Beyond Nuclear

Climate Chaos and Nuclear Power

INTRODUCTION

Nuclear power reactors will not be able to operate safely or reliably under the increasingly unstable weather conditions caused by climate change. The nuclear power industry falsely asserts that it is a solution to the climate crisis. Actually, nuclear power combined with climate chaos risks potentially catastrophic radioactivity releases downwind and downstream of reactors and their on-site waste storage facilities.

1. Severe weather forecasts

The United Nations Intergovernmental Panel on Climate Change (IPCC) predicts that human-caused climate change will very likely increase and intensify heat waves and heavy precipitation. This will increase the risk of floods in some areas, while worsening droughts in others areas. Intense tropical cyclones are likely to increase. Low-lying coastal systems are especially at risk, due to the threat of sea level rise and extreme weather events.[1]

Consequently, North America can expect worsening weather extremes, including hurricanes, other severe storms, floods, droughts, heat waves and wildfires. The accelerating rise of sea level threatens coastlines with progressive inundation and storm-surge flooding, especially along the Gulf and Atlantic coasts. Climate change will further constrain North America's over-allocated water resources, increasing competition among agricultural, municipal, industrial and ecological uses.[2]

As Jerry Meehl of the U.S. National Center for Atmospheric Research has said, "It's the extreme weather and climate events that will have some of the most severe impacts on human society as the climate changes."[3]

2. The radioactive risk

Natural disasters and nuclear power plants don't mix precisely because of the risk of releasing the vast amounts of radioactivity present on site into the environment, where it can harm human beings and entire ecosystems. Operating reactor cores hold billions of curies of radioactivity. High-level radioactive waste storage pools hold decades' worth of irradiated nuclear fuel, containing tens to hundreds of millions of curies of radioactivity.[4] Outdoor irradiated nuclear fuel dry storage casks each hold over 200 times the long-lasting radiation released by the Hiroshima atomic bomb.[5]

The risk of catastrophic radiation releases, that could kill or injure many tens of thousands downwind and downstream, is increased due to global warming-induced severe weather events.

3. Hurricanes

Despite the risks of more frequent and more powerful hurricanes on the Gulf and Atlantic coasts, 18 operating nuclear reactors are currently located on the East Coast of the U.S. from New Hampshire to Florida; numerous others sit just inland, often on rivers up which severe storms could travel. Four operating reactors are situated directly on the shore of the Gulf of Mexico, with others again located just inland up rivers.[6] Most ironically, the vast majority of the 32 proposed new reactors in the U.S. would be built in the Southeast, many of them on the edge of rising and ever more turbulent seas.[7]

Hurricane Andrew

The Category 5 Hurricane Andrew passed directly over the twin-reactor Turkey Point nuclear power plant 30 miles south of Miami, Florida on August 24, 1992. It had sustained winds at 145 miles per hour, and gusts at 175 mph. Both reactors lost all off-site power during the storm and for five days afterwards. Fortunately, the emergency back-up generators functioned for the entire six days, but required that diesel fuel be diverted *away from area hospitals* to the nuclear plant as a regional safety priority. Off-site communications were lost for four hours during the storm, and access to the site was blocked by debris and fallen trees. Radiological monitoring equipment was destroyed, which would have significantly hampered emergency operations and civilian evacuation in the case of a radiation release, as its intensity and direction could not have been determined.

Hurricane Andrew also created significant fire dangers at Turkey Point nuclear plant. Both reactors' fire protection system was destroyed when winds and "missiles" toppled a water tower holding 100,000 gallons, and punctured adjacent water storage tanks holding 1,250,000 gallons. The collapse also destroyed fire protection water pumps. The hurricane stripped fire-resistant coating from reactor emergency shutdown electrical cables. An adjacent fossil fuel plant's oil storage tank ruptured, spilling 100,000 gallons of combustible fuel oil and spewing it onto the nuclear site. Given the flammable conditions, and the lack of fire fighting capability, Turkey Point was fortunate a major conflagration was not sparked.

Hurricane Katrina

While the Grand Gulf nuclear power plant in Mississippi attempted to shut down as the infamous monster Hurricane Katrina approached the Gulf Coast, the storm's leading edge knocked out the offsite power to the facility. Grand Gulf was forced to rely on its emergency diesel generators to maintain safety and cooling systems. Ironically, the storm also knocked out a number of Grand Gulf's emergency evacuation sirens, when potentially needed most. Louisiana reactors were also forced to shut down, for the hurricane's risk prohibited them from operating safely. Thus, when their electricity was needed most – during and in the aftermath of Hurricane Katrina – nuclear reactors could not be operated for safety reasons. As global warming-induced severe weather becomes more frequent and intense, nuclear power plants will be forced to shut down more often for safety reasons.[8]

Katrina also made it abundantly clear that U.S. emergency preparations and evacuation procedures are currently disasters in and of themselves, begging the question – what would happen during a severe-weather-induced radiological emergency?

