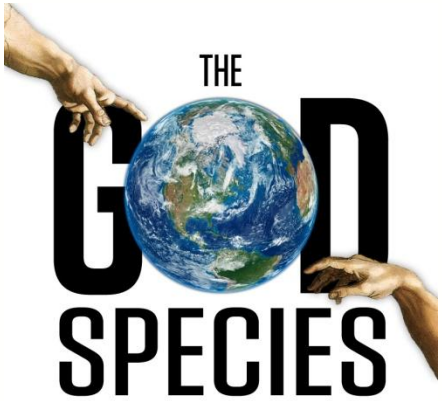
The Integral Fast Reactor/Prism: a social & climate change perspective



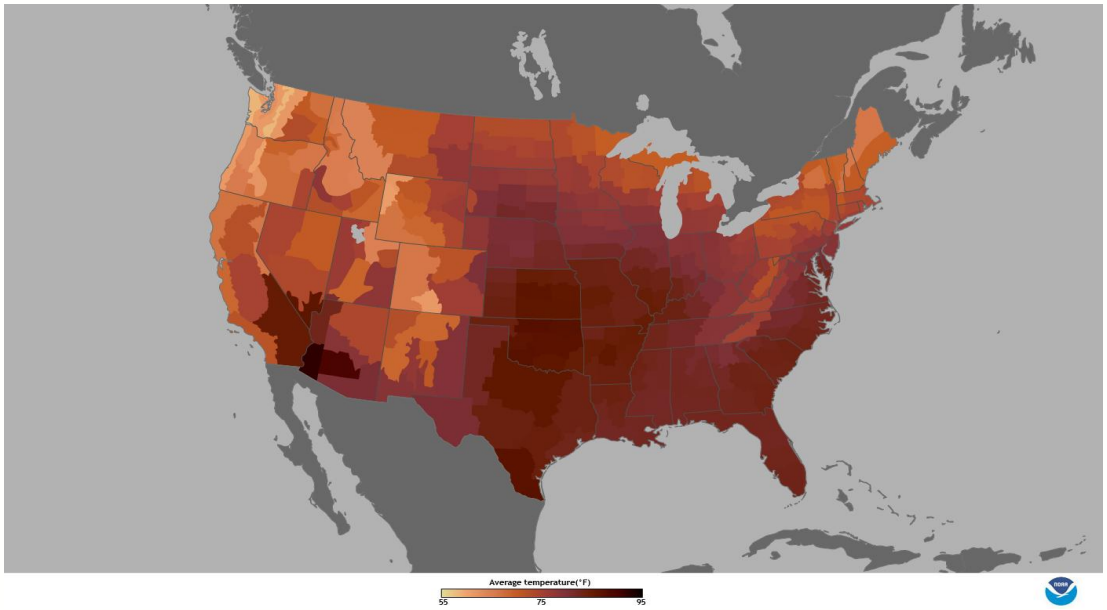
Mark Lynas

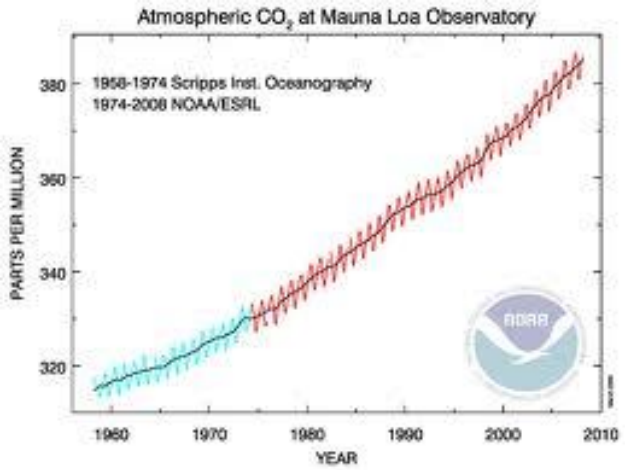
Environmentalist and author, 'The God Species'

Climate change

DANGER!

