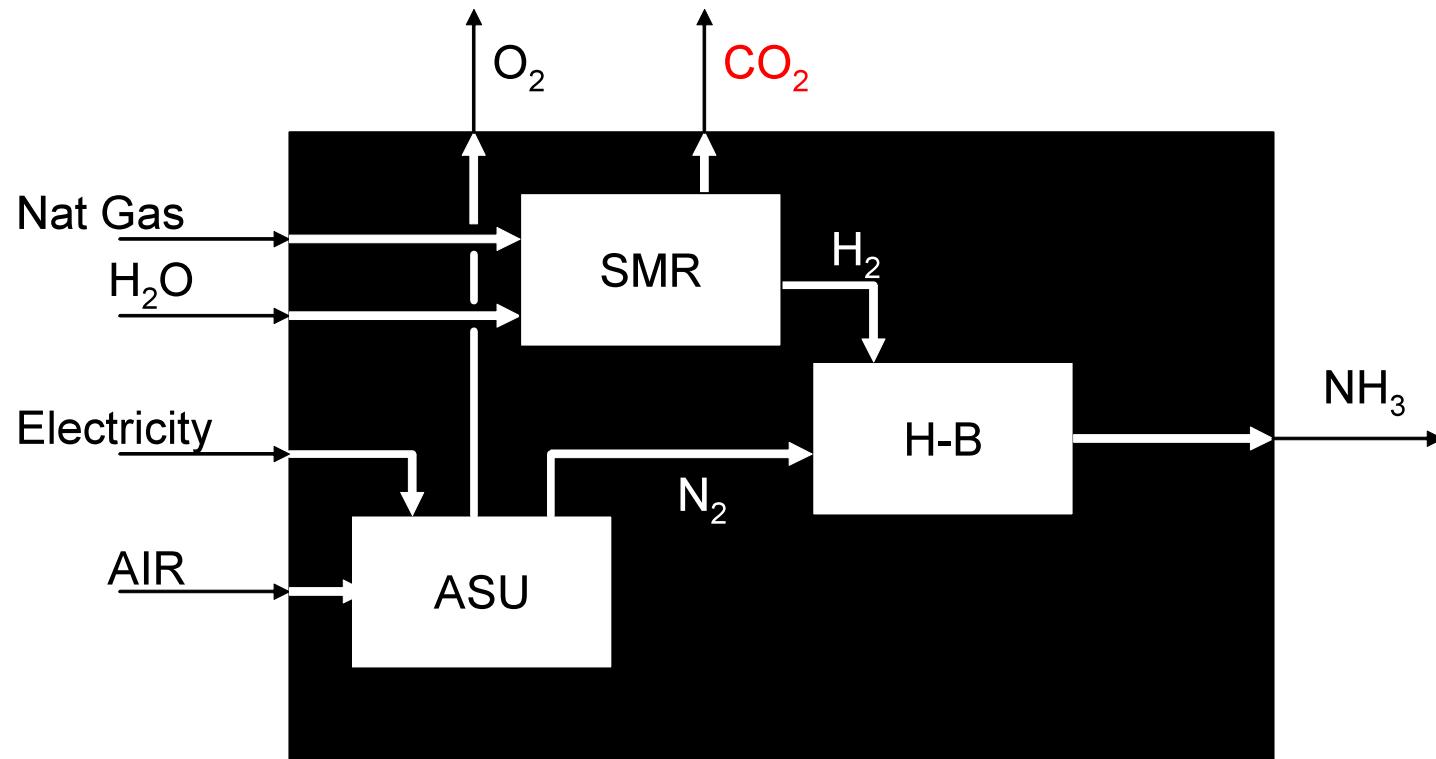
- NH_3 synthesis
- Coal gasification $\rightarrow \text{H}_2$
- WW I explosives
- 40% humanity: N fertilizer

Haber-Bosch Reactor

1921

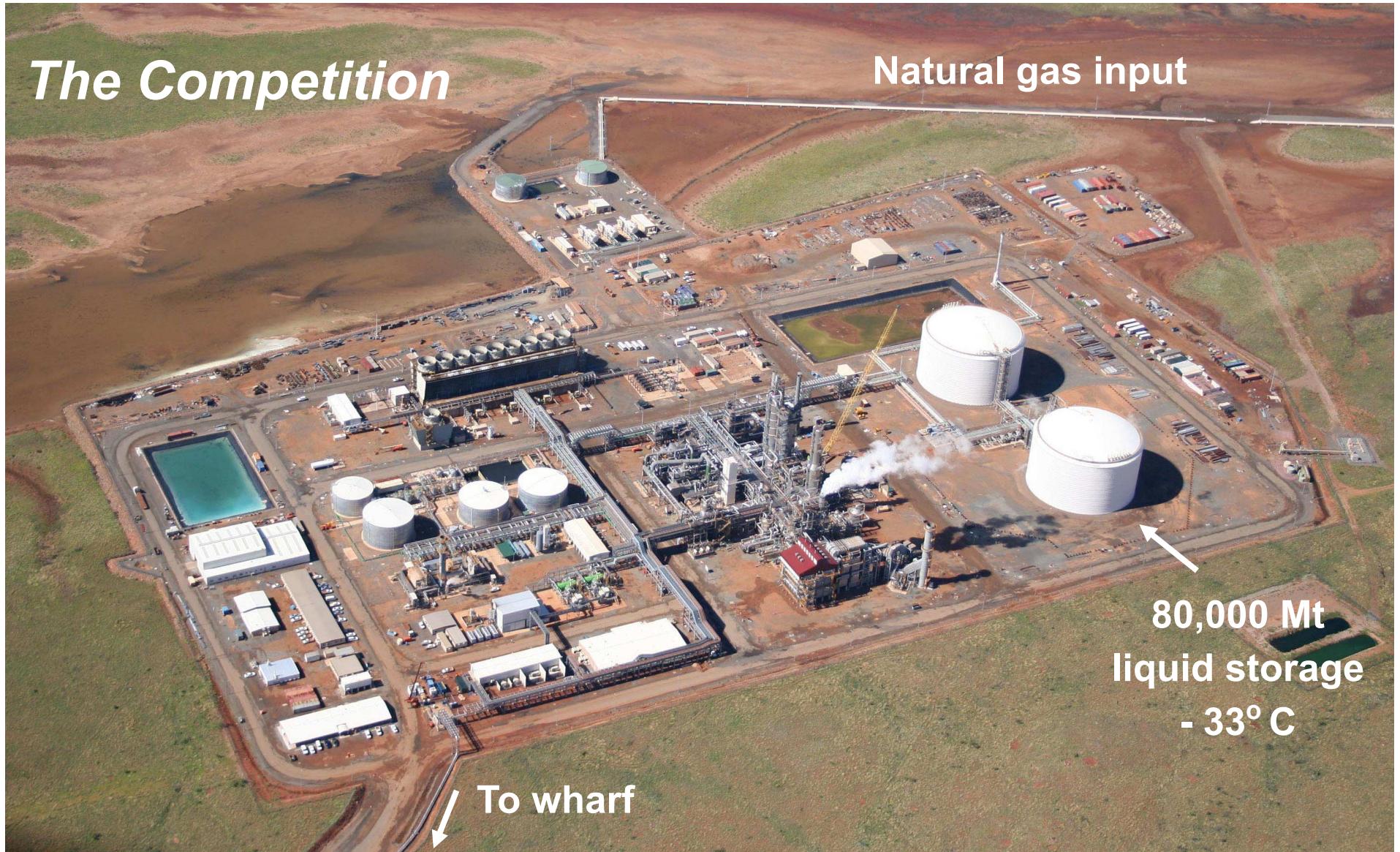
Ludwigshafen, Germany

Inside the Black Box: Steam Reforming (SMR) + Haber-Bosch



Energy consumption ~33 MMBtu (9,500 kWh) per ton NH₃
Tons CO₂ per ton NH₃ = 1.8

The Competition



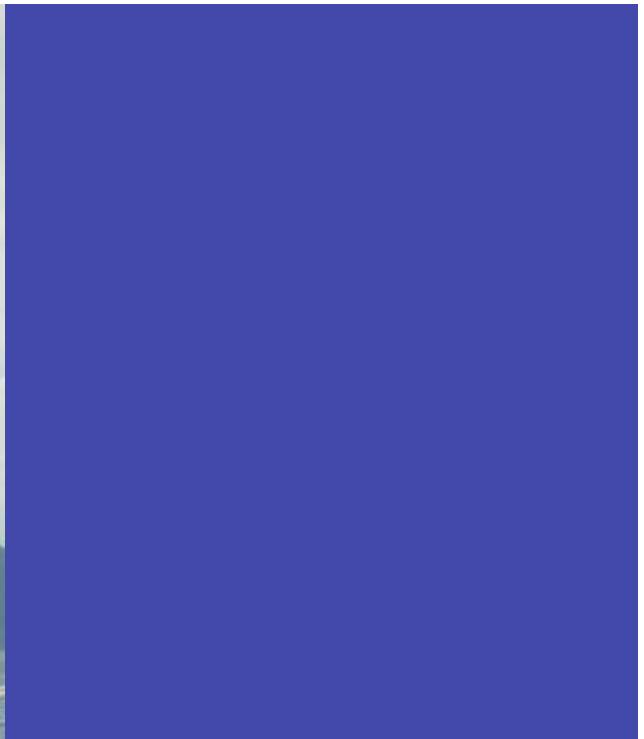
Burrup Peninsula, NW Australia, Natural Gas to Ammonia Plant

