Delivering the UK's new Nuclear Energy Infrastructure – Tony Roulstone

ICE -15 January 2013

tony@bracchium.net

Summary

- Scale of low carbon energy need up to 2030 (and 2050) - nuclear as a significant part of the energy mix;
- Current nuclear plans are focused on EdF Energy's Hinkley & Sizewell C.
- The problem – very high capital costs which means high energy costs;
- Who has done nuclear construction best?
- What can/should be done in UK to deliver the nuclear construction programme?

UK nuclear – the Task

- Slow but steady progress towards new nuclear as part of a clean energy policy;
- **D**eliver clean energy through private investment**;**
- **Doubling the scale of electricity** in our energy mix by 2050: - supplied by:
  - 30,000 large windmills ~80GWe (nominal) or 20-25 GWe (mean);
  - Limited new gas powered generation to provide both economic and grid flexibility;

  - One new nuclear power station completed each year from 2019 until ~2040 20-30 GWe;
  - Which would represent two or three times the previous – AGR & Magnox nuclear energy supply capacity.

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UK Nuclear New Build Plans

- Government Policy defined — Energy Reviews 2006/8
- Experienced & committed investors — EDF/Centrica & Horizon
- Waste costs fully funded — NLFAB
- Streamlined licensing process
  one stop shop Generic Design Assessment — In process ONR & EA & OCNS
- Licensing of new but proven designs — EPR/AP1000 by 2011/2
- Streamlined planning process — Infrastructure Planning Commission

30 GWe of new nuclear by 2040 funded by private investors without any Government subsidy

- Making nuclear energy investment case – is it affordable
  - Energy Market Reform process – 'contracts for differences'

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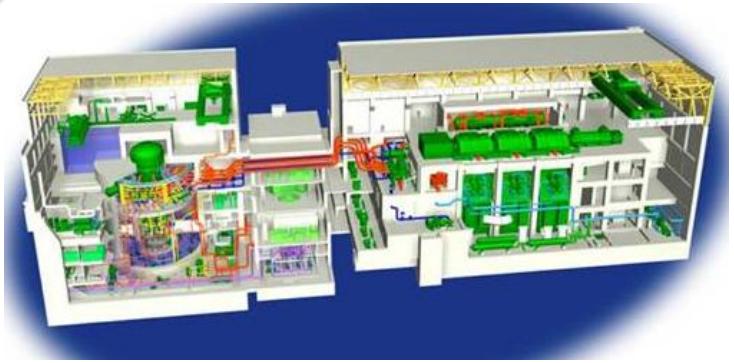
Investment & Construction task

- Three consortia of utilities and investors each selected established water reactor technology, presumption for designs that have been licensed & built elsewhere;
- Investment costs are high:

  ~£5-6bn per reactors – or £10-12bn for a twin, like the proposed EdF's Hinkley C

  Hence UK programme ~20 reactors by 2040 ~£100bn of private investment;
- Generic licensing of a reactor design – a series of identical reactors starting within a ten year period – each still require a Site-specific licence;
- Sites: existing nuclear power sites are preferred;
- Construction:

