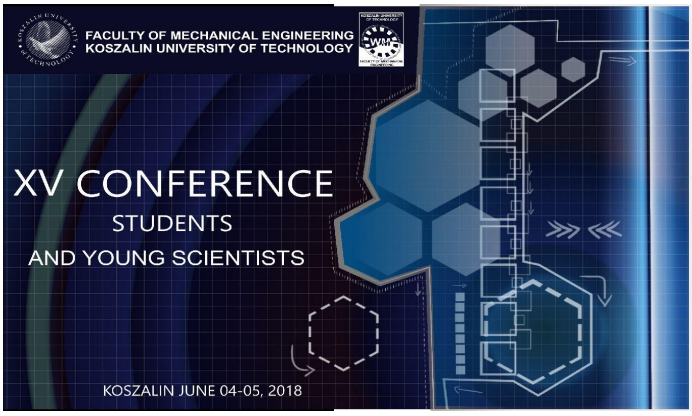

Decreasing the share of nuclear power in energy production in the United States and Germany

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ABSTRACT. For long time Germany had many atomic power plants and was important exporter of this nuclear technologies, but right now german government decided to close all their reactors up to 2020. In this presentation we will try to answer for one important question. "Why?", and second one "is it a good idea?". We will try to find out answer for first question and later prove that withdrawing from nuclear energetics is one of the greater mistakes that developed countries are making right now, and please take into consideration that despite the fact i always believed that right now atomic energy is second to none of what we have right now i carried my research with open mind looking for answers forcing myself to not be biased about subject. Right now i believe in what i believed before, but the change is that now this is not "i think so", but "i know that".

KEY WORDS. Nuclear energetics. United States. Germany. Renewable technologies.

1. Nuclear Energetics in Germany

1.1. History

In 1958 world power usage equaled almost 30 000 TWh, and was believed that this number will rise tenfold up to 2000. Lucky history proven it to be overestimation and we ended with using around 120 000 TWh at the beginning of XXI century, which is “only” quadruped initial value. That is because of much greater efficiency of our ways to make things happen, but that does not change the fact that still tremendous amount of energy and with time arisen need to create new, more powerful than ever power plants and nuclear energetics for many decades was this answer.

First experimental power plant in Germany was built in 1960 by General Electrics together with Siemens. In the next decades Federal Republic of Germany build 10 next. They were small, with power output not higher than 400 MW (for comparison, greatest modern power plant, located in Kashiwazaki-Kariwa, Japan, generate almost 20 times more energy), and whole nuclear energetics had its “boom” in the 70s, when we started constructions of big reactors, and also in 70s were born anti-nuclear movements. In 1975 construction of nuclear plant was started in Wyhl, Germany. Local populace was strictly against the idea and started strong protest. After two days police had to use brutal force, and whole country was revolved by pictures of policemen dragging farmers and wives through muddy construction site. There was powerful response from public opinion. Few days later local families was supported by great crowd from whole Germany, strong in numbers of 30.000 men and women. Authorities were powerless. Few weeks later construction permit was withdrawn. This success was what made anti-nuclear movement daring and powerful. From now on they were not perceived as extremists and that allowed them to influence politics.

That does not change the fact that they were minority. German nuclear energetics were still in the rise and oil crisis in 1974 only speed up the process and soon German energetics had almost 20 000 MW of nuclear power. Later, in 1986 after Chernobyl, leakage in Hamm-Uentrop and riots by nuclear waste recycling plant in Wackersdorf 400 people was wounded. That was the moment when Green Party demanded immediate shutdown of all reactors, less extremist groups wanted to do this in period of one decade. After unification of Germany was decided that all soviet technology based nuclear plants are dangerous and were closed in 1990, and from that moment no more nuclear power plant were build in Germany. Later (1998) formed coalition of SPD and Green Party (both was strongly anti-nuclear) which immediately begun anti-nuclear negotiations with power plant owners. After two years was decided that atomic plants will be closed few years later, but there was no force-shutdowns of anything. We can try to guess the influence of project to build gas pipeline

on bottom of Atlantic Sea but noteworthy is fact that German chancellor, after lost elections was hired on very good paid position in Gazprom, which built Northern Pipeline.

