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A PUBLICATION OF WORLD INFORMATION SERVICE ON ENERGY (WISE) AND THE NUCLEAR INFORMATION &RESOURCE SERVICE (NIRS)

Dear readers of the WISE/NIRS Nuclear Monitor,

In this issue of the Monitor:

- Kumar Sundaram writes about energy and climate debates in India.
- Tim Judson writes about the Trump administration's proposed bailout for nuclear and coal.
- A summary of Jan Willem Storm van Leeuwen's new report on nuclear power's greenhouse gas emissions.
- A critique of the endless stream of misinformation from Michael Shellenberger and his pro-nuclear lobby group, 'Environmental Progress'.

Feel free to contact us if you have feedback on this issue of the Monitor, or if there are topics you would like to see covered in future issues.

Regards from the editorial team.

Email: monitor@wiseinternational.org

Monitored this issue:

Don't nuke the climate!

This November, anti-nuclear activists will converge on the UN's COP23 climate conference in Bonn, Germany, campaigning against proposals to subsidize nuclear power under UN climate mechanisms. In Bonn, the *Don't Nuke the Climate* contingent will march, advocate, and rally to call for the transition to an energy system that no longer depends on polluting nuclear power and fossil fuels. Instead, we must rely on safe, clean, affordable, sustainable renewable energy, energy efficiency, conservation and 21st century grid technologies.

Under the expiring Kyoto Protocol, nuclear energy is rightly excluded from UN climate mechanisms such as the Green Climate Fund. Yet the nuclear industry, in collaboration with certain nations, is lobbying for their dangerous and polluting technology to be seen as a climate-friendly option. This would obstruct real progress in protecting the climate.

Among a myriad of other problems, nuclear power is:

- Rooted in human rights violations and environmental racism.
- Too Dirty: Nuclear reactors and the nuclear fuel chain produce vast amounts of lethal radioactive waste.
- Too Dangerous: Continued use of nuclear power will inevitably lead to more Fukushimas, Church Rocks, and Chernobyls. The technology and materials needed to generate nuclear energy can be – and have been – diverted to nuclear weapons programs.
- Too Expensive: Nuclear power is the costliest means possible of reducing carbon and methane emissions; its use crowds out investment in clean energy sources.
- Too Slow: Use of nuclear power to reduce fossil fuel emissions would require an unprecedented nuclear construction program, beyond the capability of the world's manufacturers within an acceptable time frame.

Please sign the petition:
www.dont-nuke-the-climate.org/sign

More information: www.dont-nuke-the-climate.org

Energy security, climate change and nuclear power: India's real problems and false solutions

Author: Kumar Sundaram – researcher with the Coalition for Nuclear Disarmament and Peace.

NM853.4686 Dubbing nuclear energy as a solution to climate change has been a key strategy of the Indian government in recent years. The government has been using "clean energy" as a short-hand for nuclear power in international nuclear deals[1], and offered nuclear power as part of its climate pledge submitted to the UNFCCC ahead of the COP21 meeting.

India is one of the few countries in the post-Fukushima world to have massive nuclear expansion plans. The Indian government has planned an expansion of the total installed nuclear capacity to 63 gigawatts (GW) by the year 2032.[2] At present, the total installed capacity is 6.8 GW, merely 1.8% of the total electricity production capacity.[3] In July 2017, Dr. R B Grover, senior nuclear scientist who holds Homi Bhabha Chair in India's Department of Atomic Energy, called for promoting 'Nuclear Variable Renewable Energy' for achieving 40% of electricity by 2030 from non-fossil sources.[4]

However, an intriguing display of extreme opposites can be seen when it comes to the Indian government's policy on climate change under Prime Minister Narendra Modi. His brazen denial of climate change, during a patronising address to young students in 2014 – where he claimed "it's not the climate, but *we* who are changing"' – came under heavy criticism.[5]

However, at the Paris Summit in 2015, Modi adopted a strongly assertive posture against the West from a developing world perspective, which understandably resonated with some sections of international civil society, but actually meant garnering more concessions for the home-grown industries.[6] In his most recent trip to France this June, Modi was seen expressing concern about Trump's exit from the Paris climate accord and reassuring the new French President of reinforced support from India.[7]

In terms of actual policies back home, the Modi government has been hugely scaling up the renewable sector[8], but has also made an unwavering support for nuclear power, purportedly as a solution for climate change.[9]

To understand the co-relation between climate change and nuclear power generation, experts the world over have conducted comprehensive research on the carbon-footprints of the entire nuclear fuel-cycles and compared them to other energy sources, in the specific context of their countries.

In India, such research on the nuclear fuel cycle is rendered effectively impossible by the non-transparency of the country's nuclear establishment, which does not share with its citizens even basic information like radiation readings, Safety Assessment Reports and Site Selection Reports for its installations. The Atomic Energy Act of 1962 provides insulation to the nuclear sector here, providing it with a fig leaf of 'national security' to avoid public scrutiny. Faced with such situation, we can adopt an alternative method – study the impacts of climate change on the surrounding environment of the sites where new nuclear plants are proposed, and what would it imply for communities living there.

Chutka, in central India, and Gorakhpur, just 150 km from the national capital, offer good case studies in this regard. Both these projects are inland, so they will impact huge areas and large populations. Moreover, they are being built in ecologically sensitive regions. As such they offer important counterpoints as case studies. Also, nuclear power plants in Chutka and Gorakhpur are being set up using the 'indigenous' Pressurised Heavy Water Reactor technology, so these plans are in fact more feasible and more likely to be built than sites like Jaitapur and Kovvada where imported nuclear projects face hurdles such as financial cost, liability and the declining financial health of foreign suppliers.

