

CUNY- High School Initiative in Remote Sensing of Earth System Engineering and Sciences (HIRES) The City College of New York, NY 10031

Background

Fossil fuel use such as coal, oil, and natural gas has been linked to numerous harmful and potentially deadly impacts on human health and the environment, affecting ecosystems worldwide. In contrast, nuclear energy is often promoted as a clean and efficient alternative. However, its adoption remains limited due to concerns stemming from catastrophic events like the Chernobyl and Fukushima disasters. Our study aims to compare the consequences of both nuclear energy and fossil fuels, focusing on their effects on health and the environment.

Methods

First, we established what research question we would aim to answer which was: How does potential radioactive exposure and byproducts on health and the environment from the usage of Nuclear Energy differ from the health and environmental consequences of fossil fuel usage? To answer this question we looked through databases like Google Scholar and JSTOR for literature review. Lastly, we created maps based on the courses on GIS and how to use ARCGIS we learned at CUNY HIRES,

Environmental Consequences

1. Climate Impact & Emissions

- Fossil fuels are the largest source of global CO₂, CH₄, and N₂O emissions, contributing to global warming, extreme weather, and air quality decline.
- Nuclear energy is a low-carbon source with negligible GHG emissions during operation.
- Transitioning to nuclear power can significantly reduce emissions from electricity generation.

2. Ecological Footprint

- Nuclear energy helps reduce a country's ecological footprint.
- A 10% rise in fossil fuel subsidies, however, can increase a country's ecological footprint by up to 1.5%.
- Fossil fuel use leads to air/water pollution, resource depletion, and ecosystem damage.

3. Pollution & Waste

- Fossil fuels produce short-lived pollutants: smog, acid rain, PM2.5, PM10, SO₂.
- Nuclear energy generates long-lived radioactive waste (spent fuel, mill tailings).
- Nuclear waste remains hazardous for thousands of years; disposal remains a challenge.
- Transportation and storage of radioactive materials pose long-term environmental risks.

4. Risk & Accidents

- Fossil fuels cause daily environmental harm and millions of premature deaths annually.
- Nuclear accidents are rare but severe (e.g., Chernobyl, Fukushima).
- Accidents release isotopes like iodine-131 and cesium-137, with long-term health effects.
- Advancements in reactor safety (e.g., small modular reactors) aim to minimize risks.

5. Community Impact

- Fossil fuel facilities are often located near low-income communities, increasing exposure to pollutants and related health issues (e.g., asthma, stress).
- Living near nuclear plants may raise psychological concerns, though evidence of health risks is mixed.
- Nuclear energy can improve public health by reducing air pollution and supporting local economies through stable, high-paying jobs.
- Plant closures lead to declines in income, employment, population, and HS graduation rates, while increasing poverty and reducing public service

