Fight carbon: why ALARA should become the leading principle of electric power generation infrastructure planning

by Stephen E. Aplin • January 7, 2015 • 12 Comments

As **L**ow **A**s **R**easonably **A**chievable. ALARA for short. This regulatory requirement for the design of nuclear power plants means, in the words of the Health Physics Society, "making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical." Because dose limits were guided more by politics than health physics, and because the politics involved public fear of nuclear war, ALARA seemed the moral way to go. In the mood that prevailed at the time, to question the reasonableness of the dose levels—let alone the reasonableness of designing as far below them as possible—was to question the morality of opposing nuclear war. For this reason, few people dared to question it. The heavy emphasis on the possibility, however remote, that ionizing radiation might cause harm (when the possibility also exists that will cause no harm at all), was a product of the anti-weapons morality. ALARA today, in the nuclear power field, serves no practical purpose other than to require over-engineering of new nuclear plants for no increased safety benefit or risk mitigation; in effect serving only to impose unreasonable obstacles and costs to building nuclear plants, which are already by far the safest power generation plants in the world.

How reasonable is it to require electric power utilities to reduce CO_2 as much as possible? Germany, which has failed to reduce CO_2 since it embarked on its much-vaunted Energy Transition, might think it is not reasonable. But France, which cut itsCIPKby about 90 percent over a short decade and a half beginning in 1974, would find it very reasonable. Who is right?

But when it comes to other types of power generation, ALARA, as a guiding principle, is useful. Hugely useful, in fact. If ALARA were applied to planning across the entire power sector, not just nuclear, and if it referred to carbon emissions instead of ionizing radiation (the mitigation of which was easily mastered in the early days of non-weapon nuclear engineering), then we could very easily and quickly eliminate enormous amounts of carbon emissions from power generation.

For ALARA to work in minimizing carbon, regulatory authorities would have to become as familiar with such terms as CIPK as nuclear regulatory authorities are with terms like becquerel or curie, gray or rad, and sievert or rem. Fortunately for the carbon regulators, CIPK is easy to comprehend and communicate.

Once regulatory authorities, and the general public, become familiar with CIPK, the easy and fast route to massive CO_2 reductions will become immediately obvious.

And if there was ever a time to apply easy and fast solutions to an existential problem, this is it. Item A1 in the upper left shows the current concentration of CO_2 in the air at the Mauna Loa CO_2 observatory. It just dipped below 400 parts per million, but it will soon rise above 400 and will stay there, permanently, until we humans quit dumping so much CO_2 into the air.

Here is a presentation that lays out how we can quickly and easily achieve giant-size CO_2reductions.

1. Andrew Jaremko *January 7, 2015 at 12:48 pm*

Steve – thanks for the presentation. I hope you'll be giving it in person at as many venues as you can.

In the text of this post, about the only thing I'd comment on is that nuclear doesn't just minimize, or make As Low As Reasonably Achievable, carbon emissions. It's ALARA for materials use in building power plants. It's ALARA for mass and volume of fuel used and all residuals generated, even for enriched uranium light water reactors. It's ALARA for the land use footprint of the power plant. I think the list could go on for a while.

Thanks again! I've been waiting to see this presentation.

Reply

2. *Stephen E. Aplin* *January 7, 2015 at 1:43 pm*

Andrew, thanks — good point, the ALARA list could go on and on. But I especially like it for "fuel used and residuals generated" — we are talking about one 20 gram uranium fuel pellet versus more than 400 litres of oil.

You could carry the pellet in your pocket and not even notice it, but you'd need two and a half oil barrels to carry 410 litres.

On the waste side, after creating enough energy to power a 4-person home for one-and-a-half months, the pellet is still roughly 20 grams.

The 410 litres of oil are now roughly 0.9 metric tons of CO2, and if you wanted to store and sequester it, you would need over 3,000 oil barrels to hold it.

It is pretty easy to see which generation type we would choose if we were required to follow ALARA in the area of fuel used and residuals generated.

Reply

3. Ed Pheil *January 10, 2015 at 5:00 am*

ALARA should be stricken from all use because it has no bottom. By definition that is NOT reasonable. Every time you reach a reasonable level, the next lower level becomes reasonable to someone even though it is at a totally unreasonable level. It is one of the things used to drive up the cost of nuclear to unreasonable level.

Driving energy cost through the roof would cause massive poverty and increased death rates that cheaper energy rates allowed.

I am pro-nuclear, but also pro-reason, and ALARA does not use reason.

Reply

- *fireofenergy* *January 12, 2015 at 1:04 am*

If coal's fly ash had to be restricted by the same rules of ALARA, I believe nuclear would by far, prevail, since it is slightly radioactive and in very much larger volume.
So, even without consideration for excess CO2, nuclear should still "win".

