CISA Student Showcase

Energy Creation Study

"Deaths" / Megawatt [6]

SCAN ME

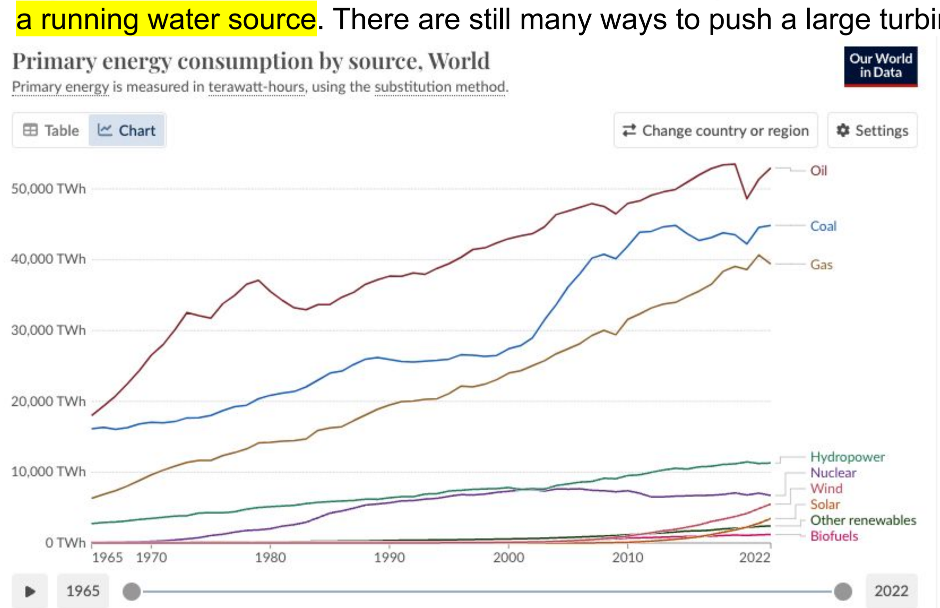
Abstract

With energy being a vital resource for humankind's sustainability, it may deem pragmatic to delve deeper into what happens behind the scenes when developing different energy sources.

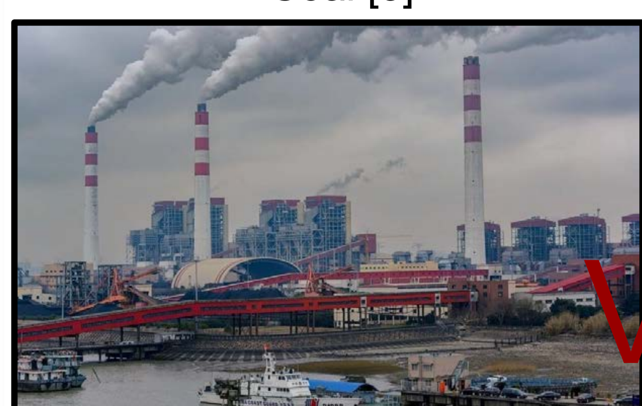
In this study, we will take a closer look into the many different effects that come with energy creation such as costs of energy plants, fuel, potential byproducts, what technology is used, and the dangers of running energy plants. These perspectives become necessary to make an overall claim. Take a look below for these claims and feel free to ask questions if you have any.

Takeaways

While researching how countries produce their energy and the different methodologies of creation, we encounter a diverse arrangement of perspectives. Countries like Canada and Sweden for instance, produce the most amount of energy per capita with hydroelectric power taking the lead. In the case of the United States, the third most abundant energy supplier per capita, uses natural gas as the most prominent source. Therebeit that hydroelectric power is situational requiring a heavy reliance on a running water source. There are still many ways to push a large turbine that do not require fossil fuels.



Coal [3]



VS

Nuclear [4]

Favorite Sources of power with all factors combined

Oil, Coal, and gas the top 3 producers of energy in the world.
Oil, which is not used by the united states on a large scale to produce energy is #1 on the list. Due to its large versatility and density as a fuel coupled with its historical importance during the industrial revolution, oil stands to be the most prominent source of energy. Oil and natural gas are both very alike in their nature as energy sources, with oil being more dense and more pollutant and natural gas being less dense and less pollutant.

