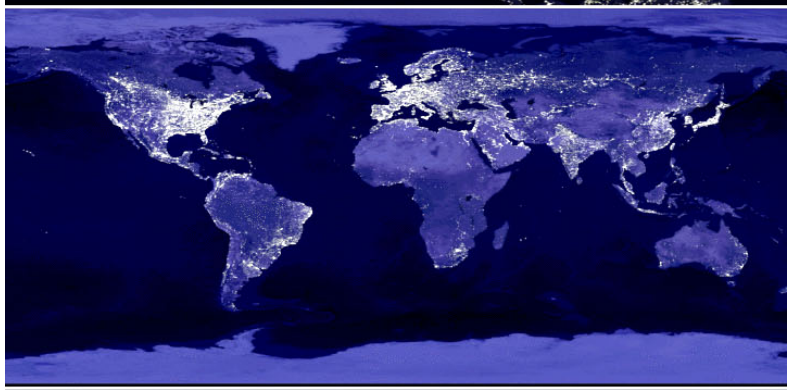


Future Energy

John Reinker

Sustainable Energy
Advanced Technology Leader

GE Global Research

GE's Commitment to Sustainable Energy Production … **ecomagination**

Deliver on Aggressive Goals

- 2X annual R&D spend ($1.5B)
- 1% absolute reduction in GHG emissions from current levels by 2012 … while GE growing +40%
- Improve energy efficiency of GE's operations 30% by 2012
- Revenue from "Eco" products and services … double by 2012
- Expand customer partnerships

Dynamics of Our Changing World …

Growing population & energy density

Cost of energy … fuel supply & demand

Increasing environmental requirements

Escalating security concerns

Heightened investor demands

Everyone Under Pressure

Dynamics of Our Changing World …

Everyone Under Pressure

Our purpose

Enable the energy industry to sustainably meet increasing challenges

… through technology

Town of Shenzhen in 1987

City of Shenzhen in 2001

Electrical Consumption Growing 16% Annually

Technology Drives Industry…

Today - 150 acres a day!

…Mid 1900's- 50 acres a day …

… 1900 - 5 acres a day ….

Prior to 1900 - 1 acre a day ….

