Nuclear Energy Narratives and Realities

19th INPRO Dialogue Forum

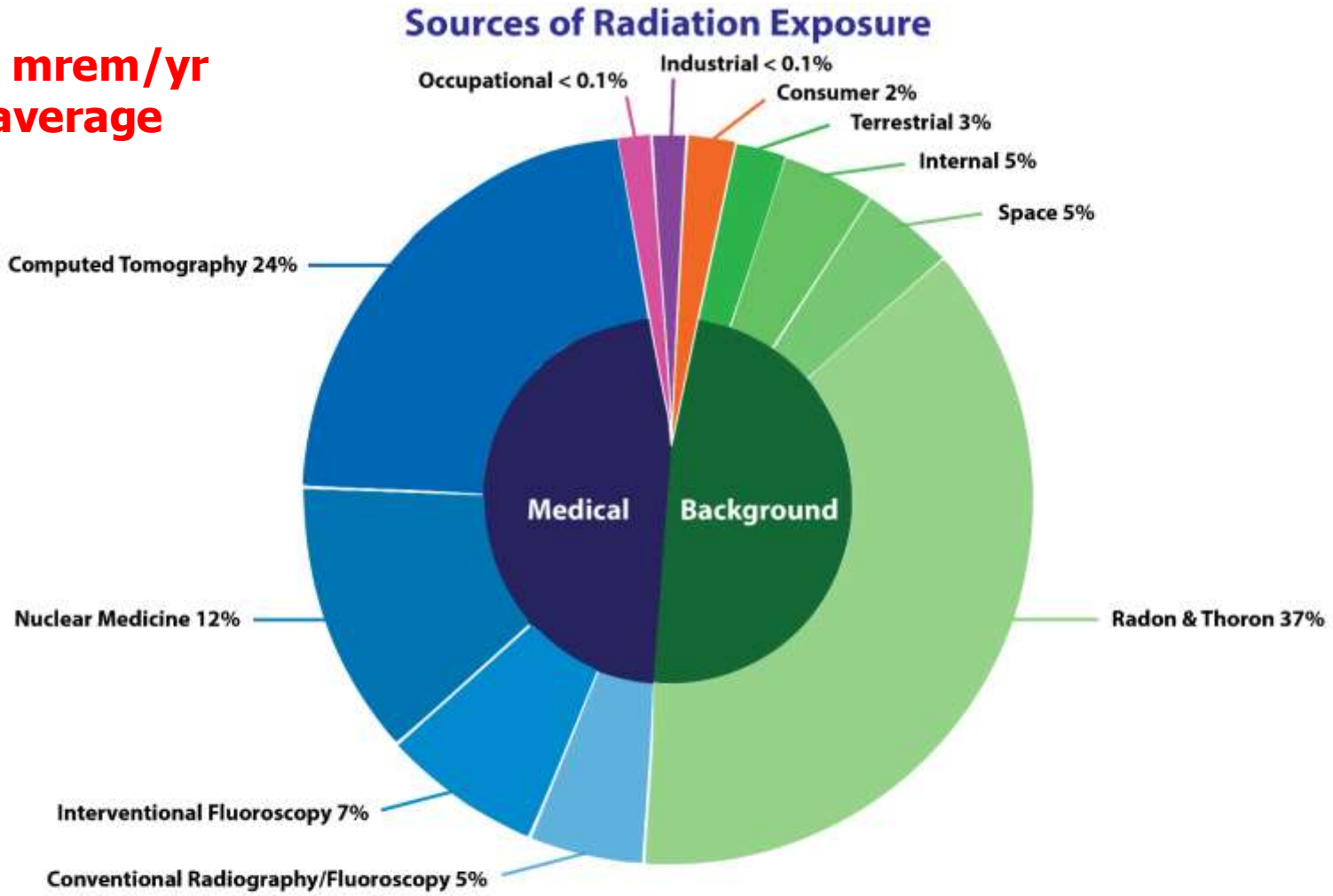
on Enhancing Public Acceptance of Nuclear Energy through Institutional Innovations

Robert B. Hayes, PhD, CHP, PE, Associate Professor
Fellow of the APS, Associate Editor Radiation Physics & Chemistry