As for excess CO2, *diesel* may be the best energy choice to conquer it. A carbon tax could pay for an entire new industry which extracts, pulverizes and distributes olivine rock to sequester hundreds of gigatons via magnesium carbonate. Such a process is said to emit far fewer emissions than that sequestered. And should be benign. Search Shuiling olivine.

Reply

- fireofenergy *January 12, 2015 at 1:06 am*

That's Schuiling (not Shuiling, sorry)

Reply

- *Stephen E. Aplin* *January 12, 2015 at 12:21 pm*

Ed — if we were to apply ALARA to fossil and relax it for nuclear we'd get what we should get: low cost AND low carbon. Here in Ontario our ALARA-genic price for nuclear electricity is still the second-lowest of the major generating "fuels" (hydro is the lowest).

i.e., the generation type that makes the most electricity the most reliably and with zero carbon per kWh, and that is the only one in which the (low) rate pays up front for decommissioning and long-term used fuel management, is the second-cheapest. It could be cheaper per kWh if we added more of it without bogging it down with excessively ALARA-driven regulation.

I totally agree with your position on poverty caused by excessive energy prices. But I strongly believe that an ALARA approach to fossil would direct investment into nuclear which is proven low-cost and zero-carbon.

The CO2 concentration in the atmosphere is 400 ppm and rising, and we're running out of time. We need massive economy-friendly GHG reductions, asap. Only nuclear has proven it can quickly achieve this.

Reply

Peter Lang *January 12, 2015 at 10:16 pm*

Ed Pheil,

I agree 100%. ALARA should be stricken from all use. It says nothing about what is economically rational, nothing about the costs, etc. It is great to support scaremongering. And it is irrational to use it to support one cult belief and argue it is not appropriate for another.

ALARA should be replaced by AHARS (as high as relatively safe).

The word relatively is important and useful. If AHARS was applied to nuclear, and the criterion was fatalities per TWh on a life cycle analysis basis, I believe all followers of Stephen Aplin would know what this would mean for the relative constraints on nuclear v fossil fuels (and indeed renewables).

I'd advocate dropping ALARA completely and replacing it with AHARS.

Wade Allison (retired professor of physics at Oxford University) has been promoting this for some time.

Reply

4. ### Peter Lang *January 12, 2015 at 10:07 pm*

I am far from persuaded that regulatory approaches such as carbon pricing or mandating renewable energy are viable. In fact, I am strongly persuaded they are highly unlikely to succeed (with some experience having been involved in this since 1991). It is the wrong approach, IMO. There is a better way that has high probability of success.

I use William Nordhaus' DICE-2013R model, the most widely accepted and cited model for projecting global climate damage costs, social cost of carbon and the abatement cost with various policies to demonstrate why carbon pricing is highly unlikely to succeed. See Part 1 and Part 2 here:

Part I: "Why carbon pricing will not succeed"

http://catallaxyfiles.com/2014/10/26/cross-post-peter-lang-why-carbon-pricing-will-not-succeed-part-i/

Part II: "Why the world will not agree to pricing carbon"

http://catallaxyfiles.com/2014/10/27/cross-post-peter-lang-why-the-world-will-not-agree-to-pricing-carbon-ii/

Reply

Peter Lang *January 13, 2015 at 8:11 pm*

Stephen,

Since you are interested in policy and I am too, I hope I can post a long post and not overdo my welcome here. It explains some of my high level arguments of what I believe is the pragmatic way we should proceed, what policies are most likely to succeed in the real world, where we should focus our efforts to influence policy towards policies that have a high probability of succeeding over the long term.

Nuclear power is the least cost and fastest way to substantially cut GHG emissions from electricity

1 Energy supply requirements

The most important requirements for energy supply are:

1. Energy security (refers to the long term; it is especially relevant for extended periods of economic and trade disputes or military disruptions that could threaten energy supply, e.g. 1970's oil crises [1], world wars, Russia cuts' off gas supplies to Europe).

2. Reliability of supply (over periods of minutes, hours, days, weeks – e.g. NE USA and Canada 1965 and 2003[2])

3. Low cost energy – energy is a fundamental input to everything humans have; if we increase the cost of energy we retard the rate of improvement of human well-being.

Policies must deliver the above three essential requirements. Second order requirements are:

4. Health and safety

5. Environmentally benign

1.1 Why health and safety and environmental impacts are lower priority requirements than energy security, reliability and cost:

This ranking of the criteria is what consumers demonstrate in their choices. They'd prefer to have dirty energy than no energy. It's that simple. Furthermore, electricity is orders of magnitude safer and healthier than burning dung for cooking and heating inside a hut. The choice is clear. The order of the criteria is clearly demonstrated all over the world and over thousands of years – any energy is better than no energy.