760,000 Mt / year

\$US 650 million capital cost '06

*Ammonia Tanker
Burrup Peninsula
Western Australia*



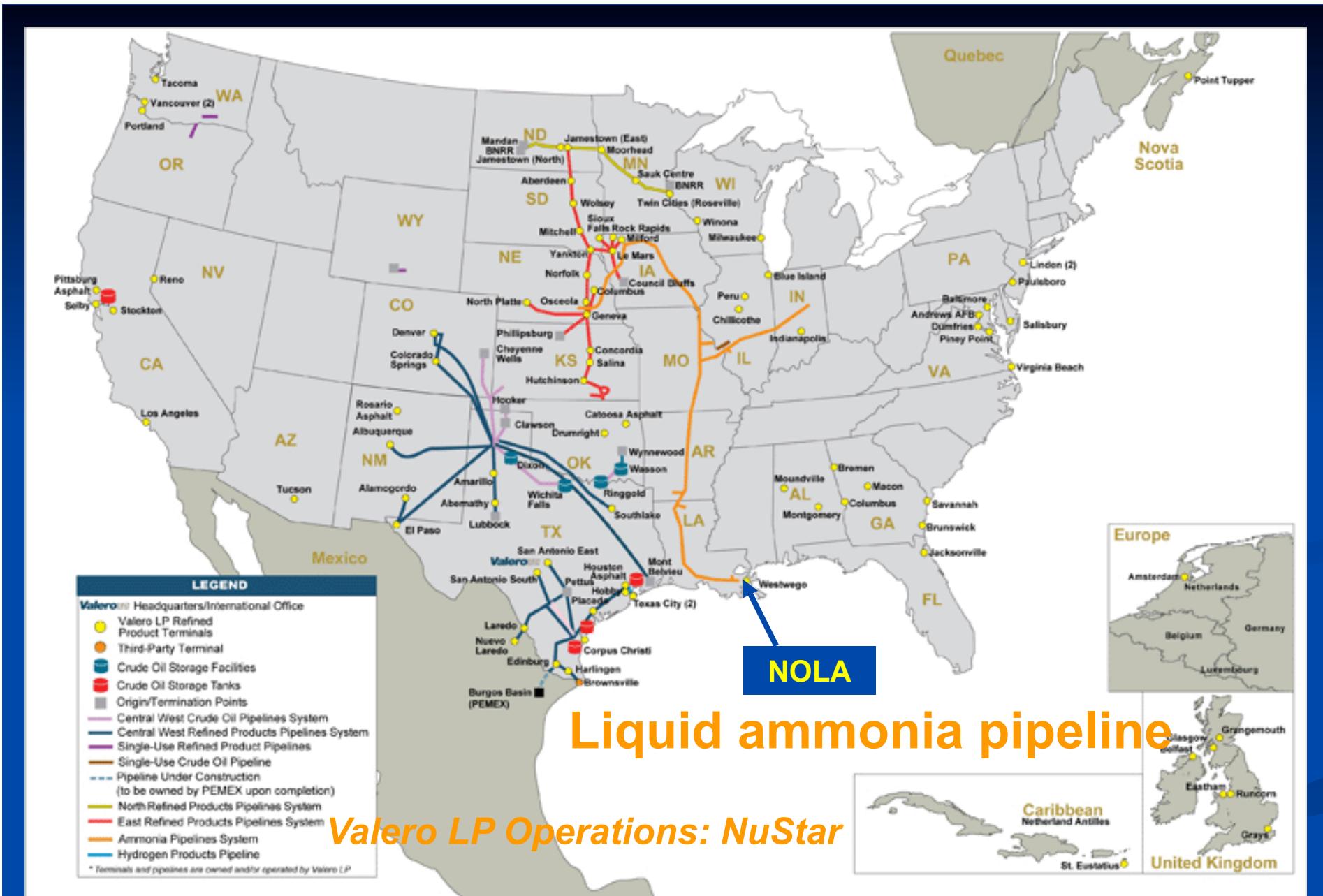


Ammonia or LPG Tanker

9,000 – 35,000 Mt

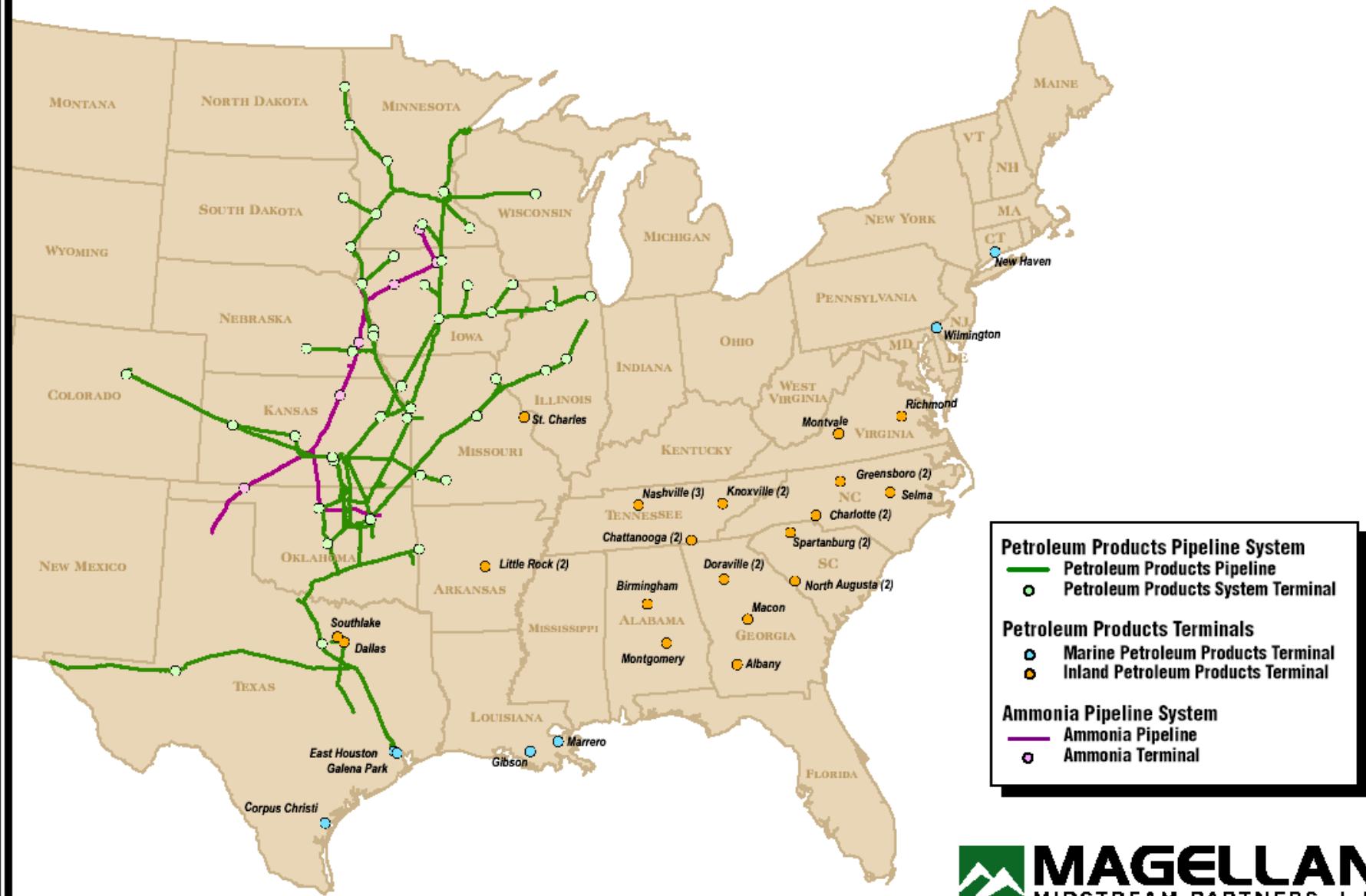
Refrigerated





USA imports ~70% of NH₃

Asset Portfolio



The logo for Magellan Midstream Partners, L.P. It features a green square icon with a white stylized mountain range graphic inside. To the right of the icon, the word "MAGELLAN" is written in a large, bold, black, sans-serif font. A registered trademark symbol (®) is located at the top right of "MAGELLAN". Below "MAGELLAN", the words "MIDSTREAM PARTNERS, L.P." are written in a smaller, black, sans-serif font.

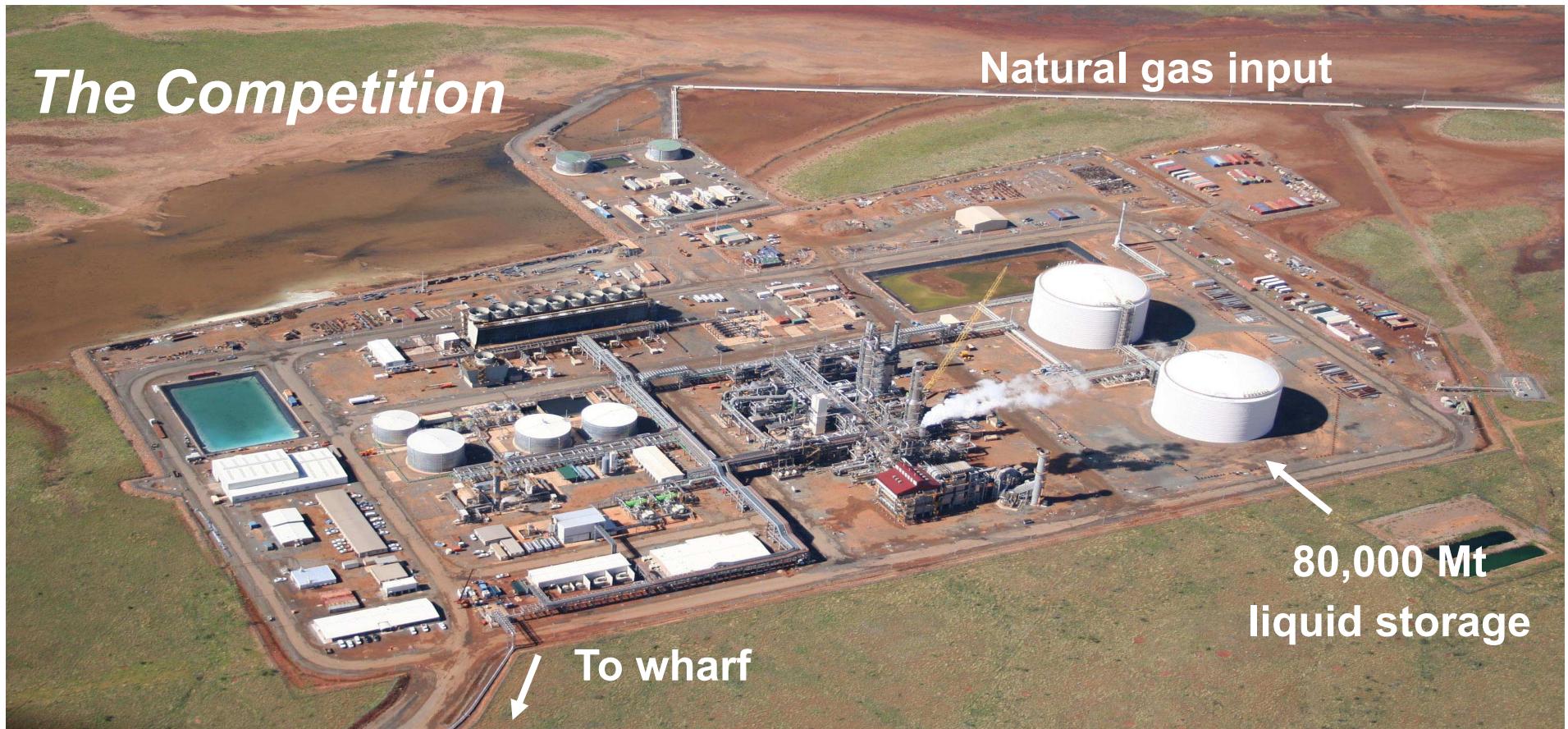
**Ammonia Storage Terminal
Mississippi River
Winona, MN**



USA NH3 Infrastructure

- ~ 3,000 miles pipelines
 - ~ 250 psi liquid
 - Smaller diameter than NG or hydrogen
- ~ 4.5 MMt large “atmospheric” tank storage
- Mild steel construction
 - Low cost
 - No corrosion or embrittlement

The Competition



Global Ammonia = 140 million Mt / year

- #2 chemical
- 200 plants, nat gas + coal
- ~ 500 Million Bbl oil
- ~ 2% oil
- ~ 0.5% energy

14 million Mt / yr USA; 60% imported; corn ethanol

Cost: Ammonia from Stranded Natural Gas (NG)

- > Burrup, Australia Plant: 750,000 Mt / year
- > \$650M capital @ 15% capital recovery factor (CRF)
- > 34 MMBtu NG / Mt NH3
- > NG cost \$1.20 / MMBtu long-term
- > Tanker shipping to New Orleans, LA (NOLA) \$50 / Mt
- > CO2 emission 1.8 Mt / Mt NH3

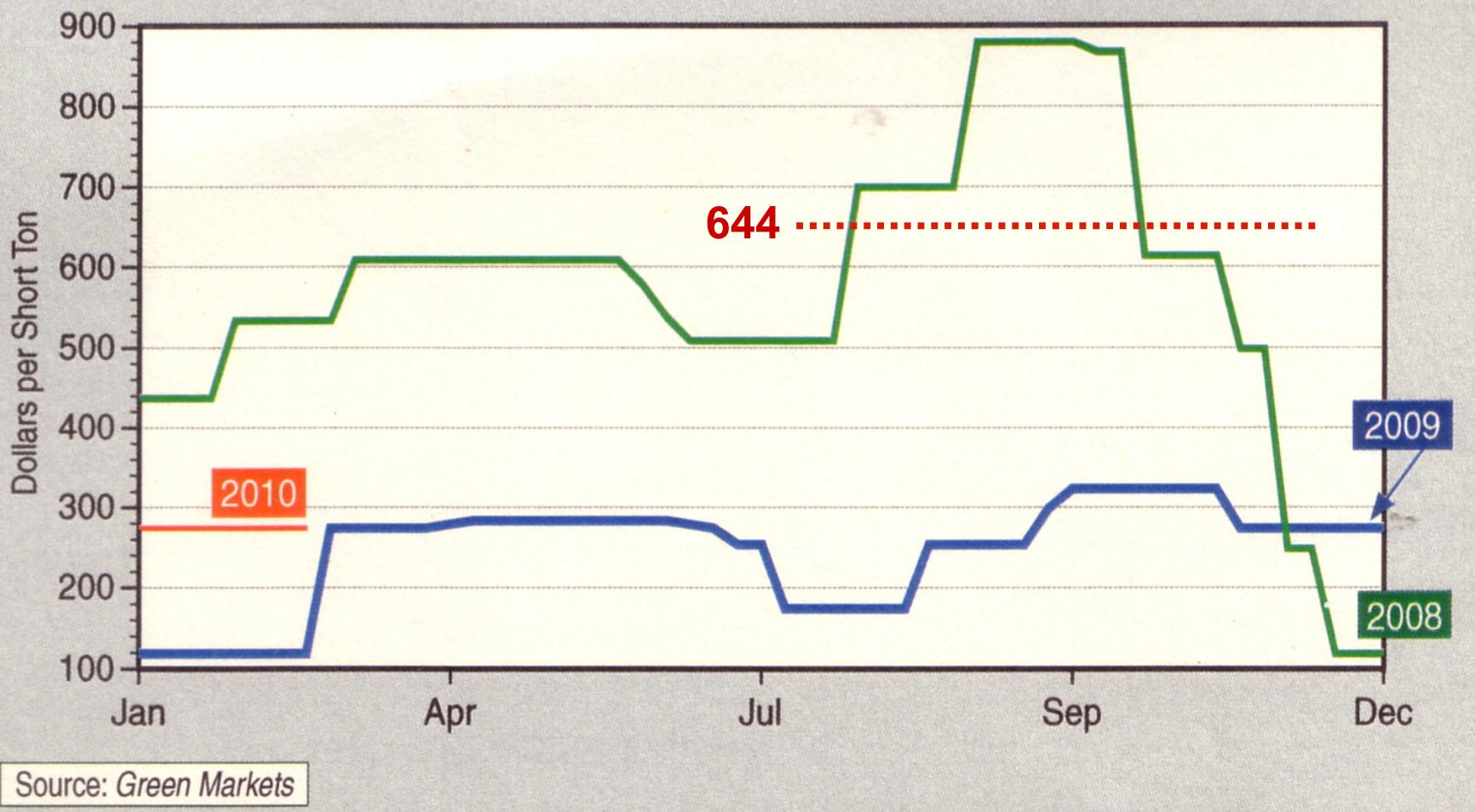
	C-tax 0	C-tax \$50 / Mt CO2	C-tax \$100 / Mt CO2
Capital	98	98	98
NG	41	41	41
Shipping	50	50	50
C-tax	0	90	180
Plant O&M	2	2	2
Total NOLA / Mt	\$191	\$281	\$371

1. *Increase Cash IN:* *Export AK GW-scale RE as* *“Green” Ammonia*

- Can RE compete with “brown” ?
- What would C-tax need to be ?
- What would global NG price
need to be?

