Five Myths about Nuclear Power

Van Snyder

van.snyder@sbcglobal.net

vandyke.mynetgear.com/Nuclear.html

28 June 2019

"The great enemy of the truth is very often not the lie – deliberate, contrived, and dishonest – but the myth – persistent, persuasive, and unrealistic."

– John F. Kennedy, Yale University commencement speech, 1962

Why Nuclear Power?

Why Nuclear Power?

Nothing else will work (and not emit CO_2)

– Patrick Moore, early member of Greenpeace, 2006

http://www.washingtonpost.com/wp-dyn/content/article/2006/04/14/AR2006041401209.html

100%-renewable electricity system can't work

B.P. Heard, B.W. Brook, T.M.L. Wigley, C.J.A. Bradshaw, *Burden of proof: A comprehensive review of the feasibility of 100% renewable-electricity systems*, **Renewable and Sustainable Energy Reviews 76**, Elsevier (2017), pp 1122-1133.

Storage is not economically feasible

Matthew R. Shaner, Steven J. Davis, Nathan S. Lewis, Ken Caldeira, *Geophysical constraints on the reliability of solar and wind power in the United States*, **Energy and Environmental Science**, Royal Society of Chemistry (February 2018): 36 years North America geophysical data. 400-800 watt hours per average watt.

Euan Mearns, **Energy Matters**: 2016 England & Scotland renewable output. 390 watt hours per average watt.

Norman Rogers, **Is 100 Percent Renewable Energy Possible?** Same for Texas. 400 watt hours per average watt.

James Hansen and Michael Shellenberger: Nuclear Power? Are Renewables Enough?

US economy would need 1,700 GWe. Tesla PowerWall 2 price is \$0.578/Wh. 1,700 GWe $\times$ 390 Wh/W $\times$ \$0.578/Wh = \$383 trillion. Five year battery life = \$76 trillion per year =

Four times US 2016 GDP EVERY YEAR!

Why NOT Nuclear Power?

The Five Myths

Everything you've been told about nuclear power:

- It's too dangerous
- No one knows what to do about waste
- It's too expensive
- It leads to weapons proliferation
- There isn't enough uranium

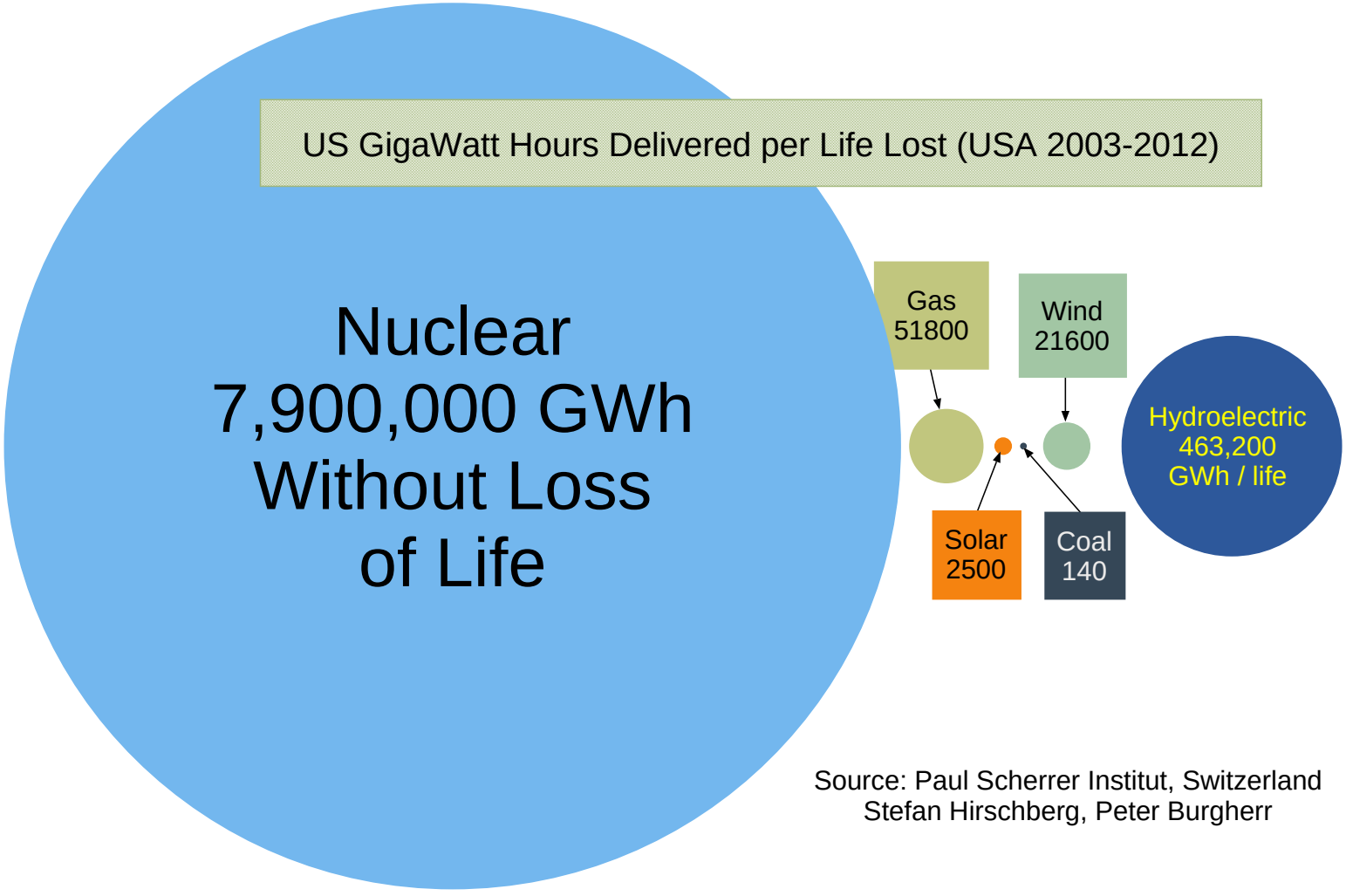
Is False!

