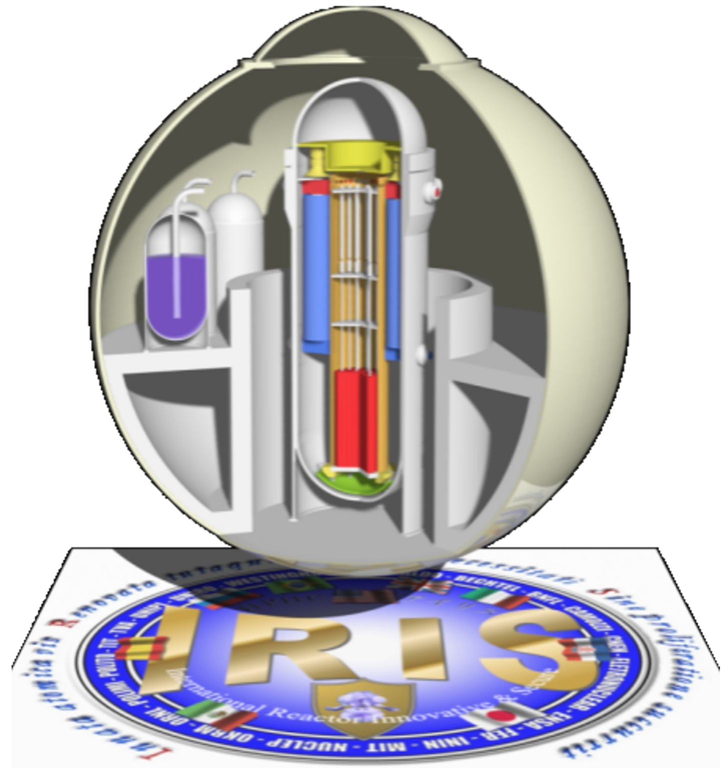
IRIS: Ready To Proceed Toward a Worldwide Deployment

Westinghouse Electric Co. LLC



Engineers' Week

February 23, 2006

An Advanced, Modular, Medium-Power (335 MWe) LWR

The Global Nuclear Energy Partnership (GNEP)

GNEP Element: Demonstrate Small-Scale Reactors

GNEP will provide small-scale reactors suitable for emerging economies that currently depend on oil and other fossil fuels for growing energy demands. Addressing this market is essential to safely expanding nuclear energy in developing nations and small-grid markets without increasing proliferation concerns.

Small, More Proliferation-Resistant Power Reactors

Light water reactors (LWRs) dominate the commercial use of nuclear power. Historically, the requirements of large national markets with big electricity grids have driven the development of nuclear power reactors, resulting in commercial units of about 1000 MWe. Markets with much smaller grids and less well-developed technical infrastructures have not had much impact on power reactor designs and technologies. A different reactor design approach, tailored for this market segment, could help meet the rising power demands associated with economic growth and urbanization, while avoiding the use of fossil fuels that would otherwise be burned in power plants.

In order to expand the use of nuclear energy in these small electricity markets, a small

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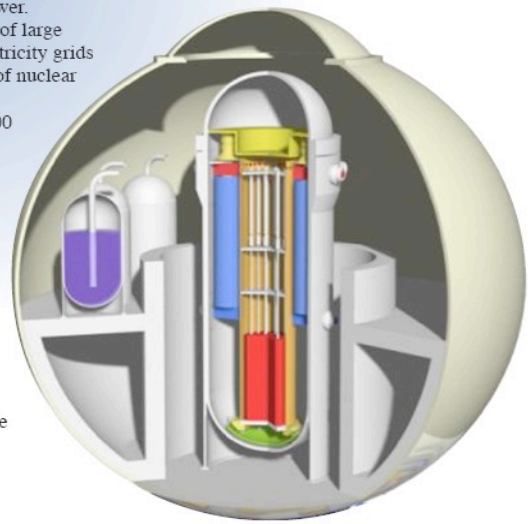
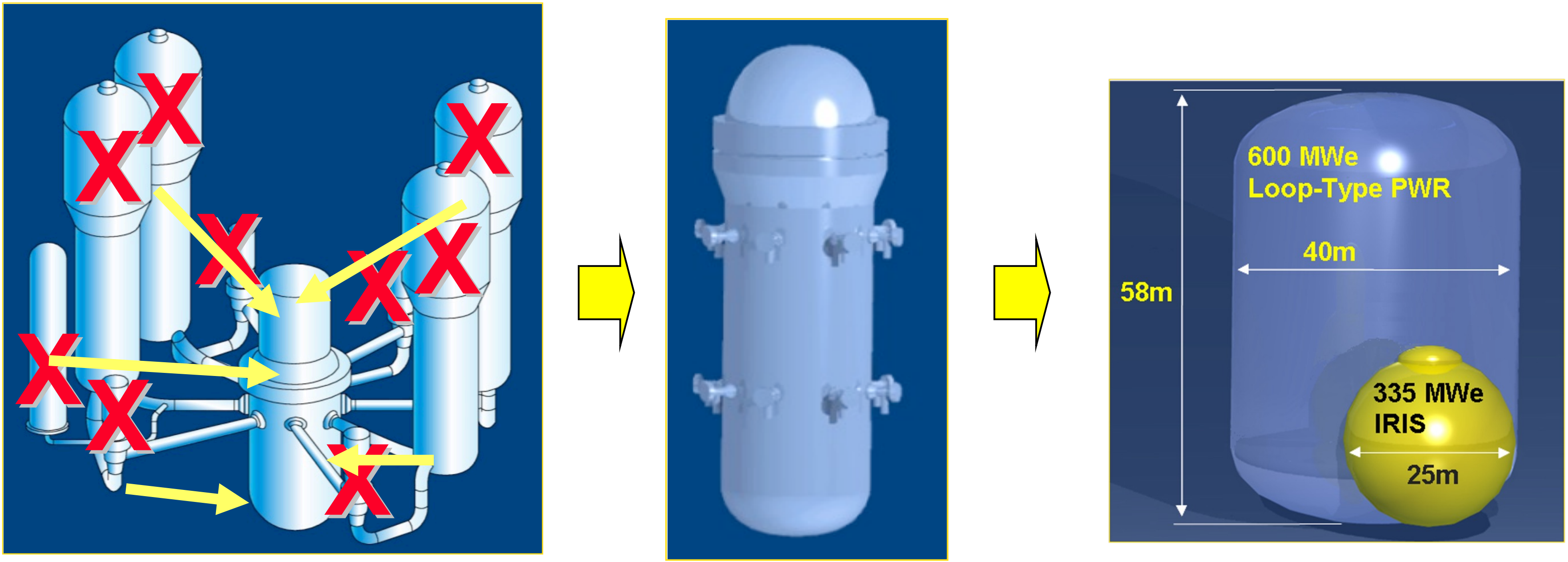
An example of a "small reactor" is IRIS, **International Reactor Innovative and Secure** *(www.irisreactor.org)*



United States Department of Energy

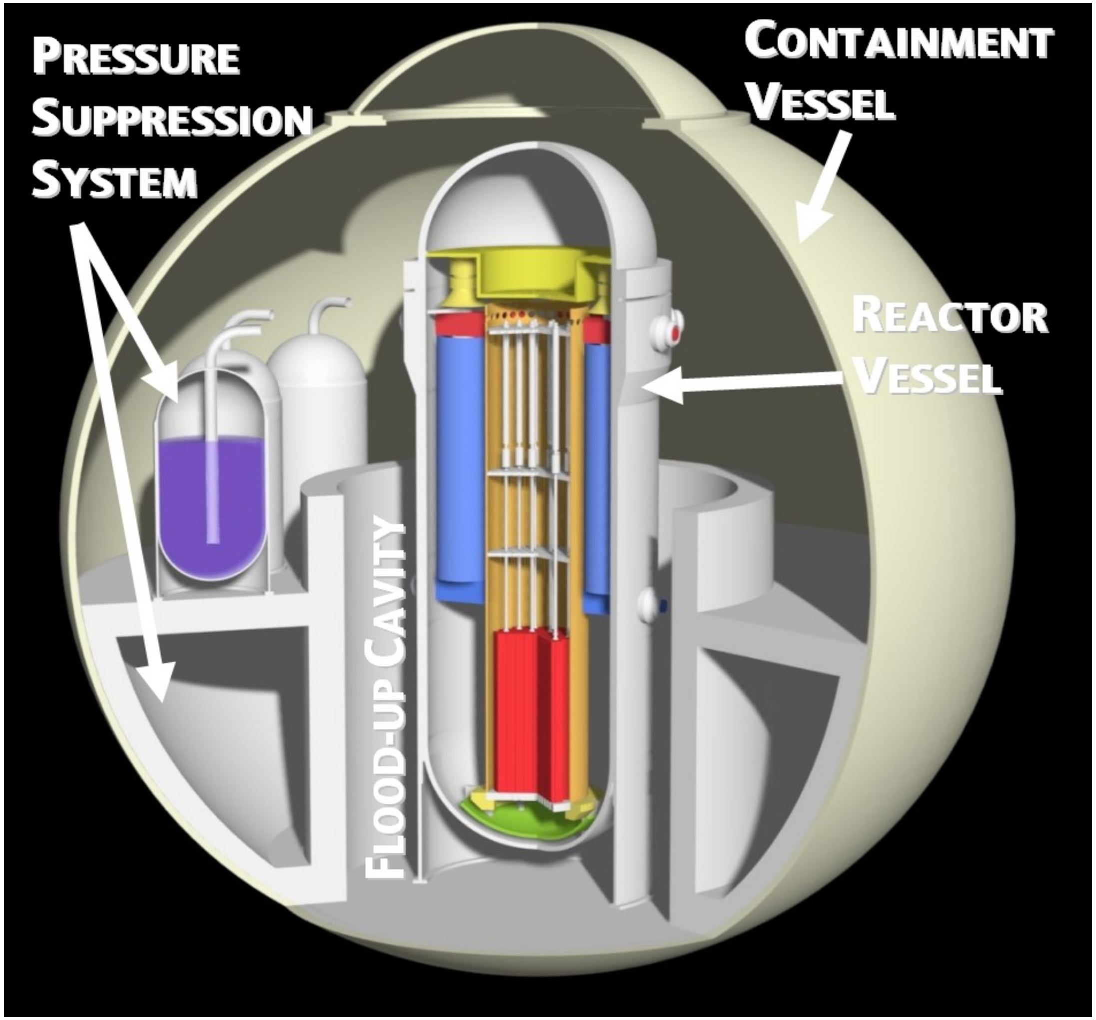
NSSS - Integral Primary System Configuration (IPSR)



Integral vessel configuration eliminates loop piping and external components, thus enabling compact containment and plant size

