

NUCLEAR MONITOR

October 24, 2013 | No. 770

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

Editorial

Dear readers of the WISE/NIRS Nuclear Monitor,

This issue of the Monitor focuses on the nuclear industry's contribution to unsustainable water consumption and water pollution. We look at the impacts of nuclear power reactors including their huge water consumption and impacts on aquatic life. We briefly consider the impacts of other stages of the nuclear fuel cycle on water resources. And we have longer articles on climate-related problems as water sources dwindle and heat up, and the related topic of flooding of nuclear plants.

The next issue of Nuclear Monitor will be produced next week and will include articles on a recent anti-uranium conference in Tanzania, plans for new nuclear plants in the UK and Vietnam, and updates from Japan.

Feel free to contact us if there are issues you would like to see covered in the Monitor.

Regards from the editorial team.
Email: monitor@wiseinternational.org

Water and power plants

This is a summary of a Union of Concerned Scientists (UCS) report released in July 2013 – 'Water-Smart Power: strengthening the U.S. electricity system in a warming world'. The report is posted at www.ucsusa.org or use this shortcut: <http://tinyurl.com/ucs-water>

770.4339 The power sector is built for a water-rich world. Conventional fossil-fuel and nuclear power plants require water to cool the steam they generate to make electricity. At some power plants, a lot of the water they withdraw gets evaporated in the cooling process; at others, much of the water is discharged back to its source (albeit hotter). The bottom line: Most power plants need a huge, steady supply of water to operate, and in hot dry summers, that water can become hard to secure.

As climate change brings extreme heat and longer, more severe droughts that dry up – and heat up – freshwater supplies, the US electricity system faces a real threat. Shifting to less water-in-

tensive power can reduce the risk of power failures and take pressure off our lakes, rivers, and aquifers.

The phrase "energy-water collision" refers to the range of issues that can crop up where our water resources and the power sector interact. The UCS report provides some recent examples of each type of collision:

- *Not enough water:* Heat and drought in Texas in 2011 caused water levels in Martin Creek Lake to drop so low that Martin Creek Power Plant had to import water from the Sabine River to cool its coal-fired plant and keep it operating.
- *Incoming water too warm:* During a 2006 heat wave, incoming Mississippi River water became too hot to cool

Monitored this issue:

Water and power plants	1
Licensed to kill	3
How much water does a nuclear power plant consume?	4
Other stages of the nuclear fuel cycle	5
Jellyfish shut down Swedish nuclear plant	6
Climate change, water and energy	7
'Hot water' documentary	10
Flooding of nuclear plants	11



the two-unit Prairie Island nuclear plant in Minnesota, forcing the plant to reduce output by more than 50%. In the first such case in northern New England, the Vermont Yankee nuclear plant was forced to reduce its power production by as much as 17% over the course of a week in the Summer of 2012 due to high water temperatures and low flow in the Connecticut River. One of the two reactors at the Millstone nuclear plant, Connecticut, was shut down for 11 days in mid-July 2012 as its water source, Long Island Sound, got too warm – this was the first open-water collision on record and signals that even plants on large bodies of water are at risk as temperatures increase.

- *Outgoing water too warm:* To prevent hot water from doing harm to fish and other wildlife, power plants typically aren't allowed to discharge cooling water above a certain temperature. When power plants bump up against those limits, they can be forced to dial back power production or shut down. Alabama's Browns Ferry nuclear plant, on the Tennessee River, has done that on several occasions in recent years – cutting its output during three of the past five summers, for example, and for five consecutive weeks in one of those years (2010). In the Summer of 2012, four coal plants and four nuclear plants in Illinois each sought and received "thermal variances" from the state to let them discharge hotter water than their permits allow, even amidst extensive heat-related fish kills and tens of millions of dollars in fisheries-related losses.

Nuclear power cycle

The nuclear power cycle uses water in three major ways: extracting and processing uranium fuel, producing electricity, and controlling wastes and

risks. Reactors in the US fall into two main categories: boiling water reactors (BWRs) and pressurised water reactors (PWRs). Both systems boil water to make steam (BWRs within the reactor and PWRs outside the reactor); in both cases, this steam must be cooled after it runs through a turbine to produce electricity.