It's Too Dangerous (no it's not)

It's Too Dangerous (no it's not)

- **No one** was injured (except financially), made ill, or killed by Three Mile Island and **no significant amounts of radioactive materials were released.**
- **No one** was made ill or killed by Fukushima, and residents could return to their homes without risk (UNSCEAR 2013). Japan over-cleaned. The dirt in Fukushima is half as radioactive as the dirt in Denver.
- 28 fatalities among plant workers and emergency responders, and fifteen delayed fatal thyroid cancers at Chernobyl, **the irrelevant Hindenburg of nuclear power** (UNSCEAR 2008).
  43 radiation-related deaths in the entire six-decade worldwide history of nuclear power!
  Nothing else that humanity does is this safe!
- 7 million deaths per year, worldwide, from air pollution.

It's Too Dangerous (no it's not)



Source: Paul Scherrer Institut, Switzerland
Stefan Hirschberg, Peter Burgherr

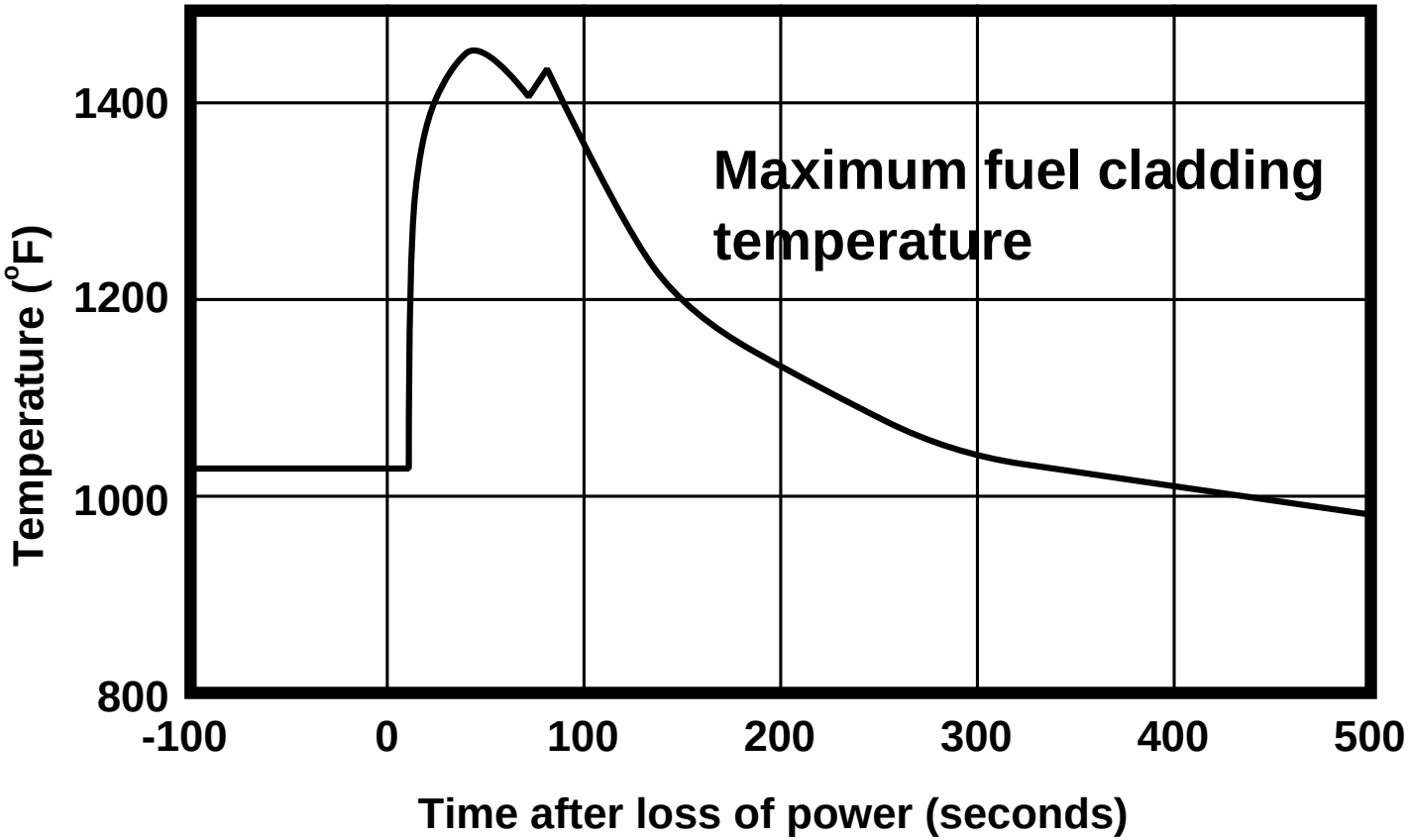
It's Too Dangerous (no it's not)

Scientists, engineers, chemists, and metallurgists at Argonne National Laboratory and Idaho National Laboratory set out to **solve all the world's energy problems** with one system that

- Is inherently safe,
- Consumes existing nuclear waste, effectively destroying it,
- Is economical to build and operate,
- Is extremely resistant to diversion for nefarious purposes, and
- Creates more fuel than it consumes.

And they did it! Then the Clinton administration canceled the project in 1993, when it was an inch from completion, at more cost than finishing it. Clinton pandered "I know; it's a symbol."

It's Too Dangerous (no it's not)



Result of 1986 safety test at EBR-II

Coolant boils at 1620°F. Fuel cladding melts at 3360°F.