Timescale:	6-8 years
Peak site manpower:	5-6000



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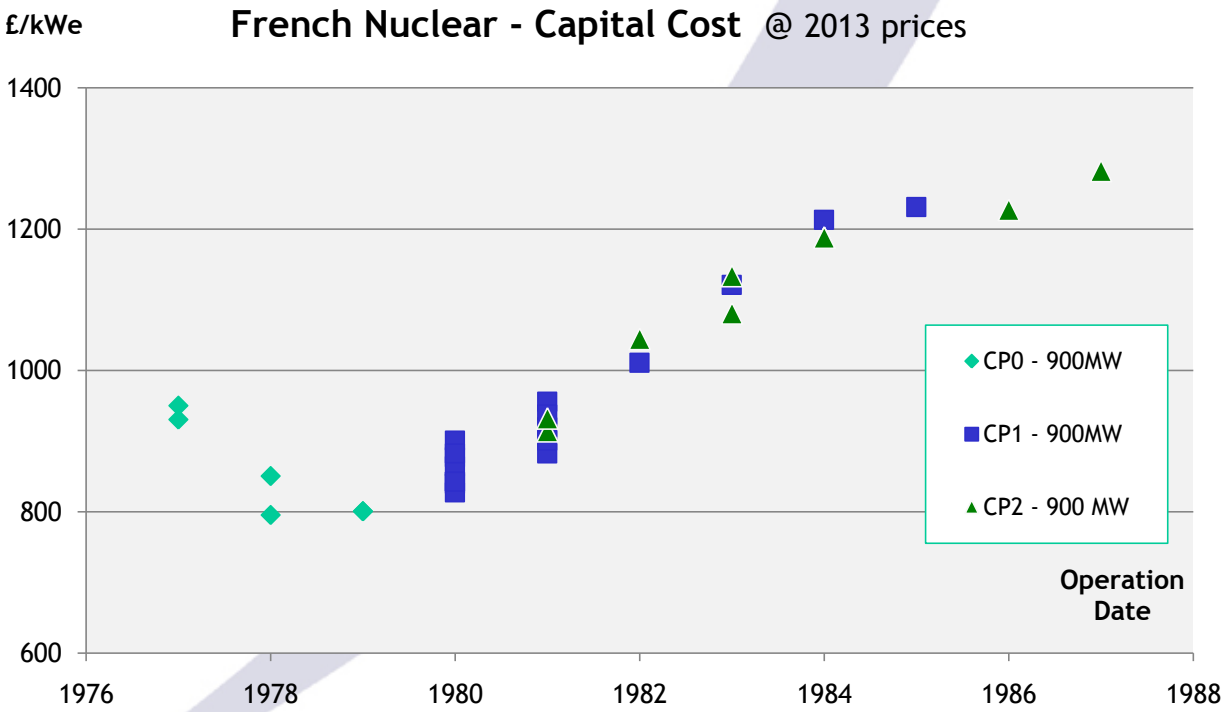
France Nuclear Build

Most successful nuclear build programme?

- Government decision for nuclear 1973;
- First plant operating 1977
- First 33 reactors built closely to a licensed Westinghouse design;
- By 1981 – seven reactors completed in one year – 20 in the four years 1981-4;
- Some evidence of cost learning (16%) in early years;



Source: Grubler - Energy Policy 38 (2010) restated from FF1998 to £2013

Much better record on duration and cost than US equivalents

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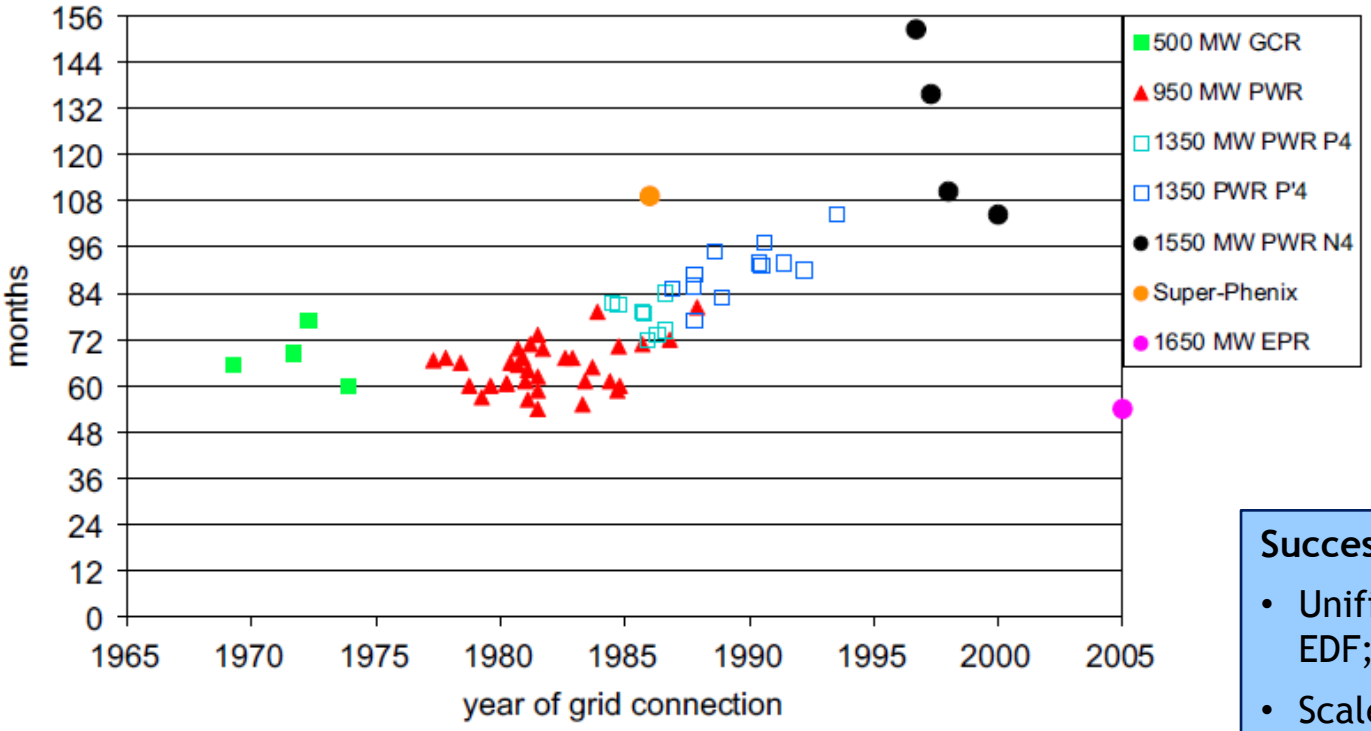
French nuclear construction timescales

