

# The Future of Dealing With the Past

(Thoughts on how decommissioning  
might progress from here)

Stan Gordelier

# How Much Decommissioning is there still to do?

Countries with substantial decommissioning liabilities

- Commenced nuclear power generation early
- Also had substantial military programmes
  - USA
  - France
  - United Kingdom
  - Russia (not covered here)



# Reactor Decommissioning Sites



# Complex Materials Sites



# NRC Regulated Decommissioning Sites.



Source NRC Website

A map of Canada is shown in the background, with various provinces and territories labeled (BC, AB, SK, MB, ON, QC, NL). The map includes a compass rose and a zoom-in button. A large blue text box is overlaid on the map, containing the title and a list of bullet points. At the bottom left of the map, there are several colored circles (green, red, purple) and a legend entry for 'Research & Test Reactors'.

## Approximate US Liabilities

- US DOE has approx 1000 nuclear/radiological facilities to decommission at a cost of \$33 – 38B US
- DOE's current spend is ~\$6B/a
- US civil power reactor fleet is
  - 69 PWRs of total capacity 67GWe
  - 35 BWRs of total capacity 34GWe
- Liability for this civil fleet is \$46B US

▪ Sources: Andy Szilagyi, DOE; WNA; author's estimate based on NEA decomm study.

Research & Test Reactors



# France

*(See Gerard Luarent later)*



# EDF's Nuclear Power Plants in France

under deconstruction (9 facilities, 4 10<sup>9</sup>€, 30 y)