Figure III

Ammonia Prices
(Average, New Orleans)

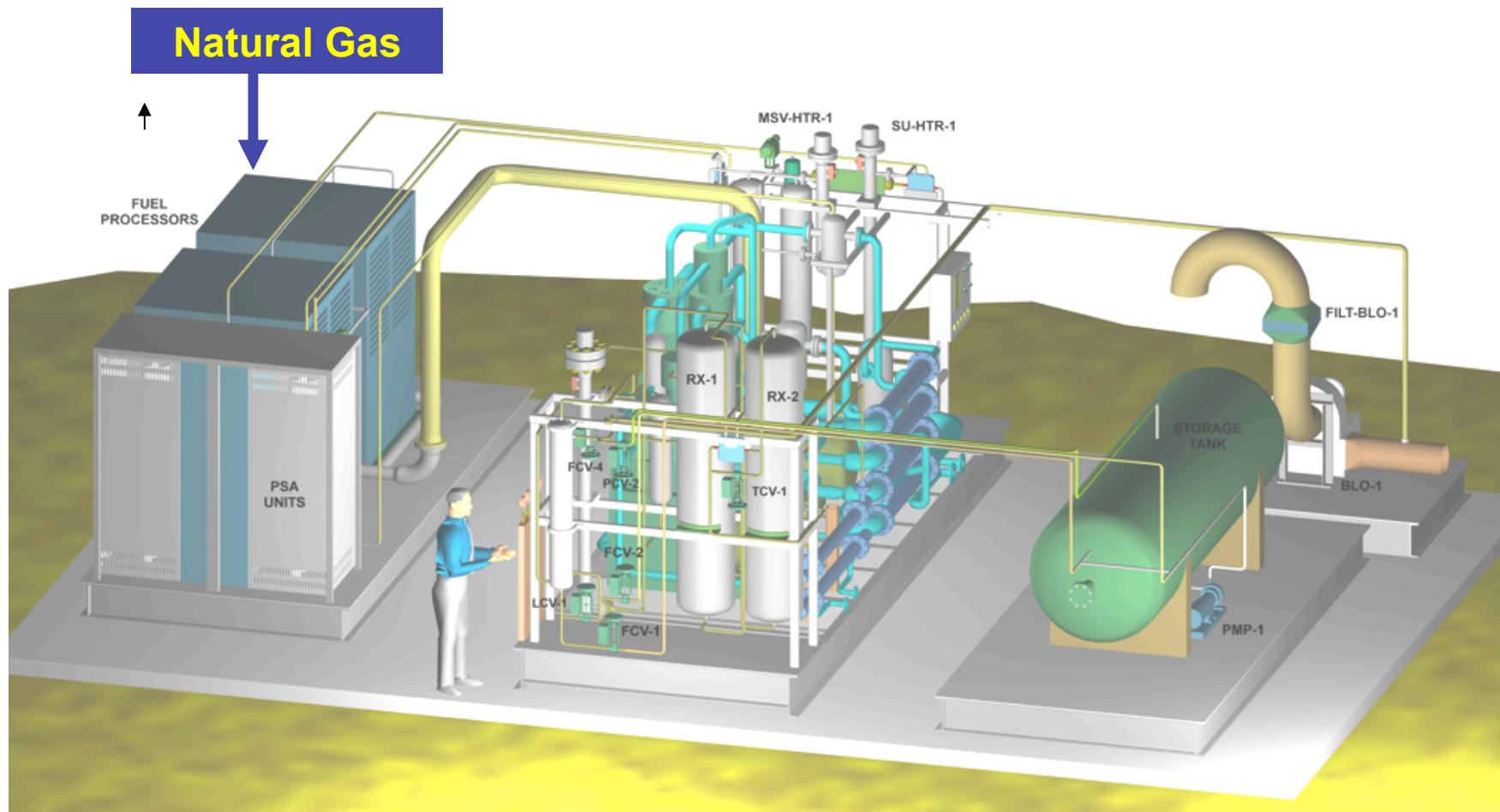


**Anhydrous Ammonia (NH₃) wholesale price,
NOLA (New Orleans, LA)**

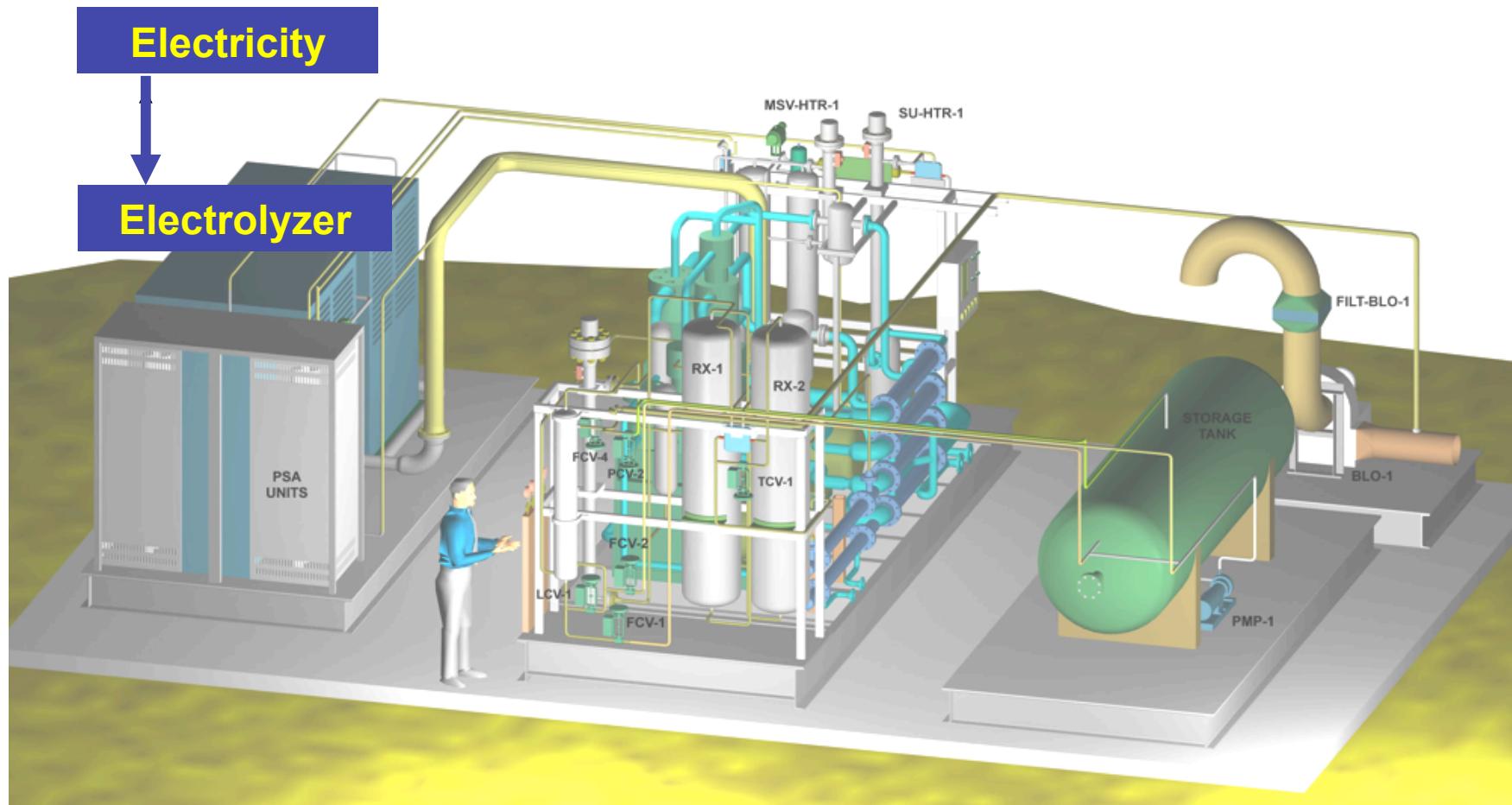
2. Decrease Cash *OUT*: Village “*Energy Independence*” via *RE Generation + Storage*

- Energy Islands
- What's Annual Average Cost of Energy (COE) ?
- Competitive ?
- What degree of “energy independence” ?
- Is SSAS required ?