In 2005 nuclear physics Angela Merkel become chancellor, and looked like she was pro-nuclear, but that was not the case. During her government nuclear power production is in almost constant recess and after Fukushima in 2011 trend only sped up… There was no backlash of anti-nuclear movement in Japan… but over 9 000 kilometers was born immediate cross-generational consensus… "we do not want nuclear plants in our country" without any consideration to the economic issues of such decision. Hundreds of thousands of protesters left their homes and marched through the streets demanding to withdraw from nuclear energy. German economy is fourth largest in the world and second industrial exporter. It requires cheap energy, and one third of its national production was nuclear based (look at Figure 1) and with agreement of European Commission from 2007 which require all Member States to greatly reduce CO_2 emission, primary energy usage and increase renewable energetics that is really not easy task, and chancellor Merkel declared that all nuclear plant will be closed by 2020 and 8 of them was closed immediately. As we can see that decision was as far from reason as it can be, and after that carbon and natural gas based energetics gained its renaissance as easiest and cheapest alternatives to power of atom. We do not think that this is necessary to mark its effect on natural environment…

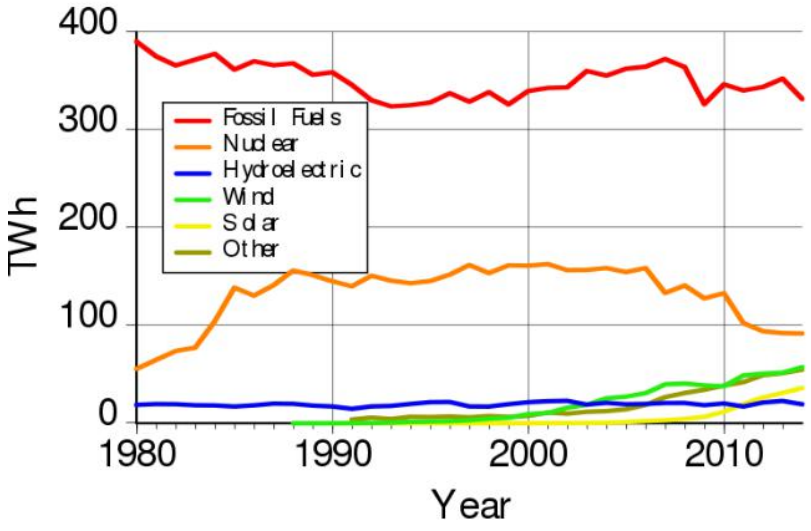

Figure 1: Electricity production in Germany

Noteworthy is curvature of fossil fuels and nuclear power usage and their correlation. That also do not look so bad after 2011 because wind and solar energetics are fast developing fields (despite not favorable circumstances when for 1/4 of the year is cloudy when sun rays have power lesser than 800 Wh/m^2), and it looks like the Germany can handle this transition despite weaknesses of this politics and as we can see in figure 2 there is huge increase in usage of natural gas in recent years, but cannot blame them when we look at hard coal and lignite curves, but there is still valid assumption that they would look much better if they would still advance in nuclear power energetics.

1.2. Germany Today

For many years Germany is becoming "greener and greener" advancing in renewable energy technologies and implementing them into economy. There is still long way ahead of them but we can observe steady growth of renewable energy usage.

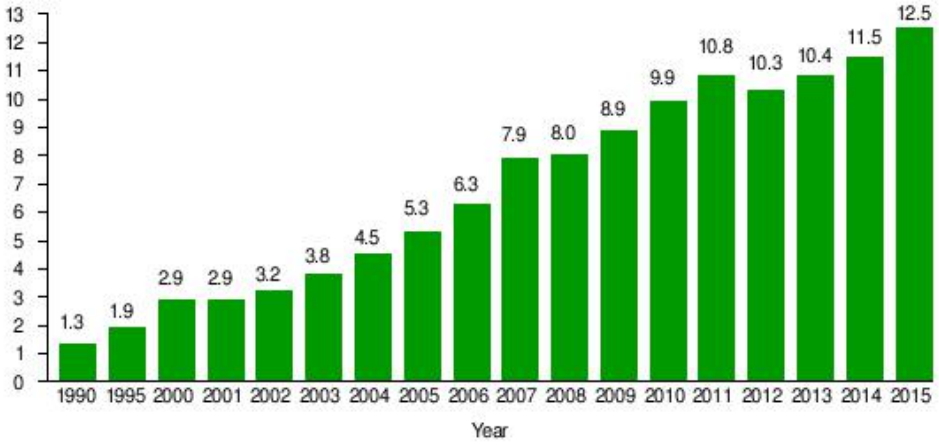

Figure 3: Growth of renewables as percentage of primary energy consumption

If they keep this growth then in XXII century they will absolutely independent of any non-renewable energy source, but this is long time and they are few issues. Today they are still dependent on natural gas from Russia (in 2016, Germany imported 49.8 billion cubic meters of gas from Gazprom) and general energy import from other countries (but they balance that with their own export). Most of its green energy comes from wind as stated on figure 4, which is highly unreliable source that cannot be planned at length, that is the reason why Germany buys and sells a lot of electricity… one time it needs to buy energy, and other to sell. Depending on weather. That do not have to be something wrong per se, but it is hard to believe

that whole country with german-like economic power could work purely on unstable energy source.

