The Twin Challenges of Abundant Nuclear Energy Supply and Proliferation Risk Reduction – A View

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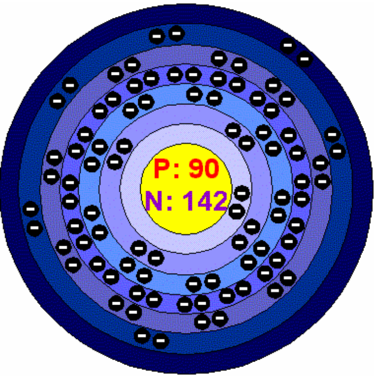
Objective and Scope of the Presentation



- Objective:
  - To compare various alternative options to burn or recycle plutonium from thermal nuclear reactors and to explore the role of thorium in this context.

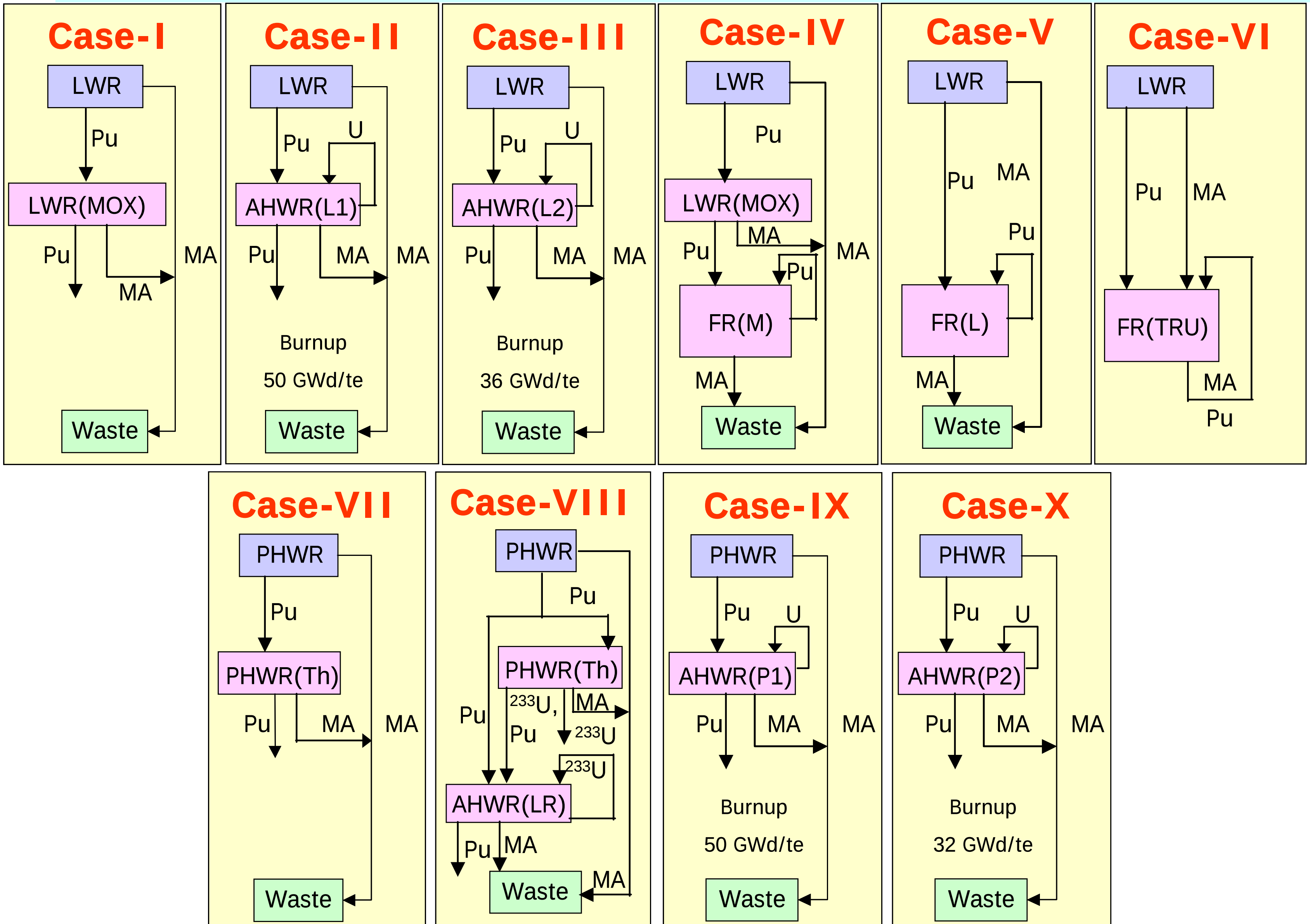
- Scope:

