Nuclear Energy in the Generation Mix of the Future

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Entergy Nuclear

Tulane Engineering Forum

June 2, 2006, New Orleans

Entergy

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Earth at night NASA

A Unique Perspective

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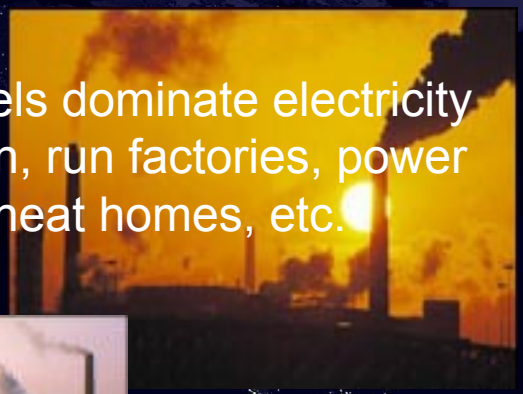
Our planet today

Population ~ 6 Billion

GHG Emissions (per capita)
North America → 54 kg
Europe & Japan →23 kg
China → 6 kg

Fossil Fuels dominate electricity generation, run factories, power vehicles, heat homes, etc.



25 Billion Tons Of CO_2 Into The Atmosphere Per Year

Consumption & Emission Rates Will Increase With Economic Development And Growth

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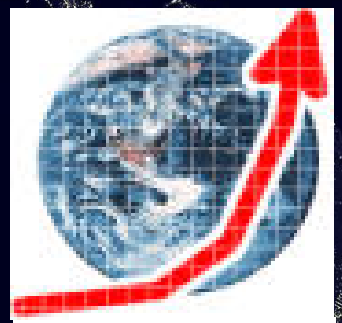
To Stabilize GHGs → 50% - 75% Reduction in Global Emissions

Our next century

50 Years . . . . .

Economies Will Grow
Developing Countries Will Evolve

~ 9 Billion



Population

~ 6 Billion

By 2050 Global Energy Consumption Will Double

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The global challenge

It took us 125 years to use the first trillion barrels of oil…We'll use the next trillion in 30 years

The world consumes two barrels of oil for every barrel discovered

Oil production is in decline in 33 of the 48 largest oil producing countries

www.willyoujoinus.com

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The global challenge

In the Next 50 Years . . . . .

More Energy Will Be Consumed Than In All Previous History

GHG Emissions Could Double

<u>Our Challenge</u> - To Produce Clean Energy On A Global Scale.

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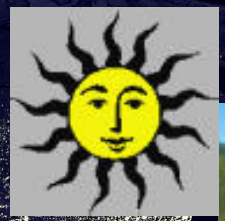
Renewables

"Clean Energy"



Solar

Biomass

Wind

Renewable Development Must Be Strongly Supported

Geothermal

<u>Realistic Perspective</u> – Collective impact will be quite limited – for decades to come. OECD projects less than 3% of world electricity demand at peak.