Department of NUCLEAR ENGINEERING

NC STATE UNIVERSITY

625 mrem/yr
US average



Average Annual Radiation Dose

Sources	Radon & Thoron	Computed Tomography	Nuclear Medicine	Interventional Fluoroscopy	Space	Conventional Radiography/ Fluoroscopy	Internal	Terrestrial	Consumer	Occupational	Industrial
Units											
mrem (United States)	228 mrem	147 mrem	77 mrem	43 mrem	33 mrem	33 mrem	29 mrem	21 mrem	13 mrem	0.5 mrem	0.3 mrem
mSv (International)	2.28 mSv	1.47 mSv	0.77 mSv	0.43 mSv	0.33 mSv	0.33mSv	0.29 mSv	0.21 mSv	0.13 mSv	0.005 mSv	0.003 mSv

(Source: National Council on Radiation Protection & Measurements, Report No. 160)

Level of conservatism in dose effects

- Annual average US citizen (natural and medical) is ~0.6 rem
- 1 rem = minimum EPA evacuation dose
- Regulatory limits are far below any measurable effects, generally by a few orders of magnitude
- Radiophobia can prevent individuals from needed medical treatments or promote suicide and panic in accident situations
  - 1 R ≈ 1 rad = 1 rem = 0.01 Sv = 0.01 Gy
    - For gammas & betas*
  - 1 rad ≠ 1 rem
    - For alphas, neutrons & protons

Comparative levels of radiation dose

- 1 mrem ≈ daily background from natural sources alone
- 10 mrem ≈ minimum annual internal potassium dose or a single mammogram, EPA annual public limit
- 100 mrem public dose limit from any nuclear facility or ~ a single X-ray to pelvis or hip, NRC public limit
  - 500 mrem just above annual natural background
- 1 rem minimum EPA evacuation guideline or ≈ nuclear medicine stress test or head, chest or hip CT scan
  - 5 rem maximum radiation worker legal dose ~ 0.2% LTCR
- 10 rem ≈ 0.5% cancer probability increase
  - Typical cancer probability from all sources is just under 50%
- 100 rem ≈ 5% increase in cancer probability
  - 500 rem ≈ LD30/50 dose (lethality)
- 1000 rem ≈ certain death and acute radiation syndrome

Chernobyl's psychosomatic effects

- The largest overall health consequence to date has turned out to be suicide for these individuals† (greater than thyroid cancers)‡
  - The statistically-significant increase in suicides is attributed radiophobia†‡
- All ill effects are assumed due to the contamination
  - This is a very profound result, the psychological effects from the Chernobyl event have now been found to be the largest public health consequence from the event††
  - It appears as though fear is the real enemy in nuclear accidents

† Rahu K, Rahu M, Tekkel M, Veidebaum T, Hakulinen T, Auvinen A, Bigbee WL, Hartshorne MF, Inskip PD, Boice JD. Chernobyl cleanup workers from Estonia: cohort description and related epidemiological research. Review *Journal of Radiological Protection* **35**, R35-R40, 2015.

‡ 1986-2016: CHERNOBYL at 30. The World Health Organization, 25 April 2016. Geneva, Austria.

†‡ Bromet EJ, Havenaar JM, Guey LT. A 25 Year Retrospective Review of the Psychological Consequences of the Chernobyl Accident. *Clin. Oncol.* **23**(4) 297-305, 2011.

†† Bromet EJ, Havenaar JM, Guey LT. A 25 year retrospective review of the psychological consequences of the Chernobyl accident. Overview. *Clinical Oncology* **23**, 297-305, 2011.

Do you believe the IPCC? Why?

- How would the narrative be different if there were, "*no discernible difference from natural rates and effects*" from all the Fukushima releases to the Japanese public in general?
  - What if a UN expert panel made this claim? ‡
  - What if the world health organization (WHO) made this claim? †
  - What if all the expert review papers made this claim? [2, 3, 4, 5]

‡ *Sources, Effects and Risks of Ionizing Radiation*, United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2013, Report to the General Assembly with Scientific Annexes VOLUME I Scientific Annex A

† *Health risk assessment from the nuclear accident after the 2011 Great East Japan earthquake and tsunami, based on a preliminary dose estimation*, 2013 World Health Organization, Geneva, Switzerland.

