

# LTA Irradiation Programs in Spanish Reactors in collaboration with Japanese Organizations

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## Background

- By the end of the 80's, based on the good relationship between Kansai Electric Co. and Endesa, it was successfully explored the opportunity of a LTA irradiation Program in a Spanish reactor supported by Japanese organizations
- Program was to be devoted to research of various promising fuel materials under bounding operational conditions
- In 1991, the so called "Segmented Fuel Irradiation Program 5-Party General Agreement" was signed among KEPCO, Endesa, MHI, WEC and Enusa, which established the bases for the collaboration

### SEGMENTED FUEL ROD IRRADIATION PROGRAM GENERAL AGREEMENT

WHEREAS KEPCO, as a representative of applicants utilizing in Japan, and MHI are interested in irradiating new fuel materials in an operating power reactor, which is to be followed by fuel testing and hot cell PIC with the financial support of WEC, and,

WHEREAS Westinghouse has close cooperation with ENCSA and ENUSA to realize the interest of KEPCO and MHI, and has agreed to provide the necessary technical support to the program, and,

WHEREAS ENUSA has expressed interest in permitting the new fuel materials to be irradiated in reactors, on condition to be supplied by WEC as part of a normal reload, and,

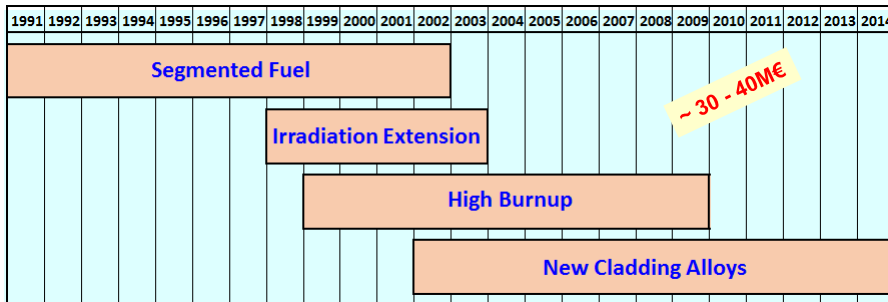
WHEREAS WEC is interested in manufacturing and marketing such demonstration assemblies, with the support of Westinghouse and,

WHEREAS ENCSA and KEPCO have a cooperative agreement in place to exchange plant operating experience,

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## LTA Irradiation Programs in Spain



- Thorough materials and product characterization
- Extensive on-site PIE at every end of irradiation cycle
- Selected rods removed along the irradiation for further PIE work at hot cells
- Some of the removed rods also subjected to further in-reactor tests (i.e., ramp tests, BOCA, Cabri, NSSR, ...)

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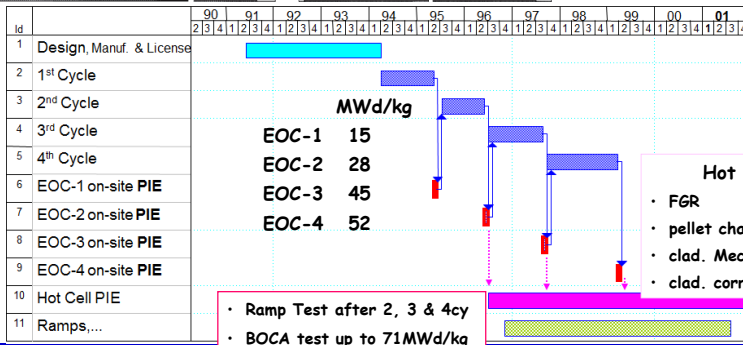


## Vandellos LTA's: Segmented Fuel Program

- Develop of "segmented fuel" concept to characterize performance of various
  - cladding: Zirlo, MDA, texture
  - pellet: grain size (9, 12, 30 μm)
- burnup ~ 60 MWd/kg
- power transients (ramp tests)

### scope

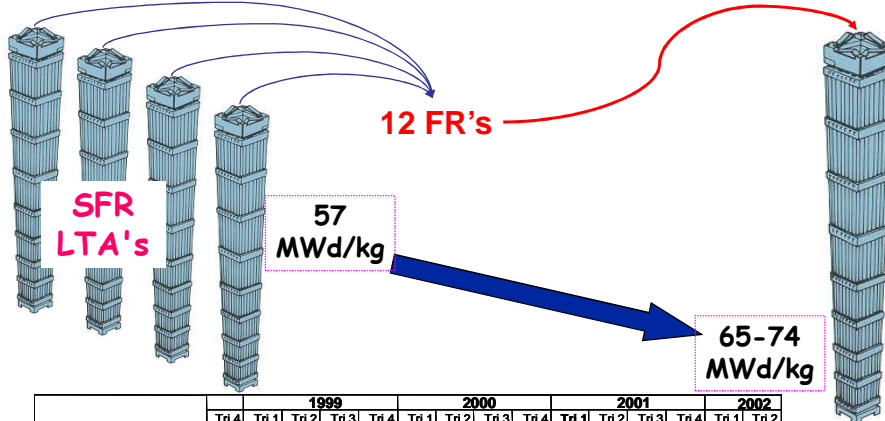
- 4 FA's
- 32 segmented FR's
- 80 special FR's