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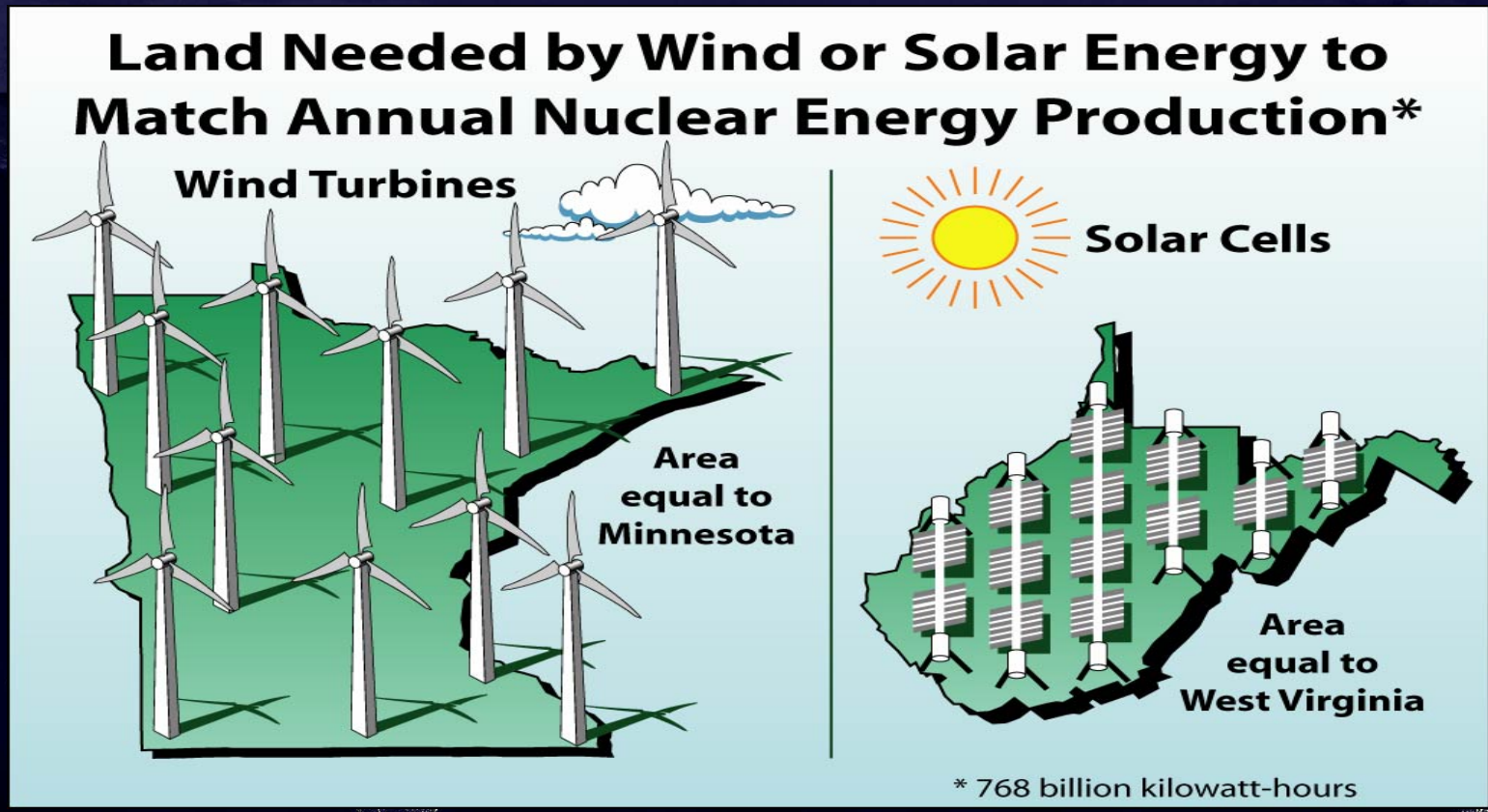
Reality of renewables



Want energy from renewables?
Add more states!

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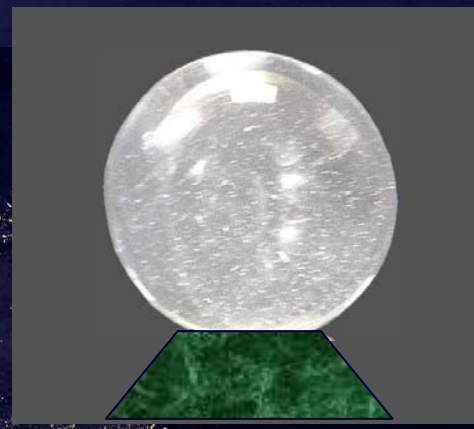
Entergy does not have a crystal ball



But we do know

- **World needs more energy**
- **Finite supply of conventional oil and gas**
- **Stricter environmental regulations**
- **America needs energy security/diversity**

Nuclear energy's potential is not fully exploited

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Nuclear: A realistic option?

Consider:

- **Nuclear is the largest source of emission-free electric energy**
- **Nuclear is among the lowest-cost energy**
- **Nuclear fuel costs are stable and a relatively small component of production cost**
- **Nuclear's safety record is second to none**

The answer is YES!