2. Akiba, S. (2012). Epidemiological studies of fukushima residents exposed to ionising radiation from the fukushima daiichi nuclear power plant prefecture--a preliminary review of current plans. Journal of Radiological Protection : *Official Journal of the Society for Radiological Protection,* 32(1), 1-10. doi:10.1088/0952-4746/32/1/1

3. McLaughlin PD, Jones B, Maher MM. (2012) An update on radioactive release and exposures after the Fukushima Dai-ichi nuclear disaster. Review Article. *The British Journal of Radiology* **85**, 1222-1225

4 Ishikawa T. (2016) Radiation doses and associated risk form the Fukushima nuclear accident: A review of recent publications. Review Article. *Asia Pacific Journal of Public Health* **29**(2S) 18S-28S.

5. Akiba S. (2012) Epidemiological studies of Fukushima residents exposed to ionizing radiation from the Fukushima Daiichi nuclear power plant prefecture – a preliminary review of current plans. *Journal of Radiological Protection* **32** 1-10.

World Health Organization on Fukushima

- **What were the main public health consequences of the disaster?**
- There were public health consequences related to the response actions to the disaster, such as **evacuation and relocation of people**. These measures were taken based on radiation safety considerations and the massive damage to the infrastructure and facilities following the earthquake and tsunami. **These measures resulted in a wide range of social, economic, and public health consequences**. A sharp increase in mortality among elderly people who were put in **temporary housings** has been reported, along with increased risk of non-communicable diseases, such as **diabetes** and mental health problems. The lack of access to health care further contributed to deterioration of health.
- Similar to what was observed and reported for the Chernobyl population, the displaced Fukushima population is suffering from **psycho-social and mental health impact** following relocation, ruptured social links of people who lost homes and employment, disconnected family ties and stigmatization. A higher occurrence of **post-traumatic stress disorder** (PTSD) among the evacuees was assessed as compared to the general population of Japan. Psychological problems, such as hyperactivity, emotional symptoms, and conduct disorders have been also reported among evacuated Fukushima children. While no significant adverse outcomes were observed in the pregnancy and birth survey after the disaster, a higher prevalence of postpartum depression was noted among mothers in the affected region.

https://www.who.int/ionizing_radiation/a_e/fukushima/faqs-fukushima/en/

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II.A.3 Health Implications

- **No radiation-related deaths or acute diseases have been observed among the workers and general public exposed to radiation from the accident.**
- **The doses to the general public, both those incurred during the first year and estimated for their lifetimes, are generally low or very low.**
- **No discernible increased incidence of radiation-related health effects are expected among exposed members of the public or their descendants.**
  - The most important health effect is on mental and social well-being, related to the enormous impact of the earthquake, tsunami and nuclear accident, and the fear and stigma related to the perceived risk of exposure to ionizing radiation.
  - Effects such as depression and post-traumatic stress symptoms have already been reported.

https://www.unscear.org/unscear/en/fukushima.html

Exclusion zones

1. The Fukushima exclusion zone estimate ~ 371 km^2
2. The Fukushima power station rated at 4.6 GWe total power.
3. Standard commercial-off-the-shelf solar panels provide around 12 MW per km^2.
4. To generate the same power as Fukushima, approximately the same area would have to devoted to solar panels.
5. The replacement of Fukushima with equivalent solar panels will require devoting approximately equal area to solar panels as that lost from the radiological release.
6. Is this an equivalent comparison?
7. Nuclear is energy dense, solar is not.