Like other thermoelectric power plants, nuclear reactors use once-through and/or recirculating cooling systems. Once-through systems withdraw enormous amounts of water, use it once, and return it to the source. Recirculating (or closed-loop) systems circulate water between the power plant and a cooling tower. About 40% of nuclear reactors in the US use recirculating cooling systems; 46% use once through cooling. Recirculating cooling systems withdraw much less water than once through systems but they consume much of what they do withdraw, typically operate less fuel-efficiently, and cost more to install. Dry (air) cooling is not currently used in nuclear power generation due to high costs (although World Nuclear News reported on 17 April 2013 that an air cooling system is to be constructed for Loviisa's two pressurised water reactors in Finland.)

Boiling water reactors and pressurised water reactors use comparable amounts of water to produce a unit of electricity. Nuclear plants as a whole withdraw and consume more water per unit of electricity produced than coal plants using similar cooling technologies because nuclear plants operate at a lower temperature and lower turbine efficiency, and do not lose heat via smokestacks.

In addition to cooling the steam, nuclear power plants also use water in a way that no other plant does: to keep

the reactor core and used fuel rods cool. To avoid potentially catastrophic failure, these systems need to be kept running at all times, even when the plant is closed for refueling.

During an accident, 10,000 to 30,000 gallons (38,000–114,000 litres) of water per minute may be required for emergency cooling.

Low-carbon power is not necessarily water-smart. Electricity mixes that emphasise carbon capture and storage for coal plants, nuclear energy, or even water-cooled renewables such as some geothermal, biomass, or concentrating solar could worsen rather than lessen the sector's effects on water. That said, renewables and energy efficiency can be a winning combination. This scenario would be most effective in reducing carbon emissions, pressure on water resources, and electricity bills. Energy efficiency efforts could more than meet growth in demand for electricity in the US, and renewable energy could supply 80% of the remaining demand.

Further reading:

- Synapse Energy Economics, paper prepared for the Civil Society Institute, Sept 2013, 'Water Constraints on Energy Production: Altering our Current Collision Course', www.synapse-energy.com/Downloads/SynapseReport.2013-06.CSI.Water-Constraints.13-010.pdf
- Benjamin Sovacool, January 2009, 'Running On Empty: The Electricity-Water Nexus and the U.S. Electric Utility Sector', *Energy Law Journal*, Vol.30:11, pp.11-51.
- Benjamin Sovacool and Kelly Sovacool, 2009, 'Identifying future electricity–water tradeoffs in the United States', *Energy Policy*, 37, pp.2763–2773.

Licensed to kill

Water outflows from nuclear plants expel relatively warm water which can have adverse local impacts in bays and gulfs, as can heavy metal and salt pollutants.

770.4340 The US Environmental Protection Agency states: “Nuclear power plants use large quantities of water for steam production and for cooling. Some nuclear power plants remove large quantities of water from a lake or river, which could affect fish and other aquatic life. Heavy metals and salts build up in the water used in all power plant systems, including nuclear ones. These water pollutants, as well as the higher temperature of the water discharged from the power plant, can negatively affect water quality and aquatic life. Nuclear power plants sometimes discharge small amounts of tritium and other radioactive elements as allowed by their individual wastewater permits.”[1]

A report by the US Nuclear Information and Resource Service (NIRS), US Humane Society and other groups,

‘Licensed to Kill: How the Nuclear Power Industry Destroys Endangered Marine Wildlife and Ocean Habitat to Save Money’, details the nuclear industry’s destruction of delicate marine ecosystems and large numbers of animals, including endangered species. Most of the damage is done by water inflow pipes, while there are further adverse impacts from the expulsion of warm water. Another problem is ‘cold stunning’ – fish acclimatise to warm water but die when the reactor is taken off-line and warm water is no longer expelled. For example, in New Jersey, local fishers estimated that 4,000 fish died from cold stunning when a reactor was shut down. (See the report and 6-minute video at www.nirs.org/reactorwatch/licensedtokill and the video is also posted at www.youtube.com/watch?v=VVsw3rmCnnU)

Case Study: Close to one million fish and 62 million fish eggs and larvae died each year when sucked into the water intake channel in Lake Ontario, which the Pickering nuclear plant uses to cool steam condensers. Fish are killed when trapped on intake screens or suffer cold water shock after leaving warmer water that is discharged into the lake. The Canadian Nuclear Safety Commission told Ontario Power Generation to reduce fish mortality by 80% and asked for annual public reports on fish mortality.[2]