- Simplicity, enhanced safety, reduced cost

IRIS



PRESSURE SUPPRESSION SYSTEM
CONTAINMENT VESSEL
REACTOR VESSEL
FLOOD-UP CAVITY

IRIS Main Design Parameters

General Plant Data	
Core thermal power	1000 MWt
Power plant output, net	335 MWe
Nuclear Steam Supply System	
Number of coolant loops	Integral primary system
Steam temperature, pressure	317°C, 5.8 MPa
Feedwater temperature, pressure	224°C, 6.4 MPa
Reactor Coolant System	
Primary coolant flow rate	4700 kg/s
Reactor operating pressure	15.5 MPa
Core inlet / outlet (riser) temperature	292°C / 330°C
Reactor Core	
Active core height	4.267 m
Fuel inventory	48.5 tU
Average linear heat rate	10.0 kW/m
Fuel material	Sintered UO_2
Number of fuel assemblies	89
Rod array	Square, 17x17
Number of fuel rods/assembly	264
Outer diameter of fuel rods	9.5 mm
Enrichment	Up to 4.95 wt% U-235
Equilibrium cycle length	30-48 months
Average discharge burnup	Up to 60,000 MWd/tU

Reactor Pressure Vessel	
Cylindrical shell inner diameter	6.21 m
Wall thickness of cylindrical shell	285 mm
Total height	21.3 m
Steam Generators	
Type	Helical coil tube bundle, once-through, superheated
Number	8
Thermal capacity (each SG)	125 MWt
Reactor Coolant Pump	
Type	Spool type, fully immersed
Number	8
Pump head	19.8 m
Primary Containment	
Type	Pressure suppression, steel
Geometry	Spherical, 25 m diameter
Design pressure, temperature	1300 kPa, 200 °C

IRIS Schedule Targets

• Program started	End 1999
• Assessed key technical & economic feasibility	End 2000
• Performed conceptual design, preliminary cost estimate	End 2001
• Submitted pre-application licensing for Design Certification (DC)	Fall 2002
• Completed NSSS preliminary design	Mid 2005
• On-going pre-application review with the US NRC	
• Initiate testing necessary for NRC Design Certification	Early 2006
• Complete testing	Mid 2008
• Start NRC Design Certification	Late 2008
• Obtain Final Design Approval from NRC	Late 2012
• First module deployment (e.g., in IRIS Consortium state)	2015-2017

IRIS Most Significant Discriminators

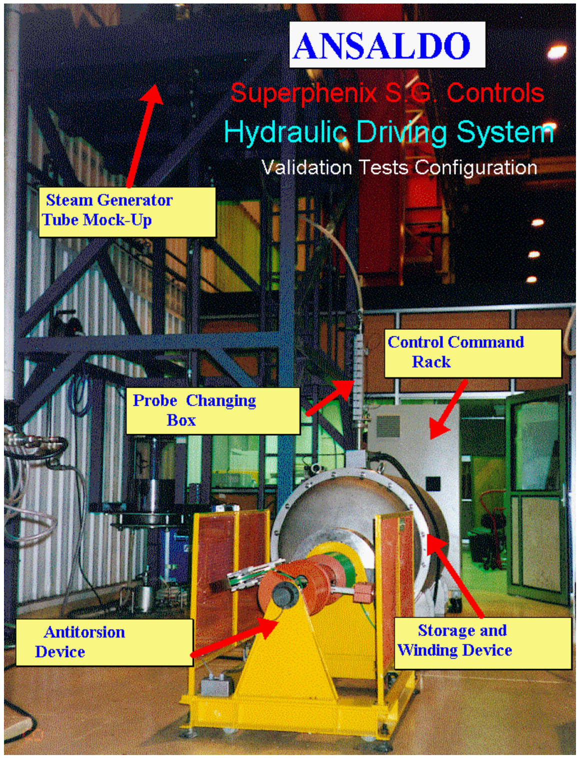
- Integral design configuration
- Simplicity
- Uses proven light water technology
- Implements engineering innovations, new solutions, but does not require new technology development
- Safety approach through safety-by-design™
- International consortium

An Integral PWR Powered the Nuclear Ship Otto Hahn

German nuclear-powered freighter & research facility:

- Launched in 1964 and commissioned in 1968
- Sailed 650,000 miles in 10 years without any technical problems
- Integral PWR with helical coil, superheated steam SG
- SG and internals inspected at the second refueling after 5.5 years (47,700 hrs) operation

Other Experience with Integral, Helical Steam Generators



ANSALDO NUCLEARE
Division of Ansaldo Energia SpA

ANSALDO CAMOZZI

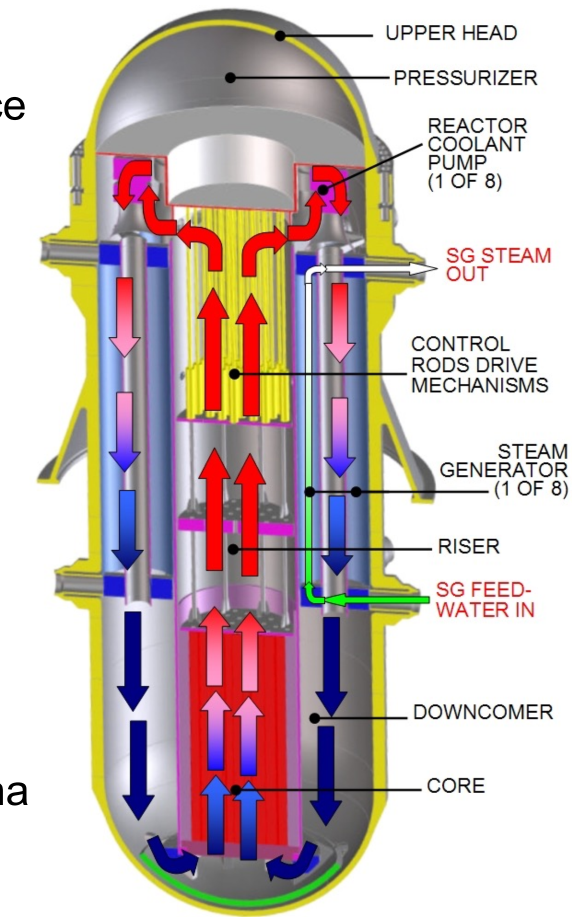
- Operated in LMFBR (SuperPhenix)
- On line inspection (ultrasound and visual) and maintenance (cleaning and gauging)

- Almost prototypic mockup (same diameter, 8.5 m long) of IRIS SG bundle has been tested (thermal, hydraulic, vibration, stability)

- Ansaldo Energia is responsible for IRIS SG design and Ansaldo Camozzi for fabrication

Integral Components Offer Better Design and Performance

Steam generators	Tubes in compression. Tensile stress corrosion cracking eliminated
Primary coolant pumps	No seal leaks. No shaft breaks. No maintenance
Internal CRDMs	No head penetrations, no seal failures, no head replacements
Pressurizer	Much larger volume/power ratio gives much better pressure transients control. No sprays.
1.7m thick downcomer	Vessel fast flux ~10^5 times lower. "Cold" vessel. Almost no outside dose. No embrittlement, no surveillance. "Eternal" vessel. Simpler decommissioning.
Fuel assembly	Almost the same as standard W PWR, but can ha extended cycle up to 48 months
Maintenance	Intervals can be extended to 48 months



Major / Integral Components

- Containment
- Pressure vessel and internals
- Core
- Steam generators
- Reactor coolant pumps
- Internal CRDMs
- Pressurizer
- Intermediate closure ring

- Status: Preliminary (or conceptual) design completed at different level of details

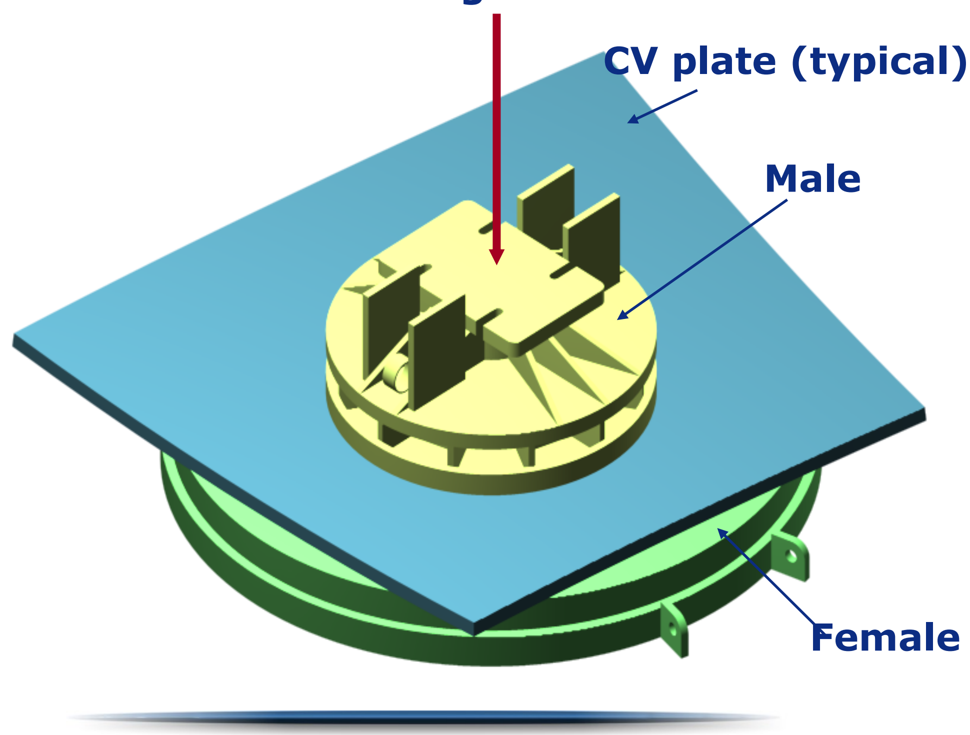
IRIS Design Parameters – Reactor Vessel and Containment

Reactor Pressure Vessel	
Type	Cylindrical, low carbon steel
Cylindrical shell inner diameter	6.21 m
Wall thickness of cylindrical shell	285 mm
Total height	21.3 m
Design basis vessel lifetime	60 years (due to very low fast neutron fluence, lifetime over 60 years is possible)
Containment	
Type	Pressure suppression, steel
Geometry	Spherical, 25 m diameter
Design pressure and temperature	1300 kPa, 200 °C