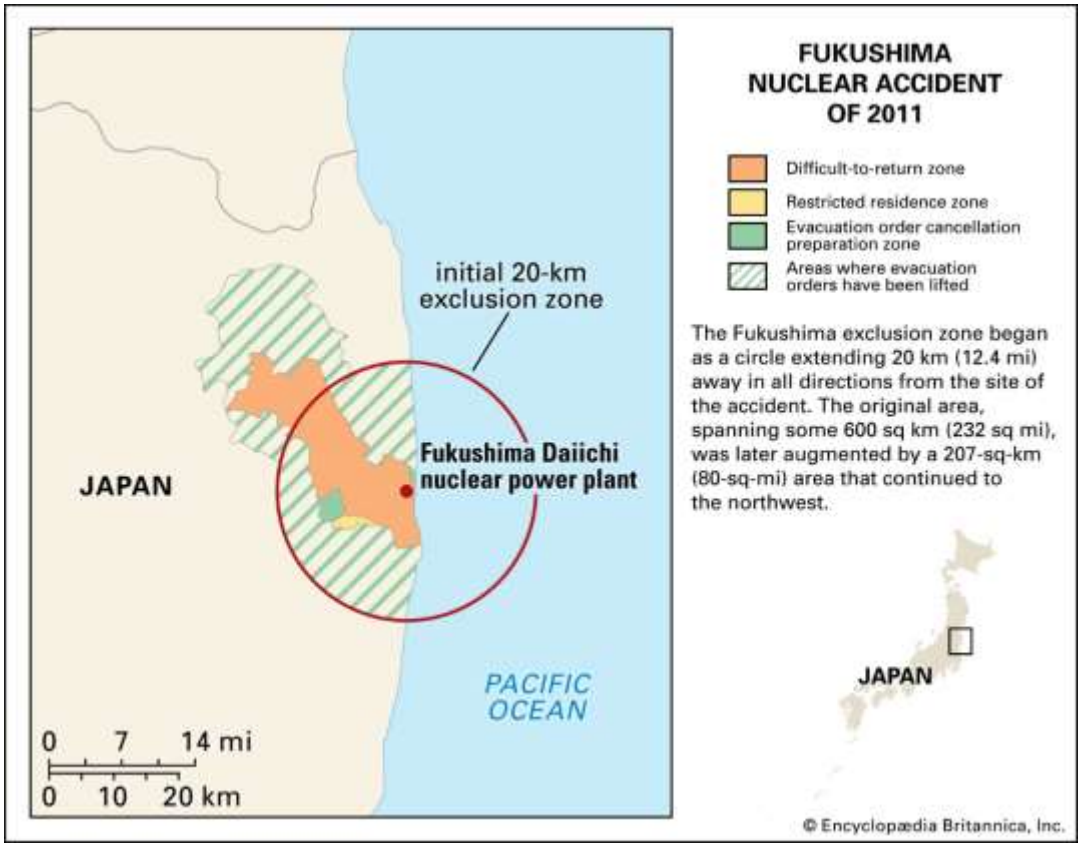


Image taken from
https://www.britannica.com/event/Fukushima-accident
Accessed 11/28/2021

Ong, S., Campbell, C., Denholm, P., Margolis, R. and Heath, G., 2013. *Land-use requirements for solar power plants in the United States* (No. NREL/TP-6A20-56290). National Renewable Energy Lab.(NREL), Golden, CO (United States).

Tribalism as an opinion

- vaccination (or an inhibition to receive them), climate science and religion. It has even been argued that this is the very effect in religion which can lead to terrorism. If you have ever seen a debate over who's team, religion or politics are best, you might understand the potential (or lack thereof) to have the facts change an anti-nuclear mind-set, irrespective of the facts. Given that it has been shown how anti-nuclear perspectives have become part of the very ethnography of those who oppose the use of nuclear science,

Attwell, K., & Smith, D. T. (2017). Parenting as politics: Social identity theory and vaccine hesitant communities. *International Journal of Health Governance*, **22**(3), 183-198. doi:10.1108/IJHG-03-2017-0008

Beck, S. (2012). Between tribalism and trust: The IPCC under the "public microscope". *Nature and Culture*, **7**(2), 151-173. doi:10.3167/nc.2012.070203

Weissman, D. (2017). Tribalism with a human face. *Journal of Ecumenical Studies*, **52**(1), 169-177. doi:10.1353/ecu.2017.0008