Chutka: Nuking Narmada

The proposed Chutka nuclear plant in the tribal-dominated Mandla district in central India will displace hundreds of people for the second time and dangerously compound climate change impacts.[10] The scars of displacement and fear of being uprooted again is visible on the faces of all inhabitants of the village – most of whom are Gond adivasi tribes. For the Bargi dam, built between 1974 and 1990, they had to leave their villages in the valley and flee uphill. They were driven out of their ancestral villages, where they had been living for centuries, for as little as 500 Rupees (less than US$10 dollars) for an acre of land.

Faced with such injustice and threats to their safety and livelihoods, villagers have started a two-month long intensive campaign which started on Mahatma Gandhi's anniversary and will culminate on International Human Rights Day, December 10.[11] Memories of being uprooted are still fresh in their minds. They were among the inhabitants of 162 villages displaced for the Rani Avantibai Bargi Dam built on River Narmada.

However, the real red-herring might be the cumulative climate change impacts in the region when seen in the long-term perspective. Undemocratic and irresponsible changes in water-usage at Bargi Dam, coupled with the general decrease in water levels in Narmada owing to massive deforestation upstream, spell catastrophe especially with the siting of the Chutka nuclear plant on the same dam. When seen on a time-scale of the next 60–70 years, there are ominous indicators that

People against the proposed Chutka nuclear plant in Mandala district. *indiawaterportal.org*

communities and industries will compete for the fast-decreasing water reserves of Narmada, and a massively water-guzzling nuclear plant on the bank of Bargi Dam will make the scenario much worse.

The problem of decreasing water availability in Bargi Dam will lead to two serious challenges – nuclear reactors in Chutka will scramble for water, along with other industries rapidly coming up in the region, and compete with the local communities including the Jabalpur city, with a population of 1.56 million, that sources its drinking water from Bargi Dam. Water shortages would also pose an insurmountable safety risk in case of a serious nuclear accident.

Gorakhpur: Nuclear plant over a canal

Four Pressurised Heavy Water Reactors are being constructed in Haryana, the state neighbouring New Delhi, the national capital of India. This nuclear plant would have a total capacity of 2.8 GW, with four reactors of 700 MW each. This will be India's largest indigenous nuclear power project built so far. The water usage for the reactor complex would be 320 cusec (783 million litres daily) for cooling and other purposes.[12] However, the entire project will depend for water on a small canal, Fatehabad branch of the Bhakhra Branch Canal, which is the main source of water for irrigation in the region.[13] This is perhaps the only nuclear power project in the world to have such a limited and unreliable source of water supply.

Water will pose three huge problems in Gorakhpur: the water will be inadequate even for the cooling of reactors in their normal operation; in case of an accident, the situation could be worse than even Fukushima due to non-availability of water; and the high temperature of the discharge water from the reactor will destroy agriculture downstream of the canal, which dozens of villages depend on for irrigation. Here too, like Chutka, the water was initially meant only for irrigation but now the government is undemocratically diverting it for a nuclear plant. With changing climate, water supply in the canal is expected to decrease.

Therefore, far from being a solution to climate change, nuclear power expansion is going to compound the problems in India's most eco-sensitive regions. Destroying fragile ecologies and depriving local communities of their livelihoods is all that such ill-conceived plans would achieve.

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Trump administration rushing bailout for nuclear and coal

Author: Tim Judson – Executive Director, Nuclear Information & Resource Service

NM853.4687 Until last month, it wasn't clear whether US President Donald Trump intended to follow through on his promises to promote dirty energy. The signs had been bad since the early days of his campaign – from bellicose claims about "bringing coal back" and intending to pull out of the Global Climate Agreement, to cancelling the Clean Power Plan and opening up public lands to drilling and mining.

While these actions undermine climate progress, they would be relatively easy for the next president to reverse. Even more importantly, they would not be enough to counter the fundamental economic and technological trends that are starting to put coal and nuclear power out of business. Almost all nuclear reactors and coal plants are decades old, and more and more of them simply can't compete with newer, more efficient and cost-effective energy sources: fracked natural gas (which, unfortunately, is booming in the U.S.) and renewable energy sources like wind, solar, and energy efficiency (which are now growing more than any other sources of energy).

Reality boils down to this: keeping coal and nuclear plants from closing would require both giving those two energy sources a lot more money, and blocking their competitors. And that would take a radical change to the whole way energy is priced and regulated in the US and many other parts of the world.

As it turns out, that is exactly what Donald Trump is proposing to do ... and it's even more extreme than most people expected.

At the end of September, the US Department of Energy (DOE) took action, through a little-used power under the DOE Organization Act to order a little-known but powerful agency, the Federal Energy Regulatory Commission (FERC), to radically reorganize the country's energy markets to favor nuclear and coal. FERC regulates the interstate electricity and gas transmission systems and wholesale energy markets, as well as licensing hydropower facilities and other duties.

DOE's proposed bailout rule would cover four electricity markets in the Midwest and Northeast regions of the US, where electricity is priced and traded on wholesale markets; and it would apply to power plants that store 90 days of fuel on-site – in practical terms, that means nuclear reactors and coal-fired power plants. Overall, this would apply to about 104 power plants, including 43 nuclear reactors at 28 sites – nearly half of all operating reactors in the US.

Electricity prices for those plants would be set to cover their full operating and maintenance costs, plus a guaranteed rate of return (profit) on investment in the power plant. However, not only would this guarantee the profitability of nuclear and coal power plants, it would set in motion sweeping changes in the electricity market under the false claim that wholesale power markets, regulated by FERC, are underpricing coal and nuclear plants by failing to properly value their true contributions to grid reliability.

