# How nuclear safety regulation makes a difference

A comparison between UK and US nuclear safety regimes by David Toke, University of Aberdeen

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# Key questions

- What are the differences and similarities between US and UK nuclear safety regulatory systems?
- How can we explain these outcomes?
- I deal with safety regulations aiming to prevent release of radioactivity from planned or operating nuclear power plant
- These potentially can make substantial differences to costs of nuclear power stations (as opposed to planning matters which have little impact on costs).

# Method

- How can we use political science theory here?
- Examine philosophy of the two systems
- Look at 21st century cases – high profile egs selected- a) aircraft protection (post 9/11) and b) post Fukushima measures

# Historical institutionalism (eg Hall and Taylor 1996)

- Path dependence – present governed/constrained by shapes of institutions that already exist and created at ‘critical junctures’
- Institutions can be studied through their dominant norms – can be different in different cases
- ‘unintended consequences’ of interaction between individual actors and institutions (Hay and Wincott 1998)

# Cultural approach to regulation (Lodge 2009, adapted)

- Different approaches to regulation:
- **Individualist** - cost benefit based, market oriented, sceptical of environmental risks
- **Hierarchical** – takes environmental risk values into account but assumes they can be managed by centralised decisions
- **Egalitarian** – decentralised, full application of precautionary principle
- **Fatalistic** – intermittent intervention

# US and UK nuclear power sectors

- US: 99 reactors supplying about 20% of US electricity – 2 power plant under construction, another 2 recently abandoned
- UK: 8 reactors supplying about 20% of UK electricity – a twin power plant under construction (?), another twin project under consideration
- Both use Probabilistic Safety Assessment (PSA) but interpret this differently
- Both draw from IAEA guidelines, but IAEA rules exist as a lowest common denominator which say little about key safety controversies – national regulatory systems are most important for nuclear safety issues

# US regulation

- Initially by Atomic Energy Commission but after controversies about nuclear safety AEC stripped of its safety function which was given to **Nuclear Regulatory Commission (NRC)** in 1975
- Vague guidelines of giving ‘adequate protection’ to public and reliance on cost-benefit analysis for anything over this
- **Influenced by anti-regulation culture since Reagan in the 1980s – moral issues left for public debate and petition system**
- Public discussion of rule setting/transparency in decisions and documentation

# Institutionalism of US NRC

- Critical junctures in 1970s and 198s in anti-regulatory context
- Individualistic style of regulation
- Non-hierarchical allowing challenge from egalitarian campaigns
- Confrontational and changeable in rules
- Individualist hierarchy?