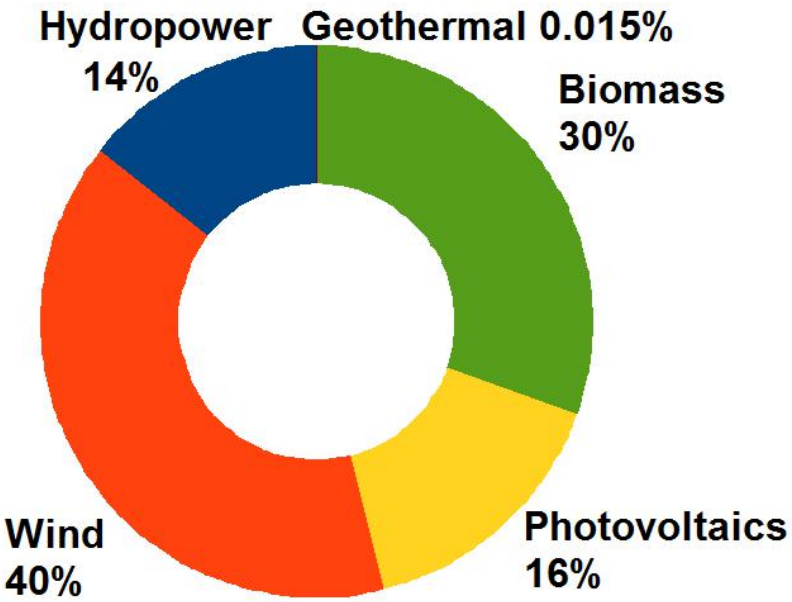

Figure 4: Green energy in Germany

Answer to that can be biomass. Advancing and possibly powerful branch of technology which is, in full right, treated as renewable and can be expected to provide stable power to country.

But with all this assets Germany is still one of the greatest economies in the world and is fifth in coal usage (look at figure 5), fifth to eight (depending on the source) in oil consumption (figure 6), third (after US and Russia) in natural gas consumption (figure 7) and fourteen in renewable energy as percentage of gross energy consumption with value below European Union average (figure 8). Considering that, by logic, they are doing great in self-improvement but environment would be grateful if they stayed with nuclear energy for few more decades.