Serving Our Global Customers

Customer Types

Utilities

Oil & Gas Companies

Industrial Customers

Governments

Consumers

Product Offering Examples

Gas Turbines

Steam Turbines

Wind Turbines

Hydro Plants

Coal Gasification

Nuclear Plants

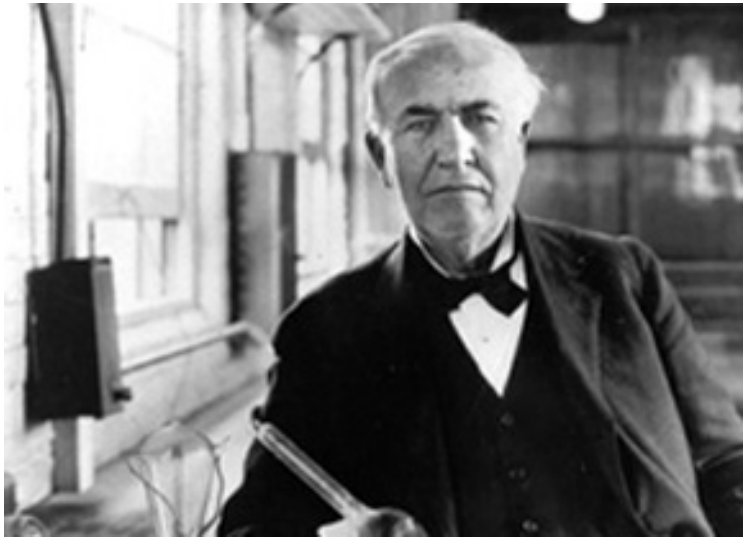