4. Tornadoes

A "significant" tornado, with wind speeds between 113 and 156 mph – Fugita Scale Category F2 – scored a direct hit on the Davis-Besse nuclear power plant near Toledo, Ohio on June 24, 1998 while the reactor was at 99% power. The plant had not been notified of the approaching storm, and personnel inside the facility were unaware of it despite National Weather Service warnings. Lightning and high winds caused a loss of off-site power, automatically shutting down the reactor – 11 transmission towers toppled in the vicinity. Although the reactor automatically shut down within seconds, and emergency diesel generators started up to provide electricity to key safety systems to cool the reactor core, high-level radioactive waste storage pool cooling remained blacked out. One of the diesel generators became inoperable just 16 hours into the emergency, due to overheating caused by inadequate ventilation in the room housing it. As Union of Concerned Scientists (UCS) nuclear safety engineer Dave Lochbaum put it, "On paper, the ventilation system for the emergency diesel generator rooms worked just fine for 30 days after an event. When actually confronted with 90-plus degree temperatures during this June event, the ventilation system was unable to protect the emergency diesel generators from failing in less than 30 hours."[9]

The second diesel generator continued to cool the core, but the waste pool water continued to heat up. Luckily, 25 "tense hours" later, offsite electricity was restored, returning cooling water circulation to the waste pool, stopping the heat up at 140 degrees Fahrenheit. But troublingly, the second emergency diesel generator also failed, just one hour later. Thus, offsite power was restored just in time. Had the pool reached 212 degrees F, the cooling water would have begun to boil away. Loss of cooling water in the pool would eventually have led to overheating of the irradiated nuclear fuel, deadly radioactivity doses in the vicinity of the pool, and ultimately the spontaneous combustion of the fuel rods, and a radioactive inferno that could have led to tens of thousands of latent cancer fatalities out to 500 miles downwind.[10] While "Nuclear Disaster Averted" ran in newspaper headlines, it came way too close.[11]

An even larger tornado (F3 to F5 on the Fugita Wind Damage Scale, with wind speeds from at least 158 to over 260 miles per hour, and damage ranging from "severe" to "devastating" and even "incredible") passed within one mile of the twin reactors at the Calvert Cliffs Nuclear Power Plant on the Chesapeake Bay in Lusby, Maryland on April 28, 2002. This tornado went on to devastate the town of La Plata, Maryland.

The U.S. Nuclear Regulatory Commission (NRC) has reported that F4 & F5 tornadoes can generate winds and tornado "missiles" which can severely damage steel reinforced concrete structures. F2 to F5 tornadoes can also damage or destroy support systems for onsite irradiated nuclear fuel storage pools, such as offsite power supply, onsite emergency backup power supply, cooling pumps, and make-up water supply.[12]

5. Flooding

Past near misses also serve as forewarnings that increased flooding due to climate change presents risks at atomic reactors. For example, a flood significantly impacted the Cooper Nuclear Power Station on the Missouri River in southeastern Nebraska in July, 1993. The reactor was forced to shut down as dikes and levees failed, blocking many emergency escape routes in the region. Although the NRC and the nuclear utility assured the public there was no danger during the flood, it was later revealed that: below-ground rooms in the reactor and turbine buildings were extensively flooded; "the floor drain system had backed up so that standing water from within areas known to be radiologically contaminated had migrated out into designated clean areas"; plant personnel "had not established measures to divert the water away from important components"; flood waters within the reactor building had impinged on electrical cables and equipment such as the Reactor Core Isolation Cooling pump room (a critical reactor safety system during station blackout conditions), causing short circuits; and "This event demonstrates that flooding problems and degradation of equipment may be caused by water in-leakage even though flood waters are not above grade elevations."[13]

Inundation of a nuclear power plant built on a flood plain in the Mississippi River has likewise raised alarm bells. Prairie Island, Minnesota suffered a major flood in 1965, just three years before Northern States Power (now Xcel Energy) began building its twin reactors without the informed consent of the Mdewakanton Dakota Indian tribe which inhabits the small island. Large floods in the mid-1990s required sandbagging and active pumping. Seasonal floods regularly block the only emergency evacuation route from Prairie Island to the mainland. As the NRC itself has reported, "The NRC found that the plant's emergency plan did not meet the requirements for actions to be taken in the event of flooding at the plant."[14]

Flooding has been a recurrent problem at radioactive waste dumps as well. The so-called "low" level radioactive waste dumps at Maxey Flats, Kentucky and West Valley, New York flooded so badly that they had to be shut down, although radioactive contamination had already escaped into the groundwater.[15]

6. Droughts and heat waves

Many atomic reactors across the Southeastern U.S. (where 33 already operate, and where 26 new reactors are proposed to be built) face shutdowns or reduced generation now and in the future due to insufficient water in drought-stricken lakes and rivers needed for cooling.[16] Currently, 24 of the 104 operating U.S. reactors are located in regions suffering severe drought.