- July hottest month ever in USA
- Arctic ice melt heading for new 2012 record
- Runaway climate change greatest external danger to human civilisation



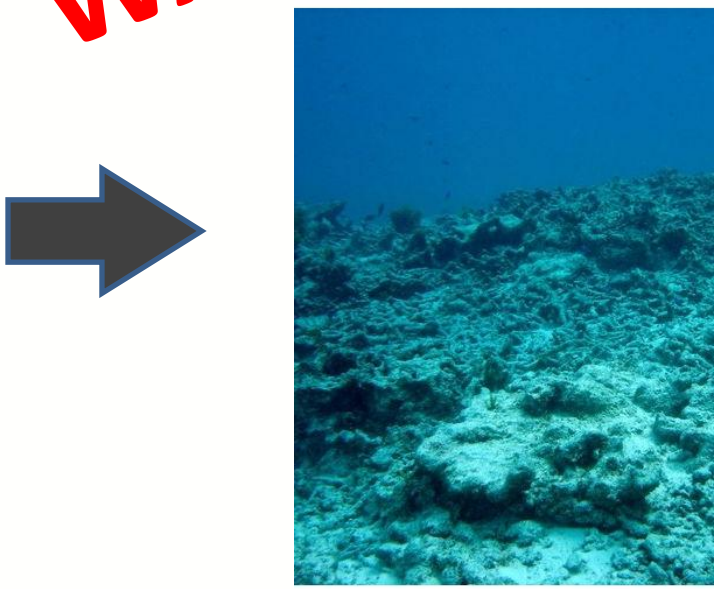


Ocean acidification

- Endangers survival of tropical coral reefs
- Harms calcifying organisms at base of marine food chain
- Oceans 30% more acidifc already than pre-industrial
- CO2 dissolving into water = carbonic acid

WARNING!

Photograph by Tim Laman



$$CO_2(aq.) + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+ \leftrightarrow CO_3^{2-} + 2H^+$$

The 2050 Challenge:

9.5 billion people living out of poverty and at Western levels of consumption

Without destroying the climate/ acidifying the oceans

The importance of energy

- Energy can desalinate water = more land

- Energy produces fertiliser = more food

- Energy essential for economic development

- 1.3 billion people still lack access to electricity

Carbon-free energy options

- Renewables: wind, solar, water – expensive, extensive & unreliable
- Biofuels: land-intensive, harm biodiversity/food production
- Carbon-capture and storage: still not scaled-up, serious technical challenges, expensive
- Nuclear fission: major public acceptability/political challenges

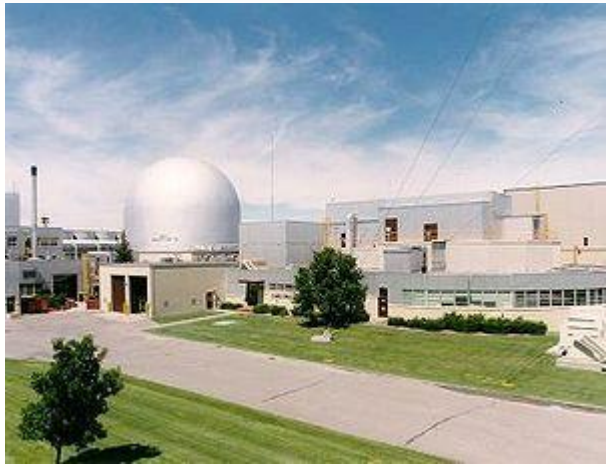
Nuclear's (perceived) unsolved problems

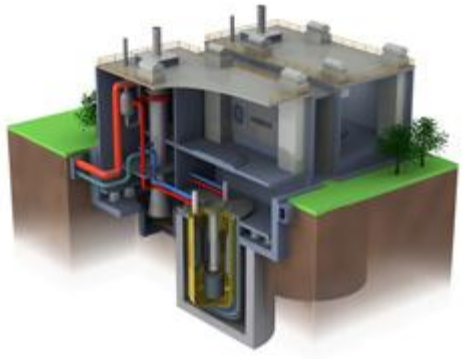
- Nuclear waste disposal
- Proliferation
- Fuel supply
- Safety
- Cost

<u>These problems are not 'real' in any technical sense, but are political, and must be seen to be solved for public acceptance of nuclear power</u>