Best practice ~50 months, norm 84 months



Source: Grubler - Energy Policy 38 (2010)

- Construction timescales regularly 6-7 years until after 1987;
- Later programme slowed & built new larger more complex P4 & N4 designs

Success factors:

- Unified client & engineer - EDF;
- Scale of program & design standardisation;
- Rigorous control of quality, design change & cost.

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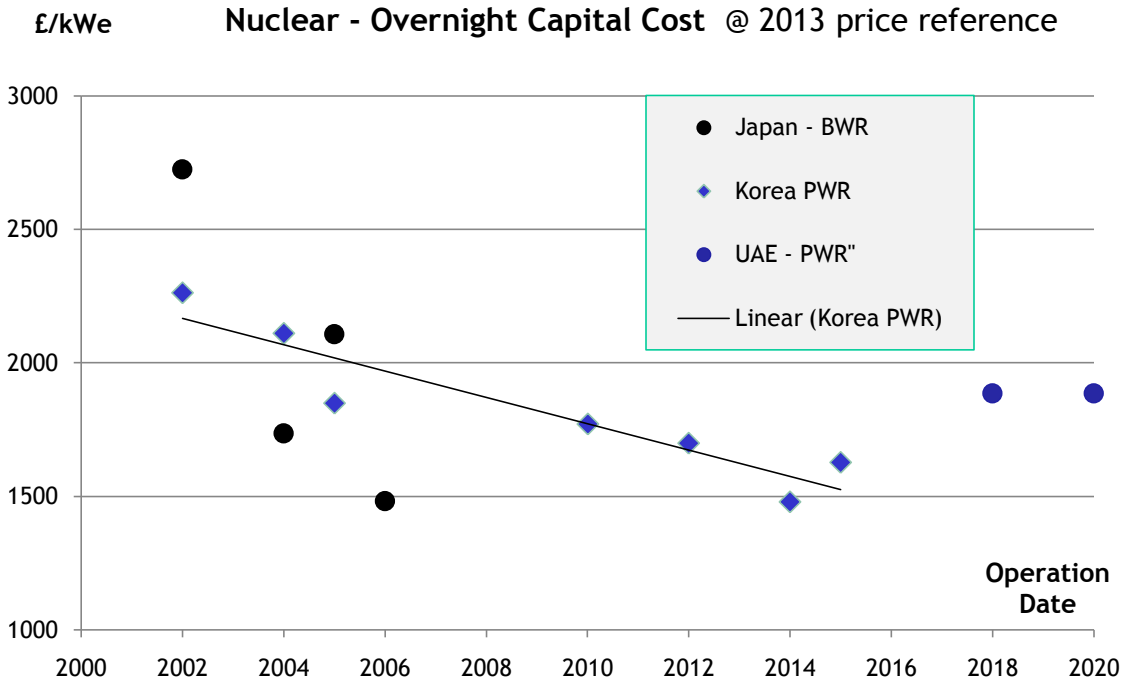
Korea Nuclear programme

Capital cost improvement - £50/kWe pa ~33% in 10 years

Korean programme:

- Was regular – one reactor of a consistent design each year for ten years;
- Organised as a national effort;
- Learned lessons from Japan BWR construction;
- Focused on reducing construction time and lower costs.