Reactors need enormous quantities of water for cooling. Massive concrete pipes, 18 feet in diameter and a mile long, jut out into lakes and rivers, sucking in around a billion gallons of water per day for cooling a typical full-sized reactor, and then returning it super-heated to the body of water from which it was drawn. If the reactor has cooling towers, significantly less water is required, but half of it is lost to the atmosphere as steam.

The extended drought has lowered water levels close to the minimum allowed by NRC; continued drought forecast for this summer could lower water levels below the intake pipes altogether. The ever more shallow water remaining could also become too hot for cooling purposes. Extending water intake pipes risks sucking up lake or river bottom sediments and wildlife which could block up the cooling system.

There are also temperature limits imposed on discharge water as hotter water can significantly damage or even destroy the aquatic plants and animals. Such limits, combined with the on-going drought, caused the Tennessee Valley Authority's Browns Ferry nuclear plant in Alabama to shut down one of its reactors for one day, on August 16, 2007.[17]

Similar power down-rates or even shutdowns had occurred previously. In Illinois in 1988, Commonwealth Edison reactors experienced 100+ reactor-days of curtailed power output or complete shutdown related to excessive thermal discharge into area rivers.

This subsequently resulted in Com-Ed spending millions of dollars for water-cooling retrofits for their reactors. Despite this, a number of the same reactors (now owned by Exelon) came close to power curtailment once again during the 2005 drought in Illinois. And during the heat wave of 2006, Exelon's four Quad Cities and Dresden reactors had to curtail power output because the hot water discharged into the Mississippi and Illinois Rivers exceeded Environmental Protection Agency heat discharge regulations. Similar shutdowns occurred elsewhere, as at the Fermi 2 reactor, located on the relatively shallow Lake Erie; and at Exelon's Limerick reactor in Pennsylvania, which had to curtail power output.[18]

The Cook Unit 1 reactor on southwest Michigan's Lake Michigan shoreline had to shut down for safety reasons related to ambient environmental temperature on July 29-30, 2006. As UCS's Lochbaum explained it: "Rising summer temperatures also reduce margins available for a nuclear power plant to cope with an accident. Just as the increasing lake, river, or ocean temperature impairs heat removal capability from the condenser, the rising water – and ambient air – temperatures impair heat removal capabilities from safety equipment. Federal regulations require detailed calculations of the heat released into the containment structure during postulated accidents along with the ability of cooling systems to remove that heat. These calculations rely on assumptions about the air temperature inside containment when the accident starts, the ambient air temperature, and the cooling water temperature. These parameters are routinely monitored during plant operation and if any one of them moves non-conservatively past a value assumed in a safety study, federal regulations require that the plant be shut down because its underlying safety studies have been invalidated. The Unit 1 reactor at the Donald C. Cook nuclear plant in Michigan was forced to shut down in July 2006 for such a reason."[19]

Such reactor woes extended to Europe, where some reactors in France, Germany Romania, and Spain had to shut down completely, while others had to lower power, because of low water levels during the 2006 heat wave. A similar heat wave in 2003 had killed 30,000 Europeans and forced 17 French reactors to power down or shut down completely, leaving no choice but to import costly electricity from abroad. As in 2003, the French government gave permission for 37 of its 54 reactors to exceed heat discharge and even safety standards during the 2006 heat wave. Germany allowed several reactors on the Elbe River to discharge water in excess of thermal standards. One reactor in Spain was shut down completely rather than be allowed to thermally contaminate the Ebro River. A reactor in Romania was forced to shut down when the Danube River's water level dropped below the plant's intake pipe.[20]

In the year 2000, about 195 billion gallons of water each day were used to produce electricity (excluding hydroelectric power) in the U.S. Surface water was the source for more than 99 percent of total thermoelectric-power withdrawals (both nuclear and fossil fuel generators). Thermoelectric-power withdrawals accounted for 48 percent of total water use in the U.S., 39 percent of total freshwater withdrawals for all sectors of the U.S. economy, and 52 percent of fresh surface-water withdrawals.[21]

As climate change worsens, water shortages will be more common in many places. It makes no sense to generate electricity using the two largest consumers of water for cooling purposes – nuclear and fossil fuel power plants – which together account for nearly 50% of all water use in the United States.

As Lochbaum surmised in his "Nuclear Heat" issue briefing, "Mercury rising means nuclear power electrical output and safety margins falling."