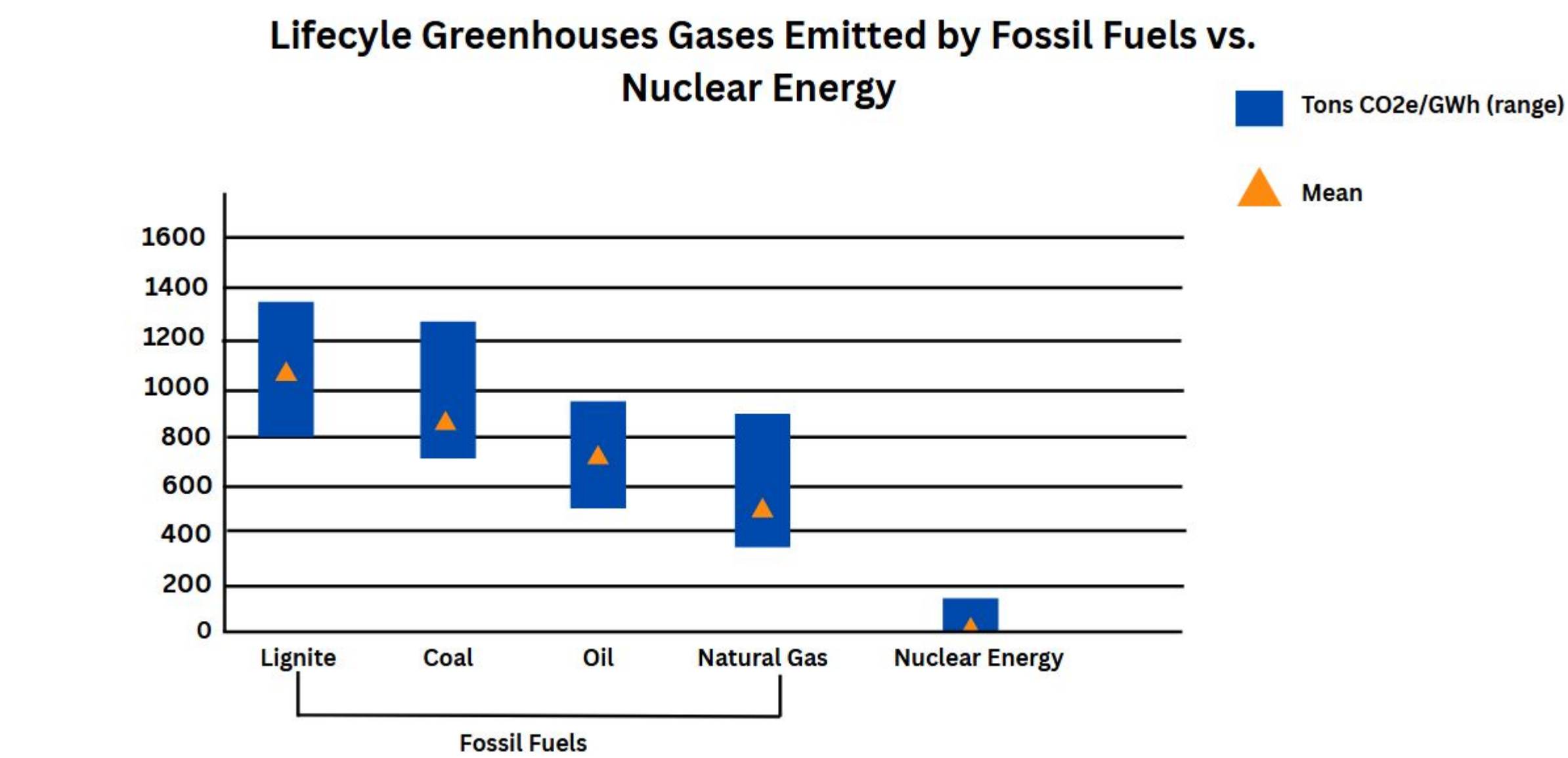


Figure 1 (Bofa Global Research, World Nuclear Association)

