

GAS TURBINE - MODULAR HELIUM REACTOR (GT-MHR)

COMMERCIALIZATION PROGRAM BRIEFING

March 2001



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COMMERCIALIZATION PROGRAM BRIEFING

- **PLANT DESCRIPTION**
- **PROGRAM DESCRIPTION**



GT-MHR COMMERCIALIZATION PROGRAM

PLANT DESCRIPTION



Nuclear Power Generation IV Initiative

The Evolution of Nuclear Power

Generation I

Early Prototype Reactors



- Shippingport
- Dresden, Fermi I
- Magnox

Generation II

Commercial Power Reactors



- LWR-PWR, BWR
- CANDU
- VVER/BBMK

Generation III

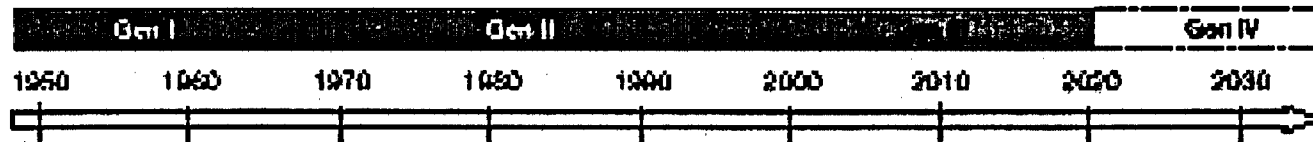
Advanced LWRs



- ABWR, System 80+, AP600, EPR

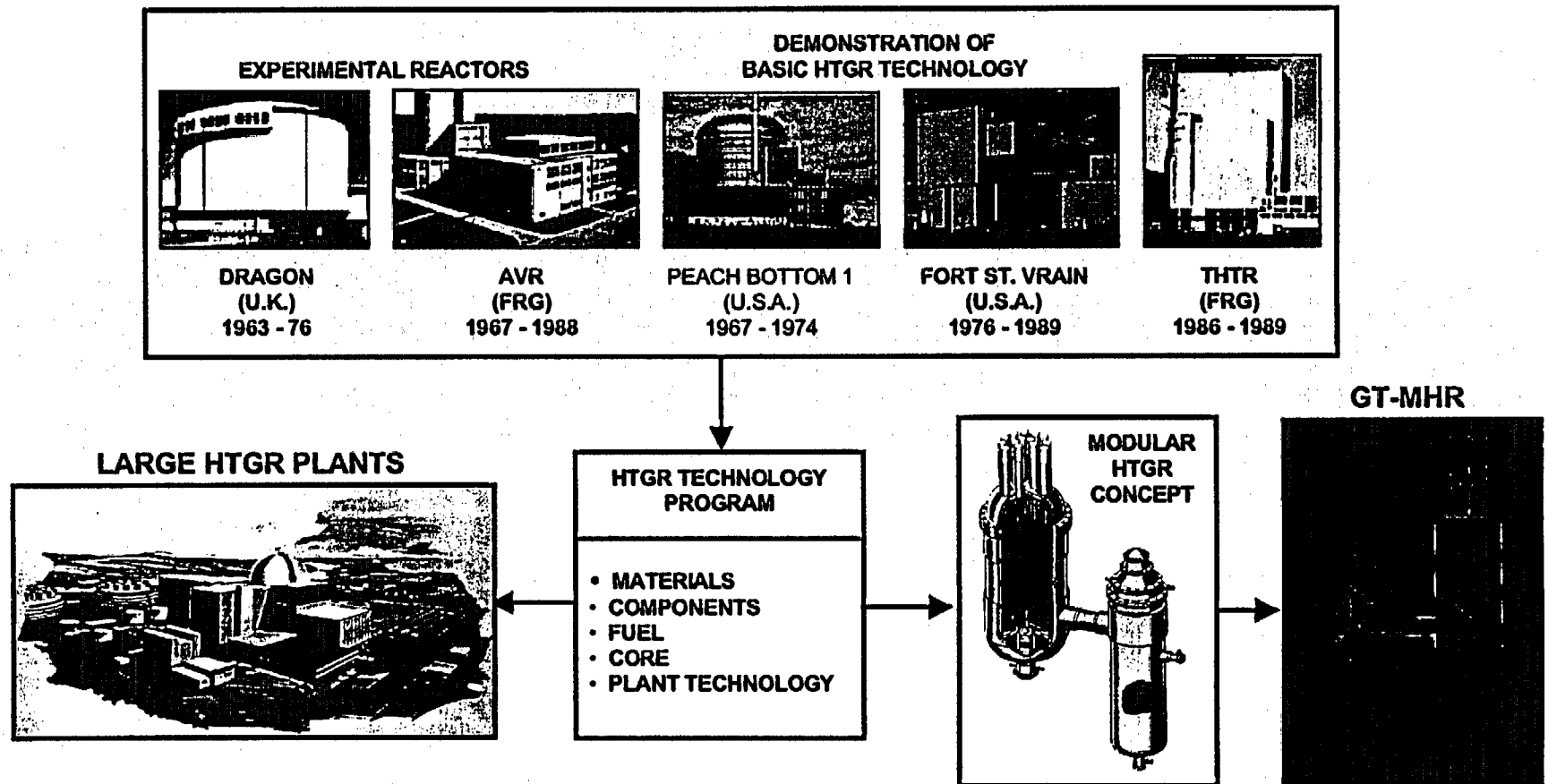
Generation IV

- Highly economical
- Enhanced safety
- Minimized wastes
- Proliferation resistant