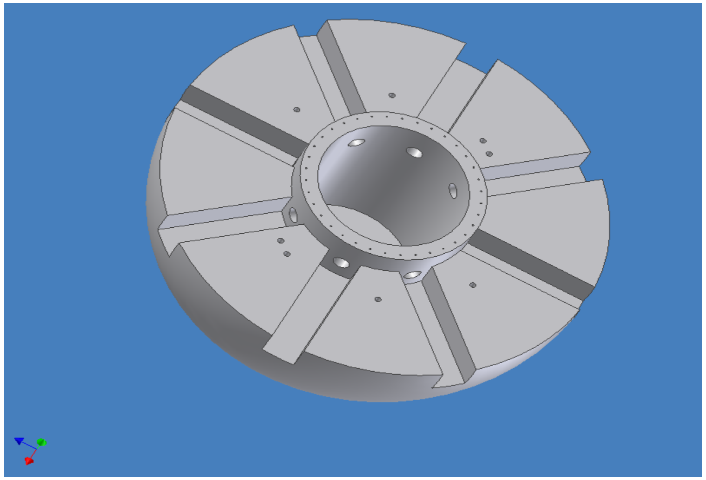
IRIS Containment

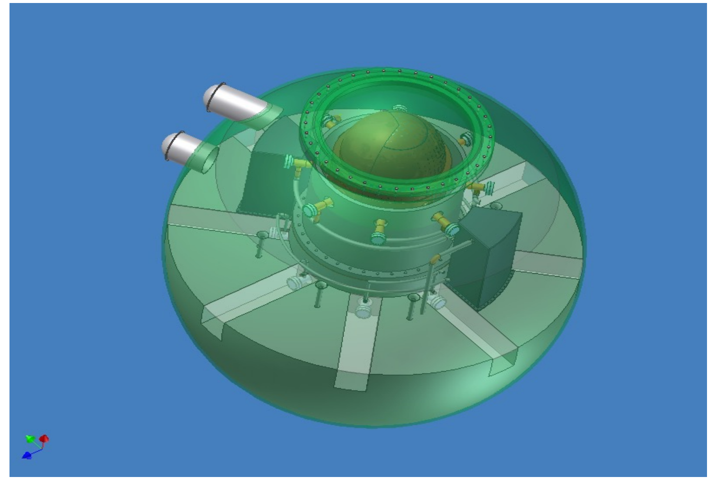
- Designed by NUCLEP with Westinghouse input
- Conceptual design completed
- Simple design
- Containment internal layout needs to be completed/refined

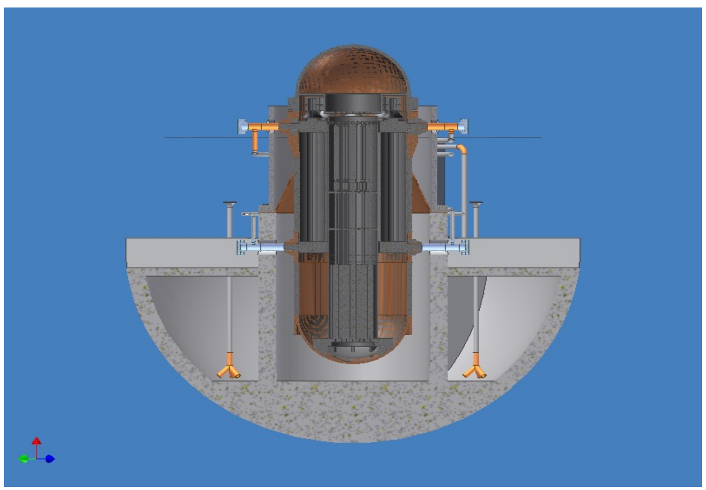
FORMING OF PLATES:

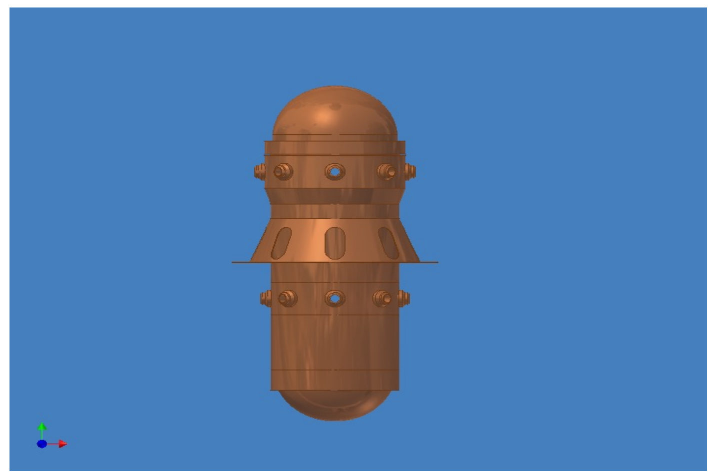


IRIS Containment Layout

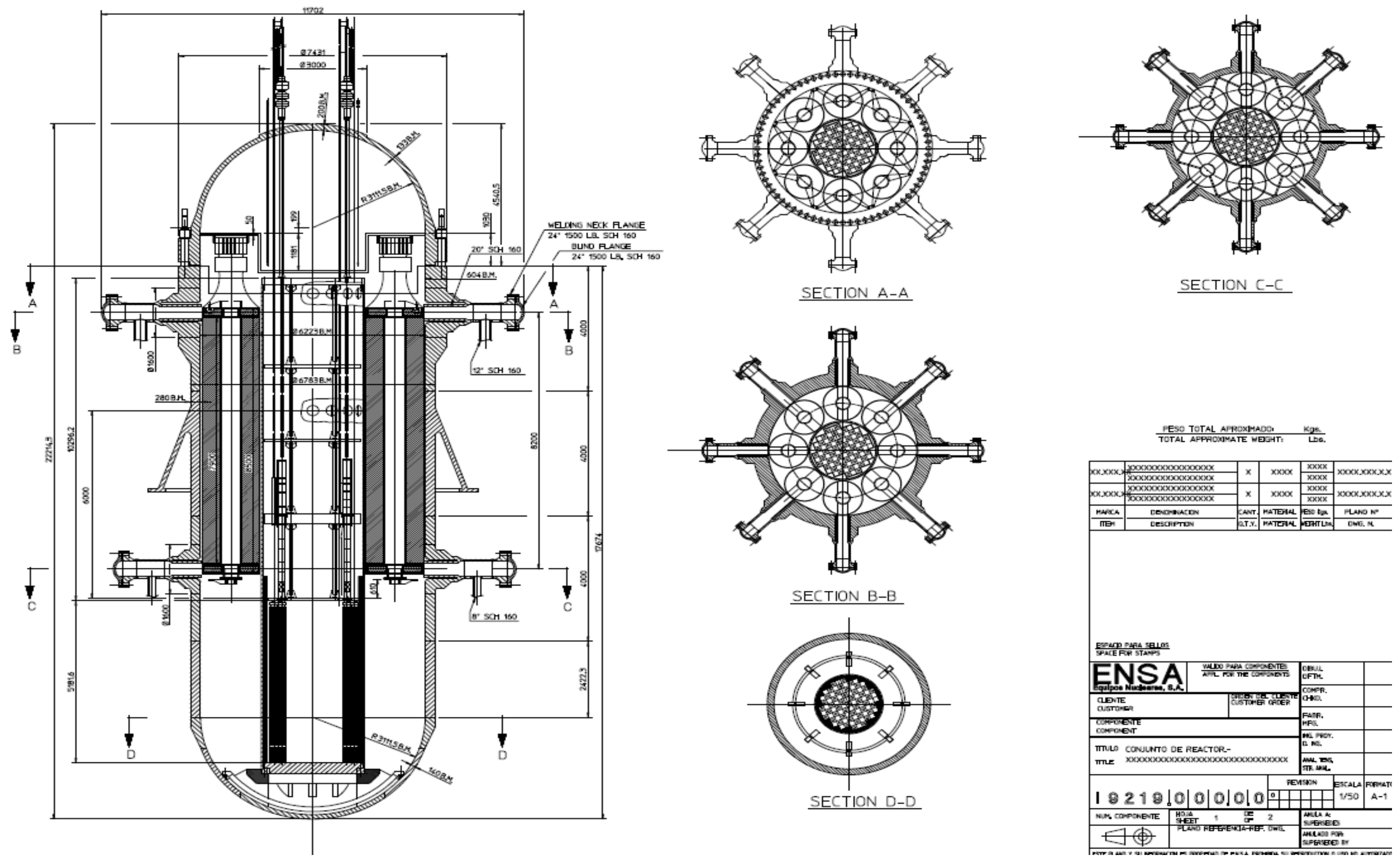








IRIS Reactor Vessel and Internals



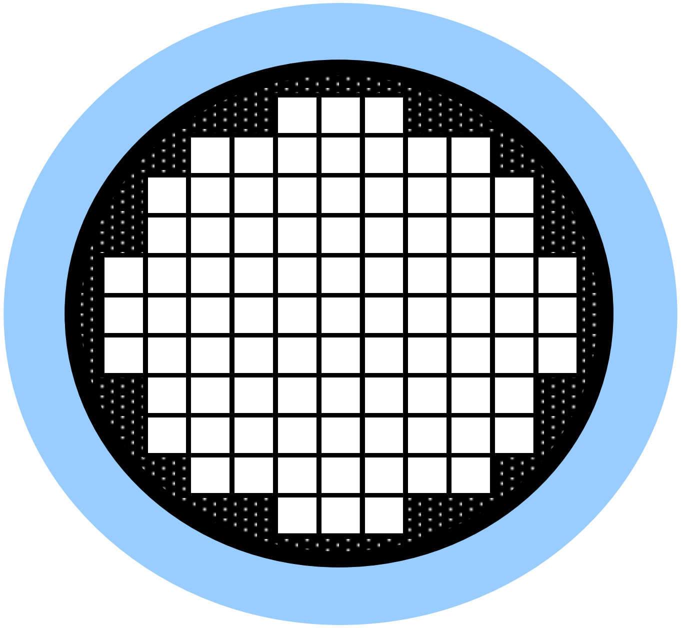
- Designed by ENSA
- Relatively high level of detail
- Some preliminary analyses performed
- Need to update, develop final design

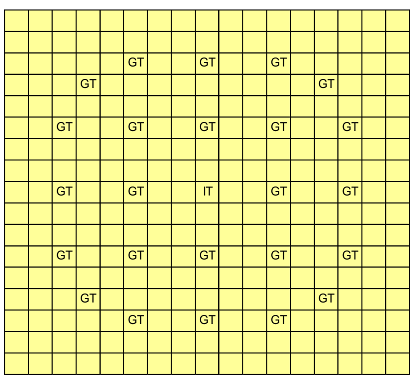
IRIS Design Parameters – Core and Fuel

Reactor Core	
Equivalent diameter	2.41 m
Active core height	4.267 m
Fuel inventory	48.5 tU
Average linear heat rate	10.0 kW/m
Number of fuel assemblies	89
Number of fuel rods/assembly	264
Outer diameter of fuel rods	9.5 mm

Fuel	
Fuel material	Sintered ceramic $UO_{2\ /\ MOX\ pellets}$
Enrichment	Up to 4.95 wt% ^{235}U fuel readily available Option for infrequent refueling requires ~7-10% fissile content

