Nuclears Frequently Asked Questions (NFQs): Responses to Common Anti-Nuclear Perceptions & Myths

v2.0

This document is part of a suite of three documents, the others being 'Why Nuclear' and the 'Net Zero Needs Nuclear' Nuclear for Climate position paper. The three documents should be studied as a set.

The purpose of these NFQs is to concisely dispel myths and common questions lay people may have about nuclear energy. The document is split into six key common areas which are broken down into more detailed questions. The format of answering questions is to first detail a few key bullet points, next is to demonstrate the answer with an image (hosted on Imgur where possible) or video link. Finally, a detailed, peer reviewed reference is given where possible to backup the arguments and graphical items. The intent behind the responses within this document is not to be anti-renewables, but for it to be acceptable to accurately discuss the real risks and benefits of all energy technologies. Responses are generally reactive in nature to the query listed.

Advice to user

All common responses should fit into the "validate and reframe" method. This is a way to make the person feel that their opinion matters and they aren't conceding by listening to what you have to say. E.g.

- ***Validate**:*
  - *I hear you.*
  - *So that sounds like you feel that (repeat what they said back to them.)*
  -
- ***Reframe**:*
  - *What really surprised me as I started digging into this issue is that…*

See Volunteer Handbook - Advocacy - Google Docs *for further guidance on this methodology.*

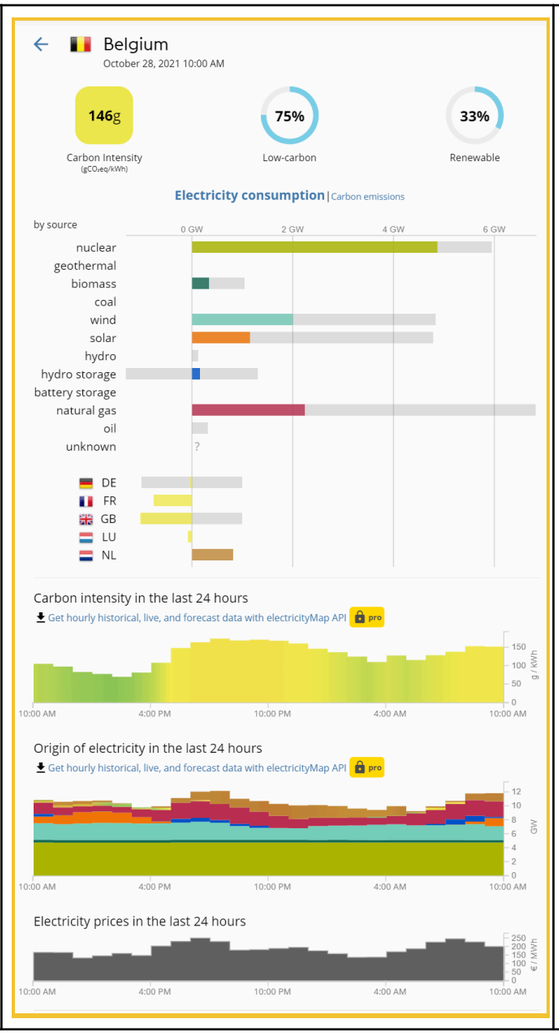
Ref	Question / Topic / Issue	Response	Image / Graphical / Video (Link)	Detailed References
1	**Safety**			
1.1	What about all the deaths from accidents?	• Yes the deaths are tragic, however when compared to all energy sources, nuclear comes out as having one of the lowest death rates, it is comparable with wind and solar.	Graphic showing death rates per energy source Table showing fossil fuel and nuclear health impacts	1. Our World in Data. 2. https://doi.org/10.1016/S0140-6736(07)61253-7 3. https://www.unscear.org/unscear/en/chernobyl.html 4. https://www.who.int/news/item/05-09-2005-chernobyl-the-true-scale-of-the-accident
1.2	What about Chernobyl?	• Chernobyl was a terrible disaster, but did you know that actually 31 people died as a direct result of the accident; two died from blast effects and a further 29 firemen died in the days that followed from radiation. • The long term deaths from radiation exposure are contested, and range from between 4,000 to 60,000. To put this in context, the Banqiao dam disaster of 1975 directly killed between 85,600-240,000 people in China. • Even when including the deaths from Chernobyl, nuclear still shows one of the lowest death rates for an energy source.	Graphic showing death rates per energy source	1. Our World in Data. 2. https://doi.org/10.1016/S0140-6736(07)61253-7 3. https://www.unscear.org/unscear/en/chernobyl.html 4. https://www.who.int/news/item/05-09-2005-chernobyl-the-true-scale-of-the-accident
1.3	What about Fukushima?	• Did you know that only 1 person died from radiation at Fukushima? • Nearly 600 people died from rushed evacuations that didn't necessarily need to happen, due to fear of the radiation. • The Fukushima accident showed that fear of radiation can be more damaging than radiation itself.	https://ourworldindata.org/grapher/estimated-mortality-from-fukushima-nuclear-disaster Zion lights explaining Fukushima	Our world in data lists references.
1.4	Fukushima Tritiated water release	• The release will be at a level below the operational target value for tritium discharge of the Fukushima Daiichi plant before the accident." These discharge amounts are well within the standard range of the amounts from any operational nuclear power station around the world. • The radiation levels are trivial – drinking 1L contains dose equivalent to eating 4 bananas. •	Japan Will Release Radioactive Fukushima Water Into The Ocean, And Why That's O.K. (forbes.com) Tritium - aka radioactive hydrogen - from reactors is not a threat to human health - Atomic Insights	[INFORMATION WELCOMED]
1.5	What about Three Mile Island...	• There were no injuries or adverse health effects from the Three Mile Island accident.	[INFORMATION WELCOMED]	1. The Kemeny Report 2. NRC TMI Overview 3. https://doi.org/10.1038/nenergy.2017.51
1.6	Nuclear carries an "Unacceptable Risk"	• We all take risks in everyday life, a report 'the tolerability of risk' was produced in the 1970s to show the risks of activities and what people deemed was acceptable or unacceptable. This report has informed the level of 'acceptable risk' from nuclear installations. Nuclear installations are	Graphic showing death rates per energy source	1. https://www.onr.org.uk/documents/tolerability.pdf