2 Nuclear better than renewables

Nuclear power is better than renewable energy in all the important criteria. Renewable energy cannot be justified, on a rational basis, to be a major component of the electricity system. Here are some reasons why:

1. Nuclear power has proven it can supply over 75% of the electricity in a large modern industrial economy, i.e. France, and has been doing so for over 30 years.

2. Nuclear power is substantially cheaper than renewables

3. Nuclear power is the safest way to generate electricity; it causes the least fatalities per unit of electricity supplied.

4. Nuclear power is more environmentally benign than renewables.

5. ERoEI of nuclear is ~75 whereas renewables are around 1 to 9. An ERoEI of around 14 is needed to support modern society. Only nuclear, fossil fuels and hydro meet that requirement.

6. Material requirements per unit of electricity supplied through life for nuclear power are about 1/10th those of renewables

7. Land area required for nuclear power is very much smaller than renewables per unit of electricity supplied through life

8. Nuclear power requires less expensive transmission (shorter distances and smaller transmission capacity in total because the capacity needs to be sufficient for maximum output but intermittent renewables average around 10% to 40% capacity factor whereas nuclear averages around 80% to 90%).

9. Nuclear fuel is effectively unlimited.

10. Nuclear fuel requires a minimal amount of space for storage. Many years of nuclear fuel supply can be stored in a warehouse. This has two major benefits:

• Energy security – it means that countries can store many years or decades of fuel at little cost, so it gives independence from fuel imports. This gives energy security from economic disruptions or military conflicts.

• Reduced transport – nuclear fuel requires 20,000 to 2 million times less ships, trains etc. per unit of energy transported. This reduces shipping costs, the quantities of oil used for the transport, and the environmental impacts of the shipping and the fuel used for transport by 4 to 6 orders of magnitude.

There is no rational justification for renewable energy to be mandated and favoured by legislation and regulations.

2.1 Nuclear cheaper and lower emissions than renewables
Renewables v Nuclear: Electricity Bills and Emissions reductions by technology proportions to 2050

The CSIRO 'MyPower' calculator shows that, even in Australia where we have cheap, high quality coal close to the main population centres and where nuclear power is strongly opposed, nuclear power would be the cheapest way to reduce emissions:

http://www.csiro.au/Outcomes/Energy/MyPower.aspx

MyPower is an online tool created by CSIRO that allows you to see the effect of changing the national 'electricity mix' (technologies that generate Australia's electricity) on future electricity costs and Australia's carbon emissions.

Below is a comparison of options with different proportions of electricity generation technologies (move the sliders to change the proportions of each technology). The results below show the projected change in real electricity prices and CO2 emissions in 2050 compared with now.

Change to 2050 in electricity price and emissions by technology mix:

1. 80% coal, 10% gas, 10% renewables, 0% nuclear:
electricity bills increase = 15% and emissions *increase* = 21%

2. 0% coal, 50% gas, 50% renewables, 0% nuclear:
electricity bills increase = 19% and emissions *decrease* = 62%.

3. 0% coal, 30% gas, 10% renewables, 60% nuclear:
electricity bills increase = 15% and emissions *decrease* = 77%.

4. 0% coal, 20% gas, 10% renewables, 70% nuclear:
electricity bills increase = 17% and emissions *decrease* = 84%.

5. 0% coal, 10% gas, 10% renewables, 80% nuclear:
electricity bills increase = 20% and emissions *decrease* = 91%.

Source: CSIRO 'MyPower' calculator

Points to note:

• For the same real cost increase to 2050 (i.e. 15%), BAU gives a 21%*increase* in emissions c.f. the nuclear option a 77% *decrease* in emissions (compare scenarios 1 and 3)

• For a ~20% real cost *increase*, the renewables option gives 62%*decrease* c.f. nuclear 91% *decrease* in emissions (compare scenarios 2 and 5).

• These costs do not include the additional transmission and grid costs. If they did, the cost of renewables would be substantially higher.

3 Conclusion:

Nuclear is the least cost way to significantly reduce the emissions intensity of electricity.

The difference is stark. Nuclear power is far better.

But progress to reduce emissions at least cost is being thwarted by the anti-nuclear activists.