DOE also instructed FERC to fast-track the process to have the bailout in place by the end of the year – which FERC has agreed to do. DOE's rationale for the program is not climate change, as nuclear promoters have stressed over the last few years. DOE argues that if coal and nuclear reactors continue to shut down, the power grid could fail. The move completes a 180-degree turnaround in how nuclear subsidies are being promoted, and weds nuclear to coal in Trump's dirty energy revival scheme. The nuclear industry's claims to "carbon free emissions" aren't a selling point with this administration, which is seemingly doing everything it can to increase greenhouse gas emissions.

So now the bailouts of nuclear and coal companies are all about "national security" and keeping the lights on. The DOE has been trying to cue up the bailout since April, when Energy Secretary Rick Perry ordered his staff to produce a "grid reliability" report showing that our national security is threatened by the closure of coal and nuclear power plants. Finally published in August, the report was a weak shadow of what Perry promised, failing to show that the electrical grid is threatened at all by power plant closures. Even with the biased conclusions the administration threw into it, the report found that wind and solar energy are strengthening the affordability, reliability, and resilience of the grid.

FERC would essentially "re-regulate" those coal and nuclear plants by ensuring they earn prices for their electricity that cover each reactor's or coal plant's operating costs, plus a significant margin of profit. That is typically set in the range of a 10% return on investment in the US utility sector. Since coal and nuclear make up about 50% of the country's electricity supply, the bailout would totally undermine "competitive" electricity markets – leaving only natural gas plants to compete with renewables, for a possibly shrinking share of electricity sales due to energy efficiency.

When DOE Secretary Perry announced the grid reliability study in April, he said the federal government may need to limit renewable energy, even to the extent of overriding state-level renewable energy laws. That may be the practical outcome of the nuclear and coal bailout proposal – even if it is not adopted in its present form. The natural gas industry is fighting the bailout right now, arguing that it undermines wholesale markets, but

they may be able to strike a compromise with the Trump administration. Because of the specious legal rationale and technical justification for the nuclear and coal preferences, FERC could be forced to pass additional rules guaranteeing market preferences to natural gas plants, as well.

Alternatively, FERC could reject the proposal and, instead, promote market reforms based on protecting coal, nuclear, and natural gas for reliability purposes.

Regulators of the regional energy markets have already been working on plans like this, essentially to balance protecting the interests of coal, nuclear, and natural gas corporations. The result would effectively be a new energy policy in the US, established through energy markets rather than by legislation, based on the outdated scheme of "baseload" power generation. That would severely limit the growth of renewable energy and make it impossible to reduce greenhouse gas emissions from power plants.

An analysis of nuclear greenhouse gas emissions

NM853.4688 *'Climate change and nuclear power: An analysis of nuclear greenhouse gas emissions'* is a new report written by Jan Willem Storm van Leeuwen, commissioned by WISE Amsterdam. The full report is online and the Summary & Findings are reproduced here.

Points at issue

- This study assesses the following questions:
- How large would the present nuclear mitigation share be, assuming that nuclear power does not emit carbon dioxide (CO2)?
- How large could the reduction become in the future, starting from nuclear generating capacity scenarios published by the IAEA, and also assuming that nuclear power does not emit CO2?
- How feasible are the projections of the nuclear industry?
- How large could the actual nuclear CO2 emissions be, estimated on the basis of an independent life-cycle analysis?
- Does nuclear power also emit other greenhouse gases?

These issues are assessed by means of a physical analysis of the complete industrial system needed to generate electricity from uranium. Economic aspects are left outside the scope of this assessment. Health hazards of nuclear power are also not addressed in this report.

Present nuclear mitigation contribution

The global greenhouse gas (GHG) emissions comprise a number of different gases and sources. Weighted by the global warming potential of the various GHGs, 30% of the emissions were caused by CO2 from the burning of fossil fuels for energy generation. Nuclear power may be considered to displace fossil-fuelled electricity generation. In 2014 the nuclear contribution to the global usable energy supply was 1.6% and the contribution to the emission reduction of nuclear power displacing fossil fuels would be about 4.7%, provided that nuclear power is free of GHGs (which it is not).

Nuclear mitigation contribution in the future

A hypothetical nuclear mitigation contribution in 2050, based on two scenarios of the IAEA and provided that nuclear power is free of GHGs, comes to:

- IAEA Low scenario (constant nuclear capacity, 376 GWe in 2050): 1.3 – 2.4%
- IAEA High scenario (constant nuclear mitigation share, 964 GWe in 2050): 3.8 – 6.8%.

The high figures are valid at a growth of global GHG emissions of 2.0%/yr, the low figures at a growth of 3.5%/yr.

Global construction pace

By 2060 nearly all currently operating nuclear power plants (NPPs) will be closed down because they will reach the end of their operational lifetime within that timeframe. The current construction pace of 3–4 GWe per year is too low to keep the global nuclear capacity flat and consequently the current global nuclear capacity is declining. To keep the global nuclear capacity at the present level the construction pace would have to be doubled.

- in the IAEA low scenario: 7–8 GWe per year until 2050.
- in the IAEA high scenario: 27 GWe/yr until 2050.

In view of the massive cost overruns and construction delays of new NPPs that have plagued the nuclear industry for the past decade, it is not clear how the required high construction rates could be achieved.

Prospects of new advanced nuclear technology

The nuclear industry discusses the implementation within a few decades of advanced nuclear systems that would enable mankind to use nuclear power for hundreds to thousands of years. These concepts concern two main classes of closed-cycle reactor systems: uranium-based systems and thorium-based systems. However, the prospects seem questionable in view of the fact that, after more than 60 years of research and development in several countries (e.g. USA, UK, France, Germany, the former Soviet Union) with investments exceeding €100bn, still not one operating closed-cycle reactor system exists in the world.

Failure of the materialisation of the uranium-plutonium and thorium-uranium breeder systems can be traced back to limitations governed by fundamental laws of nature, particularly the Second Law of thermodynamics. From the above observation it follows that nuclear power in the future would have to rely exclusively on once-through thermal-neutron reactor technology based on natural uranium. As a consequence, the size of the uranium resources will be a restricting factor for the future nuclear power scenarios.