7. Sea level rise

Current rates of sea-level rise are expected to increase as a result both of thermal expansion of the oceans and of partial melting of mountain glaciers and the Antarctic and Greenland ice caps. Consequences include loss of coastal wetlands and barrier islands, and a greater risk of flooding in coastal communities. Low-lying areas, such as the coastal region along the Gulf of Mexico and estuaries like the Chesapeake Bay, are especially vulnerable. Warning signs today include: the current pace of sea-level rise is three times the historical rate and appears to be accelerating; global sea level has already risen by four to eight inches in the past century. Scientists' best estimate is that sea level will rise by an additional 19 inches by 2100, and perhaps by as much as 37 inches.[22]

As the companion website to Al Gore's film An Inconvenient Truth states "Global sea levels could rise by more than 20 feet with the loss of shelf ice in Greenland and Antarctica, devastating coastal areas worldwide."[23] Although such dramatic sea level rise might take millennia, the IPCC points out that "Partial loss of ice sheets on polar land could imply metres of sea level rise, major changes in coastlines and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands. Such changes are projected to occur over millennial time scales, but more rapid sea level rise on century time scales cannot be excluded."[24]

Depending on their elevation above sea level, coastal reactors – and their high-level radioactive wastes stored on-site – could eventually be flooded by rising sea levels, or made more vulnerable to storm surges during hurricanes and tropical storms. As mentioned above, dozens of U.S. reactors are already located on or near the Atlantic and Gulf coasts, and many more are proposed to be built.

8. Weather-related grid instability

Because reactors must shut down as a safety measure in the face of severe weather, their large base load electricity supplies will be unavailable when most needed. As a case in point, dozens of nuclear power plants in the Northeastern and Midwestern U.S., as well as in Canada, were forced to shut down as a safety measure during the August 2003 "Blackout," spreading the power outage to 50 million people across Connecticut, Maryland, Massachusetts, Michigan, New Jersey, New York, Ohio, Ontario, Pennsylvania, and Rhode Island.[25] The power outage originated in the FirstEnergy grid in Ohio, when tree limbs short-circuited power lines. FirstEnergy's attention to maintaining its transmission lines was distracted, at least in part, to the long-term safety-related shut down woes at its Davis-Besse nuclear reactor, which was costing the nuclear utility hundreds of millions of dollars in repairs, replacement power and NRC fines.[26]

Former U.S. Department of Energy Secretary and current New Mexico Governor Bill Richardson said in the aftermath that the U.S. is "a superpower with a third-world electricity grid".[27] Severe weather due to climate destabilization will put more pressure on the unreliable electricity grid, forcing safety shutdowns at atomic reactors, exacerbating the power outages.

Other weather-related events such as lightning, ice storms, and wild fires can contribute to increased safety risks at nuclear power stations. All U.S. nuclear power plants receive their electrical power for reactor safety systems primarily from the offsite electrical grid system. A typical nuclear power station will be connected to the electric grid through three or more transmission lines. Should these power lines go down or a regional electrical grid collapse occur, on-site emergency generators (diesel, gas turbines or in a few cases hydroelectric dams) are designed to automatically start with manual back up capability. Emergency power is then prioritized to a limited number of safety class (1-E) circuits.

“Station Blackout” is defined as the simultaneous loss of all off-site alternating current and on-site emergency power backup systems. Over 50% of all postulated accidents leading to a core melt accident begin with a station blackout, according to NRC studies. A weather related disaster that disables the incoming power lines coupled with the failure of on-site emergency generators (i.e. fouled diesel fuel in leaky storage tanks) can result in the depletion of the emergency battery supply system after just four hours. Without electricity (AC and DC) the operator loses instrumentation and control power leading to an inability to cool the reactor core, which still remains dangerously hot for many hours after reactor shutdown. According to one U.S. NRC report “Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants,” in the event of station blackout at the Surry or Peach Bottom nuclear power stations “core damage was estimated to begin in approximately 1 hour if the auxiliary feedwater system and HPI (high pressure injection) flow had not been restored in time.”[28]

Moreover, there are the converging risks associated with nuclear power stations growing older, with deteriorating safety margins, nuclear power operators cutting staff and costs by reducing inspections and maintenance programs in order to save money, and a steady retreat of federal oversight from enforcement of safety regulations. Taken together with ever more severe weather due to climate destabilization, this is a recipe for worsening natural disasters leading to nuclear disaster.

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[11] *DAVIS-BESSE DAMAGED*, Toledo Blade, June 26, 1998.

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[26] See *BORIC ACID LEAK EATS 6-INCH HOLE IN CAP OF DAVIS-BESSE REACTOR*, Toledo Blade, March 12, 2002 and extensive coverage following that.

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