Core and Fuel Assembly





- 89 assemblies, 1,000 MWt
- 17x17 fuel assembly, XL
- UO_2 fuel
- Standard fuel rod size (0.374”)
- Incorporates standard W design features
- Enhanced moderation
- Enrichment <5%
  Burnup <62 GWd/tU
- Long plenum eliminates
  potential rod internal pressure issues, enables future core upgrades and increased discharge burnup

IRIS Design Parameters – Steam Supply System

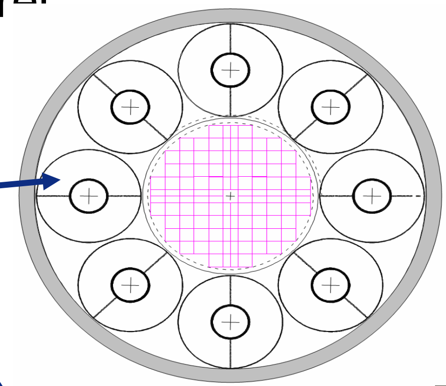
Reactor Coolant System	
Number of coolant loops	Integral primary system
Primary circulation	Forced circulation, 8 in-vessel fully immersed pumps
Primary coolant flow rate	4700 kg/s
Reactor operating pressure	15.5 MPa
Core inlet / outlet temperature	292°C / 330°C
Nuclear Steam Supply System	
Cycle type	Indirect
Thermodynamic efficiency	34.9% (site dependent)
Steam temperature and pressure	317°C, 5.8 Mpa
Feedwater temperature and pressure	224°C, 6.4 Mpa
Steam Generators	
Type	Once-through with superheated steam
Tubes	Helical coil tube bundle, primary outside the tubes
Number	8
Thermal capacity (each SG)	125 MWt

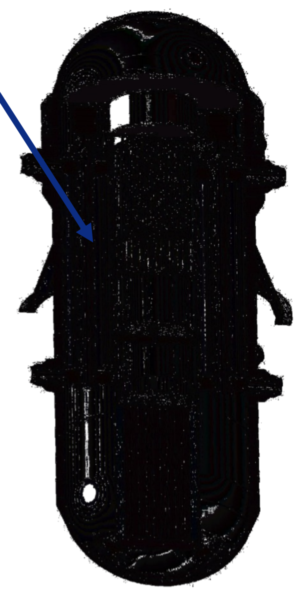
IRIS Helical Coil Steam Generators

- 8 helical-coil steam generators located in the annular region between the core barrel and reactor

HELICAL STEAM GENERATOR

- Primary outside SG tubes (tubes in compression)
- Allows thermal expansion, good heat transfer characteristics
- LMFBR SG operating experience
- Fabricated and tested for LWR
- Test confirmed performance (thermal, pressure losses, vibration, stability)
- IRIS - 8 SG, 8.5 meters long, same bundle diameter as Ansaldo test
- Once through with superheat





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IRIS Helical Coil Steam Generators

- Pre-IRIS tests by Ansaldo Energia
- Preliminary performance data generated by Ansaldo Energia
- Currently design activities led by Camozzi

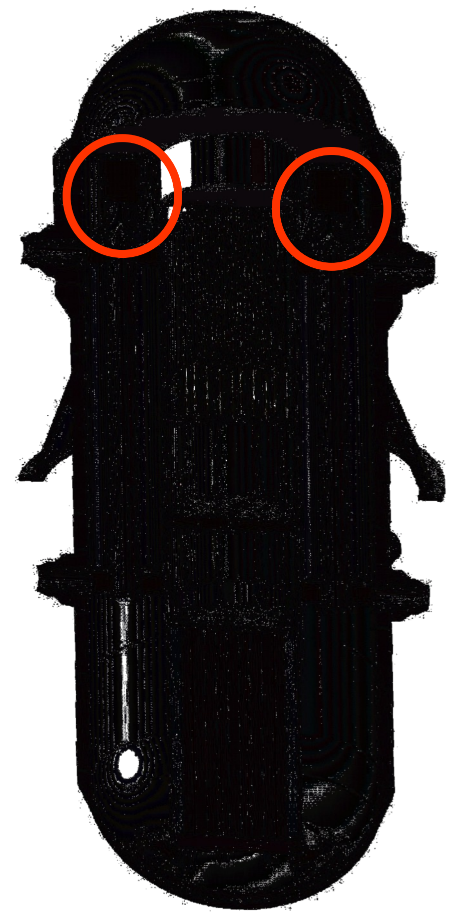
- Need to finalize/optimize header design
- Bundle manufacturing/assembling issues
- Demonstrate performance
- Demonstrate cleaning/maintenance

IRIS Design Parameters – Reactor Coolant Pumps

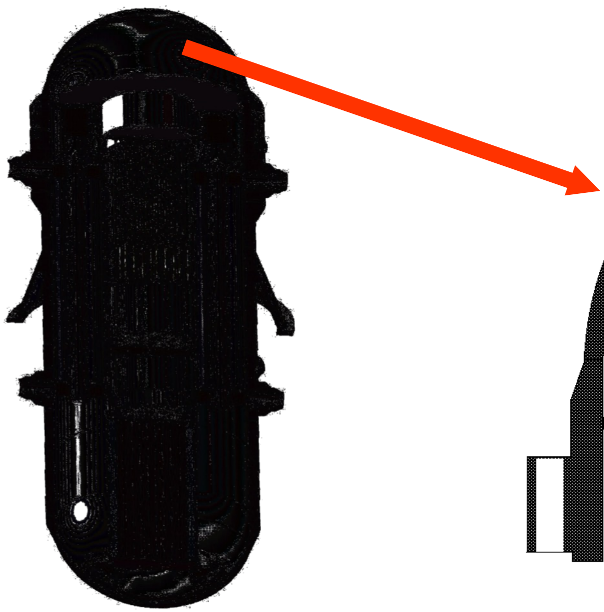
Reactor Coolant Pumps	
Type	Axial (propeller) type pumps, fully immersed
Number	8
Pump head	19.8 m

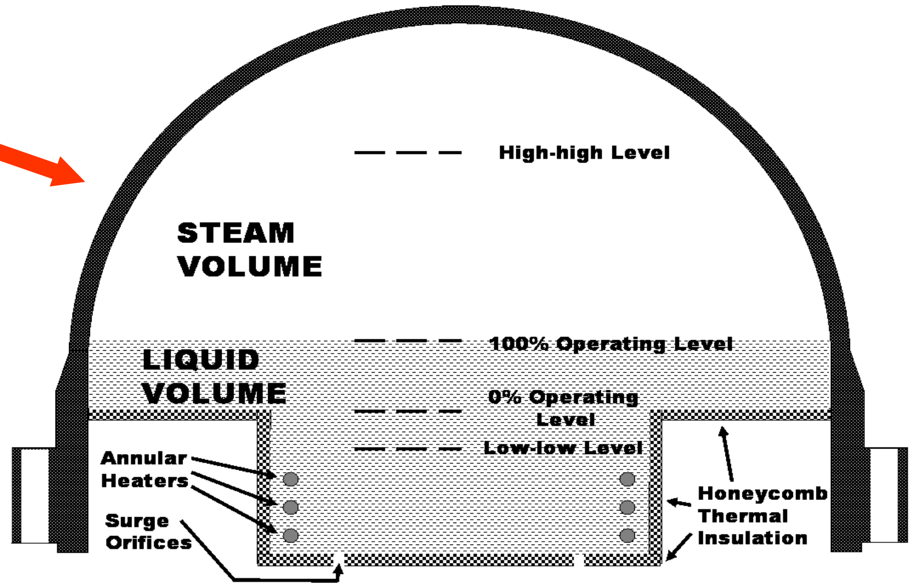
Primary Coolant Axial Flow Pumps

- Axial flow (propeller) pumps - developed for marine and chemical applications, requiring large flowrate and low developed head
- Completely immersed, no vessel penetration except electrical cable
- Reactor water cooled high temperature motor and lubricated bearings
- Virtually no maintenance
- Reduced vibration
- Operating experience
- Tested up to 500^{o}C
- Must be qualified for nuclear applications



Pressurizer





- **About one-third power of a large PWR**
- **About 50% larger pressurizer volume**
- **Due to integral layout, five times larger volume-to-power ratio then in large loop PWRs**
- **Improved response for pressure transients**

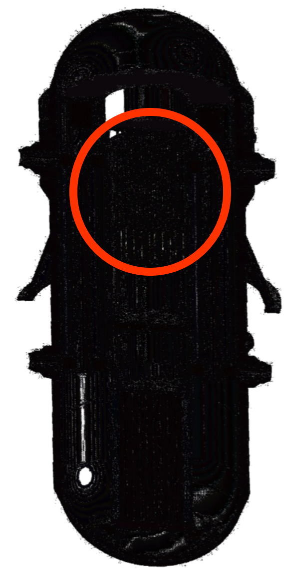
- **Developed by CNEN/NUCLEP with Westinghouse input**