Nuclear generating capacity after 2050

The IAEA scenarios are provided through 2050. Evidently the nuclear future does not end in 2050. On the contrary, it is highly unlikely that the nuclear industry would build 964 GWe of new nuclear capacity by the year 2050 without solid prospects of operating these units for 40-50 years after 2050. How does the nuclear industry imagine development after reaching their milestone in 2050? Further growth, leveling off to a constant capacity, or phase-out?

Uranium demand and resources

The minimum uranium demand in the two IAEA scenarios can be estimated assuming no new nuclear power plants (NPPs) would be built after 2050 and consequently the NPPs operational in 2050 would be phased out by 2100.

The presently known recoverable uranium resources of the world would be adequate to sustain the IAEA Low scenario, but not the IAEA High scenario.

According to a common view within the nuclear industry, more exploration will yield more known resources, and at higher prices more and larger resources of uranium become economically recoverable. In this model uranium resources are virtually inexhaustible.

Energy cliff

Uranium resources as found in the earth's crust have to meet a crucial criterion if they are to be earmarked as energy sources: the extraction from the crust must require less energy than can be generated from the recovered uranium. Physical analysis of uranium recovery processes proves that the amount of energy consumed per kg recovered natural uranium rises exponentially with declining ore grades. No net energy can be generated by the nuclear system as a whole from uranium resources at grades below 200–100 ppm (0.2-0.1 g U per kg rock); this relationship is called the energy cliff.

Depletion of uranium-for-energy resources is a thermodynamic notion. Apparently the IAEA and the nuclear industry are not aware of this observation. Some resources classified by the IAEA as 'recoverable' fall beyond the thermodynamic boundaries of uranium-for-energy resources.

Actual CO2 emission of nuclear power

A nuclear power plant is not a stand-alone system, it is just the most visible component of a sequence of industrial processes which are indispensable to keep the nuclear power plant operating and to manage the waste in a safe way, processes that are exclusively related to nuclear power. This sequence of industrial activities from cradle to grave is called the nuclear process chain. Nuclear CO2 emission originates from burning fossil fuels and chemical reactions in all processes of the nuclear chain, except the nuclear reactor. By means of the same thermodynamic analysis that revealed the energy cliff, the sum of the CO2 emissions of all processes constituting the nuclear energy system could be estimated at 88–146 gCO2/kWh. Likely this emission figure will rise with time, as will be explained below.

CO2 trap

The energy consumption and consequently the CO2 emission of the recovery of uranium from the earth's crust strongly depend on the ore grade. In practice the most easily recoverable and richest resources are exploited first, a common practice in mining, because these offer the highest return on investment. As a result the remaining resources have lower grades and uranium recovery becomes more energy-intensive and more CO2-intensive, and consequently the specific CO2 emission of nuclear power rises with time. When the average ore grade approaches 200 ppm, the specific CO2 emission of the nuclear energy system would surpass that of fossil-fuelled electricity generation. This phenomenon is called the CO2 trap.

If no new major high-grade uranium resources are found in the future, nuclear power might lose its low-carbon profile within the lifetime of new nuclear build. The nuclear mitigation share would then drop to zero.

Emission of other greenhouse gases

No data are found in the open literature on the emission of greenhouse gases other than CO2 by the nuclear system, likely such data never have been published. Assessment of the chemical processes required to produce enriched uranium and to fabricate fuel elements for the reactor indicates that substantial emissions of fluorinated and chlorinated gases are unavoidable; some of these gases may be potent greenhouse gases, with global warming potentials thousands of times greater than CO2. It seems inconceivable that nuclear power does not emit other greenhouse gases. Absence of published data does not mean absence of emissions.

Krypton-85, another climate changing gas

Nuclear power stations, spent fuel storage facilities and reprocessing plants discharge substantial amounts of a number of fission products, one of them is krypton-85, a radioactive noble gas. Krypton-85 is a beta emitter and is capable of ionizing the atmosphere, leading to the formation of ozone in the troposphere. Tropospheric ozone is a greenhouse gas, it damages plants, it causes smog and health problems. Due to the ionization of air krypton-85 affects the atmospheric electric properties, which gives rise to unforeseeable effects for weather and climate; the Earth's heat balance and precipitation patterns could be disturbed.

Questionable comparison of nuclear GHG emission figures with renewables

Scientifically sound comparison of nuclear power with renewables is not possible as long as many physical and chemical processes of the nuclear process chain are inaccessible in the open literature, and their unavoidable GHG emissions cannot be assessed.

When the nuclear industry is speaking about its GHG emissions, only CO2 emissions are involved. Erroneously the nuclear industry uses the unit gCO2eq/kWh (gram CO2-equivalent per kilowatt-hour), this unit implies that other greenhouse gases also are included in the emission figures, instead the unit gCO2/kWh (gram CO2 per kilowatt-hour) should be used. The published emission figures of renewables do include all emitted greenhouse gases. In this way the nuclear industry gives an unclear impression of things, comparing apples and oranges.

A second reason why the published emission figures of the nuclear industry are not scientifically comparable to those of renewables is the fact that the nuclear emission figures are based on incomplete analyses of the nuclear process chain. For instance the emissions of construction, operation, maintenance, refurbishment and dismantling, jointly responsible for 70% of nuclear CO2 emissions, are not taken into account. Exactly these components of the process chain are the only contributions to the published GHG emissions of renewables. Solar power and wind power do not consume fuels or other materials for generation of electricity, as nuclear power does.