  1) Options for burning LWR Pu in Fast Reactors (based on published OECD study, 2002*)

  2) Options for burning LWR and HWR Pu in thorium based reactor configurations (BARC study).

* Accelerator-driven Systems (ADS) and Fast Reactor (FR) in Advanced Nuclear Fuel Cycles, Organisation for Economic Co-operation and Development, OECD (2002)

Ten different reactor configurations, including three using FRs and six using thorium in PHWR/ AHWR have been studied.



The three cases highlighted in the next slide serve to compare Fast Reactors with a thorium based AHWR(L1)

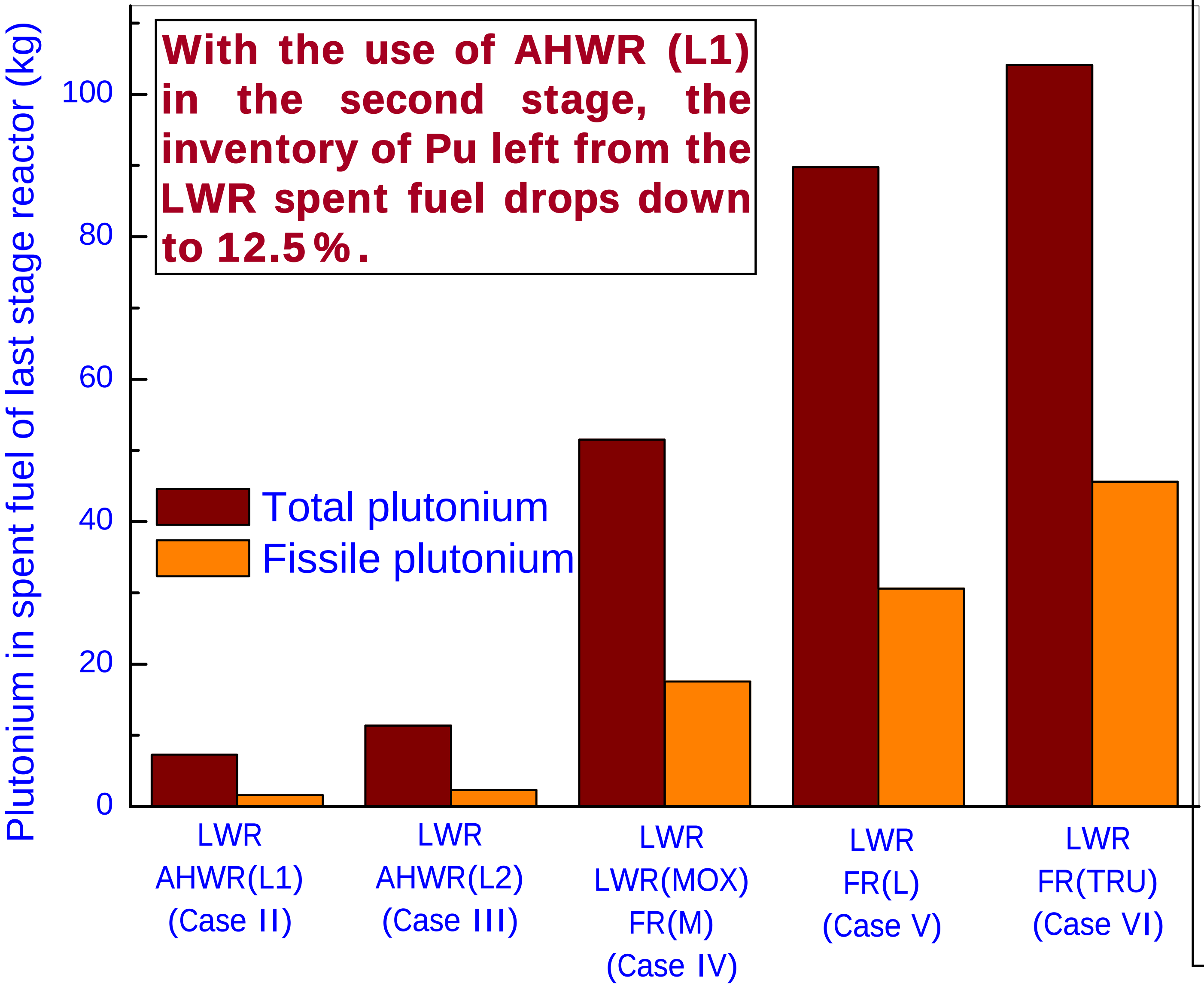
- Case II: LWR Pu used in Advanced Heavy Water Reactor variant AHWR(L1) with self-sufficiency in ^{233}U and 50 GWd/t burnup.
- Case IV: LWR Pu used in a MOX fuelled LWR(MOX), and the discharged Pu of LWR(MOX) used in CAPRA type Pu burning Fast Reactor, designated FR(M) – *This is the reference Pu burner case in the OECD Study.*
- Case VI: LWR Pu used in an ALMR type TRU burning Fast Reactor FR(TRU) – *This is the reference TRU burner case in the OECD study.*