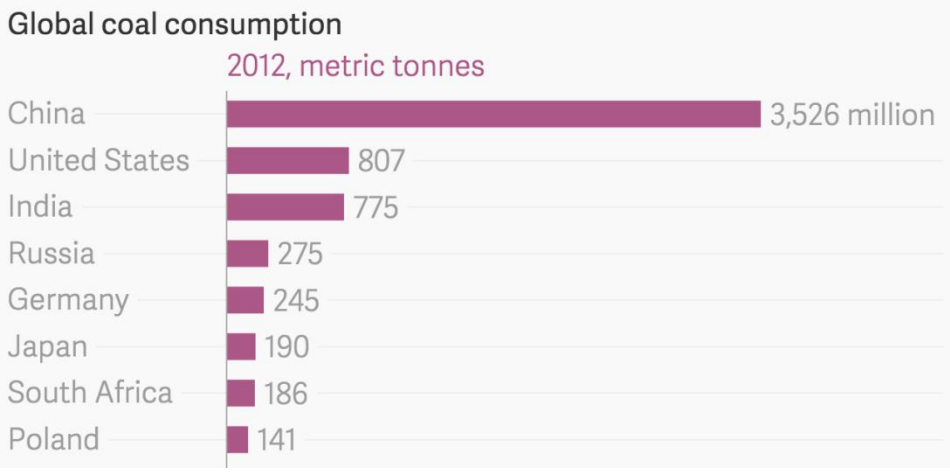

Figure 5: Coal Consumption by countries

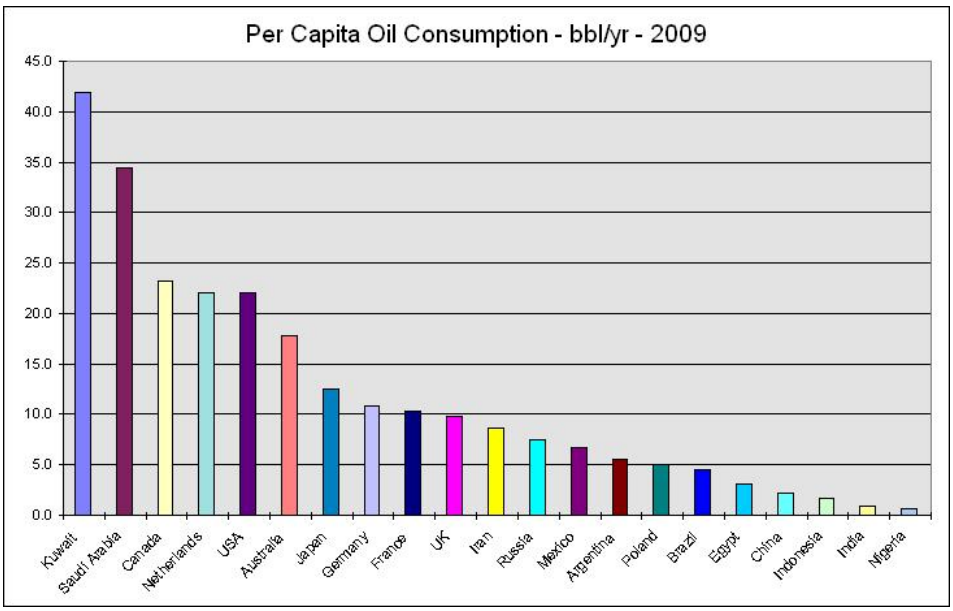

Figure 6: Oil Consumption by countries

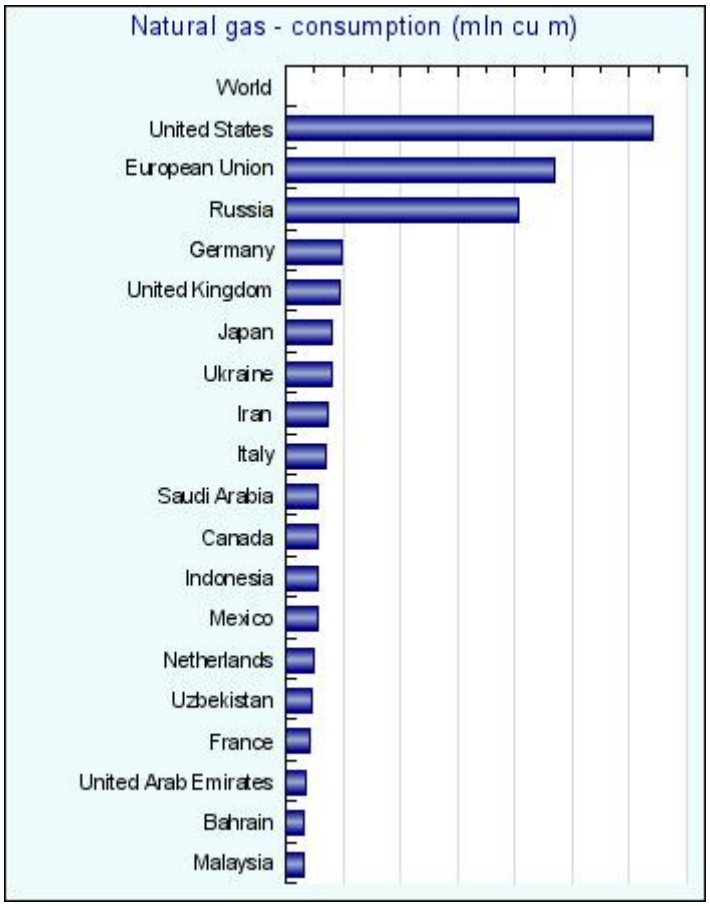

Figure 7: Natural Gas consumption by countries

	Country	2013	2020 target
1	Norway	65,5	67,5
2	Sweden	52,1	49
3	Latvia	37,1	40
4	Finland	36,8	38
5	Austria	32,6	34
6	Denmark	27,2	30
7	Estonia	25,6	25
8	Romania	23,9	24
9	Bulgaria	19	18
10	Italy	16,7	17
11	Spain	15,4	20
/	EU average	15	20
12	Greece	15	18
13	France	14,2	23
14	Germany	12,4	18