Energy debt and delayed GHG emissions

Only a minor fraction of the back end processes of the nuclear chain are operational, after more than 60 years of civil nuclear power. The fulfillment of the back end processes involve large-scale industrial activities, requiring massive amounts of energy and high-grade materials. The energy investments of the yet-to-be fulfilled activities can be reliably estimated by a physical analysis of the processes needed to safely handle the radioactive materials generated during the operational lifetime of the nuclear power plant. No advanced technology is required for these processes. The energy bill to keep the latent entropy under control from 60 years nuclear power has still to be paid. The future energy investments required to finish the back end are called the *energy debt*.

The CO2 emissions coupled to those processes in the future have to be added to the emissions generated during the construction and operation of the NPP if the CO2 intensity of nuclear power were to be compared to that of other energy systems; effectively this is the *delayed CO2 emission* of nuclear power. Whether the back end processes would also emit other GHGs is unknown, but likely.

Stating that nuclear power is a low-carbon energy system, even lower than renewables such as wind power and solar photovoltaics, seems strange in view of the fact that the CO2 debt built up during the past six decades of nuclear power is still to be paid off.

Jan Willem Storm van Leeuwen, 2017, 'Climate change and nuclear power: An analysis of nuclear greenhouse gas emissions', Amsterdam: World Information Service on Energy (WISE), https://wiseinternational.org/will-nuclear-power-save-climate

Direct download: https://wiseinternational.org/sites/default/files/u93/climatenuclear.pdf

Exposing the misinformation of Michael Shellenberger and 'Environmental Progress'

Author: Jim Green – Nuclear Monitor editor, and national nuclear campaigner with Friends of the Earth Australia

NM853.4689 Michael Shellenberger's pro-nuclear lobby group 'Environmental Progress' (EP) is celebrating the decision to proceed with two partially-built reactors in South Korea. A citizens jury appointed by the government voted almost 60% in favor of completing the reactors. President Moon Jae-in said the government would allow construction of the reactors to proceed but "we will completely stop all plans for the construction of new nuclear reactors."[1]

It's doubtful that Shellenberger's California-based organization could have significantly swayed the citizens jury in South Korea, but EP was very active in the debate and presumably had some effect in shifting opinions. Here is a summary of the work EP carried out in South Korea this year:[2]

- EP published a 62-page pro-nuclear report – 'The High Cost of Fear: Understanding the Costs and Causes of South Korea's Proposed Nuclear Energy Phase-Out'.[3]
- Shellenberger visited South Korea four times between April and October 2017, giving speeches, holding press conferences on collaborating with nuclear advocates. He claims that dozens of media outlets reported on EP's visits, that a press conference in Seoul was "packed"[4], and that he enjoyed "a crush of media attention".[5]
- EP sent a sign-on letter to South Korean President Moon Jae-in in July 2017 and another in August 2017.
- In October, EP wrote to the citizens jury tasked with deciding the fate of the two partially-built reactors (Shin Kori 5 and 6).[6]
- EP produced a video promoting nuclear power in South Korea.
- Shellenberger has been talking and writing about his bizarre plan to bring peace to the Korean Peninsula by supporting the development of nuclear power in North Korea.
- And, according to Shellenberger, EP countered the "lies" of Friends of the Earth (FOE) and Greenpeace in "two investigative pieces and three separate open letters to President Moon and the citizens jury that were signed by climate scientists and environmentalists from around the world."[6]

EP's campaign has involved a blizzard of misinformation and relentless, dishonest attacks against environment groups, particularly Friends of the Earth (FOE) and Greenpeace. Shellenberger claims[4] that the "greatest coup" of the two groups was the "Hollywood-style anti-nuclear disaster movie" called Pandora[7] which was released last year and has been watched by millions, mostly on Netflix. But FOE and Greenpeace had nothing to do with the production of the Pandora film!

Shellenberger states: "After it was accused of secretly financing the film, Greenpeace insisted it had merely funded the screenings ..."[8] To translate and correct Shellenberger's misinformation: Greenpeace was falsely accused of secretly financing the film (it isn't clear why funding an anti-nuclear film would be objectionable, any more than EP's funding of a pro-nuclear film). The source of the accusation isn't named – perhaps it was Shellenberger himself! Greenpeace merely hosted a screening of the film (or at most a few screenings) and spoke at Q&A sessions at a few film screenings.[9]

Shellenberger claims the Pandora film must have cost tens of millions of dollars to make (although the film-makers say the budget was half a million) but that "amount is peanuts to an organization like Greenpeace International and natural gas interests".[8] He seems to be insinuating that Greenpeace and/or natural gas interests funded the film but provides no evidence in support of his claims.

The funding of the Pandora film isn't an important issue but it neatly illustrates Shellenberger's M.O. of relentless repetition of falsehoods in the hope that some mud sticks.

The Pandora film "propelled to the presidency an anti-nuclear candidate, Moon Jae-in", Shellenberger claims.[4] Seriously? Moon Jae-in would not have been elected if not for a Netflix film?!

Shellenberger himself featured in the dishonest and wildly inaccurate 'Pandora's Promise' film a few years ago.[10,11]

South Korea's 'nuclear mafia'

Arguably the main reason Moon Jae-in was elected to the presidency in May 2017 was to clean up widespread corruption – including corruption in the nuclear industry.[12]

EP describes the nuclear corruption scandal as a "paperwork scandal".[3] But it wasn't just a "paperwork scandal" – it involved serious incidents such as a power failure in May 2012 which led to a rapid rise in the Kori-1 reactor core temperature, and a cover-up up of that incident.[13] That was followed by revelations of an industry-wide scandal involving fake safety certificates ("paperwork") for reactor parts, sub-standard reactor parts, and bribery.[13] The sub-standard reactor parts included safety-critical components such as defective control cabling that triggered shutdowns at two nuclear plants.[14] According to a whistleblower, equipment failed under Loss-Of-Coolant-Accident conditions during at least one concealed test.[15] Another whistleblower revealed that control cables supplied to four reactors with faked certificates had failed safety tests.[16]

EP argues that the nuclear corruption scandal "demonstrated the independence of the Korean safety regulator". But the corruption dated back to 2004[14] and possibly earlier and went undetected for at least seven

years. Public revelation of the scandal was a triumph for a small number of whistleblowers; it was deeply embarrassing for the regulator.