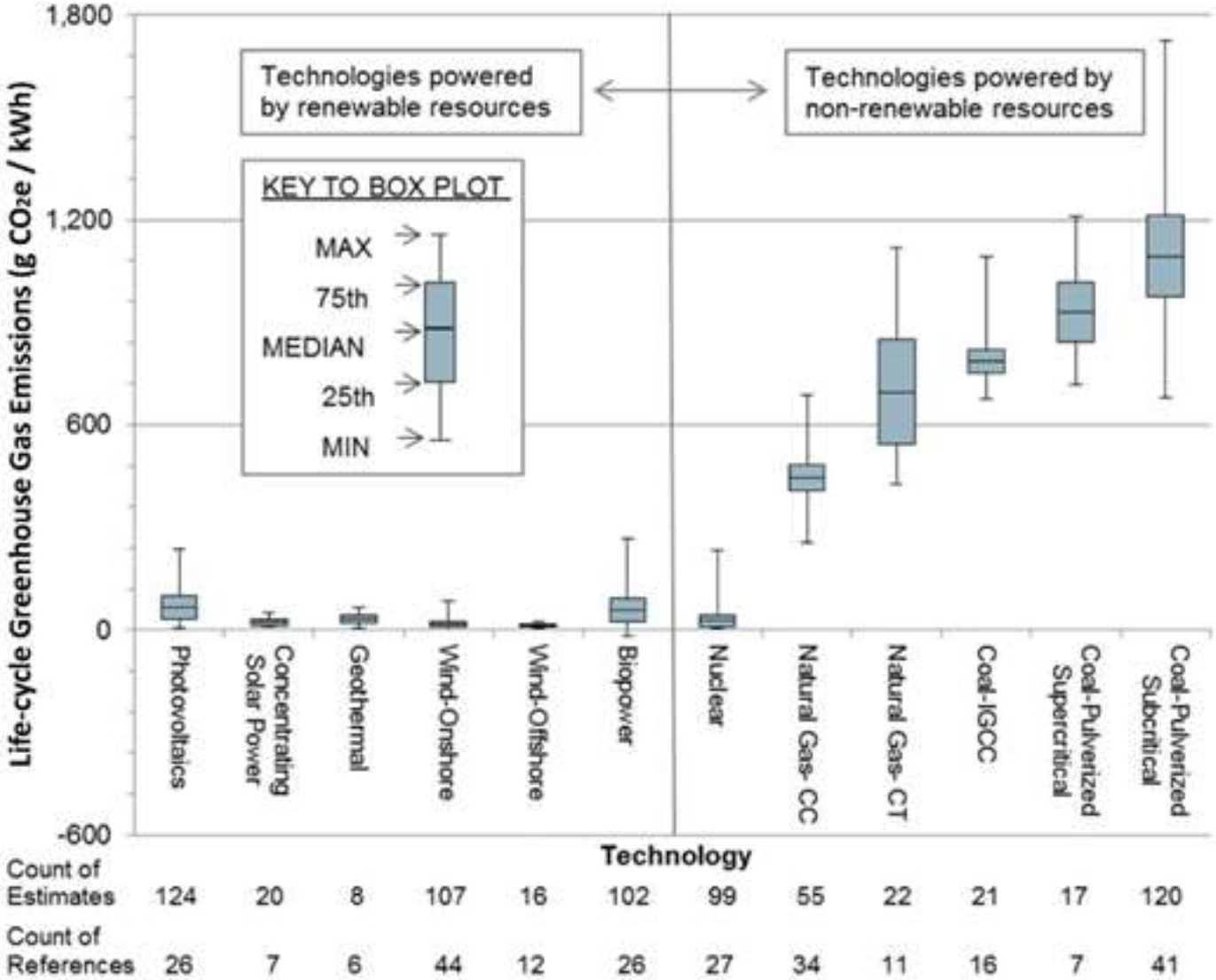
Cross, L. (2014). The deadly mix of tribalism and religion. *Quadrant*, **58**(9), 46-49.

Siemer, D., & Wiley InterScience (Online service). (2019). *Nuclear power: Policies, practices, and the future*. Beverly, MA;Hoboken, NJ;: Scrivener Publishing.

Greenhouse gas emissions

Life-cycle greenhouse gas emissions per kWh generated from all energy sources.

Quadrennial Technology Review An Assessment of Energy Technologies and Research Opportunities, US Department of Energy, Washington DC, Sept 2015



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What are energy death rates?

Note that only the prompt Chernobyl fatalities are shown for the Non-OECD country results in GW electric year (GWey) output.