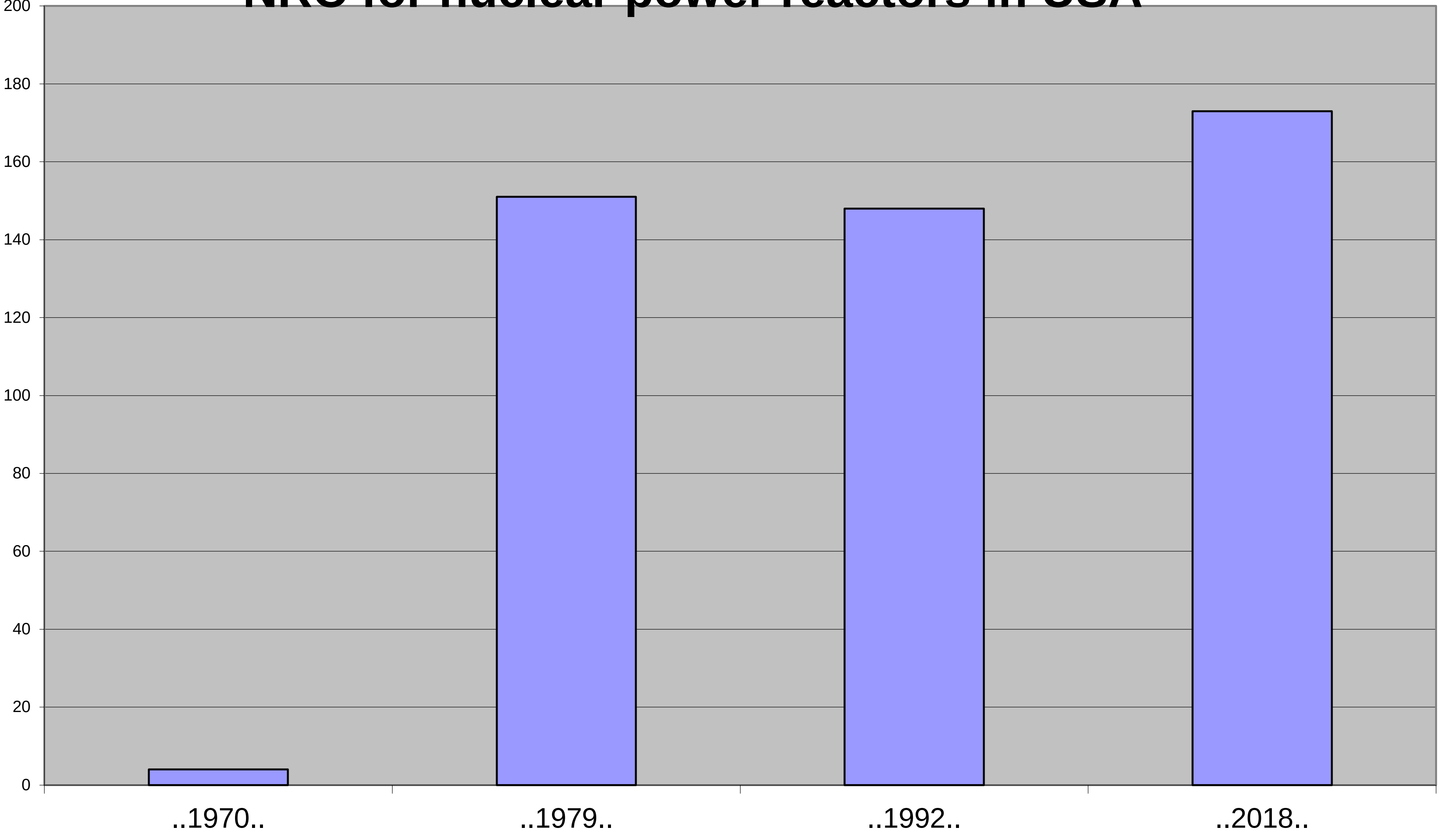
# UK Nuclear Regulation

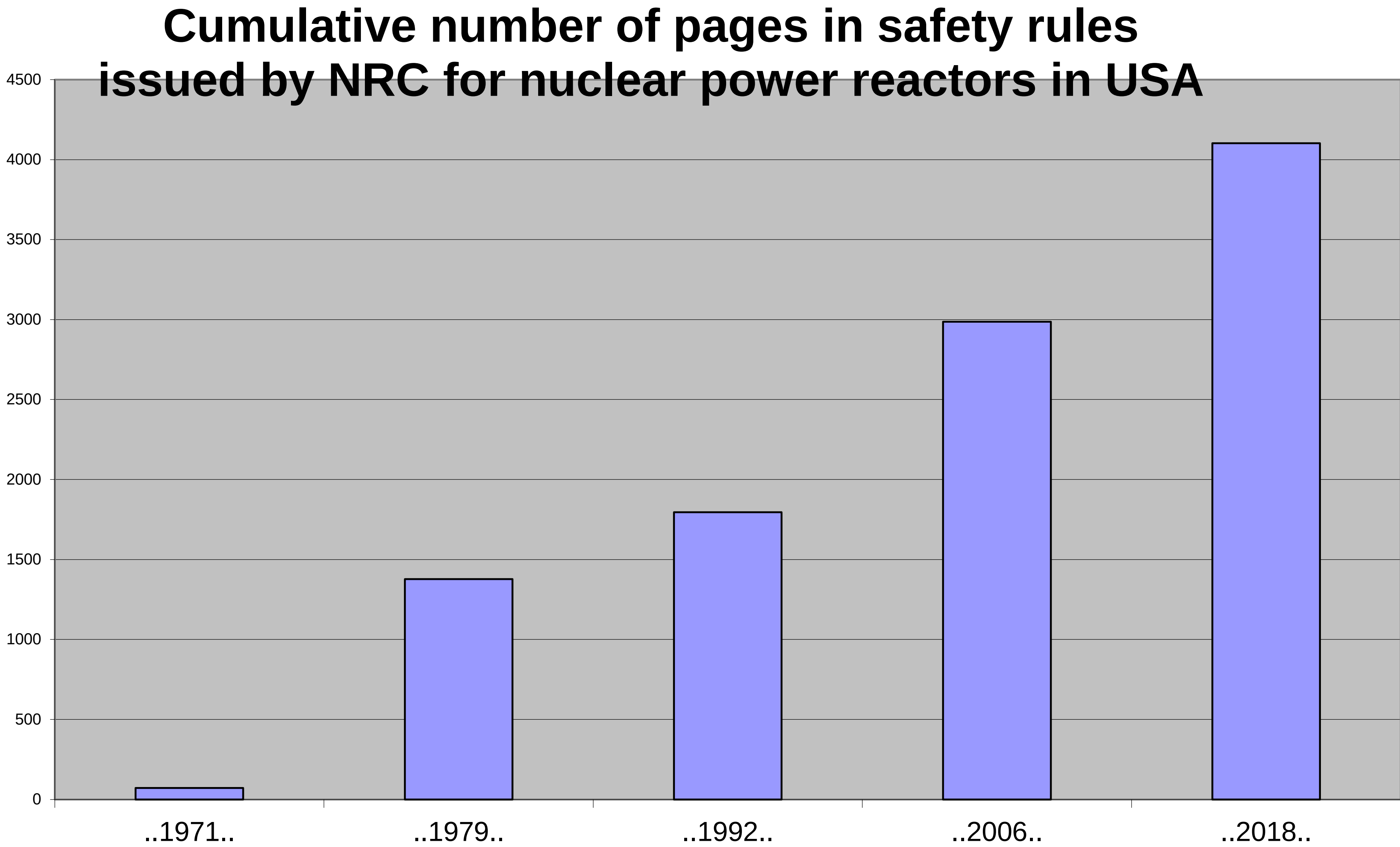
- Emerged in 1975 as semi-independent with Nuclear Installations Inspectorate as part of Health and Safety Executive and evolved in 2011 into Office for Nuclear Regulation (ONR) with two key features from British health and safety approach:
- A) ‘goal oriented’ rather than prescriptive
- B) Guided by notion of ‘disproportionality’ whereby bias given to allowing disproportional (but not grossly disproportional) bias to safety concerns
- Hierarchical and opaque decision-making process
- Precedent set by 1949 court judgement over measures to protect coal miners and 1974 Health and Safety Act which codified ‘disproportionality’ into statute law

# UK nuclear regulation

- Now done by Office for Nuclear Regulation (ONR)
- Emerged from semi-precautionary ‘health and safety’ approach
- Errs on side of safety in cases of doubt
- Little room for challenge (opacity) from egalitarian campaigns, but policies give less cause than US
- Hierarchical egalitarian?

# Cumulative number of safety rules issued by NRC for nuclear power reactors in USA




Cumulative number of pages in safety rules
issued by NRC for nuclear power reactors in USA
4500
4000
3500
3000
2500
2000
1500
1000
500
0
..1971..
..1979..
..1992..
..2006..
..2018..

# Two case studies compared for 21st century

- Aircraft impact protection (post 9/11)
- Post Fukushima measures

# Aircraft protection

- Demands for extra containment increased after 9/11
- Resisted by (US) NRC initially – conceded finally in 2009 after campaigns by anti-nuclear groups and change of membership of NRC Commission
- Accepted by (UK) ONR immediately (in 2001) and incorporated into designs for EPR etc

# Fukushima

- Post-Fukushima changes to operation and design demanded including alternative power for cooling systems for extended periods and measures to mitigate hydrogen build-up
- In USA Task force established but proposed changes resisted: no firm back-up power period (in some cases no more than 6 hours), and hydrogen mitigation measures resisted
- In UK minimum of 72 hours back-up power operation guaranteed and hydrogen mitigation measures incorporated into PWR