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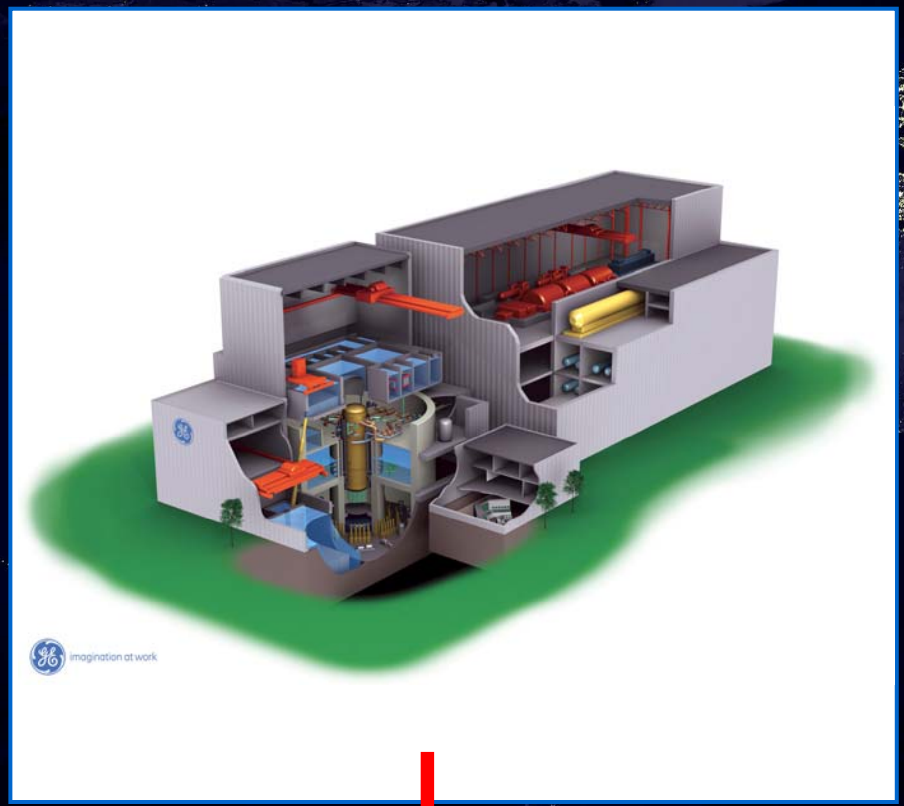
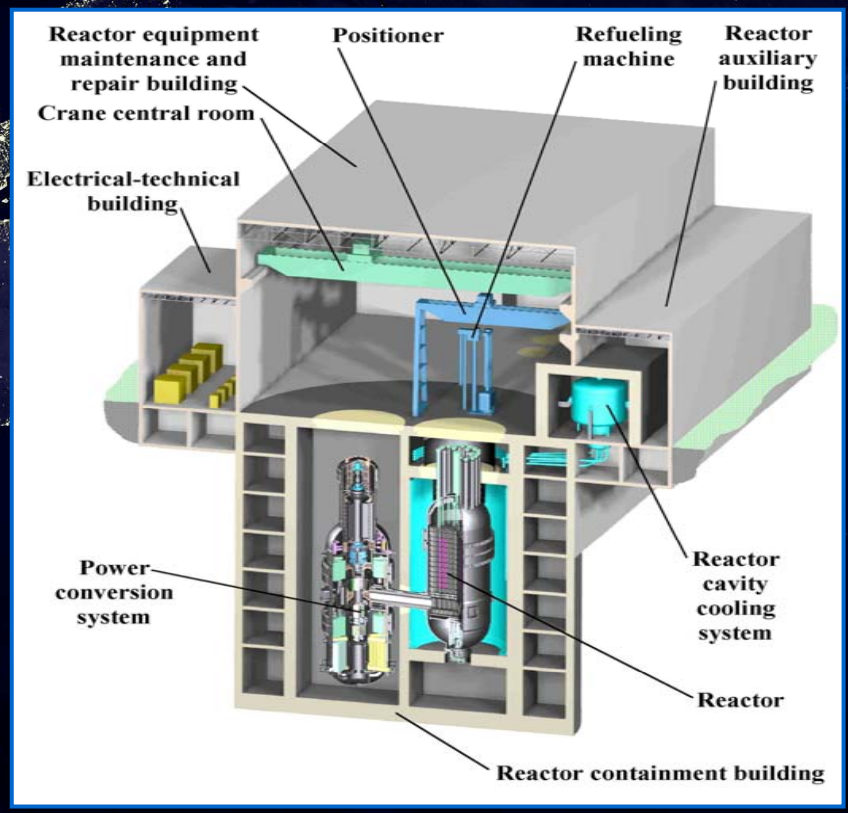
Entergy's 2-track approach