Corroborated Health Ramifications

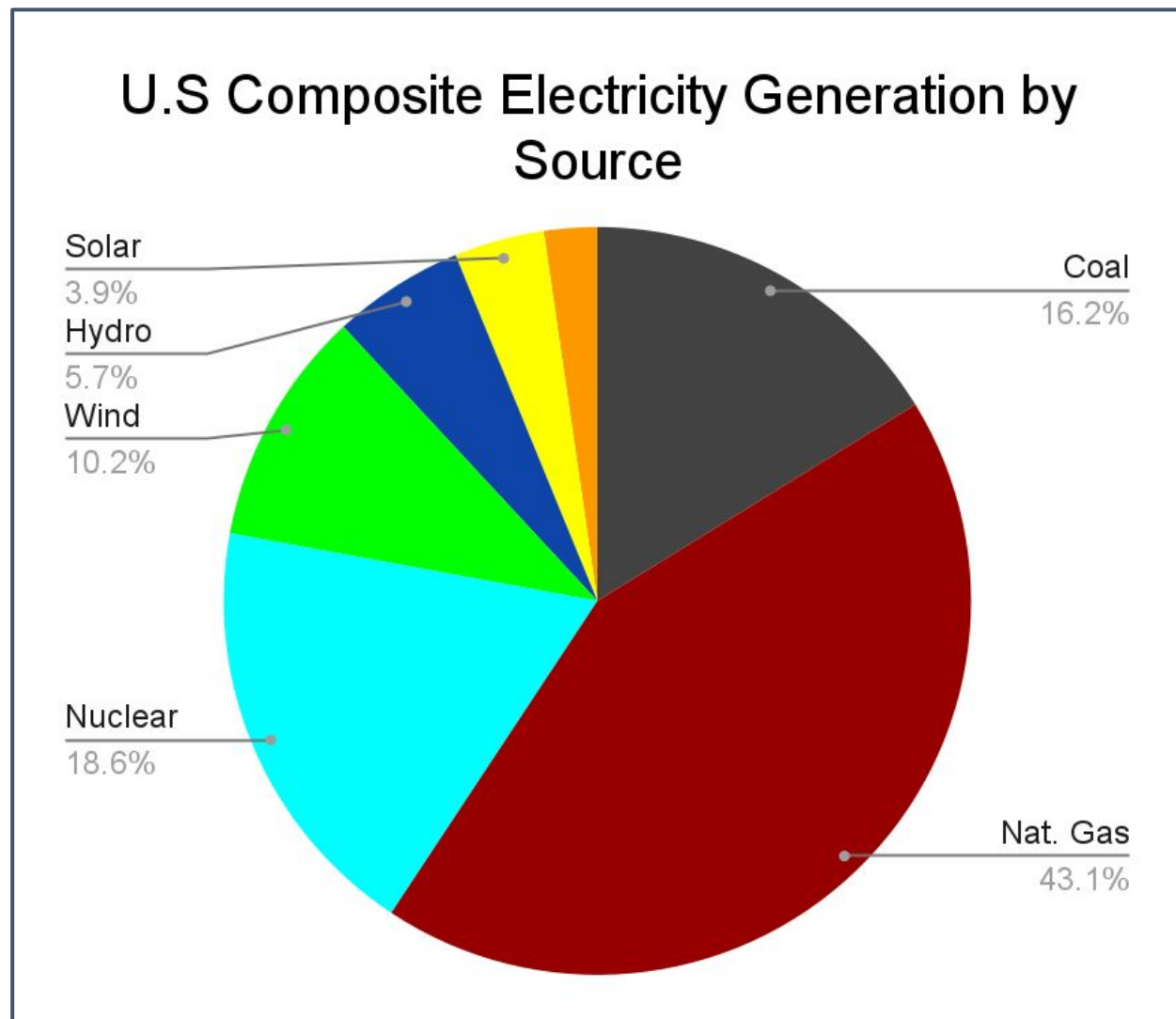


Fig. 2a (U.S. Energy Information Administration, 2024)

Modern Fossil Fuel Reliance

Millions die worldwide as result of toxic air emissions caused by the combustion of coal, oil, or natural gas taking place in thousands of fossil fuel plants globally. [Fig. 2a] 20% of worldwide mortalities can be attributed to the harmful effects coming as result of the use of fossil fuels. In the year 2018, according to the British Medical Journal, 8.7 million people died globally from the emissions of fossil fuel plants. Specific complications may arise, ranging from asthma and lung cancer to coronary heart disease and strokes in those plagued by polluted air.