recherche scientifique - énergies alternatives



Chinon A



St Laurent A



Bugey 1

GGR



Chooz A

PWR



Creys  
Malville

FBR



Brennilis

HWGCR

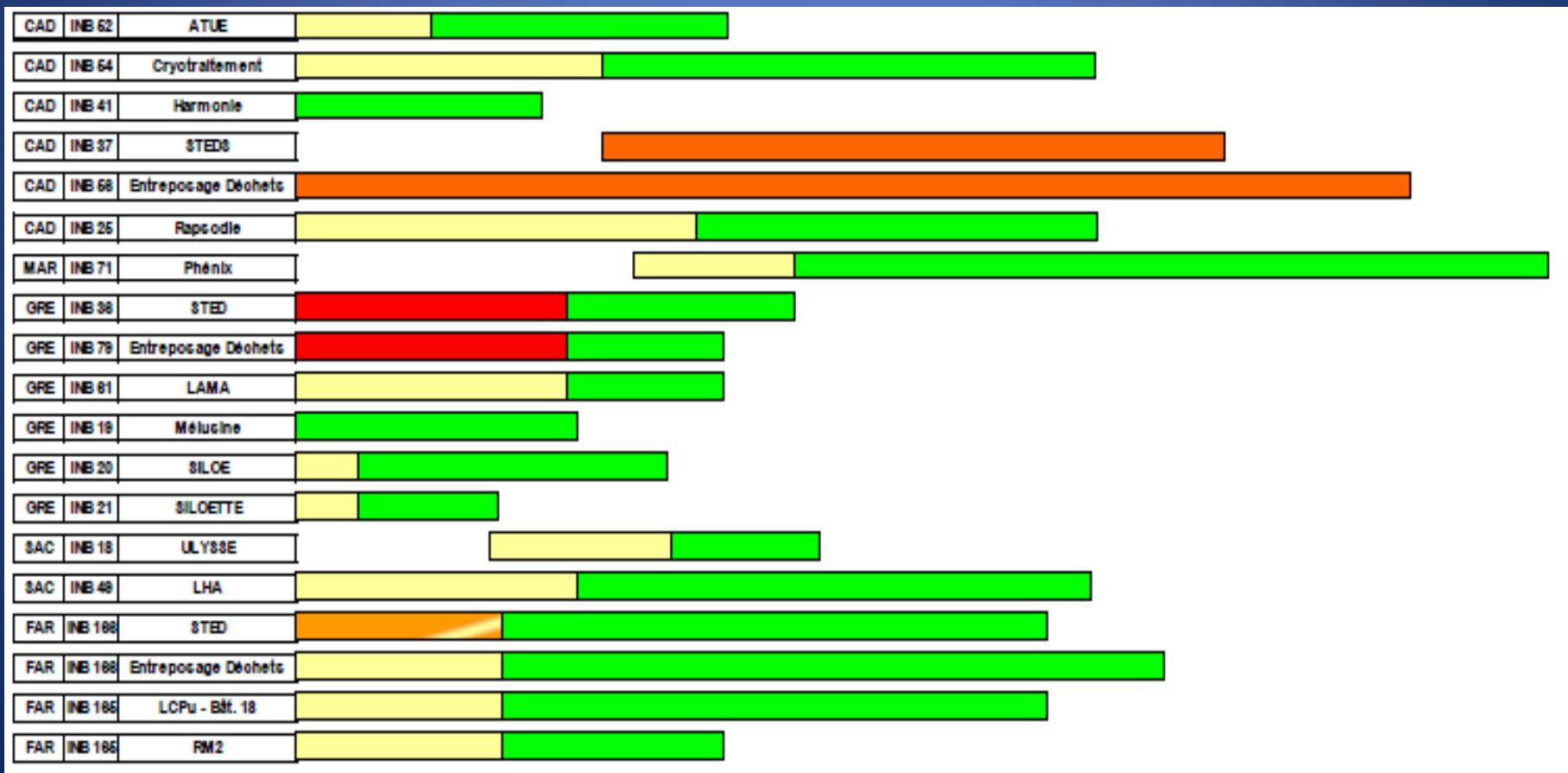


# Decommissioning Plan 2015



Source: J-G  
Nokhamzon CEA

2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
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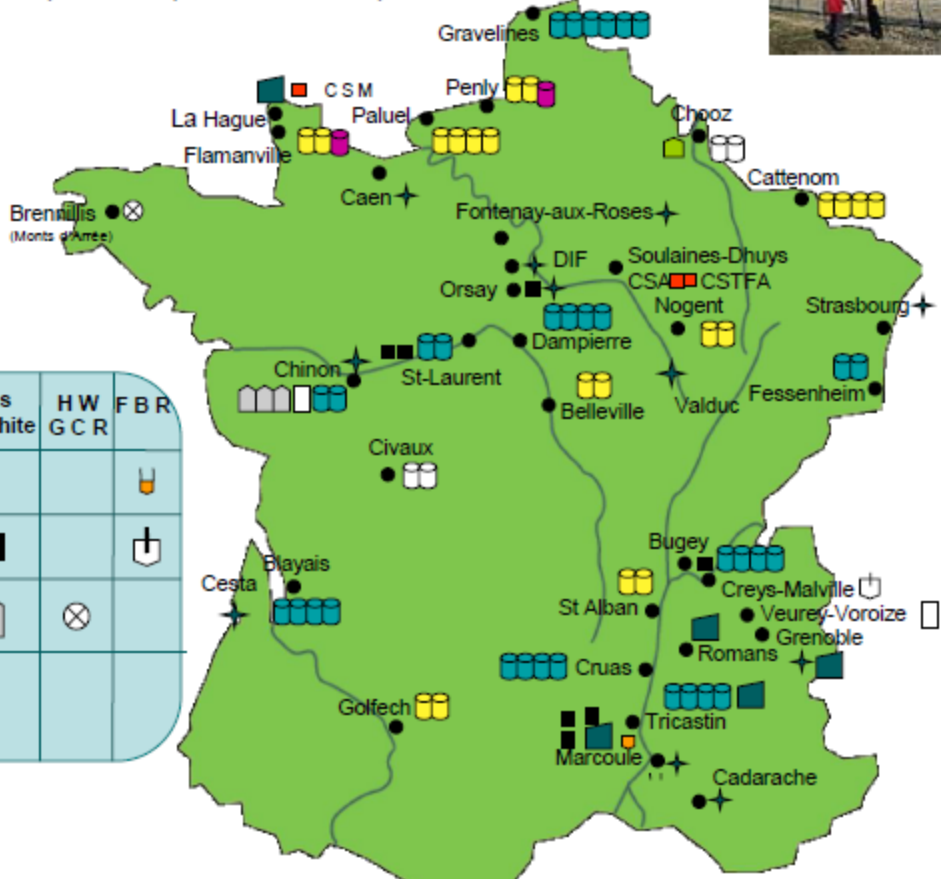