Case Study: The Oyster Creek nuclear plant in New Jersey, US, has killed 80 million pounds (36,300 tonnes) of aquatic organisms in the Barnegat Bay over the past 40 years, according to the US Fish and Wildlife Service.[3]

References:

- 1 US Environmental Protection Agency, ‘Nuclear Energy’, www.epa.gov/cleanenergy/energy-and-you/affect/nuclear.html
- 2 Carola Vyhnak, 6 July 2010, ‘Pickering nuclear plant ordered to quit killing fish’, ‘Millions of adults, eggs and larvae perish when sucked into intakes or shocked by cold water’, www.thestar.com/news/gta/article/832748--pickering-nuclear-plant-ordered-to-quit-killing-fish
- 3 Todd Bates, 22 March 2012, ‘Oyster Creek nuclear plant kills 1,000 tons of sea life a year, agency says’, <http://blogs.app.com/enviroguy/2010/03/22/oyster-creek-nuclear-plant-kills-1000-tons-of-sea-life-a-year-agency-says>

How much water does a nuclear power plant consume?

770.4341 First, a definition and some generalisations. Consumption is the net water loss from evaporation and equals the amount of water withdrawn from the source minus the amount returned to the source. With cooling towers, the amount of water withdrawn from the source is similar to consumption. With once through cooling, withdrawal is vastly greater than consumption. But overall consumption is greater with cooling towers than with once through cooling. Generally, cooling towers reduce the impacts on aquatic life but increase water consumption. For coastal sites, the loss (consumption) of water is rarely if ever a problem but the impacts on marine life (and other environmental impacts) can be significant.

Woods [1] gives figures of 1,514 to 2,725 litres of water consumption per megawatt-hour (MWh) for nuclear power reactors and the Nuclear Energy Institute gives identical figures. [2] For a 1 GW reactor, that equates to daily water consumption of 36.3 to 65.4 million litres. The lower figure is for once-through cooling, the higher figure is for systems using cooling towers (a.k.a. closed-loop, recirculating).

A 2009 World Economic Forum (WEF) paper gives a near-identical figure for

closed-loop cooling (2,700 l/MWh) – plus 170–570 l/MWh for uranium mining and fuel production, giving a total of 2,870 to 3,270 l/MWh (68.9 to 78.5 million litres daily) .[3]

For coal, the WEF paper gives figures of 1,220 to 2,270 l/MWh (including mining).

For gas, the WEF paper gives figures of 700 to 1,200 l/MWh, and the Nuclear Energy Institute gives figures of zero (dry cooling) to 380 l/MWh (once through cooling) to 1,400 l/MWh (cooling towers).

The Nuclear Energy Institute claims that hydro plants consume 17,000 l/MWh, largely due to evaporation from reservoirs. The Nuclear Energy Institute further states that “renewable energy sources such as geothermal and solar thermal consume two to four times more water than nuclear power plants”, without providing any details or references, and without noting that some renewable energy sources (such as wind and solar PV) use negligible water.

Some nuclear advocates promote the potential role of nuclear power in addressing some water problems, e.g. low-carbon desalination. But such proposals raise familiar pro-

blems – for example Syria’s pursuit of a nuclear-powered desalination plant may have masked weapons ambitions and is believed to have been abandoned because of US pressure. Nuclear advocates are on stronger ground when they note that there is no need for nuclear plants to be located adjacent to their fuel source (typically 180 tonnes of low enriched uranium fuel annually for a 1 GW reactor); thus for example inland coal-fired power plants adjacent to coal mines can be replaced by coastal nuclear plants.

The Union of Concerned Scientists gives the following figures for water withdrawal (as opposed to consumption)[4]:

- with closed-loop recirculating cooling, water withdrawal ranges from 3,000–9,800 l/MWh (72–235 million litres daily for a 1GW reactor);
- with once through cooling, withdrawal is far greater at 95,000–227,000 l/MWh (2.3–5.4 billion litres daily for a 1 GW reactor; 0.84–1.97 trillion litres annually).