David Baurac, *Passively safe reactors rely on nature to keep them cool*, **Logos 20** (2002)
http://www.ne.anl.gov/About/hn/logos-winter02-psr.shtml

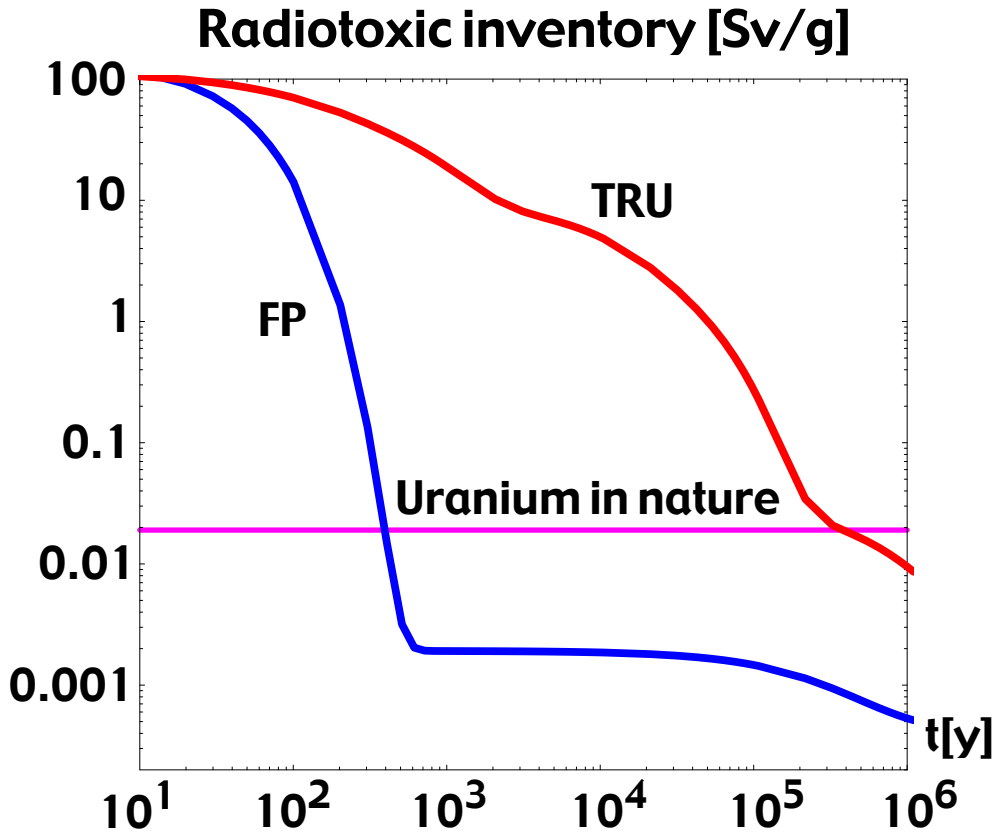
No One Knows What to Do about Nuclear Waste (yes we do know) (and we have known for seventy years)

No One Knows What to Do about Nuclear Waste

Spent fuel consists of **5% fission products** and **95% unused fuel**.

Unused fuel is dangerously radiotoxic for 300,000 years.

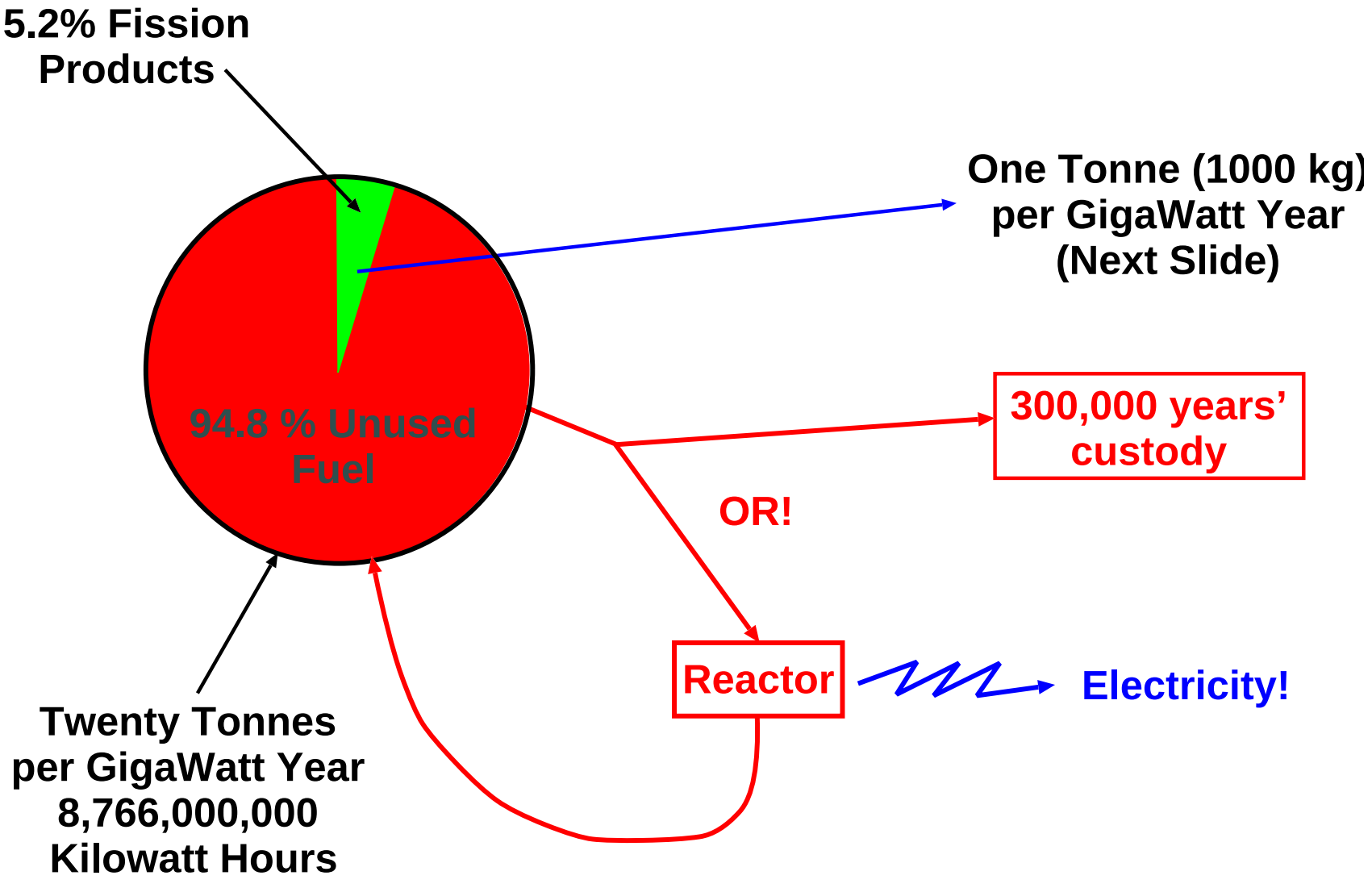
Fission products are dangerously radiotoxic for 400 years.