Results normalised for 1 TWhe energy production in the first stage (LWR or PHWR)

For Stages 2 and 3 (as applicable)

Case no.	Case description	Minor Actinides left (kg)	Pu left (kg)	
			Amount (kg)	% Fissile
I	LWR-LWR(MOX)	2.63	19.55	51.1
II	LWR-AHWR(L1)	2.28	7.30	22.1
III	LWR-AHWR(L2)	2.75	11.34	20.5
IV	LWR-LWR(MOX)-FR(M)	6.98	51.50	34.1
V	LWR-FR(L)	7.58	89.76	34.1
VI	LWR-FR(TRU)	14.06	104.1	43.8
VII	PHWR-PHWR(Th)	0.88	37.70	40.3
VIII	PHWR-PHWR(Th)-AHWR (LR)	5.30	10.79	15.7
IX	PHWR-AHWR(P1)	3.62	15.31	25.5
X	PHWR-AHWR(P2)	2.60	21.59	31.2

Comparison of residual plutonium (LWR based)

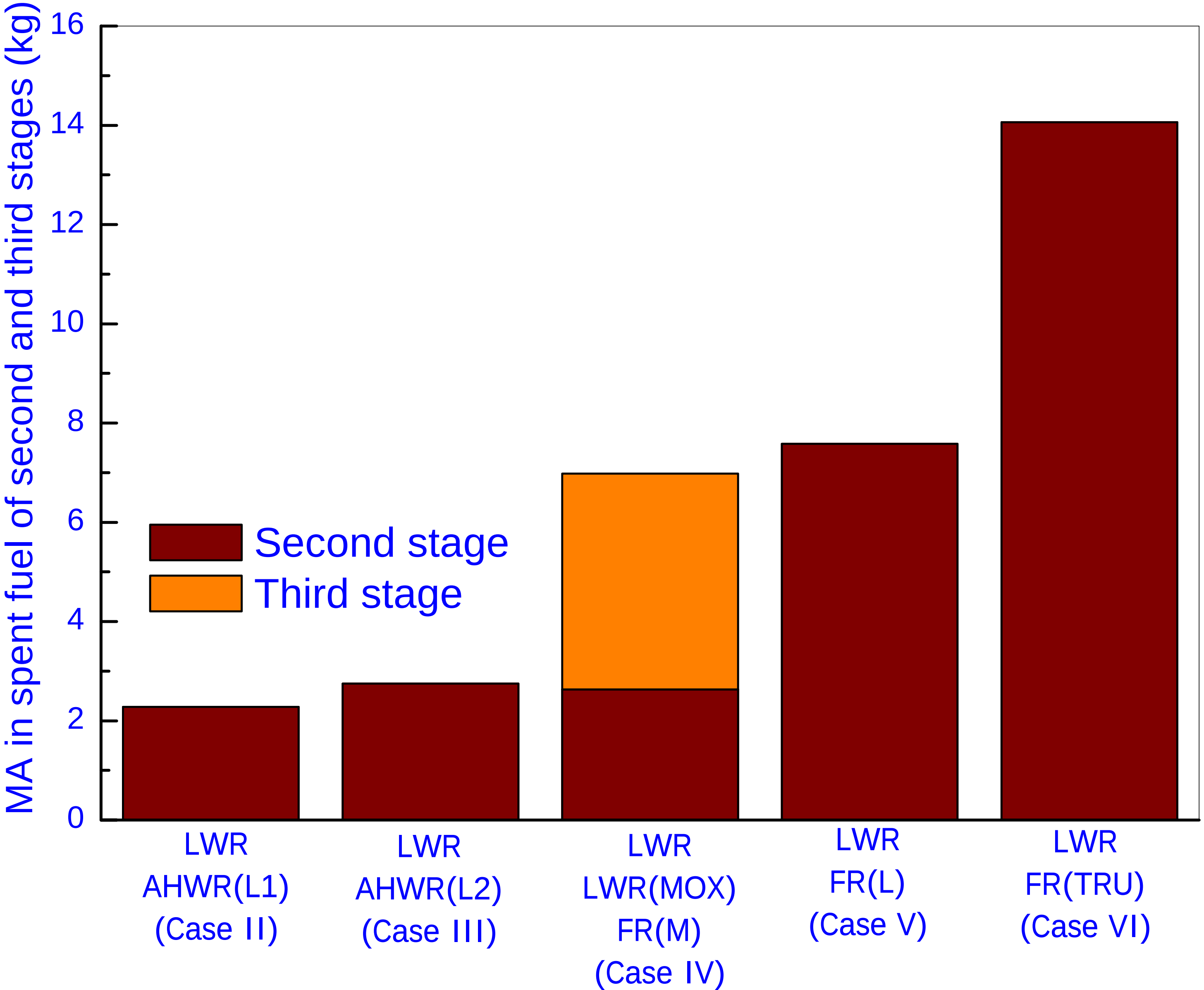


Total Pu from the LWR spent fuel used in an AHWR based configuration results in far less plutonium in spent fuel than when used in FR based configurations.

Fissile Pu content is drastically reduced in Th based options.