# CEA, EDF, ANDRA, AREVA




- Fuel Cycle Facilities (enrichment, fabrication, reprocessing)
- Waste Storages
- Nuclear Research Centres
- Laboratories

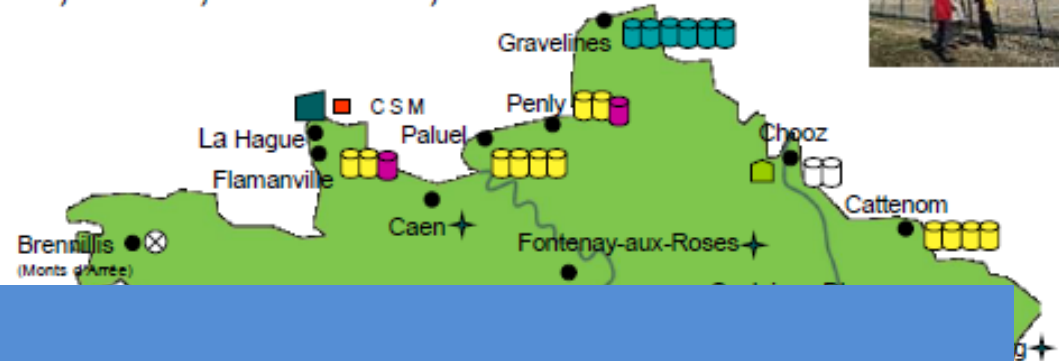
Reactors	PWR				Gas Graphite	HW GCR	FBR
	300 MWe	900 MWe	1300 MWe	1450 MWe			
In Operation							
Shutdown							
Decommissioning in progress							
Under construction EPR 1650 MWe							



Source: J-G Nokhamzon CEA



-  Fuel Cycle Facilities  
(enrichment, fabrication, reprocessing)
-  Waste Storages
-  Nuclear Research Centres
- 



- EDF has 58 operating reactors, total combined capacity 63 Gwe
  - Decomm liability ~ €25B (\$34B US)

- CEA Civilian & Military Liabilities
  - Decomm liability ~ €23B (\$32B US) 40 years

- AREVA
  - Decomm liability ~ €10B (\$14B US)

Total ~ €58B (\$80B)

- Current French annual spend on decommissioning ~€500M (\$700M)



# UK Civil Liabilities

- NDA £50B<sup>1</sup> (\$80B US)
- Spend ~£3B/a (\$5B US)
- EDF £10.5B<sup>2</sup> (\$17B US)

