

# Have we been here before?

## Nuclear power post Fukushima

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# Nuclear power – in out in out, shake it all about

Three phases of nuclear power so far:

Good idea (1960 – late 1970s)

Bad idea (late 1970s – 2005)

Good idea (2005 – March 11 2011)

***Five years after Fukushima – looks like one new project is about to be confirmed in the UK but what is coming next for Europe and the world?***

## What do we want from our electricity supplies?

Secure supplies

Economic supplies

Environmentally acceptable supplies

Socially/politically acceptable supplies

## First phase (1960-late 1970s) – good idea

***Security of supply*** – severely compromised by energy shortages, rise of Opec (especially in 1970s), gas a bit player, concerns over strength of coal mining unions in several areas of the world.

***Economics*** – oil price quadrupled in 1973, doubled in 1979, gas a bit player.

***Environment*** – not really a driver but some concerns over e.g. acid rain and local air quality.

***Social/political*** – relatively benign (sometimes enthusiastic) social and political response to nuclear power.

## **First phase (1960-late 1970s) – good idea**

Major construction programmes in many countries, over 200 plants brought on line during 1980s.

Fastest-growing of major energy sources in 1970s and 1980s (and 1990s, though dramatically curtailed by then and mainly as a result of improved output from existing plants rather than new build).

## Second phase (late 1970s-2005) – bad idea

***Security of supply*** – collapse of Opec, discovery of very large quantities of natural gas (reserves tripled 1980-2005), post oil-shock global recession left considerable overcapacity.

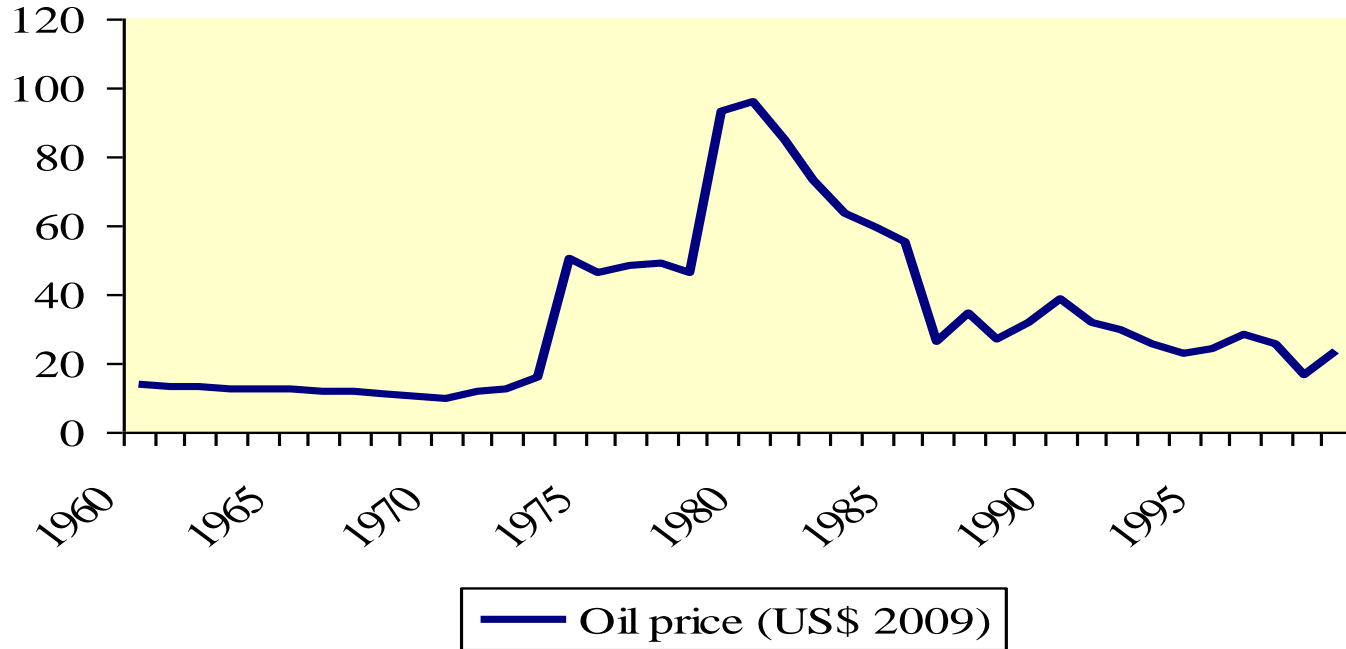
***Economics*** – collapse of oil price bringing other energy prices down, highly efficient new technology (CCGT) with low costs even in relatively small units, increases in nuclear costs owing to a number of factors including tighter regulation even before Three Mile Island and Chernobyl, effects of liberalisation of power markets.

## Second phase (late 1970s-2005) – bad idea

***Environment*** – still not major driver but growing concerns over radiation adding to costs for nuclear power: although post 1992 Rio Convention climate change emerged as a (modest) driver, the dash for gas in the UK saw significant reductions in carbon dioxide emissions in the 1990s.

***Social/political*** – severe problems after Three Mile Island and (particularly) Chernobyl – phase-out policies in Italy (fulfilled), Sweden, Germany, moratoria on more build in Netherlands, UK, Switzerland, policy or legal obstacles to entering nuclear club in many other countries.