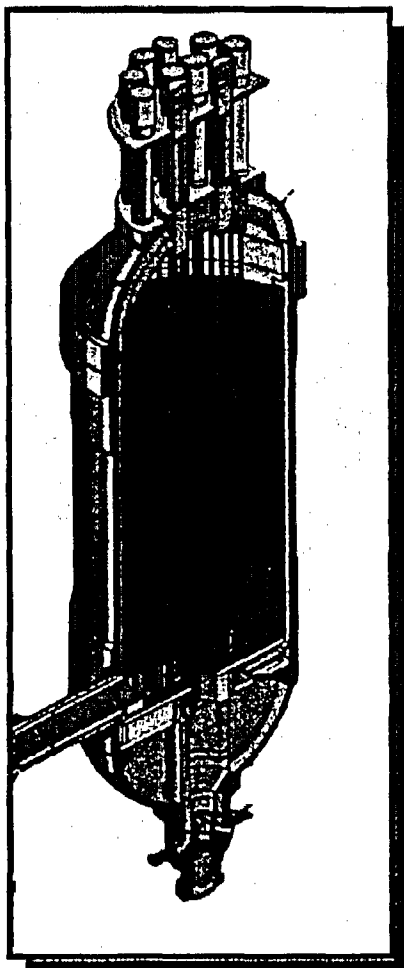


U.S. AND EUROPEAN TECHNOLOGY BASES FOR MODULAR HIGH TEMPERATURE REACTORS

BROAD FOUNDATION OF HELIUM REACTOR TECHNOLOGY



MODULAR HELIUM REACTOR CHARACTERISTICS ATTRACTIVE FOR GEN IV GOALS

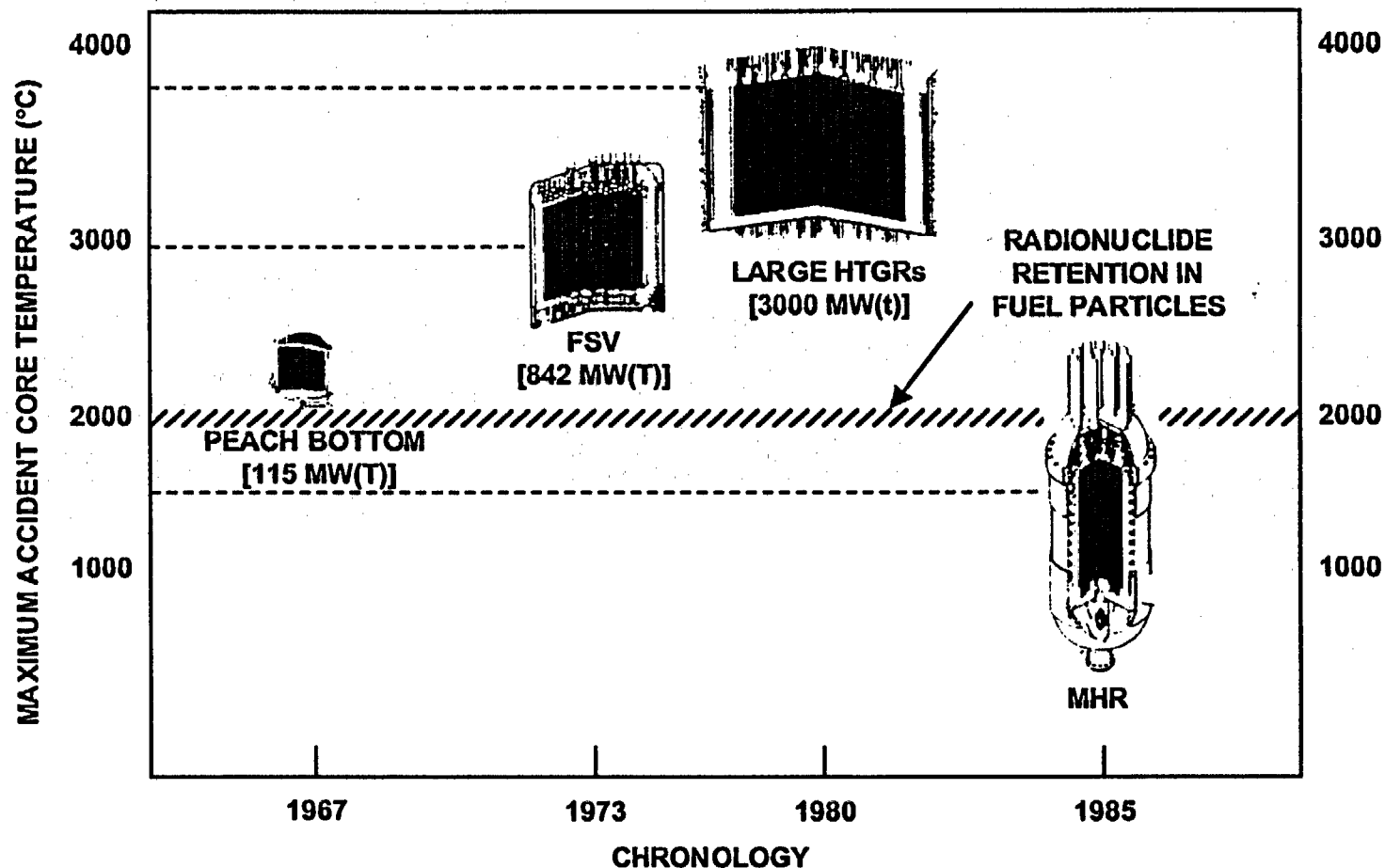


- Helium gas coolant (inert)
- Refractory fuel
(high temperature capability)
- Graphite reactor core
(high temperature stability)
- Low power density (order of magnitude
lower than LWRs)
- Demonstrated technologies

***... EFFICIENT, RELIABLE PERFORMANCE WITH
INHERENT SAFETY***



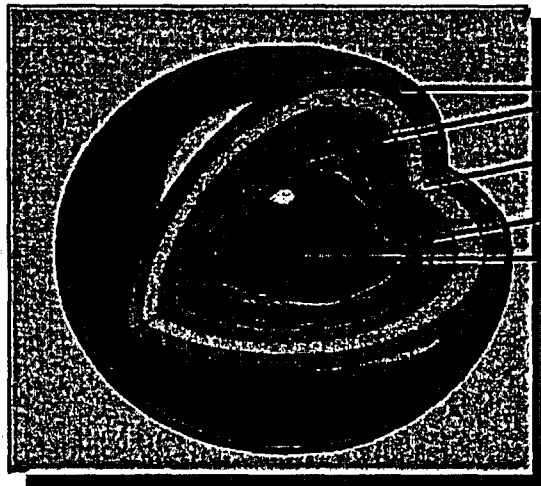
MODULAR HELIUM REACTOR REPRESENTS A FUNDAMENTAL CHANGE IN REACTOR DESIGN AND SAFETY PHILOSOPHY



...SIZED AND CONFIGURED TO TOLERATE EVEN A SEVERE ACCIDENT

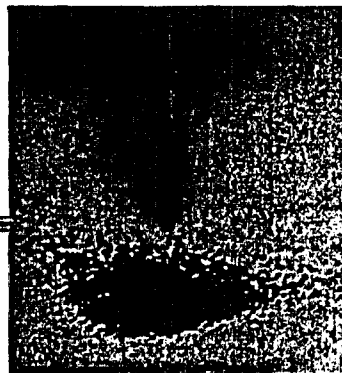


CERAMIC FUEL RETAINS ITS INTEGRITY UNDER SEVERE ACCIDENT CONDITIONS

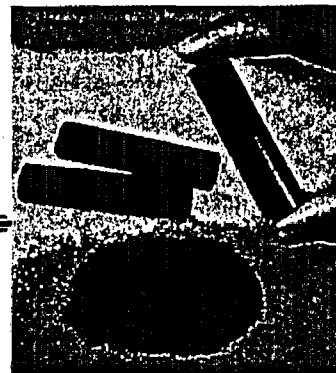


Pyrolytic Carbon
Silicon Carbide
Porous Carbon Buffer
Uranium Oxycarbide

TRISO Coated fuel particles (left) are formed into fuel rods (center) and inserted into graphite fuel elements (right).



