Philosophers, like vegetables, are profoundly influenced by their environment.

E. A. J. Johnson

1936

Some Origins of the Modern Economic World

Bill Leighty

BSEE ’65

MBA ‘71


First Congregational Church
Waterloo, Iowa

1958: NE Iowa Science Fair, SCI, 9th grade

1961

12th grade

NE Iowa

Science

Fair

SCI

Collins Radio

Field Engineer

Vietnam

’68

Alaska State Capitol, Juneau

Gold Creek Salmon Bake, Juneau, AK ’72 – ‘90

Alaska Applied Sciences, Inc.

560 kW windplant

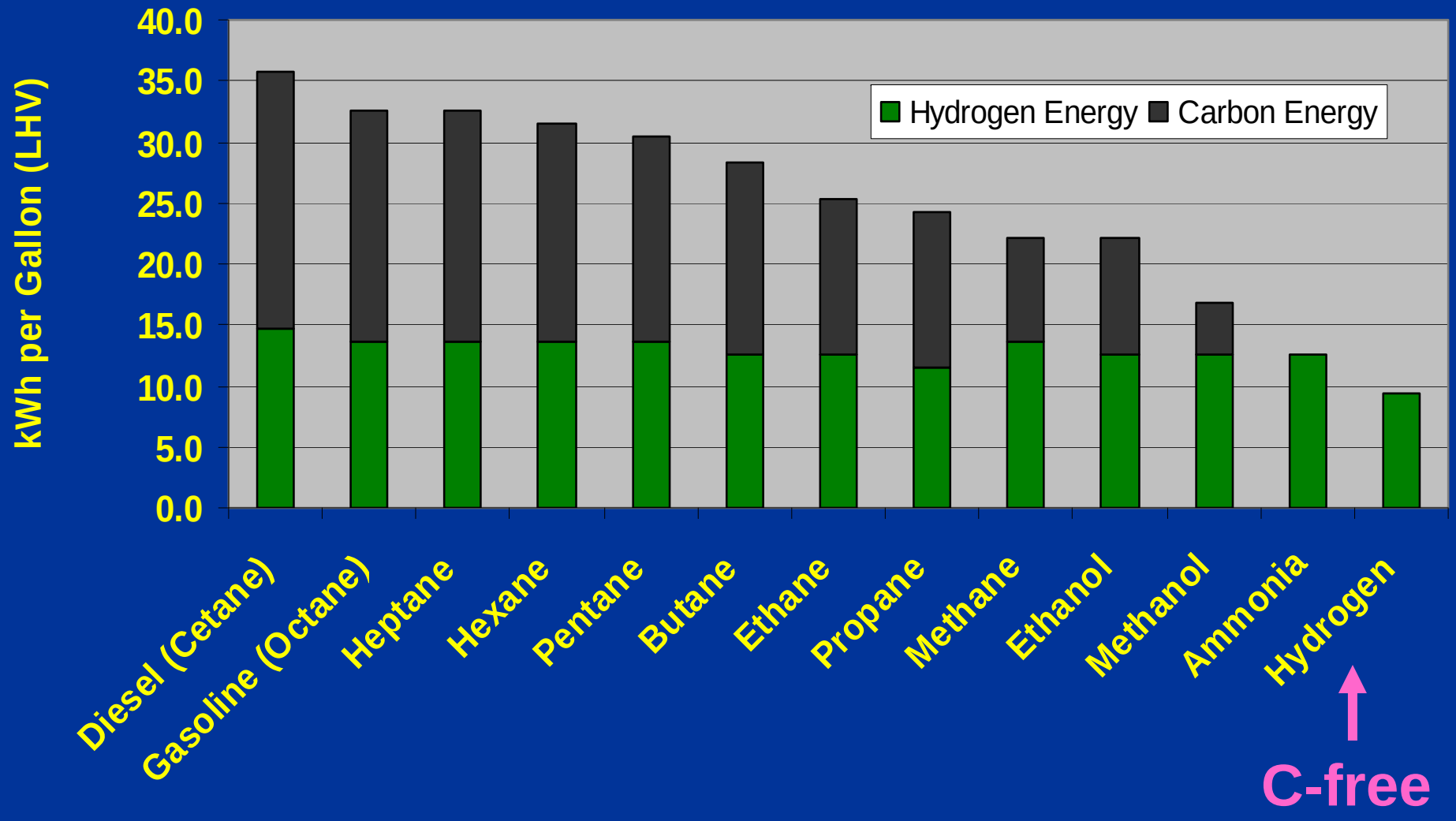
Palm Springs, CA

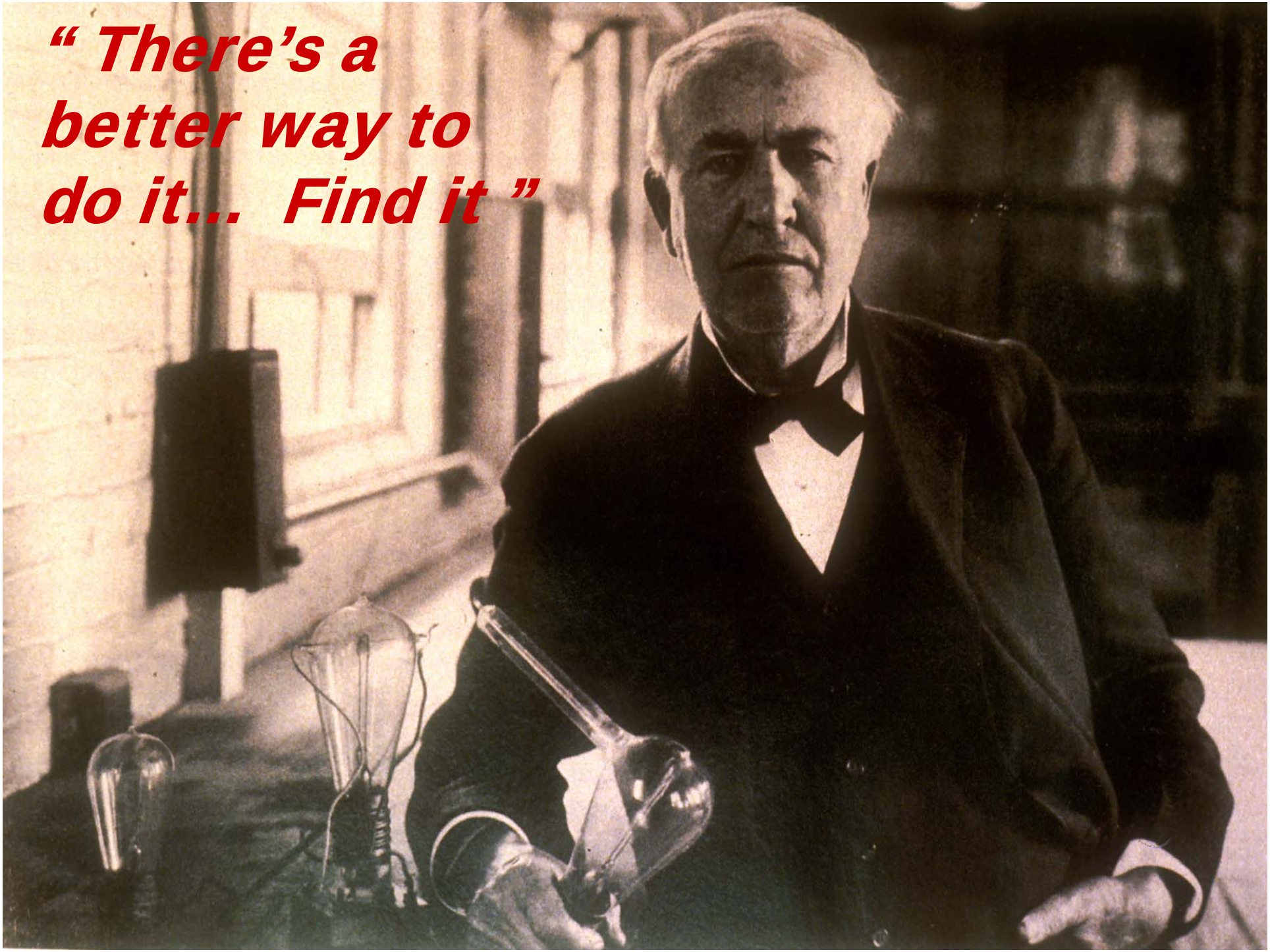
The Leighty Foundation board

- **Earth Protection**
- **20 co-authored papers: renewables transmission & Storage**

Alternatives to Electricity for Transmission and Annual-scale Firming Storage for Diverse, Stranded, Renewable Energy Resources: Hydrogen and Ammonia Fuels

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




“ There’s a
better way to
do it… Find it ”

Mendenhall Glacier, Juneau, AK

June ‘71

Mendenhall Glacier, Juneau, AK

10 October 10

Mendenhall Glacier, Juneau, AK
10 October 10

Spruce bark beetle kill, Alaska

“Drunken Trees” on thawing permafrost

Shishmaref, Alaska

Winter storms coastal erosion

MUST Run the World on Renewables – plus Nuclear ?

MUST Run the World on Renewables – plus Nuclear ?

- Only Source of Income:
  - Sunshine
  - Tides
  - Meteors and dust
- **Spend “our” capital ?**
- Only 200 years of Coal
- Leapfrog Coal? Fossil? Nuclear?
- Distributed + Centralized Generation

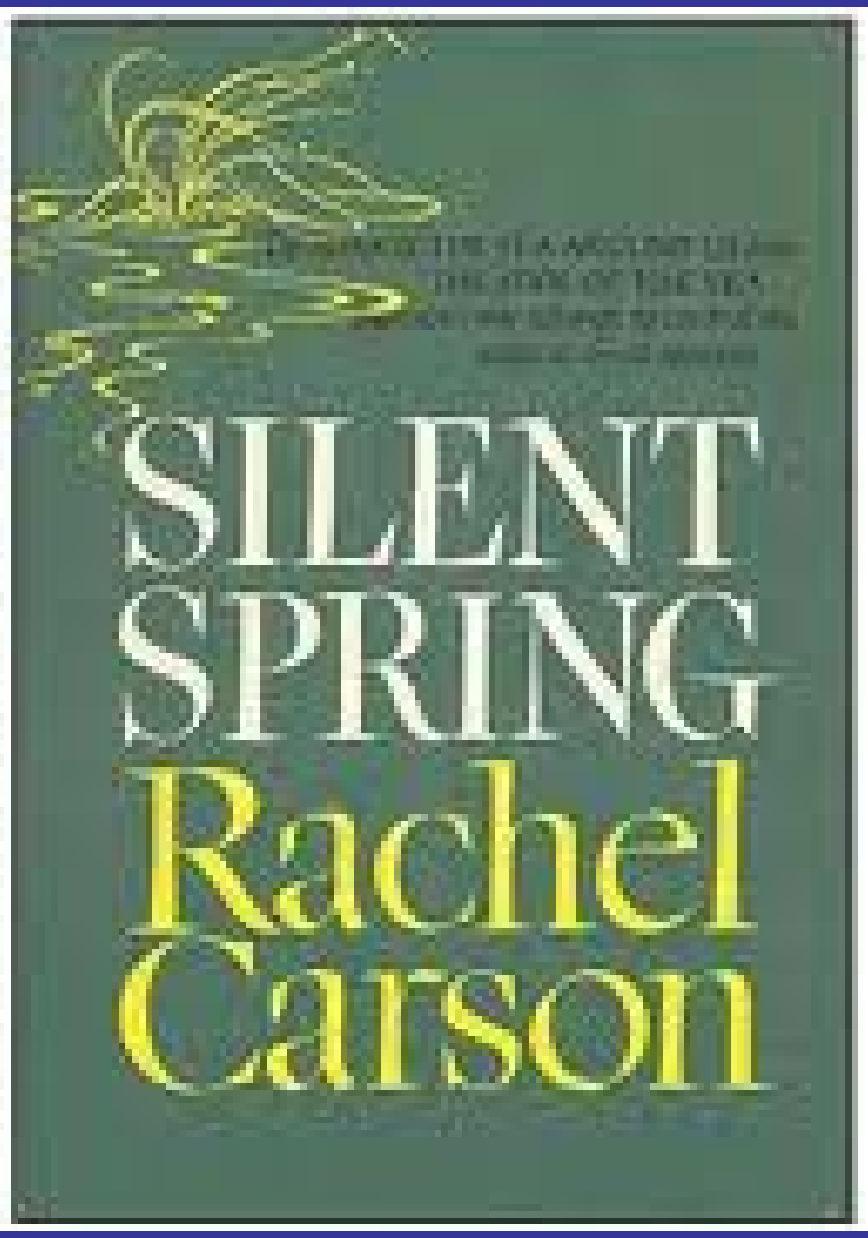
MUST Run the World on Renewables – plus Nuclear ?

- Emergencies:
  - Climate change
  - Ocean acidification
  - Demand growth
  - Energy prices
  - Energy security
- Quickly invest:
  - Conservation + efficiency
  - GW - scale renewables
  - Beyond electricity grid
  - Hydrogen, ammonia … ?

