Observations from Fukushima for Nuclear Reactor Technology

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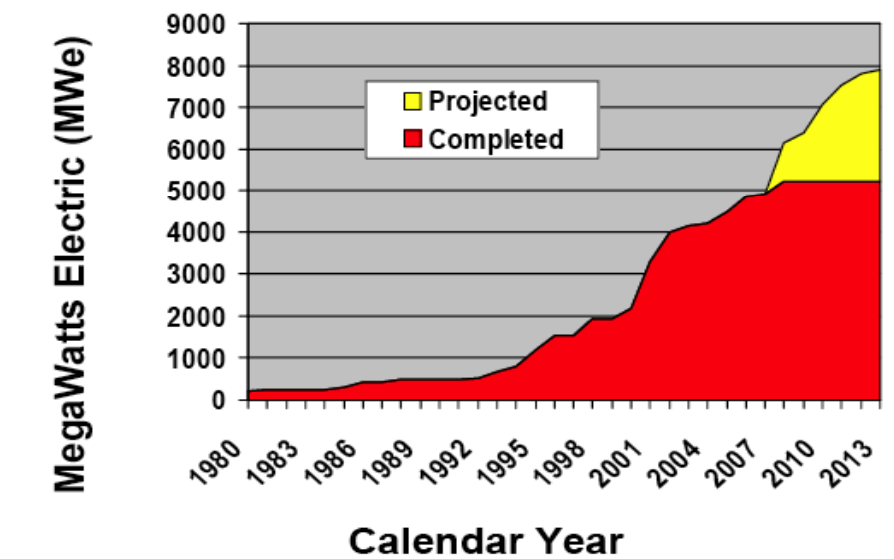
Nuclear Energy Today

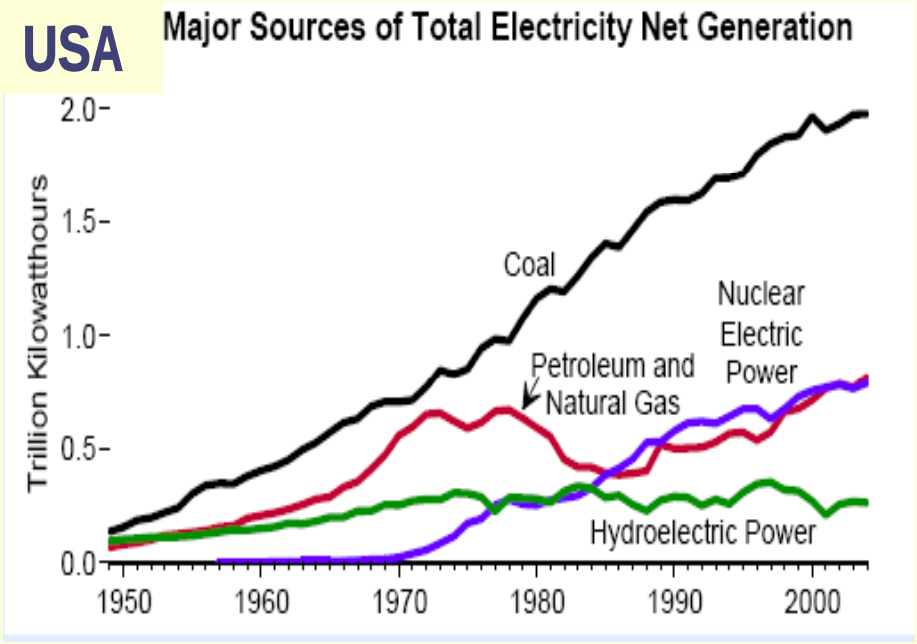
The largest non-fossil source of electricity in the US and the World

- 104 US reactors, 440 World wide
- US: 100.5 GWe, 20% of production
- World: 367 GWe, 15% of production

US nuclear energy production has been growing.

- 2 stalled plants finished last decade
- US plants have run at 90% capacity since 2000, up from 71% in 1990.
- Uprates added 5GWe. Another 3 GW pending, as seen below





- **60** reactor licenses extended, from 40 to 60 years.
- US utilities by 2009 declared plans for 31 new reactors. Only 4 appear firm now.
- China has 26 reactors under construction, and plans to have 30 more by 2035.
- Germany, Italy and Switzerland retreat from nuclear energy.
- The UK, Russia, India and South Korea plan for additions.

Observations from Fukushima

Earthquake, 4 times the design value did not prevent shutdown of the reactors and initiation of diesel power.

Tsunami, once in a 1000 years, disabled the diesel power and the electrical distribution panels.

Meltdown in 3 reactors that were operating before the event. The other 3 reactors had been in shutdown and did not suffer any meltdown.

Radioactivity from molten fuel became mobile, but only a small fraction was released to outside the environment. Before sea water was pumped into the vessels.

Spent fuel pools, did not suffer as much damage as initially assumed.

Likely outcomes from Fukushima - 2

Upgrades to LWR systems:

- Inspection of devices to mitigate severe accidents by NRC will be upgraded, closer to level of inspection of equipment for design basis accidents.
- Venting pipes from the containment buildings to the stack will be fortified to avoid leaks, and valves that can be operated with power or manually may be required.
- Water tightness of rooms with vital equipment, to ensure operability in case of flooding.

Spent fuel management system will be examined.

- Tradeoffs between pool storage and dry storage will be made.
- Plans for shipment of spent fuel to central storage should be accelerated

Both are among recommendations of MIT Fuel Cycle Study

Nuclear Energy has Challenges, but also Advantages That Justify Long Term Use

- Long term domestic and internationally stable supply of uranium: 50 to 100 years per today's technology, 5000 years with breeding. Ocean U supplies are tens of times more. Thorium can add 15,000 years.
- No air pollution by toxic gases or particulates
- No practical emissions of global warming gases
- Easy to transport and store needed fuel volume than coal, oil or gas (1 part to 10,000 to 1 part in million)
- All Spent fuel from operation of 1000MWe plant for 40 years can be stored on 3 acres of land.
- US plant reliability record is currently impressive.
- Excellent safety record in US: Almost 3000 reactor-years since first commercial reactor. One core melted in 1979, but did not harm public.
- Technology is young, and room for innovation abounds

Nuclear energy emissions to environment are thousands of times less by volume or mass than fossil fuels.

Nuclear need for land per MWhre 5,000 < biofuel, 500 < wind, and 100 times < solar.