Solar Generation

Reciprocating Engines

Compressors

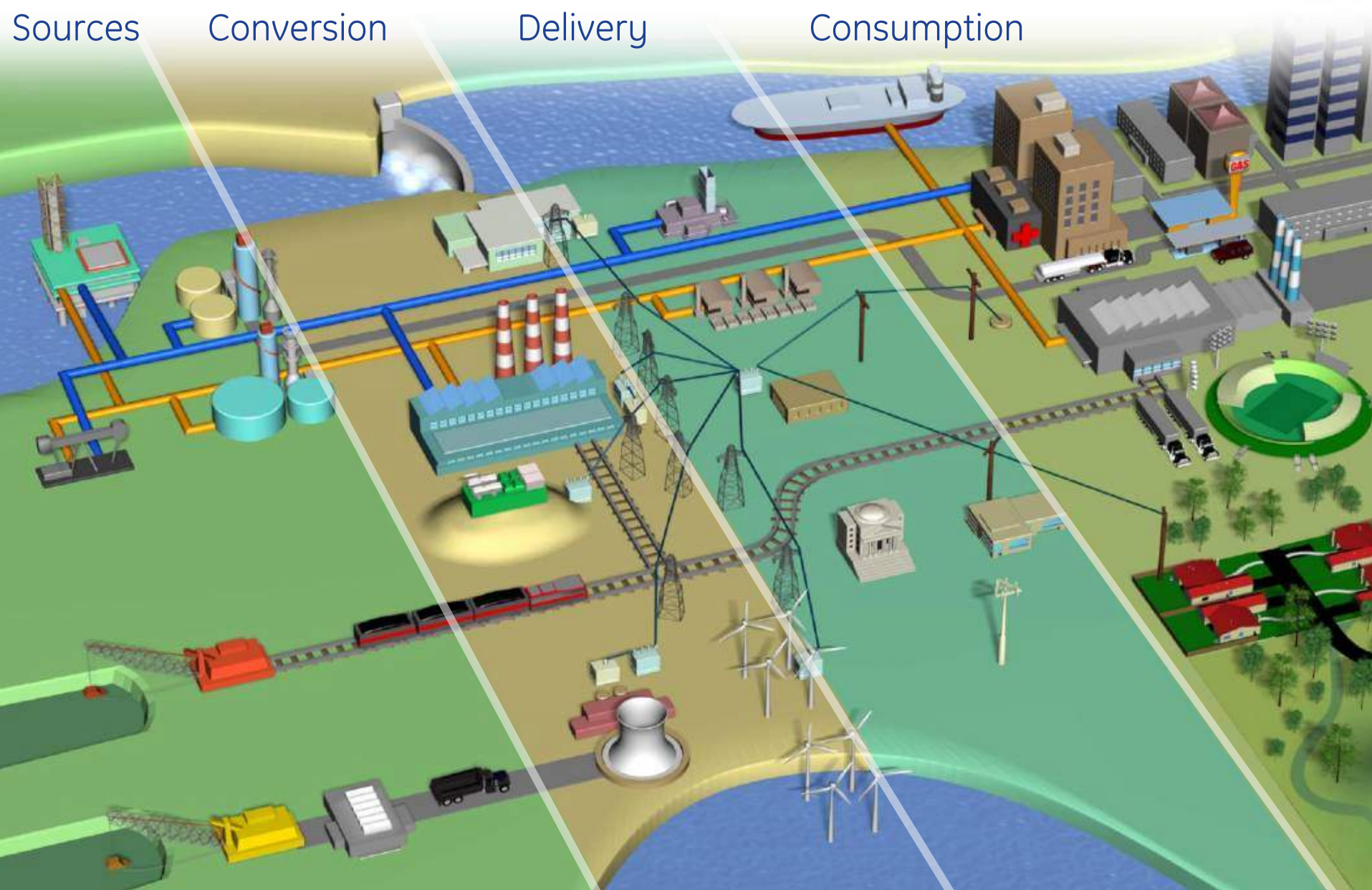
Installation and Service

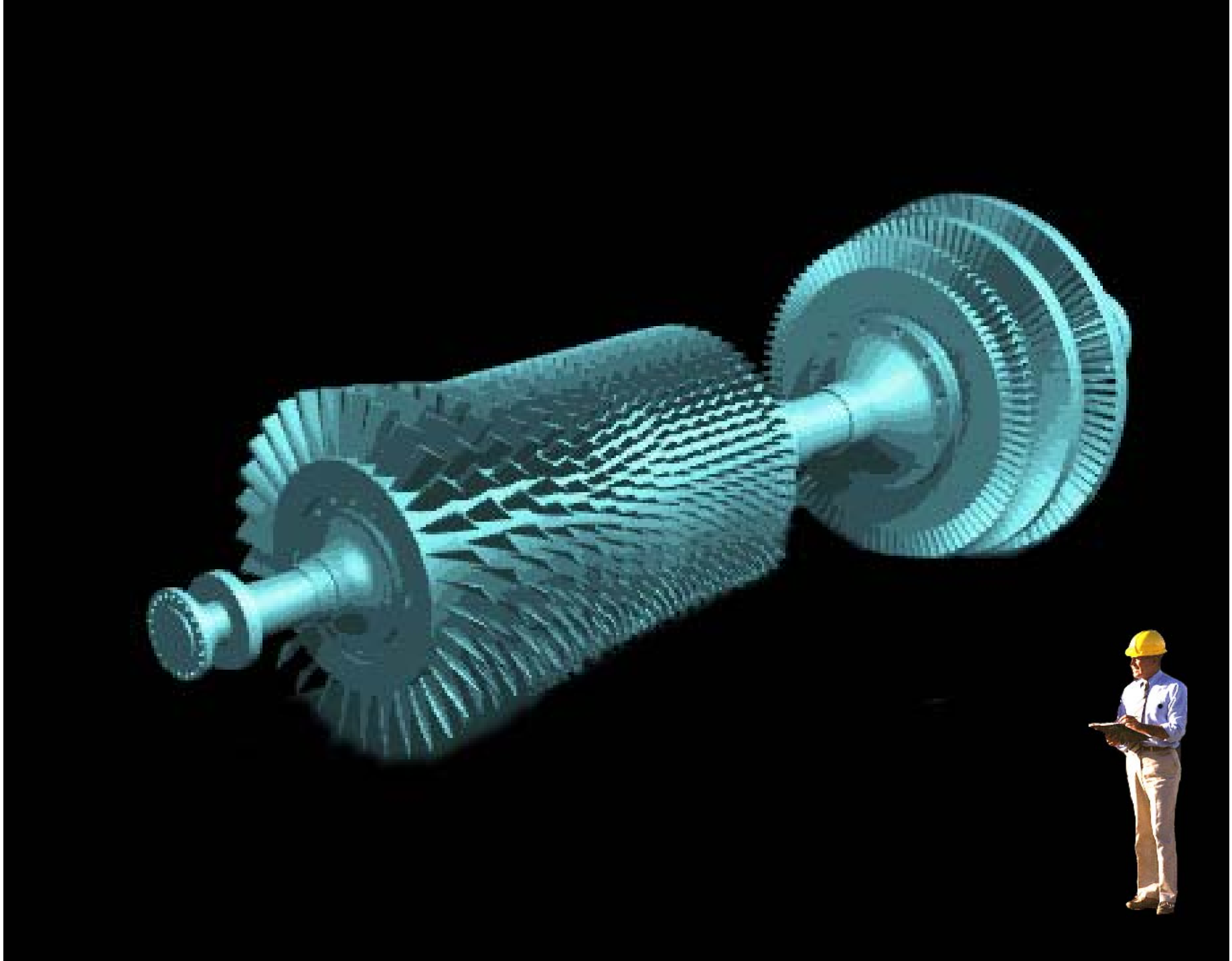
Edison's Footprint

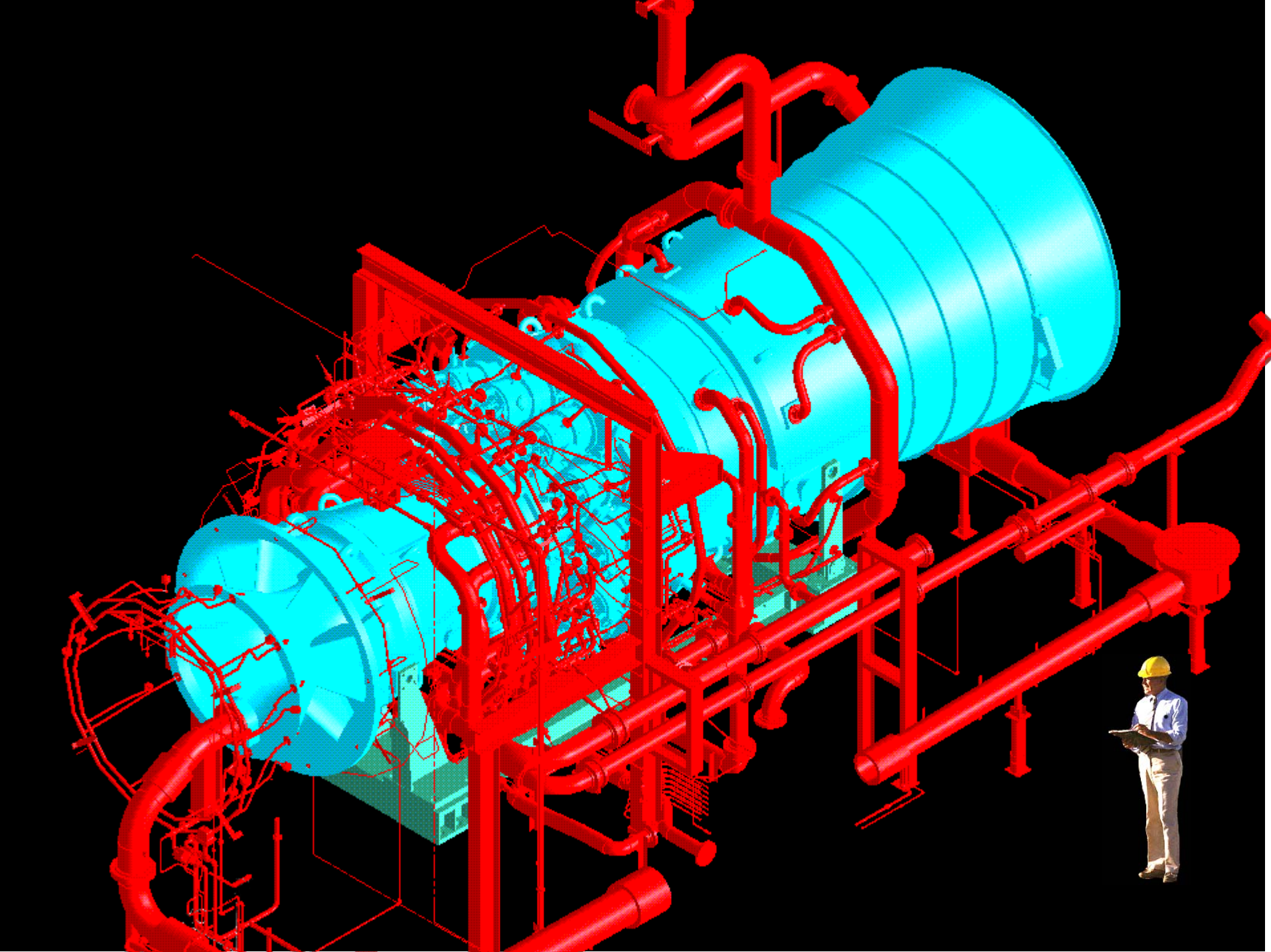


Energy Today

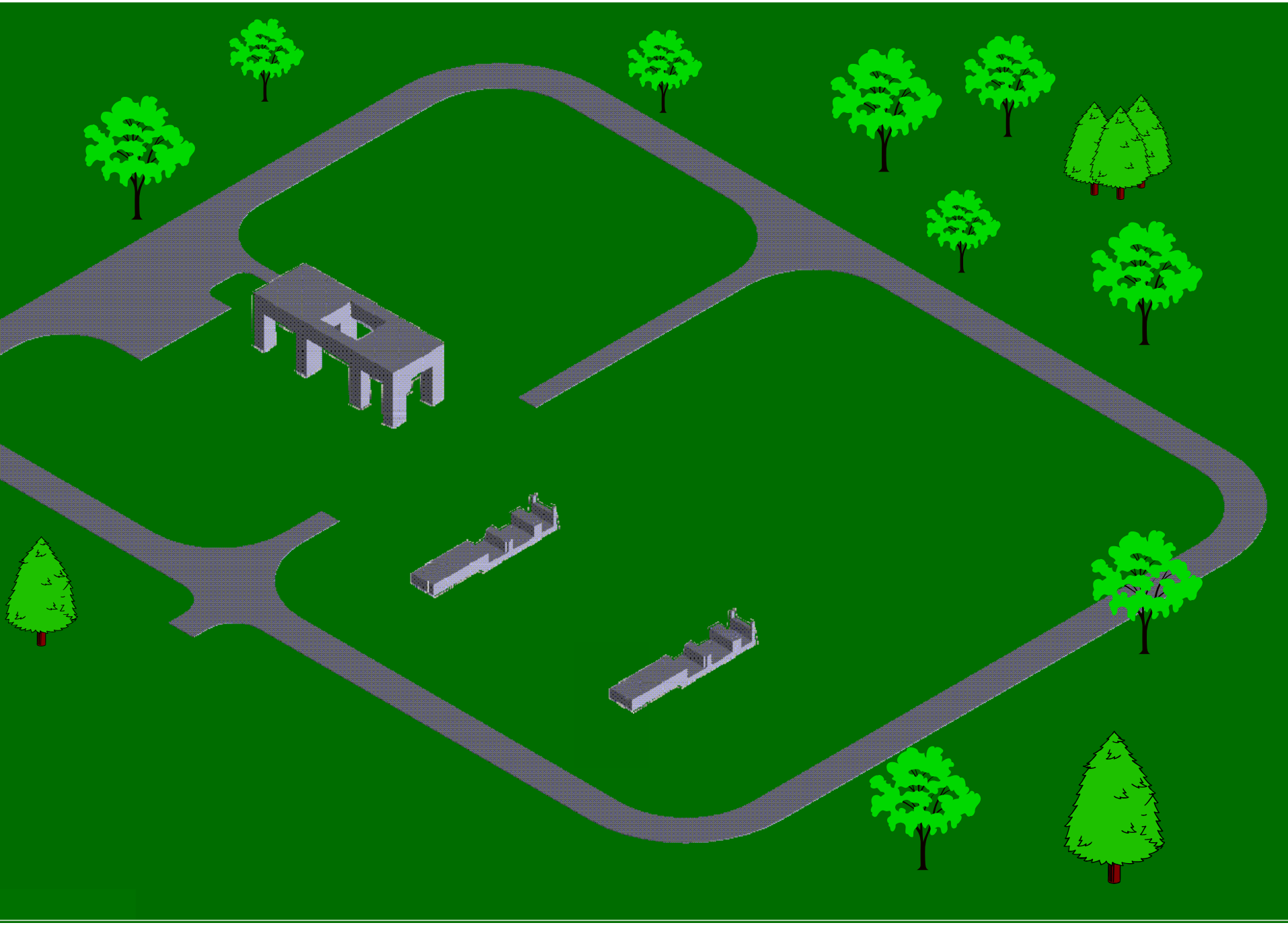