# Vogtle and Summer AP1000s

- Plants ordered in states of Georgia and South Carolina (both operate monopoly supply utility arrangements)
- Plants certified in 2006 without aircraft protection
- But approved in 2012 with aircraft protection added
- Meanwhile designs altered and construction delayed

# Unintended consequence

- An unintended consequence of weaker safety philosophy but conflictual regulatory process in US (compared to UK) has been inconsistency and delays that have increased costs
- UK's system is hierarchical but more consensual and consistent
- But still greater safety requirements demanded….e.g……… as part of ONR General Design Assessment (GDA), pre-licensing design approval……….

# Hitachi (Wylfa) cost increases

- According to press reports:
- Costs of 2.9 GW were £14 billion before ONR’s GDA assessment
- Costs have risen to £20 billion since then – increase ascribed to safety measures required by ONR

# Hitachi's Wylfa ABWR design for Wylfa – ONR decisions

## Principal design/operational changes resulting from UK regulatory requirements.

The following are changes to the extant ABWR design and operating regime that have resulted from UK regulatory requirements during Step 3. Further

- Aircraft impact protection shell
- Changes to chemical operation of plant requiring material changes
- Suppression pool to contain excess steam and prevent radioactive releases
- Removal of diesel generators from reactor building
- Separation of protection equipment requiring more complex building work
- Change to the electrical system
- Greater redundancy of the cooling system
- Increased capacity for heat removal system
- Improvements to 'low pressure safety injection' system
- Improvements to system of hydrogen control

Source: Office for Nuclear Regulation, October 2015

# Relative cost increase of 'European' reactor design compared to 'Asian' reactor design

## Desirable Reactor Features

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- High generating capacity > 1100 MWe
- High load factors LF >90%
- High fuel burn-up >35 to 65 GWtd/tU
- Good thermal-electric efficiency 35% to 39% (MWth → MWe)
- Advanced passive cooling design €€ +10%↑
- Station blackout resilience >72 hours
- Fuel melt core catcher €€ +10%↑
- 9/11 aircrash protection €€ +10%↑

Modern Western European Generation III+ PWRs probably 20% - 30% more expensive than Asian Generation II PWRs