Figure 8: Percentage of renewable energy in gross energy consumption

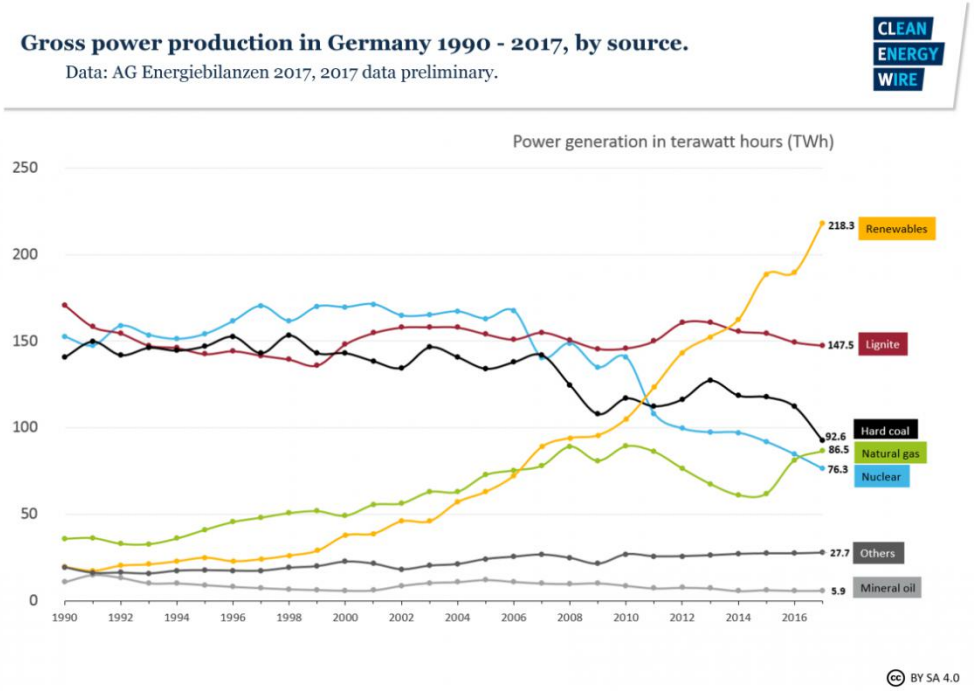

Figure 2: Gross power production in Germany

2. Nuclear Energetics in chosen states of USA

Plant	Units	Operating Company	Summer Net Capacity (MW)	Energy (million MWh)
Beaver Valley	2	FirstEnergy NOC	1,808	14.9
Davis-Besse	1	FirstEnergy NOC	894	7.1
Perry	1	FirstEnergy NOC	1,240	9.7
Three Mile Island	1	Exelon Nuclear	803	6.9
		Total:	**4,745**	**38.7**

Sources and Notes: EIA Form 906/923, data compiled by ABB Velocity Suite. Energy production is the annual average for 2013–2017.

Figure 9: Ohio and Pennsylvania Nuclear Plants to be retired

Year 2018. February. America is sustaining polar vortex. Coal stack are frozen. Diesel generators are not enough, and natural gas pipelines are choking as they could not keep with demand. Energy prices are skyrocketing, and what happened in Vermont four years in advance? Public opinion forced government to close Yankee Nuclear Plant in Vermont… in the same year inhabitants of Massachusetts opposed building of new pipelines. As effect in 2018 New England survived small energy crisis, but that was not that painful as it could. Because of nuclear power plants in states other than Vermont. In this time atomic power accounted for almost 30% of energy production. What would happen if similar movement like one in Vermont, forced other power plants to be closed?

Vermont Yankee was fifth greatest power source in whole New England contributing for 4% of its energy and 70% of Vermont. When we look at Figure 10 we can see that their hearts are at right place. Shares of energy consumption are shifting from coal and oil to natural gas which is more than two times more efficient when we talk about greenhouse gases by unit of produced electricity, but they are erasing magnificent three decades long progress of constant reducing carbon emission by closing next nuclear power plants (look at figure 11 and 12).