In the previous examples of our top two most prominent energy producers per capita we may observe hydropower topping the list of chosen methods of producing energy. However without the help from the environment, we may view nuclear power as the most efficient option that also doesn't pollute the atmosphere. With the only byproduct being hazardous waste that takes a deep understanding to realize its manageability.

Nuclear Power - Hazardous Waste

Nuclear waste is considered manageable because 97% of it consists of low and intermediate-level waste that loses its radioactivity within a few hundred years or requires basic containment methods. The remaining 3% of high-level waste, although more challenging, is handled through advanced containment strategies like deep geological repositories, ensuring long-term isolation and safety. This approach significantly mitigates environmental and health risks. [2]
What does the real life storage look like?: As of 2013, approximately 370,000 tons of used nuclear fuel have been generated worldwide, with about one-third of this (approximately 120,000 tons) having been processed into reusable materials. Each year, an additional 12,000 tons of used fuel are added globally. [2]

Under epa.gov, the current penalty per ton of C02 is $2000

"That penalty shall be calculated on the basis of the number of tons emitted in excess of the unit's emissions limitation requirement or, in the case of sulfur dioxide, of the allowances the operator holds for use for the unit for that year, multiplied by $2,000" (epa.gov)

Table 21. Example of C02 in Tons

Bailly	7	11,180
	8	15,630
Breed	1	18,500
Cayuga	1	33,370
	2	34,130
Clifty Creek	1	20,150
	2	19,810
	3	20,410
	4	20,080
	5	19,360
	6	20,380
E. W. Stout	5	3,880
	6	4,770
	7	23,610
F. B. Culley	2	4,290
	3	16,970
F. E. Ratts	1	8,330
	2	8,480
Gibson	1	40,400
	2	41,010
	3	41,080

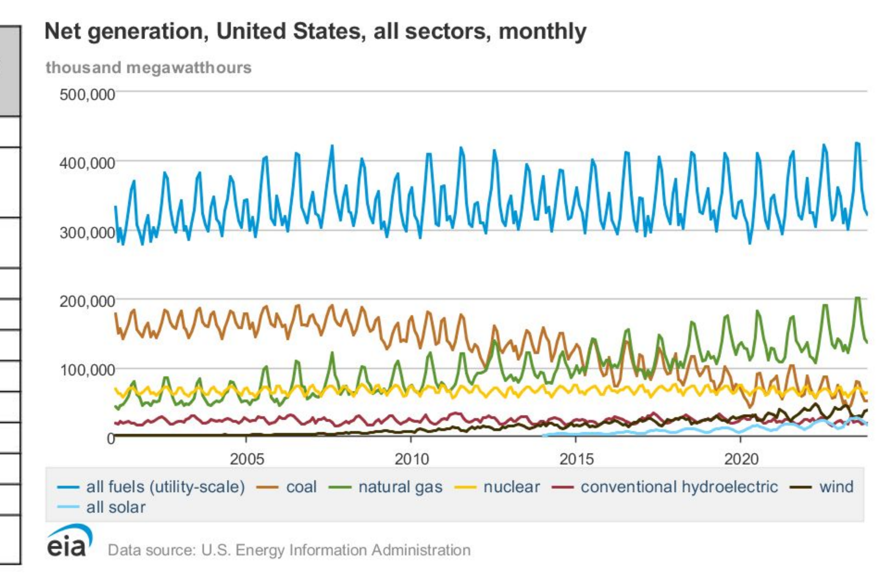
To put this into perspective, I provided some plants from Indiana that produce large amounts of C02 in tons per calendar year. Each plant has multiple generators each producing tons of C02 which cost lots of $$ in penalties.