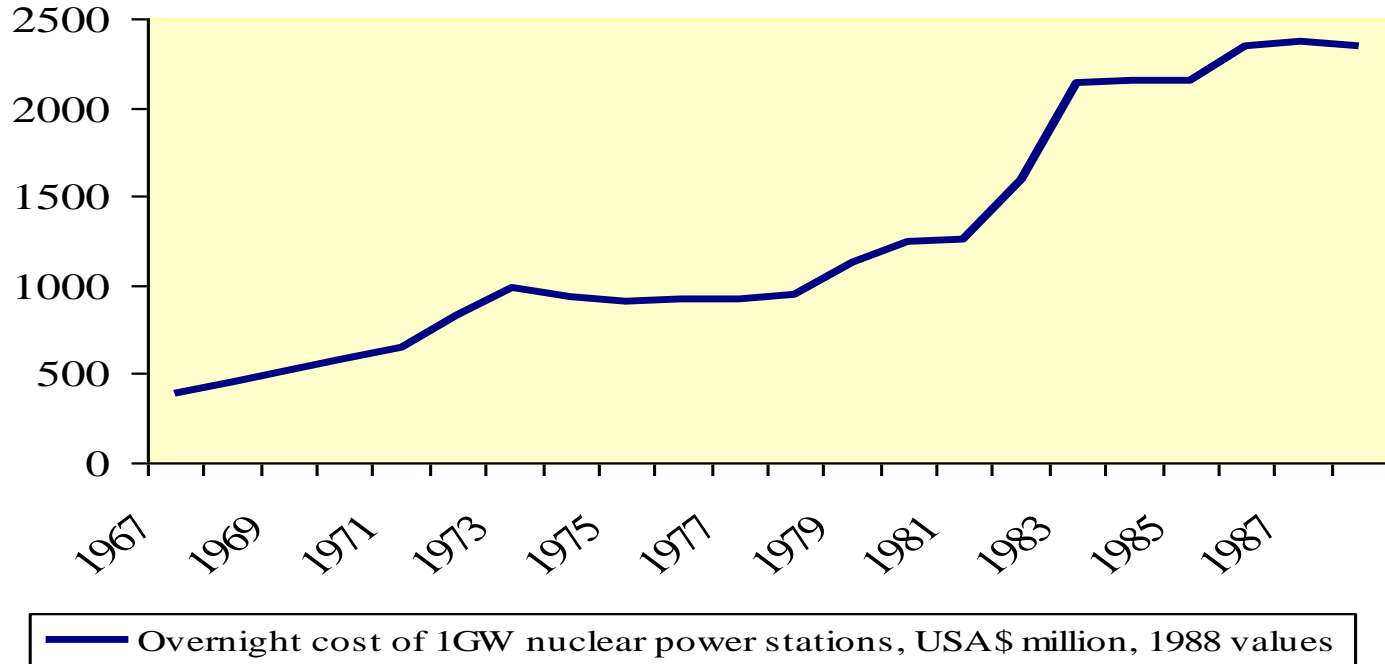
# Oil price (US\$ 2009)





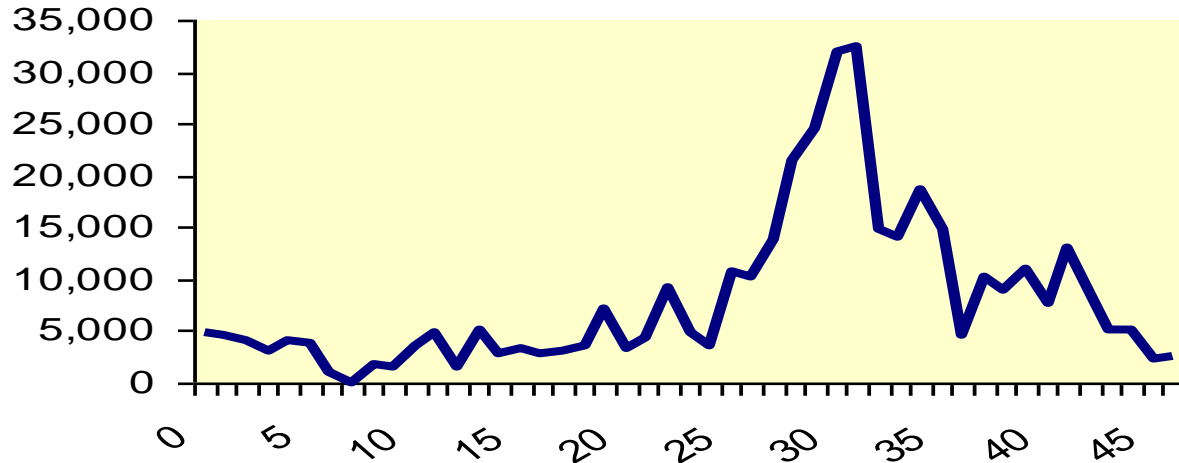
# Extent of overnight cost overruns in US nuclear construction

## \$ per kW(e)



# Global nuclear capacity (total 378,000 MW)

## 87% is 15 years old or more



— Global nuclear capacity by age (August 2015)