Janne Wallenius, *Återanvändning av långlivat kärnavfall och sluten bränslecykel möjlig i nya reaktortyper*, **Nucleus** (April 2007), page 15

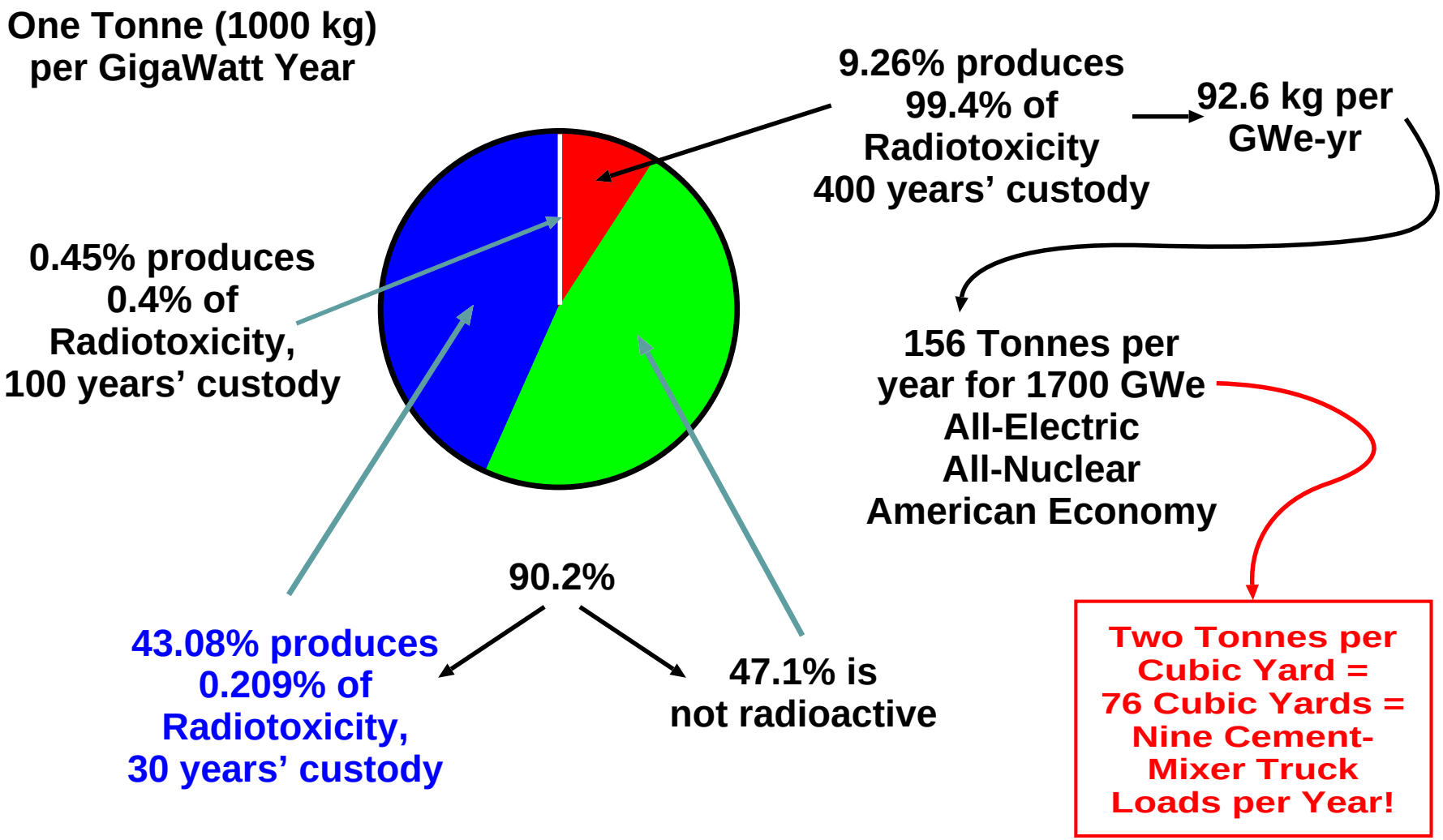
No One Knows What to Do about Nuclear Waste