Village-scale 3 Mt / day Mini-NH₃ Plant Natural Gas Fueled Haber-Bosch

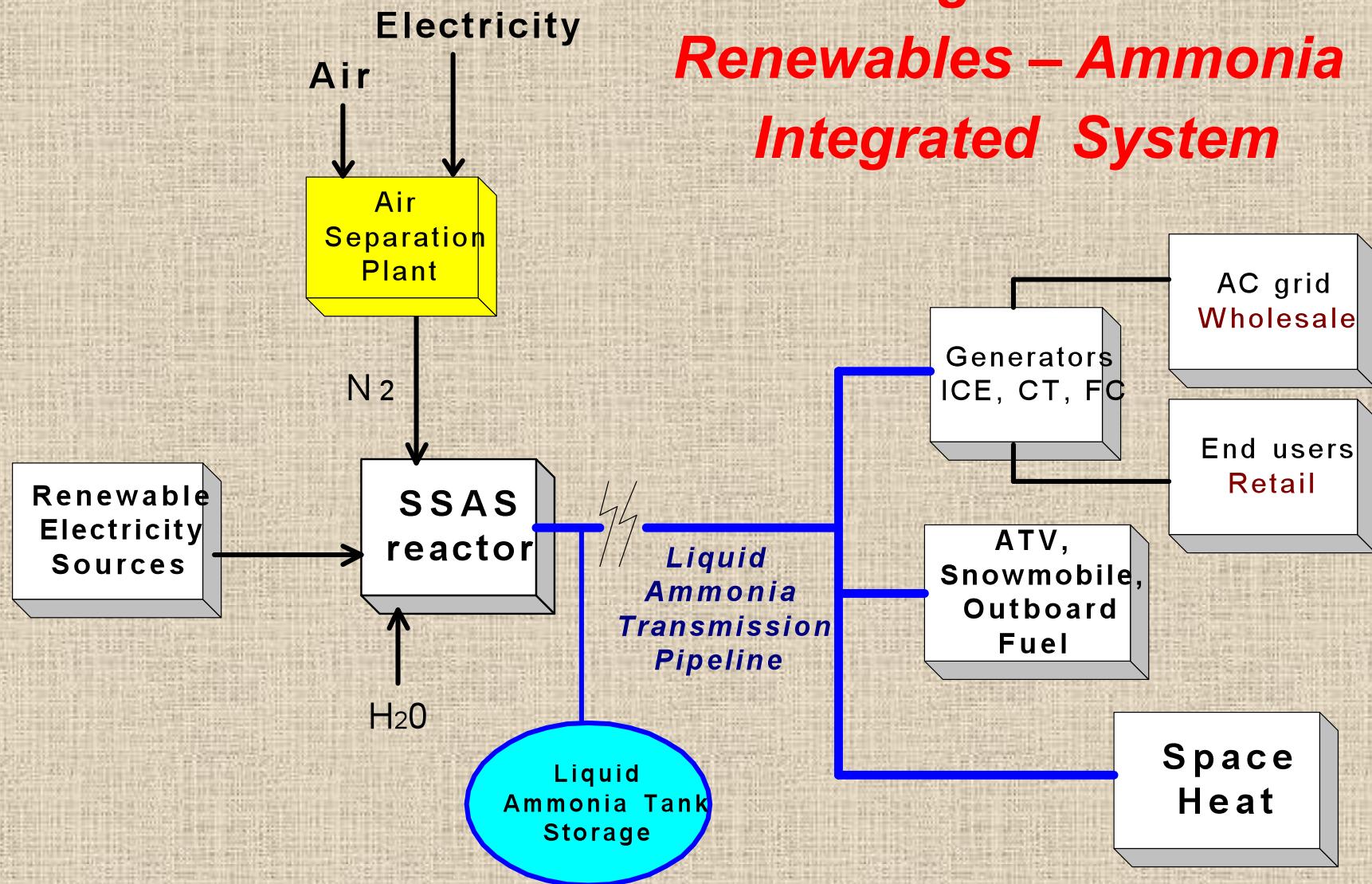


Village-scale 3 Mt / day Mini-NH₃ Plant RE Electricity Haber-Bosch



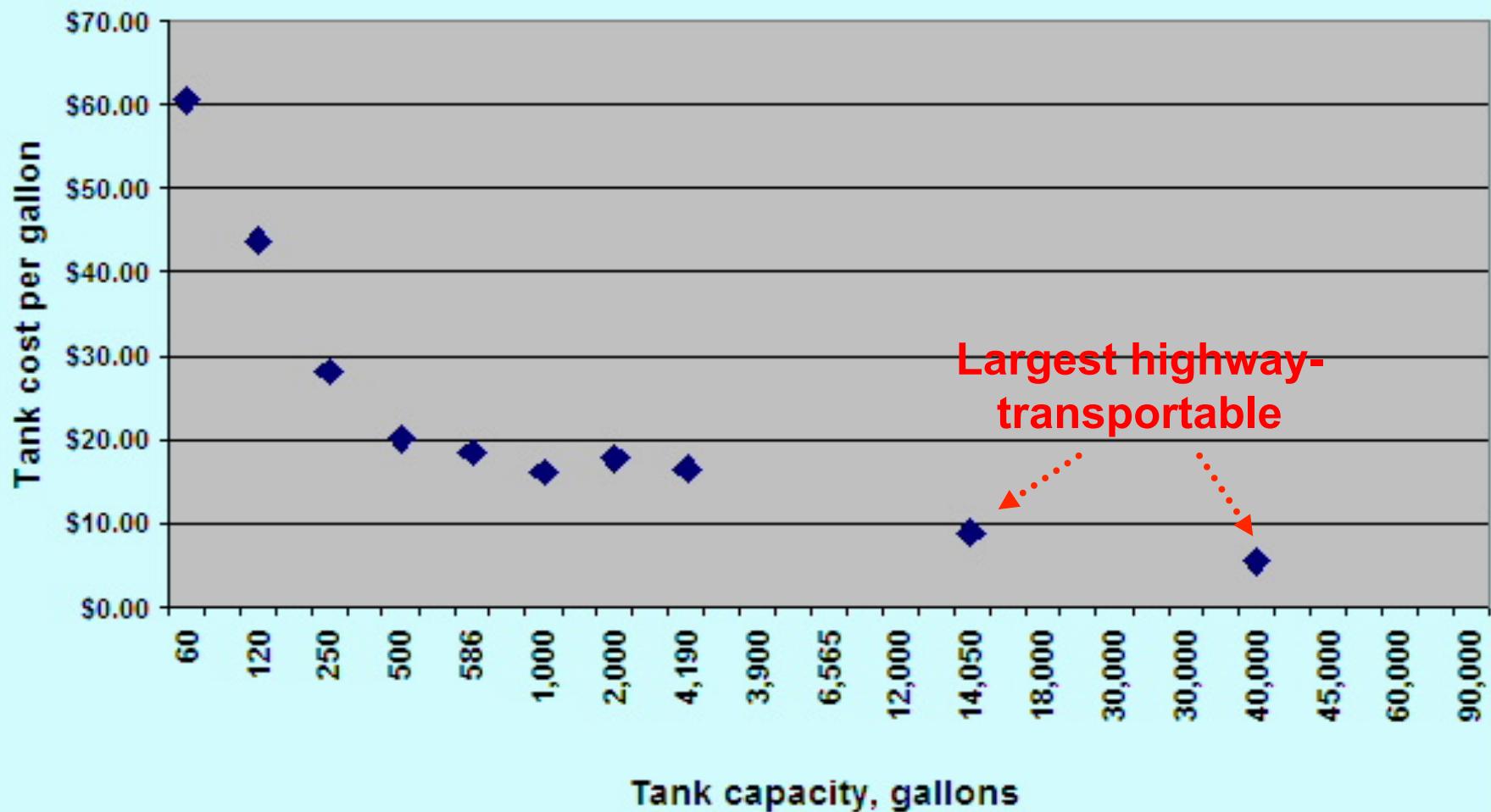
“Village” SSAS

Renewables – Ammonia Integrated System

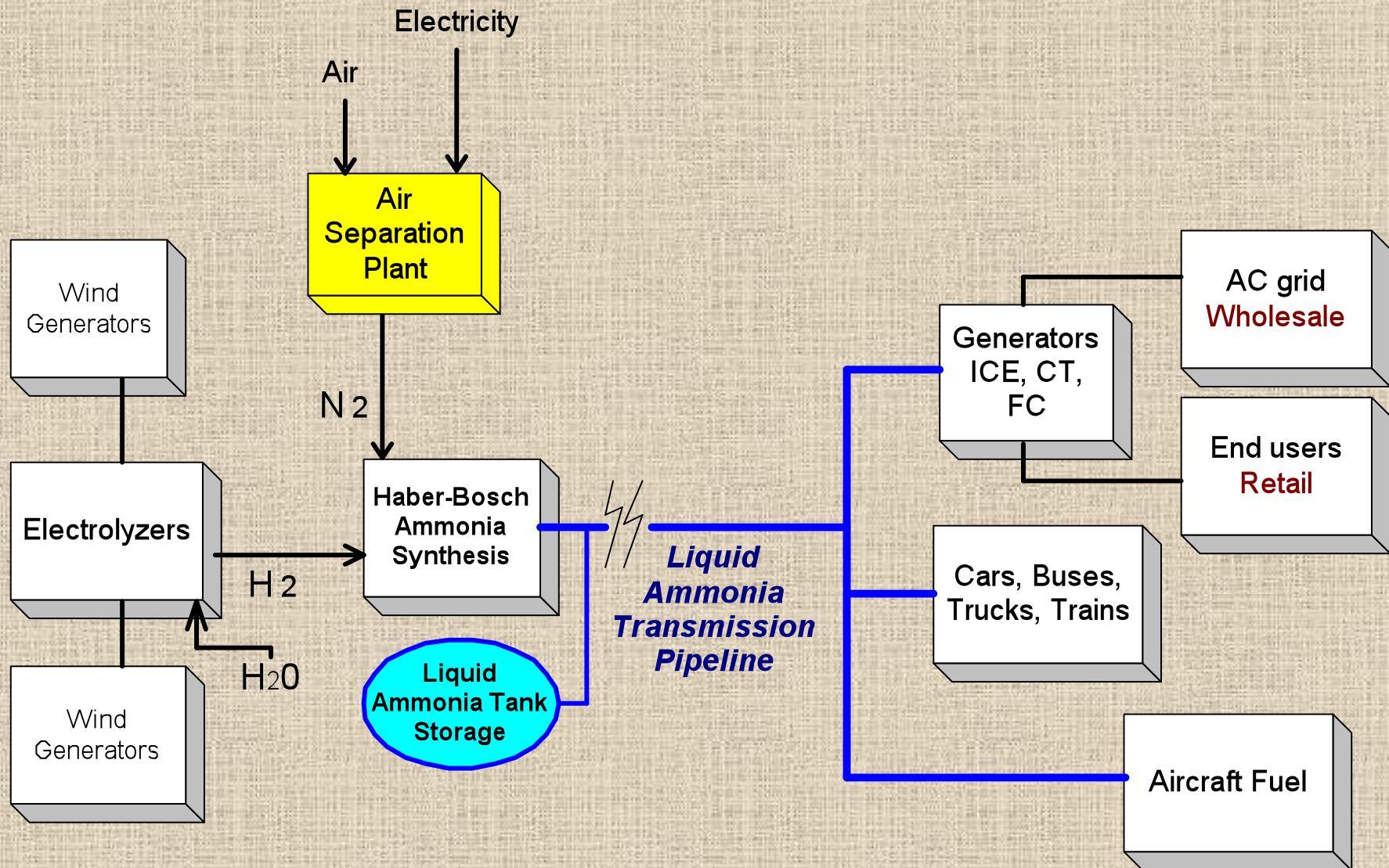


Liquid Ammonia Tank Storage

Cost per Gallon: 250 psi Ammonia Tanks



RE Ammonia Transmission + Storage Scenario



Wind – to – Ammonia Potential, NW Iowa



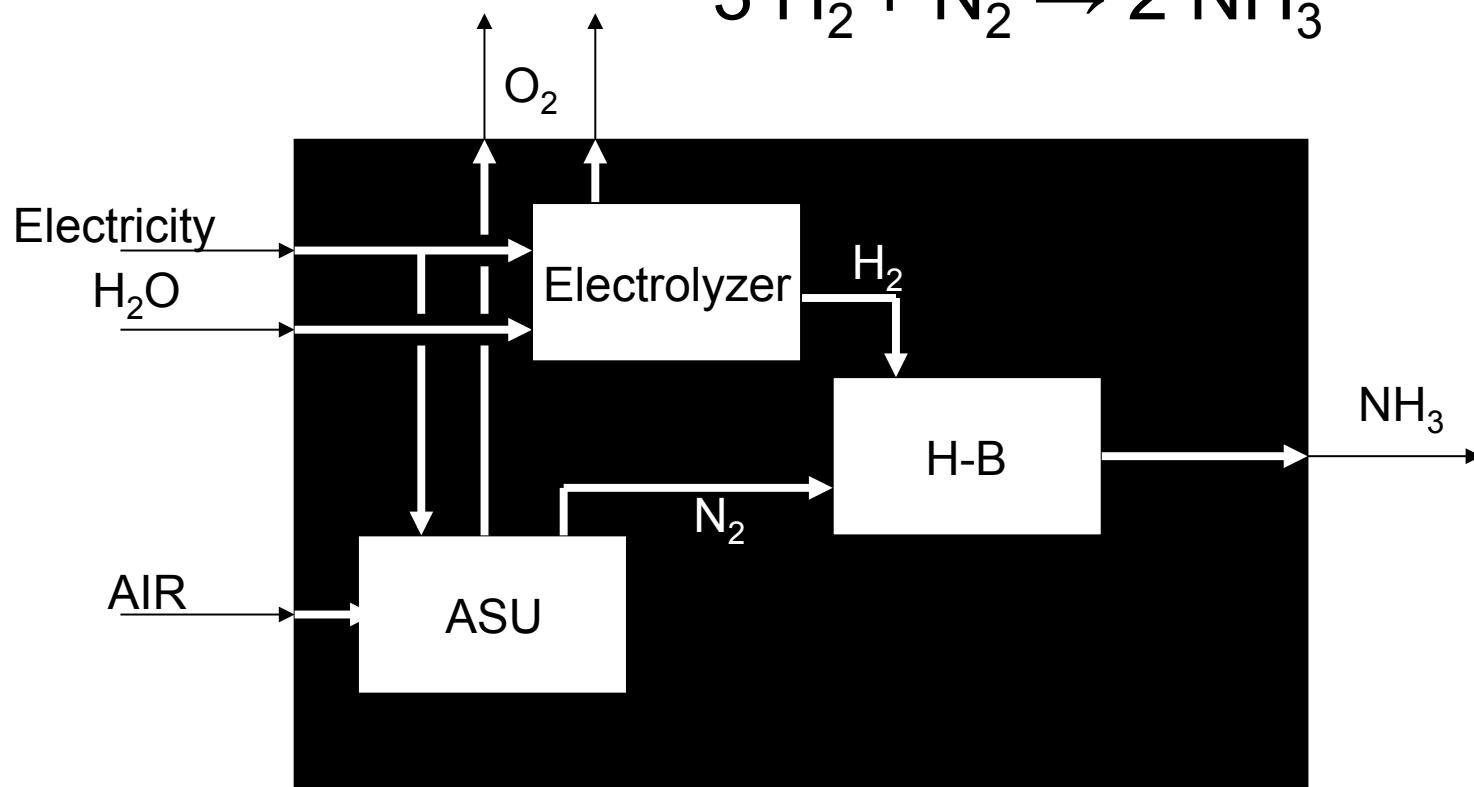
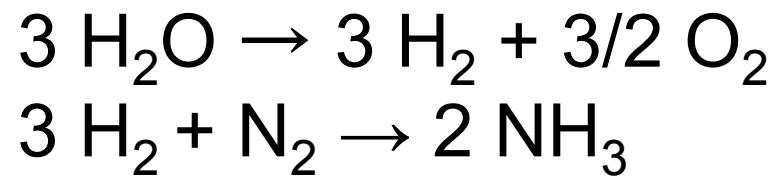


Norsk Hydro Electrolyzers 2 MW each



Ammonia from
hydrogen
from zero-cost
off-peak hydro

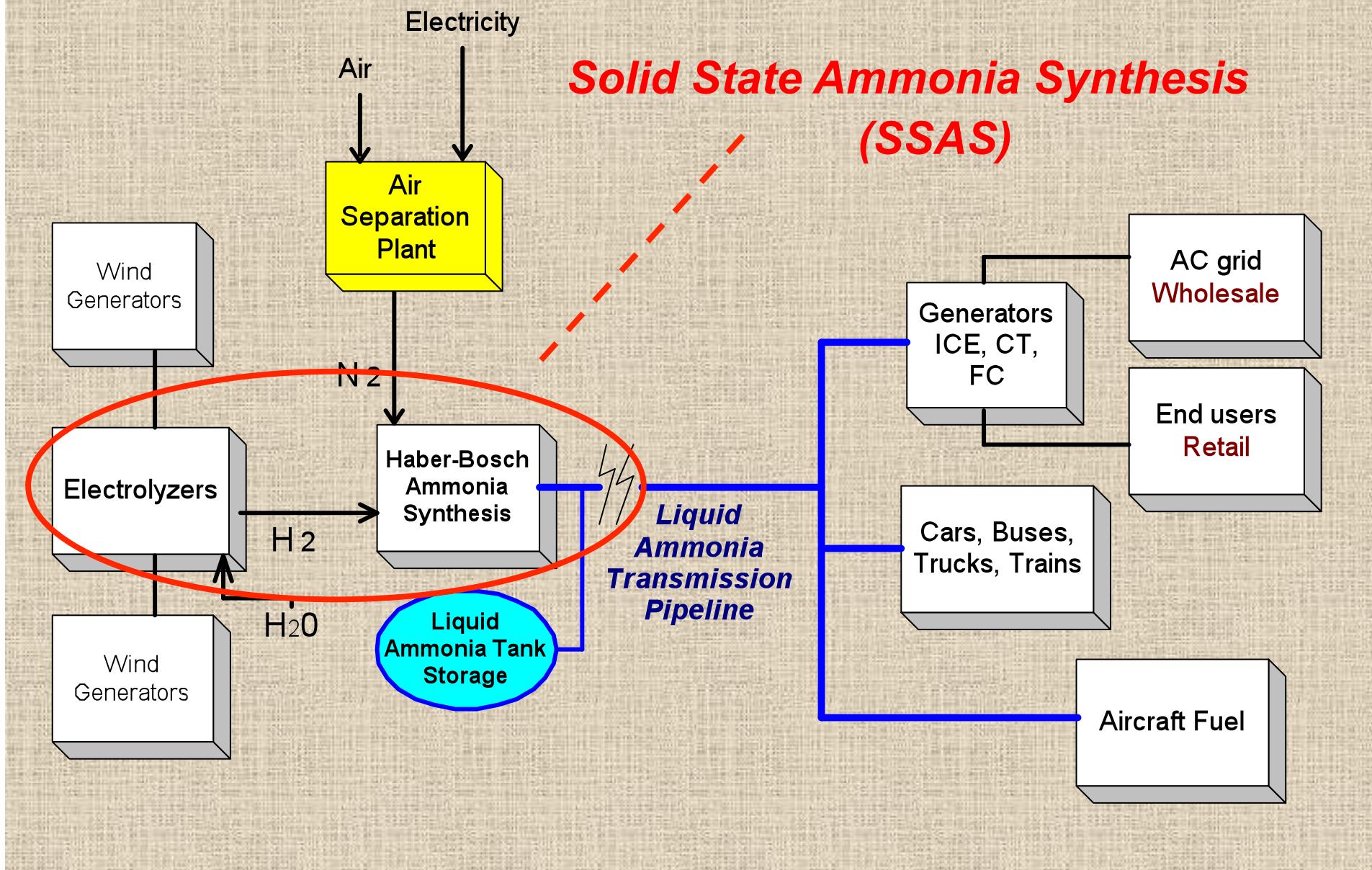
Inside the Black Box: HB Plus Electrolysis