## Third phase (2005-2011) – good idea

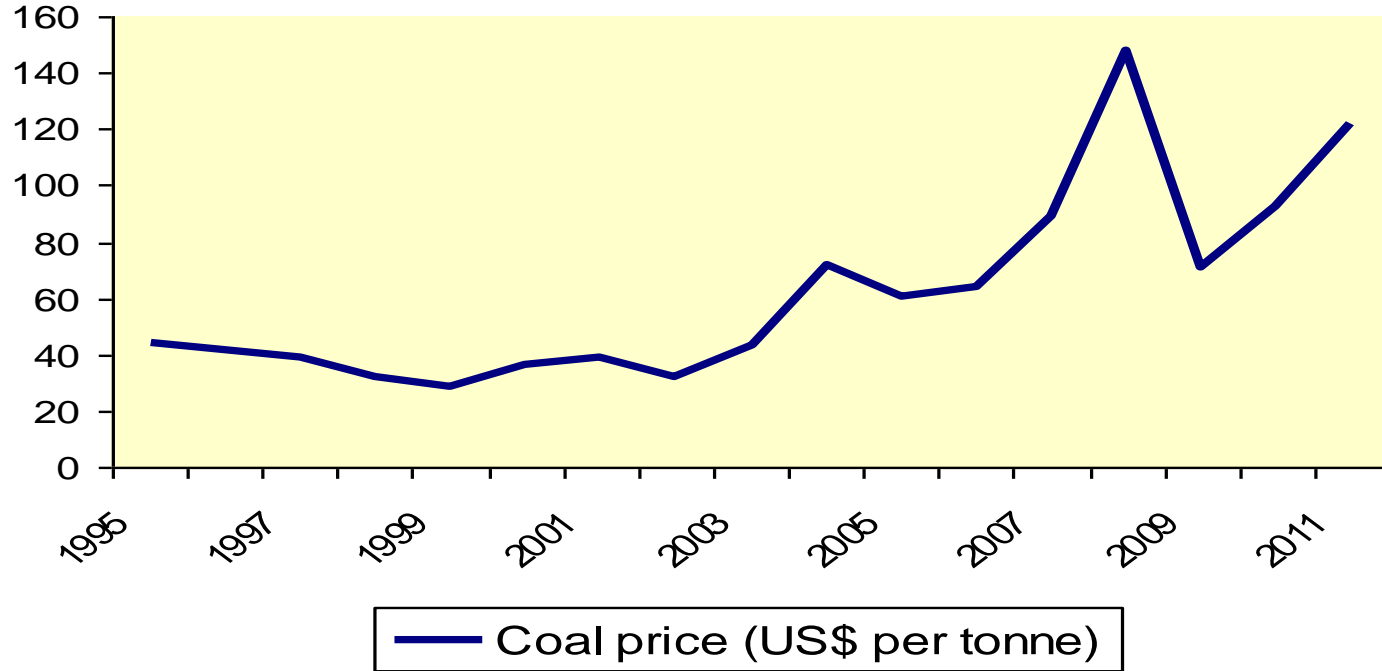
***Security of supply*** – reemergence of concerns about international security of supply after Middle East unrest, Russian interruptions of exports of gas/oil to Ukraine/Belarus 2005/6; tightening of capacity margins in many countries which had liberalised their power markets; recognition of challenge of intermittency of some renewables.

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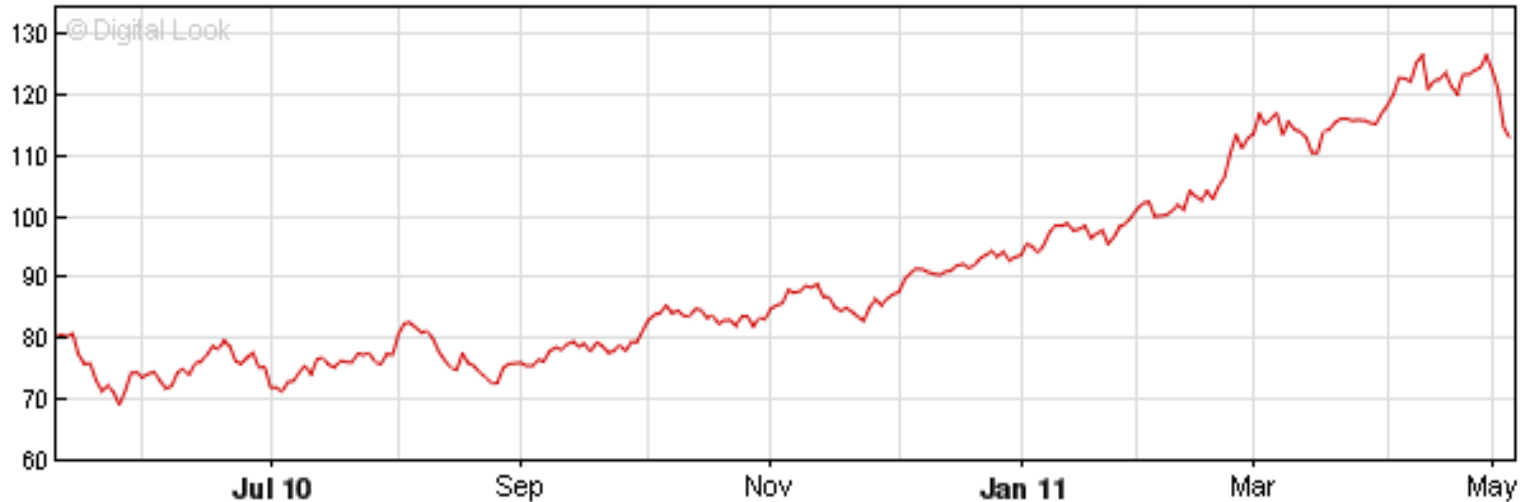
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***Economics*** – oil price reached \$147 per barrel in 2008, fell away but returned to over \$100 in 2011, with high gas and coal prices. Uranium price also rose but smaller proportion of total costs.