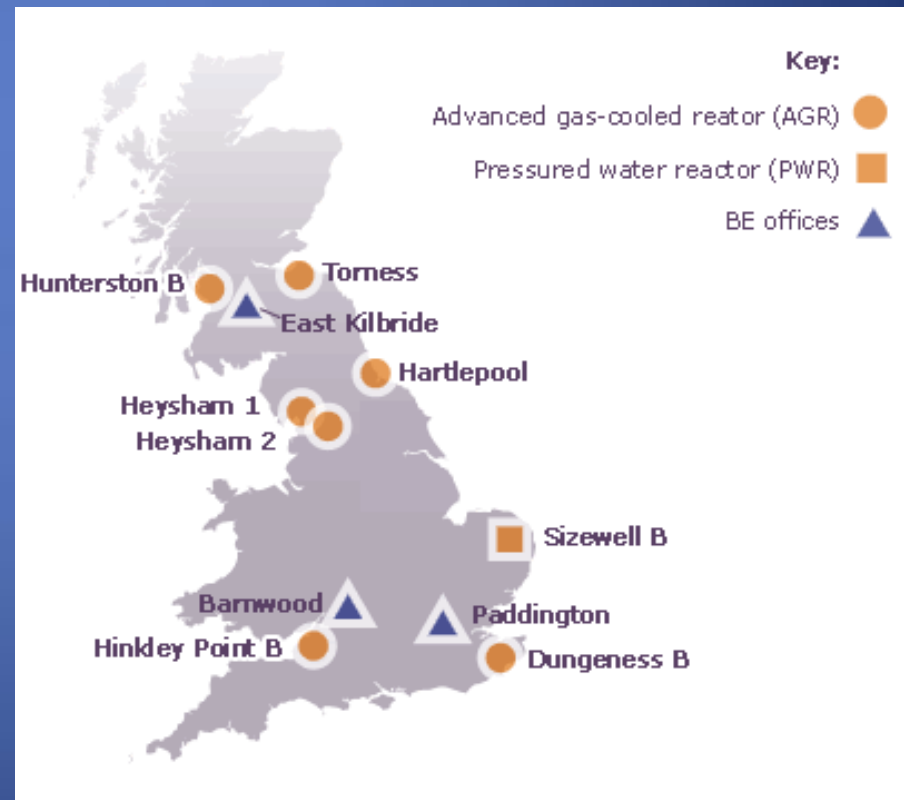
<sup>1</sup>Discounted at 2.2%

<sup>2</sup> Estimate based on BE figures escalated for inflation, undiscounted, reactors only.