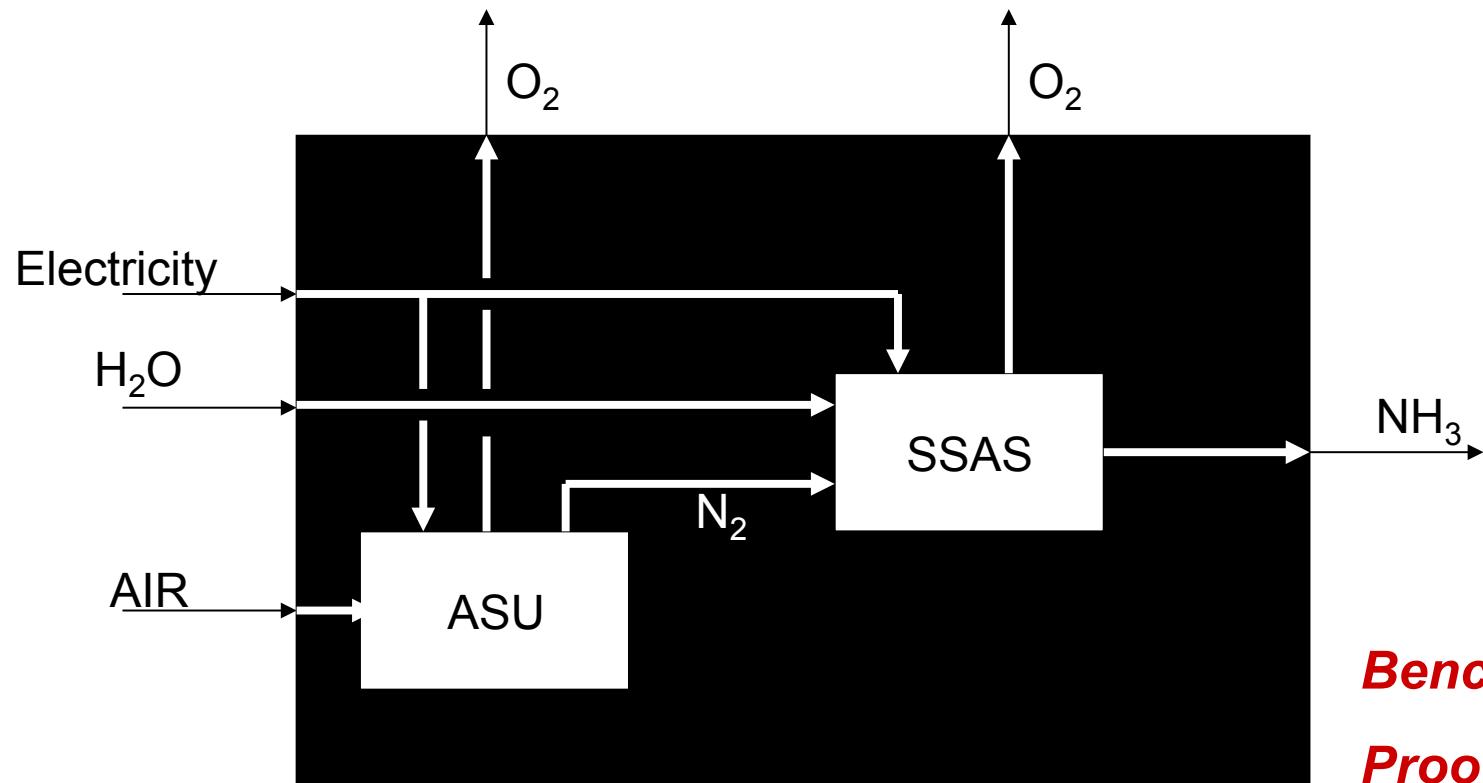
Energy consumption ~12,000 kWh per ton NH₃

RE Ammonia Transmission + Storage Scenario

Solid State Ammonia Synthesis (SSAS)



Inside the Black Box: Solid State Ammonia Synthesis



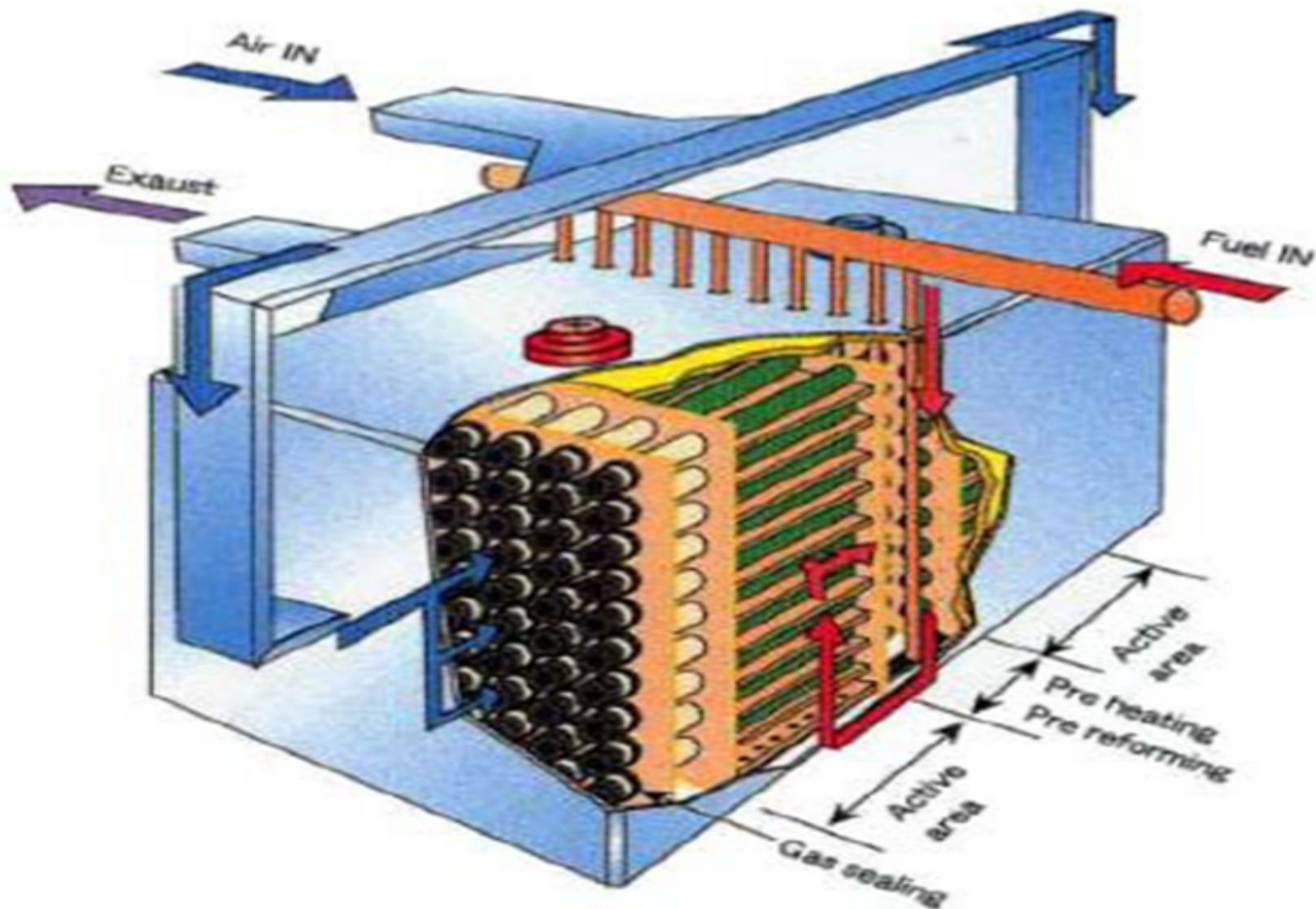
Benchtop

Proof-of-concept

Energy consumption 7,000 – 8,000 kWh per ton NH_3

Solid State Ammonia Synthesis (SSAS)

NHThree LLC patent

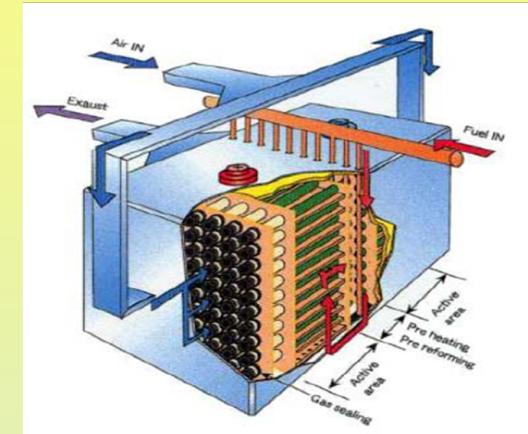


Why SSAS ?

- Electrolysis + Haber-Bosch too costly
 - From RE electricity
 - Capital components at low capacity factor (CF)
 - Energy conversion losses
- Proton conducting ceramics (PCC) now
- Solid oxide fuel cell (SOFC) success
- Need stranded RE transmission
- Need RE storage

Solid State Ammonia Synthesis (SSAS)

- Goals:
 - Renewables-source ammonia (NH₃)
 - Compete with natural gas source NH₃
- High energy conversion efficiency
 - ~50% better than electrolysis → hydrogen + H-B
 - No hydrogen production
- Electricity + water + nitrogen → ammonia
- ~ 50% lower capital cost
- SSAS reactor: SOFC * in reverse

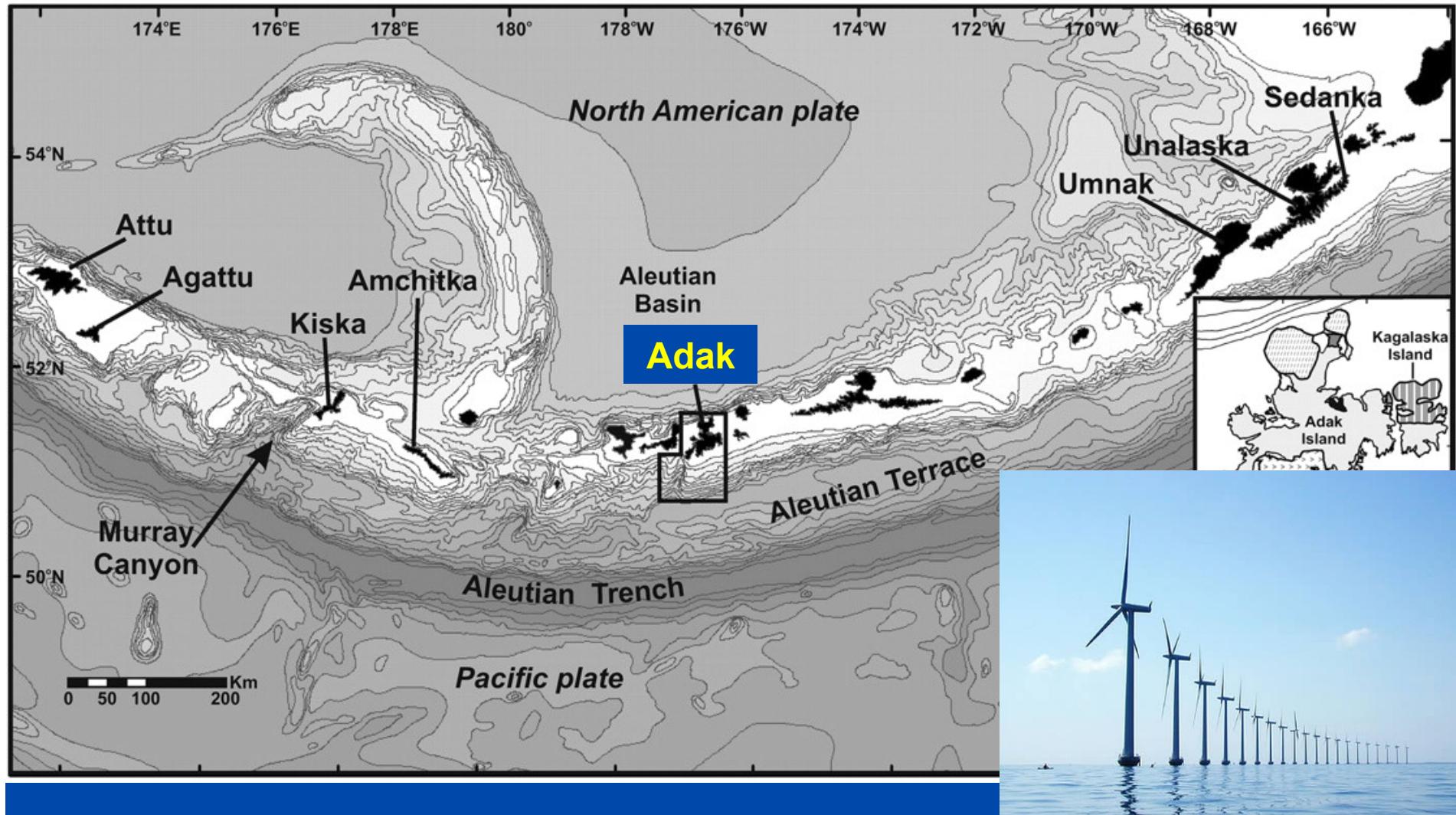


*** SOFC: Solid oxide Fuel Cell**

SSAS vs H-B NH₃ Synthesis

***Solid State Ammonia Synthesis vs Haber – Bosch
Renewable-source electricity input***

- H-B per MW input
 - Capital \$1.5 M
 - 2 tons / day output
- SSAS per MW input
 - Capital \$650 K
 - 3.2 tons / day output