# Coal price 1995 to 2011 (\$ per tonne, NW Europe market price)



# Oil price 2010/11 (\$ per barrel)

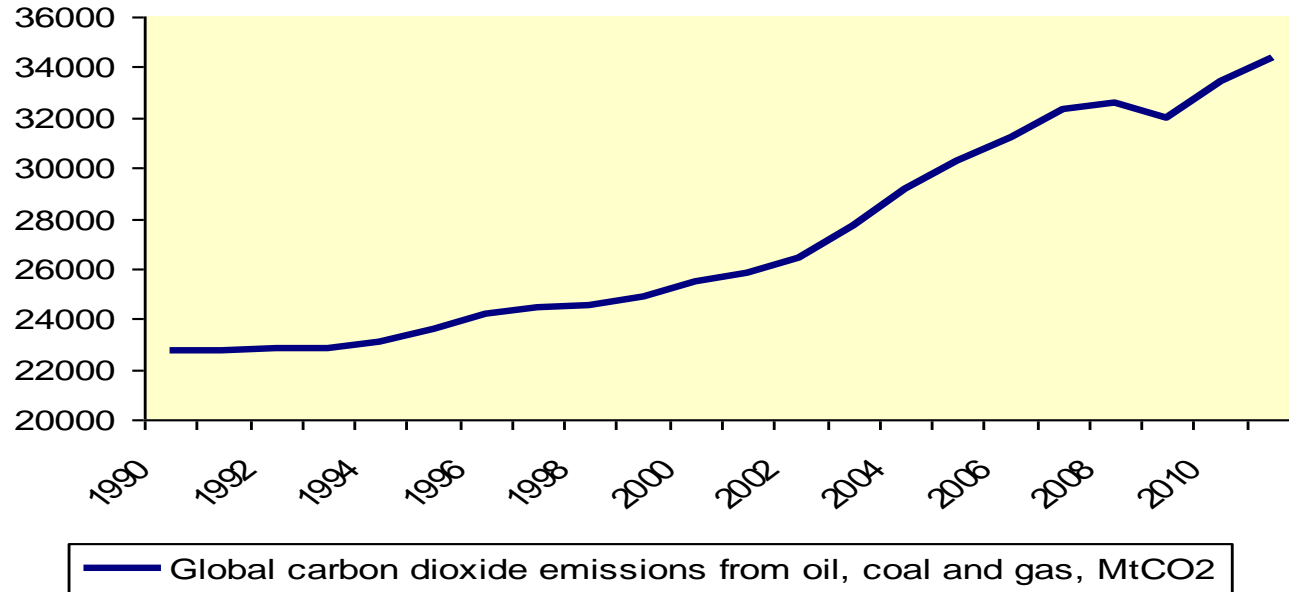


## **Third phase (2005-2011) – good idea**

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***Environment*** – growing concern about greenhouse gas emissions and their effects.

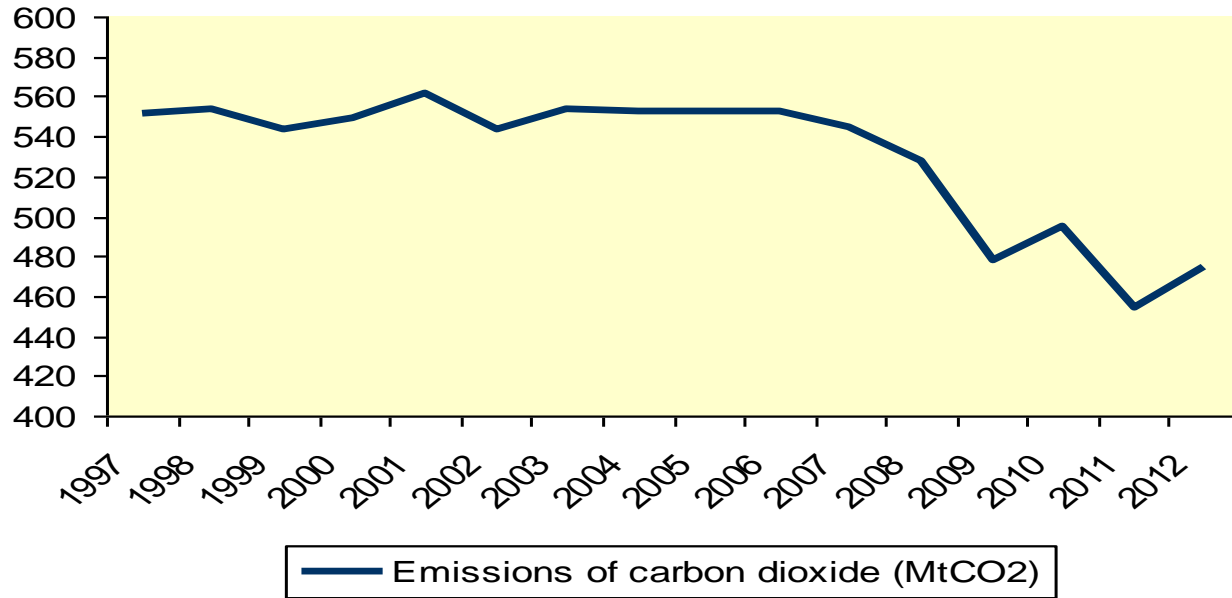
# Global carbon dioxide emissions 1990-2011