Technology of Creation

Table 18. Power Plant Technology Assumptions
(2008 $)

Energy Source	Technology	Overnight Construction Cost for Units Entering Service in 2015, 2008$ per kW[a]	Capacity (MW)	Heat Rate for Units Entering Service in 2015 (Btus per kWh)	Variable O&M Cost, 2008$ per Mwh	Fixed O&M, 2008$ per Megawatt	Capacity Factor
Pulverized Coal	Supercritical	$2,485	600	9,118	$4.68	$28,100	85%
Pulverized Coal: CC Retrofit	Subcritical	$2,192 (cost for CC retrofit only; original plant cost assumed to be paid off)	351	15,817	$16.15	$56,609	85%
Pulverized Coal: CC, New Build	Supercritical	$3,953	600	11,579	$14.32	$45,564	85%
IGCC Coal	Gasification	$3,359	550	8,528	$2.98	$39,459	85%
IGCC Coal: CC	Gasification	$4,774	380	10,334	$4.53	$46,434	85%
Nuclear	Generation III/III+	$3,682	1,350	10,400	$0.50	$69,279	90%
Natural Gas	Combined Cycle	$1,186	400	6,647	$2.05	$11,936	70%
Natural Gas: CC	Combined Cycle	$2,342	400	8,332	$3.00	$20,307	85%
Wind	Onshore	$1,896	50	Not Applicable	$0.00	$30,921	34%
Geothermal	Binary	$3,590	50	Not Applicable	$0.00	$168,011	90%
Solar Thermal	Parabolic Trough	$2,836	100	Not Applicable	$0.00	$57,941	31%
Solar Photovoltaic	Solar Cell	$5,782	5	Not Applicable	$0.00	$11,926	21%

Table 17. Energy Creation Source



We may view the critical technologies in US energy production as of date with very little difference besides the monetary values would be different in 2024 as we then view Table 17.
What does this let us know about different types of energy production?

- When taking a closer look at this table, we may see the construction costs per KW of capacity capped at its respective given capacity.
- From this we make the claim that the new generation nuclear power plants has the largest initial cost to produce energy with coal and its newest technology being a close second. This new technology for coal attempts to use an integrated gas cycle and carbon capture to make the process less pollutant.
- Heat rate simply means the BTU (raise one pound water by one F°) for each kWh).
- Fixed O&M are the operations and maintenance costs per megawatt in 2008, which are costs that do not change based on how much electricity is produced.
- Capacity Factor is an important part of the knowledge that expresses how often a plant is running at full capacity.

Table 17

1. As of the most recent report a total of 11350 plants exist in the US, with CA containing the largest out of any state with 1479
2. Natural gas is the leading energy source for power generation in the United States, accounting for 38% of the total, with around 1,900 plants in operation. On the other hand, nuclear energy, which contributes a significant 20% of the nation's clean energy, is generated by a comparatively modest number of facilities, totaling 52. To put this into perspective that means that 19 natural gas plants would equal the same output as 1 Nuclear plant in a year on average.

Table 20. Fuel and Allowance Price Projections (Selected Years)

	Delivered Fuel Prices, Constant 2008$ per Million Btus			Air Emission Allowance Price, 2008$ per Allowance		
	Coal	Natural Gas	Nuclear Fuel	Sulfur Dioxide	Nitrogen Oxides	Carbon Dioxide
2010	$1.93	$7.51	$0.73	$249	$2,636	*2012:* $17.70
2020	$1.80	$6.41	$0.78	$1,074	$3,252	$31.34
2030	$1.87	$7.48	$0.79	$479	$3,360	$63.99
2040	$1.96	$9.17	$0.76	$158	$3,180	$130.66
2050	$2.06	$11.24	$0.73	$52	$3,009	$266.80

Profit versus Environment
Top 3 sources US Energy

Sources: Forecasts other than carbon dioxide allowances are from the assumptions to the Energy Information Administration's 2008 Annual Energy Outlook (AEO). Carbon dioxide allowance prices are from the backup spreadsheets for EIA's "Core" case analysis of S. 2191 [http://www.eia.doe.gov/oiaf/servicerpt/s2191/index.html]. The original values in 2006 dollars were converted to 2008 dollars using the Global Insight forecast of the change in the implicit price deflator. The EIA forecasts are to 2030; the forecasts are extended to 2050 using the 2025 to 2030 growth rates. The sulfur dioxide allowance forecast is for the western U.S., which is the best representation of national prices following the D.C. Circuit Court decision vacating the Clean Air Interstate Rule (which would have, in effect, created a premium for eastern region SO_2 allowances). The nitrogen oxides allowance forecast is for the eastern region of the United States, the only region for which an EIA forecast is available in the AEO output spreadsheet.