Advanced Light Water Reactor



High Temperature Gas-Cooled Reactor



2005 2010 2015 2020 2025 2030 2035 2040 2045 2050

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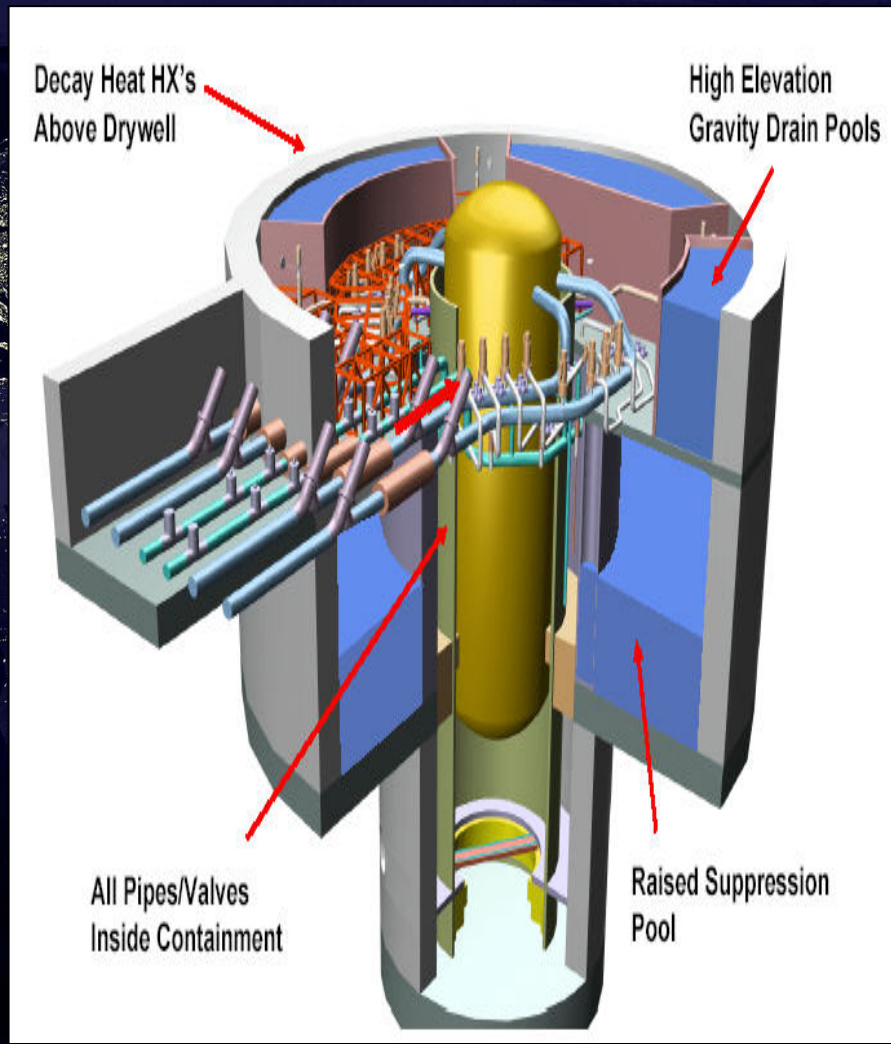
ESBWR: Design Highlights

- 25% Less Equipment
  - Cost Less to build
  - Cost less to operate
- Passive Safety Technology
  - No Active Safety Systems
  - Offsite Power Not Required
  - EDGs Not Safety Related
  - Operator Action Not Required
- 4500 MWt → 1500-1600 MWe
- Optimized Design Features
  - No Recirc Pumps (Natural Circulation)
  - Digital Control Technology
  - Fiber Optic Cabling
  - Enhanced Stability
  - Greater Safety Margins



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NuStart: 12 industry leaders

NuStart Energy℠

- *Constellation*
- *EDF International NA*
- *Exelon Generation*
- *Progress Energy*
- *Southern Company*
- *GE*
- *Duke Energy*
- *Entergy Nuclear*
- *Florida P&L*
- *SCE&G*
- *TVA*
- *Westinghouse*

Greater than 60% of US Nuclear Operators

WWW.nustartenergy.com

Develop 2 technologies anyone can build

- *GE Economic Simplified Boiling Water Reactor (ESBWR)*
- *Westinghouse Advanced Passive 1000*

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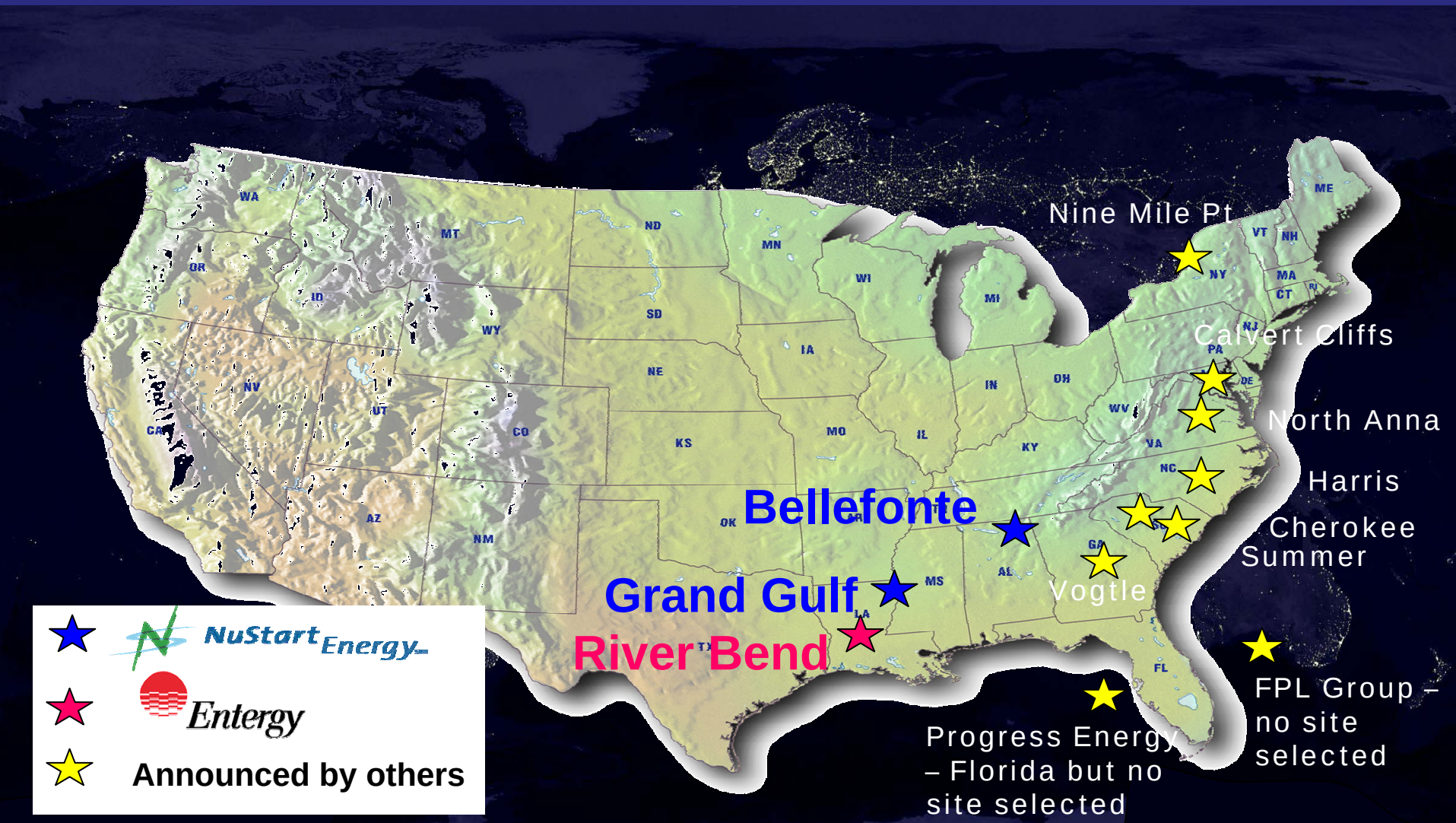
Where the new units will be