# UK carbon dioxide emissions 1997-2012

[1990 level 591.1 MtCO<sub>2</sub>]



## Third phase (2005-2011) – good idea

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***Environment*** – growing concern about greenhouse gas emissions and their effects.

***Social/political*** – major change in political sentiment (partly as result of declining influence of Green party in many countries), public becoming more comfortably in part because of (nearly!) 25 years of high safety standards.

# Nuclear renaissance

Well ...

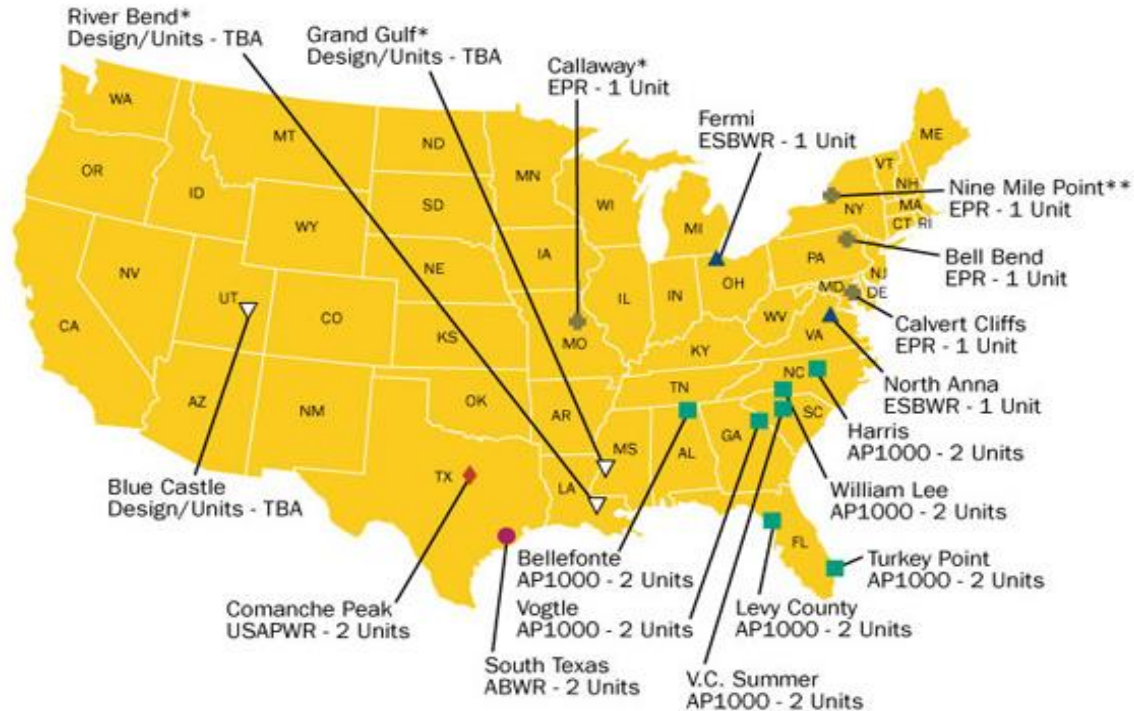
In 2003 three utilities (Entergy, Exelon and Dominion Resources) announced their intention to apply for licenses for new build in the USA and it was reported that officials in the Bush administration believed that the first new reactors would be finished around 2010.

‘There’s talk of a nuclear second coming every few years and so far, obviously, without success on their part.’

(Alan Noguee, Union of Concerned Scientists)

But ...

# 27 license applications in USA by 2009, down to 21 in 2015



## Fourth phase? – post Fukushima

Earthquake and (more devastating) tsunami.