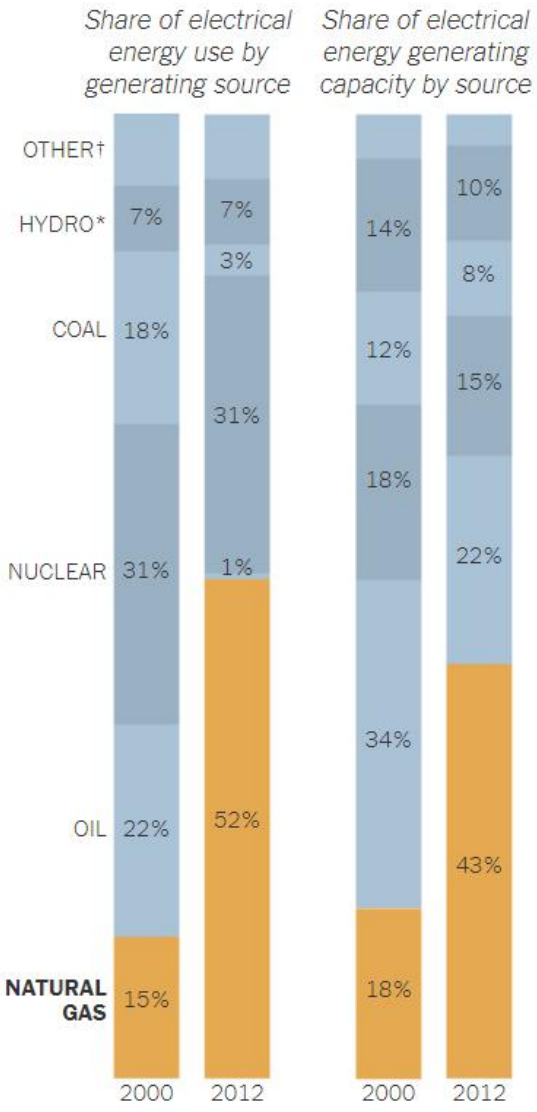

Figure 10: Energy usage shift in New England between 2000 and 2012

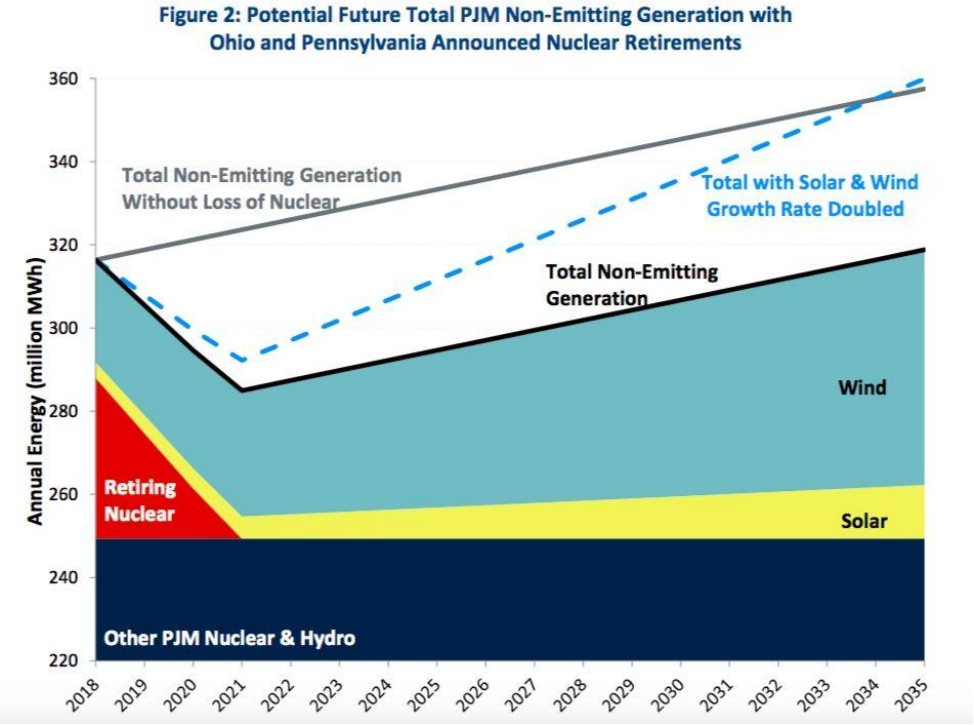

Figure 11: Expectation of clean energy production in Ohio and Pennsylvania after nuclear power plants retirement

Note that this will require next 18 years of constant, uninterrupted progress to achieve clean power generation level equal to this that two states have right now. This is long time in which we could advance even more especially when we consider that nuclear energy, when we already have built power plant and infrastructure, is second only to hydro-electricity in term of price and losing that source will definitely have its impact on economics what will make harder for new technologies to develop.