PARTICLES



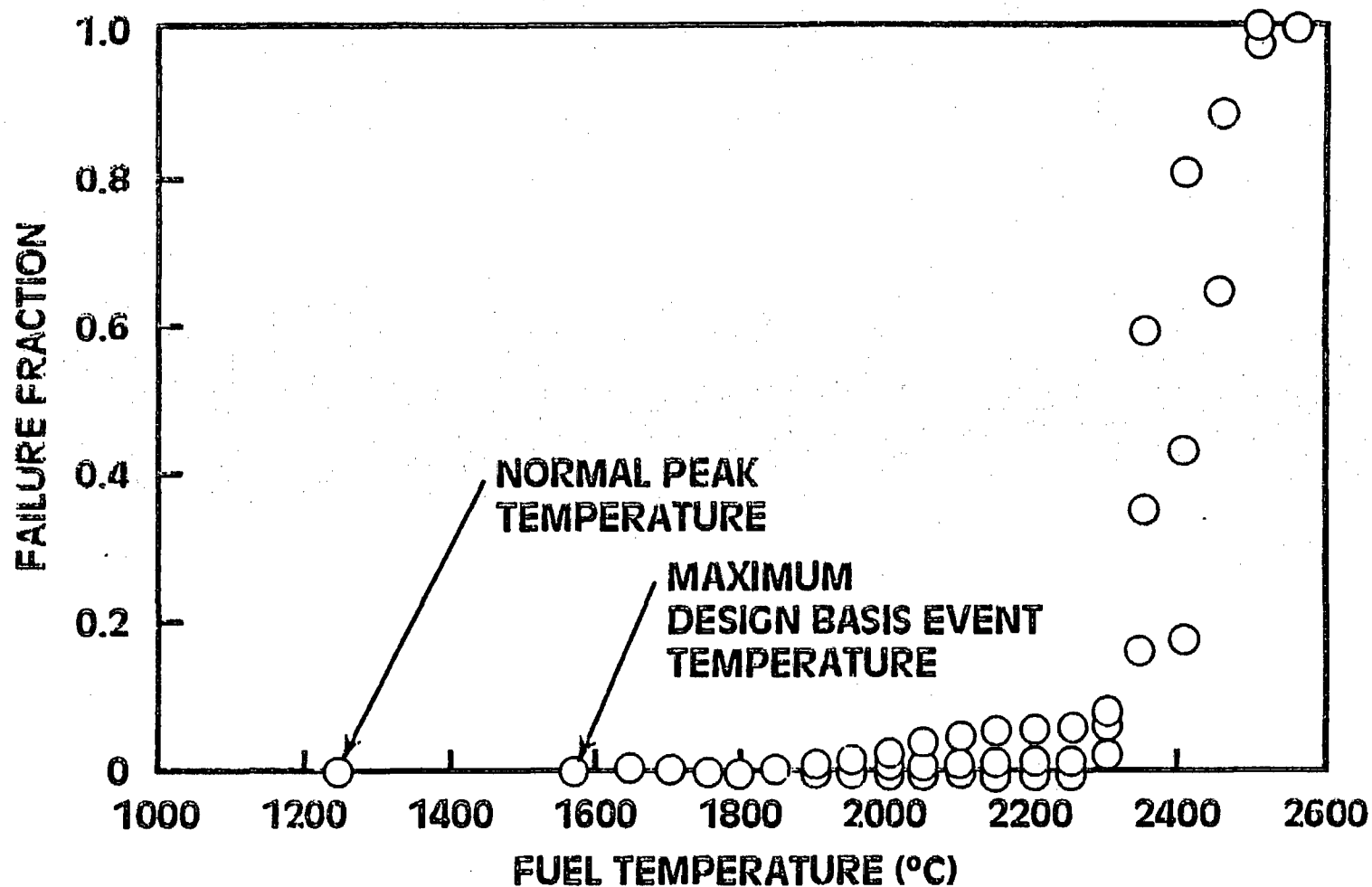
COMPACTS



FUEL ELEMENTS

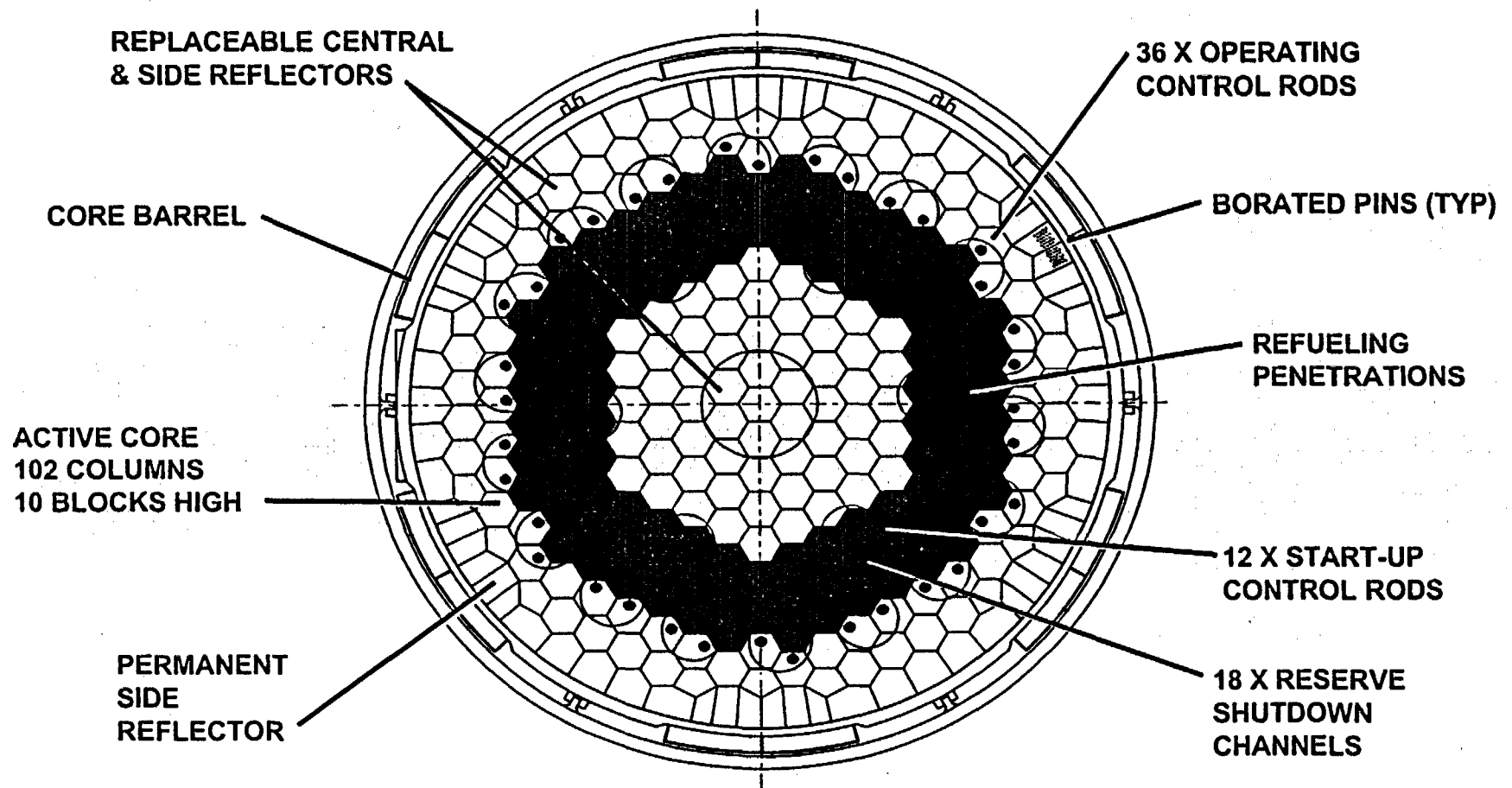
 **GENERAL ATOMICS**

COATED PARTICLES STABLE TO BEYOND MAXIMUM ACCIDENT TEMPERATURES



 **GENERAL ATOMICS**

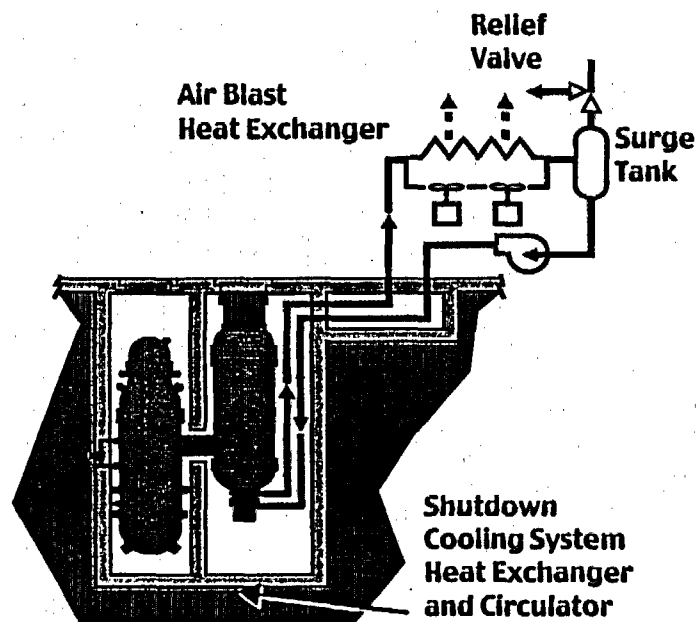
ANNULAR REACTOR CORE LIMITS FUEL TEMPERATURE DURING ACCIDENTS



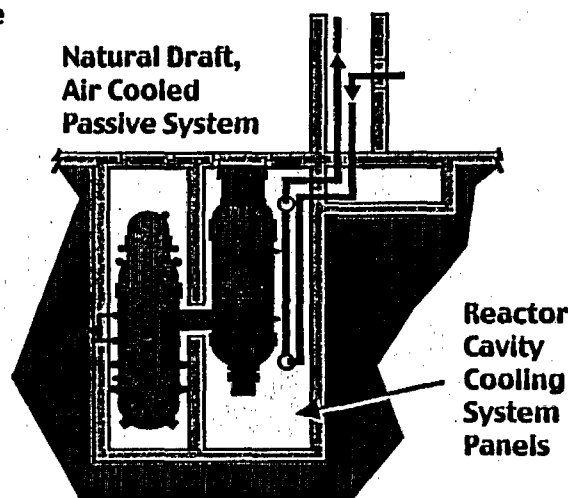
... ANNULAR CORE USES EXISTING TECHNOLOGY



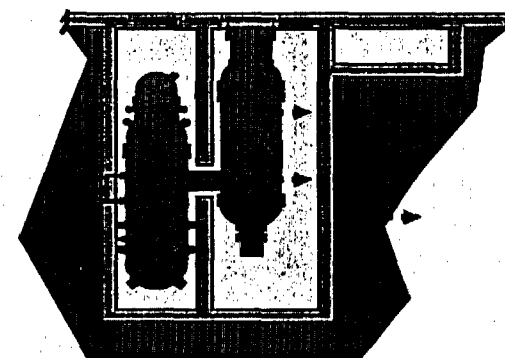
POSSIBLE DECAY HEAT REMOVAL PATHS WHEN NORMAL POWER CONVERSION SYSTEM IS UNAVAILABLE



A) Active Shutdown Cooling System



B) Passive Reactor Cavity Cooling System

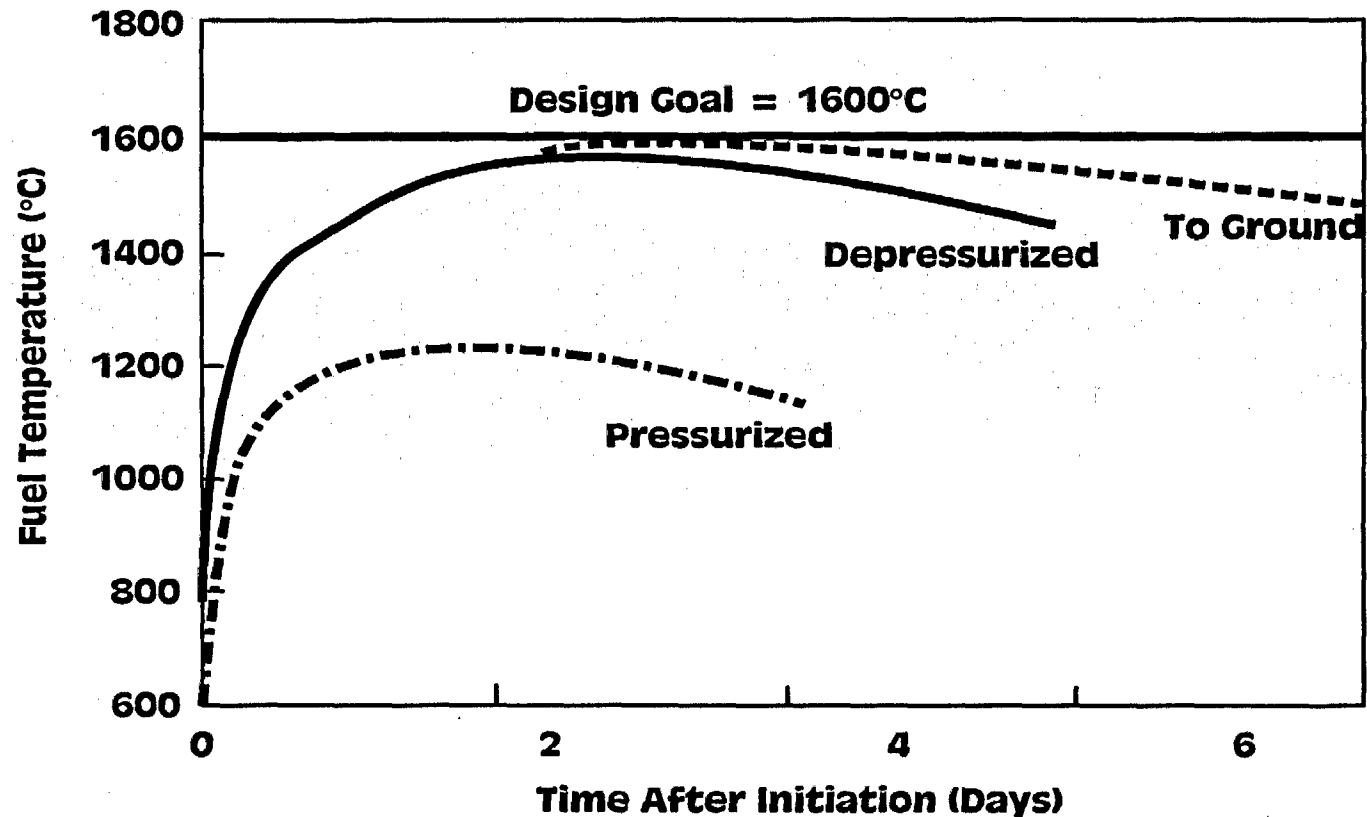


C) Passive Radiation and Conduction of Afterheat to Silo Containment (Beyond Design Basis Event)