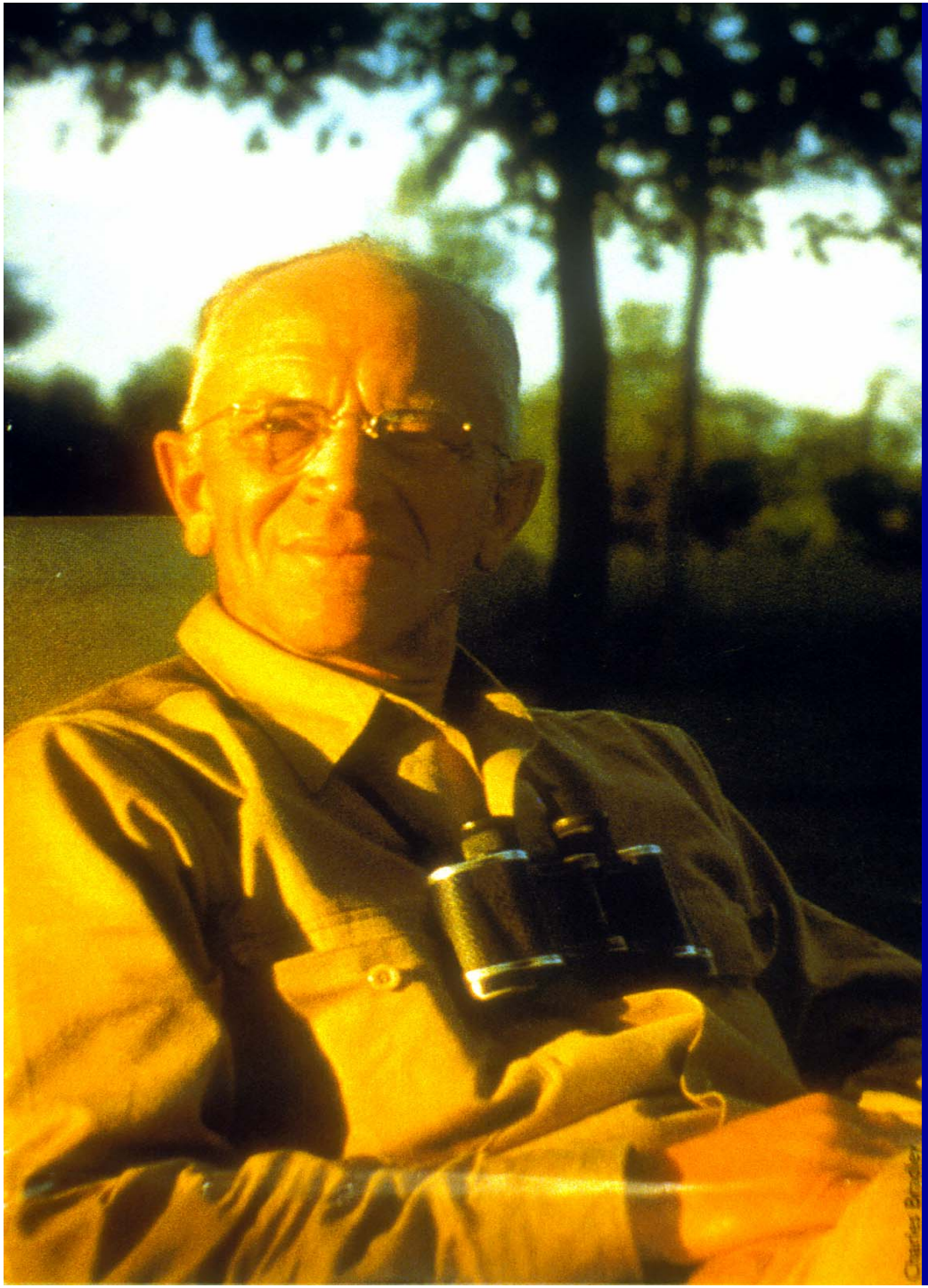

planetarydefense
.blogspot.com
In Defense of the Future
Administered by:
SpaceWorks Commercial
A Division of SpaceWorks Engineering, Inc. (SEI)
www.sei.aero
SpaceWorks
COMMERCIAL


INVASION OF THE SAUCER-MEN
CREEPING HORROR...
STEVE TERRELL · GLORIA CASTILLO · FRANK GORSHIN


THEY COME FROM ANOTHER WORLD!
INCREDIBLE! INVISIBLE! INSATIABLE!
SOMETHING IS HAPPENING! SEND YOUR MEN OF SCIENCE QUICK!
INVASION OF THE BODY SNATCHERS
DANA WYNTER
KEVIN McCARTHY · DANA WYNTER
WALTER WANGER'S
SUPERSCOPE



Published: 27 September '62



Aldo Leopold

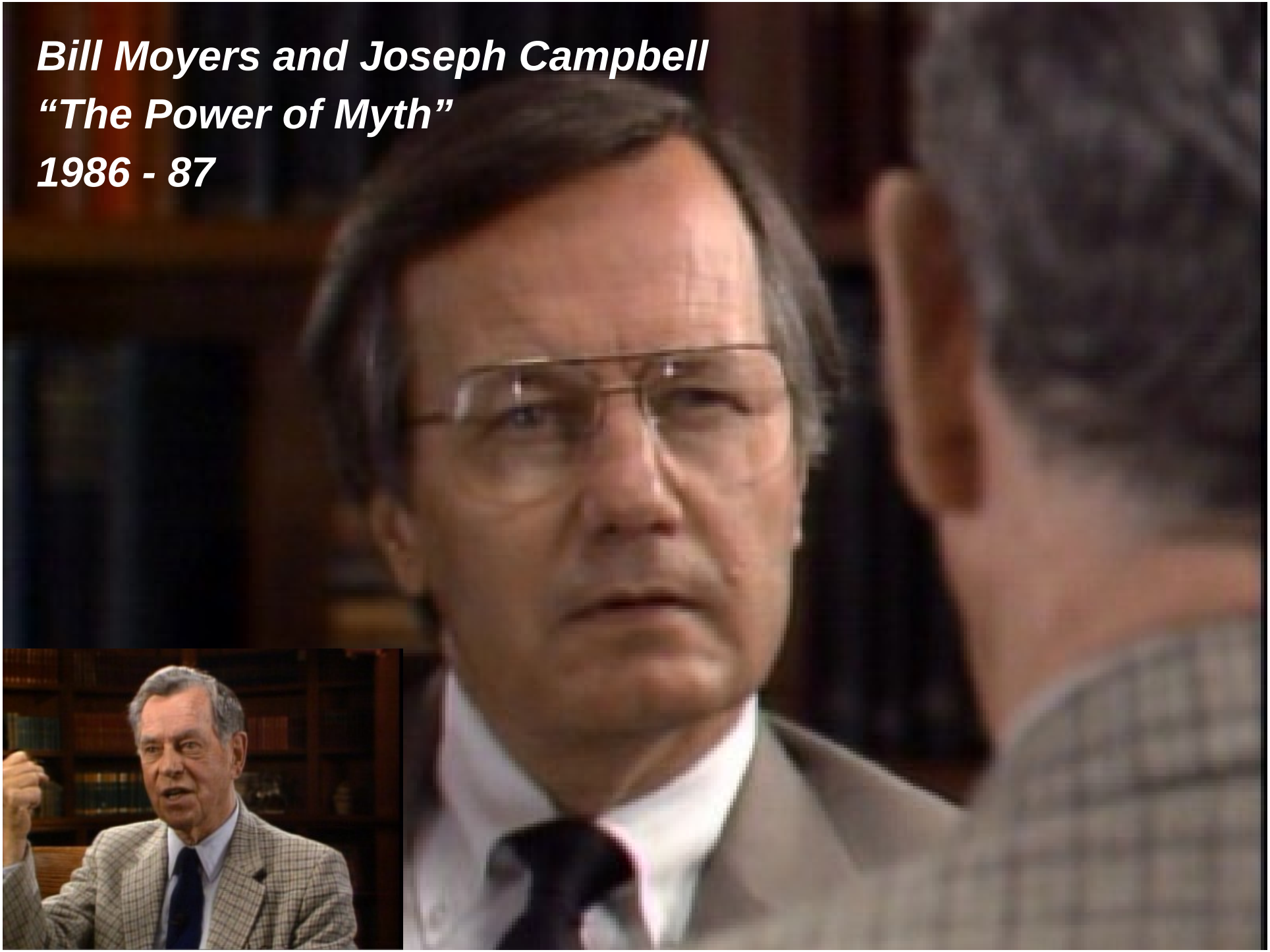
1887 - 1948

There are two spiritual dangers in not owning a farm:

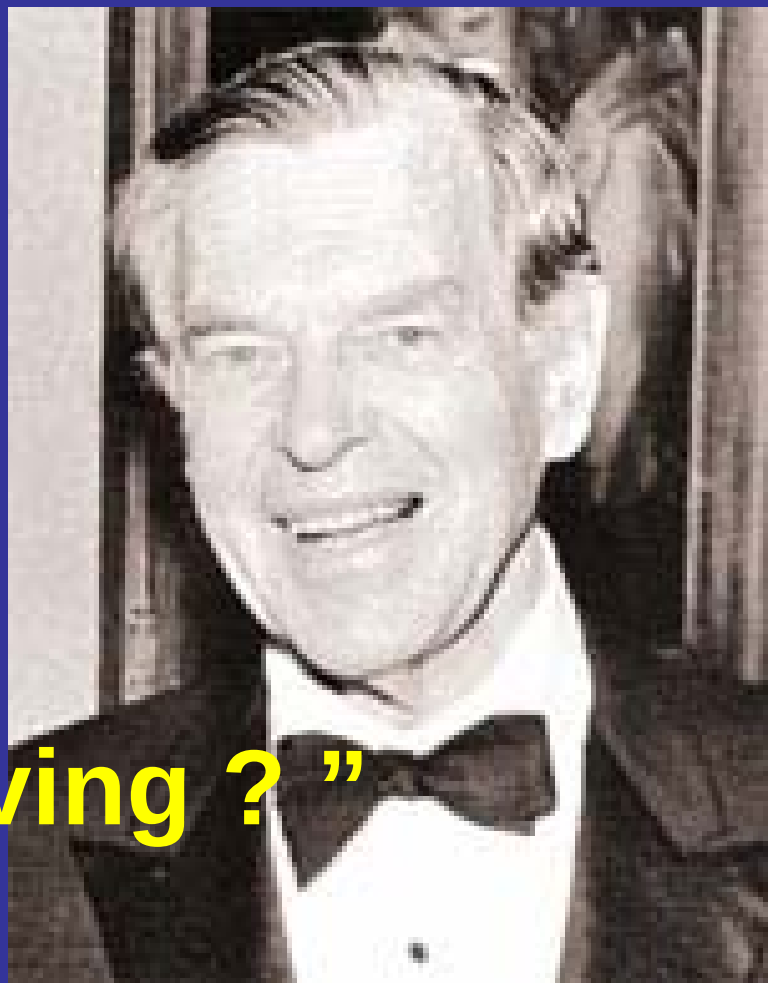
One is supposing that breakfast comes from the grocery;

The other is supposing that heat comes from the furnace.

Aldo Leopold, "A Sand County Almanac"


Bill Moyers and Joseph Campbell
“The Power of Myth”
1986 - 87

Joseph Campbell 1904 - 87



“ What Myth are we living ? ”