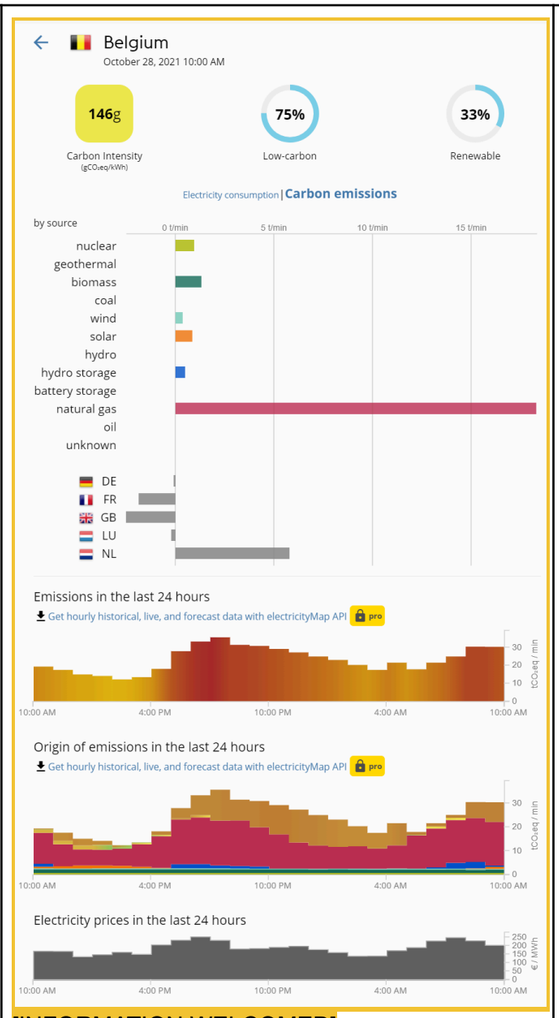
		designed using these standards using a multi layered defence in depth approach to safety, security and protection of the environment. • The nuclear industry is strongly regulated to these standards so the risks are very well managed. • The risk of unmitigated climate change is far, far worse, especially as there is scientific consensus around the continued use of nuclear energy. • The risk of death from wind and solar energy are as low as nuclear energy.		
1.7	Vulnerability to terrorist attack	• Nuclear installations are designed using a multi layered defence in depth approach to security, safety and protection of the environment. This involves measures to effect physical, cyber and human security.	[ideas on potential image/diagram welcomed] Sandia F4 Phantom - 1988 "Rocket-sled test" - YouTube	1. OPAL Reactor with external steel cage
1.8	Cancer risk (and look at all these anecdotal stories of people getting cancer)	• Radiation from nuclear plants accounts for less than half of 1% of all the radiation you receive, Significant amounts are natural sources, e.g. Radon in the ground. • In the UK and EU, any practice involving the use of ionizing radiation must clearly outline and demonstrate how the benefits of such radiation outweigh any consequences before being allowed to operate.	Banana radioactivity compared to a nuclear power plant Radiation from all sources in the UK	1. EUs JRC report (key conclusion page 7) 2. PHE Report
2	**Spent Fuel / Waste**			
2.1	Has to be stored for 10,000s years	• All forms of energy production form waste. The nuclear industry is no different, but our waste is carefully treated and stored and unlike other forms of waste, the toxicity of ours reduces over time. • The amount of nuclear waste is relatively small and since the 1940s, the UK has accumulated nuclear waste from medical, research, power, industrial and defence uses. • The UK produces 1 Albert Hall's worth of domestic putrescible waste per day. The UK only has about 5 Albert Hall's worth of radioactive waste, over 90 % of which is LLW.	45 years of Swiss nuclear waste	1. EUs JRC report (key conclusion page 8) 2. UK RWI
2.2	Dangerous / toxic waste	• More than 90% of spent fuel can be recycled • All waste from nuclear power plants is carefully treated and stored such that it cannot cause harm, • The toxicity of radioactive waste reduces over time.	Huggin spent nuclear fuel in dry casks in the USA 45 years of Swiss nuclear waste	1. Spent Fuel Pool (xkcd.com) 2. Example report (probably not the best one rn) - https://www.boell.de/sites/default/files/2019-11/World_Nuclear_Waste_Report_2019_Focus_Europe_0.pdf
2.3	Waste problem hasn't been solved	• The waste problem has been solved and there is broad scientific consensus on disposal (see 2.1) • More than 90% of spent fuel can be recycled • LLW and ILW is currently safely packaged and stored worldwide as it has been since the 1940s. • The burden of unmitigated climate change is much, much worse. • Shouldn't necessarily be considered "waste" - medical isotopes can be harvested	Spent Fuel Storage at Diablo Canyon Power Plant - YouTube	1. EUs JRC report (key conclusion page 8) 2. https://www.posiva.fi/en/index.html
2.4	Running out of space / Volume of waste	• As nuclear energy is very dense, the waste created is incredibly small. Consider that a golf-sized lump of uranium, approximately 780g, can deliver enough energy to cover all your lifetime energy use. • The lifetime nuclear waste produced for an individual, if all their energy needs came from nuclear, would fit in a small aluminum drink can. The high level waste would be about 1/10th of this can in volume.	[INFORMATION WELCOMED]	[INFORMATION WELCOMED]
2.5	Nuclear emits gases and other elements which are dangerous to health	• The lifecycle assessment of nuclear power shows that it emits very low levels of pollutant gases during its lifecycle which includes mining of uranium through to decommissioning. The majority of these are lower than renewable technologies.	[INFORMATION WELCOMED]	1. EUs JRC report (key conclusion page 9) 2. Nuclear Power prevented mortality J.Hansen / A.Kharecha
3	**Economics / Cost**			