Closed Fuel Cycle



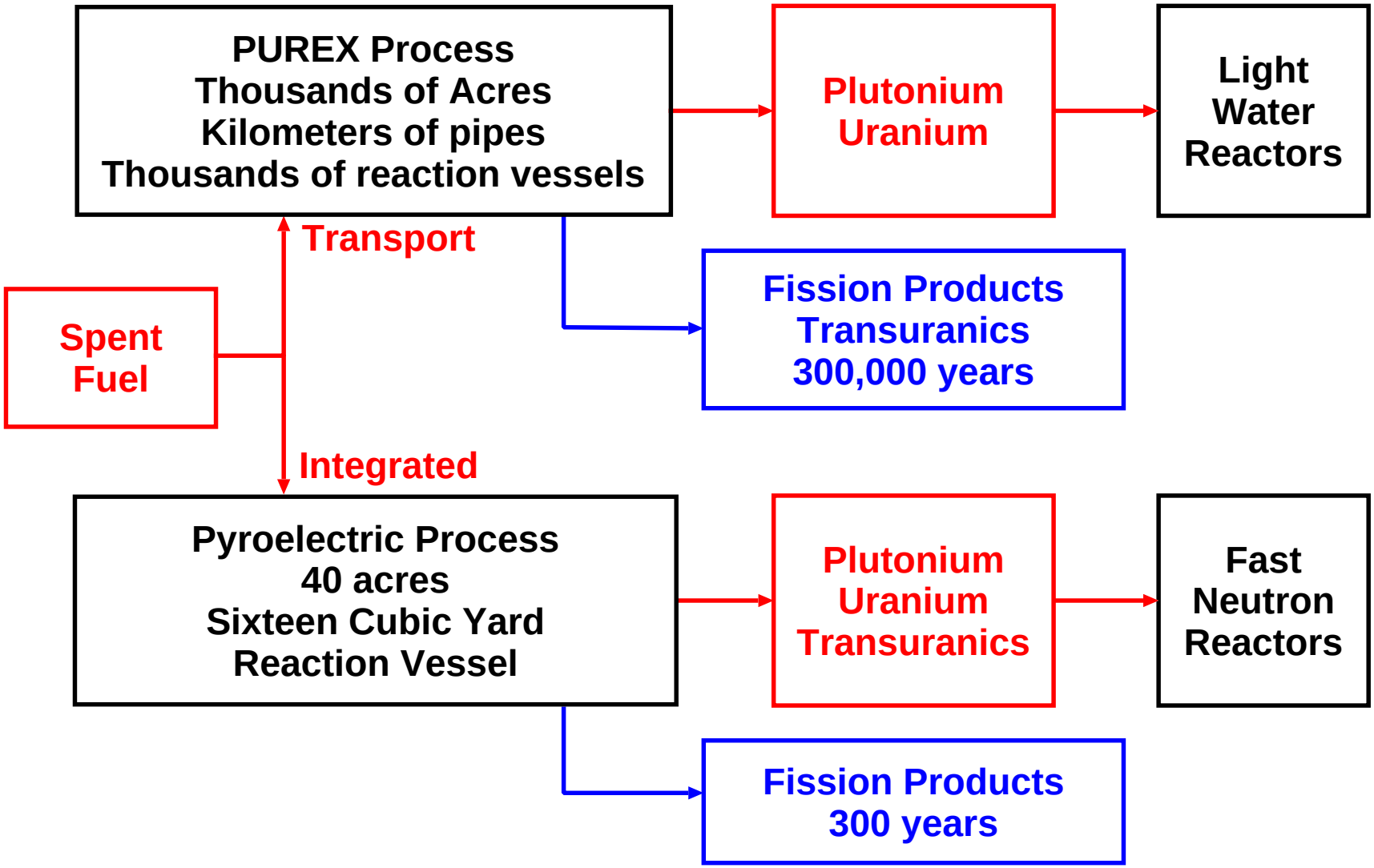
No One Knows What to Do about Nuclear Waste

Fission Products



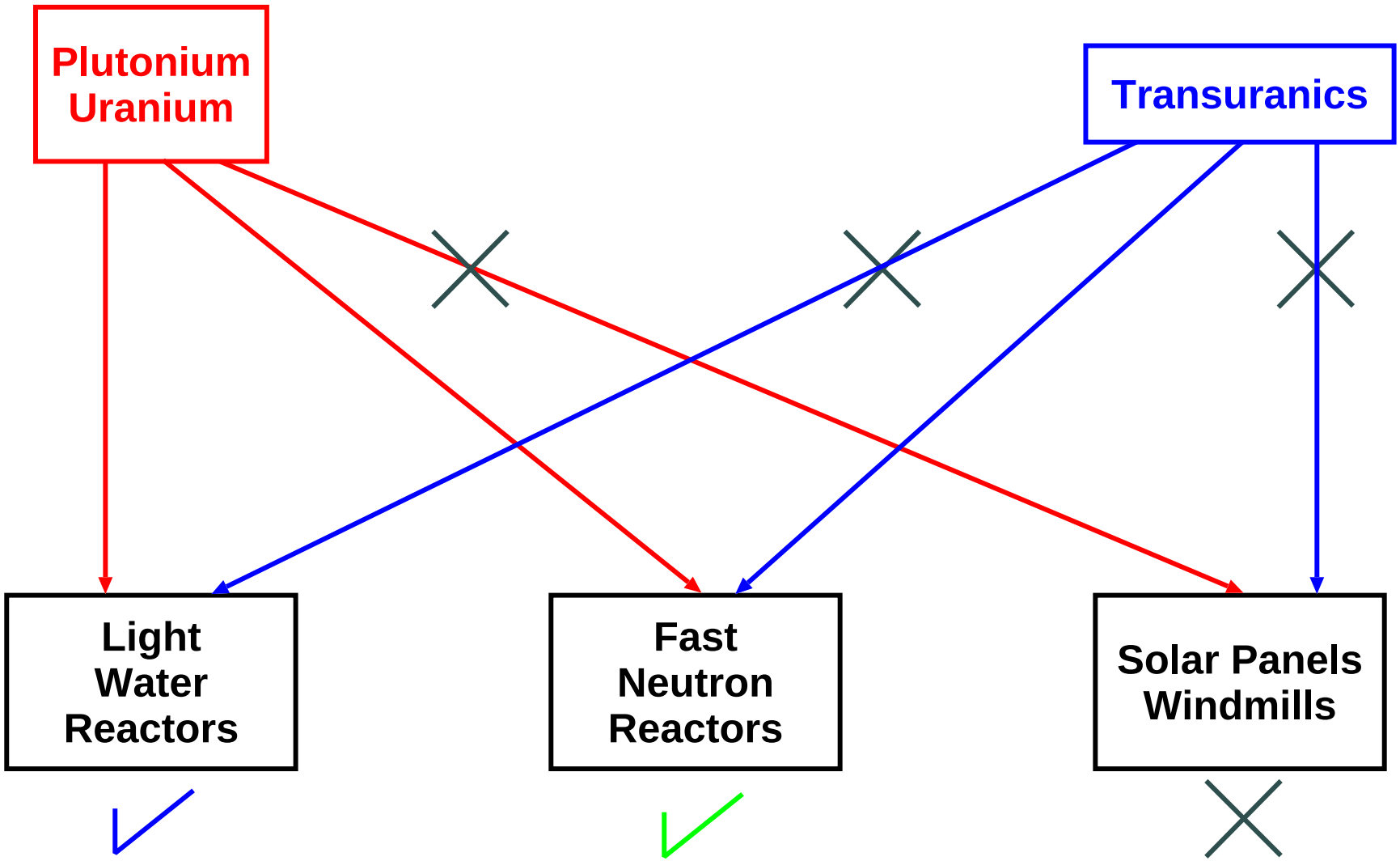
No One Knows What to Do about Nuclear Waste