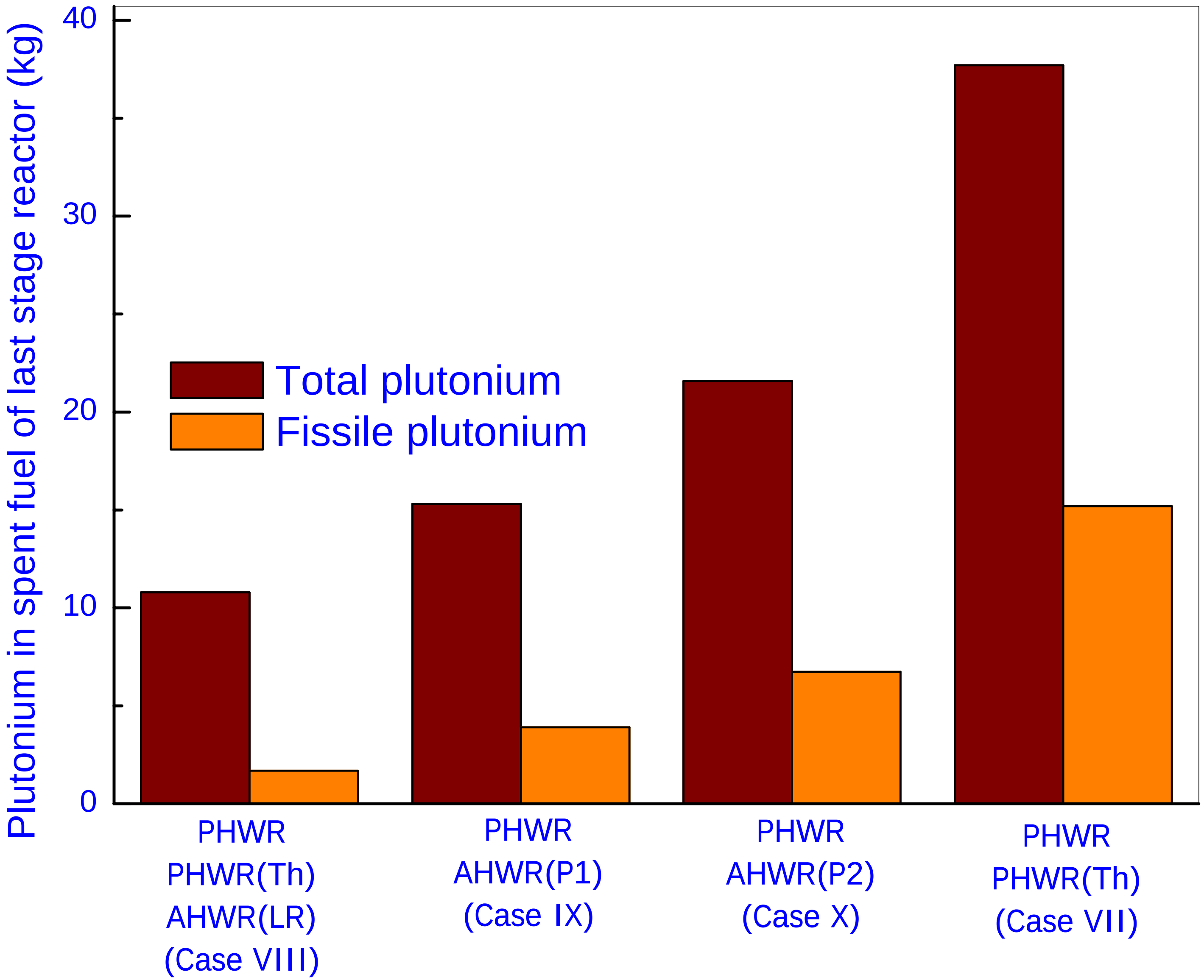
Within AHWR based configurations, higher burnup results in lower Pu content in spent fuel.

Comparison of burden for treatment of Minor Actinides (MA) produced (LWR based cases)



AHWR based options produce substantially reduced quantity of MA as compared to that produced with FRs.

Comparison of residual plutonium (PHWR based)



The multiple cases for thorium utilisation with different characteristics exhibit the flexibilities available with the use of thorium in conventional thermal reactors or in thermal reactors using conventional technologies

Gamma radiation exposure rate at 1 ft. from 5 kg mass of ^{233}U in the spent fuel after one cycle

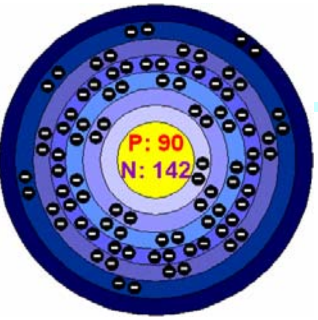
Reactor type	^{232}U concentration (ppm)	Gamma radiation exposure rate at 1 ft. distance from 5 kg. mass of ^{233}U (R/h)		
		After 1 year	Gamma dose rate after 10 years (R/h)	Gamma dose rate after 100 years (R/h)
AHWR (L1)	2368	355	1089	474
AHWR (L2)	1468	220	676	294
AHWR (P1)	2428	364	1116	485
AHWR (P2)	1289	193	593	258
AHWR (LR)	2107	316	970	422
PHWR (Th)	816	123	378	163