3.1	It's too expensive	• Salient point is large upfront capital cost which can be addressed through particular financing mechanisms e.g. Regulated Asser Base (RAB).
		• In fact it's one of the cheapest. The IEA stated that 'electricity generation from nuclear power plants is the dispatchable low-carbon technology with the lowest expected costs in 2025'.
		• Nuclear adds robust system value as there is extremely high confidence in when it can be run.
		• The IEA says that nuclear is required in the low cost scenarios to NetZero
		• Nuclear costs include externalities e.g. full waste management that other technologies do not include/account for.
		• On levelised cost of electricity (LCOE), UK context.
		  ○ 1. Comparing LCOE is not equivalent to comparing energy costs to the consumer. Look at the components of your electricity bill! Rising systems costs due to intermittency means we pay more than just the low LCOE of wind (c. £40/MWh) as you must allow for cost of back up etc.as well as new transmission systems for decentralised network, the need for H2 as energy storage etc. as well as renewable obligations in our bills. Waste & Decomm isn't included either for these wind farms.
		  ○ 2. We currently don't have any of the "cheap" wind (£40/MWh) turbines operating. What is currently on the grid is the early farms with a fleet average CfD of just above £100/MWh. We are yet to see the new turbines built)
		  ○ 3. FOAK Wind energy started of at CfDs of over £150/MWh (c.f. £92/MWh for HPC) and reduced it's costs by learning by doing. Nuclear can do the same.
		  ○ 4. According to the Treasury Infrastructure Report 2020 the UK tax payer pays £10bn every single year in subsidies for renewables (NIS page 50).
			Global annual investment in energy from IEA Net Zero Roadmap
			