**Adak, Alaska
Aleutian Islands
Class 7 Wind: Capacity Factor (CF) >45% ?**



“Green” Ammonia (NH₃) Output

- > 2,000 MW Adak Wind-to-ammonia Plant**
- > \$5 B total capital @ \$2,500 / kW**
- > 45% Capacity Factor (CF)**

Windplant Annual Energy Production

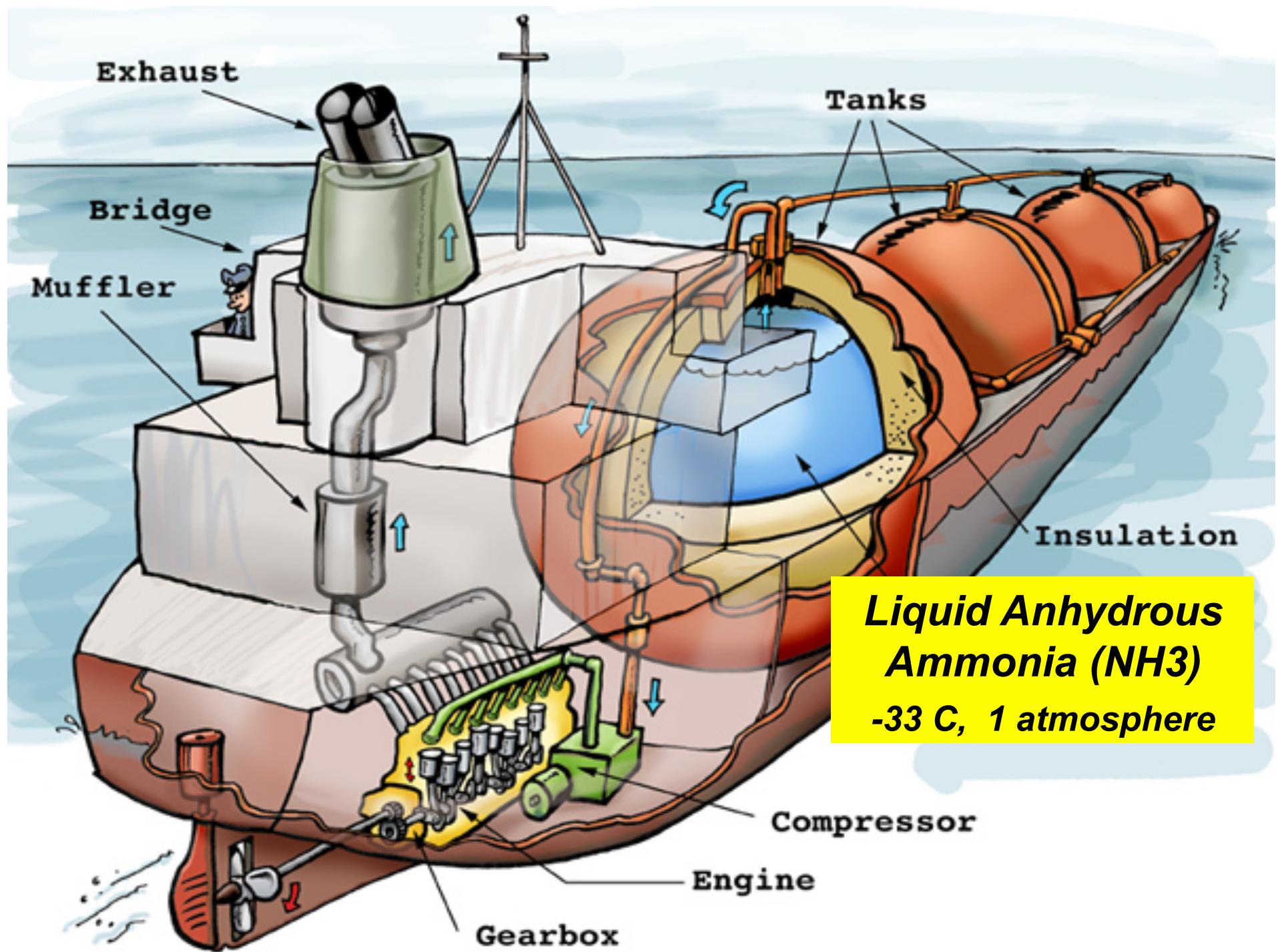
As electricity:	21,600	MWh / day
	7,884,000	MWh / year

Convert to NH ₃ by:	Electrolysis + H-B @ 12 MWh / Mt	SSAS @ 7.5 MWh / Mt
--------------------------------	-------------------------------------	------------------------

Mt (tons) / year	657,000	1,050,000
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Sales @ \$300 / Mt (plant gate)	\$197 M	\$315 M
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Simple ROI	4%	6%
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“Green” Ammonia (NH₃) Output

- > 2,000 MW Adak Wind- to- ammonia plant*
- > \$5 B total capital @ \$2,500 / kW*
- > 45% Capacity Factor (CF)*
- > 15% Capital Recovery Factor (CRF)*

Windplant Annual Energy Production

As electricity: 7,884,000 MWh / year

	Electrolysis + H-B	SSAS
Sales: Mt (tons) / year	657,000	1,050,000
Total Cost of Sales:		
Capital @ 15% CRF	\$750M	\$750M
Plant O&M @ \$0.03 / kWh	24M	24M
Input energy	0	0
TOTAL	\$774M	\$774M
Cost / Mt NH₃	\$1,178	\$ 737
Shipping @ \$50 / Mt	50	50
Total NOLA / Mt	\$1,228	\$ 787

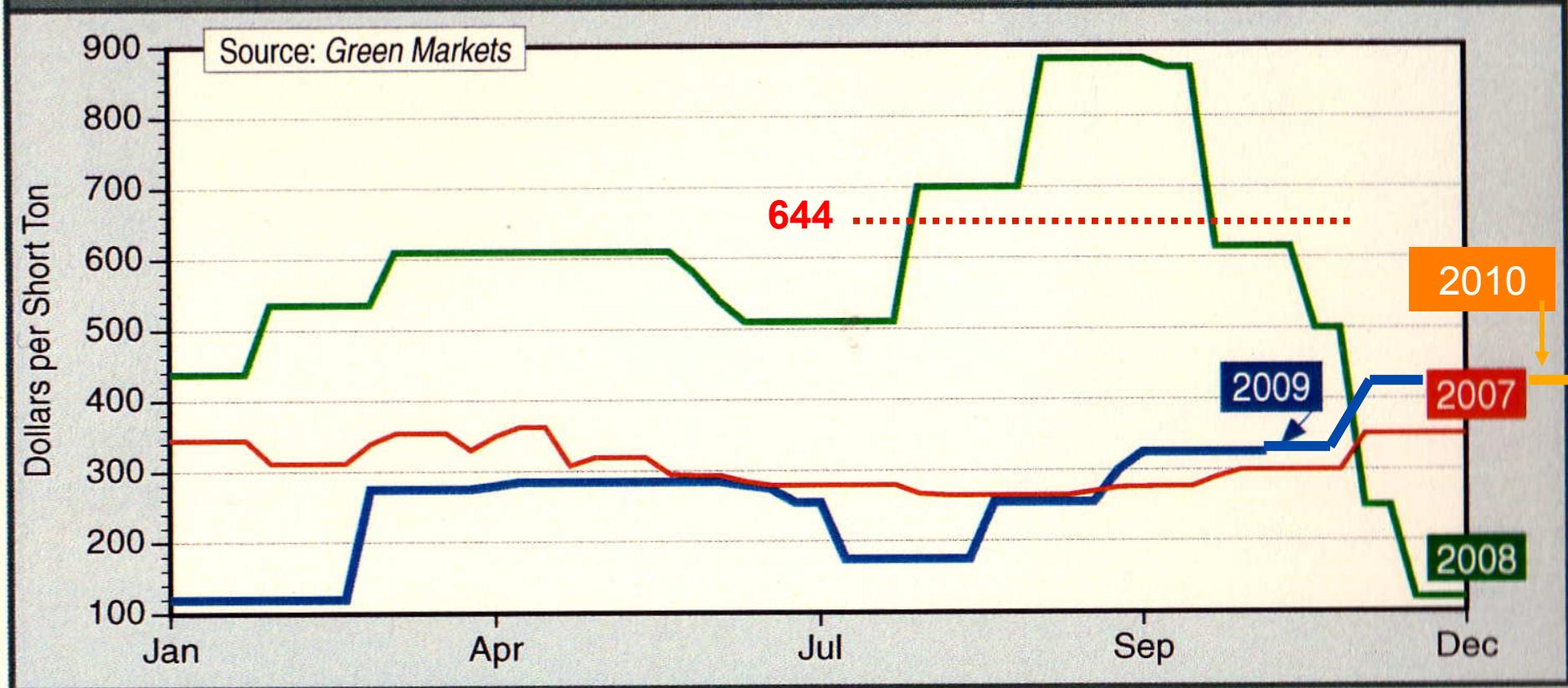
“Green” Ammonia (NH₃) Output

- > 2,000 MW Adak Wind- to- ammonia plant**
- > \$5 B total capital @ \$2,500 / kW**
- > 45% Capacity Factor (CF)**
- > 12% Capital Recovery Factor (CRF)**

Windplant Annual Energy Production

As electricity: 7,884,000 **MWh / year**

	Electrolysis	SSAS
Sales: Mt (tons) / year	657,000	1,050,000
Total Cost of Sales:		
Capital @ 12% CRF	\$600M	\$600M
Plant O&M @ \$0.03 / kWh	24M	24M
Input energy	0	0
TOTAL	\$624M	\$624M
Cost / Mt NH₃	\$ 949	\$ 594
Shipping @ \$50 / Mt	50	50
Total NOLA / Mt	\$ 999	\$ 644

Figure V**Ammonia Prices (Average, New Orleans)**

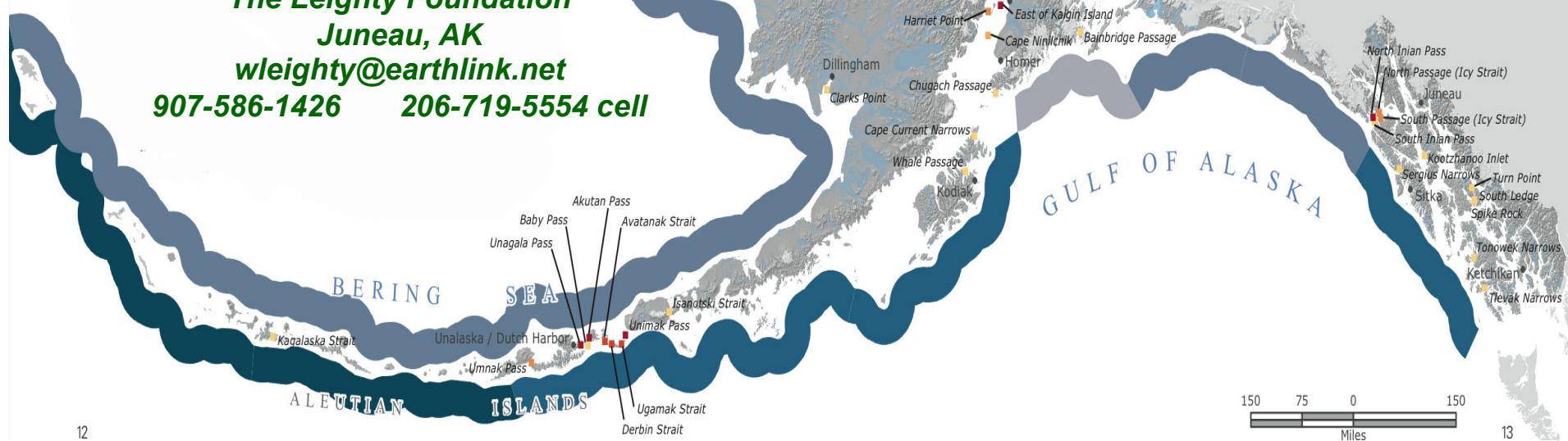
Anhydrous Ammonia (NH₃) wholesale price,
NOLA (New Orleans, LA)