PUREX vs Pyroelectric

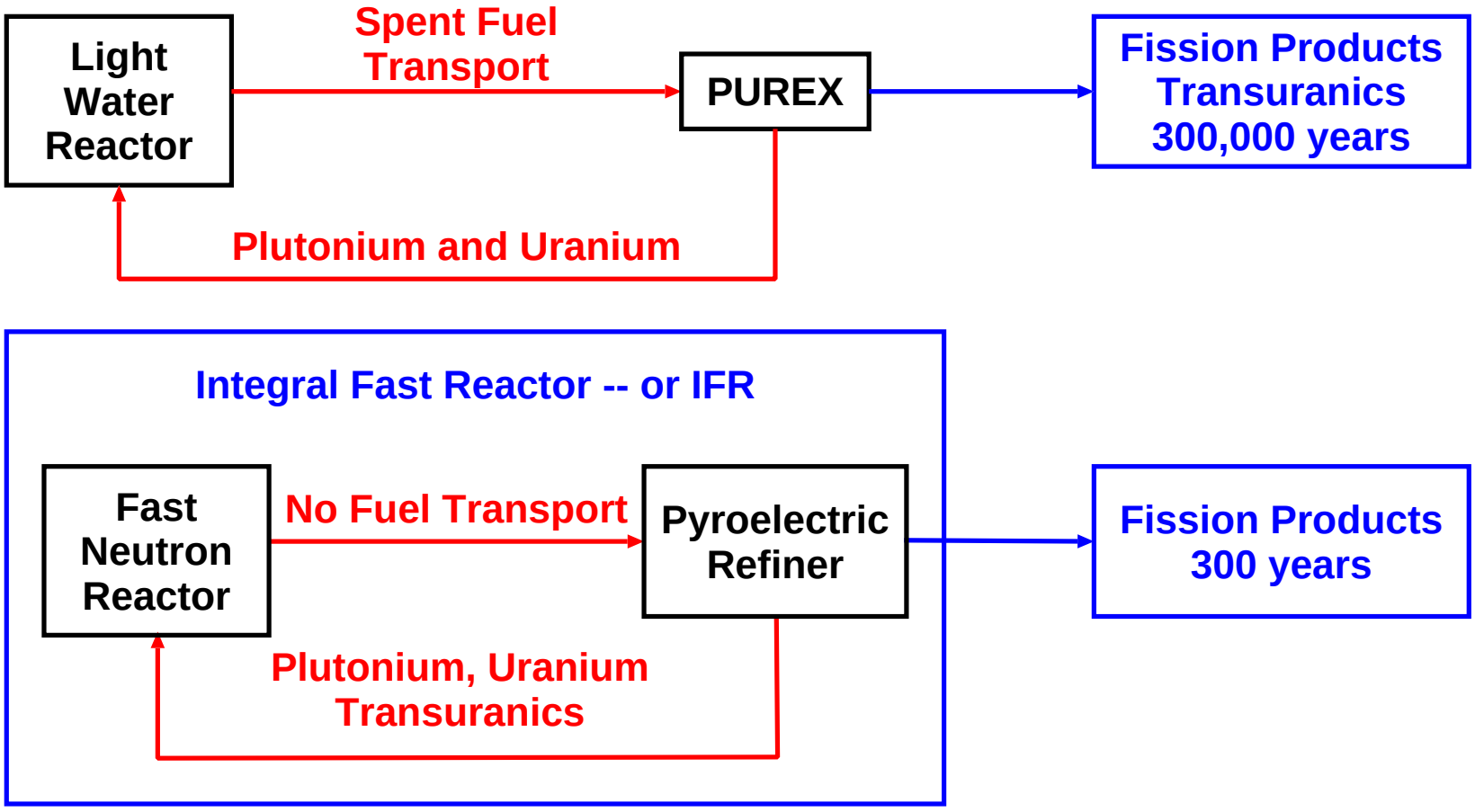


No One Knows What to Do about Nuclear Waste

The 300,000 year problem



No One Knows What to Do about Nuclear Waste



IFR was canceled after 30 years' flawless operation by the Clinton administration in 1993, when it was an inch from completion, at more cost than completing it. **Clinton pandered "I know; it's a symbol."**

It's Too Expensive

Compared to What?

It's Too Expensive

Compared to What?

- **Wind:** Cannot provide more than 15% of today's total energy use.
- **Hydro:** 7% of today's US electricity, or 1.4% of total energy; cannot increase and will probably decrease.
- **Waves, tides, ocean currents, geothermal, biofuels, unicorns, pixie dust, vigorous hand waving:** Too small to be relevant.
- **Solar** is the only "renewable" source that can in principle provide all our energy (but what about storage?).

It's Too Expensive

Compared to What?

- Solar without storage: 11.7¢/kWh **cell capital cost alone**.
- Solar with storage: $57.92/kWh (5792¢/kWh).
- Diablo Canyon: 5¢/kWh.
- Palo Verde: 4.3¢/kWh.
- Washington Nuclear Generating Station: 3¢/kWh.
- Fully-amortized nuclear plants: 2¢/kWh (1.5¢ for operations, 0.5¢ for fuel).
- California average utility price: 15.34¢/kWh.