			HPC CfD Strike Price Breakdown
			
			[INFORMATION WELCOMED]
				1. National Infrastructure Strategy Report
				
				2. ETI Nuclear Cost Drivers
				3. https://world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx
				4.

3.2	It would be cheaper to use VRE + Storage	• The IEA says that nuclear is required in the low cost scenarios to NetZero • A diverse energy mix of renewables and nuclear can deliver reliable, secure and affordable energy costs. Net Zero requires more than decarbonisation of current electricity grid (e.g. heating/transport), electrification of other sectors will likely lead to 2-3 times increase in grid size. [FURTHER INFORMATION WELCOMED]	Energy costs from different sources - Long Term Operation from Nuclear, and Nuclear is low.- IEA	
3.3	"A dollar spent on nuclear is a dollar not spent on renewables" (Opportunity Cost)	• Pitching low carbon technology against low carbon technology only serves fossil fuel interest. Given the urgency of the situation we'd prefer a dollar for both! • Fundamentally it is a dollar spent on low-carbon technology + (see other points within this section demonstrating value for money comparable to renewables (£/kWh) and need for diverse energy mix) • Nuclear cannot be directly compared against renewables. While renewables have certain advantages over nuclear, it works vice versa, nuclear being a flexible, always-on source of energy. Therefore we need both, not one or the other! [FURTHER INFORMATION WELCOMED]	[INFORMATION WELCOMED]	[INFORMATION WELCOMED]
3.4	Nuclear has been subsidised for years, it can't sustain itself	• All energy systems are subsidised to a degree, fossil fuels receive significantly more subsidies than nuclear. • All costs for energy tech are either paid by us the consumer or via out taxes – salient point is that this is driven by overall system operation costs including externalities. Optimal system cost requires diverse mix including Nuclear. • Diablo Canyon despite an incredibly hostile regulatory environment (wind/solar subsidies, often driving costs negative etc.) is a profitable plant within the Californian grid. [FURTHER INFORMATION WELCOMED]	[INFORMATION WELCOMED]	[INFORMATION WELCOMED]
3.5	Insurance of nuclear asset requires tax			