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The 300-pound gorilla

Transportation

- **Now consumes more than 20% of world's energy**
  - **28% of total energy in U.S.**
- **By 2010:**
  - **India will have 36 times more cars than in 1990**
  - **China will have 91 times more cars than in 1990**
- **In U.S., cars and light trucks are responsible for a third of all CO_2 emissions**
  - **1,934 million metric tons a year**

What's Nuclear's role in the hydrogen economy?

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Hydrogen today

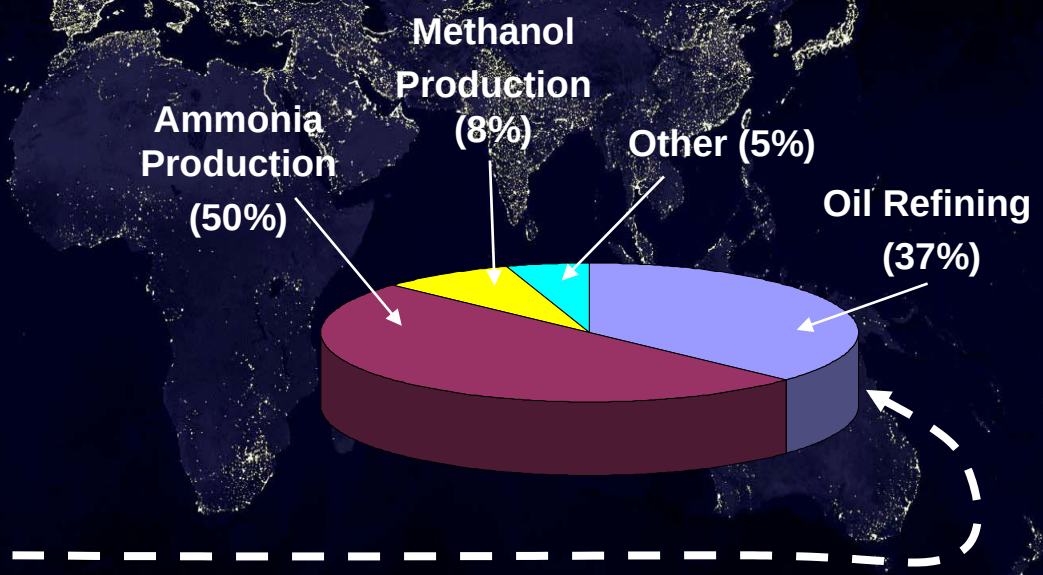
Source: Salomon Smith Barney, EIA, EPRI

World Consumption → 45 MM Tons/yr

- ~96% Produced by Steam Methane Reforming
- Releases 320 MM tons of CO_2/yr

US Consumption → 11 MM Tons/yr

- ~96% Produced by SMR
- Releases 74 MM tons of CO2/yr
- Consumes 5% of US NG Supply



Liquid Fuel Production is Rapidly Becoming Major Market for H_2

10% Annual Growth

A bridging market For deployment of nuclear is hydrogen.