Anthropocentrism

Anthro - exceptionalism

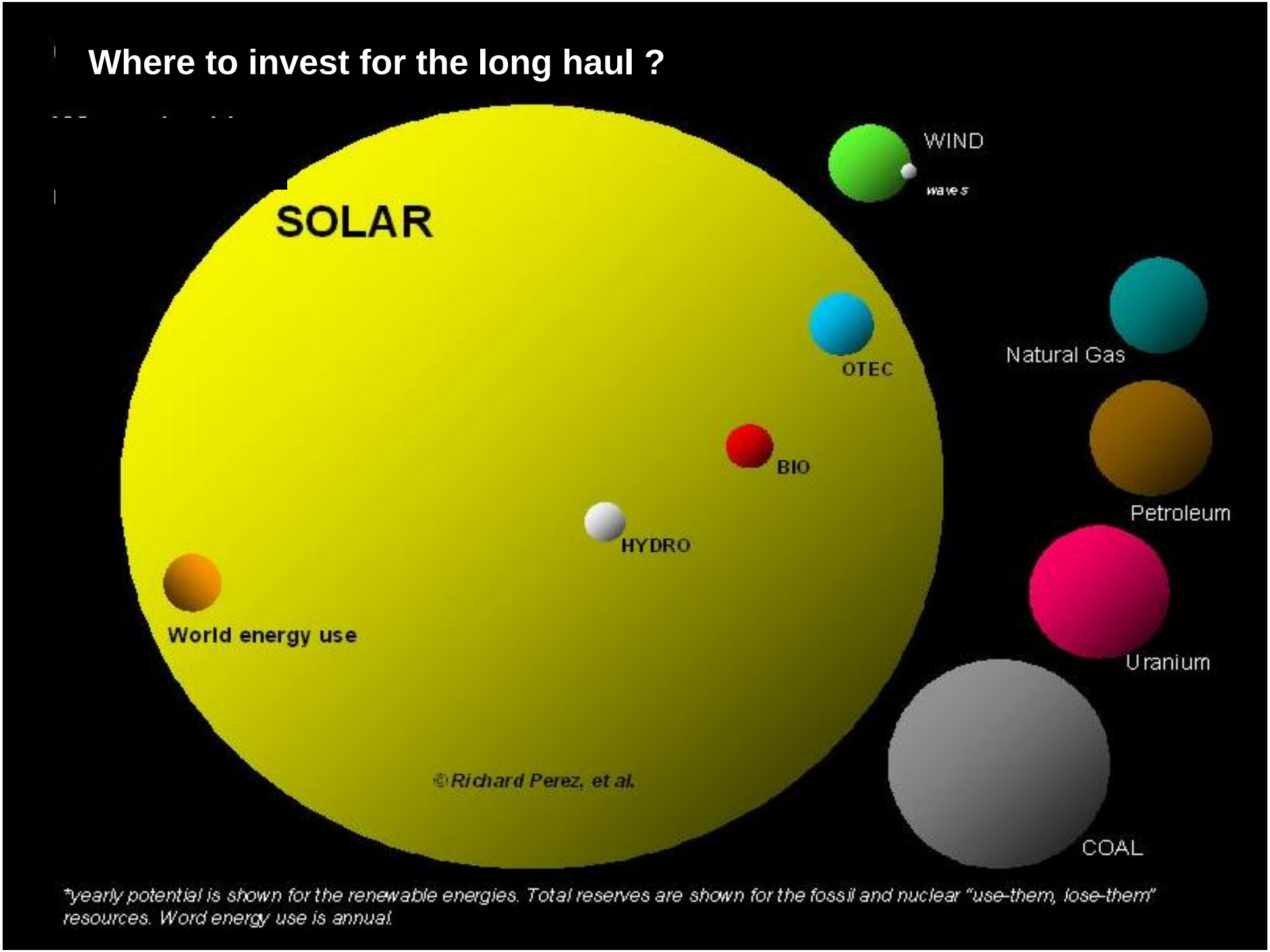
Ethno - exceptionalism

American exceptionalism

GOTT MIT UNS ***“God with Us”***

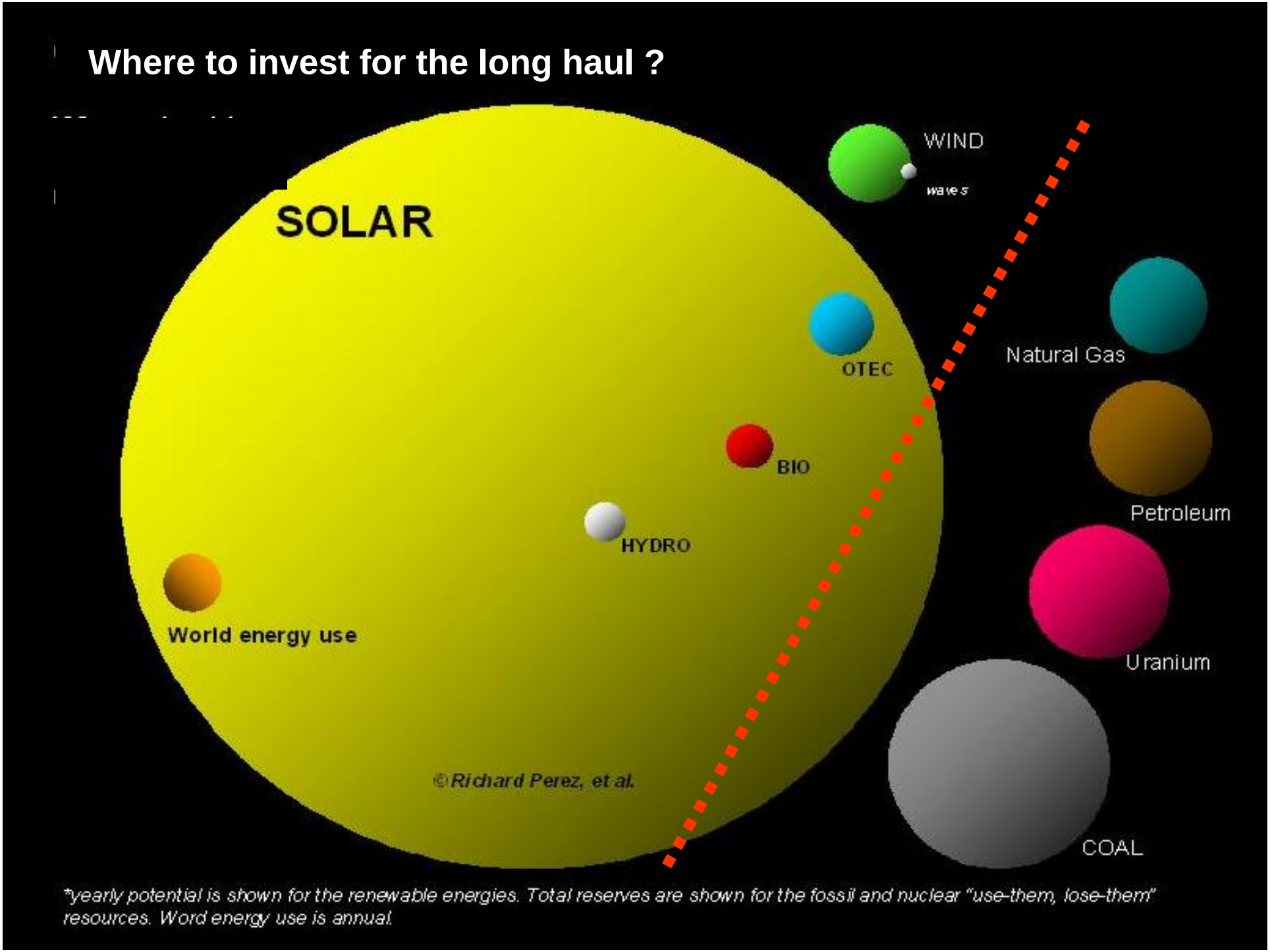

Only the Abrahamic Religions ?

Where to 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. Word energy use is annual.

Where to 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. Word energy use is annual.


The Great Plains Wind Resource
PACIFIC OCEAN
ATLANTIC OCEAN
Gulf of Mexico

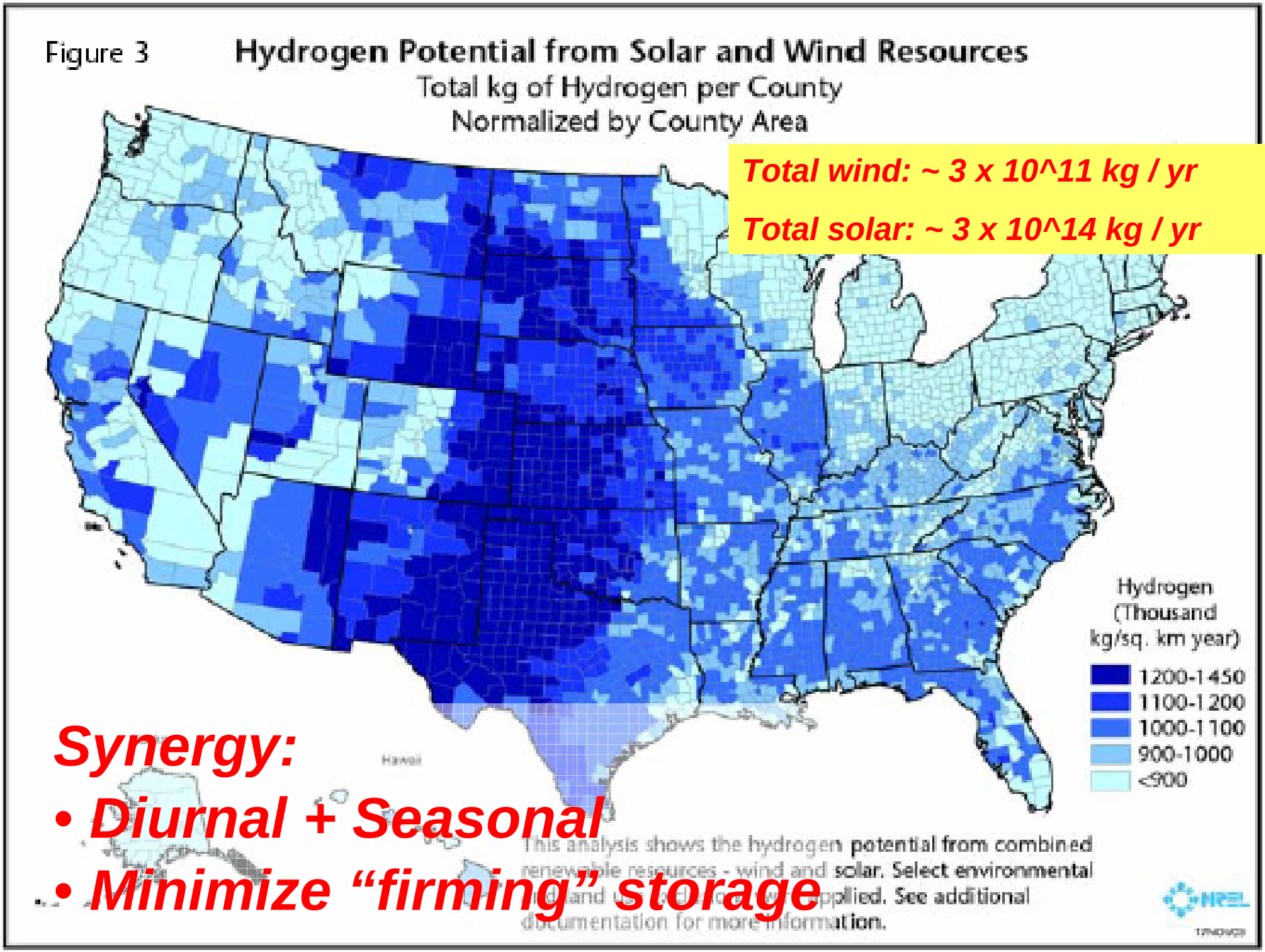
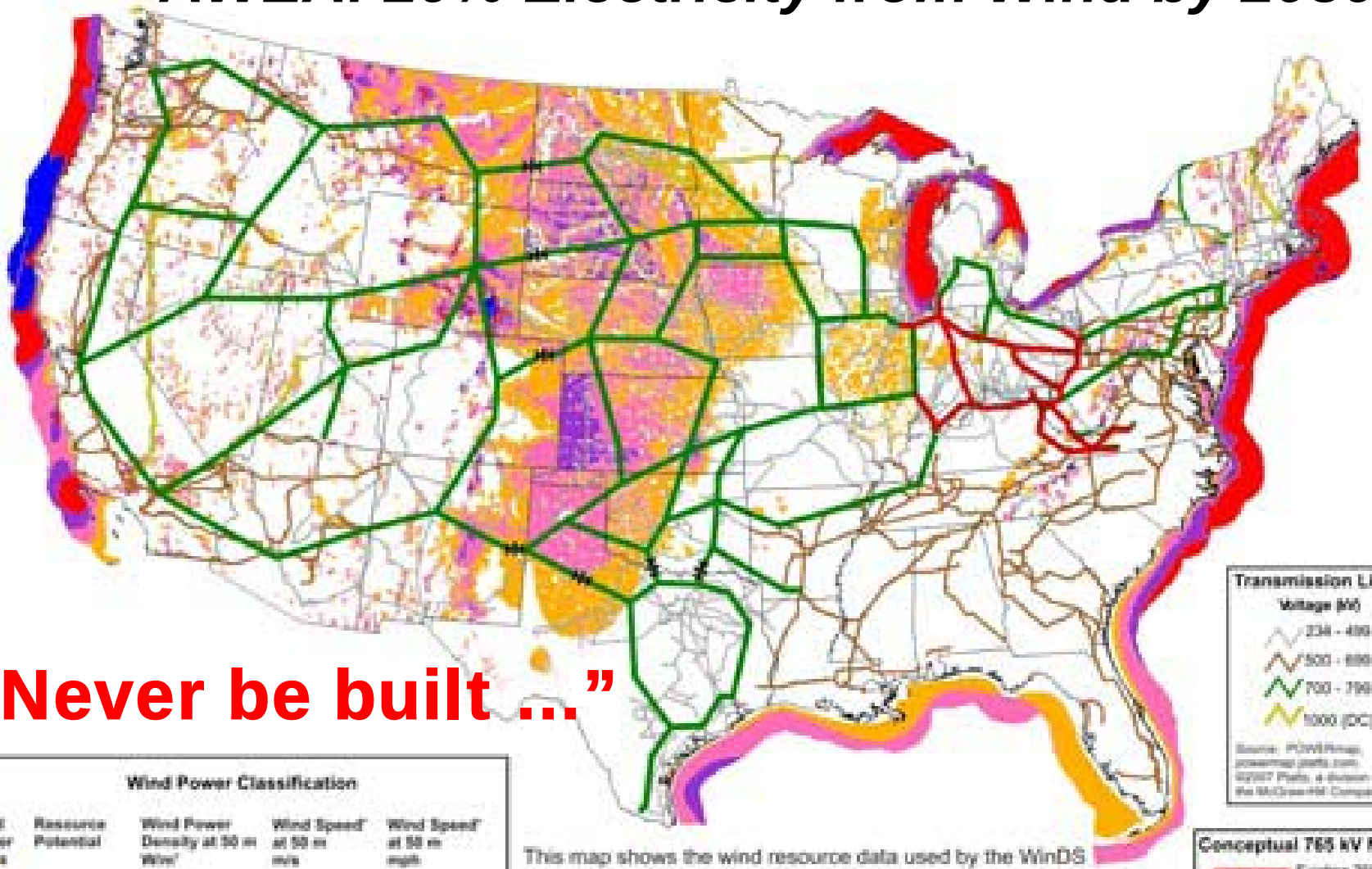


Figure 3
Hydrogen Potential from Solar and Wind Resources
Total kg of Hydrogen per County
Normalized by County Area
Total wind: ~ 3 x 10^11 kg / yr
Total solar: ~ 3 x 10^14 kg / yr
Hydrogen (Thousand kg/sq. km year)
1200-1450
1100-1200
1000-1100
900-1000
<900
Synergy:
• Diurnal + Seasonal
• Minimize "firming" storage
This analysis shows the hydrogen potential from combined renewable resources - wind and solar. Select environmental
documentation for more information.
NREL

AWEA: 20% Electricity from Wind by 2030



"Never be built …"

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m²	Wind Speed* at 50 m m/s	Wind Speed* at 50 m mph
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

* Wind speeds are based on a Weibull k value of 2.0

This map shows the wind resource data used by the WinDS model for the 20% Wind Scenario. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.

Transmission Lines

Voltage (kV)

230 - 499

500 - 699

700 - 799

1000 (DC)

Conceptual 765 kV Network

Existing 765 kV

New 765 kV

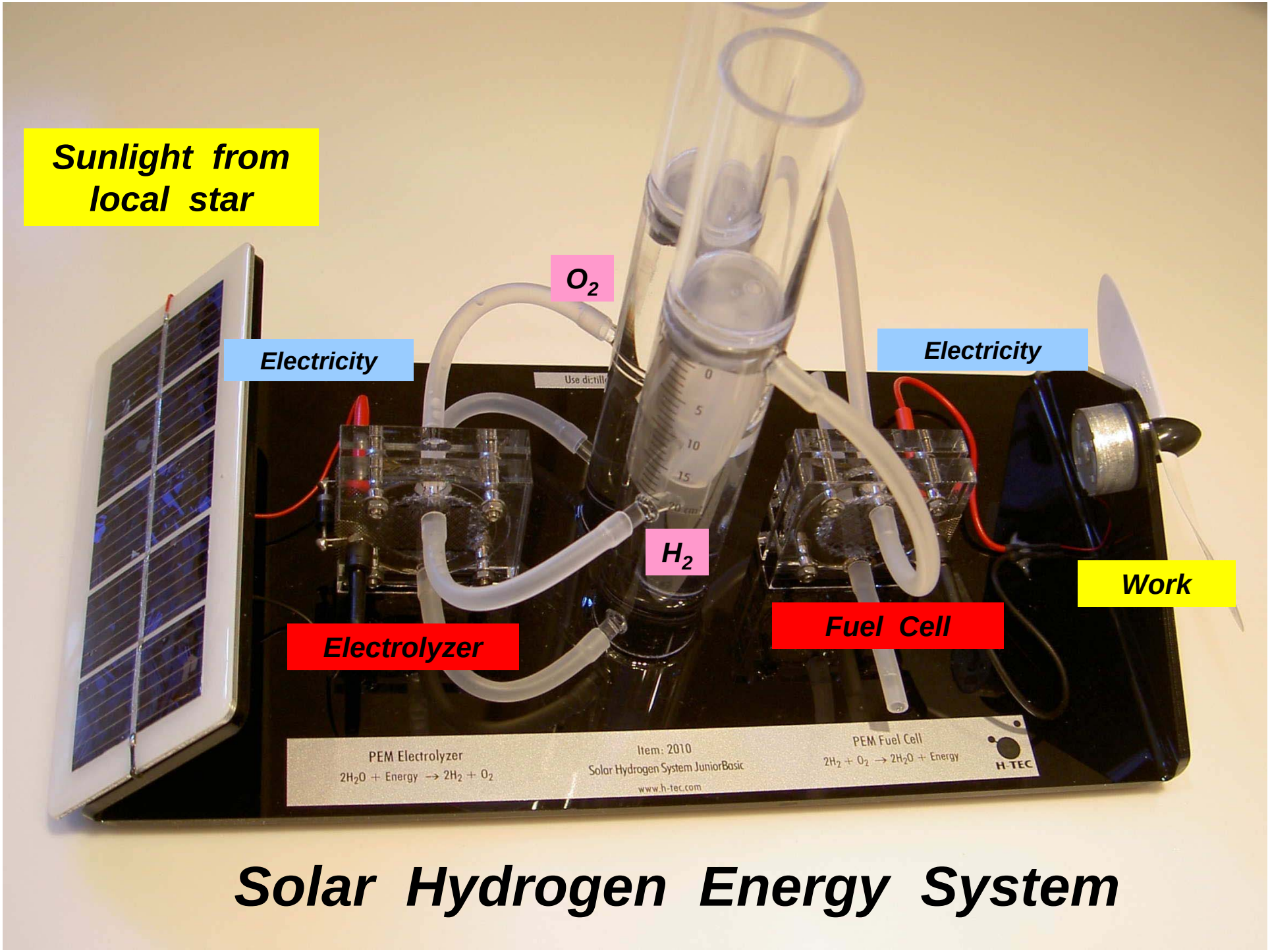
AC-DC-AC Link

Trouble with Electricity Transmission and Storage for Renewables

- **Costly per GW-mile**
- **NIMBY**
- **Grid integration**
- **Low capacity factor (CF)**
- **Firming cost:**
  - **Affordable annual-scale storage ?**
  - **Capital, O&M**
  - **Dispatchability**
- **Vulnerable:**
  - **Acts of God or man**
  - **Cyberattack**
- **Run world on renewables: poor**