BNFL

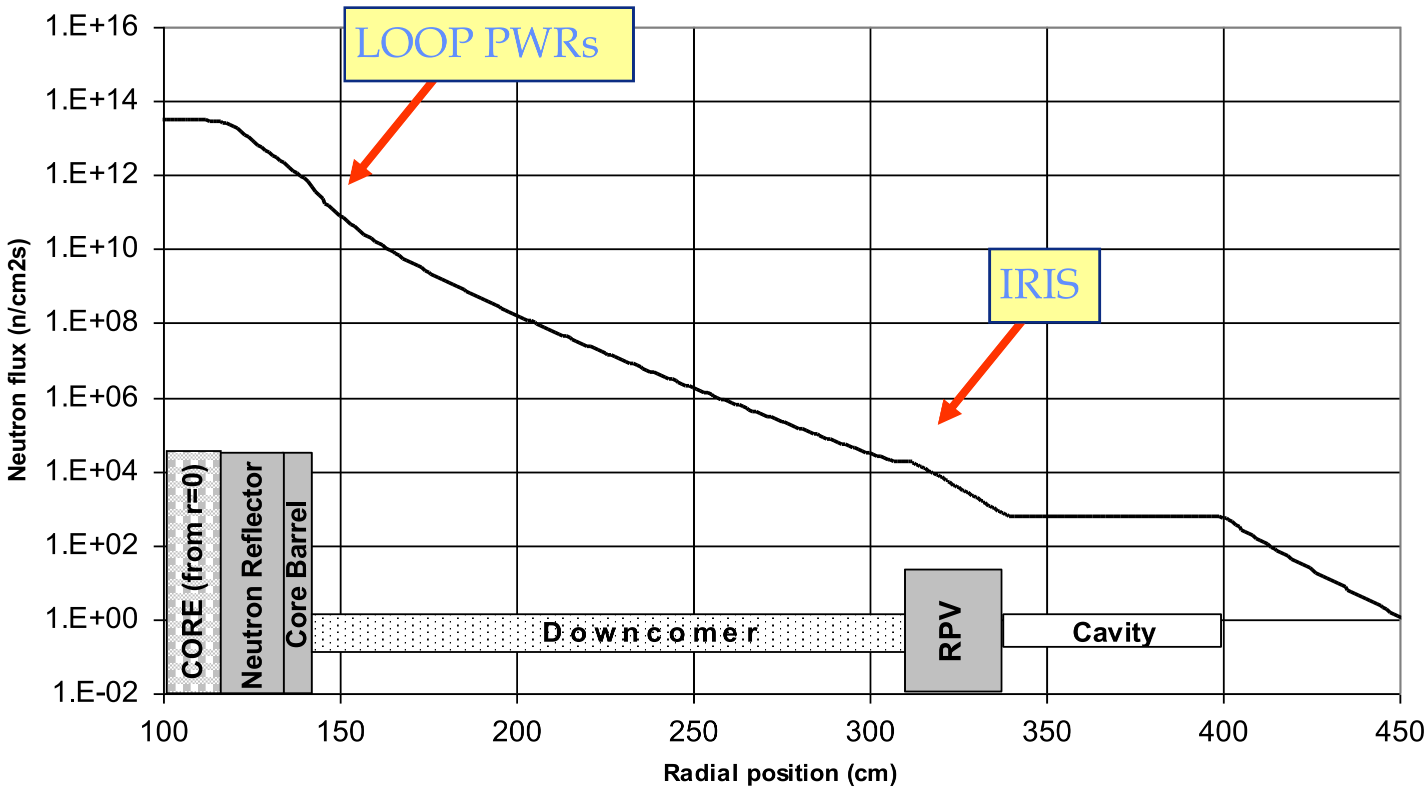
Westinghouse

Internal Control Rod Drive Mechanisms

- Eliminates rod ejection accident (safety-by-design™)
- Eliminates head penetrations
  - No boron induced corrosion of head nozzles (Davis-Besse)
  - No possibility of seal failure and secondary LOCA
  - Simpler, cheaper head design



IRIS Integral Layout Eliminates Pressure Vessel Embrittlement



Radial fast neutron flux profile

Maintenance

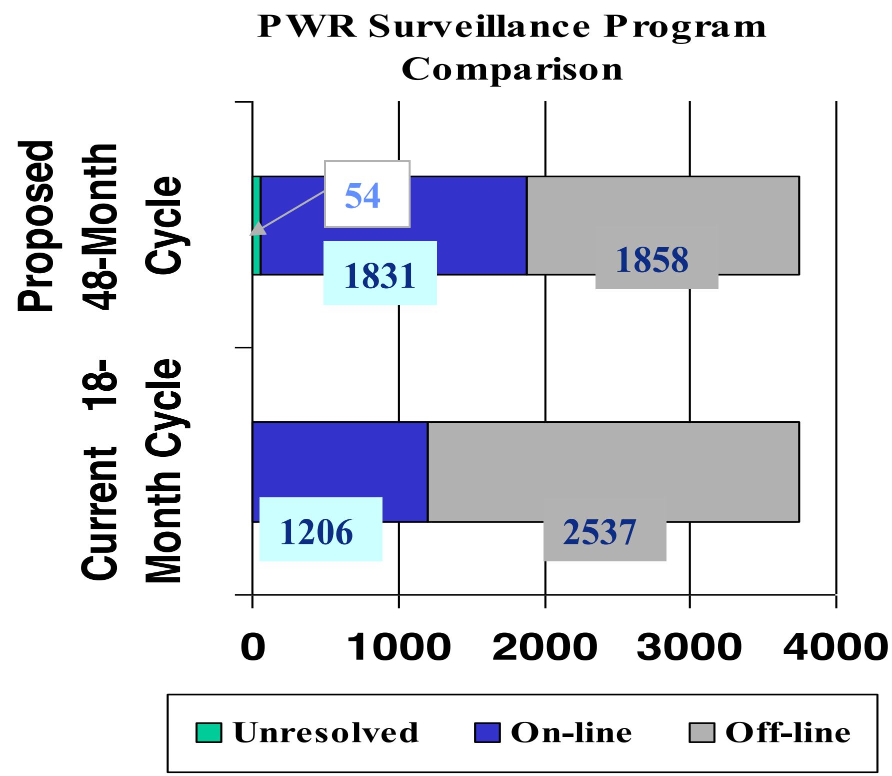
- Question/objection: OK, better design but what about maintenance?

- Answer: IRIS maintenance is better than current and advanced LWRs and scheduled maintenance interval can be extended to 48 months

- Coupled with core design capability to operate without refueling up to four years, provides improved capacity factor (> 96%), reduced personnel, reduced O&M cost, reduced cost of electricity

Previous MIT Study Identified Path to 48 Month Maintenance Cycle

- MIT study completed in 1996 investigated extending PWR to 48 month cycle
- 3743 maintenance items (on-line and off-line) identified
- By recategorizing 625 items from off-line to on-line, only 54 were left unresolved for PWR
- Accounting for IRIS configuration, unresolved items are reduced to 7
- With TVA help the 7 items were resolved



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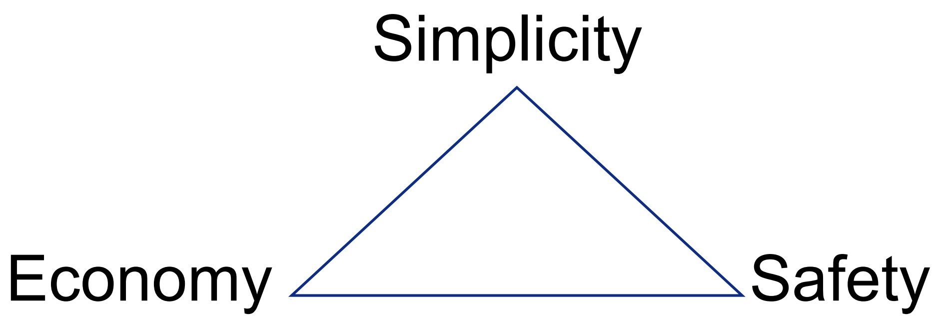
IRIS Approach



- Driven by simplicity to ensure safety <u>and</u> economy
- Uses proven light water technology
- Implements engineering innovations, new solutions, but does not require new technology development

IRIS "Safety-By-Design"™ Approach

Exploit to the fullest what is offered by IRIS

design characteristics (chiefly integral configuration) to:

- Physically eliminate possibility for some accidents to occur
- Decrease probability of occurrence of most remaining accident scenarios
- Lessen consequences if an accident occurs

IRIS – Implementation of Safety-by-Design™

IRIS Design Characteristic	Safety Implication	Accidents Affected	Condition IV Design Basis Events	Effect on Condition IV Event by IRIS Safety-by-Design
Integral layout	No large primary piping	• Large break Loss of Coolant Accidents (LOCAs)	Large break LOCA	Eliminated
Large, tall vessel	Increased water inventory Increased natural circulation Accommodates internal Control Rod Drive Mechanisms (CRDMs)	• Other LOCAs • Decrease in heat removal various events • Control rod ejection, head penetrations failure	Spectrum of control rod ejection accidents	Eliminated
Heat removal from inside the vessel	Depressurizes primary system by condensation and not by loss of mass Effective heat removal by Steam Generators (SG)/Emergency High Removal System (EHRS)	• LOCAs • LOCAs • All events for which effective cooldown is required • Anticipated Transients Without Screen (ATWS)		
Reduced size, higher design pressure containment	Reduced driving force through primary opening	• LOCAs		
Multiple, integral, shaftless coolant pumps	Decreased importance of single pump failure No shaft	• Locked rotor, shaft seizure/ break • Loss of Flow Accidents (LOFAs)	Reactor coolant pump shaft break Reactor coolant pump seizure	Eliminated Downgraded
High design pressure steam generator system	No SG safety valves Primary system cannot over-pressure secondary system Feed/Steam System Piping designed for full Reactor Coolant System (RCS) pressure reduces piping failure probability	• Steam generator tube rupture • Steam line break • Feed line break	Steam generator tube rupture Steam system piping failure	Downgraded Downgraded
Once through steam generators	Limited water inventory	• Feed line break • Steam line break	Feedwater system pipe break	Downgraded
Integral pressurizer	Large pressurizer volume/reactor power	• Overheating events, including feed line break • ATWS		
			Fuel handling accidents	Unaffected

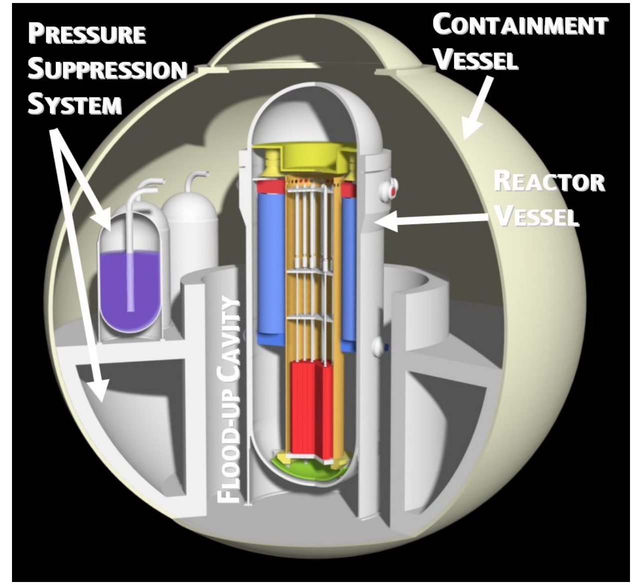
IRIS Containment and Coupled RV/CV Response to SBLOCA

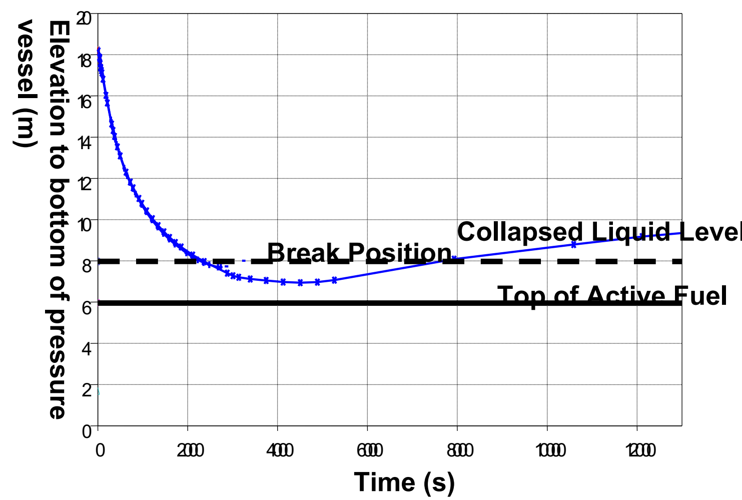
- No LB LOCA – What about SB LOCA?