Sources Conversion Delivery Consumption

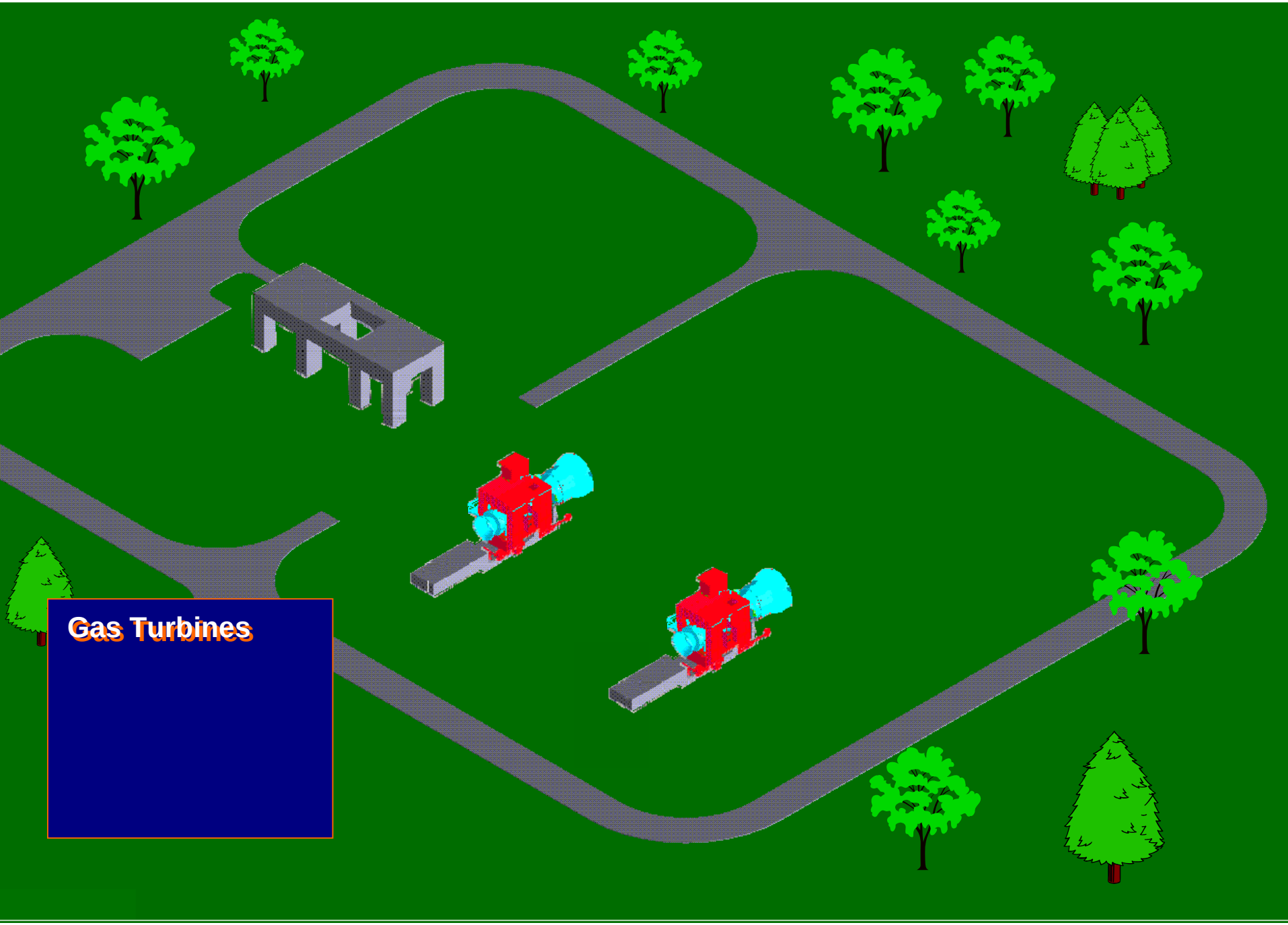


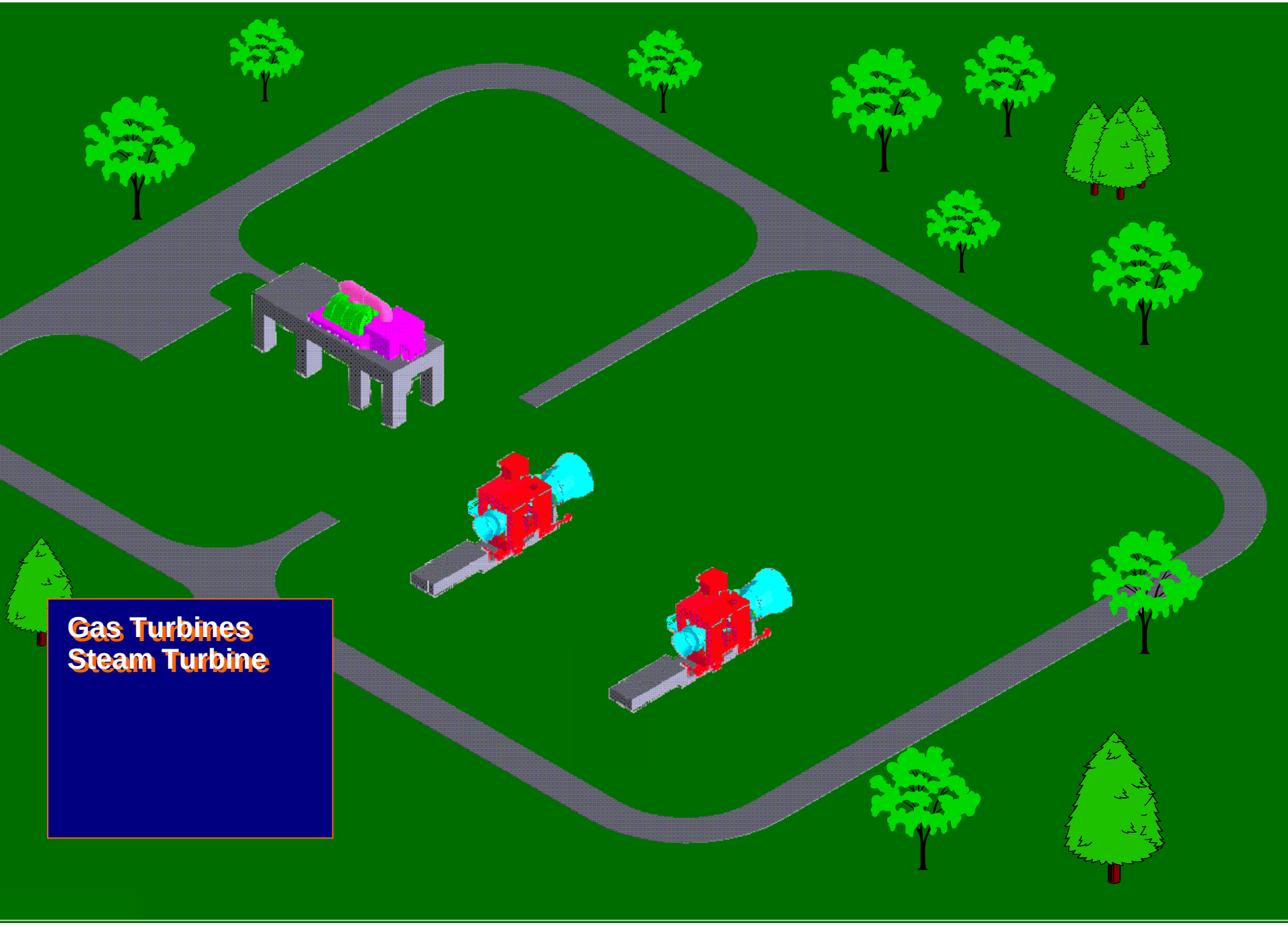


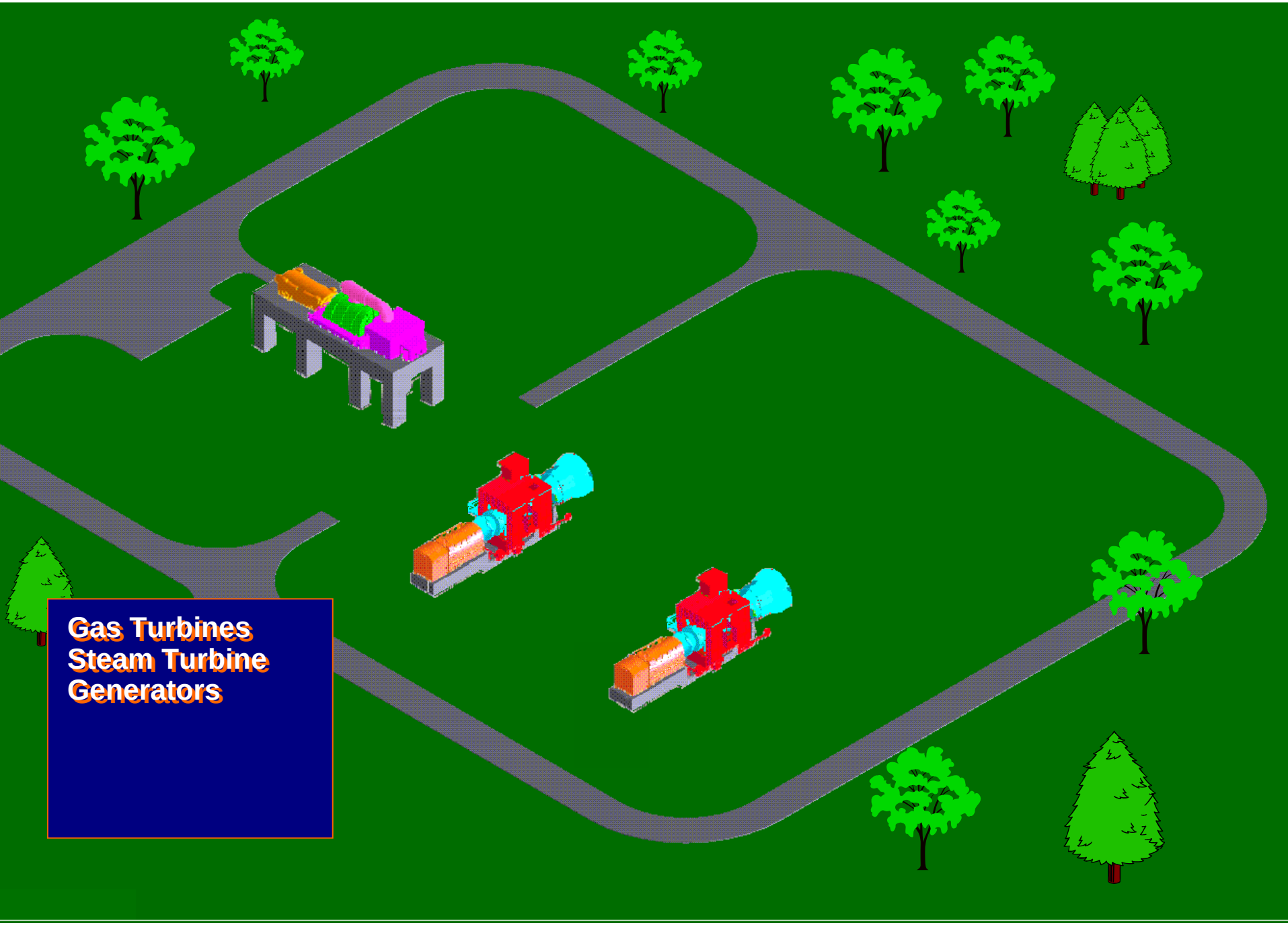


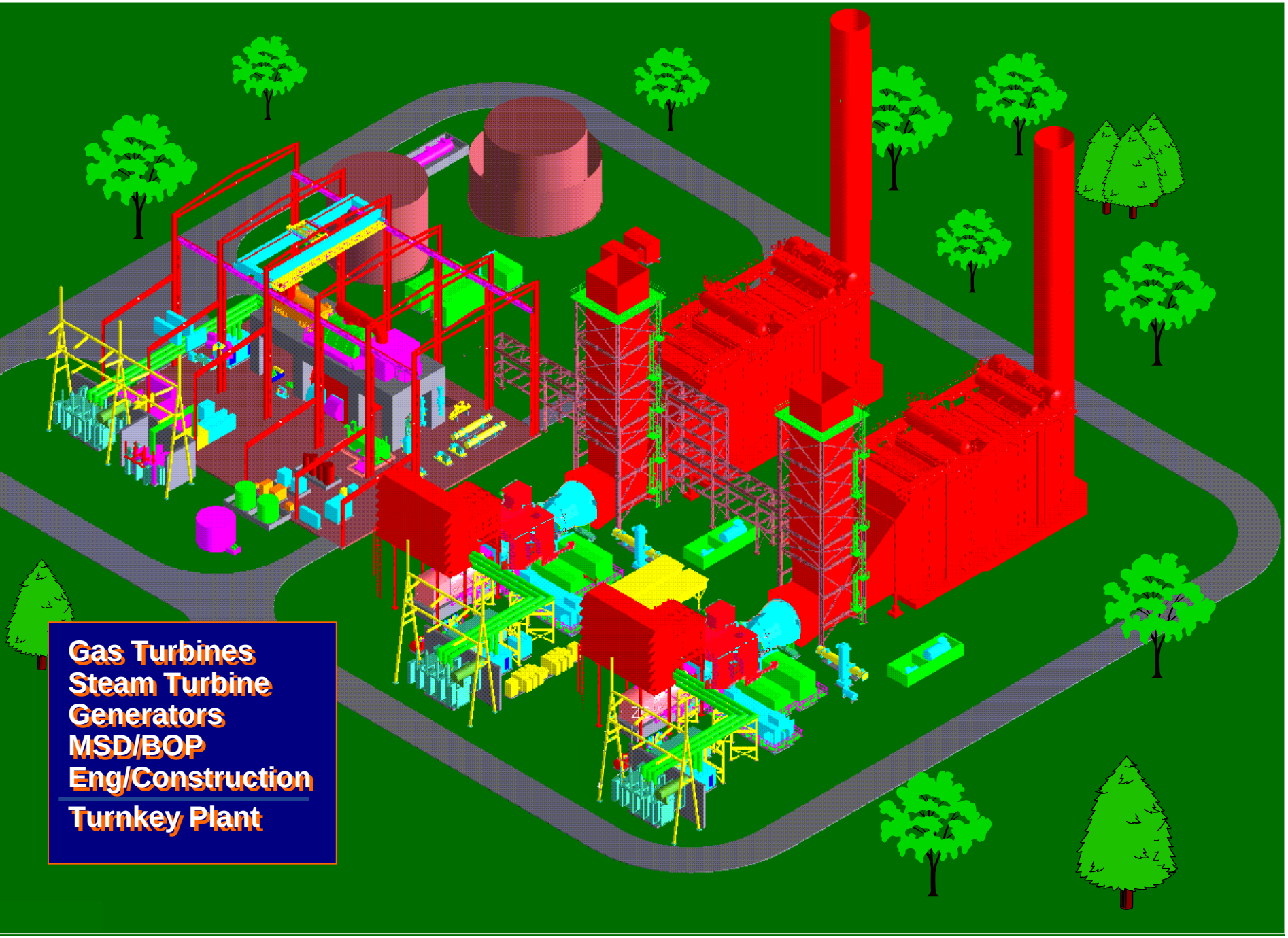

425 ft.
550 ft.
Total Site
50 Acres
550 ft.
425 ft.