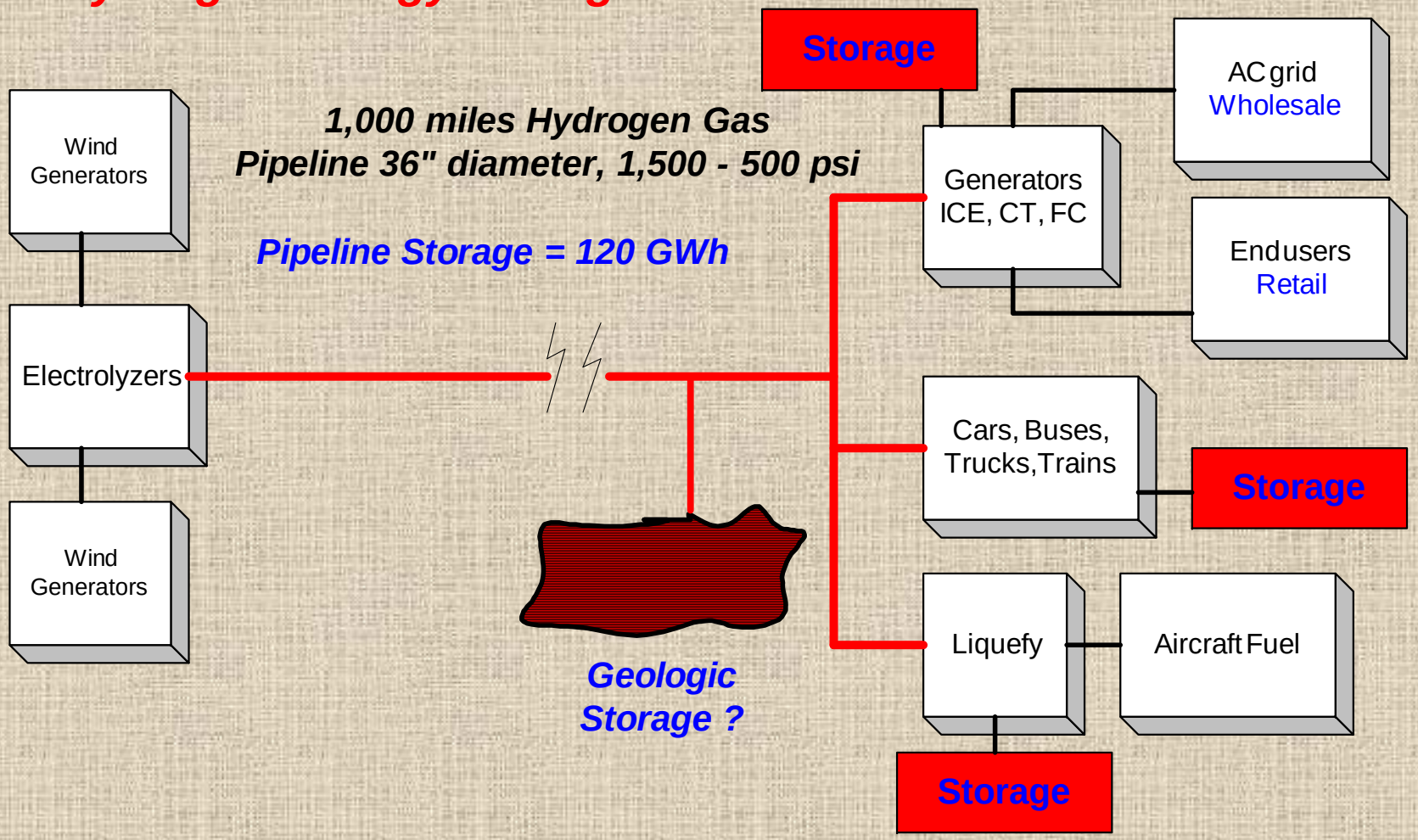
"Smart Grid"

- **Next Big Thing ?**
- **More vulnerable to cyberattack ?**
- **More renewables ?**
  - **No more transmission**
  - **No more storage**



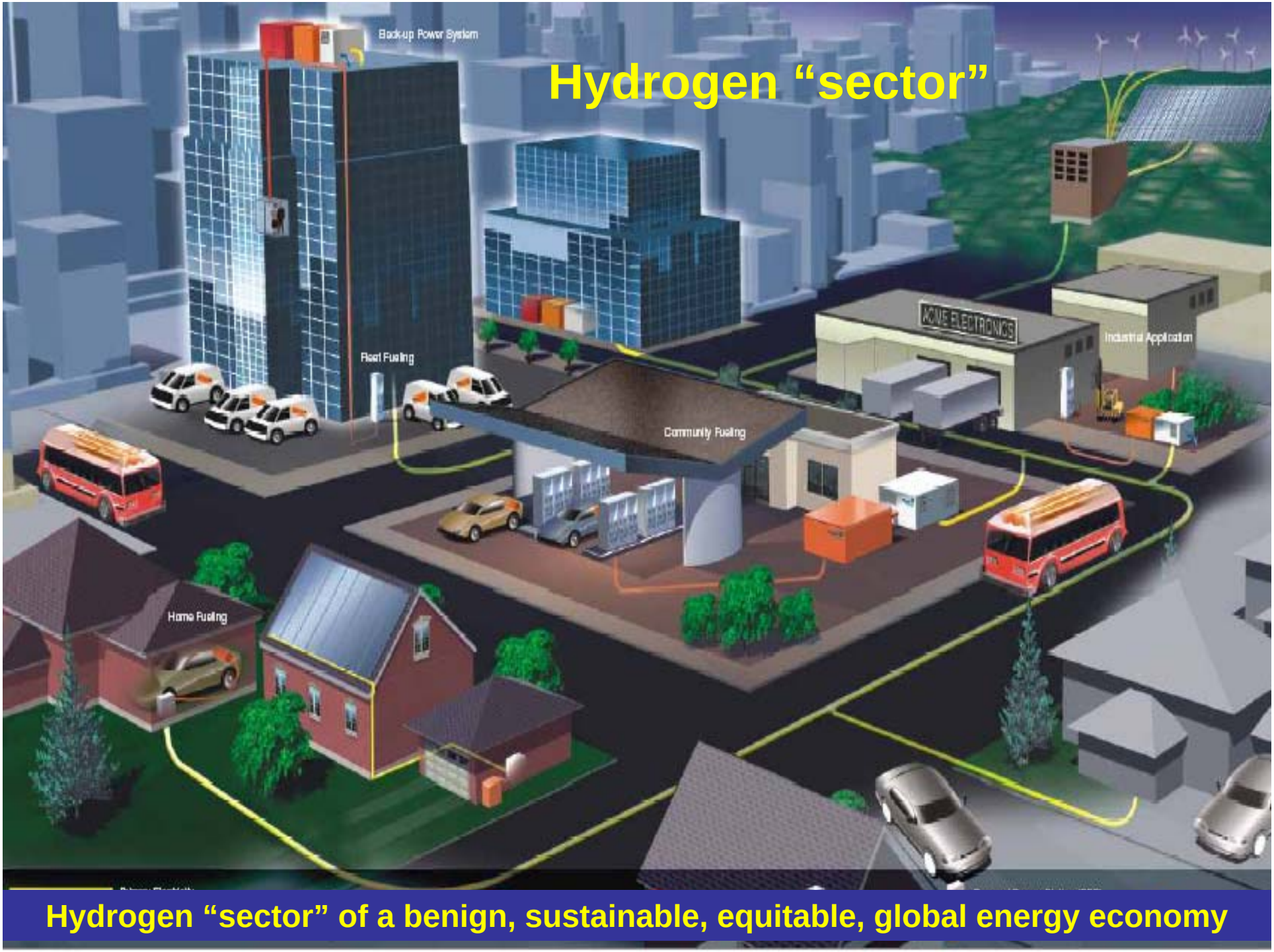
Solar Hydrogen Energy System

Hydrogen Energy Storage



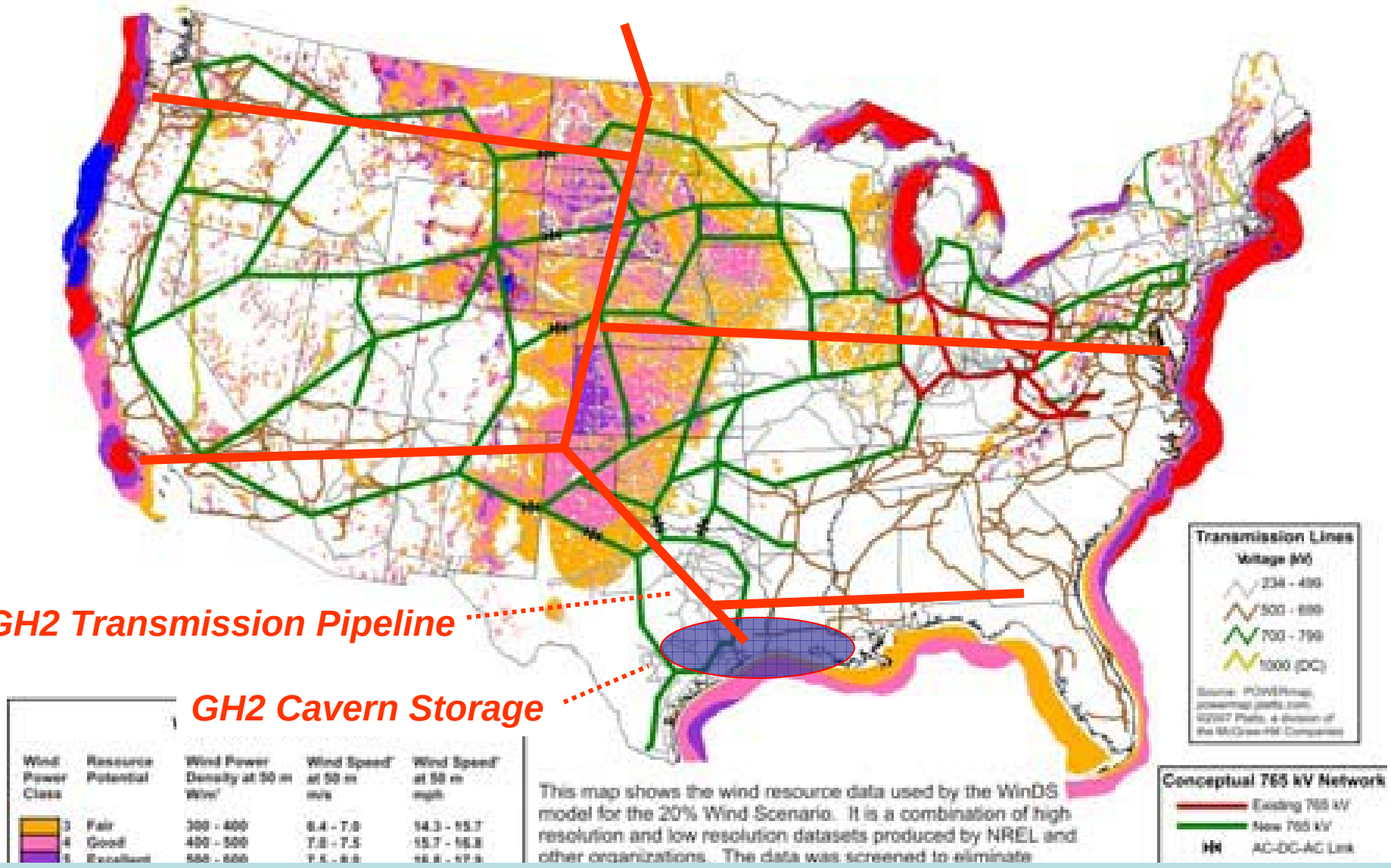
Domal Salt Storage Caverns

PB ESS

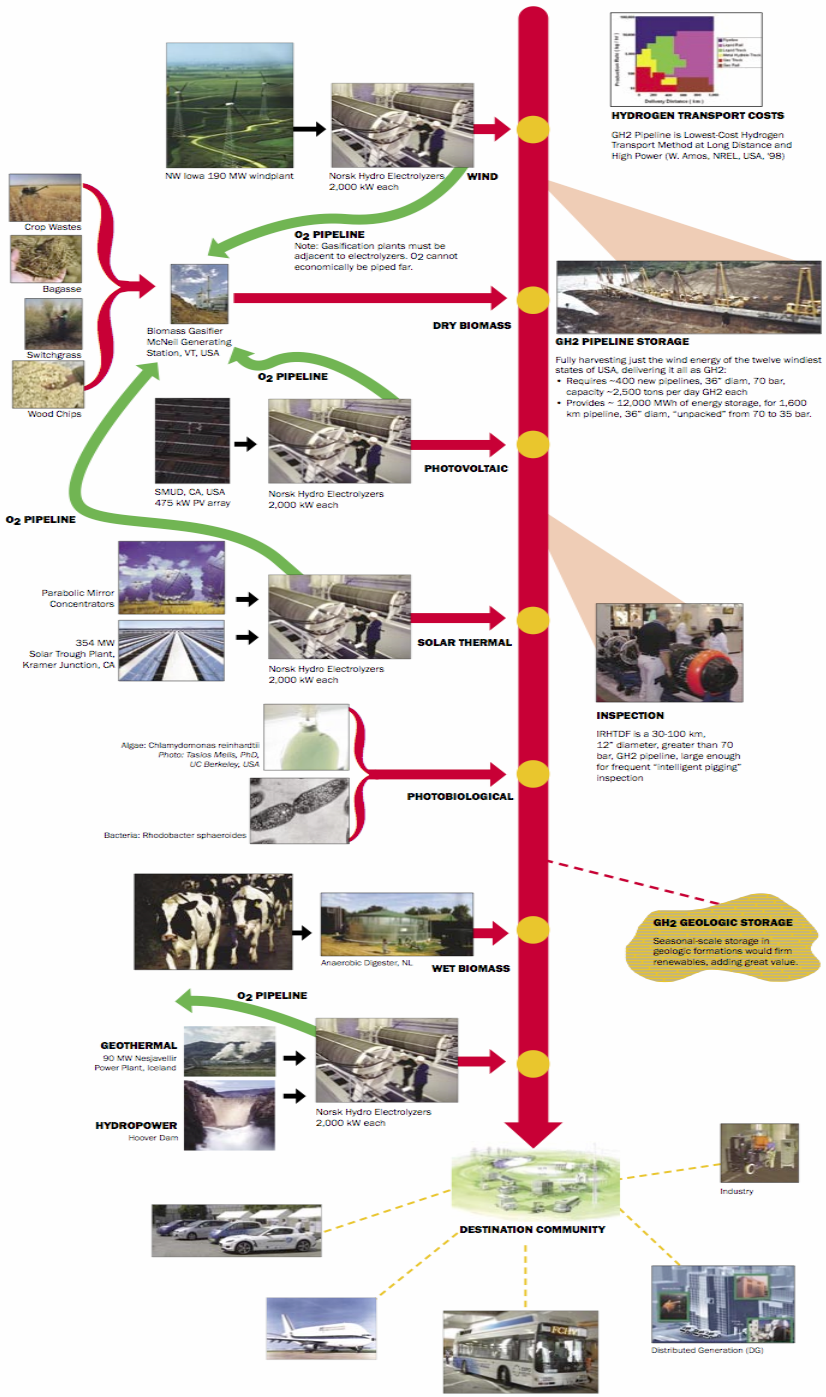

Hydrogen “sector”
Back-up Power System
Fleet Fueling
Community Fueling
Home Fueling
Industrial Application
Hydrogen “sector” of a benign, sustainable, equitable, global energy economy