The Nuclear Information and Resource Service notes that a typical once-through cooling system draws into each reactor unit more than one billion gallons (3.8 billion litres) of water daily, 500,000 gallons (1.9 million litres) per minute.[5]

References:

- 1 Guy Woods, Australian Commonwealth Department of Parliamentary Services, 2006, ‘Water requirements of nuclear power stations’, <http://efmr.org/files/07rn12.pdf>
- 2 World Economic Forum in partnership with Cambridge Energy Research Associates, 2009, ‘Energy Vision Update 2009, Thirsty Energy: Water and Energy in the 21st Century’, http://www3.weforum.org/docs/WEF_WaterAndEnergy21stCentury_Report.pdf
- 3 Nuclear Energy Institute, November 2012, Water Use and Nuclear Power Plants, www.nei.org/Master-Document-Folder/Backgrounders/Fact-Sheets/Water-Use-and-Nuclear-Power-Plants
- 4 Union of Concerned Scientists, July 2013, ‘Water-Smart Power: Strengthening the U.S. Electricity System in a Warming World’, www.ucsusa.org or <http://tinyurl.com/ucs-water>
- 5 Nuclear Information and Resource Service, ‘Licensed to Kill’, www.nirs.org/reactorwatch/licensedtokill

Other stages of the nuclear fuel cycle

The Union of Concerned Scientists summarises water issues associated with uranium fuel fabrication [1]:

770.4342 Processing uranium requires mining, milling, enrichment, and fuel fabrication, all of which use significant quantities of water.

- *Mining – Uranium mining consumes one to six gallons (3.8–22.7 litres) of water per million Btus of thermal energy output, depending on the mining method. Mining uranium also produces waste that can contaminate local water sources, and which can be especially dangerous given the radioactivity of some of the materials involved. (A Btu or British Thermal Unit is a measure of energy content, usually used to describe the energy content of fuels. One kilowatt hour is*

the rough equivalent of 3,400 Btus.)

- *Processing – Uranium processing consumes seven to eight gallons (26.5–30.3 l) of water for every million Btus of thermal output.*
- *Milling – The milling process uses a mix of liquid chemicals to increase the fuel's uranium content; milling leaves behind uranium-depleted ore that must be placed in settling ponds to evaporate the milling liquids.*
- *Enrichment – The next step, enriching the gaseous uranium to make it more effective as a fuel accounts for about half of the water consumed in uranium processing. The conventional enrichment method in the US*

is gas diffusion, which uses significantly more water than the gas centrifuge approach popular in Europe.

- *Fuel Fabrication – Fabrication involves bundling the enriched uranium into fuel rods in preparation for the nuclear reactor.*

At the 'back end' of the nuclear fuel cycle, the large commercial reprocessing plants in France and the UK are major sources of radioactive marine pollution. Cogema's reprocessing plant at La Hague in France, and the Sellafield reprocessing plant in the UK, are the largest sources of radioactive pollution in the European environment.[2]

References:

- 1 Union of Concerned Scientists, 'Water for Nuclear', www.ucsusa.org/clean_energy/our-energy-choices/energy-and-water-use/water-energy-electricity-nuclear.html
- 2 WISE-Paris, Study on Sellafield and La Hague commissioned by STOA, www.wise-paris.org/english/stoa_en.html

More information:

- Friends of the Earth, Australia, 'Impacts of Nuclear Power and Uranium Mining on Water Resources', www.foe.org.au/anti-nuclear/issues/oz/water-nuclear

Jellyfish shut down Swedish nuclear plant

A huge cluster of jellyfish forced the Oskarshamn nuclear plant in Sweden to shut down on 29 September 2013.

770.4343 The jellyfish clogged the pipes that bring in cooling water. It took two days to fix the problem.[1]

Jellyfish have caused problems at many nuclear plants around the world, as have fish and other aquatic life.[3] A few examples:

- In 2005, one reactor at Oskarshamn was temporarily shut down due to jellyfish.[1]
- EDF Energy manually shut down the Torness nuclear power plant in Scotland in mid-2011 because jellyfish were obstructing the cooling water intake filters.[3] (In May 2013, the two Torness reactors

were temporarily shut down because seaweed blocked the water intake pipe.[4])

- In 2012 a reactor at the Diablo Canyon nuclear power plant in California was shut down after sea salp – a gelatinous, jellyfish-like organism – clogged water intake pipes.[2]
- In July 2009 a reactor in Japan was forced to temporarily shut down due to infiltration of swarms of jellyfish near the plant.[5] Jellyfish disrupted operation of the Shimane nuclear plant in Japan in 1997 and 2011.[6]