Reply

5. *Rick Maltese* *January 22, 2015 at 4:09 am*

Peter Lang bravo for a well thought out hierarchy of how to rank the what needs to be taken into account. Just one point I am still not sure about and that is calling safety a secondary concern. It get's more than enough attention in the nuclear energy business but that does not necessarily mean it deserves a lower ranking. I want to hear you elaborate on safety. The safer than Dung or indoor burning and any energy is better than no energy seems a like weak arguments. You seem to be saying the average person accepts the risk therefore so should the builder of the reactor. I think that proof of safety goes a long way. There is currently too little room for error in reactor designs. Safety has been a first level priority but it needs reality glasses. So I suggest keep it a level 1 priority but redefine what how safe the reactors need to be.

Reply

6. Peter Lang *January 23, 2015 at 4:27 am*

Rick Maltese,

Thank you for your question. This is how I see it.

Nuclear is about the safest way to generate electricity. This has been demonstrated by most of authoritative studies since the 1970's or before. Here is a summary of many authoritative studies:

http://www.forbes.com/sites/jamesconca/2012/06/10/energys-deathprint-a-price-always-paid/

Energy Source Mortality Rate (deaths/trillion kWh)
Coal – global average 170,000 (50% global electricity)
Coal – China 280,000 (75% China's electricity)
Coal – U.S. 15,000 (44% U.S. electricity)
Oil 36,000 (36% of energy, 8% of electricity)
Natural Gas 4,000 (20% global electricity)
Biofuel/Biomass 24,000 (21% global energy)
Solar (rooftop) 440 (< 1% global electricity)
Wind 150 (~ 1% global electricity)
Hydro – global average 1,400 (15% global electricity)
Nuclear – global average 90 (17% global electricity w/Chern&Fukush)

Given that nuclear is the safest way to generate electricity, if nuclear displaces any other technology it reduces fatalities (i.e., it saves lives on average over the long term). Replacing all coal generation with average Gen II nuclear plants overnight would avoid over 1 million fatalities per year – over 2 million per year by 2050 (even better with Gen III+ plants).

Therefore, delaying nuclear rollout is causing fatalities that could otherwise be avoided.

The impediments that the developed countries – especially USA and its NRC – have imposed on nuclear power are causing nuclear power to be far more expensive than it could and should be. If those impediments were reduced, nuclear would become much cheaper over time. Then it would roll out faster and this would save lives.

The best thing we can do to improve safety is to remove the regulatory impediments, allow the industry to compete with other (less safe) technologies on a level playing field – allow competition and innovation to develop nuclear technologies to meet what the market wants. The market will demonstrate what it wants and the vendors will respond to meet the demand. No need for bureaucrats and regulators to second guess what the market wants. The evidence is strong that the vast majority of the world's population wants the cheapest possible energy, not the safest if it is high cost. Consumers demonstrate that they accept coal is plenty safe enough; therefore anything that is as safe as coal and cheaper will win out and displace it. The same goes for other technologies. Cheapest wins (as long as it meets the essential requirements of providing long term energy security and supply is reliable).

The faster costs come down the faster competition and innovation will increase and the faster the technologies will develop to meet customer requirements.

IMO, a catalyst to get the process going would be for the next US President to take a lead the world by gaining support from the other members of the IAEA to start raising the allowable radiation limits. This short brochure explains:http://home.comcast.net/~robert.hargraves/public_html/RadiationSafety26SixPage.pdf

Once that is underway, the US President should persuade the population of the benefits of the US regaining its leadership role in nuclear technology. Then set out to change the culture and priorities of the NRC from safety first to an evidence based balance of cost and safety – equivalent to the air safety regulators priorities.

Reply

Peter Lang *January 23, 2015 at 6:46 pm*

Rick,

Further to my comment above, I've just seen this (it is good news in my opinion):

US study on low-dose ionising radiation

The US Department of Energy (DOE) and National Academy of Sciences have been directed to work together to assess the current status of US and international research on low-dose radiation and to formulate a long-term research agenda under a bill approved by the US House of Representatives. The Low Dose Radiation Research Act of 2015 directs the two organisations to carry out a research program "to enhance the scientific understanding of and reduce uncertainties associated with the effects of exposure to low dose radiation in order to inform improved risk management methods." The study is to be completed within 18 months.

The Act arises from a letter from a group of health physicists who pointed out that the limited understanding of low-dose health risks impairs the nation's decision-making capabilities, whether in responding to radiological events involving large populations such as the 2011 Fukushima accident or in areas such as the rapid increase in radiation-based medical procedures, the cleanup of radioactive contamination from legacy sites and the expansion of civilian nuclear energy. The aftermath of the Fukushima accident has boosted concern that unduly conservative standards may have large adverse health and welfare costs."
WNN 20/1/15. 'Radiation health effects'

http://www.world-nuclear.org/info/Safety-and-Security/Radiation-and-Health/Nuclear-Radiation-and-Health-Effects/