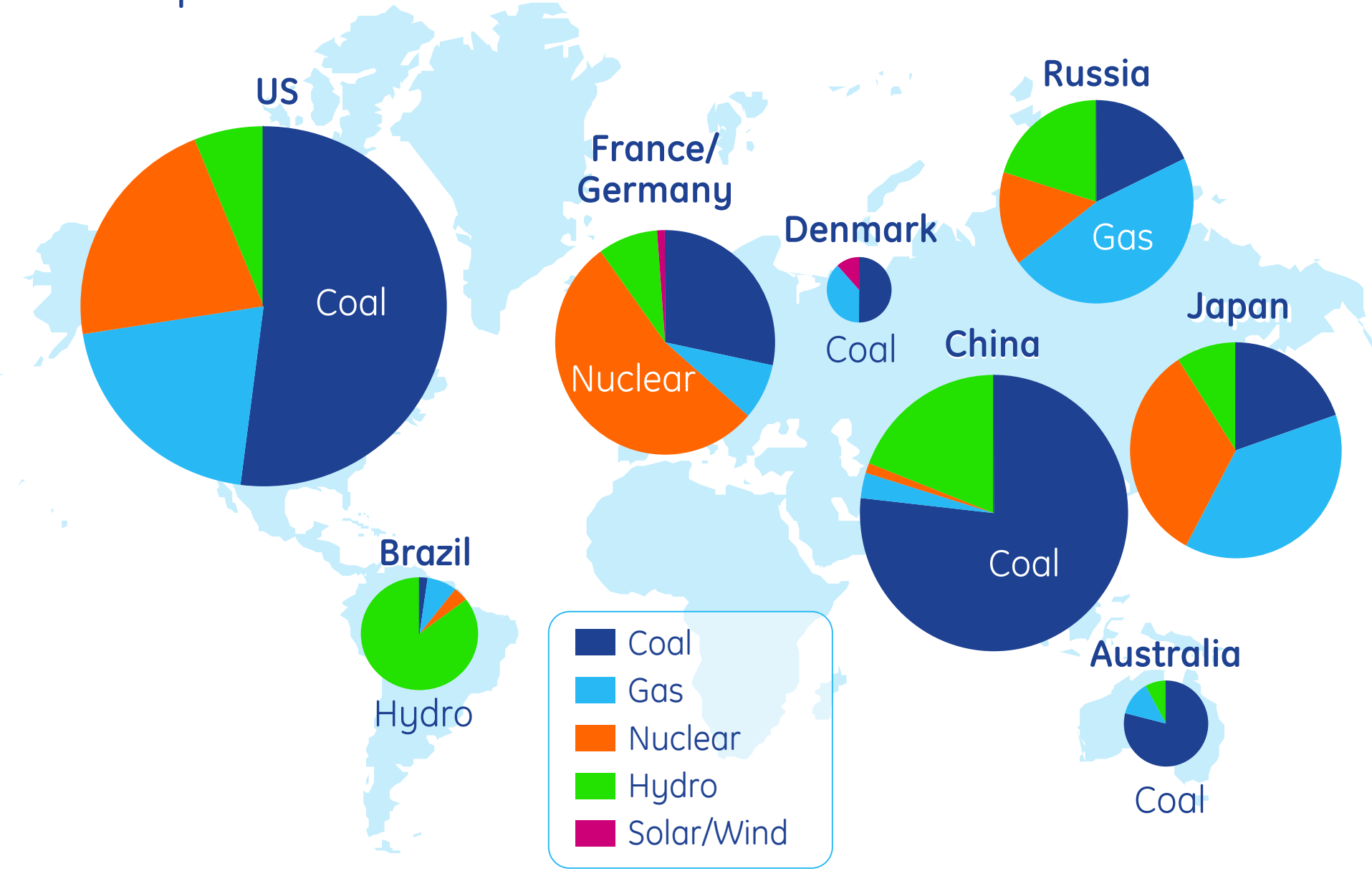

Gas Turbines


Gas Turbines
Steam Turbine


Gas Turbines
Steam Turbine
Generators

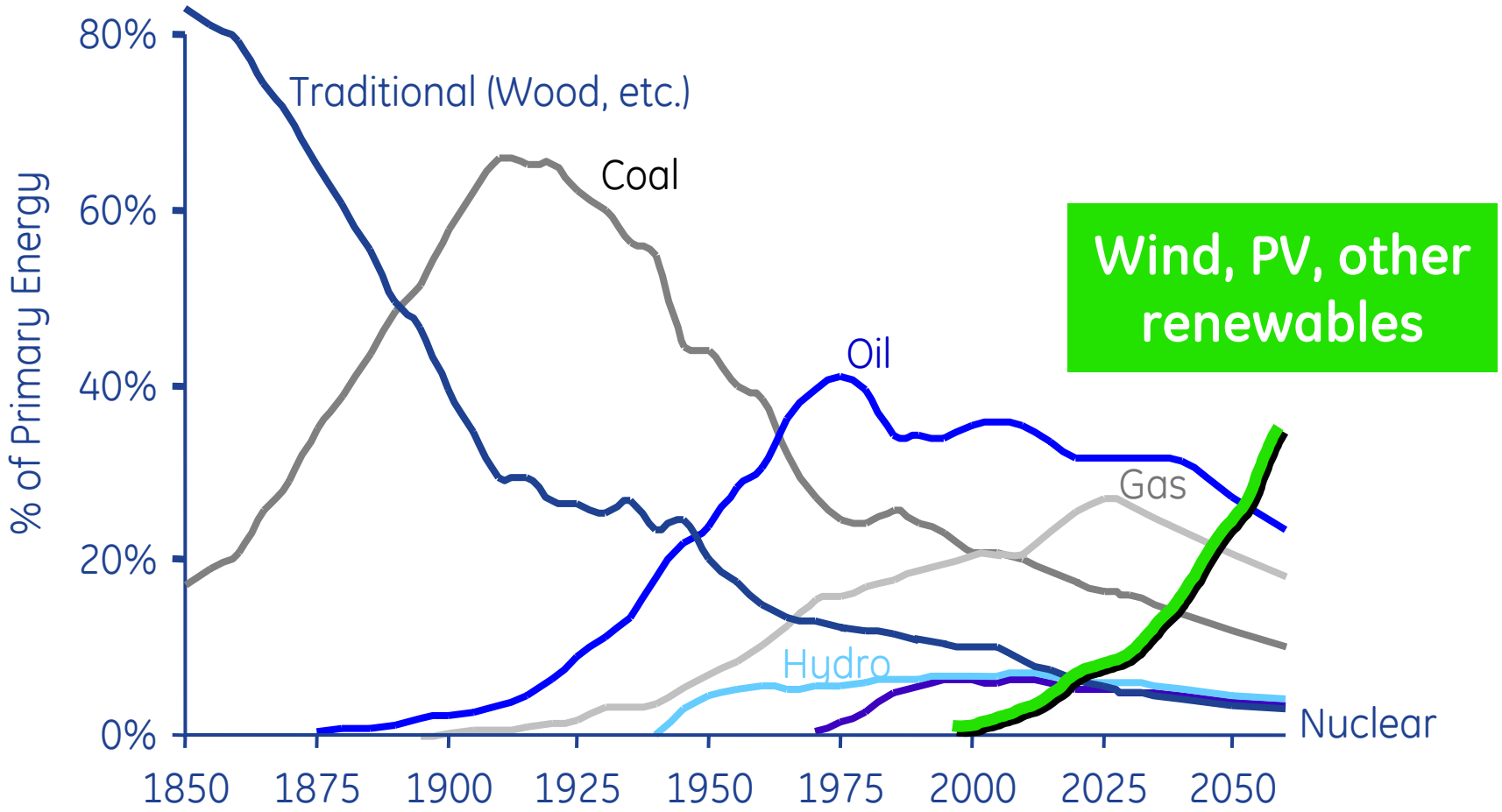

Gas Turbines
Steam Turbine
Generators
MSD/BOP
Eng/Construction
Turnkey Plant

Multiple Conversion Platforms Are Essential



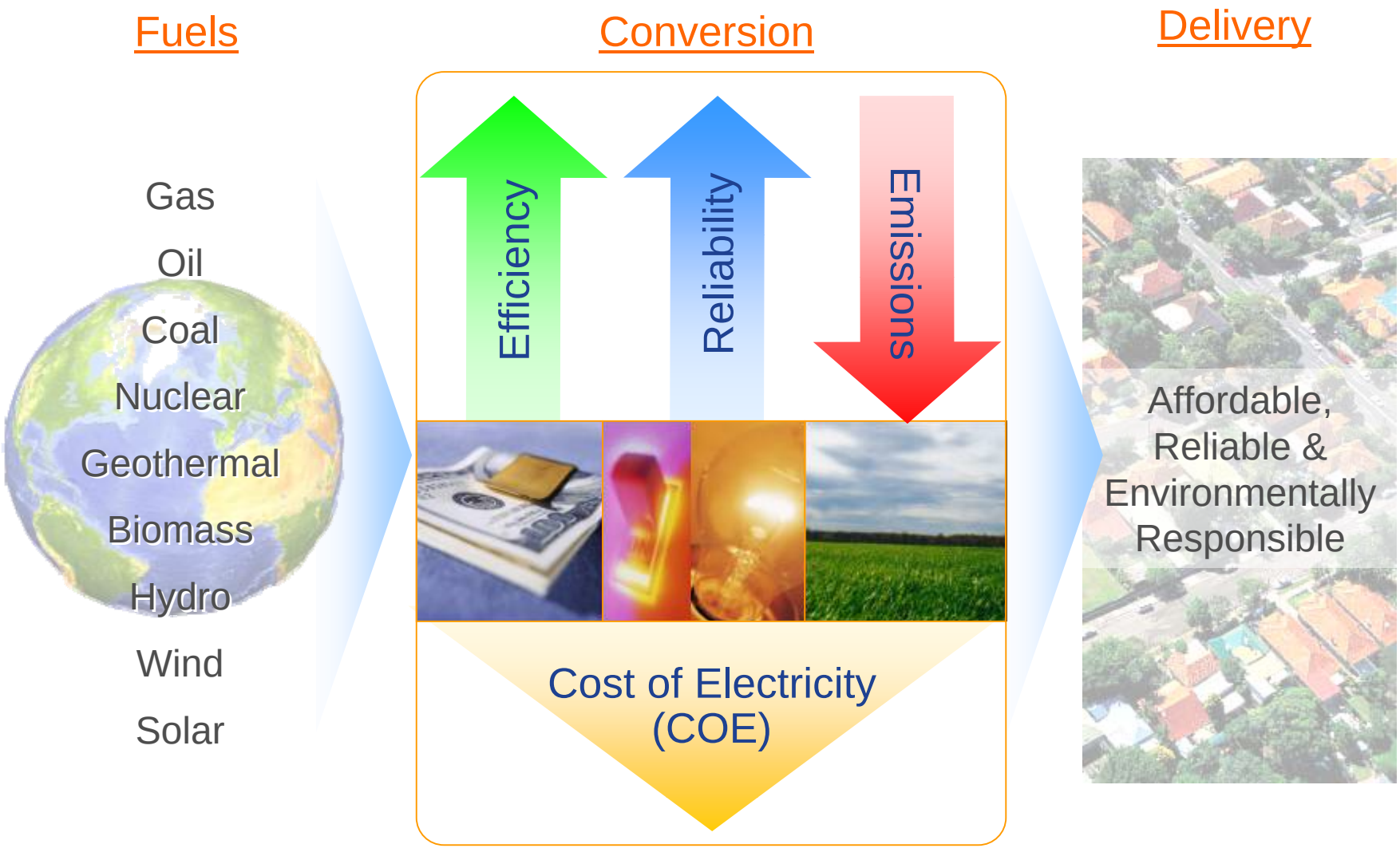
Source: IEA Electricity Information

Alternatives Becoming a Significant Contributor …



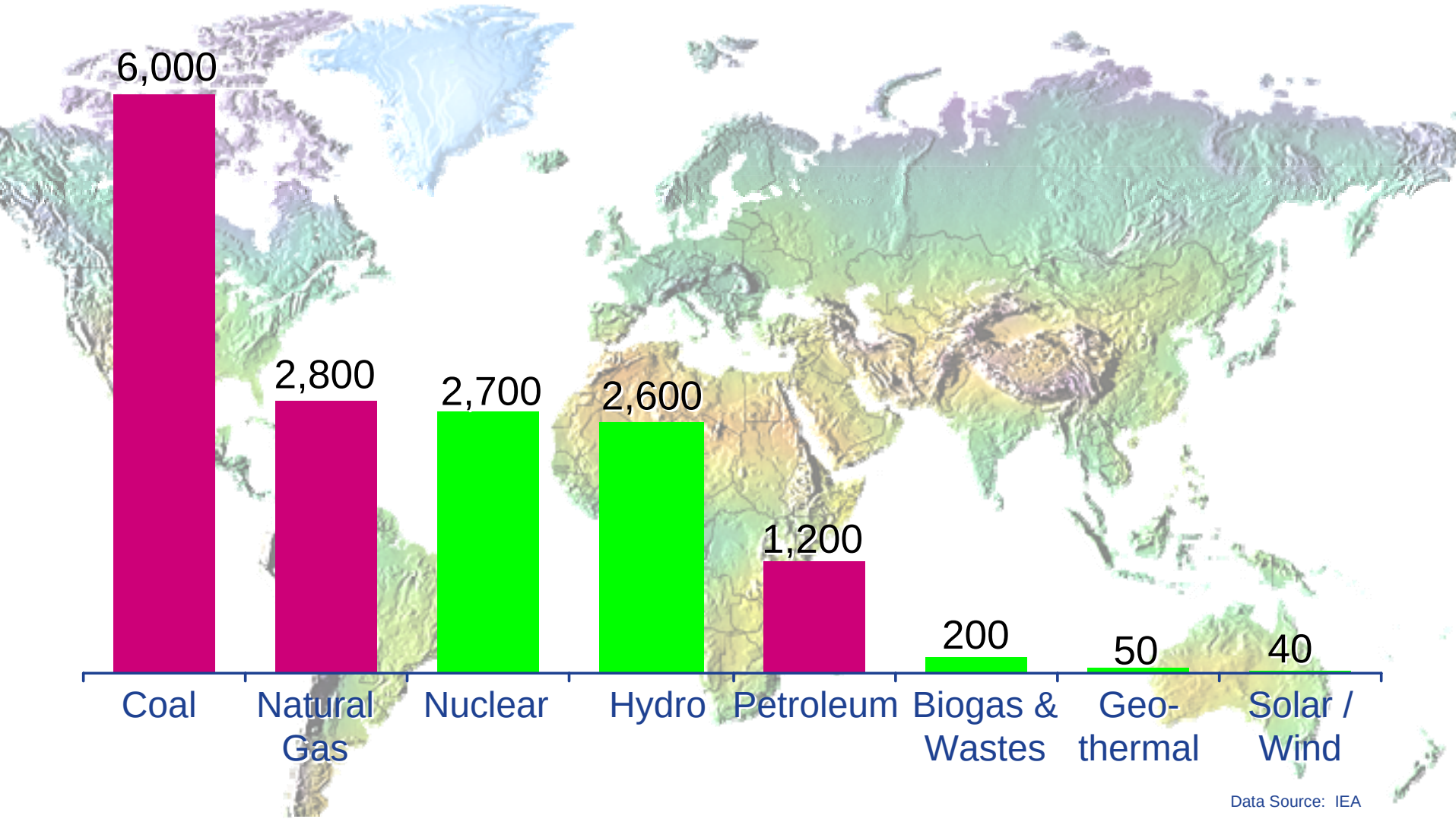
Source: Shell Global Scenarios

Power Generation Technology Objectives



Global Electrical Generation

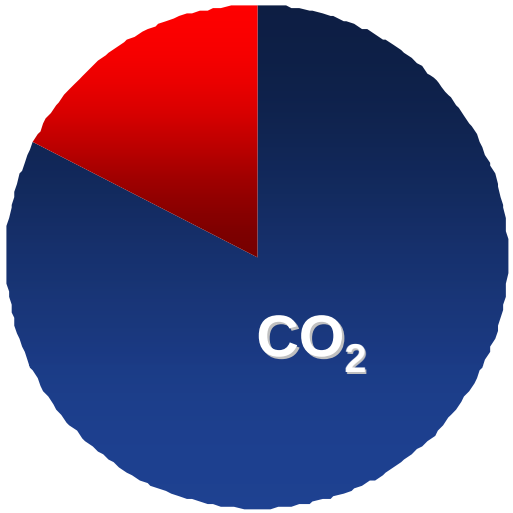
(TW Hours)