Means or reducing cost:

- Integration of client and engineering supply chain – collaborative enterprise;
- Optimisation of construction sequence and the use of cranes;
- Radical design for modular construction methods

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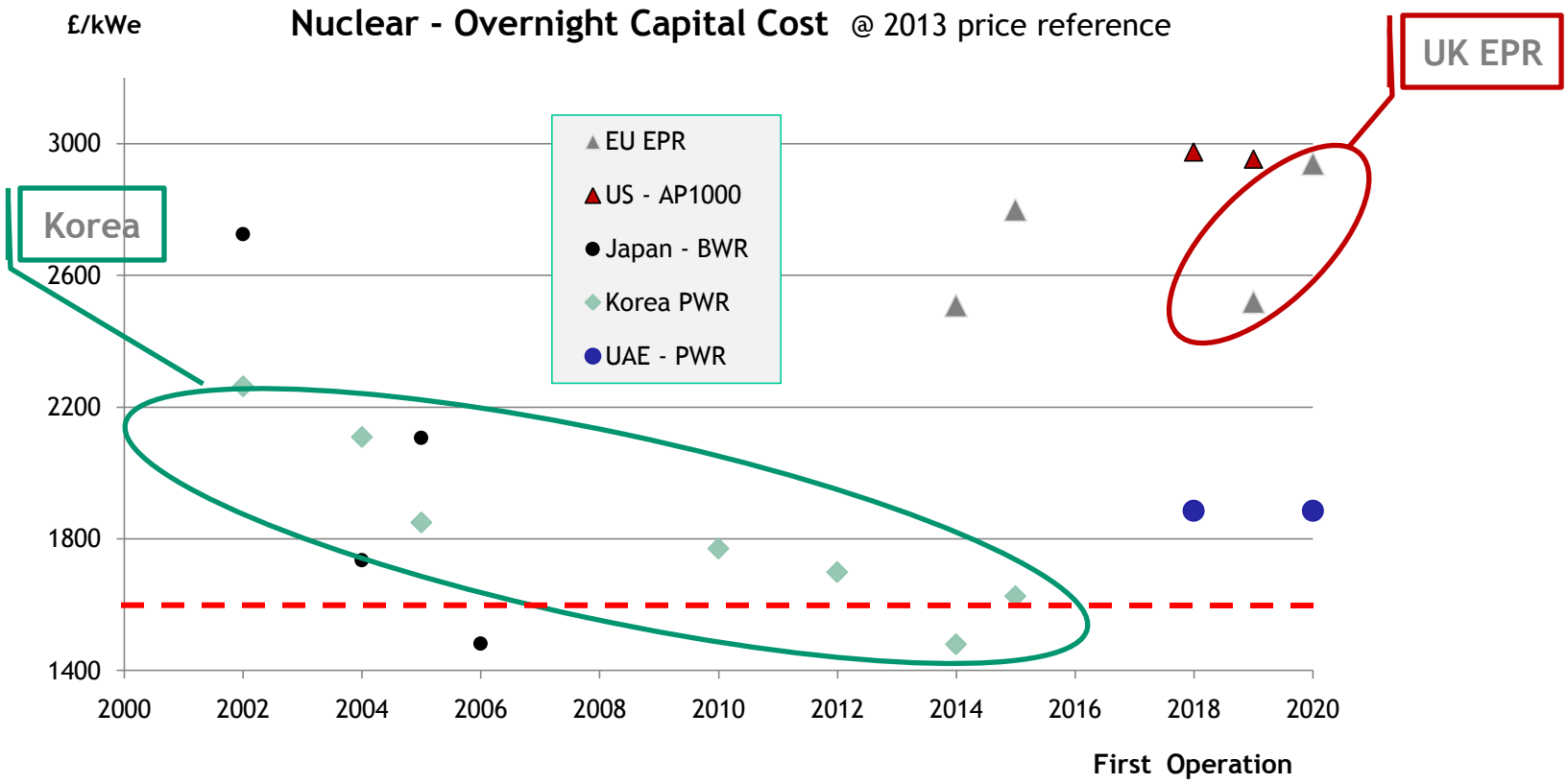
Nuclear Capital Costs

Actual & estimated costs are higher than Energy Review 2006



Sources:
'Future of Nuclear Power 2009' MIT - restated to UK £s in 2013 plus recent public data – US, UAE etc
Energy Review central cost estimate - restated to 2013.