## NDA Decommissioning Sites



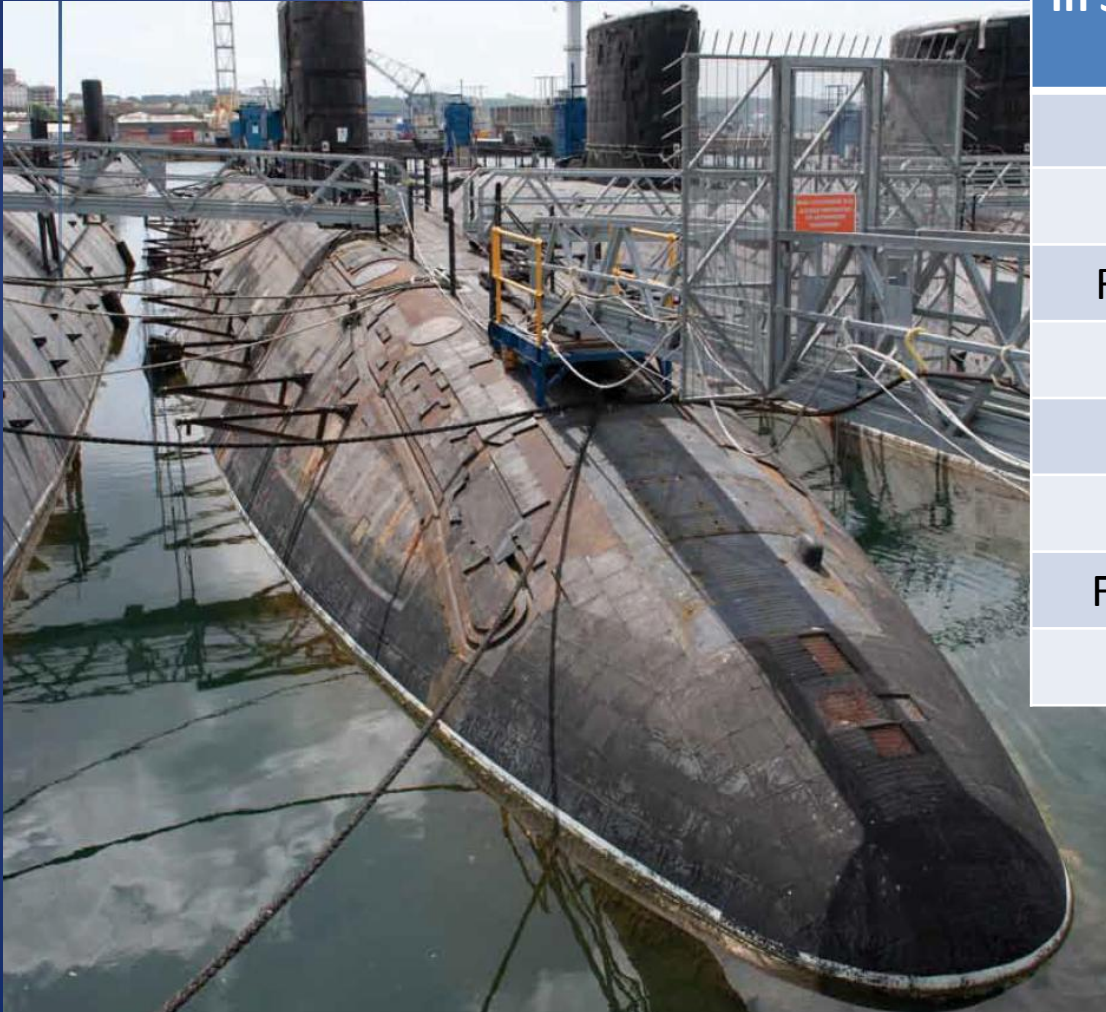
## EDF Sites





# UK Ministry of Defence Current and Future Decommissioning Liabilities

# Nuclear Submarines



In Service	Out of Service	Disposed
USA		
72	117	100
Russia		
29	274	180*
UK		
12	17	0
France		
10	6	3*

\*Reactor compartments removed, not dismantled



# The Future of Decommissioning

## Driving or Influencing Forces

- Large and rapidly growing market
- Also, plenty of new build (after the nuclear famine)
- Competitive Electricity Markets
- Financial crisis – many government's short of cash
- Repositories will finally arrive (we hope!)
- Public attitudes to nuclear and to engagement