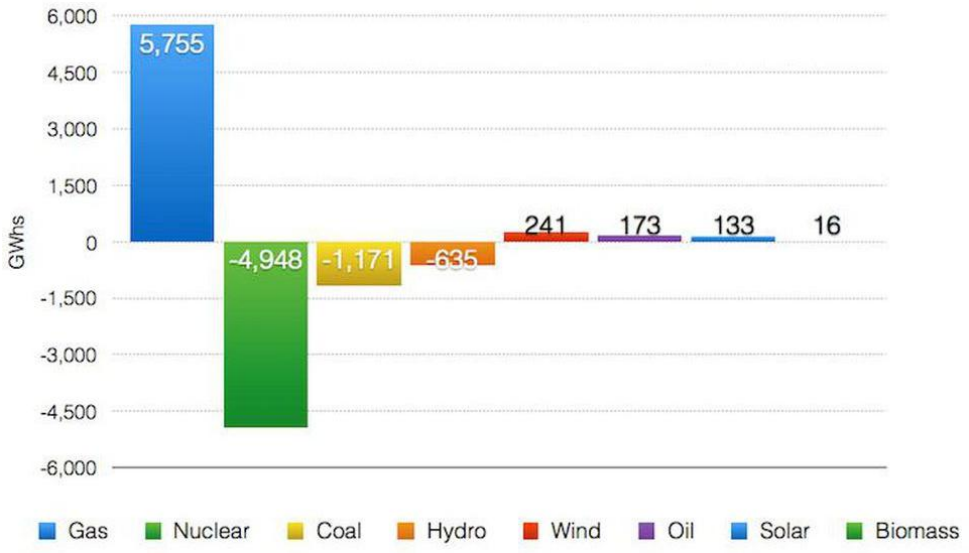

Figure 12: New England in-state electricity change 2014-2015

Closing nuclear power plants was supposed to be step to clean energetics (which is really strange argument as nuclear power is widely considered as clean) but we can see on figure 12 that it was not replaced by solar or wind power, and even not by biomass but almost completely by natural gas which is widely NOT considered as clean (but it is needed to give it its honor and admit that natural gas is much cleaner than coal or oil).

There is also idea to close nuclear plants at Palo Verde, Arizona. To some degree this can be understandable because Arizona has perfect conditions to generate power from photovoltaic cells, but that is illusory. When we look at figure 13 and 14 we can clearly see that even in such conditions single nuclear power plant generate 36% of it is energy, which simultaneously is 79% of it is clean energy. This numbers do not make it look good when we think about closing it.