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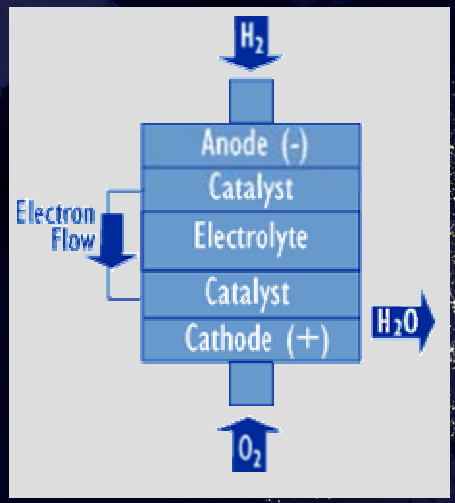
Hydrogen's promise

A Clean "Abundant" Fuel

Clean Transportation

Fuel Cell



Stationary Applications In Home & Industry

"Micro" Applications

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. . . Store Enormous Quantities Of "Electricity" For Use On Demand

Hydrogen is versatile

Multiple Sources & Applications

Biomass

Hydro
Wind
Solar

Nuclear

Oil

Coal

Natural Gas

Sequestration

H_2

Transportation

Stationary - Commercial, Residential

Micro Apps

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Makes Sense Only If Hydrogen Is Produced With Non-GHG Emitting Processes

Getting hydrogen from nuclear

- **Conventional Electrolysis (A Proven Technology)**
  - Overall Efficiency ~24% (LWR), ~ 36% (HTGR)
- **High Temperature Electrolysis (HTE)**
  - > 50% Efficiency
- **Thermo-Chemical Water-Splitting ⇒ *Developing Technologies***
  - Set Of Chemical Reactions That Use Heat To Decompose Water Into H_2 & O_2
  - Overall Efficiency ~ 50%
  - Requires Generation IV Or High Temperature Gas Reactors
  - Several Cycles under Consideration – Sulfur Iodine, Calcium Bromine, Copper Chlorine (ALTC), etc.
- **Steam Methane Reforming w/Nuclear Heat Source**
  - Transition to non-fossil fuel economy

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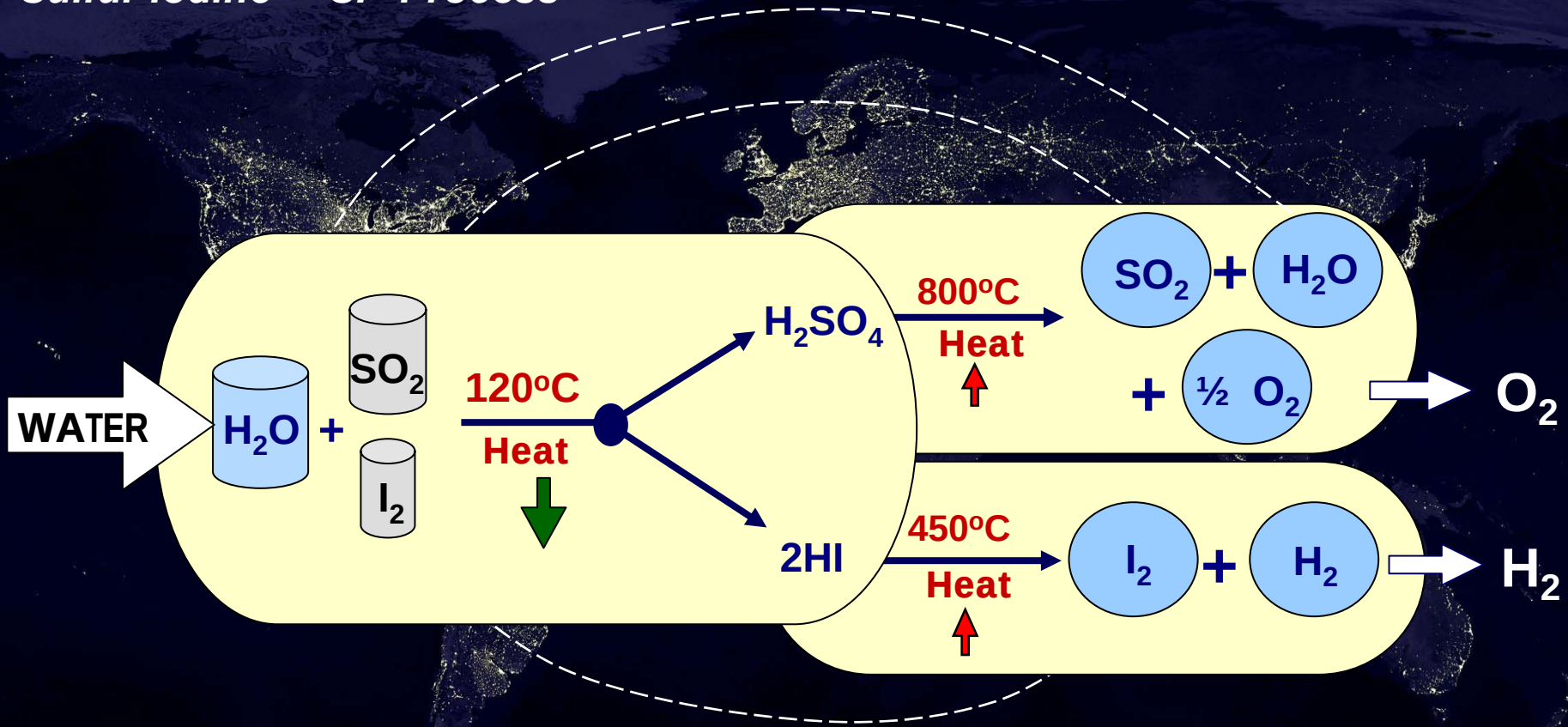
Thermo-chemical water splitting