# Large Decommissioning Market/ Plenty of New Build

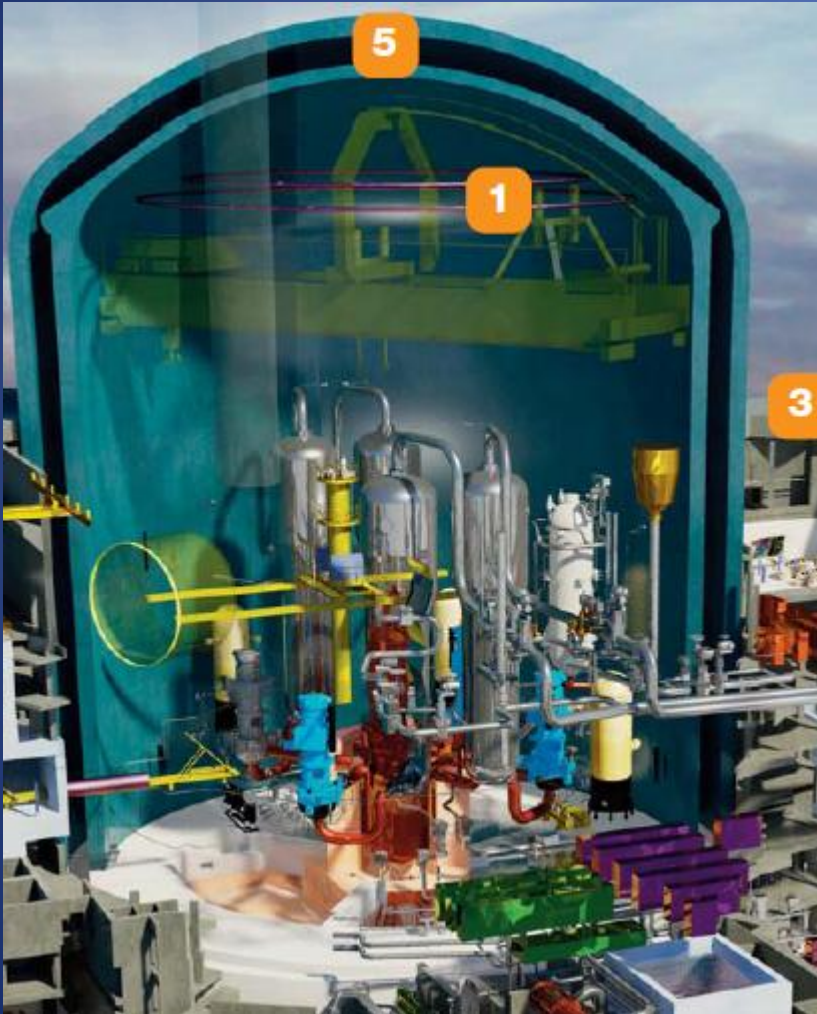
- Skill shortages (*see Ashutosh Sharma later*)
- Sites will be valuable
- Emerging new companies (decomm only specialists?)
- Sales of decommissioning sites?
- Continued development of specialist subcontractors:  
Laser cutting, Robotics, Concrete decontamination,  
Diamond wire sawing, Gama survey mapping etc.
- Accumulating experience (good for techniques,  
provisions etc. But protection of IP?)

# Competitive Electricity Markets/Governments Short of Cash

Desire for faster & cheaper decommissioning (but just as safe or better)

- Innovation in techniques
- Desire for more practical and decommissioning specific regulation
  
- Fully segregated funds (*see Janet Balfour later*)
- Slow down in government owned liability clearance?
- Further spread of Government owned/Contractor operated model?