- High design-pressure spherical steel containment
- In SB LOCA, RV and CV become thermodynamically coupled

- Reactor vessel depressurized by internal heat removal
- Containment pressure allowed to rise (small, spherical geometry)
- Pressure differential across the break equalizes quickly and LOCA is stopped
- Vessel and containment are coupled, long term sequence depends on outside heat removal
- Self-limiting, no need for water injection (no HPSI)

- Core remains covered for all postulated breaks during the whole transient
- Example: Double ended break in 2” DVI line
- Consider collapsed water level (very conservative, mixture level higher)





IRIS Three-Tier Safety

1. SAFETY-BY-DESIGN™
   Aims at eliminating by design possibility for accidents to occur
   Eliminates systems/components that were needed to deal with those accidents

2. PASSIVE SAFETY SYSTEMS
   Protect against still remaining accidents and mitigate their consequences
   Fewer and simpler than in passive LWRs

3. ACTIVE SAFETY SYSTEMS
   No active safety systems are required
   But, active non-safety systems contribute to reducing the probability of CDF (core damage frequency)

IRIS APPROACH IS ECONOMICAL:

IMPROVES SAFETY WHILE SIMPLIFYING DESIGN

Preliminary PRA Level 1

Event	IEF	Result	%
Reactor Vessel Rupture	1.00 E-08	1.00 E-08	51.03
Loss of Offsite Power	1.18 E-01	3.48 E-09	17.78
Loss of Support Systems	1.95 E-02	2.43 E-09	12.42
Anticipated Transients Without SCRAM (ATWS)	-	1.83 E-09	9.34
Transients with main feed water	8.54 E-01	8.37 E-10	4.27
Loss of Condenser	8.50 E-02	4.78 E-10	2.44
Isolable Secondary Line Break	5.96 E-04	1.80 E-10	0.92
Unisolable Secondary Line Break	3.72 E-04	1.10 E-10	0.56
Steam Generator Tube Rupture	1.88 E-04	5.48 E-11	0.28
Interfacing System LOCA	5.00 E-11	5.00 E-11	0.26
DVI Line Break	1.32 E-04	4.78 E-11	0.24
Loss of Main Feedwater	6.05 E-02	4.76 E-11	0.24
Upper LOCA	8.85 E-04	4.12 E-11	0.21
Power Excursion	4.50 E-03	2.10 E-12	0.01
RCS leakage	4.65 E-03	3.99 E-13	<0.01
ADS Related LOCA	6.49 E-06	2.55 E-14	<0.01
Total for internal events		1.96 E-08	78.7
Tornadoes (F0-F1)	8.77 E-04	2.02 E-11	0.04
Tornadoes (F2-F6)	9.45 E-05	4.31 E-09	81.1
Tornadoes (>F6)	1.00 E-10	1.00 E-10	0.4
Floods (Conservative estimate)		8.82 E-10	16.6
Total for analyzed external events		5.31 E-09	21.3
Total		2.49 E-08	

IRIS Safety-by-Design™: The Bottom Line

Criterion	Advanced LWRs	IRIS
Defense-in-Depth (DID)	Passive systems; active systems	Safety-by-Design™ Fewer passive safety systems, no active safety-grade systems
Class IV Design Basis Events	8 typically considered	Only 1 remains Class IV (fuel handling accident)
Core Damage Frequency (CDF)	$\sim10^{-6}$—10^{-7}	$\sim10^{-8}$
Large Early Release Frequency (LERF)	$\sim10^{-6}$—10^{-8}	$\sim10^{-9}$

IMPLICATIONS:

Both advanced LWRs and IRIS are extremely safe plants

Extremely Low Internal Events CDF is a Direct Consequence of IRIS Safety-by-Design™ Philosophy

- IRIS eliminates most of the accidents which are very improbable
- There is no need for corrective systems
- There are fewer things which can go wrong
- Reliability increases
- Improved response to those accidents which are less improbable

A Different Approach to Safety

- What does it really mean 10^{-6} versus 10^{-8} CDF?
- IRIS is not focused on just being “safer”
  - Make the remote probability that a serious accident might happen even more remote
- IRIS is focused on immediate, tangible advantages
  - With probability=1, provide:
    - Reduced cost
    - Improved licensing regulations

Economics

- Improved safety is not achieved by adding more and/or better safety systems
- Through safety-by-design™ improved safety is achieved by eliminating safety systems and/or simplifying remaining ones
- Result: enhanced safety <u>and</u> reduced cost

IRIS Safety-by-Design™: The 5 most severe accident precursors since 1979 as ranked by NRC (NN, Oct. 2004) cannot occur or are intrinsically mitigated in IRIS

Rank	Year	Plant	Accident Precursor	IRIS
1	1979	Three Mile Island	Pressurizer Power Operated Relief Valve stuck open **Partial Core Meltdown occurred**	Same accident cannot occur: IRIS has integral pressurizer and no power operated relief valve. Similar accidents (any small break LOCA) have intrinsic mitigation (core always covered)
2	1985	Davis Besse	Total Loss of Feedwater (main and auxiliary) **Core Damage Probability = $7*10^{-2}$**	Cannot occur: IRIS safety grade decay heat removal system (EHRS) does not require any source of water injection to the steam generators; also, increased primary side thermal inertia inherently mitigate loss of main feedwater events
3	1981	Brunswick	Residual Heat Removal (RHR) U-tubes Heat Exchanger Failure due to blockage (oyster shells) **Core Damage Probability = $9*10^{-3}$**	BWR Event; eliminated by design and operational procedures for RHR, inherent mitigating features
4	1991	Shearon Harris	Unavailability of high pressure safety injection (HPSI) pump **Core Damage Probability = $6*10^{-3}$**	Cannot occur: IRIS does not need, thus does not have safety related HPSI pumps
5	2002	Davis Besse	Degraded vessel head; unqualified coatings and debris in containment; potential HPSI pump failure during recirculation **Core Damage Probability = $6*10^{-3}$**	Cannot occur: IRIS has no vessel head penetrations by adoption of internal CRDMs and has no HPSI pumps

Licensing Regulations

- The combined effect of safety-by-design™ and PRA-guided design has given failure and release probabilities far lower values than those considered acceptable when current licensing regulations were promulgated

- Possibility to license IRIS with revised emergency planning such to significantly reduce emergency planning zone and possibly collapse it into the site boundary

Some Advantages of No Emergency Response

<u>Economic</u> (for green sites)

- No need of special measures and infrastructure (e.g., new roads) for rapid evacuation
- Can locate plant near user (reduced transmission lines, and allowance of co-generation, e.g., desalination and district heating)
- No impediment to further development and settlement in area around the plant
- No need for special training of personnel and for periodic drills

<u>Social</u>

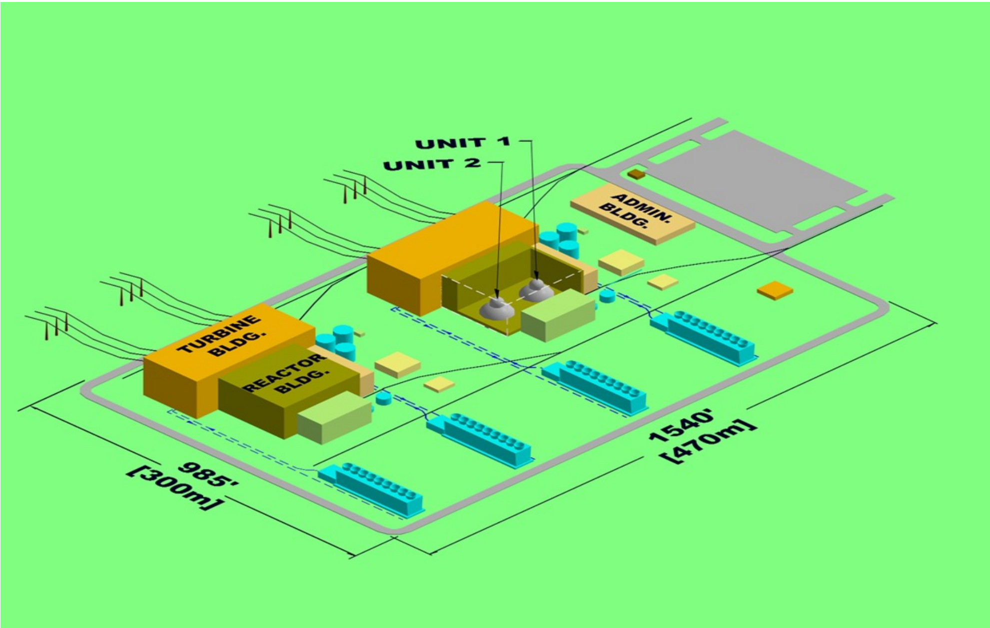
- IRIS is treated no differently than any other power producing industrial facility
- Removes stigma from nuclear power
- No more “NIMBY” (not in my back yard)
- Public acceptance increased

IRIS Emergency Planning Status

- IRIS is in forefront of effort to revise emergency licensing regulations
- Position and proposed procedure presented to NRC at Workshop on March 14-16, 2005, and well received by NRC. Also presented at OECD Workshop on April 26, 2005.
- Position and proposed procedures presented to IAEA at technical meeting on November 15-19, 2004. IAEA established within a 3-year CRP on "small and medium reactor with infrequent on site refueling" five studies on reducing/eliminating off-site emergency response planning by the following IRIS organizations:
  - Westinghouse: Regulatory procedures
  - Polytechnic of Milan, Italy: Methodology
  - University of Zagreb, Croatia: Transient analyses
  - Lithuanian Energy Institute: Impact of external events and economics aspects especially with respect to district heating
  - Eletronuclear, Brazil: Economics and utility perspective

  First year accomplishments reviewed at IAEA on November 21, 2005.
- Will be officially taken up with NRC in 2006 as part of IRIS pre-application licensing

IRIS -- Site Plot Arrangement Example



- Very compact
- Low profile
- Modular construction
- Shared buildings and systems (except containment)

Multiple twin-units
(2 twin-units, 1340 MWe)