It's Too Expensive

Nuclear power is artificially inexpensive because of subsidies (no, it's not)

2018 direct Federal subsidies for electricity generation
(latest year available from EIA)

	Coal	Gas	Hydro	Nuclear	Wind	Solar PV
¢/kWh	0.071	−0.066	0.0127	0.020	0.563	2.453
per nuclear $	2.158	−3.285	0.635	1.000	42.59	112.65

Yes, the government made a profit on gas

https://www.eia.gov/analysis/requests/subsidy/

Solar and wind subsidies, and mandates on utilities to buy solar and wind power at more than their generation cost, and distribute it, are driving utilities that own nuclear power plants into bankruptcy.

It's Too Expensive

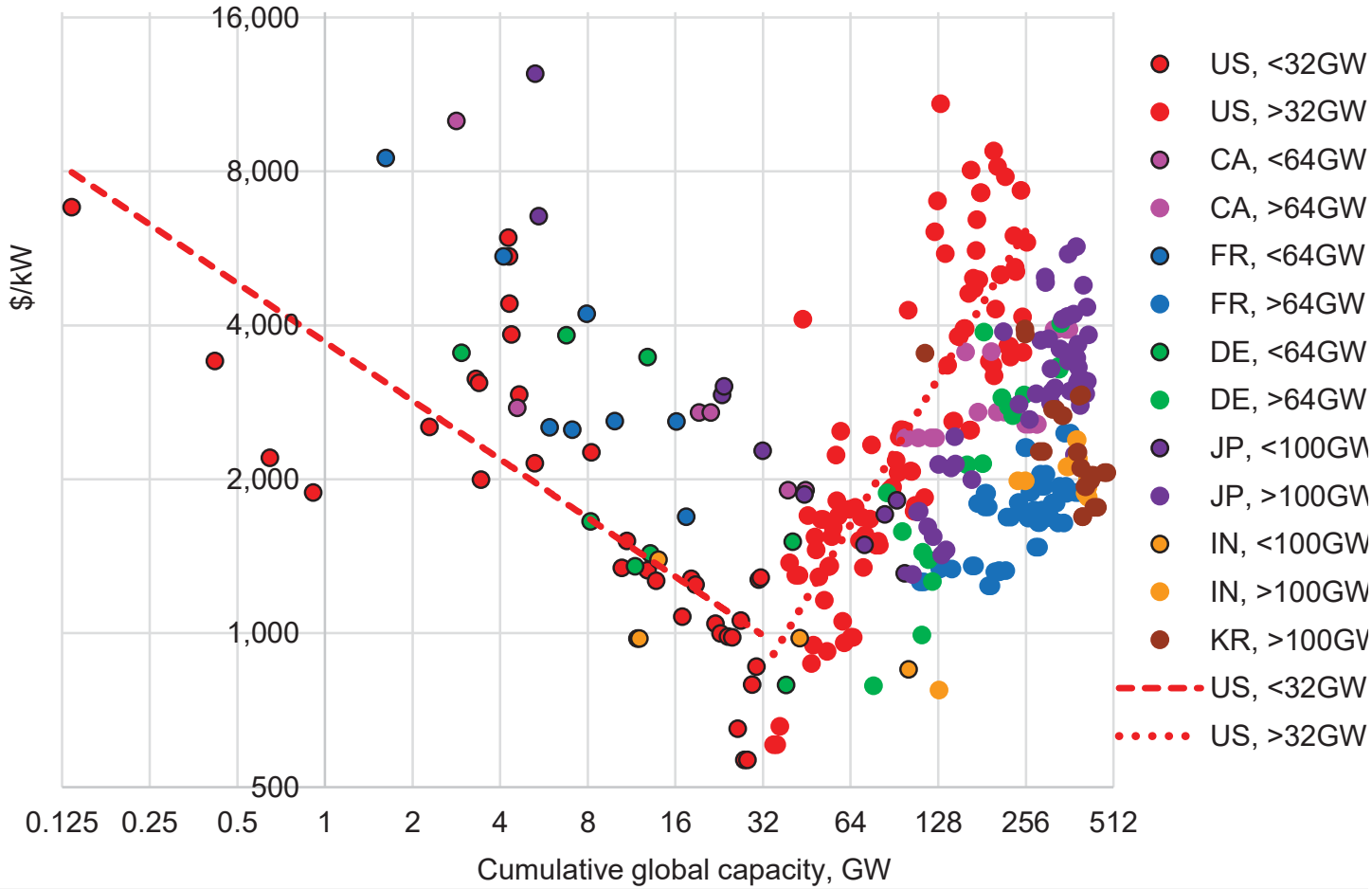


Figure 1: Overnight construction cost (in 2010 US$/kW) plotted against cumulative global capacity (GW), based on construction start dates, of nuclear power reactors for seven countries, including regression lines for US before and after 32 GW cumulative global capacity.

Peter Lang, *Nuclear Power Learning and Deployment Rates: Disruption and Global Benefits Forgone*, CAMA Working Paper No. 4/2017(January 15, 2017). Available at http://dx.doi.org/10.2139/ssrn.2899971

It Leads to Nuclear Weapons Proliferation

A Giant Stinking Red Herring

It Leads to Nuclear Weapons Proliferation

- Weapons grade plutonium is 93% fissionable ^{239}Pu.
- Plutonium in spent fuel is 55% ^{239}Pu.
- Yield of British experiment with 63% ^{239}Pu was much less than the Hiroshima uranium device.
- Plutonium in spent fuel is in a highly-radioactive and therefore easily monitored state.
- No one has ever deployed an operational weapon made from spent fuel. Heat and radiation would distort fine tolerances, require remote fabrication, damage chemical explosives, and might cause predetonation.
- LLNL report said **spent IFR fuel cannot be used to make a nuclear weapon without significant further processing.**

Weapons-ready material from spent fuel does not exist!