# More Practical Regulation

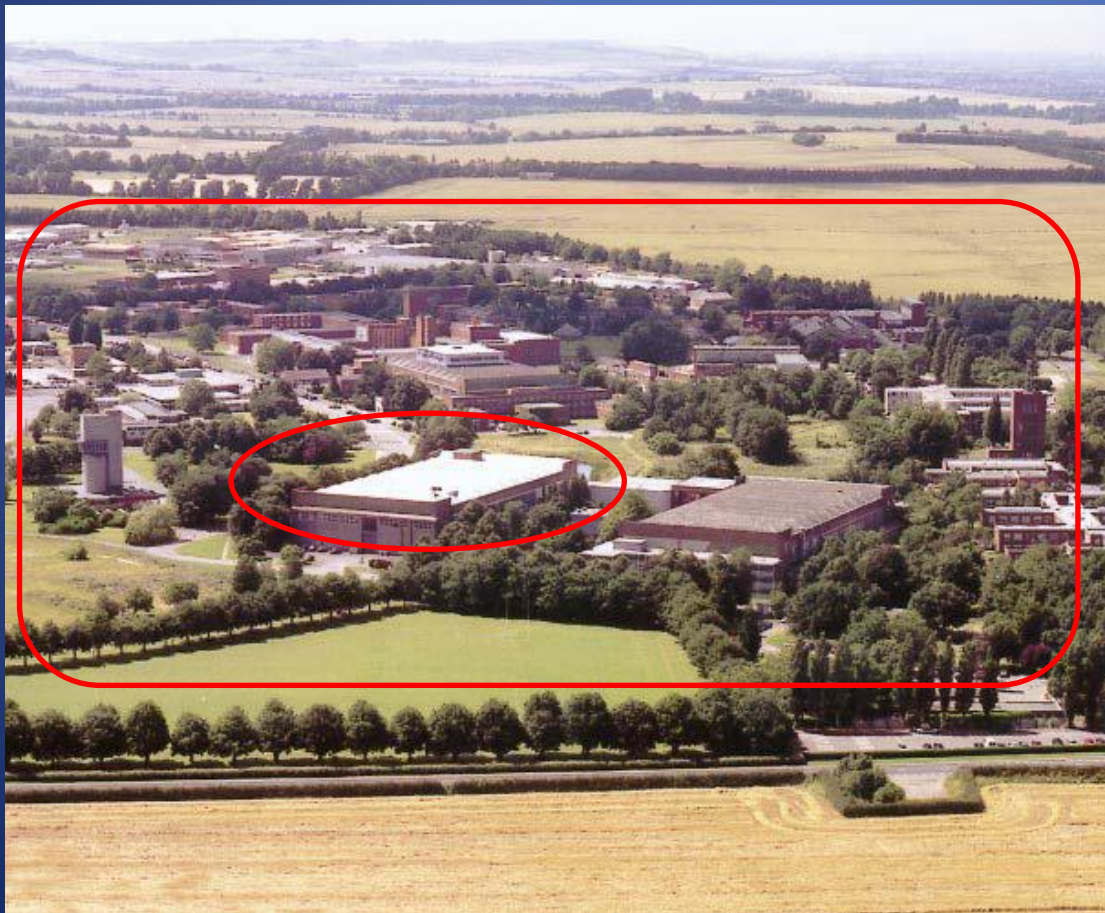


- An operating PWR Reactor typically runs at:
  - 155 bar
  - 330°C
  
- A decommissioning reactor :
  - Runs at:
    - Atmospheric pressure
    - Room temperature
  - Has had 99.9% of the radioactivity removed with the fuel

So what are the remaining driving forces to disperse the remaining radioactivity?

## More Practical Regulation: a little example from my past

- A licence is required for prescribed processes : reactors, plutonium extraction, enrichment, bulk storage of radioactive matter.
- Delicensing requires “no danger from ionising radiation”



Hawell

- A separate licence within a licence (island), without a prescribed process.
- Cannot be delicensed – still radioactivity present!
- Cannot be relicensed- no prescribed process!
- Is magic blotting paper the answer?

So why isn't delicensing the inverse of licensing?

# Repositories Arrive/Public Attitudes

Faster Progress towards decommissioning (*see Jeff Kerridge later*):