EP asserts that "suppliers as well as senior executives were held accountable" for their corruption. But a 2014 parliamentary audit revealed that some officials fired from KEPCO Engineering and Construction were rehired.[17] And the *New York Times* reported that despite the government's pledge to impose a 10-year ban on suppliers found to have falsified documents, KHNP imposed a six-month ban.[18] The *New York Times* continued: "And nuclear opponents say that more fundamental changes are needed in the regulatory system, pointing out that one of the government's main regulating arms, the Korea Institute of Nuclear Safety, gets 60 percent of its annual budget from Korea Hydro [& Nuclear]."[18]

The scandal was still on the boil in 2014. *Korea Times* noted in June 2014 that more fake quality certificates had been uncovered and that government testing facilities were found to have failed to conduct adequate tests before issuing certificates.[19]

Korea Times editorialized: "Most disheartening in the latest revelation of irregularities is that the state-run certifiers failed to detect fabrications by skipping the required double-testing. ... Given the magnitude of corruption in the nuclear industry arising from its intrinsic nature of being closed, the first step toward safety should be to break the deep-seated food chain created by the so-called nuclear mafia, which will help enhance transparency ultimately. With the prosecution set to investigate the suppliers, the certifiers will face business suspension. But it's imperative to toughen penalties for them, considering that light punitive measures have stood behind the lingering corruption in the nuclear industry."[19]

South Korea's energy mix

The Moon Jae-in government plans to reduce reliance on coal (from 43% of electricity generation to 25% by 2030[20]) and nuclear (from 30% to 18% by 2030[20], with long-term ambitions to phase-out nuclear power) in favour of gas (from 20% to 37% by 2030[20]) and renewables (from 1.8%[21] to 20% by 2030[20]).

In an August 2017 report, EP plugs in a bunch of false and arbitrary assumptions to concoct a scare-story in which the proposed changes to the power-generation mix cost a minimum of US$10 billion per year (to import gas and to build gas-fired power plants ... there is no costing for the replacement of aging reactors, apparently they will operate forever), result in thousands of avoidable deaths from air pollution, and increase carbon emissions by an amount equivalent to adding 15–27 million cars.[3]

Among other arbitrary, inexplicable assumptions is the assumption that gas replaces nuclear power.[3] (That assumption is part of a broader EP propaganda campaign to convince people of the falsehood that "every time nuclear plants close they are replaced almost entirely by fossil fuels".[22]) If EP wants to arbitrarily assume that gas replaces nuclear under the 2030 targets, then it ought to assume that the planned 18% reduction in coal is replaced by the planned 18% increase in renewables – but no such assumption is made.

Instead, the EP report asserts that "replacing the nation's nuclear plants would require a significant increase in coal and/or natural gas".[3] But the 2030 targets have the growth in renewable electricity generation comfortably ahead of the reduction in nuclear power.

And the EP report falsely asserts that the "removal of nuclear plants from the grid would extend the life of coal plants"[3] even though the government clearly plans to reduce reliance on coal plants and has already taken steps in that direction since the May 2017 election.

The EP report asserts that replacing "South Korea's remaining nuclear plants with natural gas would produce carbon pollution the equivalent of adding 27 million U.S. cars to the road."[3] But ... again ... the South Korean government isn't planning to replace nuclear with gas; it is planning to reduce reliance on coal and nuclear in favour of gas and renewables. The planned increase in gas nearly matches the decline in more carbon-intensive coal, and the growth of renewables more than compensates for the loss of nuclear.

A sign-on letter organized by EP warns that a "significant expansion of natural gas could pose a significant threat to public safety" and cites two accidents in South Korea resulting in 83 deaths and 181 injuries.[23] But it is silent about the costs, ill-health and deaths arising from nuclear disasters such as the

Fukushima fires, meltdowns and hydrogen explosions. And it is silent about the myriad benefits of expanding renewable power generation.

Peace on the Korean peninsula

Shellenberger thinks that supporting the development of nuclear power in North Korea is the key to peace on the Korean peninsula. He claims that "a nuclear phase-out in South Korea would destroy one of the best means of creating peace with North Korea" because it would compromise South Korea's ability to promote the development of nuclear power in North Korea.[4]

A sign-on letter initiated by EP advocates a new framework agreement involving US and South Korean support for the development of nuclear power in North Korea, in return for North Korea accepting IAEA inspections of its nuclear program, ending its missile tests and limiting its nuclear arsenal.[24]

The "new framework" is much the same as the old 1994 Agreed Framework, which was a complete failure. If the power reactors proposed under the 1994 agreement had been completed before North Korea terminated IAEA safeguards during the collapse of the Agreed Framework, those reactors might now be used for weapons production in addition to North Korea's small 'experimental power reactor' and its enrichment program.

There is no reason to believe the North Korean regime would limit let alone abandon its nuclear weapons program if other nations helped the regime develop nuclear power plants (or other types of power plants). Nor is there any reason to believe that the US and other nations would consider a "limiting" of the regime's nuclear arsenal (whatever that means) to be adequate.