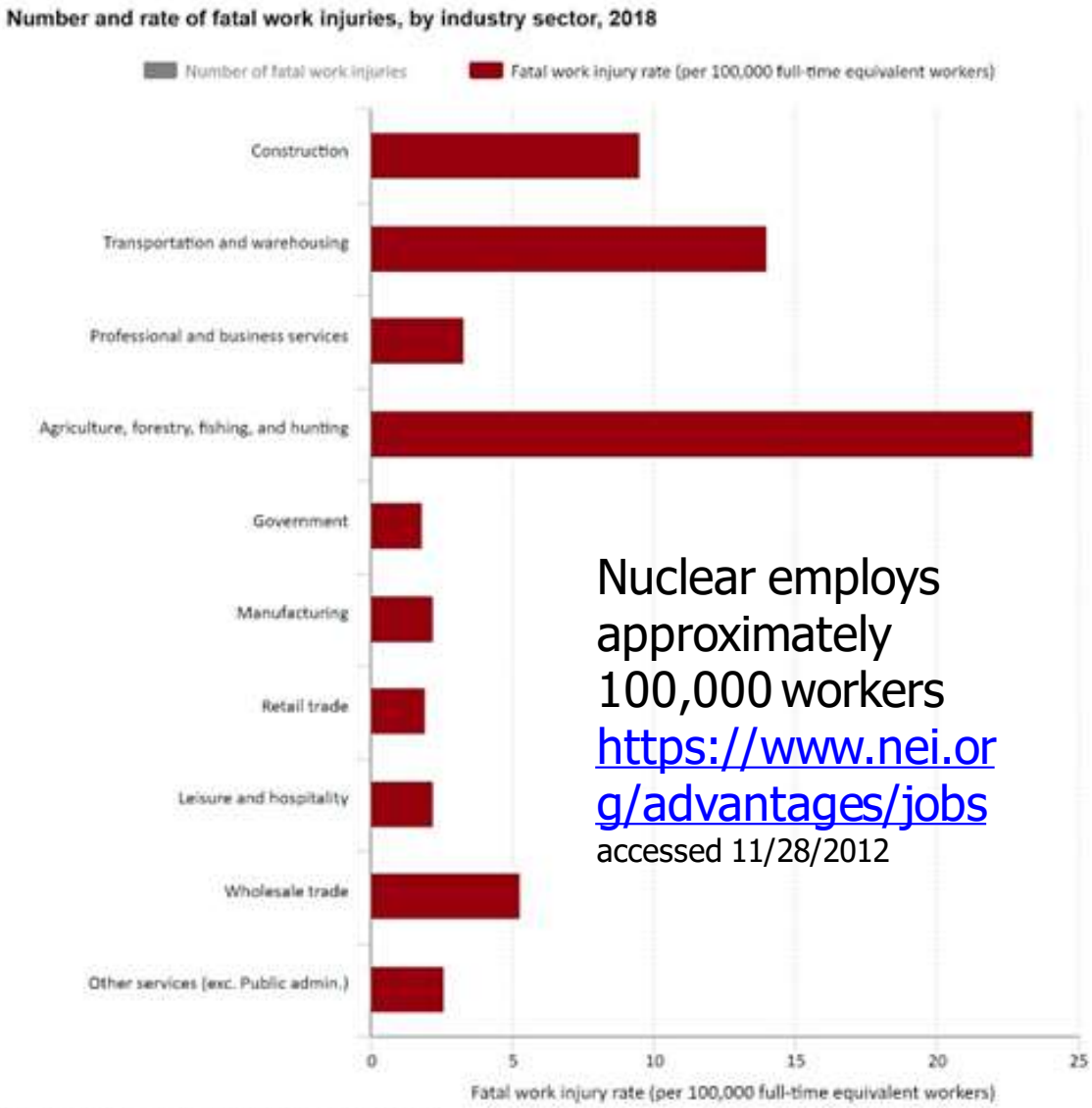
	OECD			Non-OECD		
Energy chain	**Accidents**	**Fatalities**	**Fatalities/ GWey**	**Accidents**	**Fatalities**	**Fatalities/ GWey**
Coal	75	2 259	0.157	1 044	18 017	0.597
Coal (data for China 1994-1999)				819	11 334	6.169
Coal (without China)				102	4831	0.597
Oil	165	3 713	0.132	232	16 505	0.897
Natural Gas	90	1 043	0.085	45	1 000	0.111
LPG	59	1 905	1.957	46	2 016	14.896
Hydro	1	14	0.003	10	29 924	10.285
Nuclear	0	0	–	1	31*	0.048
Total	**390**	**8 934**		**1 480**	**72 324**	

Note: * These are immediate fatalities only.

Gordelier S and Cameron R. (2010) *Comparing Nuclear Accident Risks with Those from Other Energy Sources*. Nuclear Development. ISBN 978-92-99122-4. Nuclear Energy Agency, Organization for Economic Co-Operation and Development.