The Integral Fast Reactor/PRISM

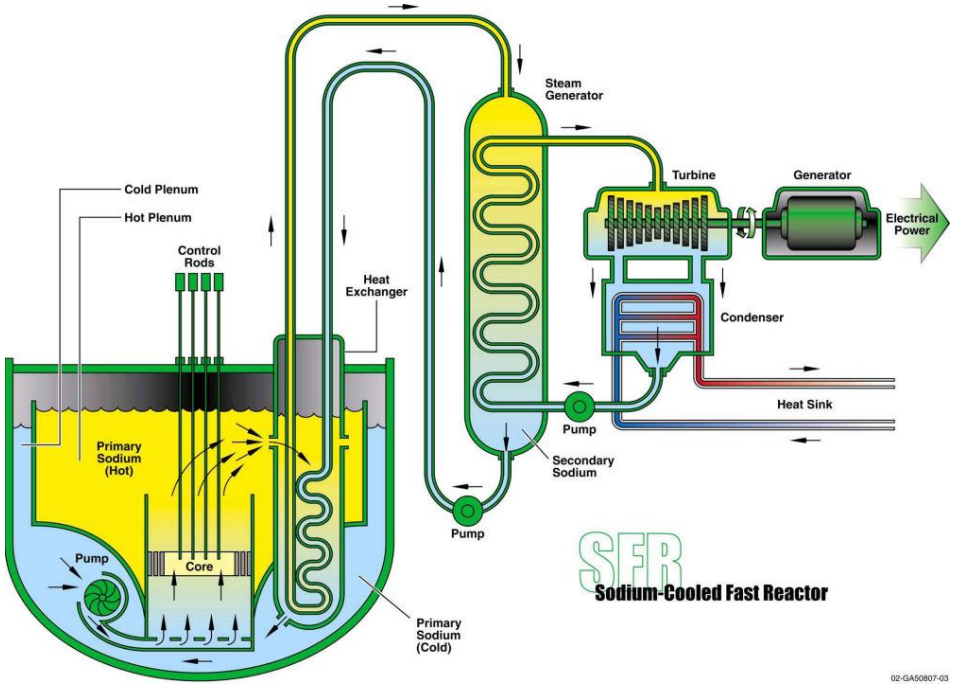
- Developed at Argonne National Laboratory, based on EBRII
- Cancelled by Clinton administration/Congress in 1994
- Now marketed worldwide by GE-Hitachi as the PRISM (Power Reactor Innovative Small Module)
- Currently considered by UK, Russia, China, South Korea for deployment





IFR/PRISM technical specifications

- Liquid sodium-cooled fast reactor
- Can be operated as breeder or burner
- Reactor core sits in pool of coolant
- Power generation from secondary (non-radioactive) coolant loop
- Two units per PRISM of 300MWe = 600MWe



Problem solved: nuclear waste

- IFR can ‘burn’ all actinides/ transuranics because fast neutrons
- Turns ‘waste’ into ‘fuel’

- Residual radiotoxicity of waste declines to original uranium ore in 300 years
- No need for geological repository with 1 million-year design life

Problem solved: proliferation

- No need to enrich uranium for fission
- Continual plutonium breeding essential however
- Potential Pu danger addressed by reprocessing technology called ‘pyroprocessing’
- Fuel reprocessing done remotely in hot cell – extremely radioactive therefore fissile material self-protecting
- Separating bomb-grade Pu would require PUREX reprocessing: massive plant which is easily detected

Problem solved: fuel supply

- Fast reactor uses 99% energy in uranium; LWRs use 0.7%
- UK has spent fuel/DU for 500 years of operation of fleet of IFRs generating entire 80GW national electricity supply
- US has enough for around 1000 years with no uranium mining
- In medium term thorium provides abundant fuel
- By year 4000AD should have nuclear fusion sorted!

Problem solved: safety

- Fukushima demonstrated safety concerns of BWRs/PWRs
- IFR/PRISM designed for full passive safety
- Sodium 90x as effective in conducting heat than water

- EBRII experiment 1986 switched off coolant pumps, reactor shut itself down in 300 seconds
- Meltdown impossible due to core design & metal (not oxide) fuel, core at atmospheric pressure

Problem solved: cost

- Fully modular design, made on factory assembly line and shipped to site
- Costs offset by nuclear waste disposal
- MOX reprocessing extremely expensive
- GE-Hitachi proposal to UK: plutonium stockpile ‘disposition’ instead of MOX, no upfront costs
- But costs always uncertain until deployment!

Conclusions

- All the supposed ‘unsolved’ problems of nuclear power have actually been solved
- The problems are only ‘unsolved’ in the minds of anti-nuclear activists
- Anti-nuclear ‘Greens’ as much a threat to the climate as Exxon-Mobil, responsible for 10s billions /tonnes CO2
- IFR/PRISM just one of a variety of competing 4th Gen designs, other fast reactors, SMRs, thorium LFTRs also important
- And Gen III+ also worth deploying at scale, need 1000s new reactors to solve climate change