Conclusions (1/2)

- Fast reactor based options
  - Multiple recycling of Pu – attendant cost and proliferation risks
  - MA burners –
    - High costs
    - Longer time frames for deployment
    - Immature technologies with attendant economical and technical risks
- Thorium based options
  - Vast superiority – considering Pu and MA content in spent fuel
  - Inherently proliferation resistant nature of ^{233}U
  - Can be utilised in reactor designs that already exist
  - New systems can be designed to utilise thorium, using existing technologies.

Conclusions (2/2)

- Out of the current fleet of 443 nuclear power reactors operating in the world, less than half are under IAEA Safeguards.
- Even in this scenario, and with a very slow growth of nuclear power in the last two decades, the volume of human and financial resources needed for the implementation of IAEA safeguards have constituted a large fraction of the resources available to the Agency.
- With the envisaged rapid growth in the demand for nuclear power, mainly in the developing countries, the ability to implement safeguards in the traditional manner could, itself, become a serious limiting factor, and perhaps a hindrance to such growth.
- It is, therefore, necessary to establish institutional as well as technological solutions that should enhance proliferation resistance along with an assured fuel supply, without adversely affecting long-term sustainability of nuclear fuel resources.
- Thorium offers a very important and attractive solution from this perspective.
- India has developed advanced capabilities in this field.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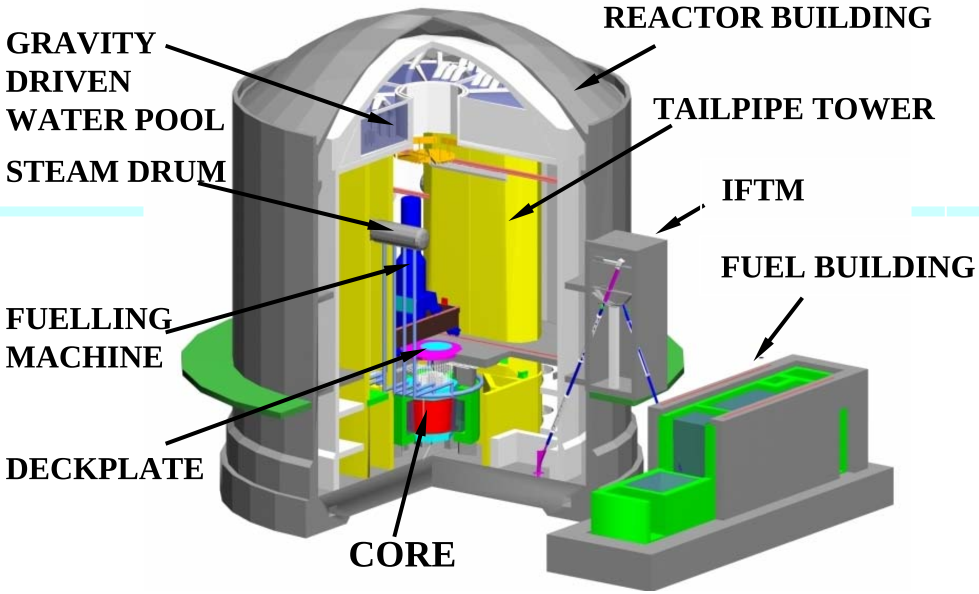
GRAVITY DRIVEN WATER POOL
STEAM DRUM
FUELLING MACHINE
DECKPLATE
CORE
REACTOR BUILDING
TAILPIPE TOWER
IFTM
FUEL BUILDING

Thank you.


3MW BOILING WATER LOOP