What are acceptable death rates?

An average of 4.4×10^{-5} fatalities per year for a 0.014 GW wind farm which looks negligibly small compared to the values on the right but not compared to nuclear. Using the value of 3×10^{-3} deaths per GW from wind, for the US nuclear capacity in 2018 of 8×10^{5} this would have been over 2500 deaths per year from nuclear (vs. 0).

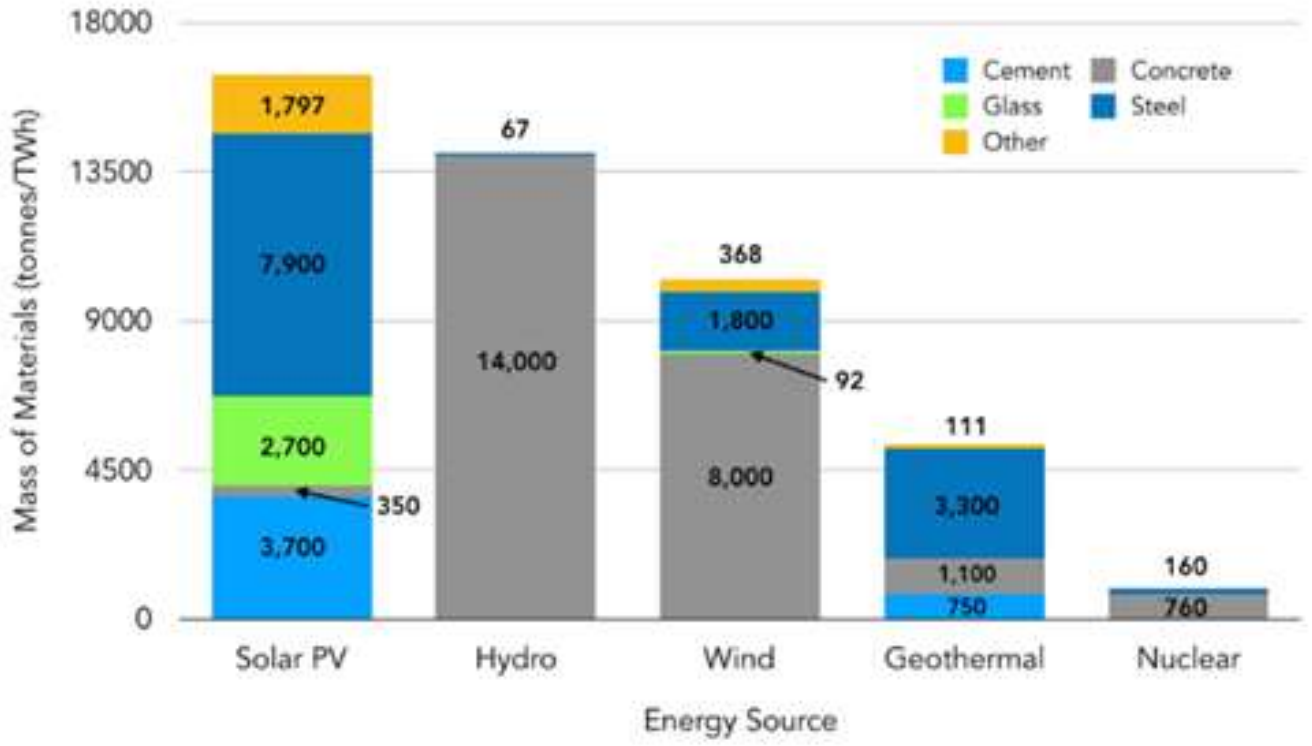


Nuclear employs approximately 100,000 workers https://www.nei.org/advantages/jobs accessed 11/28/2012

GW, Aneziris, O. N., Papazoglou, I. A., & Psinias, A. (2016). Occupational risk for an onshore wind farm. *Safety Science*, **88**, 188-198. doi:10.1016/j.ssci.2016.02.021

Material requirements

- Lifecycle material mass requirements for various energy sources per energy produced.



Quadrennial Technology Review An Assessment of Energy Technologies and Research Opportunities, US Department of Energy, Washington DC, Sept 2015

Figure used by permission http://environmentalprogress.org/big-news/2017/6/21/are-we-headed-for-a-solar-waste-crisis, accessed on 5/17/2020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