Now Leasing !
F-CELL
BlueEFFICIENCY
Mercedes B-Class Hydrogen-fueled Fuel Cell
CA leases; Dec ’10 delivery; free fuel

AWEA 20% Wind by 2030



Wind Potential ~= 3,000 GW

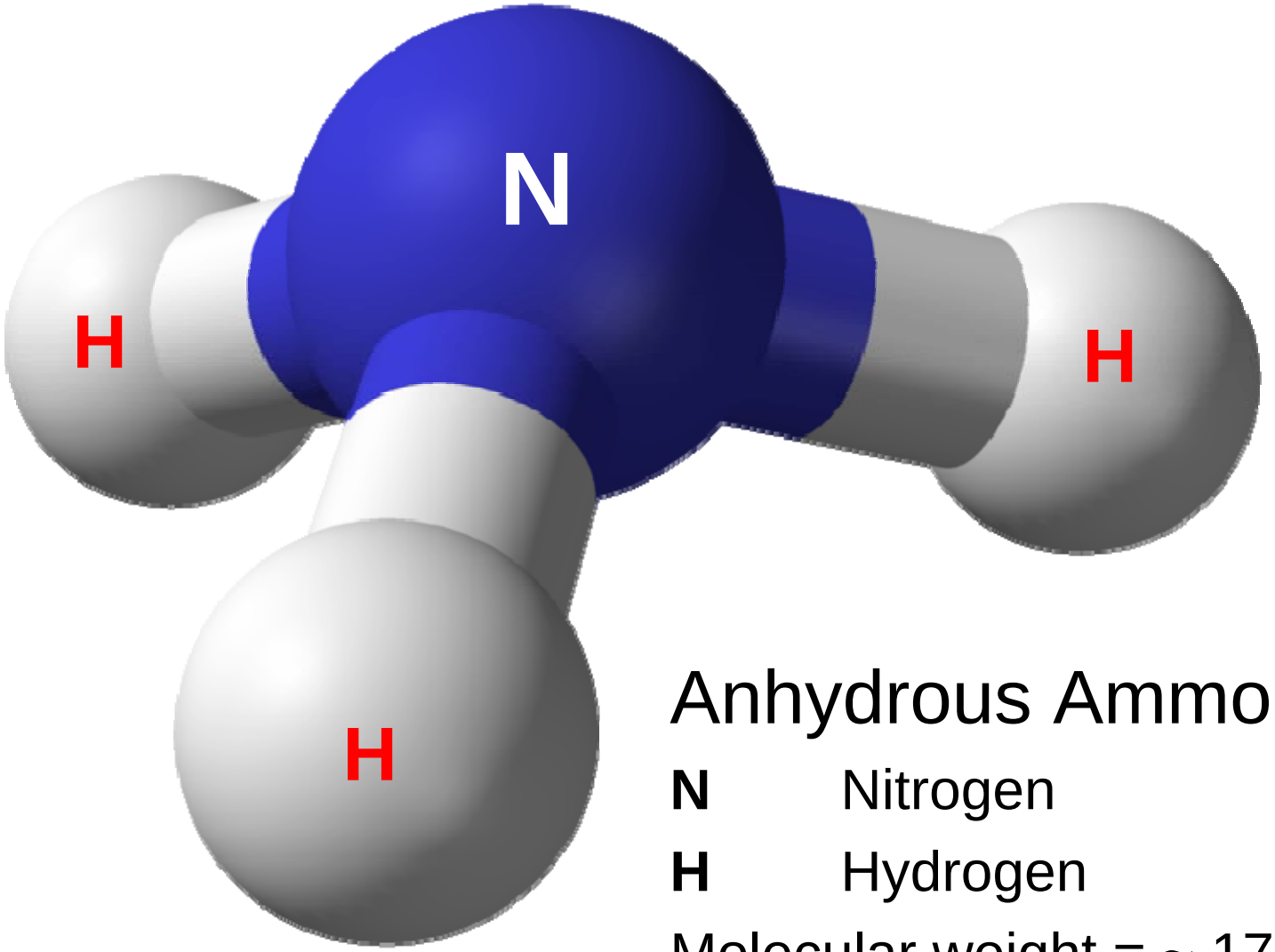


International Renewable Hydrogen Transmission Demonstration Facility

(IRHTDF)

Pilot plant

Global opportunity: IPHE project



Anhydrous Ammonia **NH_3**

N Nitrogen

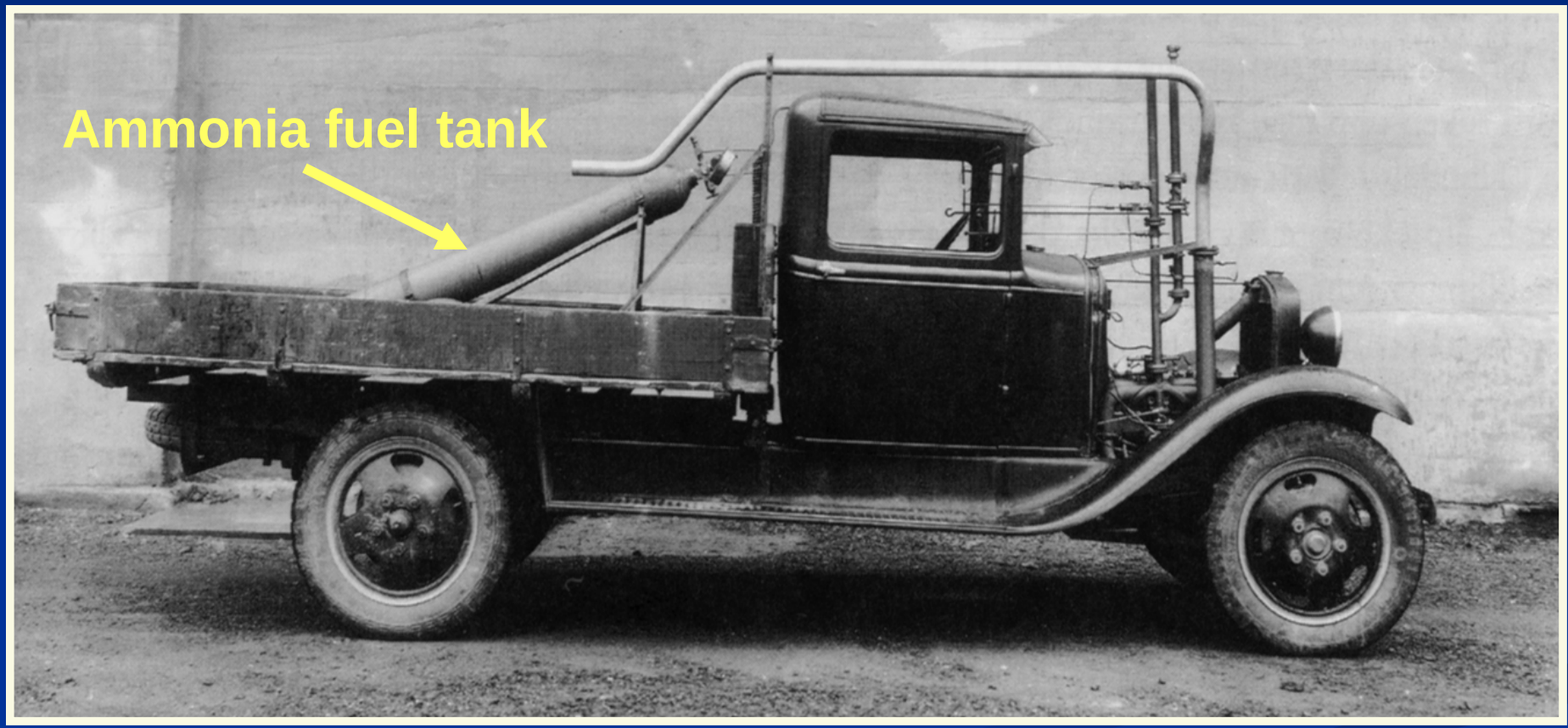
H Hydrogen

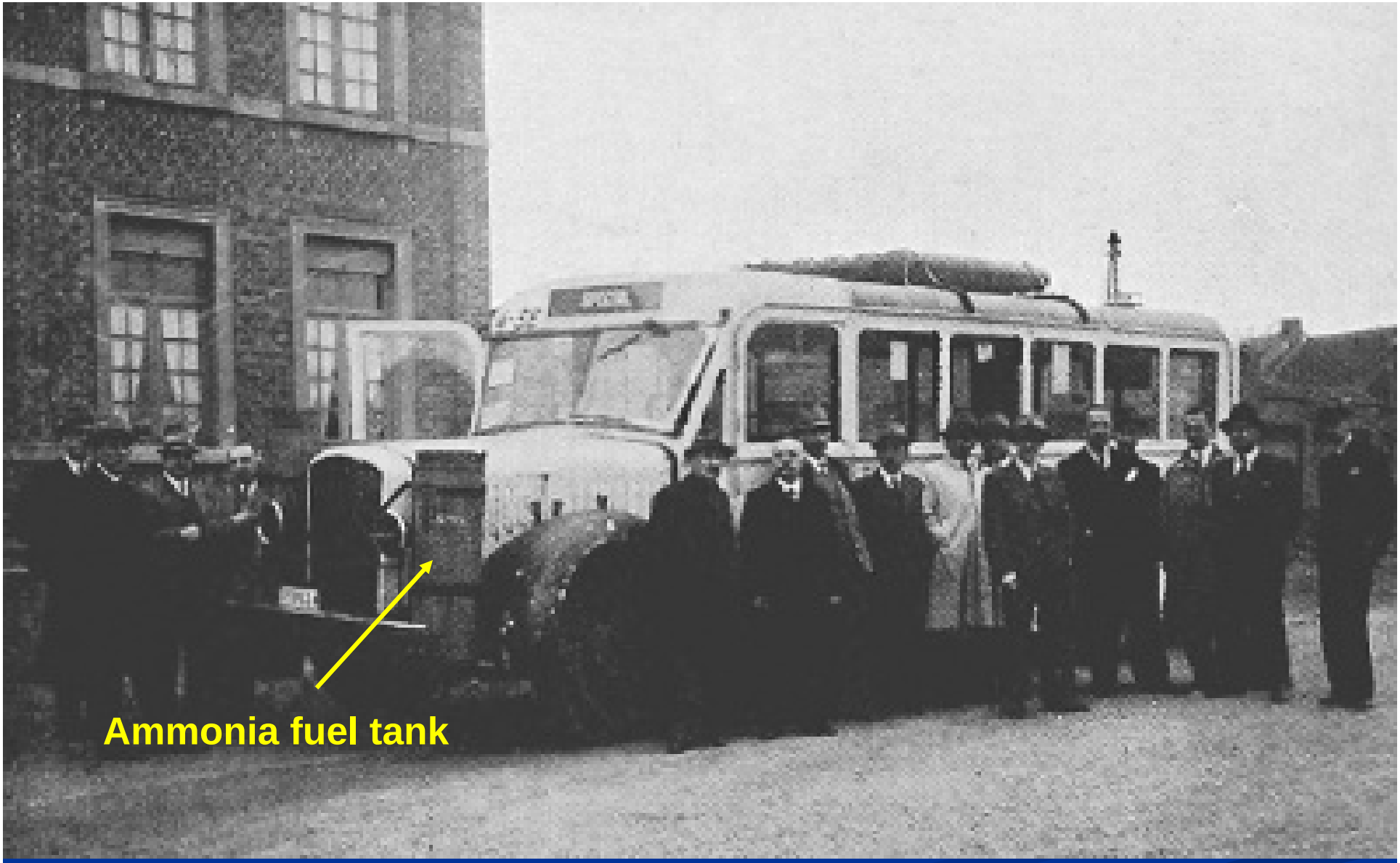
Molecular weight = ~ 17

18% **H** by weight: “other hydrogen”