**... DEFENSE-IN-DEPTH BUTTRESSED BY
INHERENT CHARACTERISTICS**

 **GENERAL ATOMICS**

FUEL TEMPERATURES REMAIN BELOW DESIGN LIMITS DURING LOSS OF COOLING EVENTS



... PASSIVE DESIGN FEATURES ENSURE FUEL REMAINS BELOW 1600°C



PASSIVE SAFETY BY DESIGN

- **Fission Products Retained in Coated Particles**
 - *High temperature stability materials*
 - *Refractory coated fuel*
 - *Graphite moderator*

- **Worst case fuel temperature limited by design features**

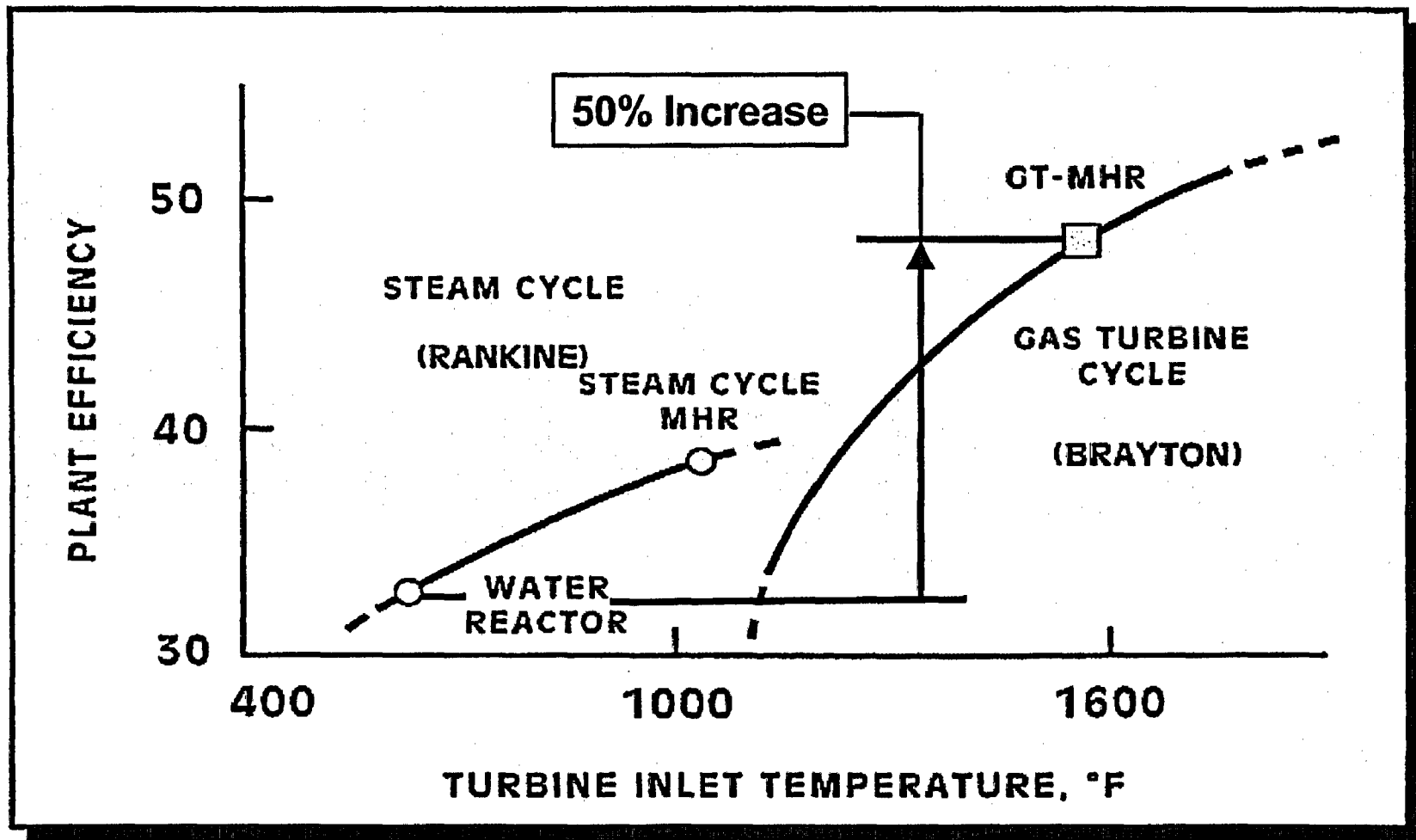
- *Low power density* 4.7 w/cc
- *Low thermal rating per module*
- *Annular Core*
- *Passive heat removal*

Net 1 V + 19% enriched U

....CORE CAN'T MELT

- **Core Shuts Down Without Rod Motion**

HIGH TEMPERATURE GAS REACTORS HAVE UNIQUE ABILITY TO USE BRAYTON CYCLE

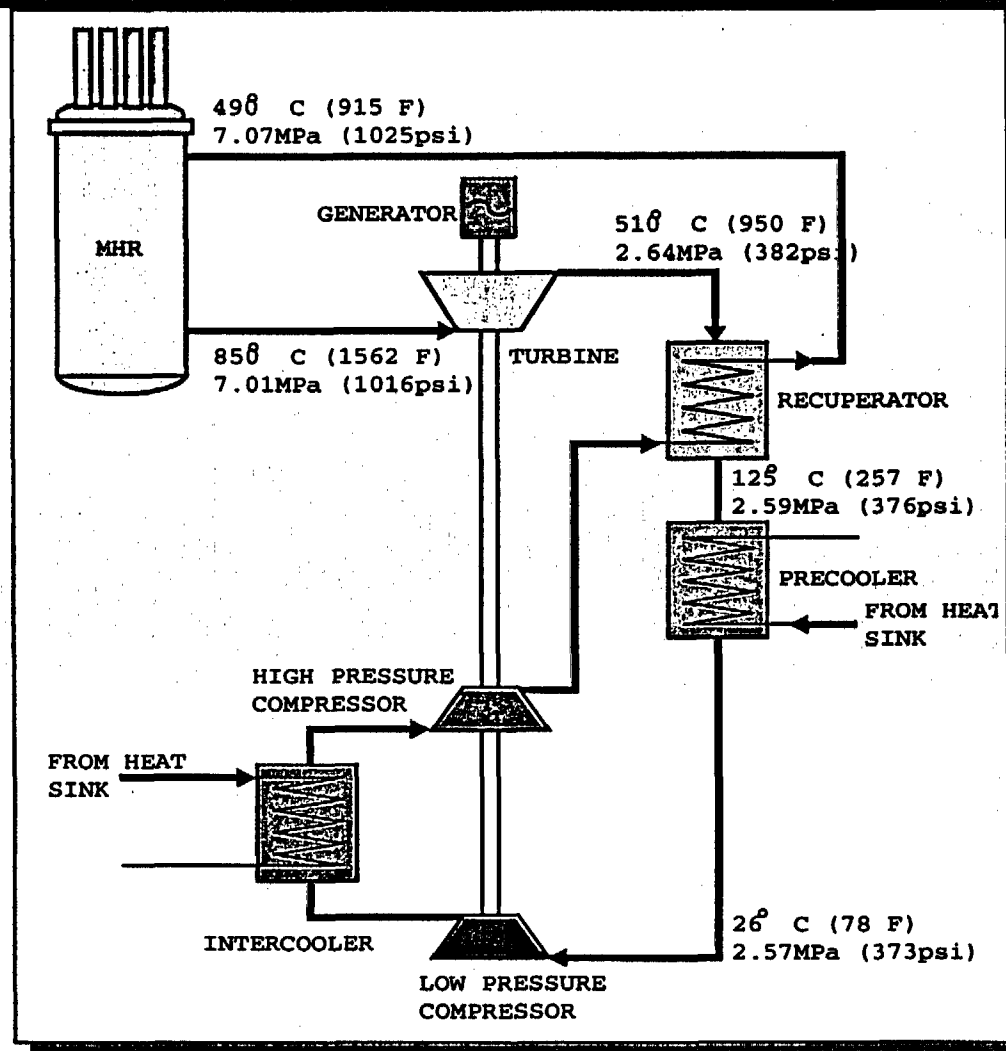


 **GENERAL ATOMICS**

TECHNOLOGY ADVANCEMENTS HAVE ENABLED THE GT-MHR

- **Small Passively Safe Modular Helium Reactor**
 - *turbine size requirements reduced*
 - *insensitive to turbine failure accidents*
- **Large Gas Turbine Engines**
 - *significant increase in industrial applications*
 - *size now match modular reactor size*
- **Magnetic Bearings**
 - *eliminates oil ingress concerns*
 - *improves performance and reliability*
 - *rapidly increasing industrial experience; larger sizes*
- **Compact Heat Exchangers**
 - *dramatically improves efficiency*
 - *size improves design integration*
 - *extensive fossil operating experience*