Notes: Btu = British thermal unit. Sulfur dioxide and nitrogen oxides allowances are dollars per ton of emissions; carbon dioxide allowances are dollars per metric ton of CO_2.

This is a helpful picture that demonstrates the fee that any company or producer must pay for each ton of emission for unsavory commonly produced byproducts while searching for energy creation. It is best to compare and contrast these 3 most popular methods of production of energy (by the US) and seek which is best for both the environment while giving economic benefits to those who fit with goals. While looking at natural gas, which is our #1 most potent method of energy production according to the EIA, we experience the most cost per million btu while producing considerable amounts carbon dioxide, as given in either Table 19 or 21. When looking at Nuclear Fuel, notably uranium, we may find that the price is the least while not producing any emissions.

How Do Emissions Affect Me?

Table 19. Air Emission Characteristics

Energy Source	Technology	Controlled SO_2 Emission Rate (pounds per MMBtu)	Controlled NOx Emission Rate (pounds per MMBtu)	CO_2 Emissions without Carbon Control (pounds CO_2 per MMBtu)	CO_2 Emissions with 90% Removal (pounds CO_2 per MMBtu)
Pulverized Coal	Supercritical Pulverized Coal	0.157	0.05	209.0	20.9
IGCC Coal	Coal Gasification	0.0184	0.01	209.0	20.9
Natural Gas	Combined Cycle	0 (no controls required)	0.02	117.08	11.708

Here are some various sources attempting to research and answer this question:

1. "Research from Harvard University, in collaboration with the University of Birmingham, the University of Leicester and University College London, found that more than 8 million people died in 2018 from fossil fuel pollution, significantly higher than previous research suggested—meaning that air pollution from burning fossil fuels like coal and diesel was responsible for about 1 in 5 deaths worldwide." [7]

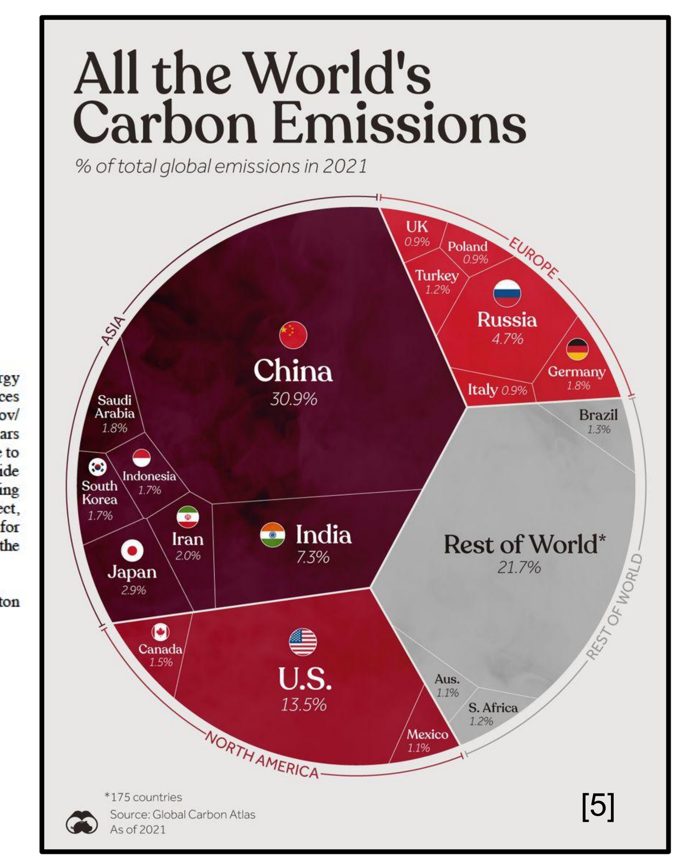
Analysis: When taking a closer look into the research that researches provided, the main conclusion was that "The burning of fossil fuels – especially coal, petrol, and diesel – is a major source of airborne fine particulate matter (PM2.5), and a key contributor to the global burden of mortality and disease"
However this statement must not be taken at face value because the article also states that
"[They] used the chemical transport model GEOS-Chem to estimate global exposure levels to fossil-fuel related PM2.5 in 2012. Relative risks of mortality were modeled using functions that link long-term exposure to PM2.5 and mortality, incorporating nonlinearity in the concentration response. [Which] estimate a global total of 10.2 (95% CI: −47.1 to 17.0) million premature deaths annually attributable to the fossil-fuel component of PM2.5. The greatest mortality impact is estimated over regions with substantial fossil fuel related PM2.5, notably China (3.9 million), India (2.5 million) and parts of eastern US, Europe and Southeast Asia.