$NH_3 + O_2 = N_2 + H_2O$

Ammonia fueled – Norway 1933





Belgium, 1943

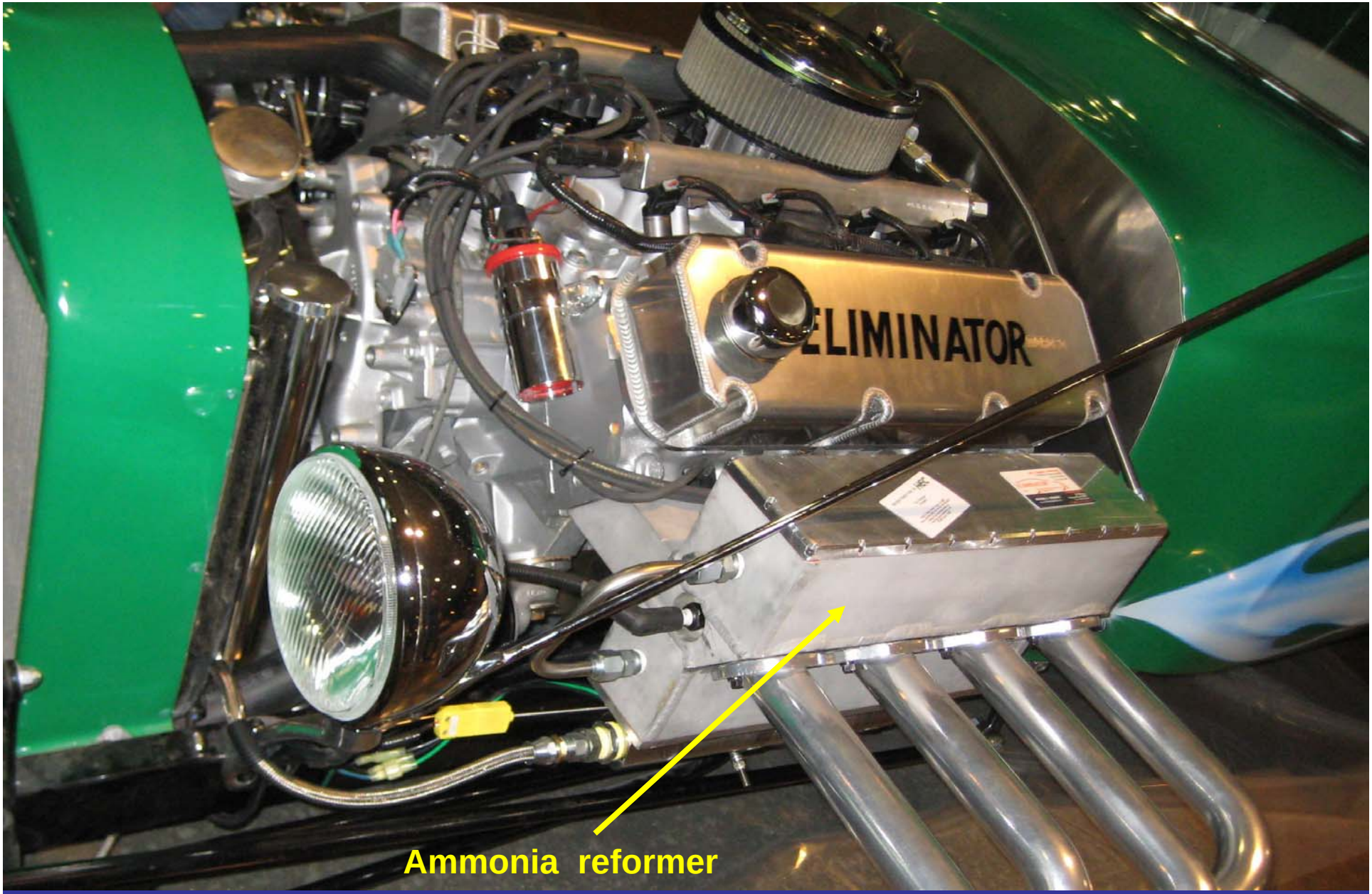
Ammonia Fueled Bus: Thousands of Problem-free Miles

X-15 rocket plane: NH3 + LOX fuel

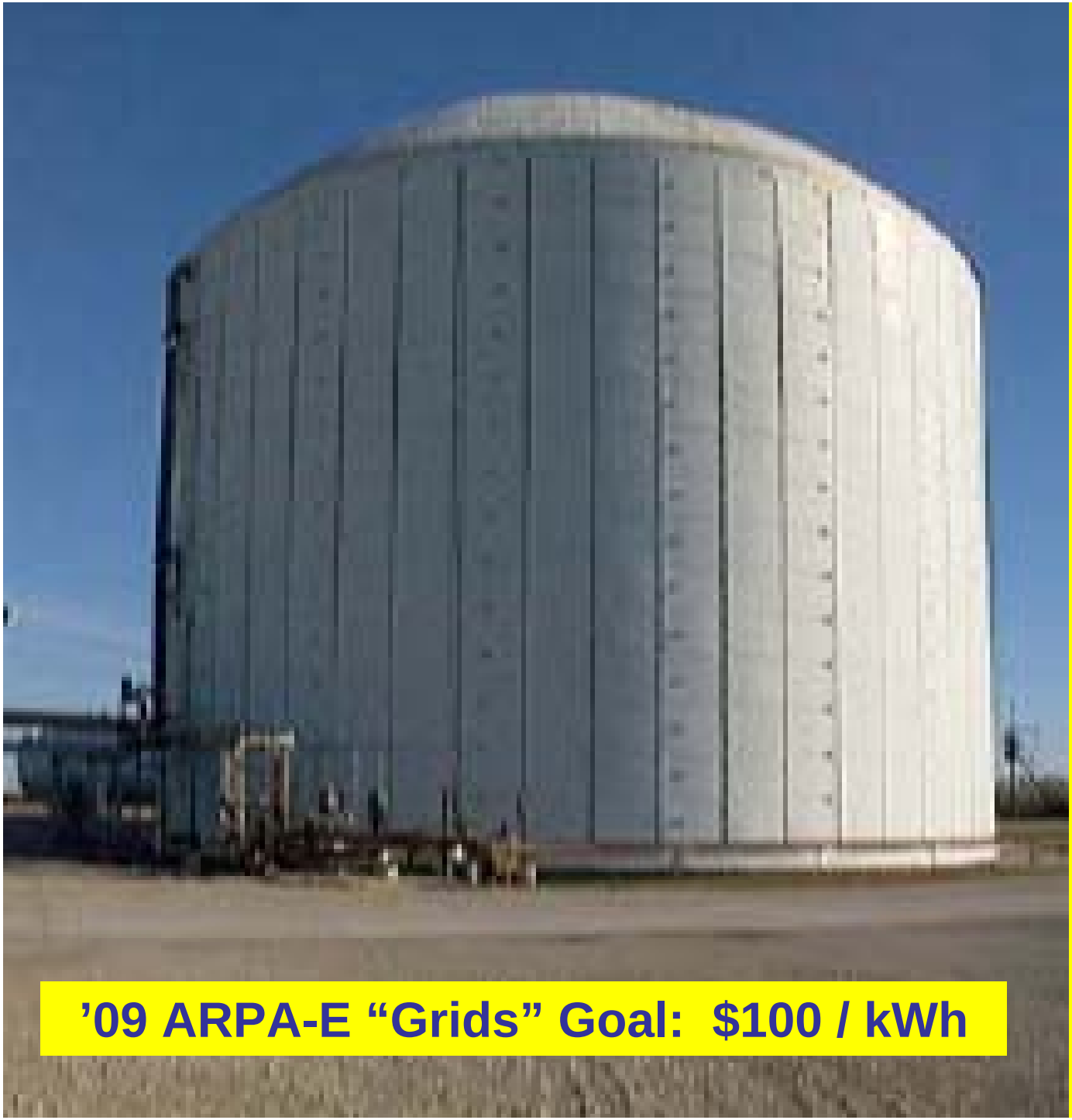
Mach 6.7 on 3 Oct 67

199 missions between 1959 and 1968

’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



’09 ARPA-E “Grids” Goal: $100 / kWh

“Atmospheric” Liquid Ammonia Storage Tank (corn belt)

30,000 Tons

190 GWh

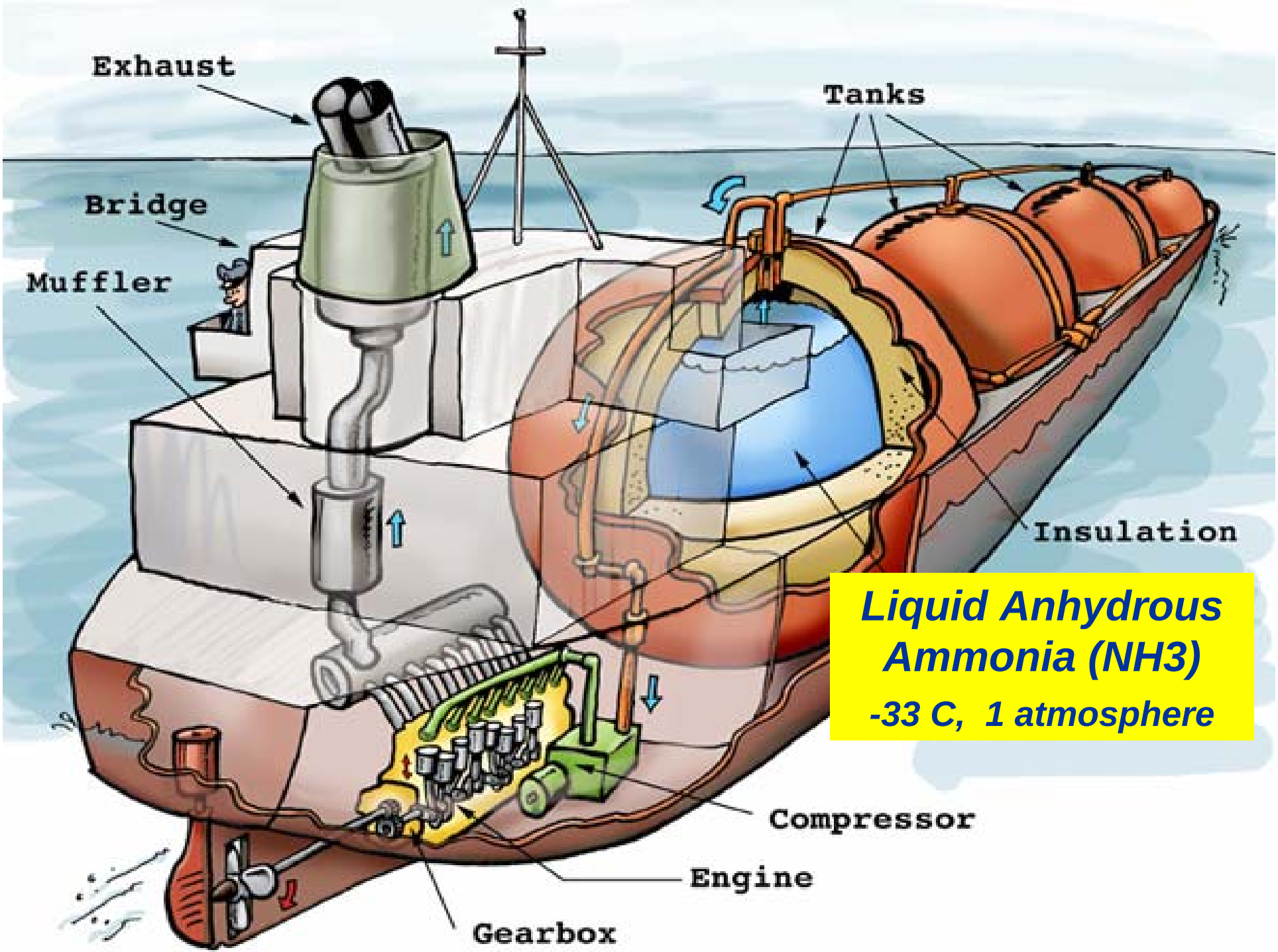
$ 15M turnkey

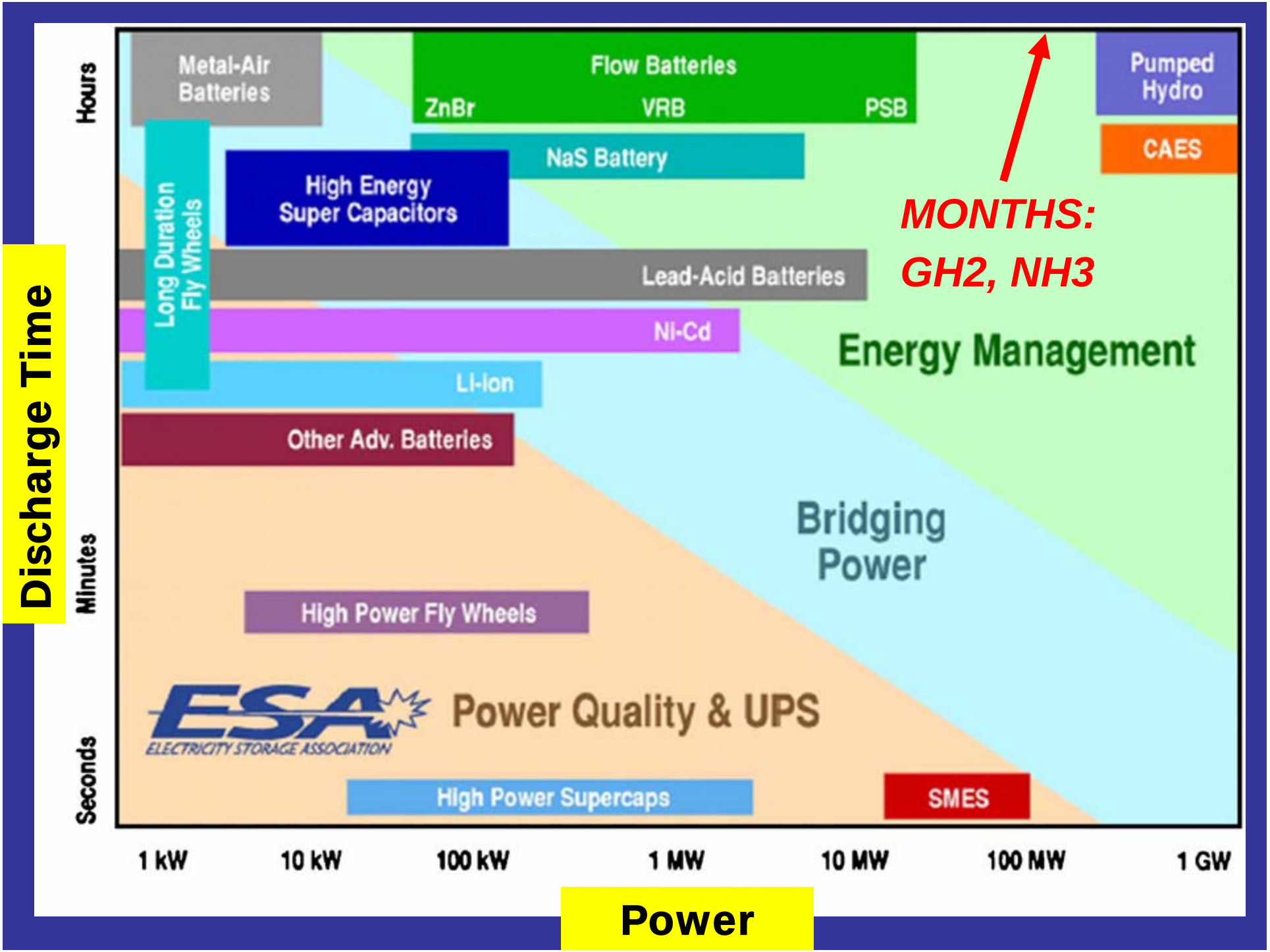
$ 80 / MWh

$ 0.08 / kWh

-33 C

1 Atm


Exhaust
Tanks
Bridge
Muffler
Insulation
Liquid Anhydrous Ammonia (NH3)
-33 C, 1 atmosphere
Compressor
Engine
Gearbox


Discharge Time
Hours
Minutes
Seconds
Metal-Air Batteries
Flow Batteries
ZnBr
VRB
PSB
Pumped Hydro
CAES
NaS Battery
High Energy Super Capacitors
Long Duration Fly Wheels
MONTHS:
GH2, NH3
Lead-Acid Batteries
Ni-Cd
Energy Management
LI-ion
Other Adv. Batteries
Bridging Power
High Power Fly Wheels
ESA
ELECTRICITY STORAGE ASSOCIATION
Power Quality & UPS
High Power Supercaps
SMES
1 kW
10 kW
100 kW
1 MW
10 MW
100 MW
1 GW
Power

Capital Cost per GW-mile

Electricity :	KV	Capacity MW	$M / GW-mile
• SEIA:	765	5,000	1.3
	345	1,000	2.6
• AEP-AWEA	765	5,000	3.2
Consensus ?			2.5
• Atlantic Wind Connection (Google)			2.8

Hydrogen pipeline:

36”, 100 bar, 500 miles, no compress 0.3

Ammonia pipeline:

10” , liquid, 500 miles, with pumping 0.2

Response to Climate Change:

- **New Myth**
- **Run World on Renewables**
- **Beyond Electricity**
- **Identification: Earth**
- **Hope, responsibility**

MUST Run the World on Renewables – plus Nuclear ?