The Nuclear Fear Question & Potential

Ionizing radiation refers to high energy matter or particles capable of disrupting chemical bonds. Radiation in high amounts is harmful due to individual high energy delivery as single ‘packets’. Cancers, genetic mutations, and premature death have all been linked to extreme exposure. Concern arises from this ‘invisible danger’ yet modern proceedings have made high exposure unfathomable. Modern nuclear practices are intricately monitored by numerous national and international authorities. Waste and leakage, areas of common concern, have been addressed and planned for meticulously by these bodies and see direct results in incredibly low mortality figures. [Fig. 2b] Nuclear usage leaves no harmful air emissions and necessitated tritium effluence is highly regulated. [Fig. 3a]

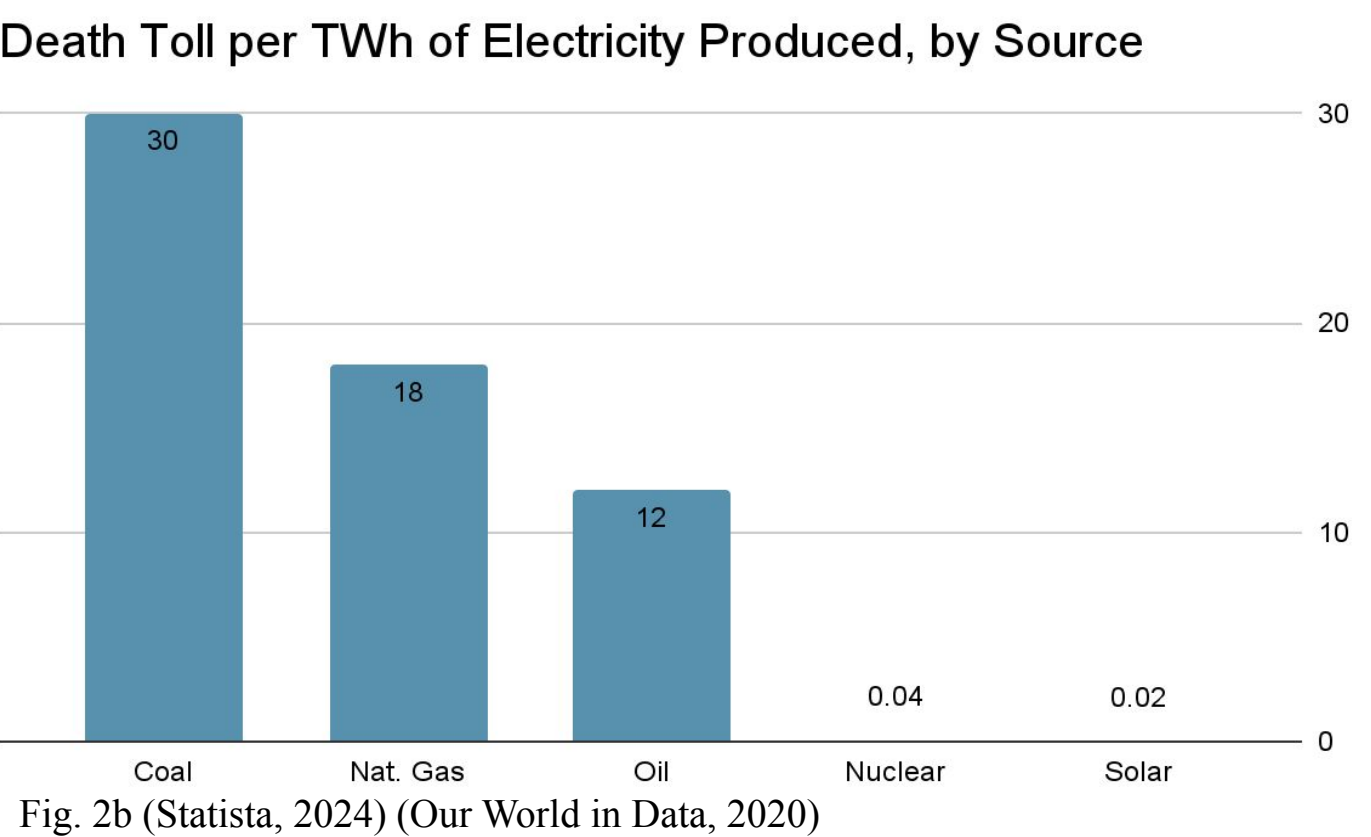


Fig. 2b (Statista, 2024) (Our World in Data, 2020)