Grant Applications for SSAS: Solid State Ammonia Synthesis

**Dr. Majumdar, ARPA-E
Anchorage, AK
17 Aug 10**

**Bill Leighty, Director
The Leighty Foundation
Juneau, AK
wleighty@earthlink.net**

907-586-1426 206-719-5554 cell



SSAS R+D+Demo Concept

- \$4 – 5 M total program
- Simulate Alaska community energy island
- SSAS offer RE-source internal energy independence ?
 - Discover, demonstrate tech & econ advantages
 - Conversions efficiency; byproduct heat used
 - Economic: capital, O&M costs
- R&D plus demo pilot plant:
 - NHThree LLC patented IP
 - PCC tube mfg pilot plant

SSAS R+D+Demo Concept

- Deploy at UAS Tech Center, Juneau
- Operate in two modes on AEL&P grid:
 - Hydroelectricity-to-NH3
 - NH3-to-AEL&P grid
- SCADA data collect, analyze
- Modify system hardware + software
- Relocate to smaller community
- Implications for export of large-scale, stranded AK RE



TDX Power, Inc., St. Paul Island

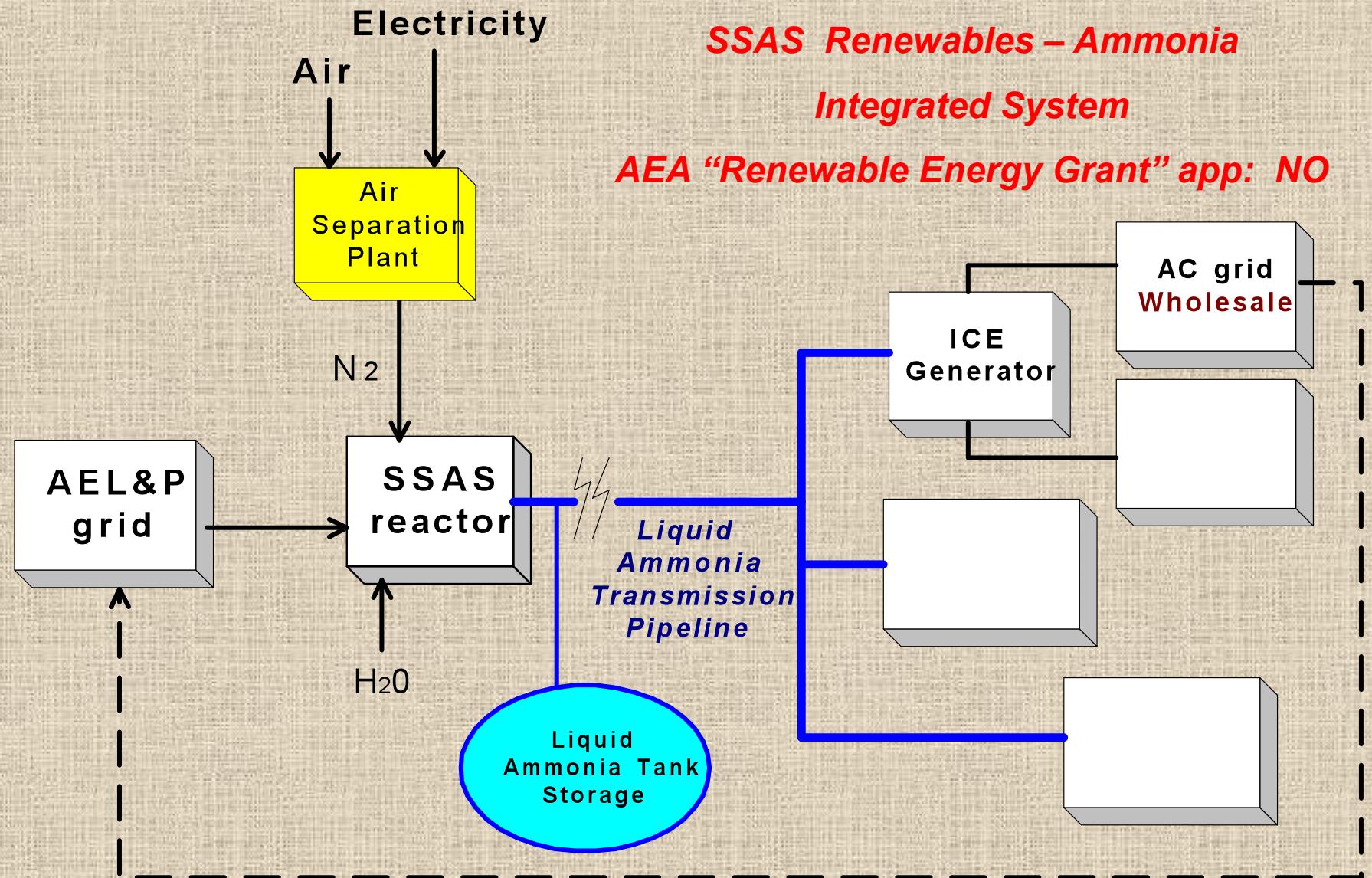
Candidate SSAS Pilot Plant Advanced Test Site

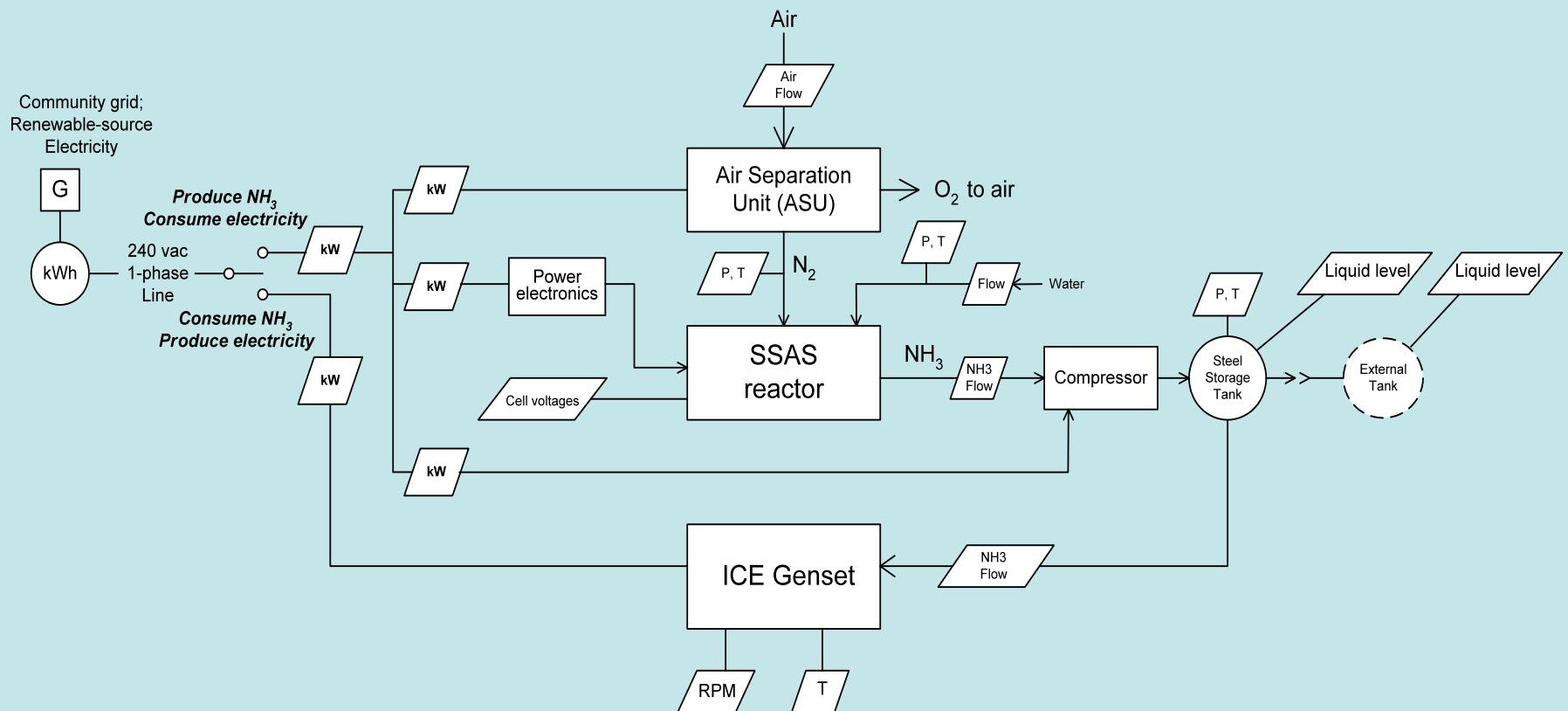
AEL&P (Juneau) R+D+Demo

SSAS Renewables – Ammonia

Integrated System

AEA “Renewable Energy Grant” app: NO





RE – SSAS pilot plant

**SSAS Pilot Plant for Denali
Commission EETG**

Rev: 6 Sep 09 W. Leighty
Alaska Applied Sciences, Inc.
PROPRIETARY

SSAS: Solid State Ammonia Synthesis

sensor, transducer: to SCADA

Figure 1. Complete, containerized SSAS renewable energy conversion and storage system pilot plant

SSAS Grant Applications

- '08 AELP via AK HB152 (RE demos)
- '09 NHThree LLC via ARPA-E
- '09 AASI via Denali Commiss EETG
- '10 Coffman + NHThree LLC via ARPA-E

'08 AEL&P Grant Application: Renewable Energy, AEA, HB152

- Alaska Electric Light & Power (AEL&P) Juneau
- R+D+Demonstration of SSAS system
- \$800K, round one, HB152 grants
- Advance SSAS from lab scale: tech + econ feasible
- Statewide application:
 - “Energy Islands”
 - “Energy Independence”
 - Village survival: imported energy cost, delivery
 - Scaleup: export NH3, tanker
- Demonstrate in major AK city, first: Juneau
- Redeployed to remote community
- Not funded by AEA: no R&D

Sept '09 AASI Grant Application: Denali Commission (Alaska) EETG (Emerging Energy Technology Grant program)

- **Alaska Applied Sciences, Inc., Juneau (AASI)**
- **\$800K: SSAS R+D+Demonstration (same as AEL+P)**
- **Not funded by Denali:**
 - Timing mismatch
 - NHThree LLC prime subcontractor: single-source
 - NHThree LLC ARPA-E application pending: mfg plant
- **Statewide application:**
 - “Energy Islands”
 - “Energy Independence”
 - Village survival: imported energy cost, delivery
- **Demonstrate in major AK city, first: Juneau**
- **Close loop to AEL+P hydro grid**
- **Redeploy to village if successful**
- **Eight support letters**

Denali Commission Summary

- R&D plus pilot plant: NHThree LLC
- Simulate Alaska community energy island
- SSAS offer RE-source **internal** energy independence?
 - Discover, demonstrate
 - Technical: conversions efficiency; byproduct heat used?
 - Economic: capital, O&M costs?
- Deploy at UAS Tech Center, Juneau
- Operate in two modes on AEL&P grid:
 - Hydroelectricity-to-NH3
 - NH3-to-AEL&P grid
- SCADA data collect, analyze
- Modify system hardware + software
- Relocate to smaller community?
- Final report; conference papers; wide distribution
- **Implications for export of large-scale, stranded AK RE ?**

SSAS Commercialization: R + D + Demonstration Funding Required by NHThree LLC

Pilot Plant for PCC tubes	\$ 2.5 M
Portable Pilot Plant: RE → NH₃ → RE	1.0 M
Portable Pilot Plant transport, install, ops	.5 M
R+D + Management	1.0 M
Total	\$ 5.0 M

SSAS Commercialization: R + D + Demonstration Potential Funding Sources

Alaska SB220 “EETG”	\$ 1 M
Iowa Power Fund	1 M
ARPA-E “unsolicited”	1 M
Farm Bill Sec 9003 Approp	1 M
Foundations	?
Private equity	1 M
Total	\$ 5 M

Alaska Business Opportunities: RE – NH3 “Green” Ammonia

Monetizing Alaska's vast RE

1. Export from GW-scale RE: Increase cash **IN**
2. Village energy “independence”
 - Indigenous renewables; diverse
 - Seasonal, diurnal variability
 - Storage as NH3: pressurized tanks
 - Reduce cash **OUT**

Alaska's Immediate Opportunity: SSAS

- Village energy “independence” - degree
 - Diverse, indigenous RE sources
 - Convert % to NH₃
 - Storage as NH₃ in steel tanks: annually-firm
 - Deliver energy services: CHP, heat, transport,
 - Competitive price: \$6-8 / gallon diesel + heat fuel
- SSAS R&D and Demonstration
 - NHThree LLC owns SSAS IP patent
 - PCC tube mfg pilot plant
 - RE – SSAS pilot plant → AK village(s)