Three reactors in operation – severe core damage

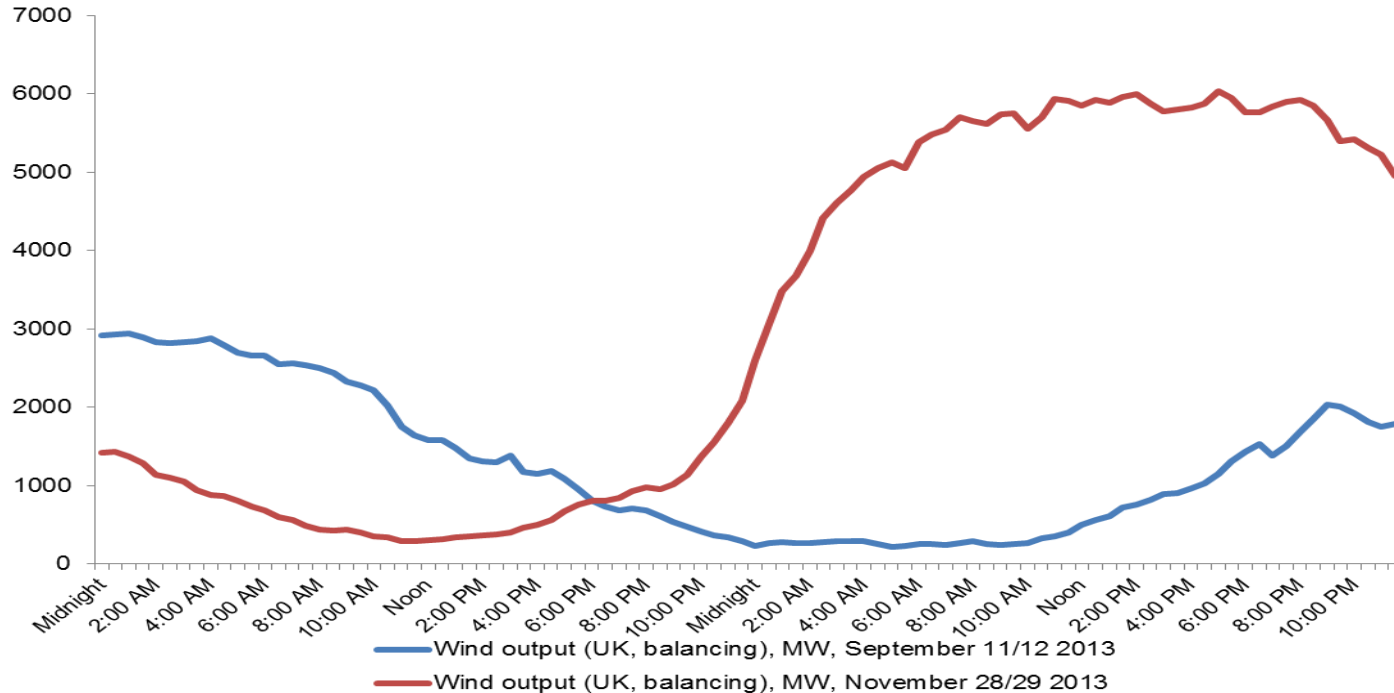
Spent fuel ponds in four reactors compromised

Sustained global coverage

## Fourth phase – good idea, bad idea?

***Security of supply*** – still concerns over lack of power capacity in future as e.g. some 30 GW of capacity comes offline in UK over next 20 years and geopolitics of hydrocarbons, but also issues over security of nuclear supplies – uranium a finite resource (perhaps one cycle of thermal nuclear plants if much expanded from current levels) and questions over effects of a Fukushima-type incident on lifetime extension or even curtailing operational plants (e.g. Germany). But renewables have their limitations too ...

# Fluctuations in wind power feed in (MW) during two 48 hour periods, UK, September/November 2013



## Fourth phase – good idea, bad idea?

***Economics*** – interesting questions as to whether liberalised markets can deliver environmentally acceptable and, ***especially***, secure supplies (they can do economics and probably social acceptability).  
Even before Fukushima costs rising, reminiscent of 1970s.



## Cost overruns

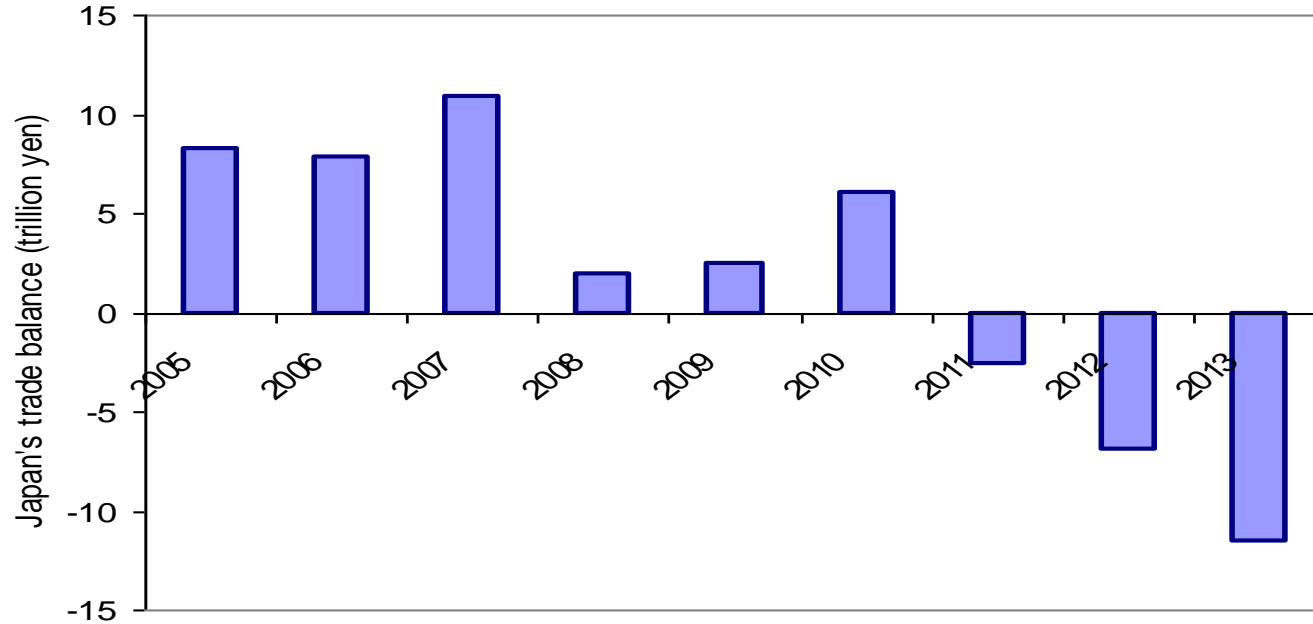
Olkiluoto-3 (Finland), 1600MW Areva EPR initially expected to cost some €3 billion and to be available in May 2009, currently running some nine years behind schedule with projected final costs of €8.5 billion.