Once this all us taken into account, researchers are presenting us with the perception that PM2.5 is not necessarily what may kill someone outright but helps encourage premature death through the bodies interaction with the airborne matter.

Another perception on the matter comes from an Our Word in Data article which gives a very user friendly explanation

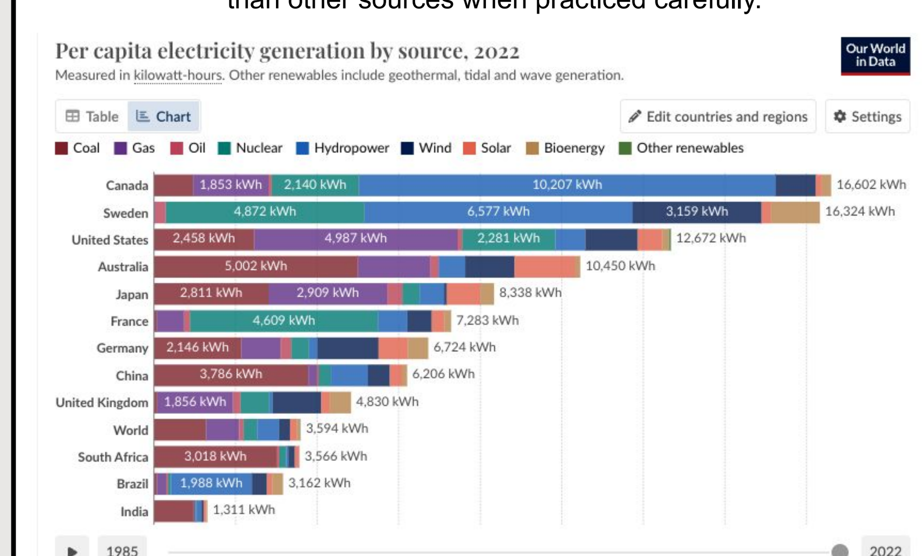
This article supports the claim that "at least 5 million deaths are attributed to air pollution each year" (Hannah Ritchie)

2. "Per the generation of one terawatt hour or the energy consumed on the average 12,600 us citizens only using coal would cause 25 deaths, oil would cause 18, natural gas 3. Now for renewables, instead of the deaths annually we would look at the deaths per 50 years, solar would cause 1 death, hydropower 1, wind 2, nuclear in its worst case would cause 3.5 deaths." [...] "Fossil Fuels contribute to "29% of Lung cancer, 24% of stroke". [1]



Where Do We Stand on Energy Creation?

This information is a great place to start for realizing the correlation between our practices of creating energy versus the world's practices of creating energy. Yes, we may have had success with making fossil fuels less pollutant but they are sometimes not as efficient and more expensive than other sources when practiced carefully.



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College of Integrative Sciences and Arts
Arizona State University

cisa.asu.edu
cisaasu