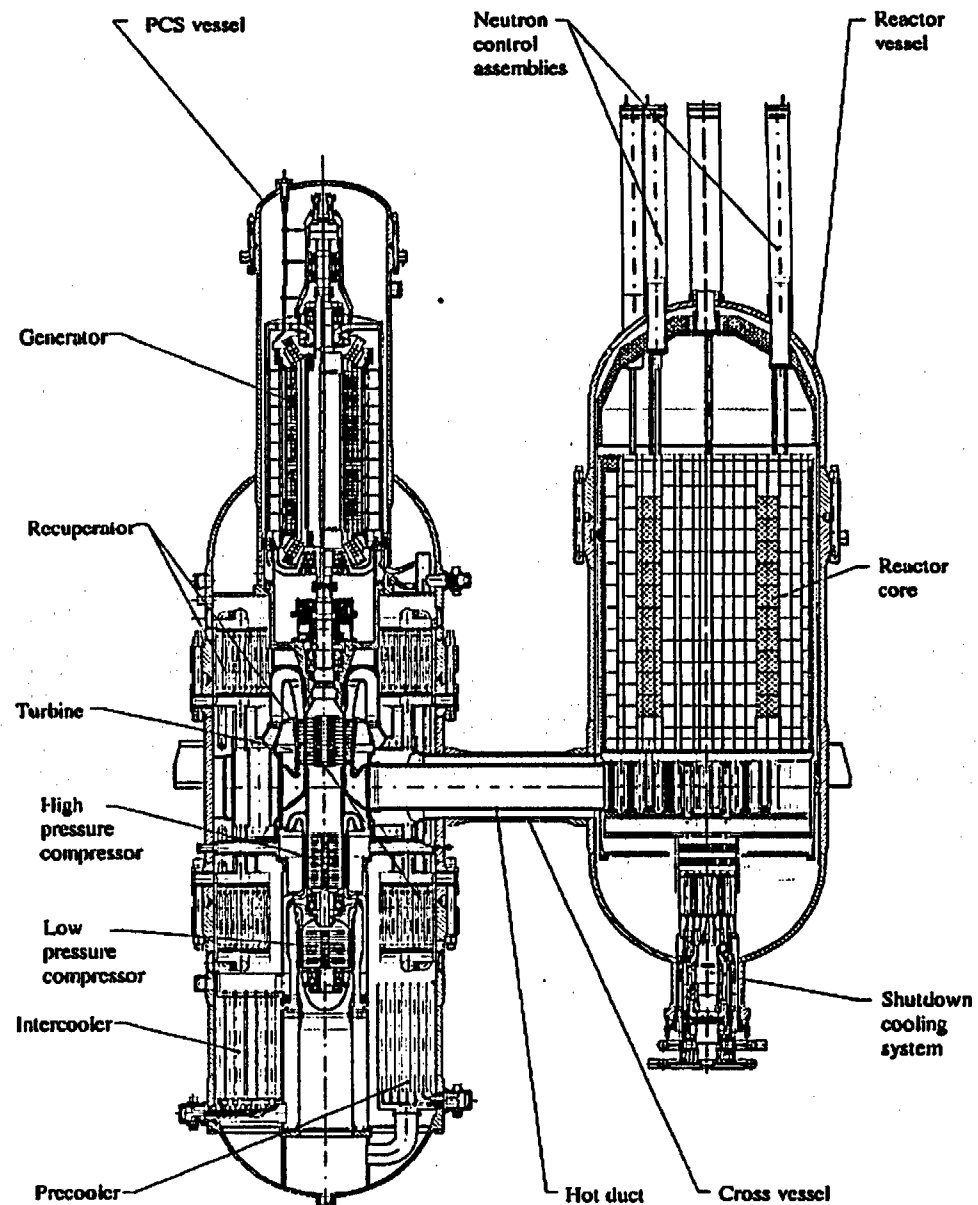
GT-MHR FLOW SCHEMATIC



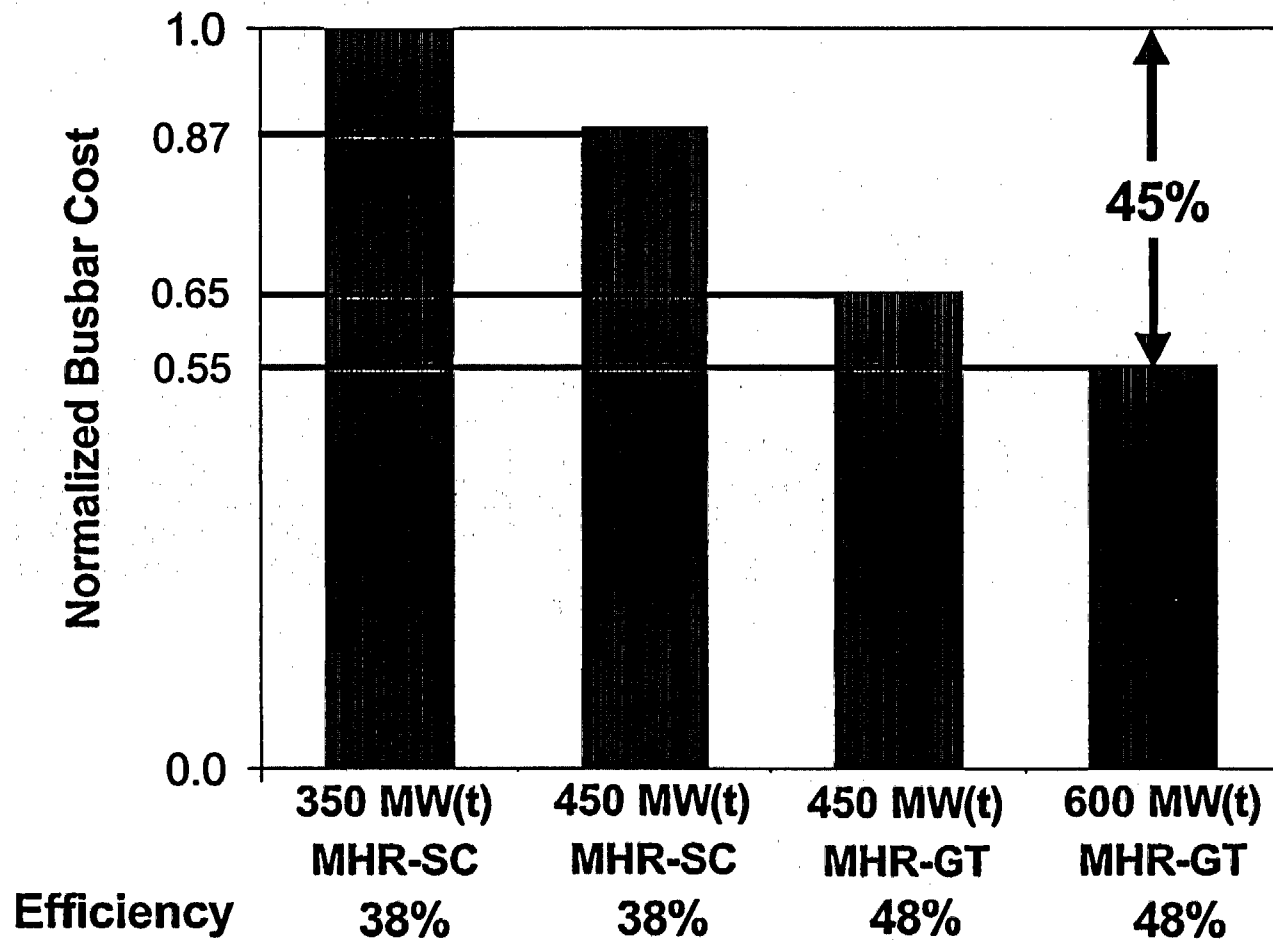
 **GENERAL ATOMICS**

**GT-MHR
COMBINES
MELTDOWN-PROOF
ADVANCED REACTOR
AND
GAS TURBINE**

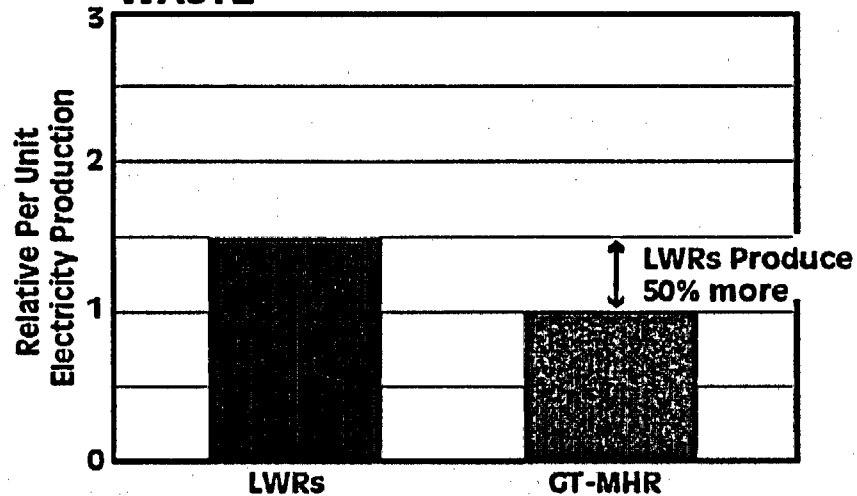
**POWER LEVEL
600 MWt**



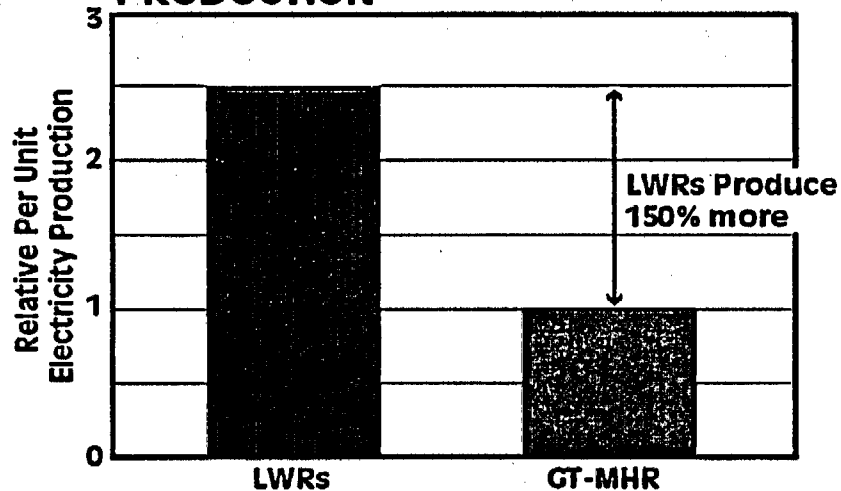
600 MW(t) GT-MHR REDUCES POWER COST BY 45% COMPARED TO 350 MW(t) STEAM CYCLE



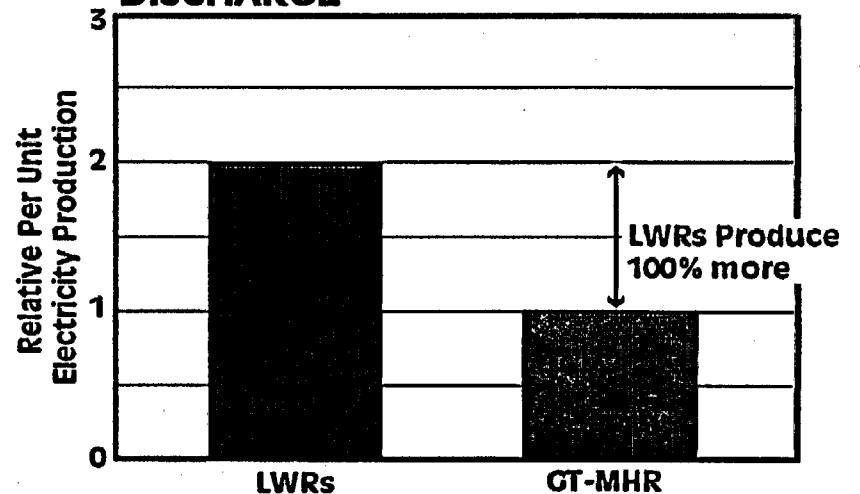
HIGH LEVEL WASTE



ACTINIDE PRODUCTION



THERMAL DISCHARGE



**GT-MHR
OFFERS MAJOR
ENVIRONMENTAL
BENEFITS**



IN SUMMARY, GT-MHR IS A GENERATION IV SYSTEM

- **Inherent safety Features- No core melt**
- **High thermal efficiency resulting Lower Cost**
- **Significantly reduced environmental impact**