1. **Rapid climate change**
2. **Biodiversity loss**
3. **Sea level rise**
4. **Ocean acidification**
5. **Extraction dangers**
6. **Finite resources: Peak oil, gas, coal**
7. **Energy security**
8. **Population & demand growth**
9. **Fairness: other humans, species**
10. **Trade balance; imports cost**
11. **Cheap insurance**
12. **Big business opportunity**

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

but only after they have tried everything else ”

Winston Churchill


Bill Leighty
BSEE ’65
MBA ’71
www.leightyfoundation.org/earth.php
DVD’s available
Philosophers, like vegetables,
are profoundly influenced
by their environment.

MUST Run the World on Renewables – plus Nuclear ?

1. **Rapid climate change**
2. **Biodiversity loss**
3. **Sea level rise**
4. **Ocean acidification**
5. **Extraction dangers**
6. **Finite resources: Peak oil, gas, coal**
7. **Energy security**
8. **Population & demand growth**
9. **Fairness: other humans, species**
10. **Trade balance; imports cost**
11. **Cheap insurance**
12. **Big business opportunity**

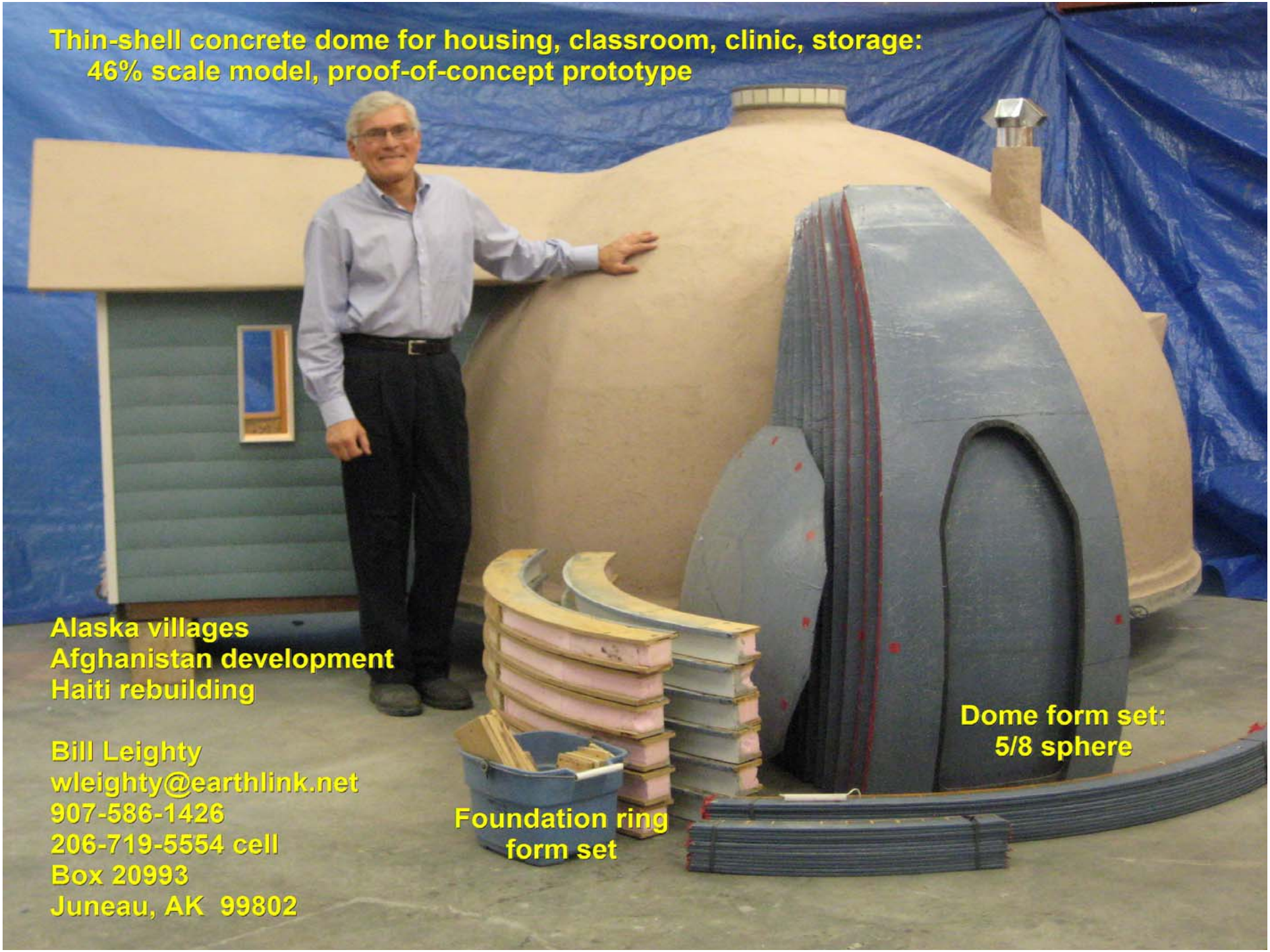
End presentation 22 Oct 10
Stanford Class of ’65 Panel

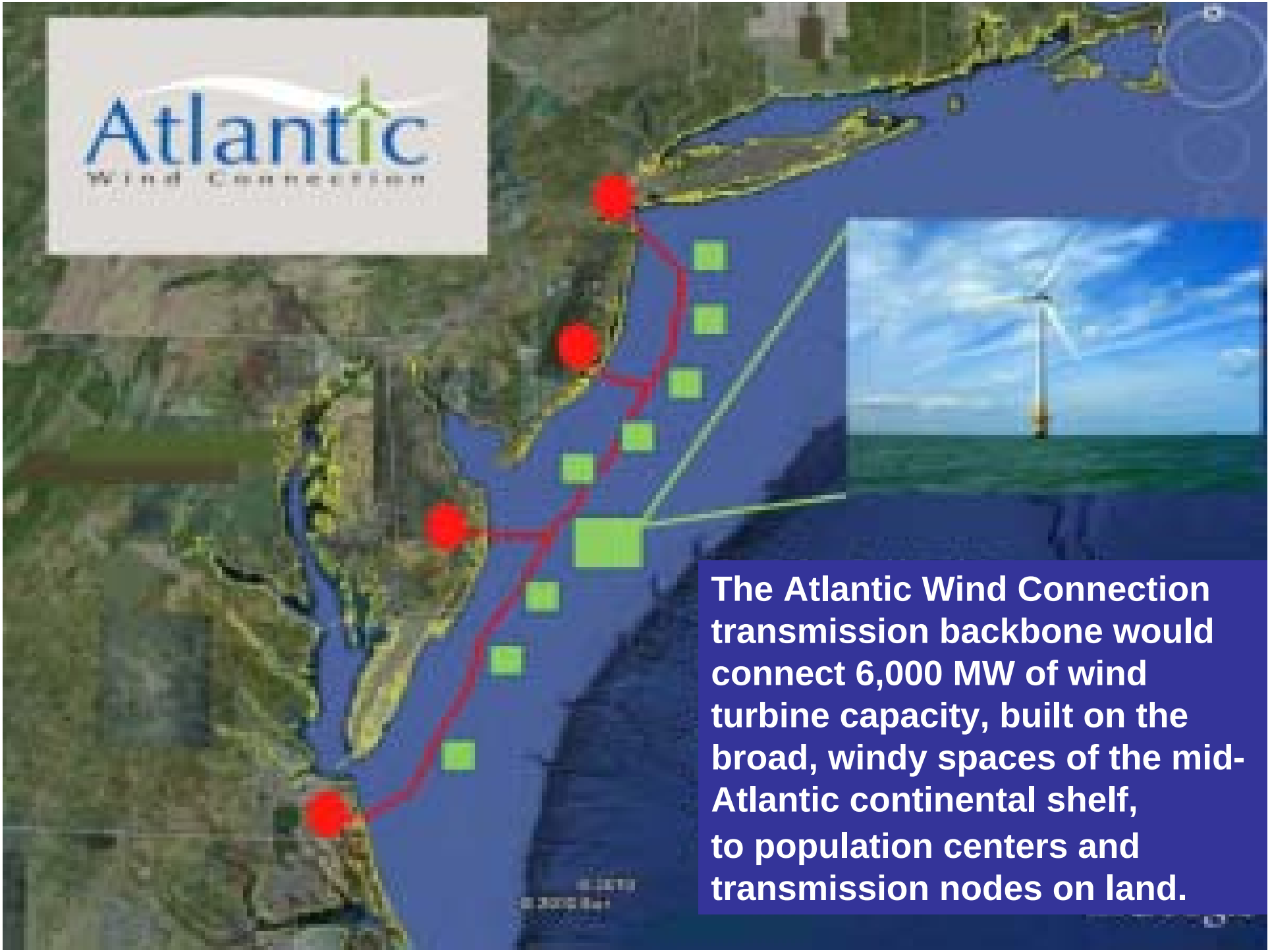
"Risks and Responses to Global Climate Change“

1300 - 1445, Pigott Theater, Memorial Auditorium

Panelist Bill Leighty
wleighty@earthlink.net
907-586-1426 cell 206-719-5554
www.leightyfoundation.org/earth.php

The following slides are supplemental


Thin-shell concrete dome for housing, classroom, clinic, storage:
46% scale model, proof-of-concept prototype
Alaska villages
Afghanistan development
Haiti rebuilding
Bill Leighty
wleighty@earthlink.net
907-586-1426
206-719-5554 cell
Box 20993
Juneau, AK 99802
Foundation ring
form set
Dome form set:
5/8 sphere


Atlantic
Wind Connection
The Atlantic Wind Connection transmission backbone would connect 6,000 MW of wind turbine capacity, built on the broad, windy spaces of the mid-Atlantic continental shelf, to population centers and transmission nodes on land.

Proposed ANS* Gas Pipeline

"ALCAN" Alaska Highway Route

TransCanada Pipelines

* Alaska North Slope

Svante Arrhenius

Sweden

1905
Nobel Prize
Chemistry

Proved CO_2 is heat-trapping gas in 1896

Ilya Prigogine

1977 Nobel Prize, Chemistry

- Surprisingly alive
- Twitchy, searching, self aware
- Self-destruct ?
- Self-shaking to higher ground

Sir William Grove 1839

Electrochemical Engine

demonstrates fuel cell:

H2 to electricity, with catalyst

Sadi Carnot

1796 - 1832

Thermodynamics:

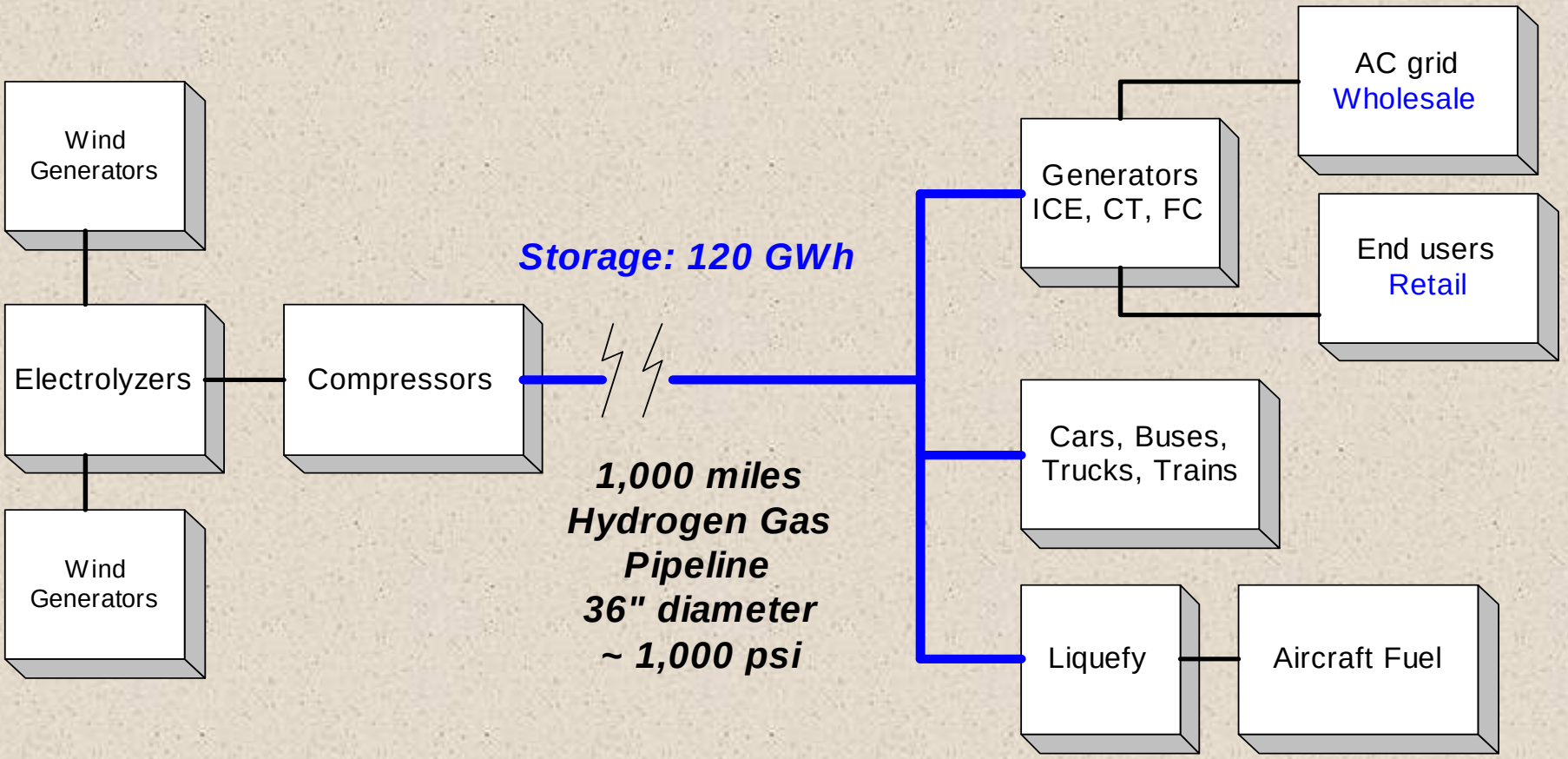
Heat engines;