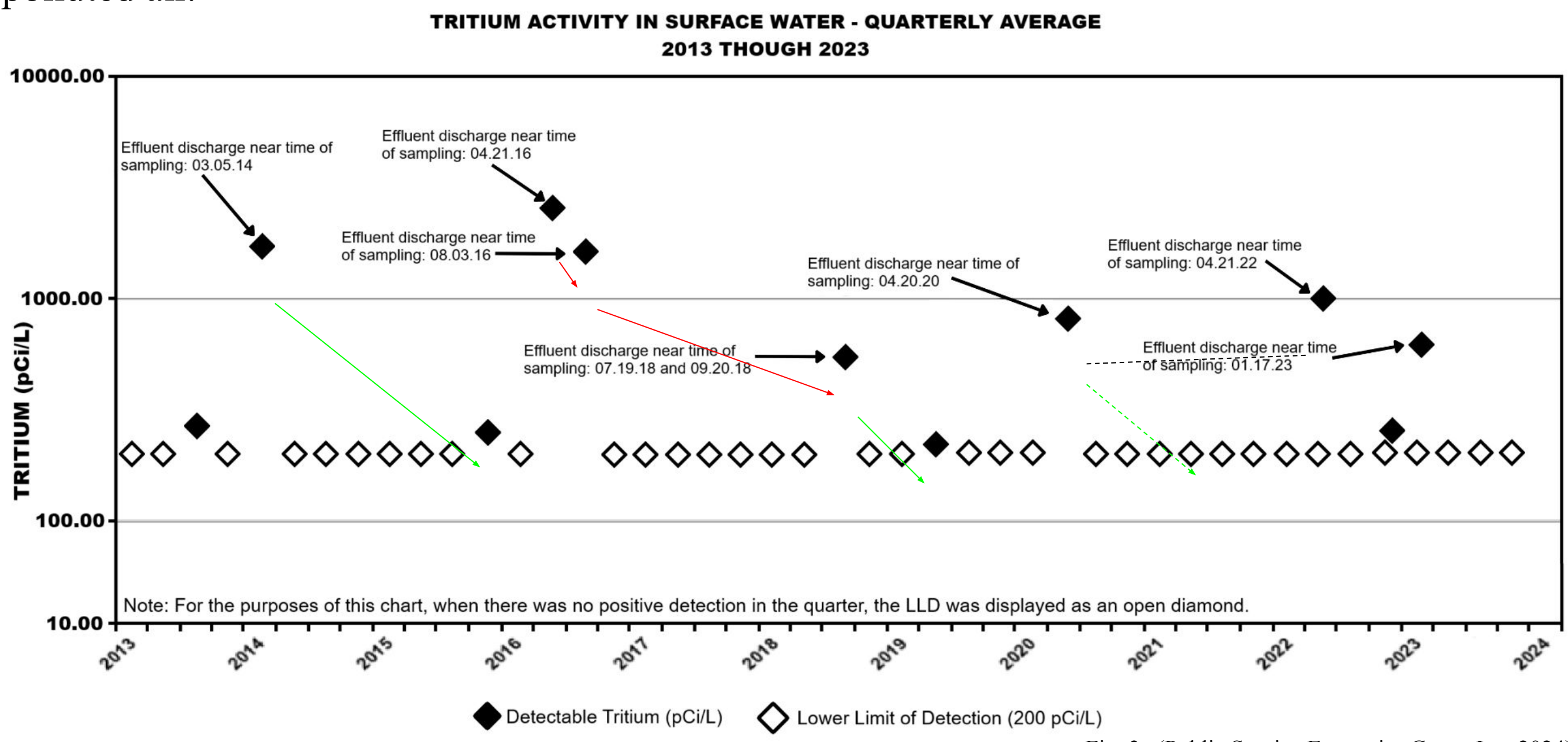


Fig. 3a (Public Service Enterprise Group Inc, 2024)