It Leads to Nuclear Weapons Proliferation

Even if "Weapons-ready material" existed "Proliferation" is still a red herring

- No country's municipal reactors or reprocessing affect any other country's ability or desire to make nuclear weapons.
- On-site reprocessing in IFR-type reactors implies very few opportunities for diversion or theft.
- Advanced industrial economies already have nuclear weapons, or have the means to make them much more effectively than from used municipal reactor fuel.

There Isn't Enough Uranium
(it's an inexhaustible energy source)

There Isn't Enough Uranium

- USA has 80,000 tonnes of used fuel and 700,000 (some say 900,000) tonnes of depleted uranium.
- Enough to power the entire American energy economy for 450 (or 575) years using fast-neutron reactors.
- Enough uranium could be recovered economically at current prices to power the entire world for 1,200 years using contemporary reactors.
- Current reactors extract 0.6% of energy in mined uranium; IFR-type reactors extract more than 99%: Currently-known reserves would last 200,000 years.
- Uranium contribution to fuel cost would still be 0.001¢/kWh if it cost 167 times more, but were used 167 times more efficiently.
- Economical to extract from lower-quality ores, and from seawater, where there's 1000 times more.

Nuclear fission is an inexhaustible energy source!

More Food for Thought

More Food for Thought

- Breeder reactors make 5% more plutonium than they consume, from non-fissionable but plentiful ^{238}U. Four times more common than silver; ten times more common than tin.
- In 14 years, they make enough plutonium to start a new reactor **without enriching new uranium**.
- With breeder reactors, it will never again be necessary to enrich uranium. **Any one who claims to need to enrich uranium for municipal electricity service would be exposed as a liar who has a weapons program.**
- Plutonium is not the most toxic substance known. It is less chemotoxic than lead, and far far far less chemotoxic than ricin or botulinus toxin, but it is dangerously radiotoxic if inhaled or ingested. Yttrium-90 is 94,490 times more radiotoxic. Praseodymium-144 is 242,960 times more radiotoxic.

More Food for Thought

Current US inventory of fissionable material is 1125 tonnes.

- **No one has any idea what to do with it, other than to make electricity from it.**
- **Solar panels and windmills cannot make electricity from it.**
- 1125 tonnes could immediately start 110-140 GWe capacity.
- At 5% breeding rate, 1,700 GWe capacity could be reached in 50-60 years without mining, milling, refining, or enriching any new uranium.

More Food for Thought

- Developed nations should spend 1% of GDP to reduce CO_2 emissions by 25-70%, and another 1% to cope with climate change.

  Sir Nicholas Stern, vice chairman and chief economist of the World Bank.
- Spending 2% of U.S. GDP during the 50-60 years required to deploy an all-IFR energy economy would cost $18-20 trillion.
- Improvements to the electrical grid necessary to use dispersed and variable sources would add $4-5 trillion.
- Storage to mitigate variability would cost **$76 trillion per year – four times US GDP** – too expensive to contemplate seriously.
- Deploying 1,700 GWe of IFR capacity would cost $2.1-3.7 trillion, and would reduce net CO_2 emissions by well over 95% (not just 25-70%).

More Food for Thought

- Russia and France have had sodium-cooled fast-neutron reactors since 1973.
- China has contracted to buy BN-800 from Russia.
- Russia is developing BN-1200.
- India is building a 500 MWe prototype fast-neutron reactor to exploit its huge thorium reserves.
- A South Korean company plans to begin selling a 500 MWe fast-neutron reactor in 2020.
- American nuclear engineers and scientists are retiring and dying faster than new ones are being prepared. America will soon be a third-world country in energy technology that **we invented!**
- Solar, wind, hydro, and minor renewable players such as tides, waves, geothermal, ocean currents, and biofuels – and conservation – **cannot do anything to mitigate the existing "nuclear waste" problem.**

Conclusions

The five oft-cited objections to nuclear power are all baseless falsehoods.

It is clearly obvious that nuclear power in the form of inherently safe fast-neutron breeder reactors with on-site pyroelectric refining **must be** a necessary (and economical) part of the American energy economy.

Should the United States develop the technology, or buy it from Russia, China, South Korea, and India?

The sooner we start, the better off we will be.

Additional Reading

William Hannum, Gerald Marsh, and George Stanford, *Smarter Use of Nuclear Waste*, **Scientific American** (December 2005 and online).

Charles E. Till and Yoon Il Chang **Plentiful Energy: The IFR Story**, Amazon (2011) ISBN 978-1466384606.

Tom Blees, **Prescription for the Planet** (2008) ISBN 1-4196-5582-5, ISBN-13 9781419655821.

UNSCEAR, *Scientific Annex D: Health effects due to radiation from the Chernobyl accident*, in **Sources and Effects of Ionizing Radiation, UNSCEAR 2008 Report to the General Assembly, Volume II**, ISBN-13 978-92-1-142280-1 (2011) 179 pp.

UNSCEAR, *Scientific Annex A: Levels and effects of radiation exposure due to the nuclear accident after the 2011 great east-Japan earthquake and tsunami*, in **Sources and Effects of Ionizing Radiation, UNSCEAR 2013 Report, Volume I**, ISBN 978-92-1-142291-7 (2014) 321 pp.

Watch these videos!

Climate Matters

James Hansen and Michael Shellenberger: Nuclear Power? Are Renewables Enough?

`https://www.youtube.com/watch?v=v1f4BKsFrCA`

The New York Times Conferences

Untying the Nuclear Knot

`https://www.youtube.com/watch?v=PHrBI1Iz_7c`

How Fear of Nuclear Ends

Michael Shellenberger
TEDxCalPoly

`https://www.youtube.com/watch?v=mI6IzPCmIW8`

Why I changed my mind about nuclear power

Michael Shellenberger
TEDxBerlin

`https://www.youtube.com/watch?v=ciStnd9Y2ak`

Five Myths about Nuclear Power

Van Snyder

van.snyder@sbcglobal.net

vandyke.mynetgear.com/Nuclear.html

28 June 2019