Sulfur Iodine - "SI" Process



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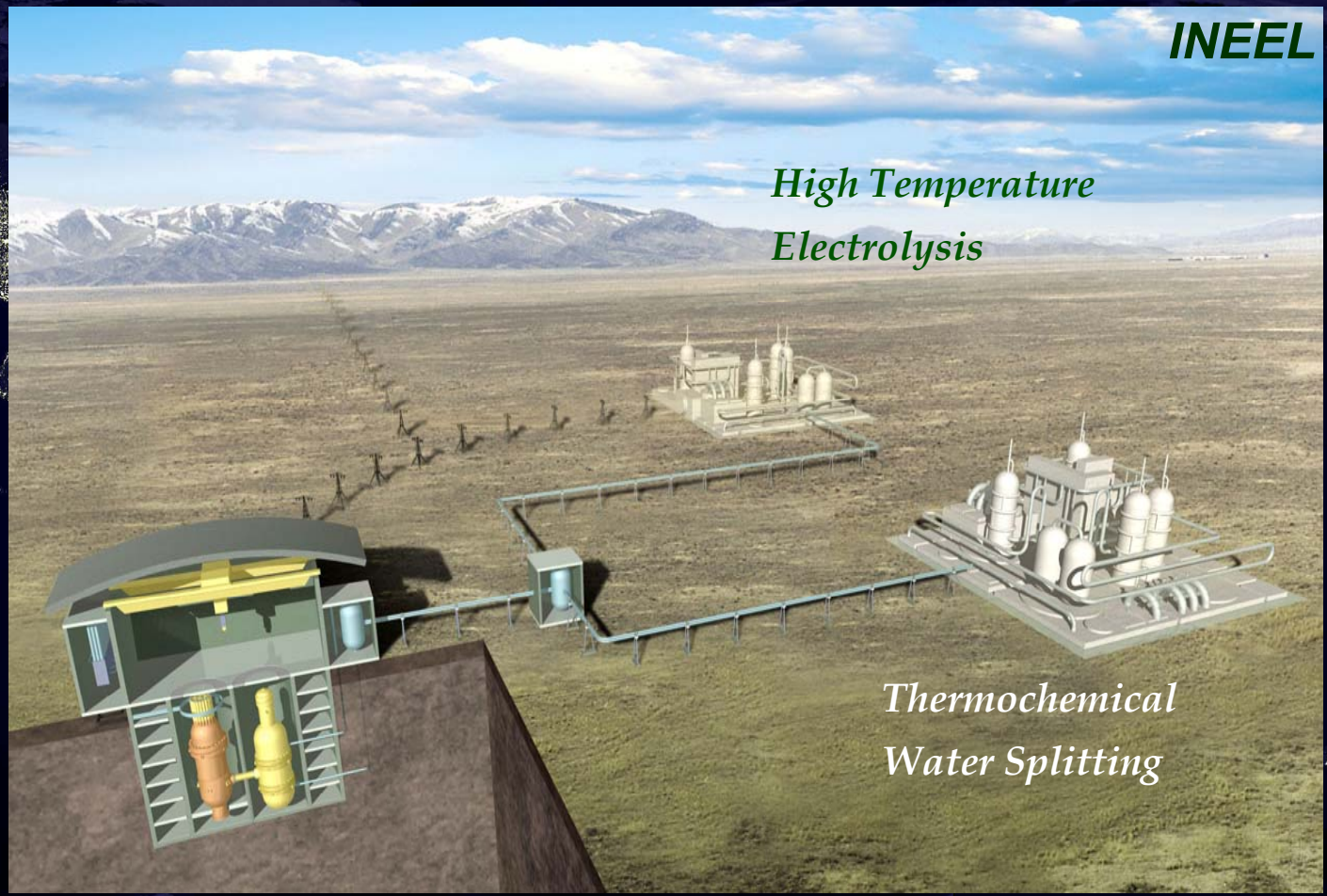
Efficiencies 47%- 53%