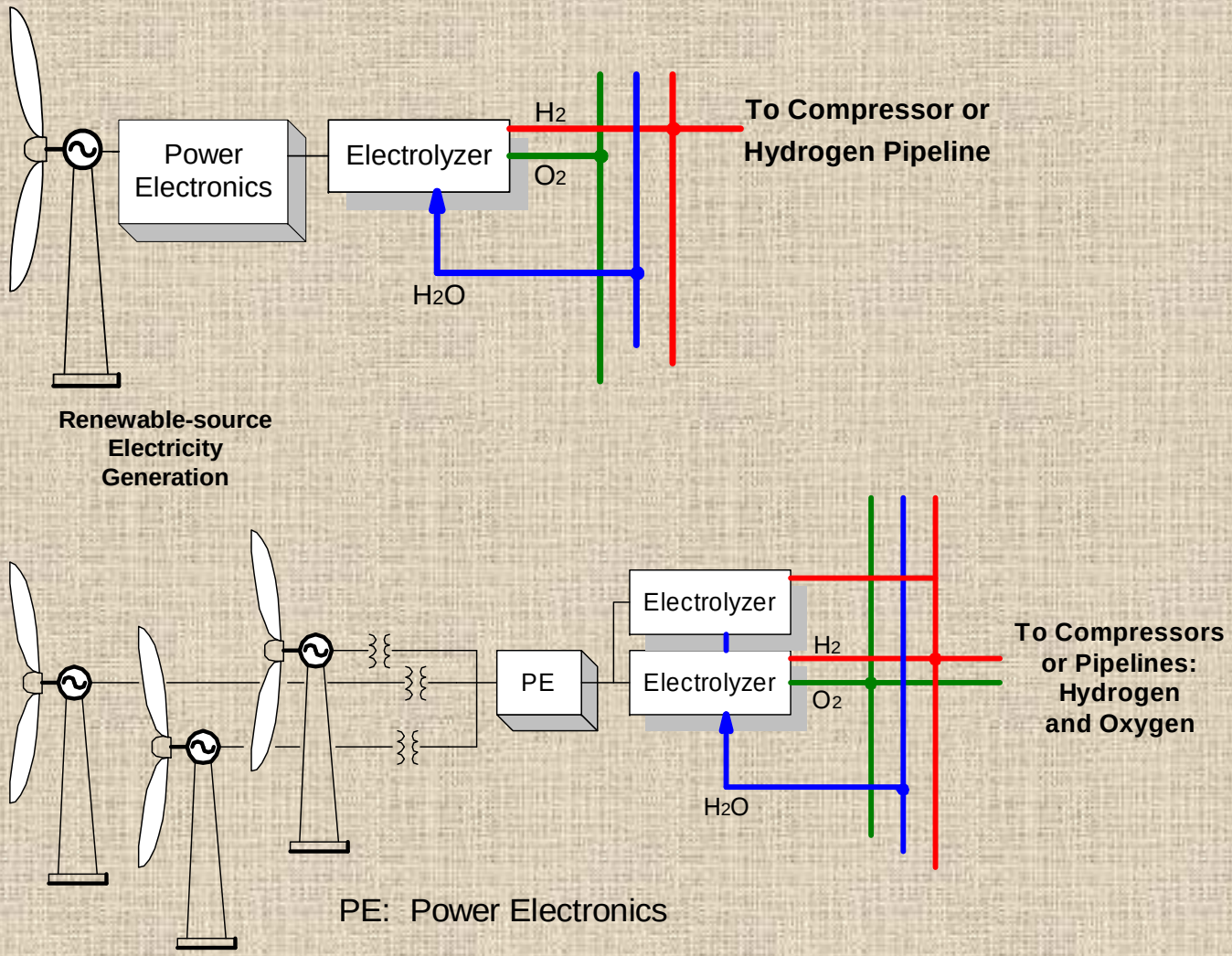
Efficiency limits


SILENT
SPRING
RACHEL
CARSON

Hydrogen Transmission Scenario

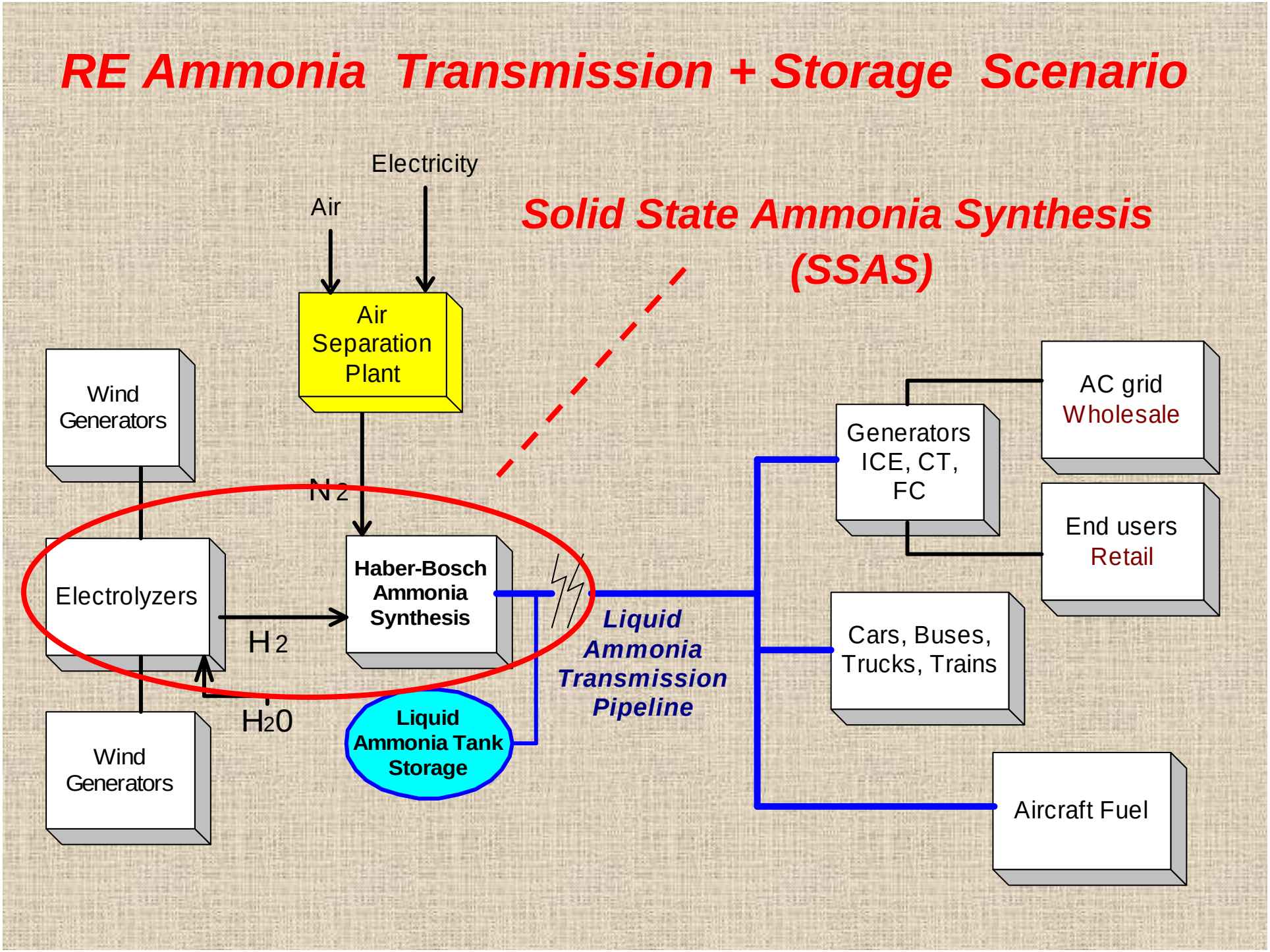
- *Low-pressure electrolyzers*
- *"Pack" pipeline: ~ 120 GWh*





Topology Options: H_2 and O_2 Production and Gathering from Renewable Energy Generation

RE Ammonia Transmission + Storage Scenario



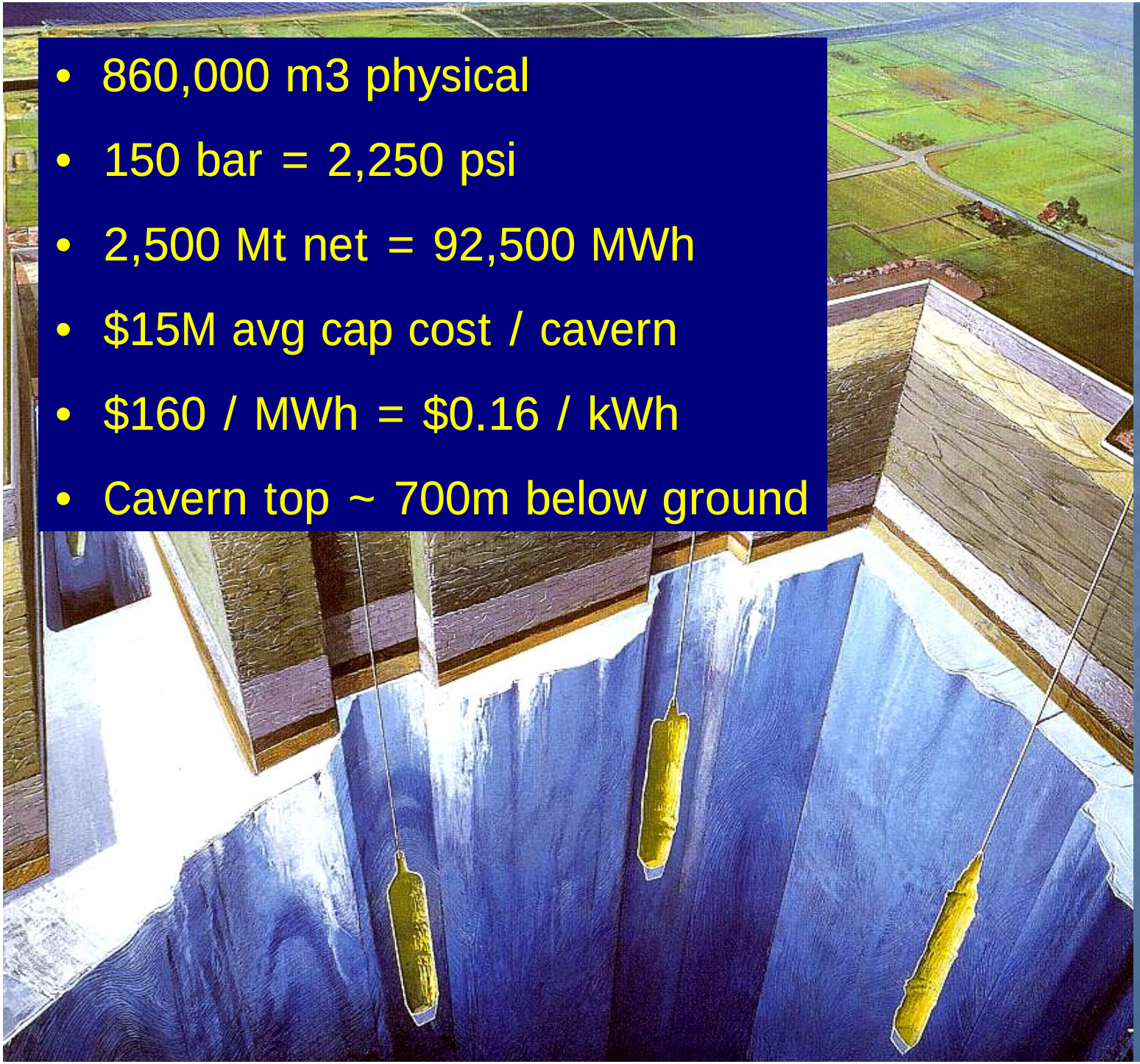
Exporting From 12 Windiest Great Plains States

Number of GH2 pipelines or HVDC electric lines necessary to export total wind resource

Wind energy source: PNL-7789, 1991

*** at 500 miles average length**

State	AEP, TWh	Wind Gen MW (nameplate) (40% CF)	6 GW 36" GH2 export pipelines	$ Billion Total Capital Cost *	3 GW export HVDC lines	$ Billion Total Capital Cost *
North Dakota	1,210	345,320	50	50	100	60
Texas	1,190	339,612	48	48	100	60
Kansas	1,070	305,365	43	43	100	60
South Dakota	1,030	293,950	41	41	100	60
Montana	1,020	291,096	41	41	90	54
Nebraska	868	247,717	35	35	80	48
Wyoming	747	213,185	30	30	70	42
Oklahoma	725	206,906	29	29	60	36
Minnesota	657	187,500	26	26	60	36
Iowa	551	157,249	22	22	50	30
Colorado	481	137,272	19	19	40	24
New Mexico	435	124,144	17	17	40	24
TOTALS	9,984	2,849,316	401	$ 401	890	$ 534



- 860,000 m3 physical
- 150 bar = 2,250 psi
- 2,500 Mt net = 92,500 MWh
- $15M avg cap cost / cavern
- $160 / MWh = $0.16 / kWh
- Cavern top ~ 700m below ground

Domal Salt Storage Caverns

Texas

“Clemens Terminal” Conoco Phillips 20 years

Praxair ‘07

PB ESS