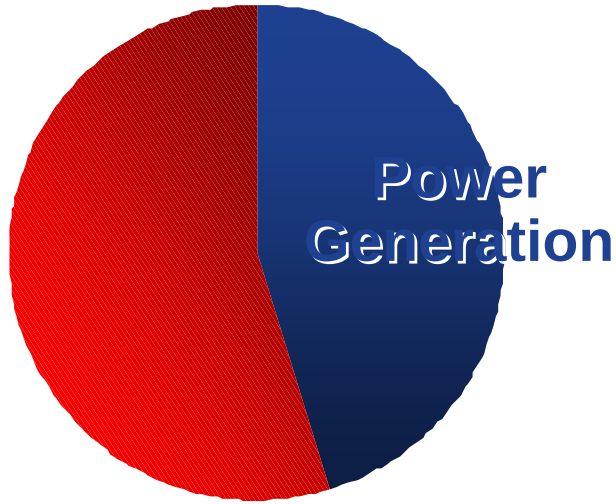
Data Source: IEA

Greenhouse Gas Emissions & Global Impact

GHG Emissions



CO_2 Emitting Segments



83% of GHG is CO_2

45% of CO_2 from Power Gen

25% of Global CO_2 in US

Source:
Reuters Business Insight

Technology Choices and Tradeoffs

Gas
High Power Density

500 MW

Wind
Low Power Density

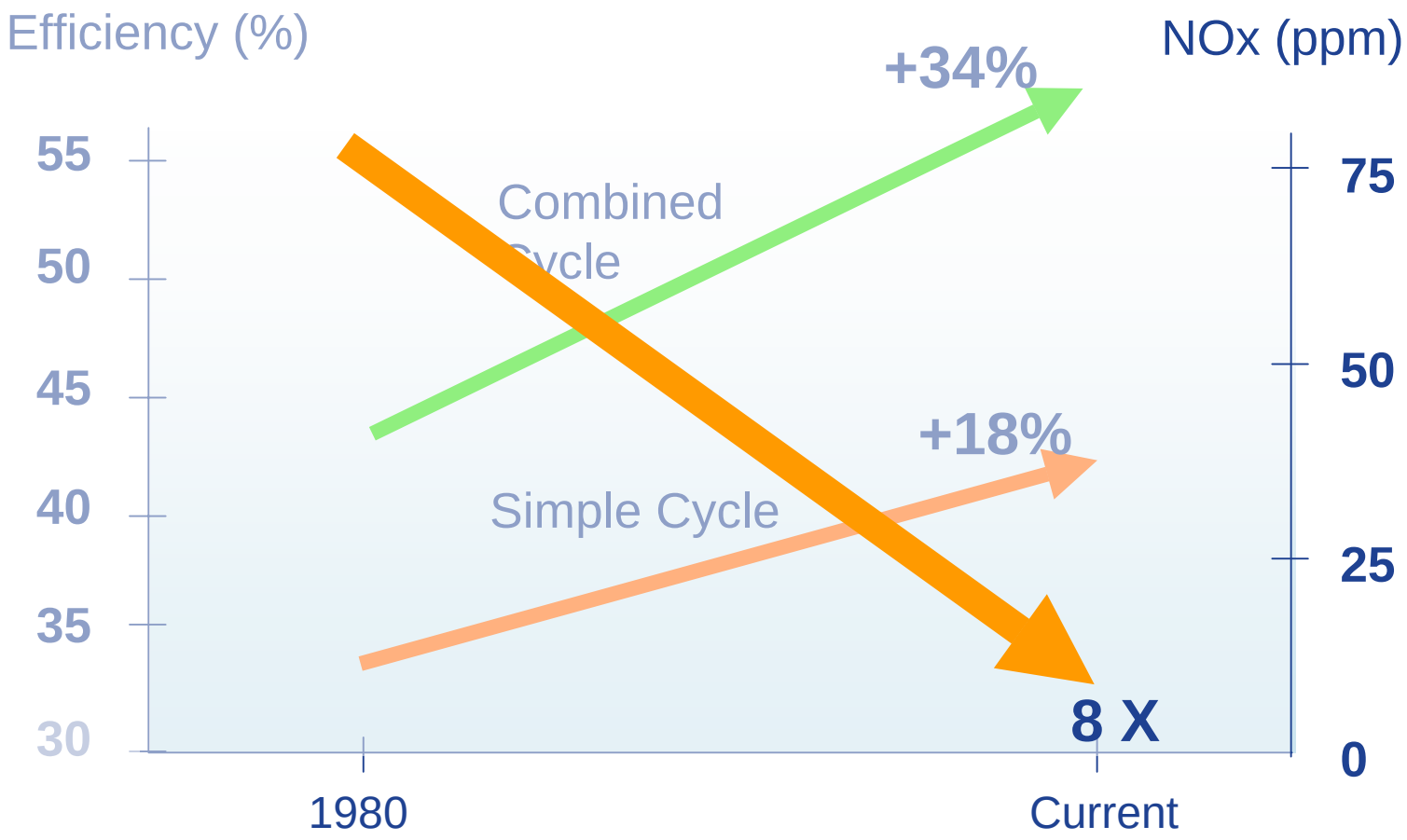
1 Turbine
5 Acres

325 Turbines
725 Acres

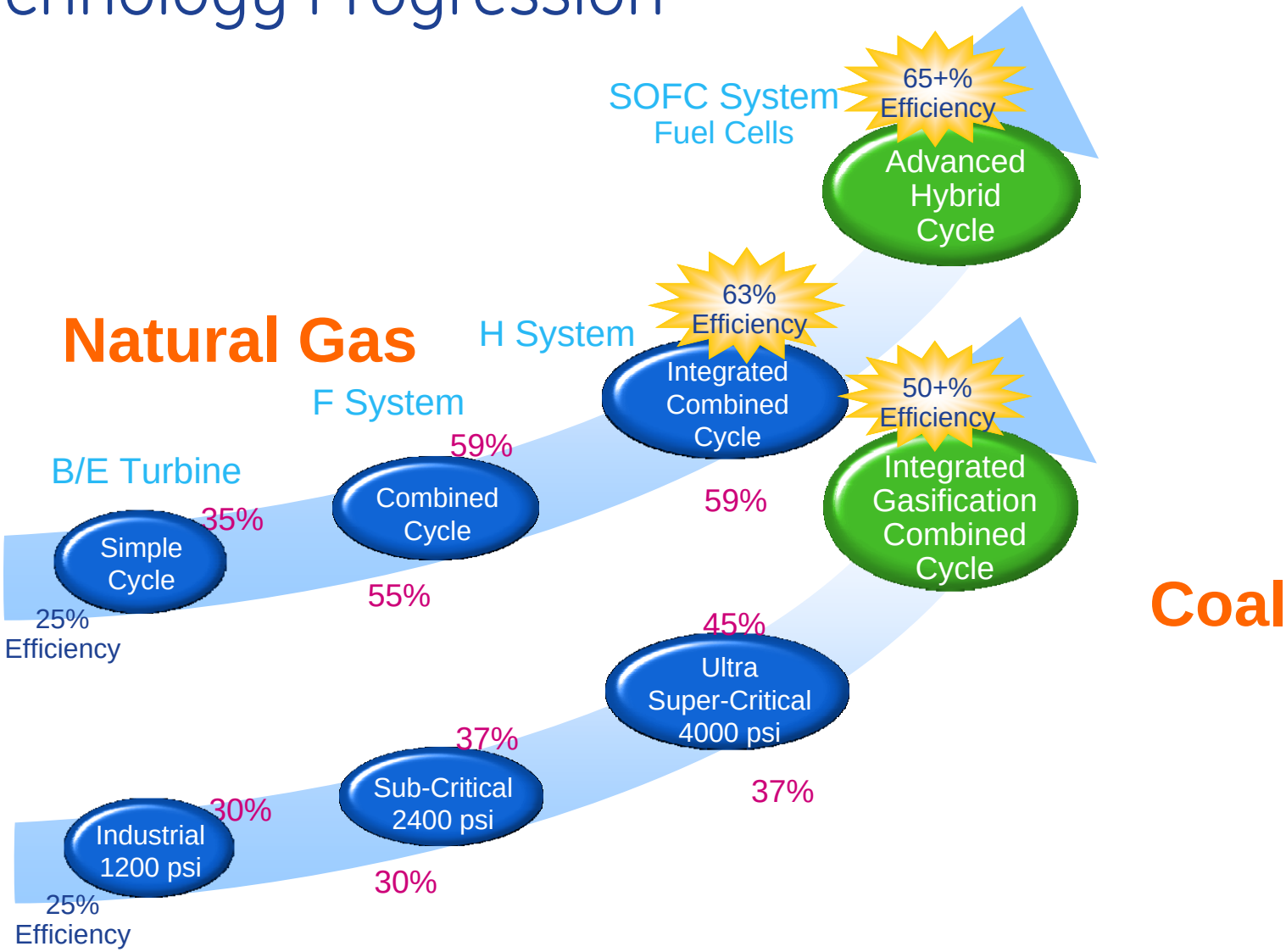
Volatile Fuel Costs
Dispatchable
Manage Emissions Impact

Free Fuel
Non-dispatchable
Emissions Friendly

Gas Conversion …
Driven by Efficiency and Emissions



Technology Progression



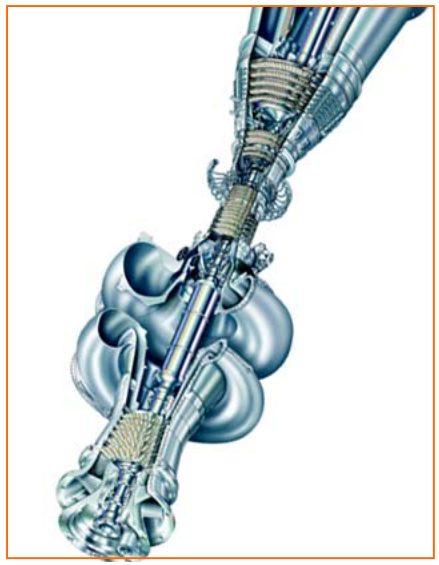
Evolving Existing Platforms … Continuing Investment is Critical