Gamma Emitter Concentration (Cs-134, Cs-137) in Water

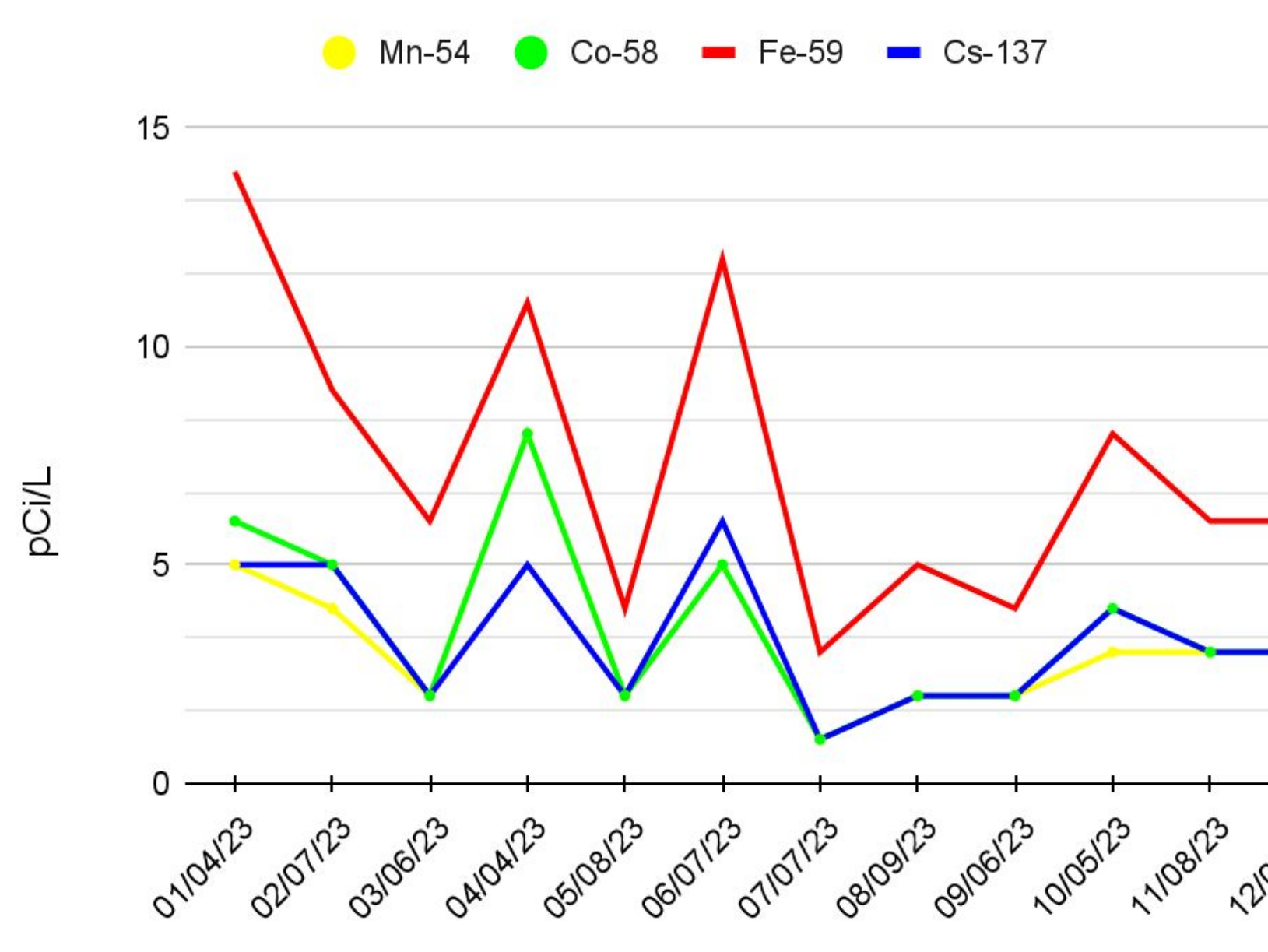


Fig. 3b (Public Service Enterprise Group Inc, 2024)



Fig. 4 Tennessee River Plants and Cities

Tennessee River Insight

5 million people, 250+ species and 50+ unique wildlife in proximity to Tennessee River.