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## Vandellos LTA's: Irradiation Extension Program

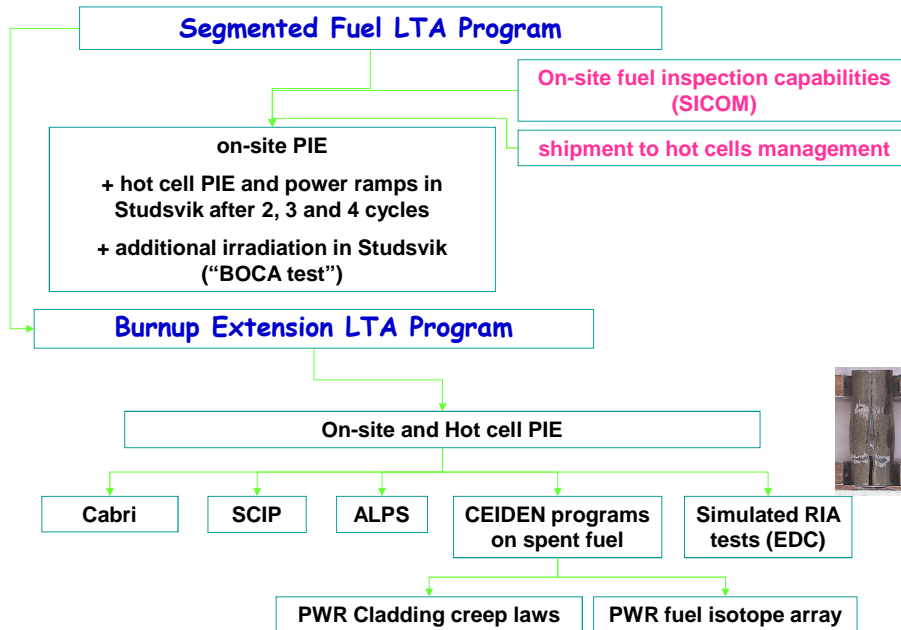


	1999				2000				2001				2002		
	Tri.4	Tri.1	Tri.2	Tri.3	Tri.4	Tri.1	Tri.2	Tri.3	Tri.4	Tri.1	Tri.2	Tri.3	Tri.4	Tri.1	Tri.2
Design + Selection	■														
Design Verification	■														
Safety Evaluation Report	◆														
EOC10 PIE + Reconstitution			■												
Irradiation			■	■	■	■	■	■	■						
EOC11 PIE															
Hot Cell PIE															
Evaluation															

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## Segmented Fuel LTA Program



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ENUSA

## Vandellos LTA's: High Burnup Program

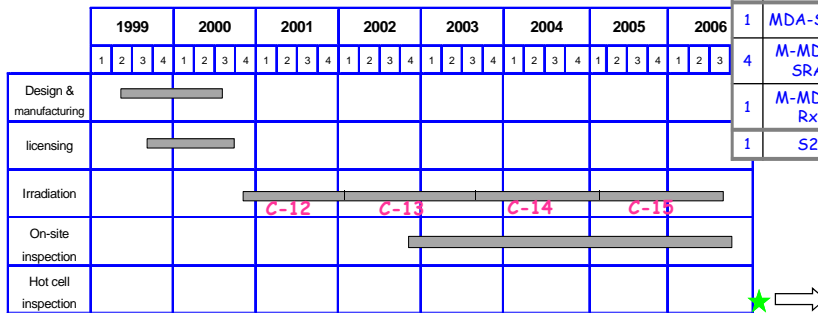
### objectives

characterize representative  
comercial fuel (RFA - Zirlo)  
irradiated ~ 70 MWd/kg  
© relatively bounding conditions