Gas

Heavy Duty

- 480 MW
- 60% Efficient

Aero-derivative



- 100 MW
- 46% Efficient

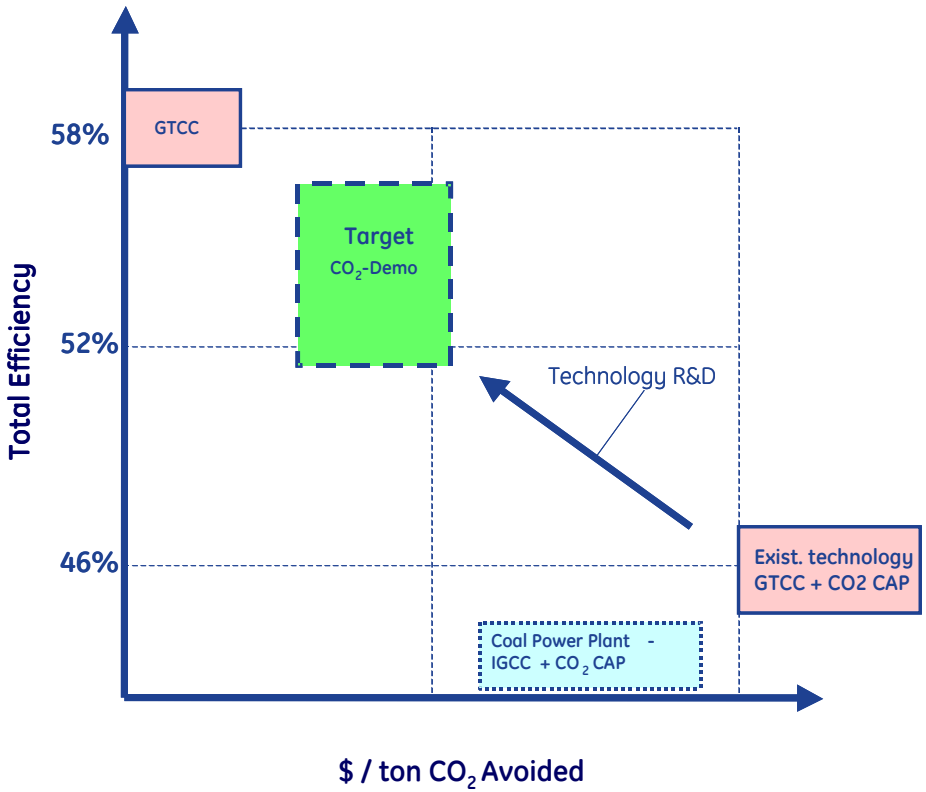
Coal

- 1,200 MW
- 45% Efficient

Nuclear

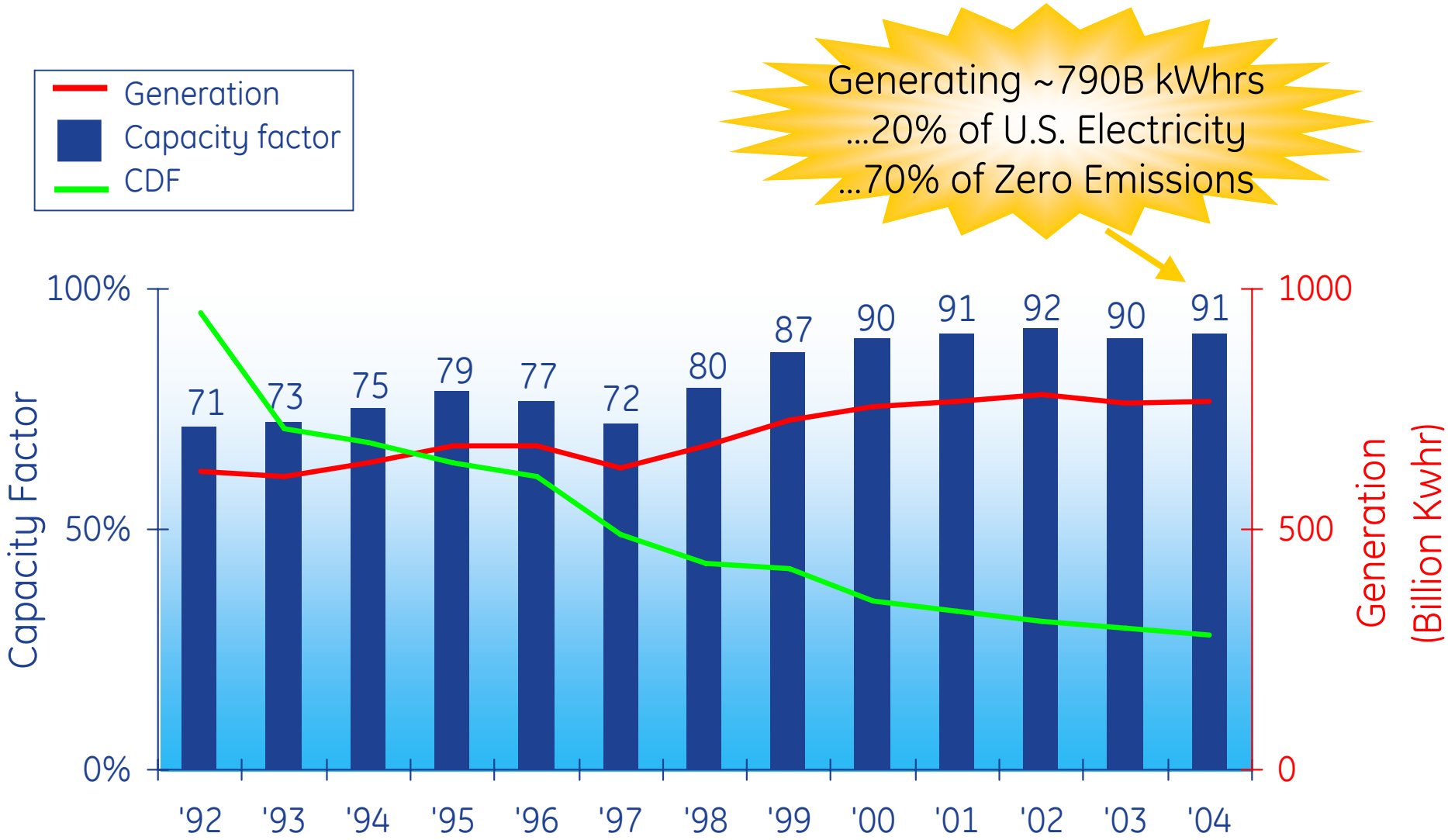
- 1,600 MW
- Emission Free

Integrated CO2 Capture Cycle

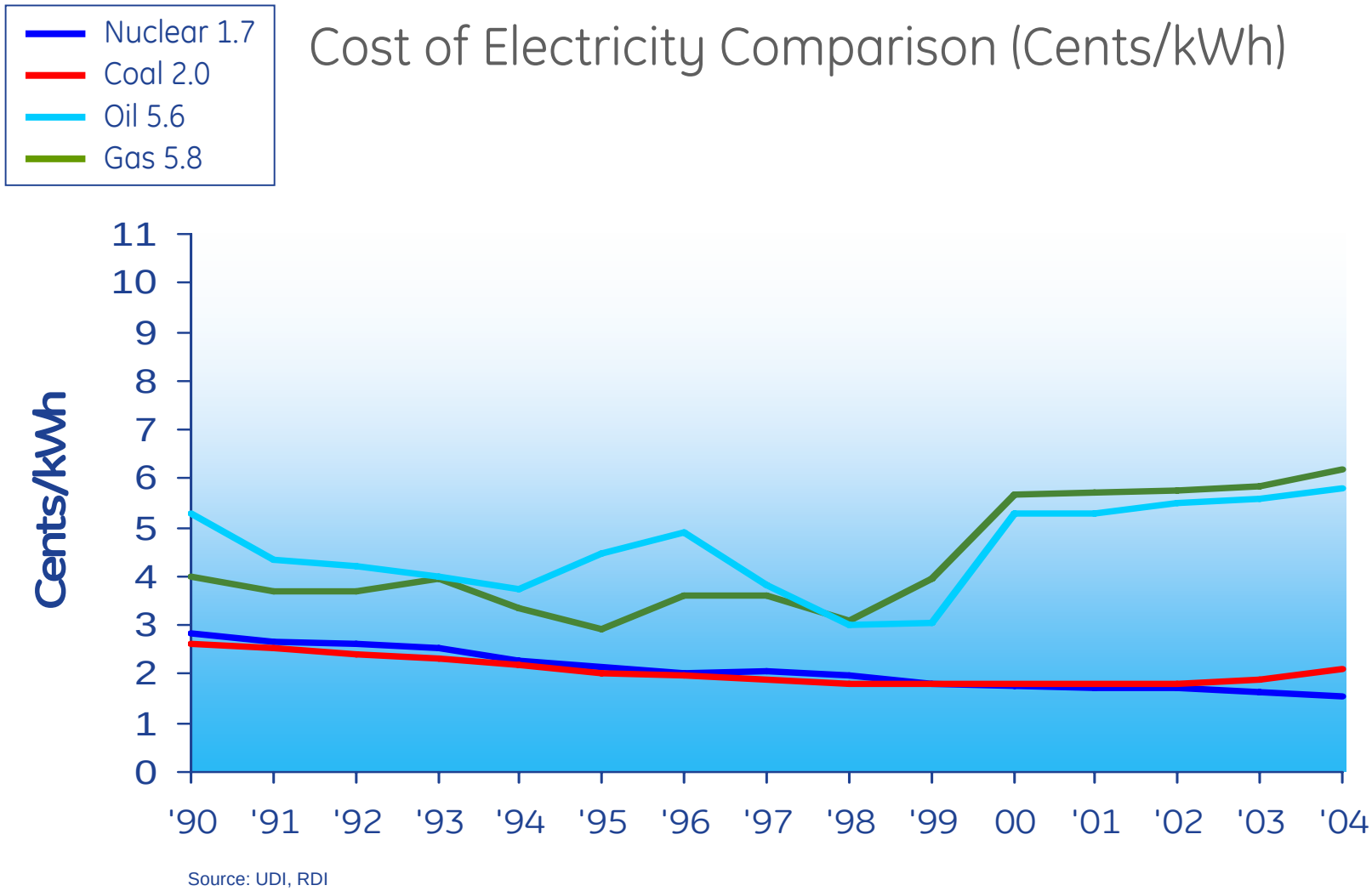


Existing Post Combustion Solutions are not viable

U.S. Nuclear Performance

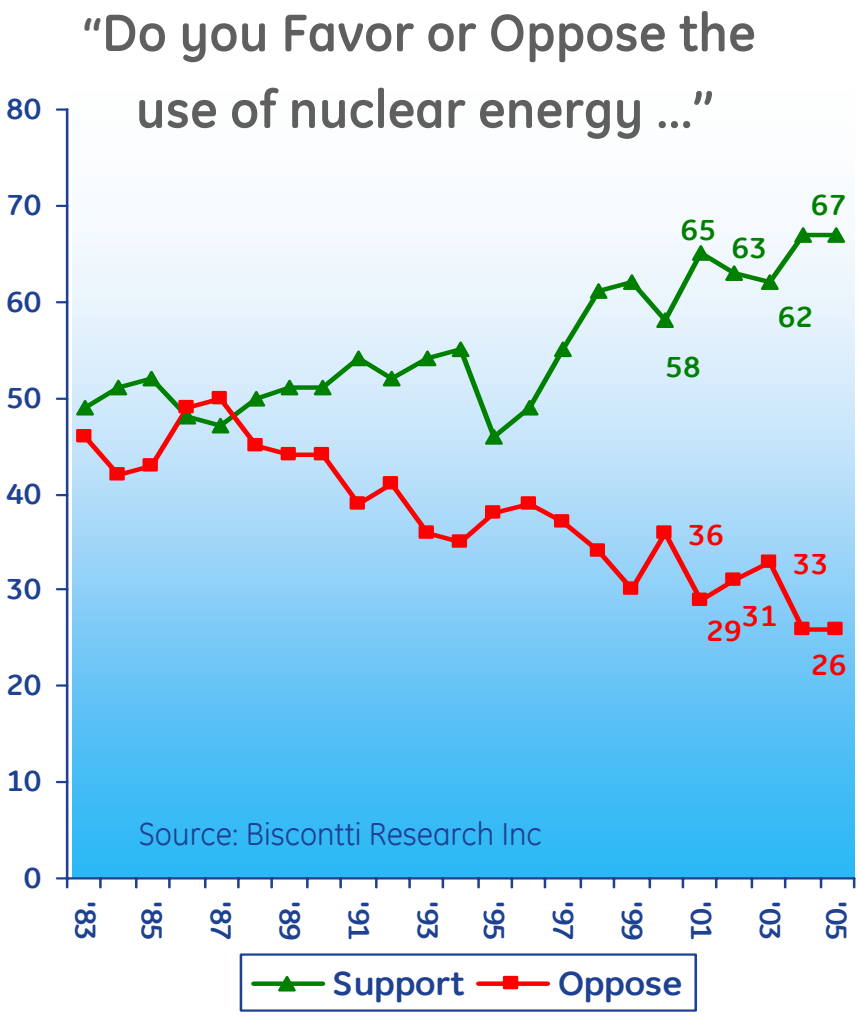


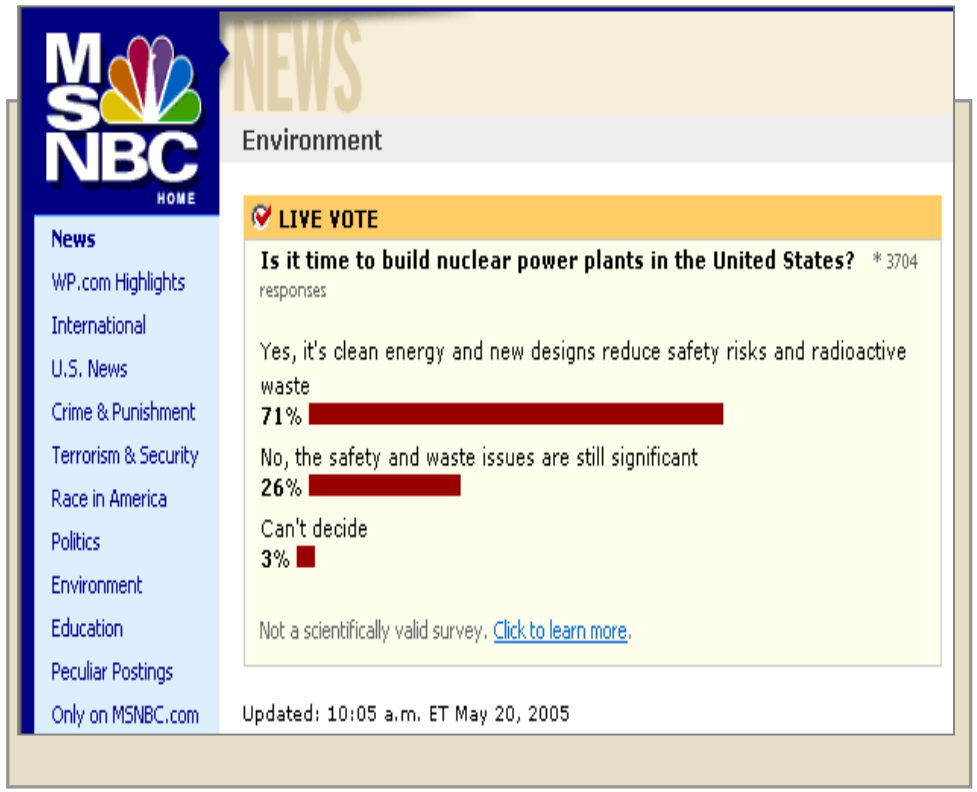
Electricity Production Costs ...