Nuclear Plant Impact

Tennessee Valley Authority (TVA) Nuclear plants run throughout the year in a highly biodiverse area, leaving little measurable impact. Plastic and chemical dumping however, have left a severe and detrimental impact, harming wildlife more of natural environment. in significance nuclear activity has not.

PSEG Hope Creek & Salem Dosimetry Monitoring

Tritium (Hydrogen-3), when detected, were measured at concentrations below the NRC limit of 30,000 pCi/L. Most values fell below the Minimum Detectable Concentration of 200 pCi/L. No tritium was detected in ground or well water samples. [Fig. 3a] Assessments of annual occupational exposure fell within the acceptable range of 64.7-78.3 mrem. (Regulation lim. 5,000 mrem) No considerable public exposure, maximum calculated dose to the nearest resident yielding .007 mrem annually. (Regulation lim. 100 mrem)

Records are all of acceptable Gamma emitter concentration in surface water is also below NRC limits averaging 10 pCi/L among Mn-59, Co-58, ... [Fig. 3b]

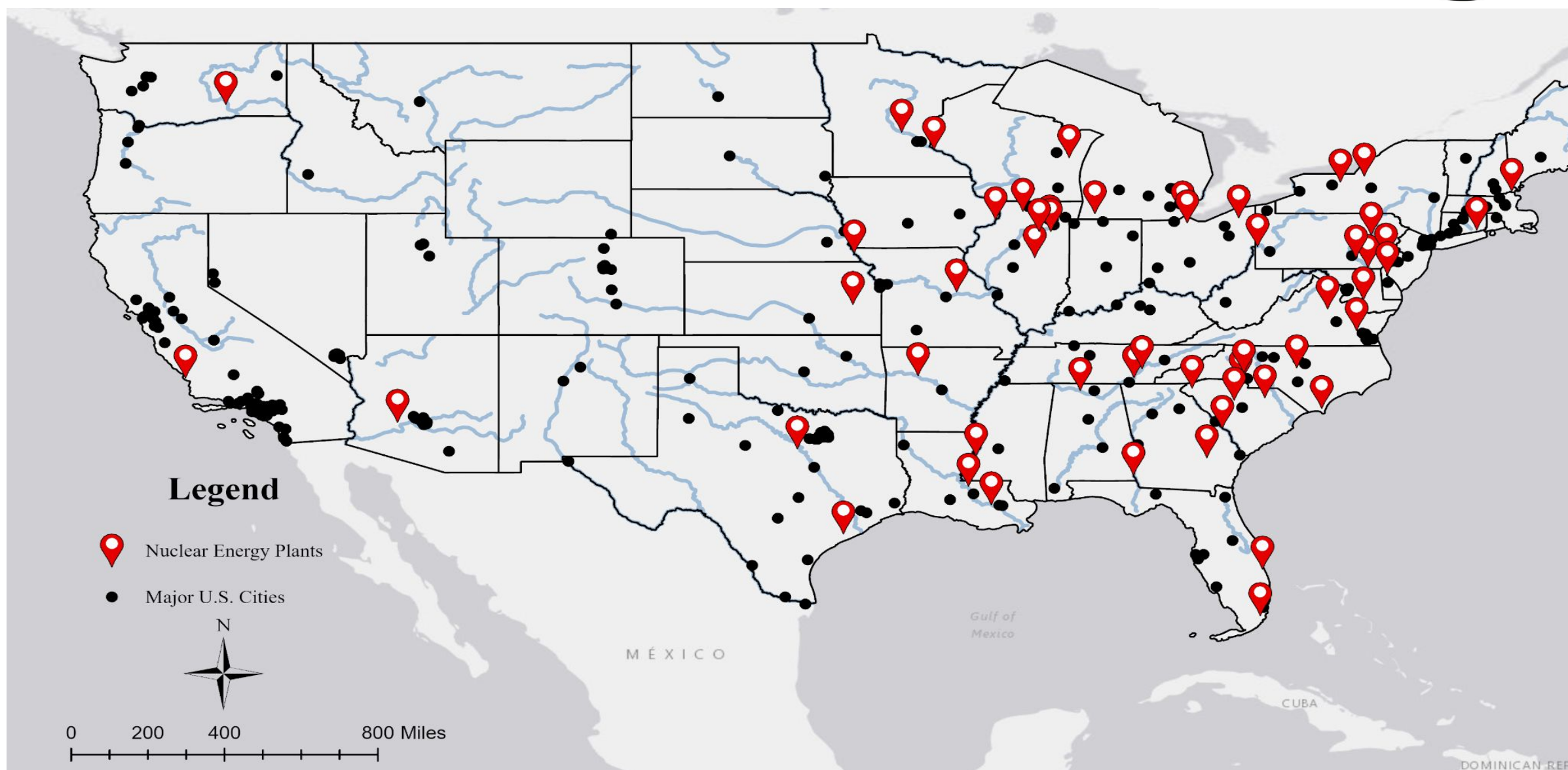


Fig. 4b Locations of U.S. Nuclear Power Plants and Major Cities

Safety Standards

The nuclear industry has adopted strict international safety standards and peer-review systems to manage hazards created by nuclear energy.

- The IAEA's Safety Fundamentals and the Operational Safety Review Team (OSART), which assess emergency preparedness and safety culture.
- The International Nuclear Event Scale (INES) helps classify and communicate the severity of incidents, ranging from minor anomalies to major accidents.
- Advanced reactor designs now incorporate passive safety systems that reduce core-melt probabilities by 10 to 100 times and do not require human intervention in emergencies.