600 MWTh Module ⇒ ~200 Tons / Day

The Idaho National Lab project

"Artist's Conception"



NGNP Demo – 2015

Electricity & H_2 Production

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Nuclear: A promising potential

A Future Of Radical Change – Either In The Way We Produce Energy Or In The Health Of Our Planet

<u>Public Mandate</u> – for improved forms of energy that are safe, clean and diverse to ensure future generations' standard of living and the health of our environment

<u>Long Term Effort</u> – transformation from fossil based to hydrogen based economy is a 20 to 30 year effort

A "Bridge" – From Electric Energy Sector To The Larger Spectrum of Energy Use

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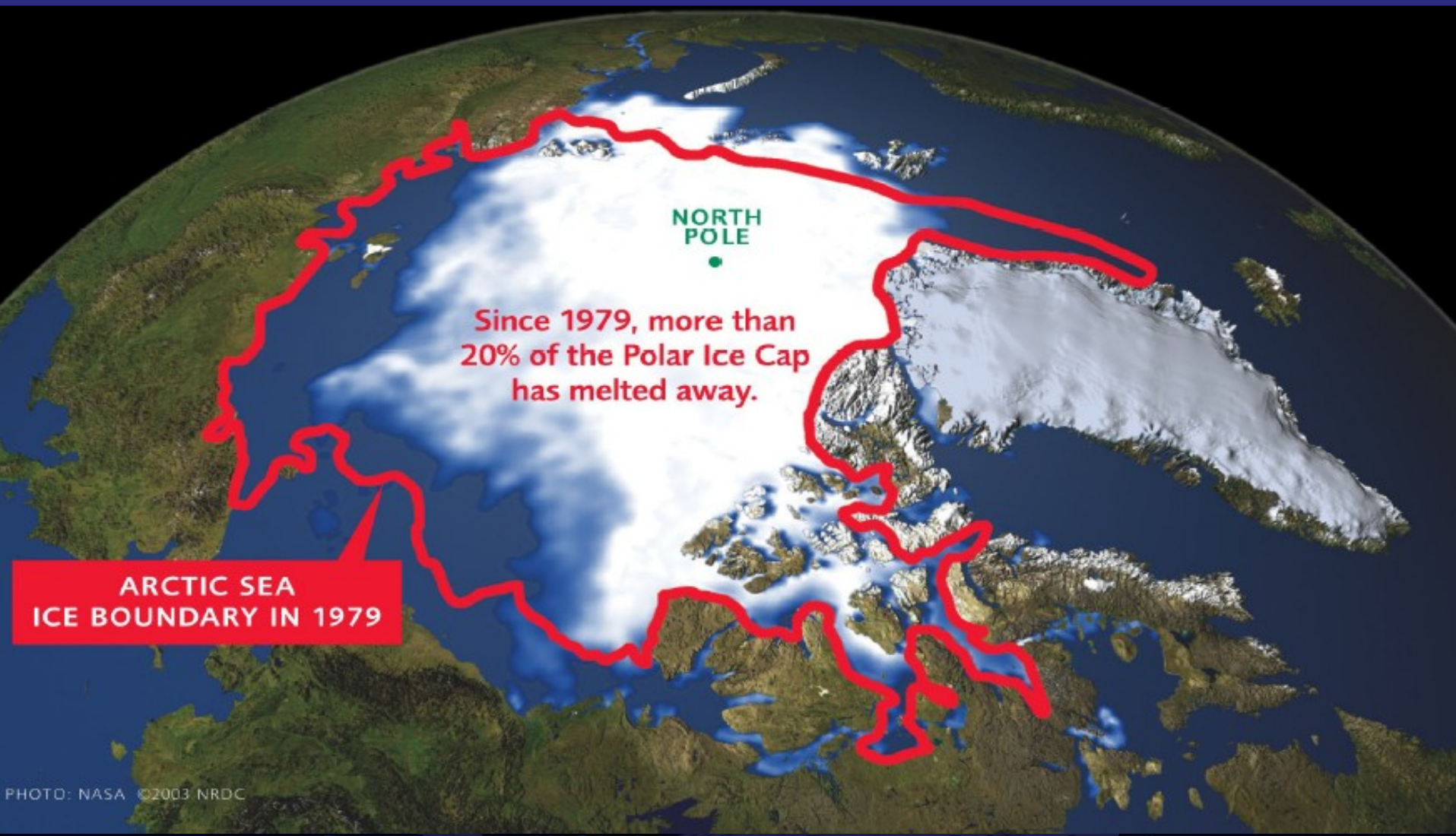
Future generations are counting on us ...
Can we afford to be wrong?



NASA photo, Natural Resources Defense Council

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