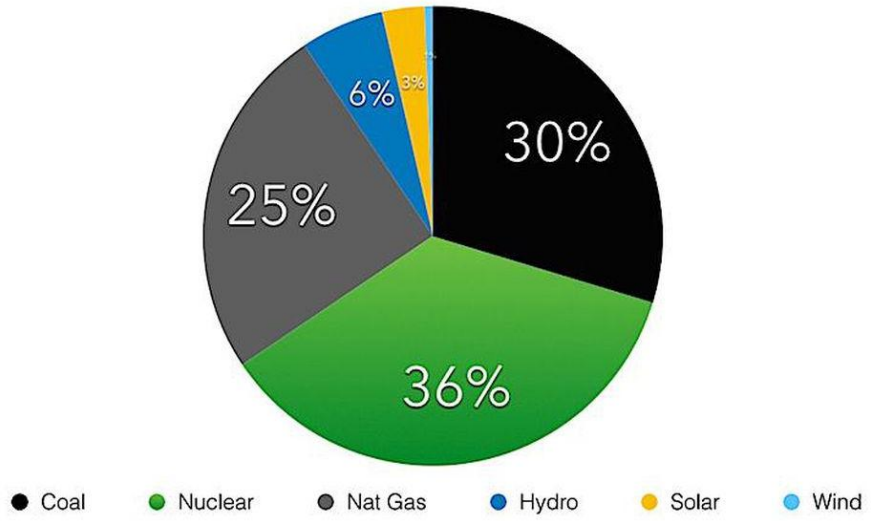

Figure 13: Shares of Arizona energy production

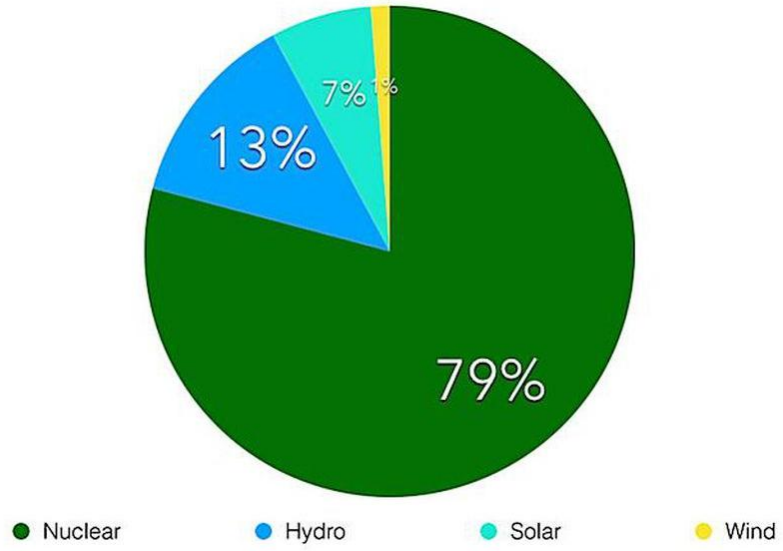

Figure 14: Shares of Arizona clean energy production

Great part of anti-nuclear movement is fear. Fear about "what will we do with nuclear wastes? They gonna radiate for next 50 000 years" or "what about deaths in accidents on nuclear plants?" or "Chernobyl", "Fukushima". So let us settle this topics one by one.

First of all, when uneducated people say "nuclear wastes that will contaminate earth for next thousand generations" those who did their research knows that today wastes are being reprocessed. Today most commonly used process is called PUREX which stands for **P**lutonium **U**ranium **R**edox **EX**traction, this is old hydrometallurgical process (and has story of abuse when in mid 40s Hanford Site released to river and air tremendous amounts of radiation in form of iodine-131) but our perspectives are electrometallurgical processes which whilst yet inoperational will allow us to reduce time of used fuel to deradiate to neutral levels in just 3 centuries, which do not seem to be that long period and even when we ignore that… we need to stop for the moment and think "what is radiation at all?", and one of possible answers would be "form of energy". Energy that can be used and i believe that we can expect to learn how to at least part of this energy (and thus reduce deradiation period) in upcoming decades. Others are afraid of deaths accidents, but this is story just like with bird and swine flu few years ago when new strain emerged and everyone panicked without listening to expert convincing that this strain is LESS infectious and LESS severe that classic flu but nobody cared. Media only listened to this few deaths caused by this particular strains. There is the same situation with nuclear energetics. Anti-nuclear movement says only about people who died on accidents on nuclear plants… but they give raw data. Without context, and when we look at data at figure 15 we can be astonished.

Energy source	**Mortality rate (in deaths/PWh)**	**Energy source**	**Mortality rate (in deaths/PWh)**
Coal (global)	100,000	Wind	150
Coal (US)	10,000	Hydro (global)	1,400
Oil	36,000	Hydro (US)	5
Natural Gas	4,000	Nuclear (global)	90
Biofuel/biomass	24,000	Nuclear (US)	0.1
Solar – rooftop	440		

Figure 15: Mortality rate in energetics by power source

Numbers are clear. Nuclear energetics is clearly most safe way to create energy if we measure that in human lives. And what about Chernobyl and Fukushima? First of them was stupid accident. Soviets were doing tests, and turned off safeties. All of them. That was literally result of them not knowing what they were doing. Ergo this is highly doubtful to recognize it as representative case. On the other hand something like that cannot be said about Fukushima, but that has to be remembered that its reactor meltdown was caused by tsunami, so there is one moral that should be acknowledged as common truth to NOT build power plant in area where tsunami, earthquake, tornado or any other natural disaster can destroy it. Japan is specific and cannot really eliminate this dangers, but US and Germany (which are main subject of this paper) can, so tragedy in Fukushima cannot be considered as good reason to close nuclear plants in those two countries.

3. Few facts and numbers about nuclear energetics

Uranium has almost 3 million times better energy output to weight ratio than widely today used coal, and we expect that in the earth crust there is 9 000 tons of uranium which matches all our resources of coal, of oil, of natural and shale gas (in our economic reach) all combined… multiplied fifteen-times-fold.

Dividing the atom is not the peak of our possibilities. If we could manage the synthesis of light nuclei (which is power source of stars) we could, in theory, catalyze $1{,}93*10^{-3}$TWh from each kilogram of water, and pessimistically $6{,}3*10^{-5}$ (which is still eight-thousand-times-fold more than from 1 kg of coal). This idea was described in 1978 by K.N. Muchin, but there was no big work on that subject in recent years, so probably this technology, for long time, will be far from our limits.

Uranium requires critical mass which can sustain reaction. That will be ~40 kg of element (around size of football). Without it neutrons will not meet enough atomic nuclei before leaving the body, and reaction will cease. That disclaims any chances for atomic-powered personal vehicles without any need to ever refuel (right now, best we can do are electric cars which use electricity generated in nuclear plants).

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