### Scope

- 4 RFA LTA's
- ~ 60 rods with design variations

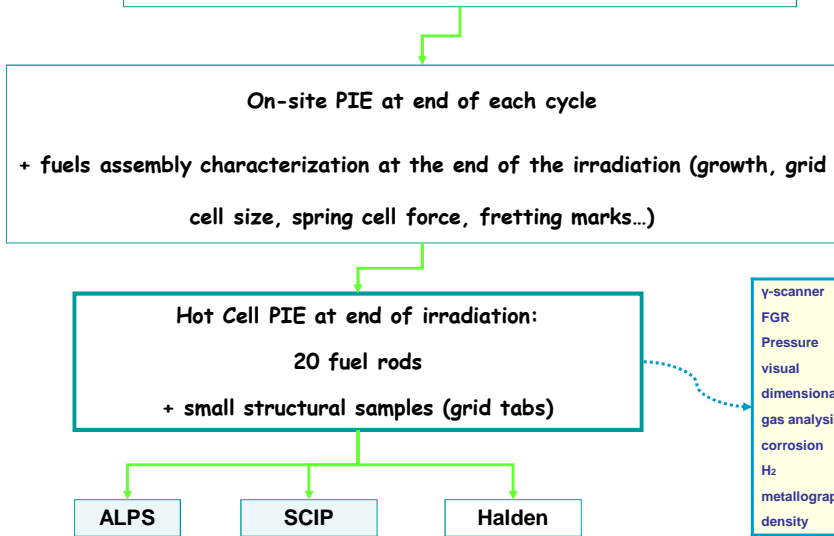
#	Cladding	Pellet
233	Zirlo	Std
16	Zirlo	Std + Gd <sub>2</sub> O <sub>3</sub>
1	Zirlo	Large grain
1	Zirlo	High density
3	Zirlo 1	Std
3	Zirlo 2	Std
1	MDA-SRA	Std
4	M-MDA-SRA	Std
1	M-MDA-Rx	Std
1	S2	Std



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### High Burnup LTA Program



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## Almaraz LTA's: New Cladding Alloy Program

### objective

- advance cladding alloys
- Higher corrosion resistance
- Equivalent mechanical properties

### Scope

- Advance cladding rods: 174 (seven types)
- Optimized Zirlo rods: 88
- Two steps irradiation target: 62 / 70 MWd/kgU
- On-site and Hot cell PIE after 1, 2 y 3 cycles

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	cycle 17	cycle 18		cycle 19		cycle 20	cycle 21		cycle 22	cycle 23
C o r r e	Y C	Z D	C <sup>1</sup> <sub>1</sub> D <sup>1</sup> <sub>1</sub>	Y <sup>1</sup> <sub>1</sub> Z <sup>1</sup> <sub>1</sub> C <sup>2</sup> <sub>2</sub>		F <sub>0 2</sub>			F <sup>1</sup> <sub>1</sub>	
P o s i		Y <sup>1</sup> <sub>1</sub> Z <sup>1</sup> <sub>1</sub>		D <sup>2</sup> <sub>2</sub> F <sub>02</sub>	Y <sup>2</sup> <sub>2</sub> Z <sup>2</sup> <sub>2</sub> C <sup>3</sup> <sub>3</sub> D <sup>2</sup> <sub>2</sub>		Y <sup>2</sup> <sub>2</sub> Z <sup>2</sup> <sub>2</sub> C <sup>3</sup> <sub>3</sub> D <sup>2</sup> <sub>2</sub> F <sup>1 3</sup> <sub>1 3</sub>		Y <sup>2</sup> <sub>2</sub> Z <sup>2</sup> <sub>2</sub> C <sup>3</sup> <sub>3</sub> D <sup>2</sup> <sub>2</sub>	Y <sup>2</sup> <sub>2</sub> Z <sup>2</sup> <sub>2</sub> C <sup>3</sup> <sub>3</sub> D <sup>2</sup> <sub>2</sub> F <sup>2</sup> <sub>2</sub>
n s p e c		corrosion, length profilometry 1 cycle		corrosion, length 2 cycles		corrosion, length 2 & 3 cycles (<62Mwd/kg)		corrosion, length profilometry 3 cycles (high Bu)		
o t h e r		1cy. rods hot cell PIE		2cy. rods removal: transfer to F hot cell PIE		3cy. rods removal: <62Mwd/kg hot cell PIE		3cy. rods removal: >62Mwd/kg hot cell PIE		
		1 <sup>st</sup> shipment				2 <sup>nd</sup> shipment			3 <sup>rd</sup> shipment	

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## Final remarks

- Almost 25 years of fruitful collaboration on different research programs on nuclear fuel performance
- Outstanding database on important fuel key characteristics has been gathered along the years to support commercial operation of the plants and to provide of adequate orientation on fuel design modifications
- An opportunity to get mutual benefit from each other experience, and to facilitate occasions for extended collaboration of another organizations on a wider kind of topics
- Valuable Contributions to other international research programs of the Nuclear Industry

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