- **Superior radio-nuclide retention for long-term spent disposal**



GT-MHR COMMERCIALIZATION PROGRAM

PROGRAM DESCRIPTION



GT-MHR NOW BEING DEVELOPED IN INTERNATIONAL PROGRAM

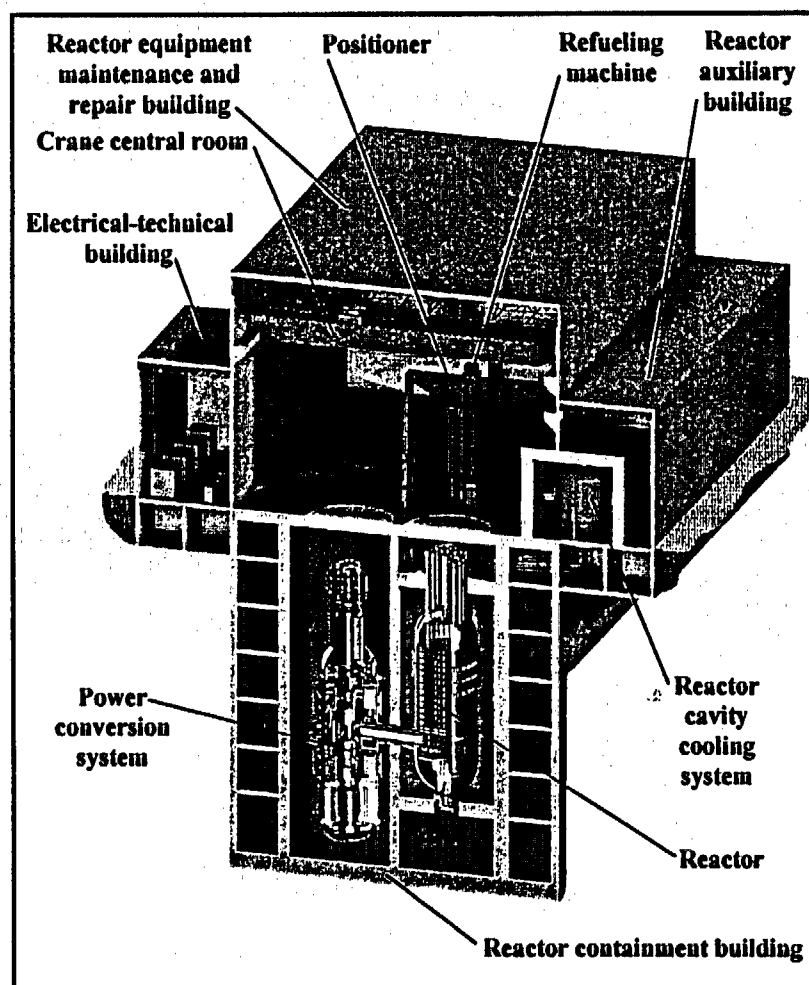
- In Russia under joint US/RF agreement for management of surplus weapons Pu
- Sponsored jointly by US (DOE) and RF (Minatom); supported by Japan and EU
- Conceptual design completed; preliminary design complete early 2002



INTERNATIONAL GT-MHR PROGRAM

- Design, construct and operate a prototype GT-MHR module by 2009 at Tomsk, Russia
- Design, construct, and license a GT-MHR Pu fuel fabrication facility in Russia
- Operate first 4-module GT-MHR by 2015 with a 250 kg plutonium/year/module disposition rate