	payer subsidy through sovereign financial backing (i.e. cannot be privately financed)			
4	**Technological Redundancy**			
4.1	Nuclear is not required to reach Net Zero	• "All illustrative pathways the IPCC have recognised that allow us to remain within 1.5C of warming show there to be a substantial increase in nuclear power in the coming decades" • The IEA's Net Zero roadmap shows a significant increase in nuclear to reach Net Zero • Although technically Net Zero can theoretically be achieved via the exclusion of any one technology, the hypothetical path to Net Zero while excluding nuclear is highly risky, requires extreme behavioral changes to lifestyles and places a higher dependance on technologies that have not be demonstrated at commercial scale yet e.g. CCS.	YGN Infographic on IPCC 1.5 Pathways. https://imgur.com/gallery/QX9oKXI https://imgur.com/gallery/C5NTzey	IPCC SR15 Summary for Policy makers - 4 Illustrative Pathways Mitigation pathways
4.2	Nuclear has had its chance, time for "new" renewables	• Actually it's time for both. Both forms of technology are required to meet our net zero targets.	[INFORMATION WELCOMED]	Development of PV This Month in Physics History (aps.org) Timeline of solar cells Development of Wind History of Wind Turbines | Renewable Energy World History of wind power - Wikipedia
4.3	Nuclear is not compatible with renewable energy	• Nuclear is flexible and can load follow e.g. France, reactors can be designed to ramp up and down at a comparable rate to CCGT. • Nuclear and renewables are both low carbon sources of energy. In times of low demand, reactors at full power can divert their energy to be used in the production of hydrogen and synthetic fuels to help decarbonize aviation and transport and other difficult to decarbonize sectors.	[INFORMATION WELCOMED]	See Moltex design [INFORMATION WELCOMED]

4.4	We can use/rely on gas as a “bridge fuel” to support renewables.	• Gas is a fossil fuel producing c. 20 times more CO2/kWh than wind or nuclear. CCUS technology is not available at scale, v.high technological risk. • Nuclear is flexible and can integrate with intermittent renewables (see 4.3) in the same way but without the carbon emissions. • In the UK, Gas is already the largest electricity source and primary contributor to emissions. Recent European gas crisis showed consequences of relying on volatile, polluting, imported gas from places such as Russia. • Gas prices hit as high as £5,000/MWh c.50 times higher than HPC CfD. • Twin unit EPR such as SZC (3.2 GW) could displace reliance of 5.4 billion m3 of gas (1.4m Olympic swimming pools).		[INFORMATION WELCOMED]

			 [INFORMATION WELCOMED]	
5	**Sustainability**			
5.1	It’s not low carbon technology / doesn’t reduce emissions	• zero carbon at point of generation, IPCC consider it to be comparable to have carbon intensity of wind generation c.12g/kWh and lower than solar. • Supply chain emissions can over time be reduced further via increased electrification - Swedish plants have nuclear plants producing at ISO certified 4g/kWh • long term operation increases “return on carbon investment” of construction steel, concrete etc, plants running 50 to 100% longer, may even go beyond that!	lifecycle-carbon-emissions-nolabel.png (1920×1440) (whatisnuclear.com)	[INFORMATION WELCOMED]
5.2	It’s not renewable / not enough uranium	• Nuclear is in fact renewable. The United nations body (WCED) that coined the term ‘sustainable development’ stated that nuclear fission technologies, specifically breeder reactors, are renewable. • The sun will exist for about 8 billion years, we have enough uranium for about 4 billion years. • Renewable sources of energy still require machines to capture the energy, due to the energy density of nuclear fuel, we need fewer materials to harness the energy than conventional renewables.	[INFORMATION WELCOMED]	Nuclear fuel will last us for 4 billion years (whatisnuclear.com) OEC-NEA Uranium 2020
5.3	It takes too long to build	• French experience in rapidly decarbonising with nuclear through Messmer Plan. • South Korean project experience and approach to APR1400 construction. • Learn through doing [FURTHER INFORMATION WELCOMED]	Rollout of nuclear power peaked at 30GWe per year in 1984	Ch 24 Page 171: Sustainable Energy - without the hot air | David MacKay (withouthotair.com) WNA Report (includes timescales)