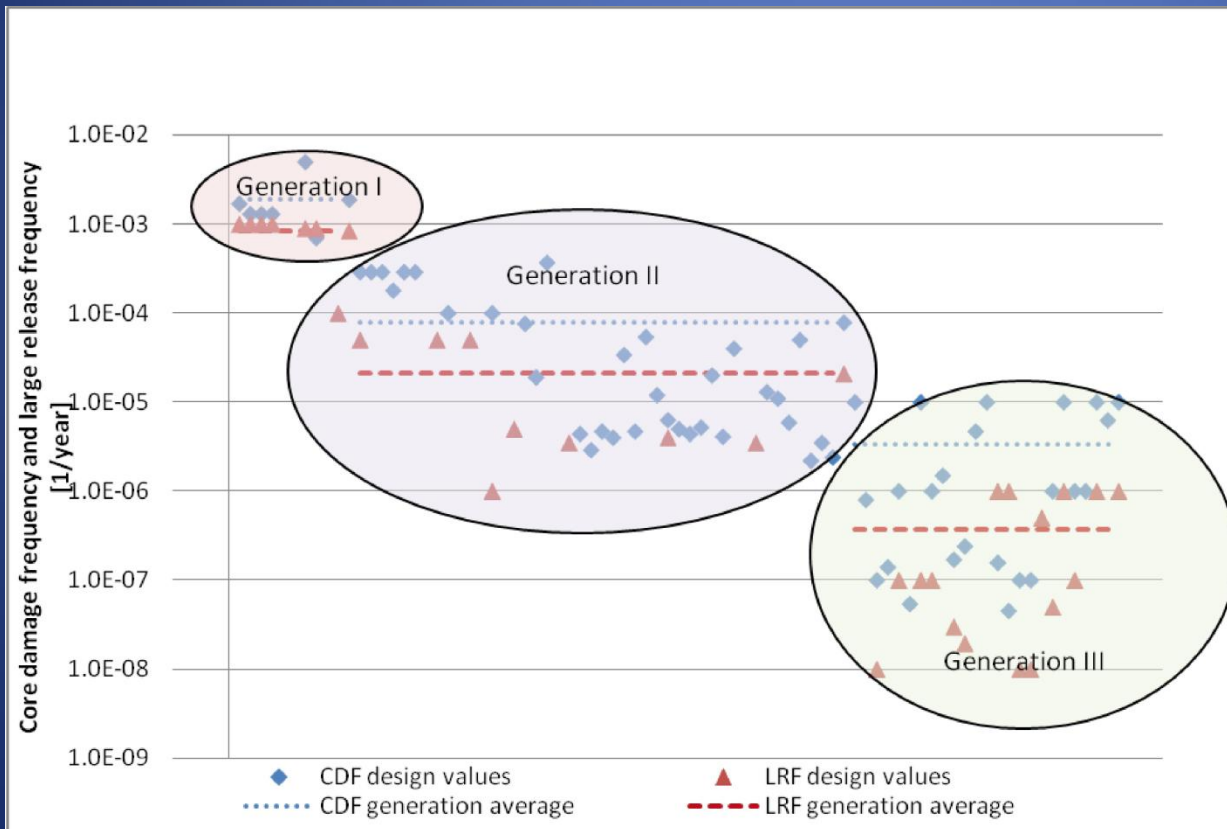
- Less reason for deferral/safestore
- Repositories designed with decomm in mind
- “VLLW” repositories in most countries
  
- Even greater pressure for public consultation
- Public desire for site clearance of old to accept the new?
- Public concern about loss of employment and what follows (ALAI BMBY v NIMBY) (*also see Bernd Rehs later*)

# Contentious Issues



# Core Damage Frequencies (CDF)

Evolution of CDF & LRF for existing and future reactors



➤ Average CDF for Generation II is  $10^{-4}/a$

➤ Average CDF for Generation III/III+ is  $5 \times 10^{-6}/a$

Source: NEA NDC publication based on IAEA data



# World Energy and Reactor Numbers

- By 2050 TPES will double (business as usual case)
- Problems:
  - Climate change
  - Energy security
- Nuclear is currently ~ 6% of World Total Primary Energy Supply (TPES)
- If nuclear is to make a serious contribution, say 50% of TPES:
  - This requires ~ 7000 GWe cf ~ 370GWe today
  - Core damage frequency (CDF) of  $10^{-4}/a$  gives 7 damaged cores per 10y!
  - CDF of  $5 \times 10^{-6}/a$  gives 1 damaged core per 25y

## Conclusions:

- We need generation III/III+ to live up to its PSA numbers
- Expect to decommission core damaged reactors (*see Andy Szilagyi and Hiroshi Rindo later*)

# Contentious Issues Continued

- Will terrorism concerns continue to drive up security costs (fear of dirty bombs etc)
- Why does every country need its own disposal facilities, particularly Geological Disposal Facilities? Is it unrealistic to have international ones?
- Final site end states
  - Does it have to be always (almost) perfect?
  - Can we accept interim or monitored end states?
- Is the market really that big?
  - Life extension, Safestore, DOE sites finish in 2020

# Concluding Thought

Benjamin Franklin (1706-1790, US author, diplomat, inventor, physicist, politician)

“Prediction is very difficult, especially about the future”

Thank you for listening and I hope that you have been provoked!