***....Fuel contains Pu only
.....No fertile component***

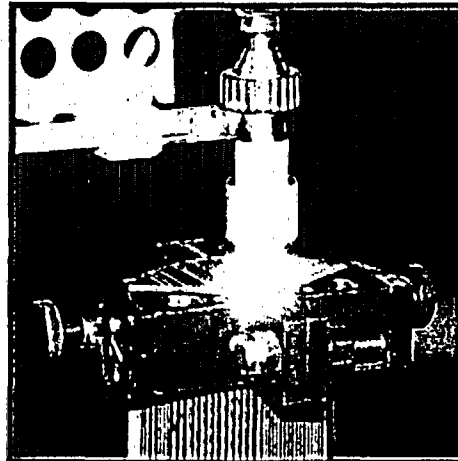


 **GENERAL ATOMICS**

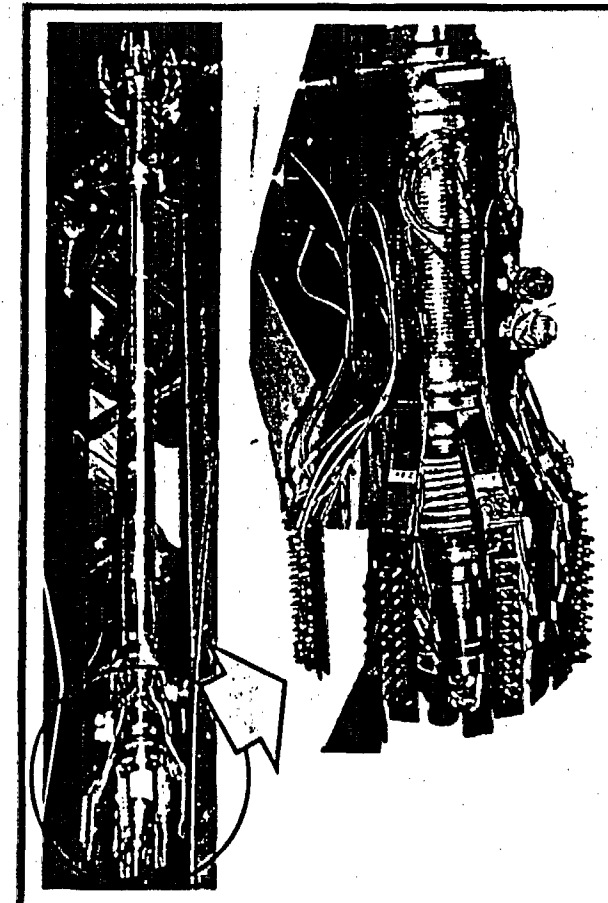
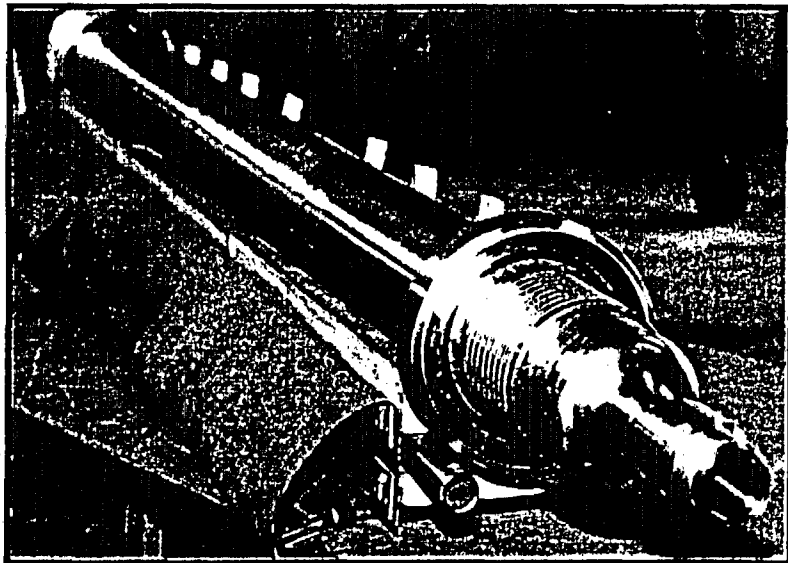
Russian Technological Developments.

Recuperator

**Heat
Exchange
Element
Fabrication**



**Recuperator Heat
Exchange Element**



**Tests of full scale heat
exchange element in
helium test facility**

COMMERCIALIZATION PROGRAM



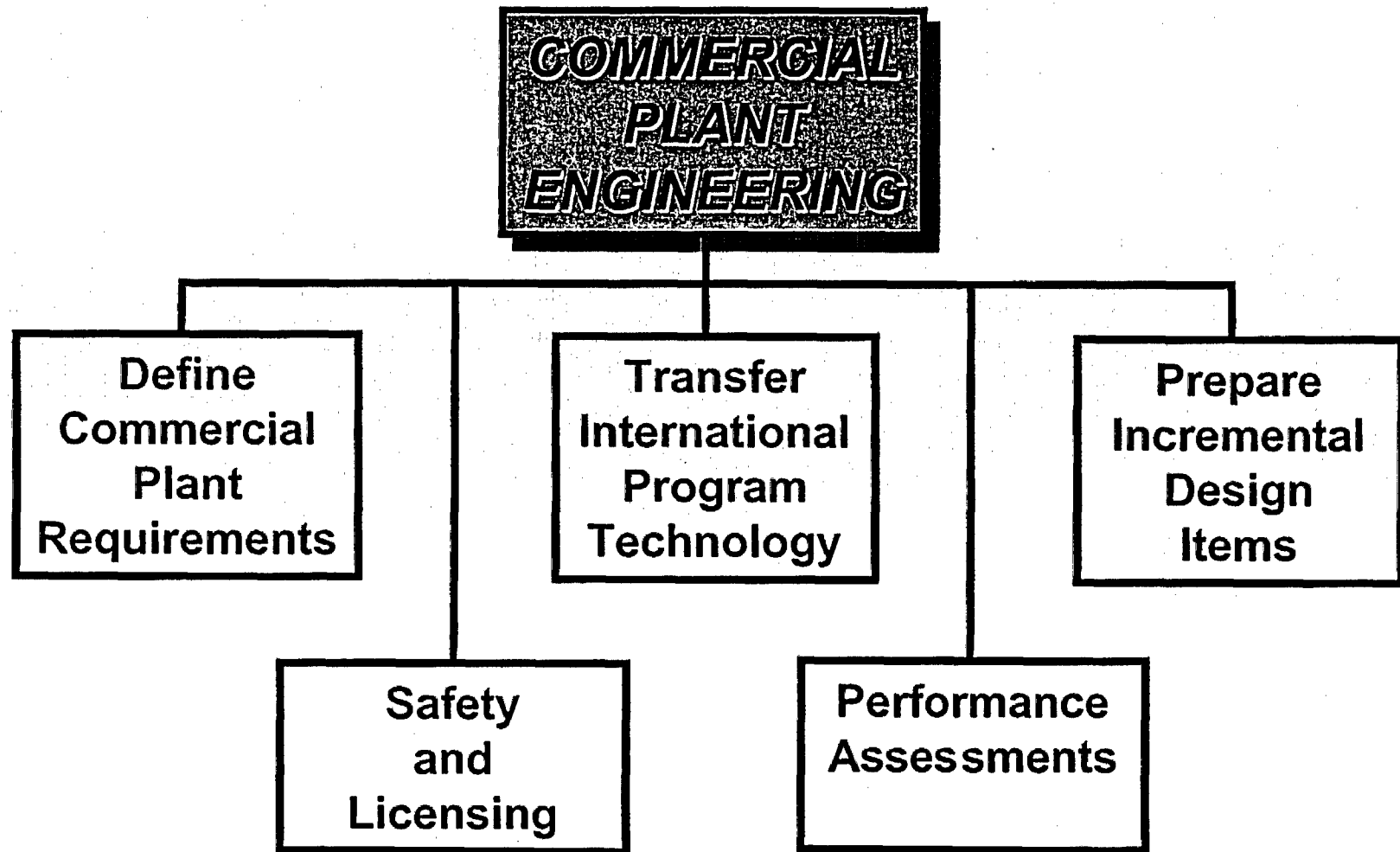
Plant construction can start in 5 years

COMMERCIAL PROGRAM FOLLOWS INTERNATIONAL PROGRAM

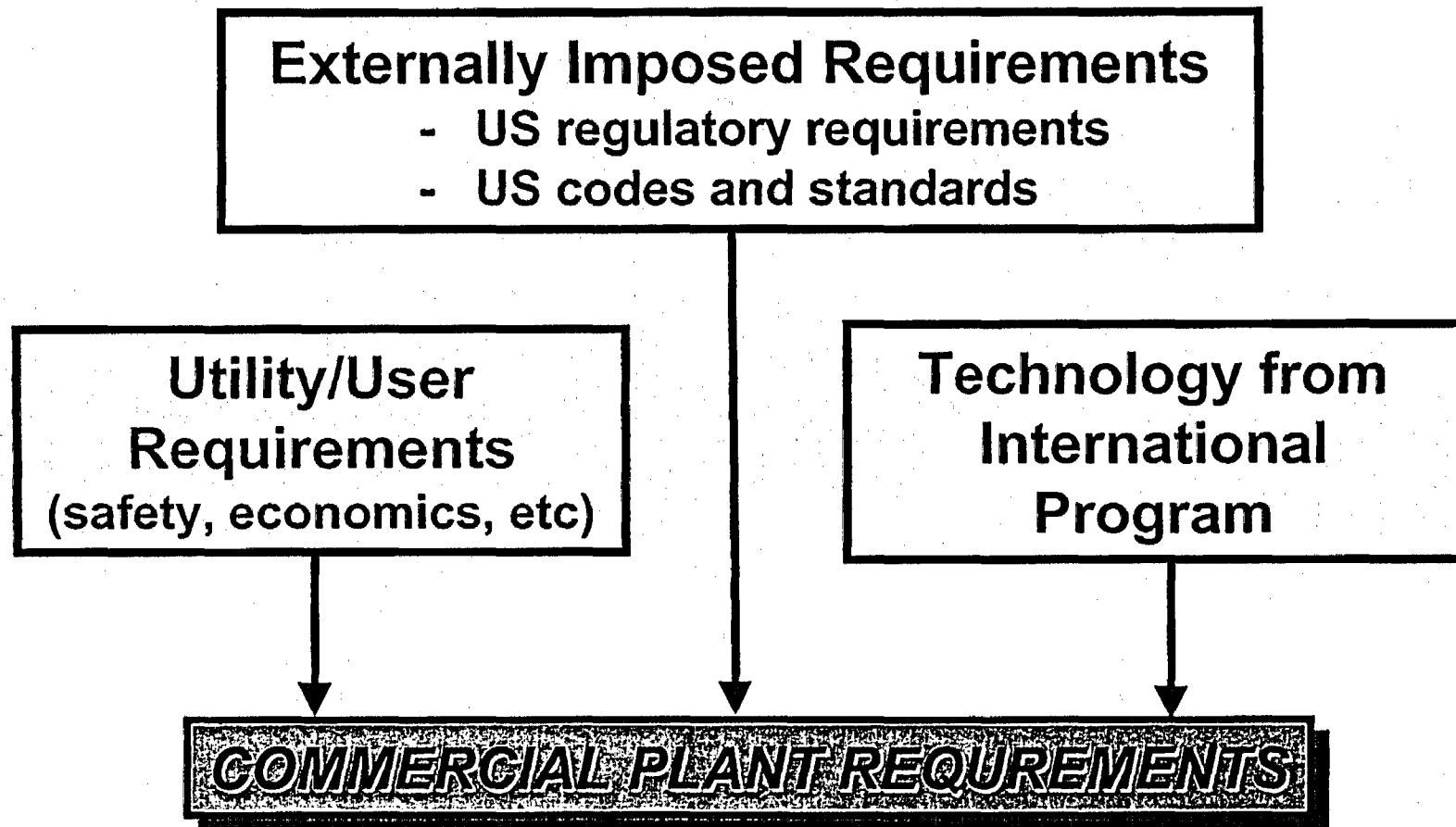
	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15
INTERNATIONAL PROGRAM														
Design and Devel				▼	Complete Design & Development									
Prototype Licensing				▼	Construction License									
Prototype constr									▼	Complete Proto Constr				
Prototype Startup										▼	Complete Proto Demo			
Full Power Operation										▼	Start Full Power Ops			
GT-MHR COMMERCIAL PROGRAM														
Prel Design			▼	Complete Plant Preliminary Design										
SAR			▼	Complete SAR										
SER				▼	Complete SER									
Final Design					▼	Complete Final Design								
Fuel														
- Automated FF Plt				▼	Complete Automated Fuel Fab Plant Pilot Plant									
- Qualified Fuel									▼	Complete Tests				
First Comm Plt														
- First Order			▼	Ltr of Intent		▼	Order for First Comm Plant							
- Constr						▼	Start Plant Construction							
- Operation Mod 1									▼	Startup of Module 1				
- Operation Mod 2										▼	Mod 2			
- Operation Mod 3											▼	Mod 3		
- Operation Mod 4												▼	Mod 4	