5.4	Waste places burden on future generations	• The burden of unmitigated Climate Change is far worse • No energy technology is without their own waste concerns, nuclear's is comparable to other technologies; unrecyclable turbine blades, rare earth elements and toxic chemical waste from PV manufacture (these don't decay). Nuclear offers one of the best environmental benefits/harm ratios! • The volume of SNF is incredibly low and we know how to manage it. Challenge is not technical merely a "political football" – see Section 3 on SNF/Waste for further details.	[INFORMATION WELCOMED]	[INFORMATION WELCOMED]
5.5	It will take (15/20) years to offset carbon emissions from construction of NPP	• Realistic models suggest it only takes a matter of months e.g. HPC • The models which yield these figures use overly pessimistic assumptions at every interval e.g. Incredibly low grade ore refined using least energy efficient means powered by coal. [FURTHER INFORMATION WELCOMED]	[INFORMATION WELCOMED]	HPC/SZC Sustainability Report [FURTHER INFORMATION WELCOMED]
5.6	NPP are often built on coast which makes them more vulnerable to sea level rise	• Delaying response to climate change by not using all tools available increases likelihood of sea level rise. • Nuclear power plants are built to withstand natural and man-made hazards including rising sea levels, flooding and climate change [FURTHER INFORMATION WELCOMED]	*Topographic map of Netherlands?* [INFORMATION WELCOMED]	[INFORMATION WELCOMED]
5.7	Resource use	• *Generation Atomic comprehensive chart*	Minerals required per energy source Raw materials per gigawatt hour.png - Google Drive	The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA
5.8	Social/Environmental Impact of mining (links to broader point re: Environmental Justice -abandoned legacy mines, particularly impacting indigenous communities)	• All energy technologies require minerals/ore and they should be obtained in the most sustainable method. Historical poor practices are no longer performed. • Key aspect is energy output per "unit" resource. See 5.7 above. • Modern mining utilises modern techniques - In-Situ Recovery • [FURTHER INFORMATION ON LEGACY MINES WELCOMED]	*Similar images to resource use?* *ISR mine?* [INFORMATION WELCOMED]	[INFORMATION WELCOMED]
6	**Proliferation Risk**			
6.1	Civil Nuclear supports Nuclear Weapons	• All civil nuclear facilities are subject to safeguarding and export control to control any export of sensitive technology. The same is true of aerospace, communications, space, lasers, materials and military equipment. • Civil nuclear subject to independent IAEA Safeguarding to ensure non-proliferation. • Many countries with civil nuclear programmes have no weapons - Japan, Canada, South Africa. • The biggest disarmament activity in history involved reprocessing weapons material to allow it to be used as a fuel for reactors ("Megatonnes to Megawatts") •	[INFORMATION WELCOMED]	Megatonnes to Megawatts [INFORMATION WELCOMED]
6.2	"A reactor can be made into a bomb"	• The configuration and enrichment of nuclear fuel means that it physically can't explode. The design ensures that the material releases its energy slowly and in a controlled manner, such that • Producing weapons material from a modern commercial power reactor is incredibly inefficient compared to other technologies and is further mitigated by independent IAEA safeguarding - it would be easier to make a nuclear bomb from scratch then to build it from a material used in a power reactor	[INFORMATION WELCOMED]	[INFORMATION WELCOMED]

Resources

Website	Notes
https://whatisnuclear.com/	
https://www.withouthotair.com/	
https://ourworldindata.org/energy	Useful resource collating data in graphical format
https://www.terrapraxis.org/general-1	
https://www.electricitymap.org/map	
The ExternE project series	Vol. 5 on nuclear
210329-jrc-report-nuclear-energy-assessment_en.pdf (europa.eu)	EU JRC report of nuclear sustainability
https://unece.org/sites/default/files/2022-01/LCA_final-FD_0.pdf	UNECE Lifecycle Analysis
NIA UK | Nuclear Energy Facts - NIA UK	
IAEA Briefs and Factsheets | IAEA	
Net Zero by 2050 - A Roadmap for the Global Energy Sector (windows.net)	
Nuclear power in a clean energy system - Event - IEA	Some useful slide packs hyperlinked from this page
Nuclear Power in a Clean Energy System (windows.net)	
https://link.springer.com/content/pdf/10.1007%2F978-94-6265-495-2.pdf	**Nuclear Law**

https://mobile.twitter.com/OperadorNuclear/status/1008262195795423233