- Probabilistic safety analysis and reliability-centered maintenance practices are also used to detect component degradation early and prevent failures, significantly lowering the likelihood of catastrophic accidents.

Banana Equivalent Radiation Dose

	Number of bananas	Equivalent Exposure
● Bananas are a natural source of radioactive isotopes (Potassium-40).	100,000,000	Fatal dose (death within 2 weeks)
● Potassium-40, a naturally occurring isotope with a half-life of about 1.25 billion years, decays via beta decay to calcium-40 or electron capture to argon-40, emitting radiation that makes bananas slightly radioactive.	20,000,000	Typical targeted dose used in radiotherapy (one session)
	70,000	Chest CT scan
	20,000	Mammogram (Single exposure)
	200 - 1000	Chest X-ray
	700	Living in a store, brick or concrete building for one year
	400	Flight from London to New York
	100	Average daily background dose
	50	Dental X-ray
● One banana gives about 0.1 microsieverts (μSv) of radiation	1 - 100	Yearly dose from living near a nuclear power station

Conclusion

While both nuclear energy and fossil fuel usage carry risks, our reliance and the devastating harm fossil fuels causes far outweighs the damage the rare and isolated incidents nuclear usage is responsible for. Modern usage of coal, oil, and natural gas is beyond unsustainability and the adoption of nuclear poses a clear solution as a clean, safe and efficient means of energy generation. Nuclear poses a dramatically minute risk to the environment as well as to persons in proximity to its usage either contained in energy production means or as waste.

Acknowledgements

This summer research project was supported by American Nuclear Society, and CUNY HIRES.

References

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Supplemental references are compiled and may be accessed via the QR Code