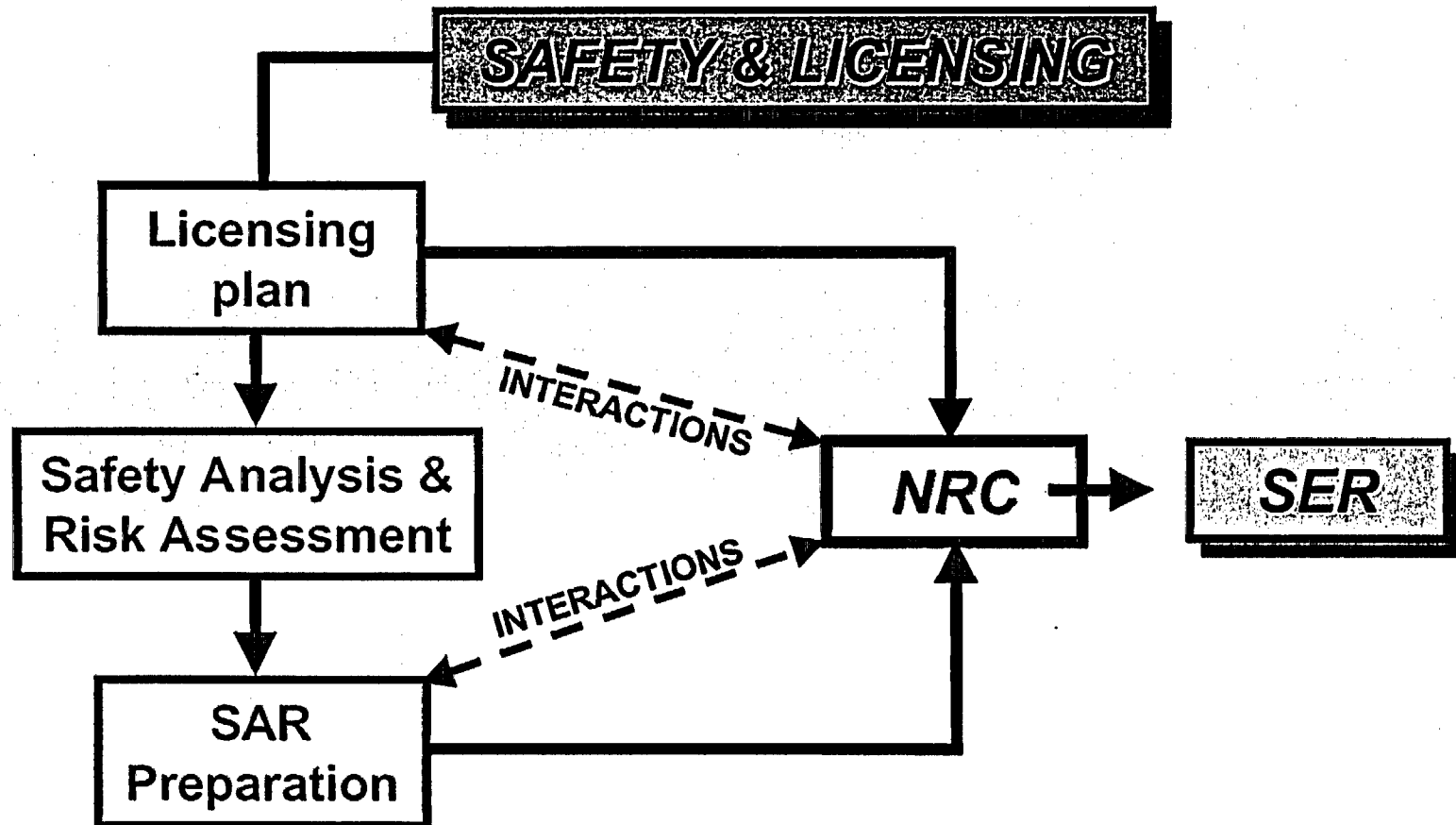
LIMITED ENGINEERING WORK REQUIRED



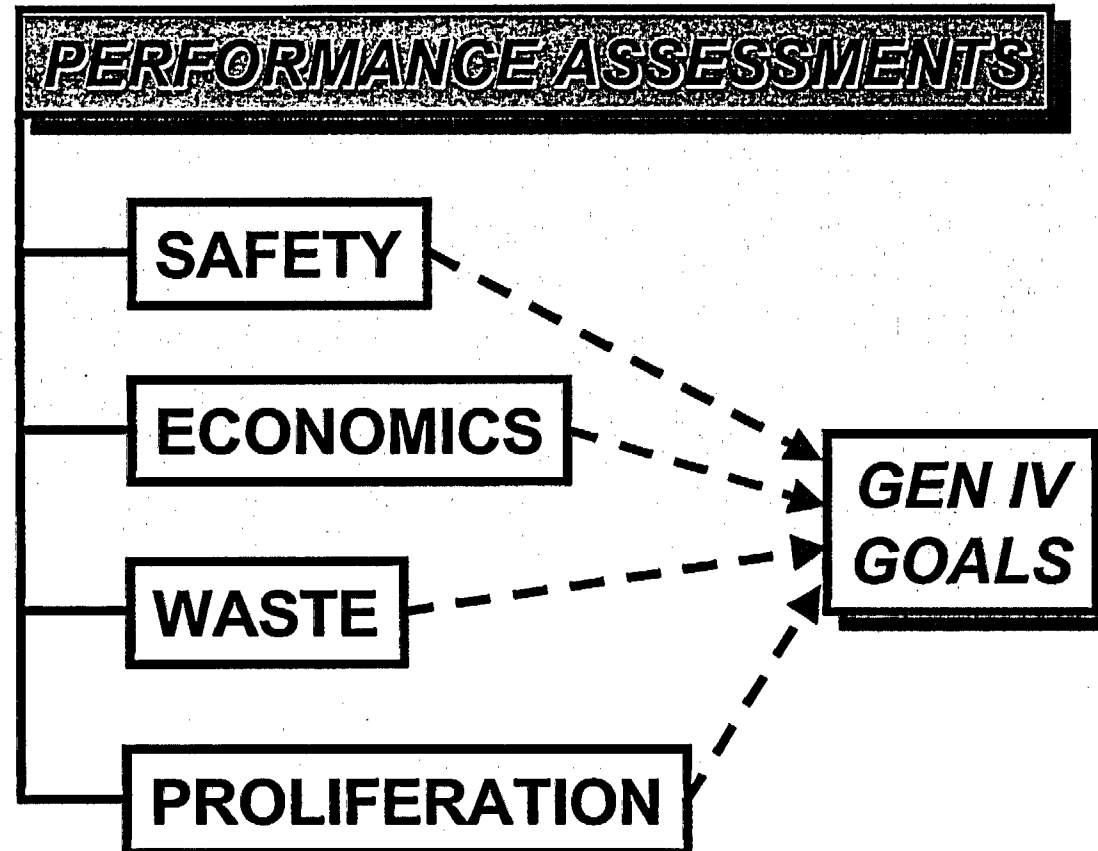
PLANT REQUIREMENTS PLANNED FROM SEVERAL SOURCES



SAFETY & LICENSING ACTIVITIES



PERFORMANCE ASSESSMENT ACTIVITIES PLANNED



COMMERCIAL PROGRAM SUMMARY

- **GEN IV PLANT**
- **COST EFFECTIVE**
- **NEAR TERM**