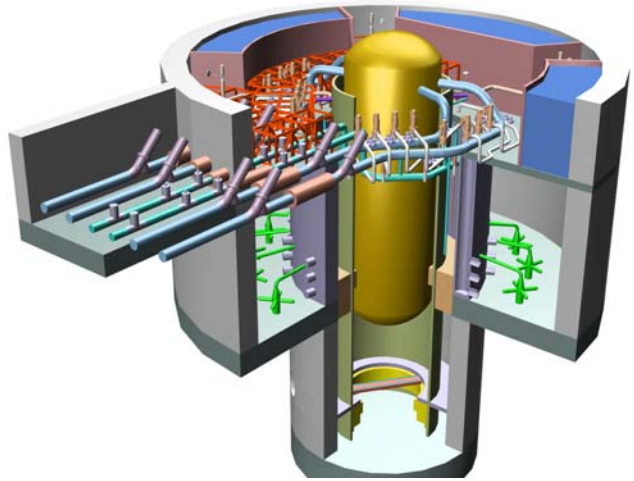
Source: UDI, RDI

USA Public Support Growing …





Advancements in Technology

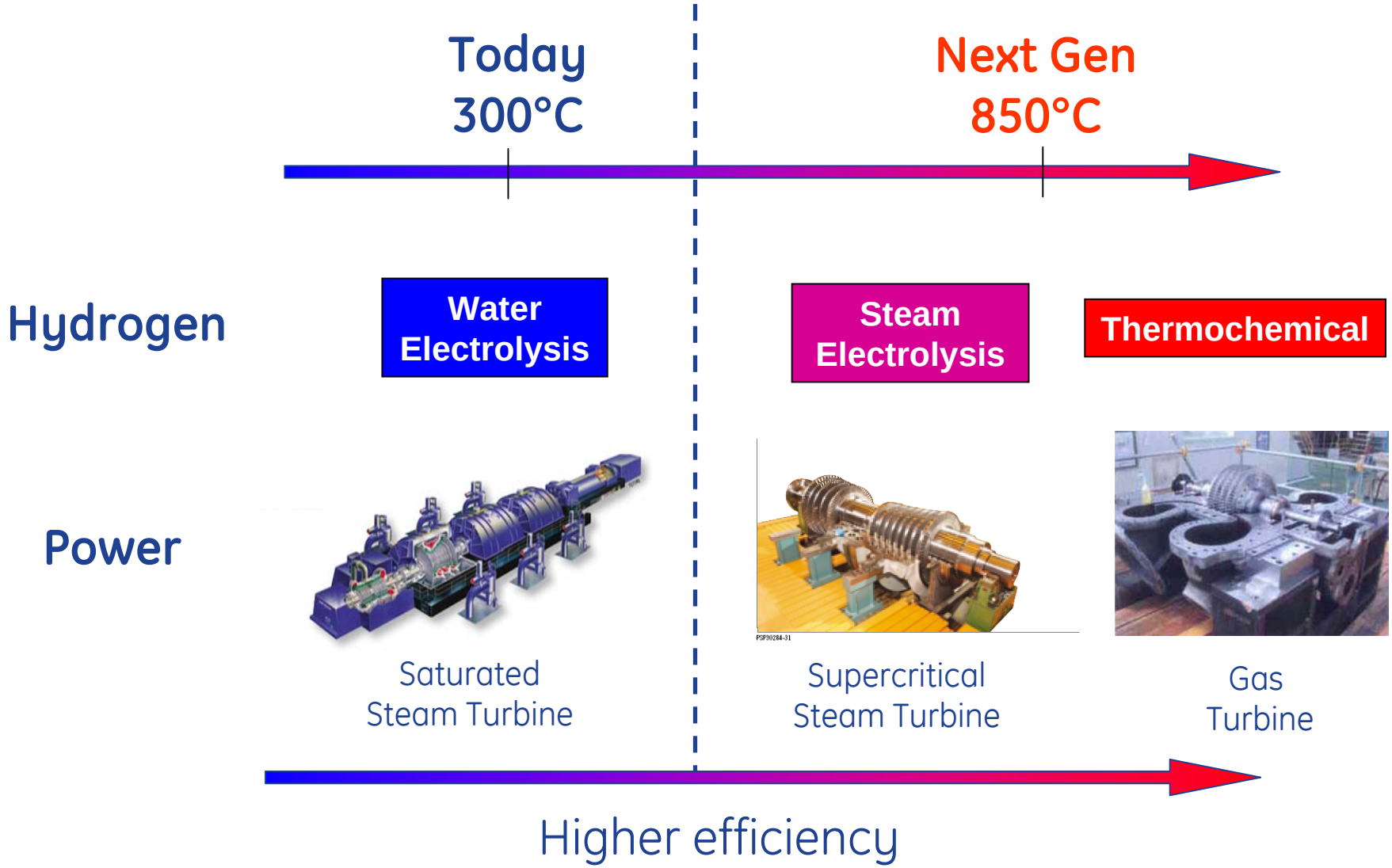


ESBWR

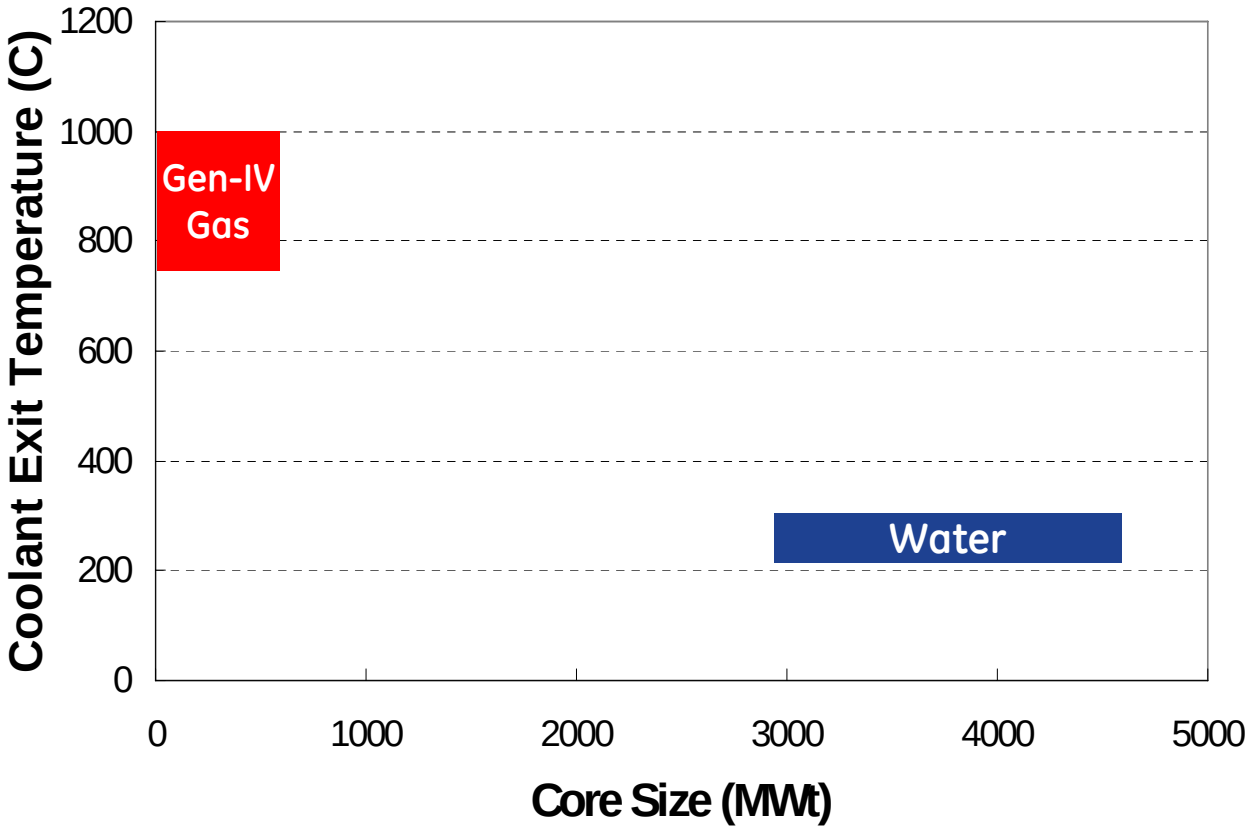
ABWR

BWR

High temperature enables new technologies

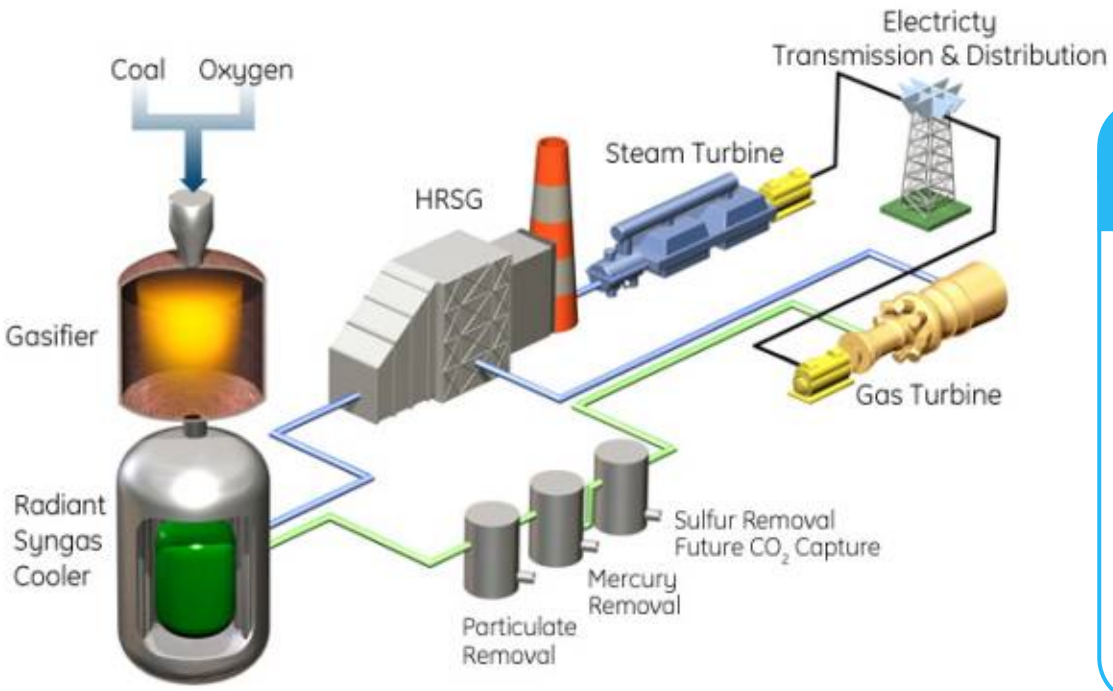


Gen-IV VHTR design space



Cleaner Coal Technology … A Necessary Part of the Solution

- Produces power and hydrogen, fertilizer, ammonia and transportation fuels
- Generates maximum value from coal



Environmental Impact

	Reduction vs PC
NOx	~33%
SOx	~75%
Particulate	~50%
Mercury	~75%

Technology Solutions … Wind

1.5 MW Platform

- Among the most proven and utilized technology
- Over 2,500 units worldwide

2.X MW Platform

- Full power conversion
- Simplified servicing
- Larger farms with easier grid integration

Future: 3 MW

- Direct drive
- '07 prototype

3.6 MW Offshore Platform

- Arklow demonstration project - 7, 3.6s

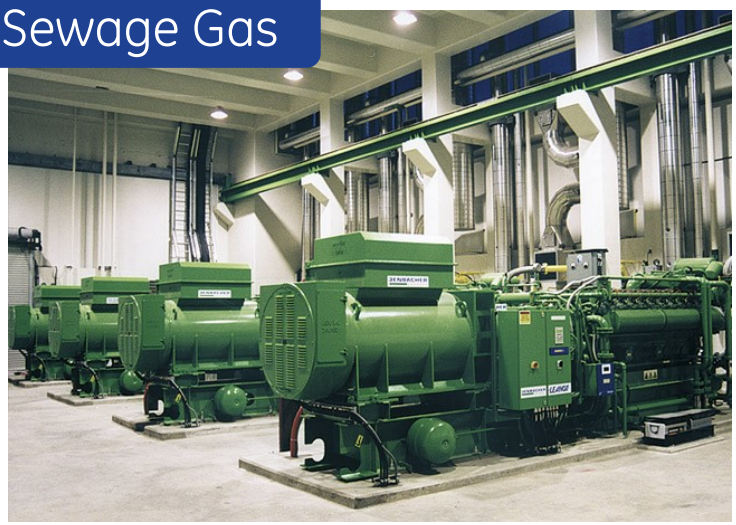
Future: 6 MW

- Based on 2.5 Onshore
- ~140m diameter

Biomass … Another Alternative

Biogas

Sewage Gas



Non-Natural Gas

- Using gas that would otherwise be vented or flared …
  - Landfill
  - Sewage gas
  - Coal mine gas
  - Wellhead flare gas
  - Industrial by-products (coke, steel gas)

Natural Gas, Low-Emissions

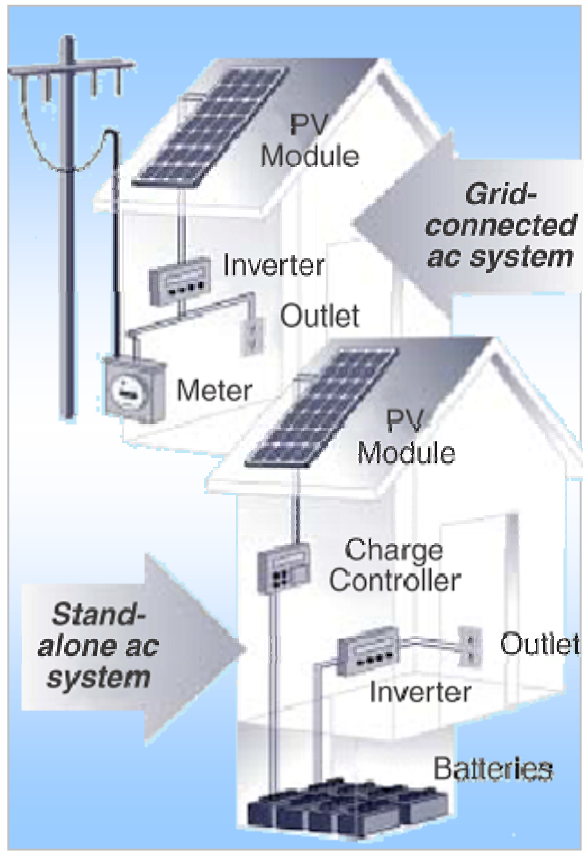
- Industrial cogeneration & trigeneration
- Municipal district heating

Technology Improving Renewable Economics …

Energy Capture

Conversion Efficiency

Power Electronics



What Can We Do

Public Sector

- **Regulatory Framework**
- **Policy Changes**
- **Intensity Reductions**
- **State Driven Cuts**

Long Term Vision … A Must

Future Energy

- We'll be living in a carbon constrained world
- Renewables will be part of the solution … but only part
- Nuclear … certain in China, India, parts of Europe; US?
- Grid congestion/site permitting remain challenges
- Convert science to technology … the key enabler

"Long term" view requires consistent framework