Flamanville-3 (France, EPR) initially expected to cost €3.4 billion, restated at €8.5 billion, five years late in 2014.

New Vogtle project in Georgia, USA, also well behind schedule (over three years).

Problems with European reactors being built in China.

# After the earthquake – Japan's trade balance



# Crude oil price (\$ per barrel) 2014-2015



## Fourth phase – good idea, bad idea?

***Environment*** – Fukushima may help to bring risks of radiation into perspective? Climate change likely to become more serious not less, as it was unlikely that international obligations would be met even with a major nuclear renaissance – Japan already talking about diluting commitment to reduce greenhouse gas emission by 25% by 2020. But growing public (if not political) scepticism about climate change.

## A UK snapshot

UK – announcements last month suggest that Hinkley Point C will go ahead, funded two-thirds by French, one-third by Chinese. 2 reactors, 3.3 GW, about 7% of UK electricity demand. ‘Overnight’ costs perhaps of the order of £16 billion.

Possibility of duplicate project at Sizewell (20% Chinese stake) – if so the ‘strike price’ for the Hinkley scheme will come down to £89.50 per MWh (in 2013 values) from £92.50 – inflation-linked. Current wholesale price below £50 per MWh.

Horizon Energy (owned by Hitachi-Westinghouse) pressing ahead with plans for two new reactors at Wylfa, north Wales, and possibly one or two more at Oldbury, Glos.

NuGen looking at a site near Sellafield, Cumbria.

In due course Chinese may build their own technology at Bradwell in Essex.

# Attitude to nuclear new build in the UK

*To what extent would you support or oppose the building of new nuclear power stations in Britain TO REPLACE those which are being phased out over the next few years? This would ensure the same proportion of nuclear energy is retained.*



# A wider perspective

Varied response in different countries, especially after Fukushima:

GERMANY – phase-out by 2022, half of reactors operating at time of Fukushima already closed down.

FRANCE – policy to reduce use of nuclear to 50%, though this will still require major new build as existing fleet ages.

SWEDEN – no formal phase-out policy but plants reaching end of life, e.g. four of current nine to stop operating by 2020.

# A wider perspective

Varied response in different countries, especially after Fukushima:

FINLAND – discussing sixth reactor (probably Russians design)  
but having trouble with Olkiluoto 3.

BELGIUM, SWITZERLAND, SPAIN – similar to Sweden.

ITALY – referendum on returning to nuclear power after phase-out  
in late 1980s defeated overwhelmingly in 2011 (perhaps in part  
as a result of anti-Berlusconi sentiment).



## A wider perspective

Varied response in different countries, especially after Fukushima:

CENTRAL AND EASTERN EUROPE – still enthusiasm for new nuclear in Czech Republic, Slovakia, Hungary, Poland (which does not currently use nuclear power), Russia, Ukraine, Belarus but concerns over finance in some countries.

# A wider perspective

Varied response in different countries, especially after Fukushima:

CANADA – bullish.

USA – lots of talk but relatively little action, several older plants now coming off line for financial reasons.

JAPAN – recently first units returned to operation after gap since 2013 but not clear how many will be restarted or if new build will recommence.