Another reason to be skeptical about the "new framework" is the possibility that reactors in both North and South Korea could be deliberately or inadvertently struck in the event of military conflict. According to *Yonhap News*, a report by South Korean energy utility KHNP noted that South Korea's power reactors have not been designed to deal with military attacks – the outer protective walls were not designed to withstand a missile strike or other forms of concerted attacks.[25] Kim Jong-hoon, a parliamentarian representing the conservative Liberty Korea Party, said earlier this year that Seoul was several years behind the US in coming up with safety measures to deal with military and terrorist attacks. "The fact that the country has not taken action in the past is a serious lapse, especially with North Korea's evolving missile threats," Kim said.[25]

Nuclear power and weapons proliferation

Shellenberger states: "One of FOE-Greenpeace's biggest lies about nuclear energy is that it leads to weapons. Korea demonstrates that the opposite is true: North Korea has a nuclear bomb and no nuclear energy, while South Korea has nuclear energy and no bomb."[4]

In fact, the connections between nuclear power (and associated industries such as enrichment and reprocessing) and weapons proliferation are well understood and there are countless real-world examples demonstrating the risks.[26]

Prominent nuclear lobbyists are now openly talking about the connections between nuclear power (and related industries) and weapons production in order to boost the case for further subsidies to support the 'civil' nuclear industry, particularly in the US.[27] It seems Shellenberger didn't get the memo.

As for Shellenberger's claims about proliferation on the Korean peninsula, he ignores the fact that North Korea uses what is calls an 'experimental power reactor' (based on the UK Magnox power reactor design) to produce plutonium for weapons.[28] He ignores the fact that North Korea acquired enrichment technology from Pakistan's A.Q. Khan network, who stole the blueprints from URENCO, the consortium that provides enrichment services for the nuclear power industry.[28] He ignores the fact that North Korea's reprocessing plant is based on the design of the Eurochemic plant in Belgium, which provided reprocessing services for the nuclear power industry.[28]

And Shellenberger ignores South Korea's history of covertly pursuing nuclear weapons, a history entwined with the country's development of nuclear power. For example, the nuclear power program provided a rationale for South Korea's pursuit of dual-use reprocessing technology.

Chernobyl and Fukushima

Shellenberger says that at a recent talk in Berlin: "Many Germans simply could not believe how few people died and will die from the Chernobyl accident (under 200) and that nobody died or will die from the meltdowns at Fukushima. How could it be that everything we were told is not only wrong, but often the opposite of the truth?"[4]

There's a simple reason that Germans didn't believe Shellenberger's claims about Chernobyl and Fukushima – they are false.

Shellenberger claims that "under 200" people have died and will die from the Chernobyl disaster. In fact, the lowest of the estimates of the Chernobyl cancer death toll is the World Health Organization's estimate of "up to 9,000 excess cancer deaths" in the most contaminated parts of the former Soviet Union.[29] And of course there are higher estimates for the death toll across Europe.[30,31]

Shellenberger claims that the Fukushima meltdowns "killed precisely no one" and that "nobody died or will die from the meltdowns at Fukushima".[4] An EP report has this to say about Fukushima: "[T]he science is unequivocal: nobody has gotten sick much less died from the radiation that escaped from three meltdowns followed by three hydrogen gas explosions. And there will be no increase in cancer rates."[3]

In support of those assertions, EP cites a World Health Organization report that directly contradicts EP's claims. The WHO report concluded that for people in the most contaminated areas in Fukushima Prefecture, the estimated increased risk for all solid cancers will be around 4% in females exposed as infants; a 6% increased risk of breast cancer for females exposed as infants; a 7% increased risk of leukaemia for males exposed as infants; and for thyroid cancer among females exposed as infants, an increased risk of up to 70% (from a 0.75% lifetime risk up to 1.25%).[32]

Applying a linear-no threshold (LNT) risk factor to the estimated collective radiation dose from Fukushima fallout gives an estimated long-term cancer death toll of around 5,000 people.[33] Nuclear lobbyists are quick to point out that LNT may overestimate risks from low dose and low dose-rate exposure. But LNT may also underestimate the risks. The 2006 report of the US National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation (BEIR) states: "The committee recognizes that its risk estimates become more uncertain when applied to very low doses. Departures from a linear model at low doses, however, could either increase or decrease the risk per unit dose."[34] And the BEIR report states that "combined analyses are compatible with a range of possibilities, from a reduction of risk at low doses to risks twice those upon which current radiation protection recommendations are based."[34]

Fukushima evacuation

Shellenberger claims that the Fukushima evacuation was "entirely unnecessary and indeed counterproductive" and it was the "outcome of the kind of fear-mongering engaged in by Moon, FOE, and Greenpeace."[4] But of course Moon Jae-in, FOE and Greenpeace had nothing to do with the evacuation of 160,000 people in the aftermath of the Fukushima disaster. Evacuations were ordered not on the basis of fear-mongering by nuclear critics; they were ordered on the basis of multiple fires, hydrogen explosions and presumed meltdowns.

EP states: "In 2013, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) concluded that the vast majority of the Fukushima evacuation zone is safe and nearly all residents could have returned long ago – indeed, most should never have left."[3] But the UNSCEAR report didn't conclude that the vast majority of the Fukushima evacuation zone is safe or that nearly all residents could have returned long ago, and it didn't state that most evacuees should never have left.[35] The UNSCEAR report states: "The actions taken to protect the public significantly reduced the radiation exposures that could have been received. This was particularly the case for settlements within the 20-km evacuation zone and the deliberate evacuation zones, where the protective measures reduced the potential exposures in the first year by up to a factor of 10."[35]

An EP report berates the Japanese government for failing to follow "normal protocols" by ordering Fukushima residents to evacuate instead of sheltering in place.[3] EP cites a 2015 IAEA report[36] in support of that argument, but nowhere in the IAEA report (or any IAEA report) is there a proscription against evacuation in response to nuclear accidents. No IAEA report states that sheltering in place should be the "normal protocol" in the event of a nuclear accident – the appropriate response depends entirely on the circumstances. A 2011 IAEA report points to the impracticality of sheltering in place as a long-term response to elevated radiation levels following nuclear accidents: "Lesson 12: The use of long term sheltering is not an effective approach and has been abandoned and concepts of 'deliberate evacuation' and 'evacuation-prepared area' were introduced for effective long term countermeasures using guidelines of the ICRP [International Commission on Radiological Protection] and IAEA."[37]

The 2015 IAEA report notes that radiation levels were astronomical in some areas in the days after the Fukushima disaster – even in some locations beyond the 20 km exclusion zone, dose rates of the order of a few hundred microsieverts per hour were measured from 15 March 2011 onward.[36] Thus the annual public limit of 1 millisievert from anthropogenic sources would be reached in just a few hours, and the Japanese government's new limit of 20 millisieverts in Fukushima-contaminated regions would be reached in just a few days.