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EPR Construction

Construction task is challenging

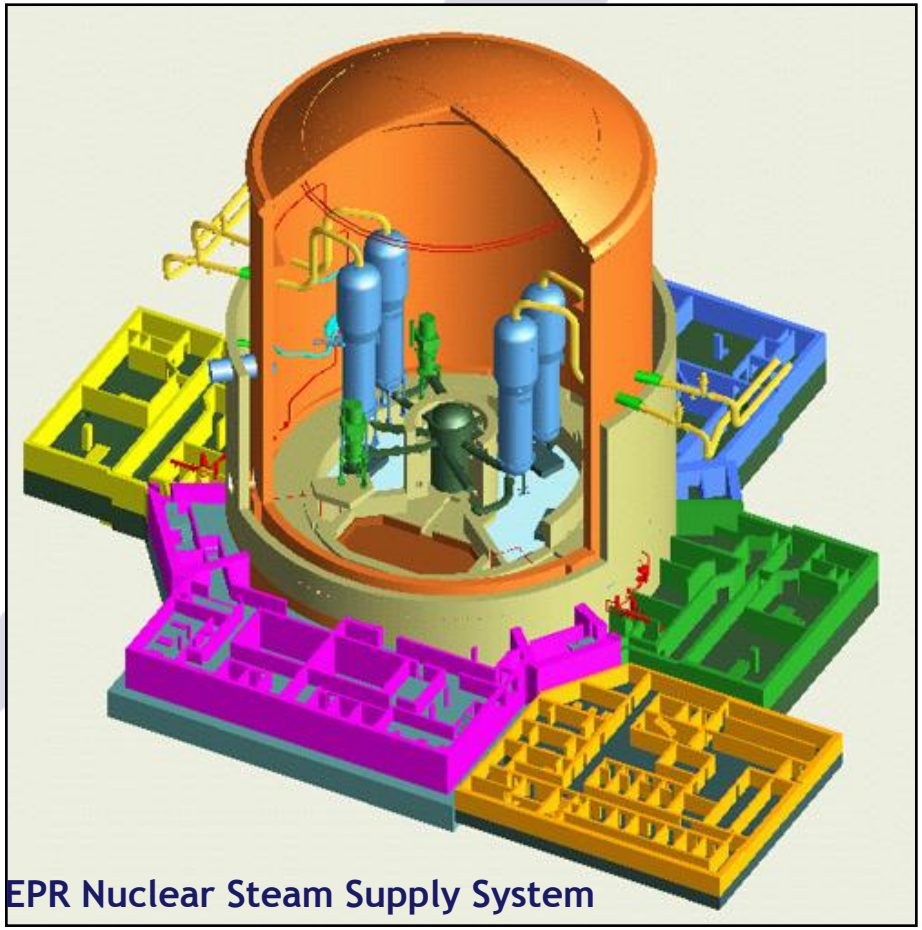
- Target construction duration is 6 years;
- Examples of complexity:
  - **Double containment structure** – designed to resist earthquake, aircraft crash, external explosion and contain core accidents;
  - **Safety system buildings** – four separate zones around reactor – each with own power supply, safety injection systems and control – earthquake and fire proof.

Hinkley C twin – typical construction quantities:

• Concrete	1 million tons
• Rebar	70,000 tons
• Piping – small/medium bore	200 km
• Valves	40,000
• Cable power, instrument & control	2,000 km

- Nuclear quality systems:

Specification; Material source verification; Trained installers; Approved procedure; Independent inspection; Systems tested & commissioned to procedure.



EPR Nuclear Steam Supply System

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Nuclear Construction – the 'Challenge'

- **Capability** – scale and number of projects –

- **Complexity** – Largest and most complex construction programme in UK e.g. 40,000 valves - joined, powered, controlled and instrumented – 250,000 terminations!

- **Cost** – at £3,000/kWe with related Contract for Differences/unit electricity prices in the range of £80-100/kWh

  – set an objective 30% unit cost reduction over 10 years with programme of lean development to achieve this target.