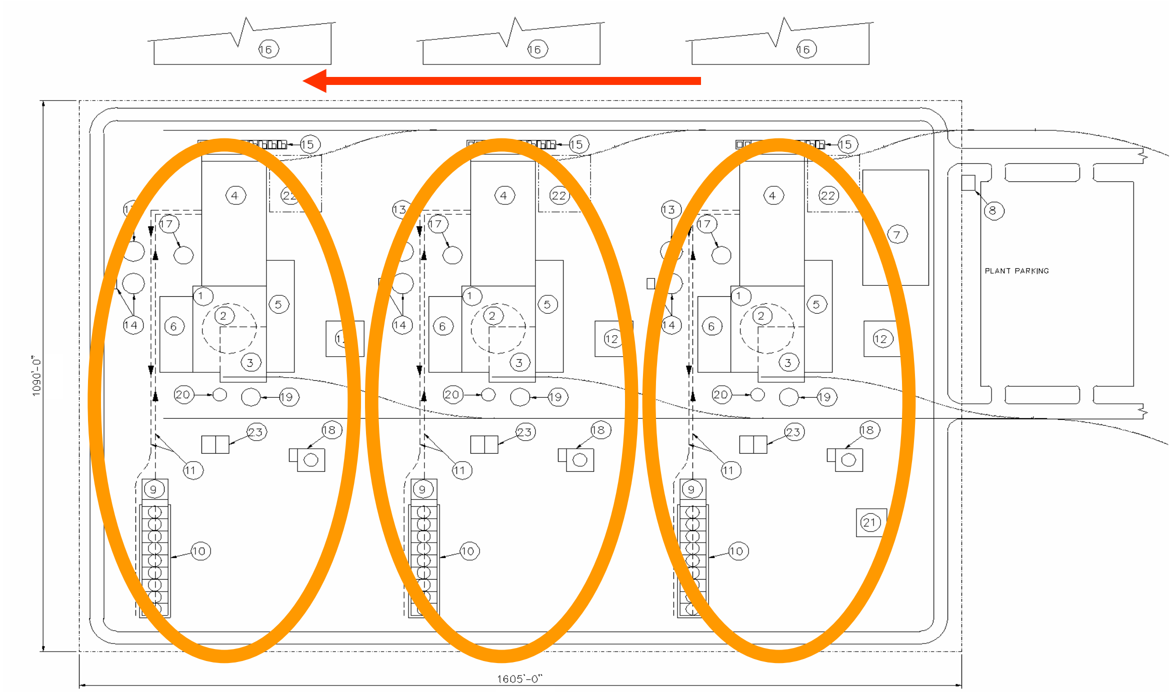
- Also well suited for co-gen (desalination, district heating, agro-industrial steam)

Iris - Multiple Single Unit Site Plot Plan

- Shared structures and systems are minimized
- Units constructed in “slide-along” manner with first unit(s) put into operation while subsequent unit(s) under construction

Goals

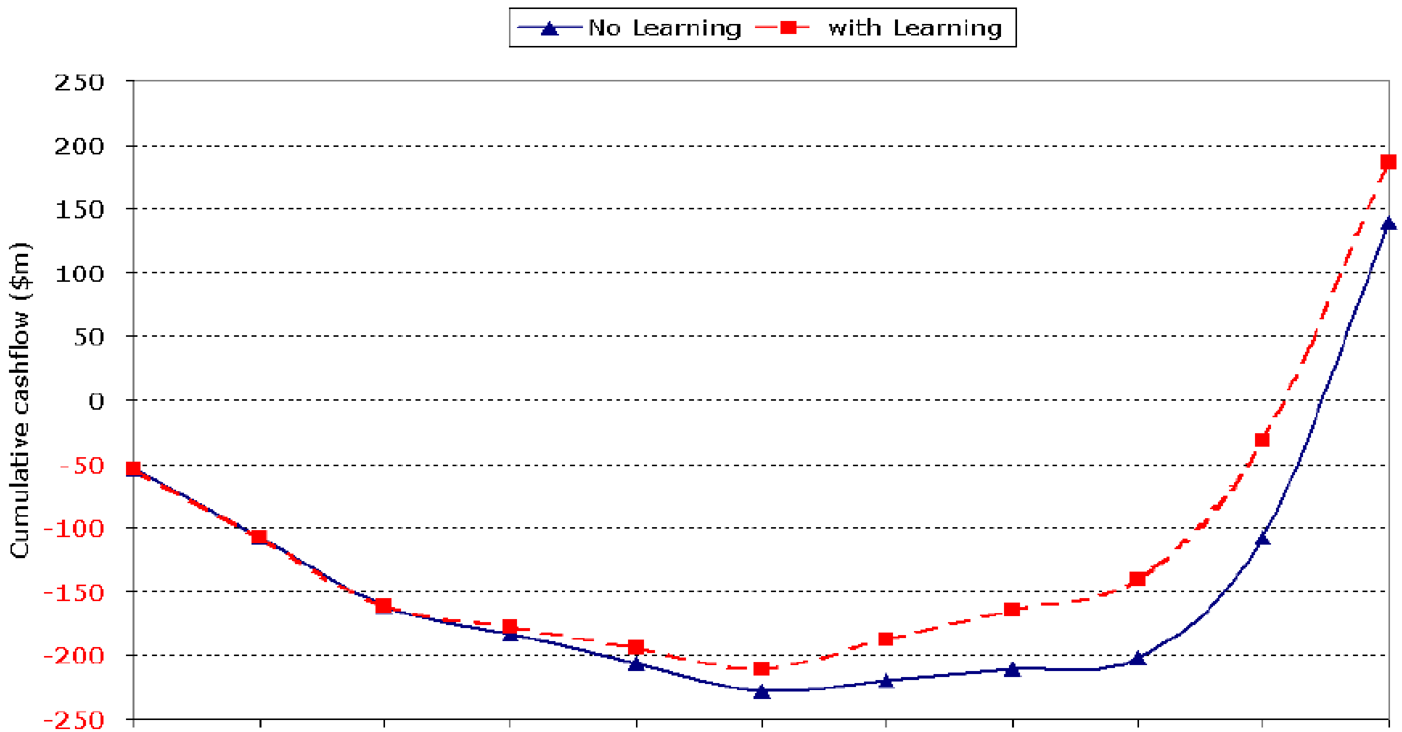
- Minimize construction time and provide generating capability ASAP
- Maximize workforce efficiency and significantly shorten 2nd and 3rd unit construction time



IRIS and the Gen IV Goals – Economics

- Simplified design eliminates: primary piping, valves and seals; pressurizer; steam generators and pumps pressure vessels; vessel head penetrations and seals
- Safety-by-design™ eliminates some safety systems (e.g., ECCS) and simplifies passive systems (e.g., only one ADS line)
- Small containment (25m spherical diameter) and footprint
- Reduced O&M cost: 48-month maintenance cycle, reduced occupational doses, eliminated or reduced emergency planning
- Reduced power generation cost due to higher capacity factor: less frequent refueling and maintenance outages
- Modularity: factory fabrication, rapid learning
- Limited investment, limited negative cash flow
- Well suited for cogeneration: desalination, district heating, process heat
- Target cost of electricity: ~4¢/kwh

Attractive Financing –
Limited Cash Outflow Due to Incremental Build



YEAR FROM START	1	2	3	4	5	6	7	8	9	10	11	12
IRIS-1 335 Mwe	CONSTRUCTION		OPERATION -->									
IRIS-2 335 Mwe			CONSTRUCTION			OPERATION -->						
IRIS-3 335 Mwe						CONSTRUCTION			OPERATION -->			

- Example – construction of 3 modules (1005 MWe) with 3 years in between
- Under the considered conditions, cumulative cash outflow for 3 modules remains below $300M


Innata atomica vis Renovata tutaque Ingenti necessitati Sine proliferatione succurrit
WESTINGHOUSE - ANSALDO - BNFL - CAMOZZI - CNEN - ELETRONUCLEAR - ENSA - FER - ININ - LEI - MIT - NUCLEP - OKBM - ORNL - POLIMI - POLITO - TIT - UNIPI - UNIROMA -
ИРИС アイリス
IRIS
International Reactor Innovative & Secure

IRIS Team

INDUSTRY		
Westinghouse	USA	Overall coordination; leading core design, safety analyses and licensing; commercialization
BNFL	UK	Fuel cycle
Ansaldo Energia	Italy	Steam generators design
Ansaldo Camozzi	Italy	Steam generators fabrication
ENSA	Spain	Pressure vessel and internals
NUCLEP	Brazil	Containment
OKBM	Russia	Testing, desalination and district heating co-gen
LABORATORIES		
ORNL	USA	I&C, PRA, desalination, shielding, pressurizer
CNEN	Brazil	Transient and safety analyses, pressurizer, desalination
ININ	Mexico	PRA, neutronics support
LEI	Lithuania	Safety analyses, PRA, district heating co-gen
ENEA	Italy	Planning to join in 2006. Testing, financial and manpower support.
UNIVERSITIES		
Polytechnic of Milan	Italy	Safety analyses, shielding, thermal hydraulics, steam generators design, advanced control system
MIT	USA	Advanced cores, maintenance, security
Tokyo Institute of Technology	Japan	Advanced cores, PRA
University of Zagreb	Croatia	Neutronics, safety analyses
University of Pisa	Italy	Containment analyses, severe accident analyses, neutronics
Polytechnic of Turin	Italy	Source term
University of Rome	Italy	Radwaste system
POWER PRODUCERS		
Eletronuclear	Brazil	Developing country utility perspective

International Consortium

- Westinghouse leads project, but all members are stakeholders
- IRIS members are making in-kind contributions to the project
- Four IRIS Consortium countries (Croatia, Lithuania, Mexico, Brazil) are investigating an IRIS deployment
- Italy has identified IRIS as the major program in renewed Italy nuclear effort. Identified ~ 10M€/yr for next five years. Will be responsible for most of testing needed for Design Certification at testing facilities previously used for AP600

Education/Research Aspect of the IRIS Project – IRIS Students (as of March 2005)

University	Undergraduate	Graduate	Doctorate
Polytechnic of Milan	1	25	7
Massachusetts Institute of Technology	1	4	1
Tokyo Institute of Technology		6	6
University of Pisa	28	8	1
University of Zagreb	3	1	3
Polytechnic of Turin		1	
University of Rome		1	1
University of California at Berkeley		2	
University of Tennessee	1	4	
Ohio State University		4	1
University of Michigan	6	2	
Total (3/1/05)	40	58	20
		118	

- IRIS project – provided opportunity to over 100 students to work on a real-life, advanced, applied technology project, and make actual contributions

Pre-application Licensing Status

- Three areas are being addressed:
  - IRIS unique safety features, safety-by-design™
    - Documentation provided to NRC for review
    - No negative responses
  - Testing for design certification
    - Prepared PIRTs, scaling approach, testing plan
    - Received and resolved comments
    - Testing to start early 2006
  - Revised emergency planning response requirements
    - To be addressed in 2006

- Design certification submittal planned late 2008

- IRIS planning to use multinational design approval process (MDAP) if implemented in time

The Global Nuclear Energy Partnership (GNEP)

United States Department of Energy

GNEP Element: Demonstrate Small-Scale Reactors

GNEP will provide small-scale reactors suitable for emerging economies that currently depend on oil and other fossil fuels for growing energy demands. Addressing this market is essential to safely expanding nuclear energy in developing nations and small-grid markets without increasing proliferation concerns.

Small, More Proliferation-Resistant Power Reactors

Light water reactors (LWRs) dominate the commercial use of nuclear power. Historically, the requirements of large national markets with big electricity grids have driven the development of nuclear power reactors, resulting in commercial units of about 1000 MWe. Markets with much smaller grids and less well-developed technical infrastructures have not had much impact on power reactor designs and technologies. A different reactor design approach, tailored for this market segment, could help meet the rising power demands associated with economic growth and urbanization, while avoiding the use of fossil fuels that would otherwise be burned in power plants.