# Safety problems which increase nuclear costs

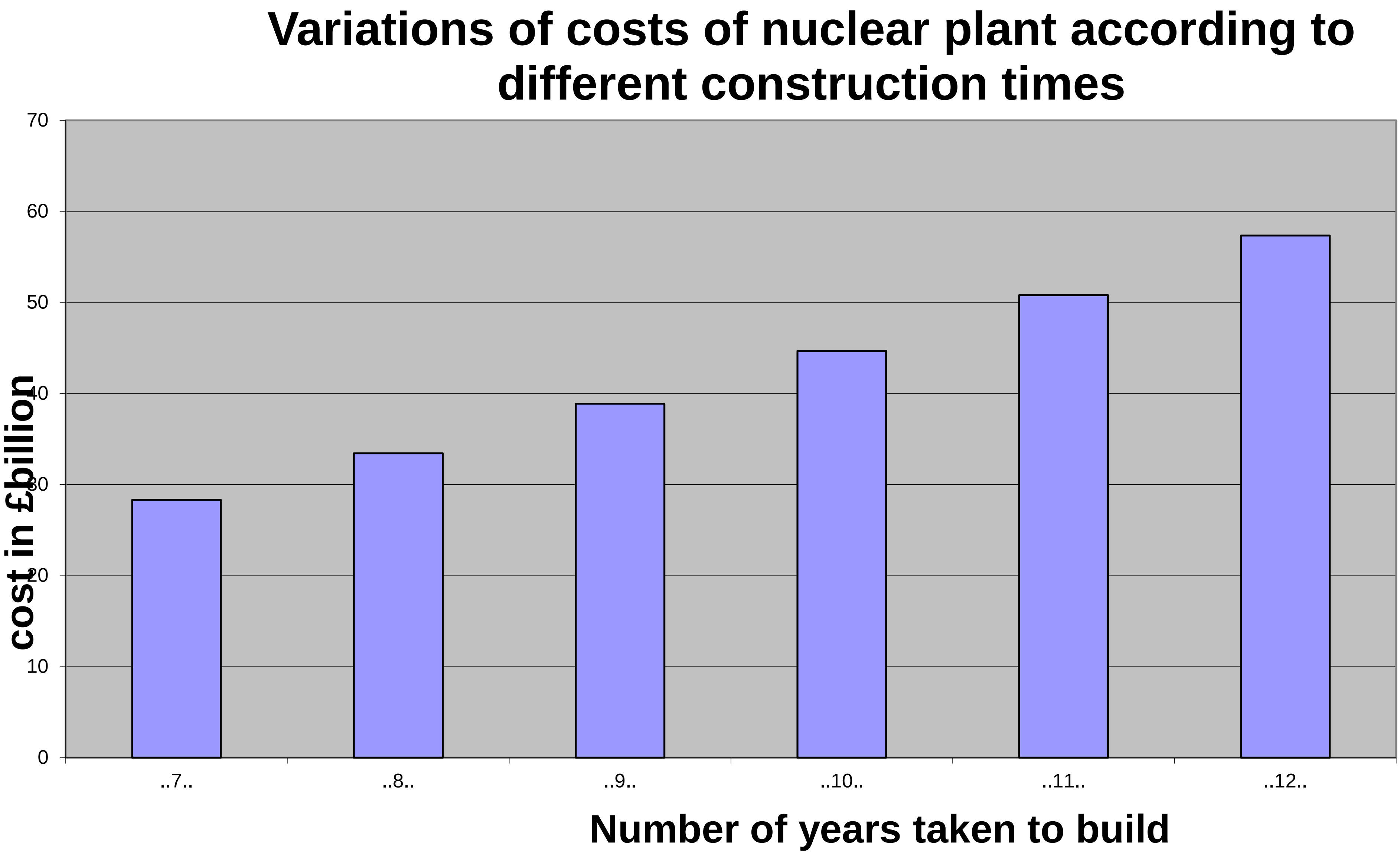
- Generation III reactors increased innovation to produce greater safety – but this increased complexity and construction times
- Existence of separate safety regulatory regime leads to complex requirements which can lead to delays (eg ‘rebar’ problem in Vogtle and Summer)
- Increased regulatory demands for safety increase complexity further

# Safety differences with competitive technologies

- central design features of nuclear power are safety related – highly regulated
- By contrast ‘safety’ of wind turbines are manufacturers concern – they occasionally break-up but there is no safety regime to ensure safe design and monitor construction
- Hence nuclear power is at a competitive disadvantage
- Moreover new designs to meet new nuclear safety design and issue challenges make the technology more complex and difficult to deliver

# But nuclear costs increase not just because of safety design costs but because of (safety related?) construction delays

- Partly  to do with complexity of implementation of new designs
- Also to do with delays from safety inspection process


Variations of costs of nuclear plant according to different construction times
cost in £billion
70
60
50
40
30
20
10
0
..7..
..8..
..9..
..10..
..11..
..12..
Number of years taken to build

# Limits of probabilistic safety analysis (PSA)

- Downer (2017) argues that PSA is incapable of predicting risks given unknowns of complex systems and their environments
- Aircraft industry has developed though practice and accident experience (not PSA), but nuclear power does not have anything like this amount of experience.
- Hence British ‘proportionality’ arguments are supported by this argument – though still unlikely to be accepted by green groups who oppose nuclear power for strategic reasons

# Conclusion

- UK nuclear safety regulation systems appears to have stricter safety rules than the USA – flowing from a more risk-averse and non-cost benefit approach
- But (counterintuitively and retrospectively ) UK system would have been cheaper for building Vogtle and Summer plants in USA
- Unintended consequences are important in the USA system which is inconsistent
- Nuclear safety regulations in West have unintended consequences in that they can make nuclear power more unlikely because of associated cost increase
- But this is politically unavoidable given that public's support for nuclear power is dependent on a strict nuclear safety regime