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Strategies for addressing the 'Challenge'

- **Capability** – built the skills and the team for a programme of reactors:
  - Learn from the best practices – not necessarily those in Europe;
  - Attract the very best construction engineers project managers;
  - One team – build a construction and supply chain for the whole programme;
  - Training of engineers & skilled workforce that addresses scale of the challenge.
- **Complexity**
  - Set a realistic timescale for the first station;
  - 'Lean construction' plans for progressive improvement.
  - Modularise construction.
- **Cost** – an integrated plan for multiple reactors:
  - Recognise duration drives cost;
  - Cost improvement plan from day one;
  - Incentives in CfD profile for later stations -> progressive improvement;
  - Reducing commercial risk will cut the headline investment figures.

Japan Best Practice:
ABWR ~40 months
1. Expand parallel work
2. Reduced field work
3. Improve field productivity
4. Total planning & management

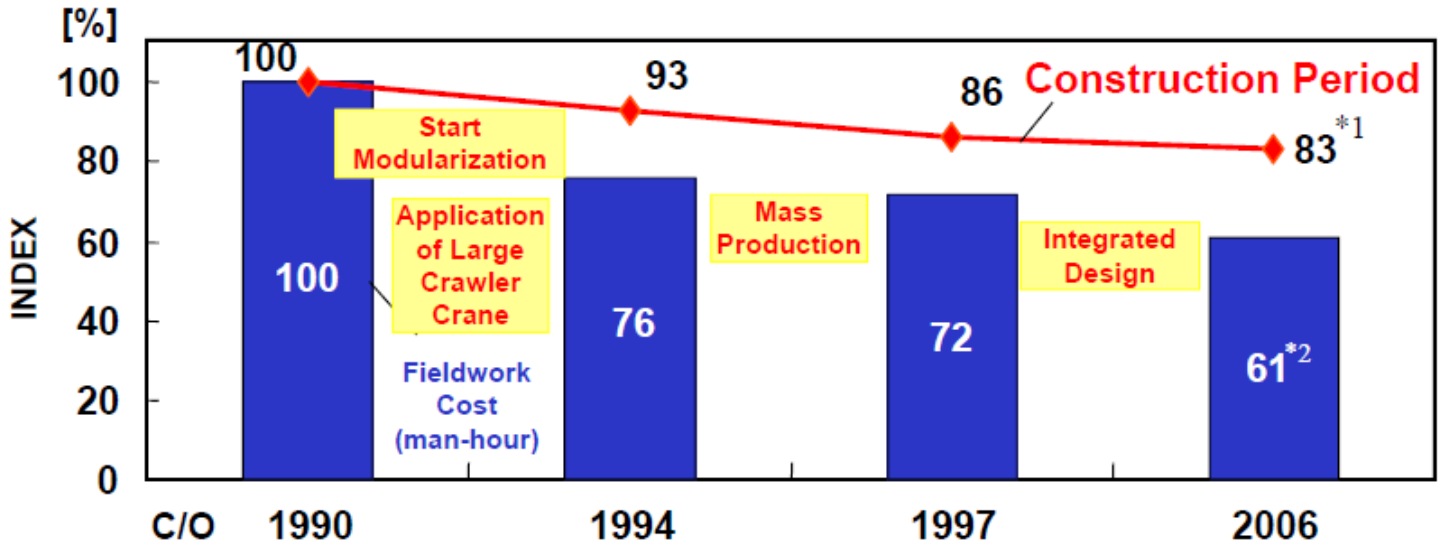
Nuclear construction - Case study

Sequence of four similar projects over fifteen years.

Methods: Optimised use of heavy lift cranes;
From stick-built to modularisation of sub-units;
Open top and parallel construction;
Skill development & site efficiency programme.

Achievements:

- Construction duration down by ~17%
- Construction man-hours down by 39%



Way Forward

Way forward **for nuclear construction**:

1. **Recognise the threat** to new nuclear **is cost** and competition from low-cost gas;
2. Other '**clean' forms of electricity cost** more than nuclear, even if some of this may be disguised by transfer prices for ROCs, or other forms of environmental levy
   - but, it **cannot be nuclear at any price**;
3. Nuclear industry needs to take the responsibility for getting:
   - **reactors built on target,** and
   - **unit capital costs down** by 30% below £2,000/kWe

     in the way that the S Korea & Japan have shown can be delivered, using methods demonstrated.

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