In order to expand the use of nuclear energy in these small electricity markets, a small

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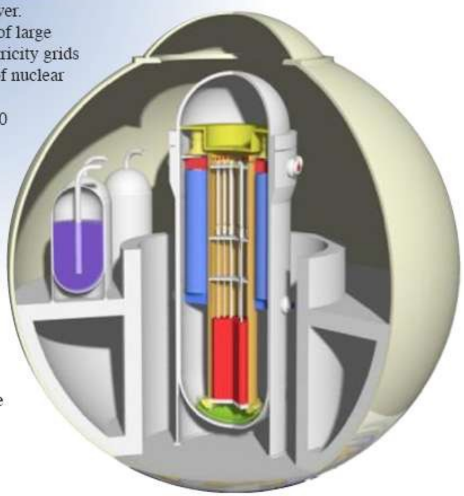
An example of a "small reactor" is IRIS, International Reactor Innovative and Secure (www.irisreactor.org)



The Global Nuclear Energy Partnership (GNEP)

United States Department of Energy

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reactor is preferred for small electricity grids. These reactors will be safe, simple to operate, more proliferation-resistant, and highly secure.

How the reactors would work

Small, more proliferation-resistant reactors could incorporate numerous features that would help address the intended market. Candidate features include fuel designs that offer very long-life fuel loads (possibly ones that last the entire life of the reactor so that refueling is not needed); effective, yet inexpensive IAEA safeguards to promote non-proliferation that might include remote monitoring; physical protection against sabotage and other terrorist acts; standardized designs in the 50 to 350 MWe range; potential for district heating and potable water production; fully passive safety systems; simple operation that requires minimal in-country nuclear infrastructure; use of as much existing licensed or certified technology as possible; and use of advanced manufacturing techniques.

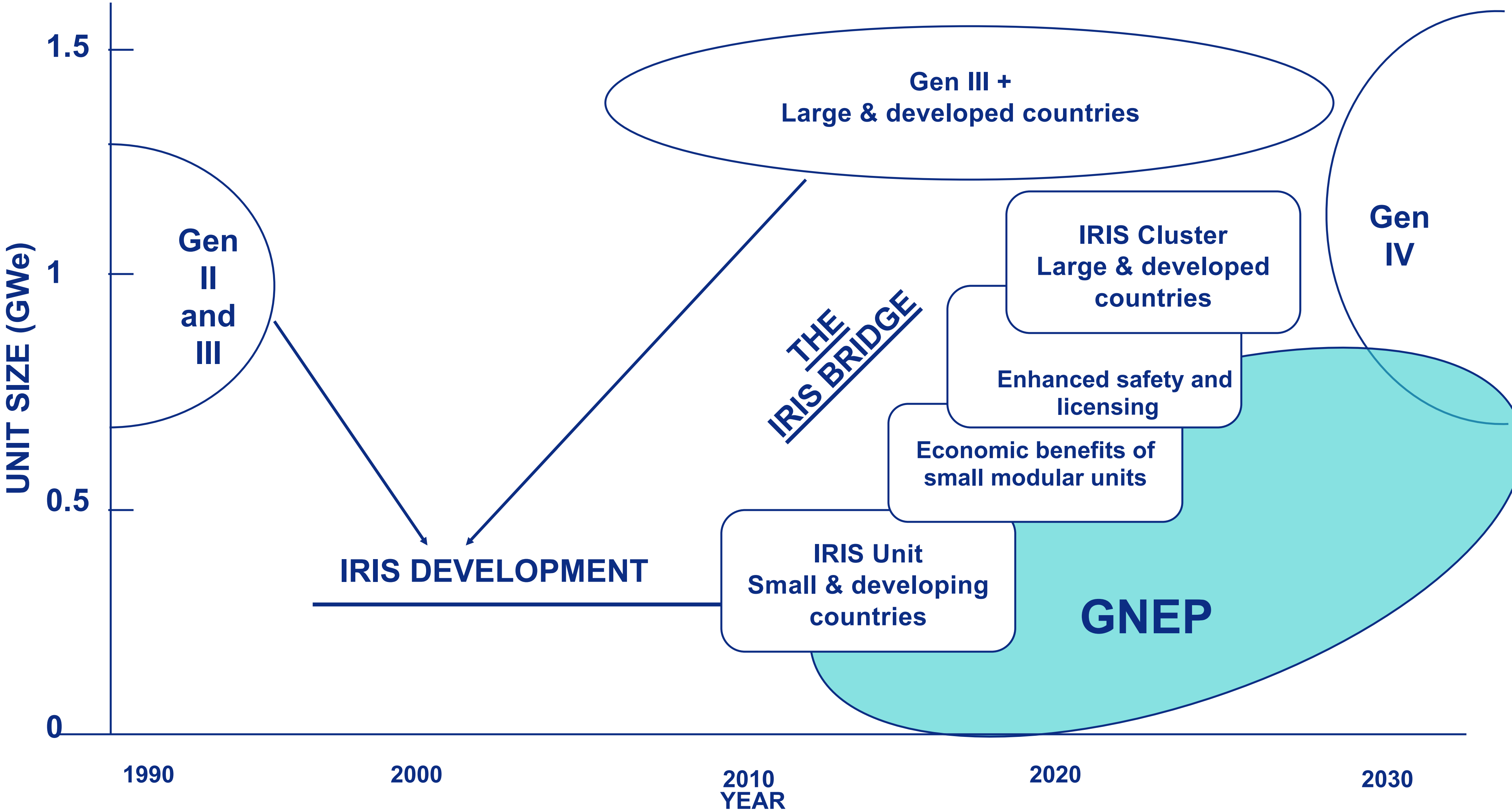
Showing that customers can count on small reactors

Today, there are no fully developed or installed reactors that have all these features. Further evaluation and exploration of these concepts with GNEP member nations would support future decisions on continued development and, eventually, deployment.

Research, development, and preliminary design of several candidate small reactors are underway in a number of advanced industrialized countries. The GNEP seeks to form international partnerships to accelerate certification of marketable designs, and deploy operational demonstration plants in parallel with advanced fuel cycle demonstrations.

February 6, 2006

IRIS Provides the Bridge Between Generation III and Generation IV



Current (2006) Effort

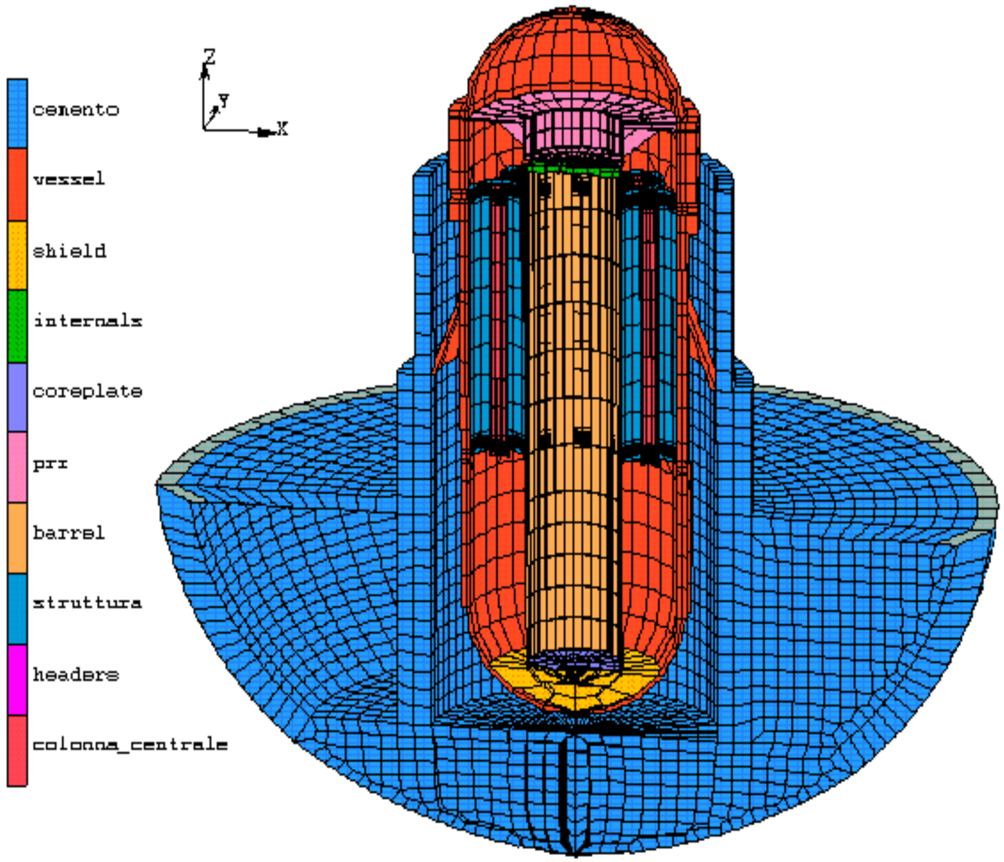
- Design certification testing
- Seismic assessment
- External events PRA
- Security assessment
- Consortium agreements

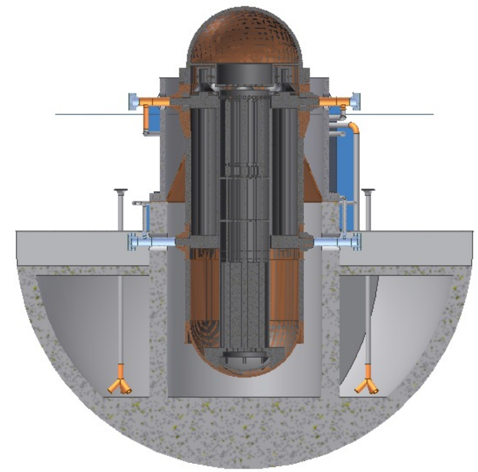
Thermal-Hydraulic Test Facilities (SIET, Italy)

IETI FACILITY (Test Sections)

Thermal-Fluid-Dynamics experiments on a full-scale helical coil tube of the IRIS Reactor Steam Generator

Preliminary Seismic Analysis on IRIS Integral RV (University of Pisa, Italy)





Model Characteristic:

- **Size of model: 40364 Elements**
- **3-D Brick: Type 7 class Hex 8**
- **Materials characteristics variable according to the different components**

Conclusions

- Simple, compact, economic design
- Takes nuclear safety one step beyond passive safety
- Niche market: Smaller a/o developing countries, but also suited for large countries and grids
- In NRC pre-licensing process with deployment about 2015
- Achievement of No EPZ would be dramatic breakthrough
- International consortium
- Exemplifies small-scale reactors in DOE newest nuclear initiative, GNEP