Fake scientists and radiation quackery

EP's UK director John Lindberg is described as an "expert on radiation" on the EP website.[38] In fact, he has no scientific qualifications whatsoever let alone specialist qualifications regarding the health effects of ionizing radiation. Likewise, a South Korean article[39] reposted on the EP website (without correction) falsely claims that Shellenberger is a scientist; in fact, he has a degree in cultural anthropology.

Lindberg is an 'Associate Member' of Scientists for Accurate Radiation Information (SARI)[40], a group comprised mostly of quacks, cranks, non-scientists and conspiracy theorists whose views are directly at odds with those of scientific associations such as UNSCEAR.

SARI is at war with the linear, no-threshold (LNT) model – the group's short 'Charter & Mission' insists three times that LNT is "misinformation".[41] Yet LNT enjoys heavy-hitting scientific support. For example the 2006 report of the US National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation states that "the risk of cancer proceeds in a linear fashion at lower doses without a threshold and … the smallest dose has the potential to cause a small increase in risk to humans."[34] Likewise, a report in the *Proceedings of the National Academy of Sciences* states: "Given that it is supported by experimentally grounded, quantifiable, biophysical arguments, a linear extrapolation of cancer risks from intermediate to very low doses currently appears to be the most appropriate methodology."[42]

A 2010 UNSCEAR report isn't sold on the linear part of LNT but it is at odds with SARI (and EP) on the question of a threshold. The UNSCEAR report states that "the current balance of available evidence tends to favour a non-threshold response for the mutational component of radiation-associated cancer induction at low doses and low dose rates."[43] By contrast, SARI promotes hormesis – the discredited view that low-dose radiation exposure is beneficial to human health.[44]

Attacking environment groups

Shellenberger reduces the complexities of environmental opposition to nuclear power to the claim that in the 1960s, an "influential group of conservationists within Sierra Club feared that cheap, abundant electricity from nuclear would result in overpopulation and resource depletion" and therefore decided to campaign against nuclear power.[4]

If such views had any currency in the 1960s, they certainly don't now. Yet EP asserts that Greenpeace and FOE "oppose cheap and abundant energy"[3] and Shellenberger asserts that "the FOE-Greenpeace agenda has never been to protect humankind but rather to punish us for our supposed transgressions."[4] And Shellenberger suggests that such views are still current by asserting that the anti-nuclear movement has a "long history of Malthusian anti-humanism aimed at preventing "overpopulation" and "overconsumption" by keeping poor countries poor."[8] Again we see Shellenberger's M.O. of relentless repetition of falsehoods in the hope that mud will stick.

In an 'investigative piece' – titled 'Enemies of the Earth: Unmasking the Dirty War Against Clean Energy in South Korea by Friends of the Earth (FOE) and Greenpeace' – Shellenberger lists three groups which he claims have accepted donations "from fossil fuel and renewable energy investors, as well as others who stand to benefit from killing nuclear plants".[4] FOE and Greenpeace don't feature among the three groups even though the 'investigative piece' is aimed squarely at them.

Undeterred by his failure to present any evidence of FOE and Greenpeace accepting fossil fuel funding (they don't), Shellenberger asserts that the donors and board members of FOE and Greenpeace "are the ones who win the government contracts to build solar and wind farms, burn dirty "renewable" biomass, and import natural gas from the United States and Russia."[4] Really? Where's the evidence? There's none in Shellenberger's 'investigative piece'.

In an article for a South Korean newspaper, Shellenberger states: "Should we be surprised that natural gas companies fund many of the anti-nuclear groups that spread misinformation about nuclear? The anti-nuclear group Friends of the Earth – which has representatives in South Korea – received its initial funding from a wealthy oil man ..."[4][5] He fails to note that the donation was in 1969! And he fails to substantiate his false insinuation that FOE accepts funding from natural gas companies, or his false claim that natural gas companies fund "many of the anti-nuclear groups".

Shellenberger's 'investigative piece' falsely claims[4] that FOE keeps its donors secret, and in support of that falsehood he cites an article[8] (written by Shellenberger) that doesn't even mention FOE. EP falsely claims that FOE has hundreds of millions of dollars in its bank and stock accounts.[3]

EP has an annual budget of US$1.5 million, Shellenberger claims, and he asks how EP "can possibly succeed against the anti-nuclear Goliath with 500 times the resources."[8]

An anti-nuclear Goliath with 500 times EP's budget of US$1.5 million, or US$750 million in annual expenditure on anti-nuclear campaigns? Shellenberger claims that Greenpeace has annual income of US$400 million to finance its work in 55 nations[8] – but he doesn't note that only a small fraction of that funding is directed to anti-nuclear campaigns. FOE's worldwide budget is US$12 million according to EP[3] – but only a small fraction is directed to anti-nuclear campaigns.

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The Nuclear Information & Resource Service (NIRS) was set up in the same year and is based in Washington D.C., US.

WISE and NIRS joined forces in the year 2000, creating a worldwide network of information and resource centers for citizens and environmental organizations concerned about nuclear power, radioactive waste, proliferation, uranium, and sustainable energy issues.

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