Alaska's Immediate Opportunity: SSAS

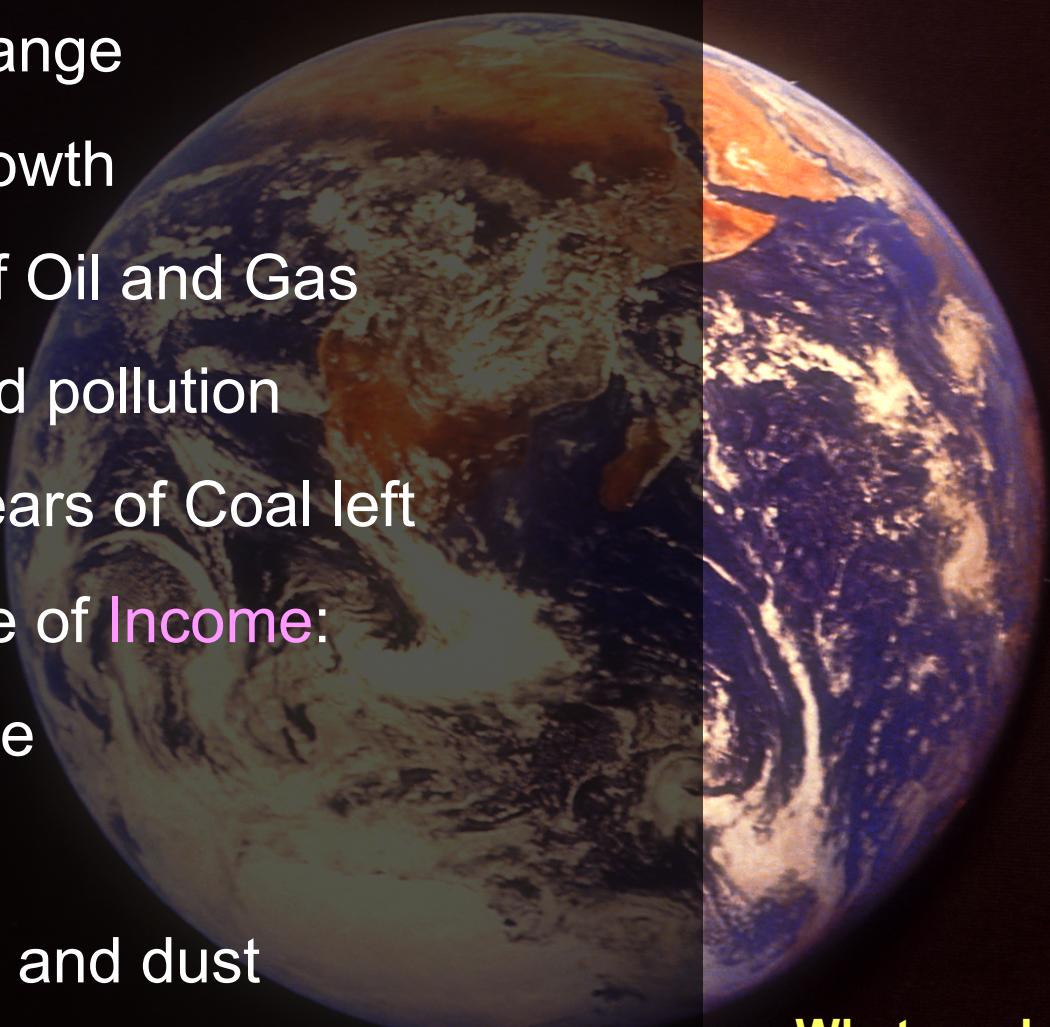
- Funding Collaboration: State of AK, Denali, Fed, Industry
 - \$4-5M total R&D&Demo
 - EETG funds
 - SB220 State \$2.5M
 - Denali Commission \$2.5M
 - USDA: '08 Farm Bill Sec 9003 "RE Fertilizer Research"
- Set stage for GW-scale NH₃ export via SSAS
 - Diverse RE
 - Capital cost; CF; lower cost of energy (COE) ?
- Barriers
 - EPA: Ammonia not a fuel
 - DOE: Currently not interested; "toxic"; electricity transmis
 - Industry: too risky, no fuel market, hazardous

*NH3 plant gate costs,
per metric ton, estimate
~130 MMt / year global*

- Stranded NG → SMR → H-B \$ 200
- Wind → electrolysis → H-B 1,000
- Wind → SSAS 600

MUST Run the World on Renewables – plus Nuclear ?

- Climate Change
- Demand growth
- Depletion of Oil and Gas
- Oil spills and pollution
- Only 200 years of Coal left
- Only Source of Income:
 - Sunshine
 - Tides
 - Meteors and dust
- Spend our capital ?

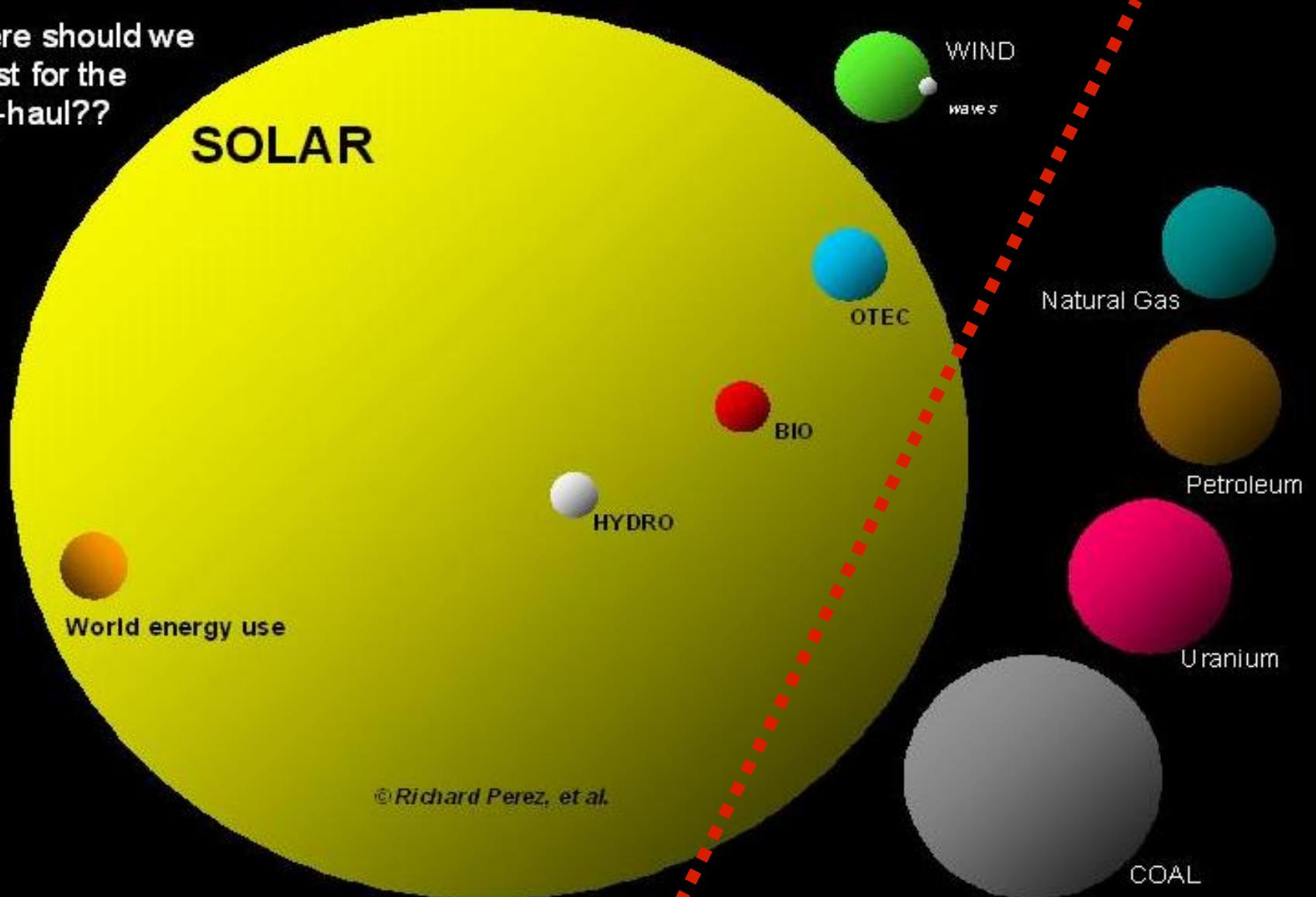


What would it take...

Joel Makower

Comparing the world's energy resources*

Where should we
invest for the
long-haul??



*yearly potential is shown for the renewable energies. Total reserves are shown for the fossil and nuclear "use-them, lose-them" resources. World energy use is annual.

©Richard Perez, et al.



**“ Americans can be
counted on to
always do the right
thing –

but only after they
have tried
everything else ”**

Winston Churchill

The dog caught the car.

Dan Reicher

Making Ammonia Fuel From Alaska's Abundant Stranded Renewable Energy

**Ammonia Fuel Conference
Detroit, MI
27 September 10**

*Bill Leighty, Director
The Leighty Foundation
Juneau, AK
wleighty@earthlink.net*

907-586-1426 206-719-5554 cell

*Brian Hirsch, Alaska Office, NREL
Anchorage, AK
Brian.Hirsch@nrel.gov*



DVD's available

SUMMARY: Dr. Majumdar, ARPA-E

- ARPA-E FOA applications
 - NHTree LLC FIRST ROUND
 - Coffman + NHTree LLC GRIDS
 - Hydrogen Discoveries, Inc GRIDS
 - Alaska Applied Sciences, Inc. GRIDS
- AK laboratory: innovation + save \$
 - 220 villages: islands, most have RE
 - Anhydrous ammonia (NH3) storage, fuel: “independence”, survival
- Handoff: print, DVD, CD

ARPA-E help

- “Broad Funding Announcement” current?
- Workshop on RE systems; global context
- Reconsider NH3 and GH2 proposals
- SSAS: Denali Commission '09 proposal
- Ammonia a fuel: DOE list
- Send rep to 7th Ammonia Fuel Conference
27-28 Sept, Detroit

SUMMARY: Dr. Majumdar, ARPA-E

“Run world on renewables” problems:

1. Transmission
2. Firming, dispatchable storage
3. Electricity grid integration
4. Curtailed RE generation

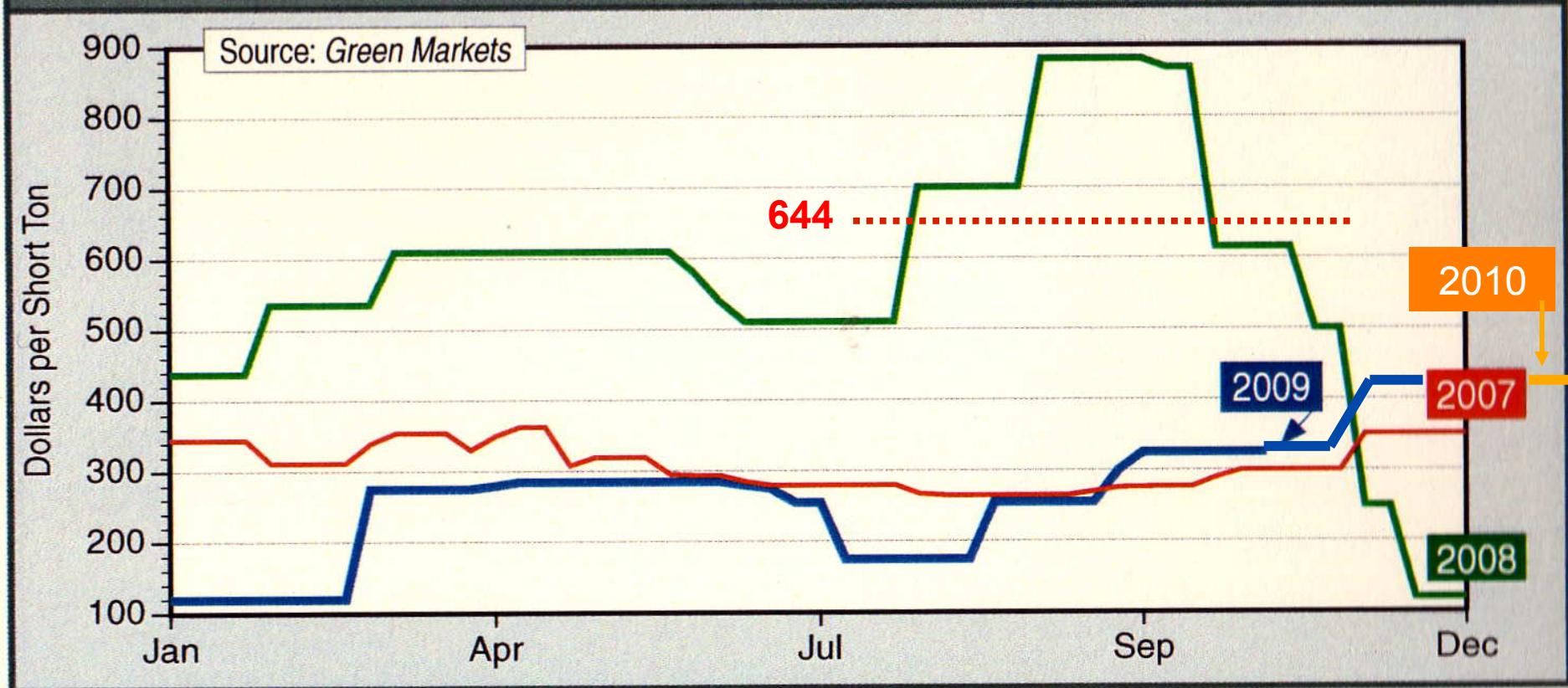
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ARPA-E help

- Collaborative funding SSAS R&D&Demo:
 - \$4 – 5M total
 - AK: SB220 “EETG”
 - AK: Denali Commission “EETG”
 - IA: Iowa Power Fund, OEI, State
 - '08 Farm Bill Sec 9003 “RE fertilizer research”
 - ARPA-E “unsolicited”

Other Alaska GW-scale Stranded RE

- Higher capacity factor (CF) → 100%
- Lower cost of energy (COE)
- Tanker transport affordable
 - Geothermal
 - Wave, tidal
 - Instream kinetic
 - Solar
 - Biomass