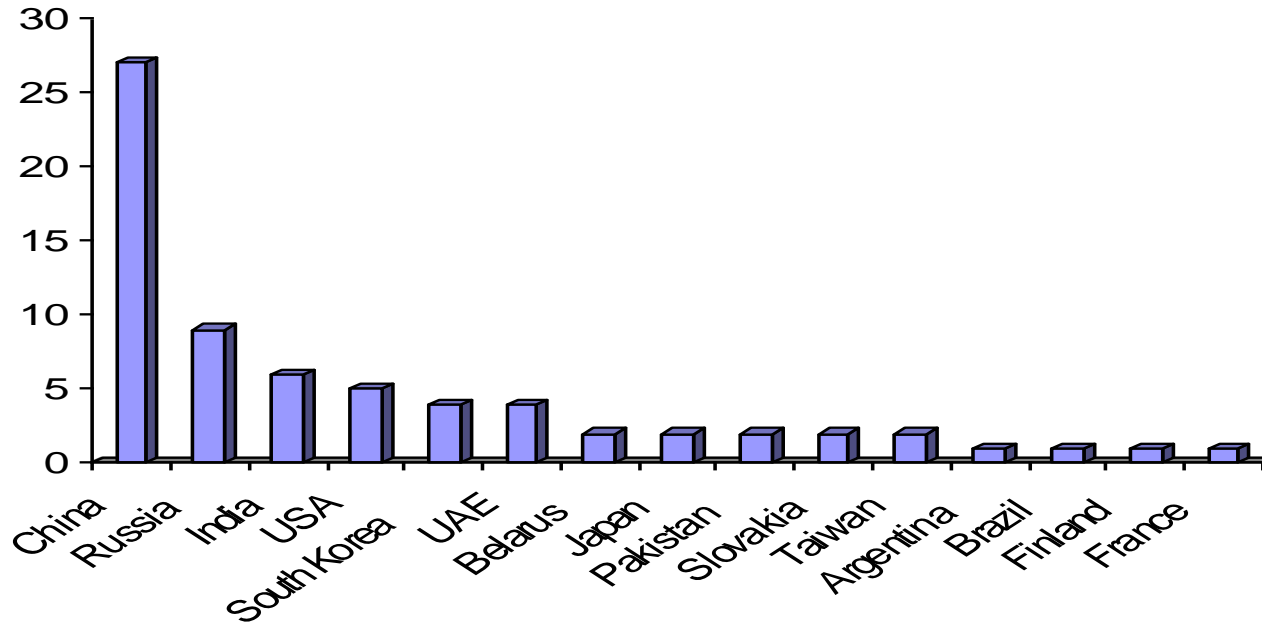
CHINA – full speed ahead until economic slowdown, still has about half of world's new build.

## A wider perspective

Varied response in different countries, especially after Fukushima:

Many countries considering entering the nuclear field for the first time – UAE, Turkey, Egypt, Saudi Arabia, Vietnam, Australia, Indonesia ...

# Plants under construction



■ Number of reactors under construction (November 2015)

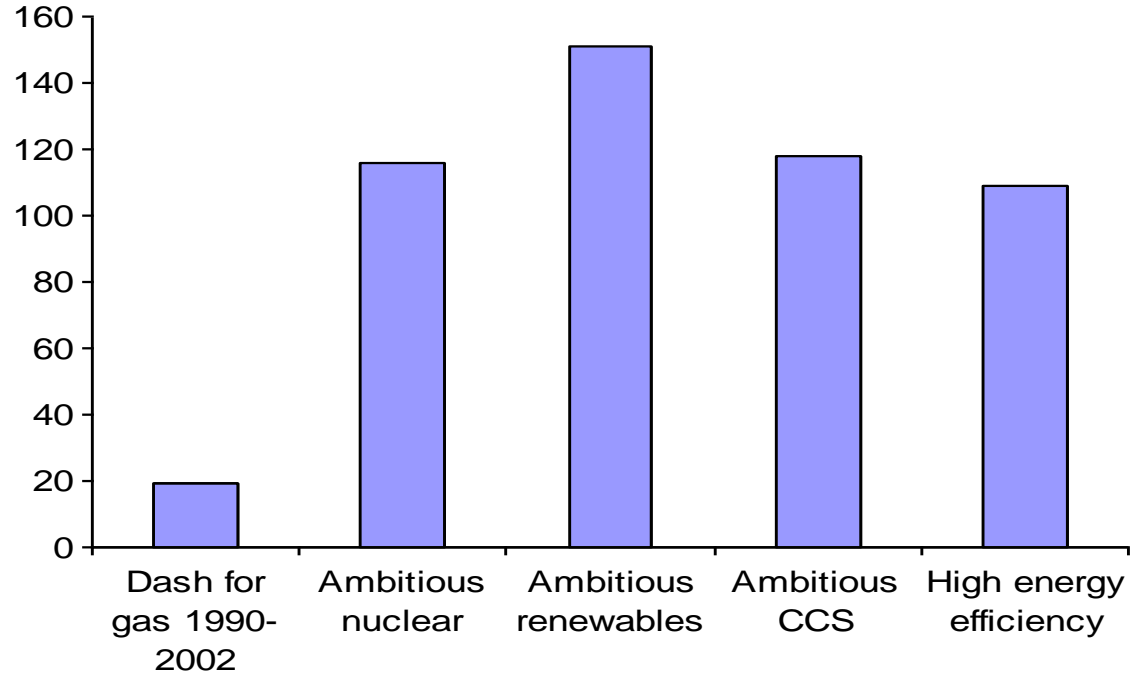
## Have we been here before?

Yes and no.

Yes – rising costs of investment even before Fukushima; major accident.

No – need for enormous investment in new capacity of some description, unlikely need for redesign on plants under construction, climate change, liberalised markets, political opposition and changed relationship among public, political and technical realms especially in age of instant mass communication.

## UK – gross new build requirements to 2030 c/w ‘dash for gas’



# Have we been here before?

World Energy Council 2030 outlook suggests 39% greater energy use than in 2010 (almost all the growth coming in less developed countries) assuming considerable improvements in energy efficiency; proportion of energy produced by oil, coal and gas falling from 88% to 81%, i.e. rising 12.5% in absolute terms.

Did we use all the awful sources of energy first and keep the really good and trivially easy ones till last? Maybe but can we bet the planet on it?