Marine biologists warn the jellyfish phenomenon could become more

common. Lene Moller, a researcher at the Swedish Institute for the Marine Environment, said: "It's true that there seems to be more and more of these extreme cases of blooming jellyfish. But it's very difficult to say if there are more jellyfish, because there is no historical data." [1]

Increased fishing of jellyfish predators and global warming are contributing to higher jellyfish populations.[3] Monty Graham, co-author of a study on jellyfish blooms published in the *Proceedings of the National Academy of Sciences* in June 2011, blames global warming, overfishing, and the nitrification of oceans through fertiliser run-off.[7]

References:

- 1 Gary Peach, 1 Oct 2013, 'Wave of jellyfish shuts down Swedish nuke reactor', <http://phys.org/news/2013-10-jellyfish-swedish-nuke-reactor.html>
- 2 Aaron Larson, 1 Oct 2013, 'Nuclear Plant Shut Down Due to Jellyfish', www.powermag.com/nuclear-plant-shut-down-due-to-jellyfish/
- 3 'Fire and Jellyfish Threaten Plant Operations', 07/06/2011, POWERnews, www.powermag.com/fire-and-jellyfish-threaten-plant-operations/
- 4 Reuters, 24 May 2013, 'Seaweed stops Scottish EDF nuclear plant', <http://uk.reuters.com/article/2013/05/24/uk-edf-britain-seaweed-idUKBRE94N0AC20130524>
- 5 Monami Thakur, 9 July 2011, 'Millions of Jellyfish Invade Nuclear Reactors in Japan, Israel', www.ibtimes.com/millions-jellyfish-invade-nuclear-reactors-japan-israel-photos-707770
- 6 Reuters, 24 June 2011, 'Jellyfish back off at Japan nuclear power plant', <http://in.reuters.com/article/2011/06/24/idINIndia-57889320110624>
- 7 Glenda Kwek, 11 July 2011, 'Jellyfish force shutdown of power plants', www.theage.com.au/environment/jellyfish-force-shutdown-of-power-plants-20110711-1haa6.html

Climate change, water and energy

A July 2013 report by the US Department of Energy details many of the interconnections between climate change and energy.[1] These include:

770.4344

- Increasing risk of shutdowns at coal, gas and nuclear plants due to decreased water availability which affects cooling at thermoelectric power plants, a requirement for operation;
- Higher risks to energy infrastructure located along the coasts due to sea level rise, the increasing intensity of storms, and higher storm surge and flooding. A 2011 study evaluated the flood risk from coastal storms and hurricanes for the Calvert Cliffs nuclear plant (Maryland) and the Turkey Point nuclear plant (Florida). Under current conditions, storm surge would range from 0.6 metres for a Nor'easter to 3.7 metres for a Category 3 hurricane, causing no flooding at Calvert Cliffs but "considerable flooding" at Turkey Point (which would be inundated during hurricanes stronger than Category 3);
- Disruption of fuel supplies during severe storms;
- Power-plant disruptions due to drought; and
- Power lines, transformers and electricity distribution systems face increasing risks of physical damage from the hurricanes, storms and wildfires that are growing more frequent and intense. For example, in February 2013, over 660,000 customers lost power across eight states in the US Northeast affected by a winter storm bringing snow, heavy winds, and coastal flooding to the region and resulting in significant damage to the electric transmission system.

Many incidents illustrate the connections between climate, water and nuclear power in the US:

- From February 8–11, 2013, Winter Storm Nemo brought snow and high winds to 19 nuclear energy facilities in the Northeast and mid-Atlantic – 18 facilities operated continuously at or near full power throughout the storm while Entergy's Pilgrim 1 reactors in Massachusetts safely

shut down on February 9 due to a loss of off-site power (restored the following day).[6]

- In October 2012, ports and power plants in the Northeast were either damaged or experienced shutdowns as a result of Hurricane Sandy. More than eight million customers lost power in 21 affected states.[1] Hurricane Sandy affected 34 nuclear energy facilities in the Southeast, mid-Atlantic, Midwest and Northeast. Twenty-four nuclear energy facilities continued to operate throughout the event. Seven were already shut down for refueling or inspection. Three reactors shut down: Salem 1, New Jersey, was manually shut down due to high water at its outside circulation water pumps; Indian Point 3, New York, automatically shut down due to external power grid disruption; Nine Mile Point 1, New York, automatically shut down due to external power grid disruption. Exelon declared an alert due to the high water level at the cooling water intake structure of its Oyster Creek, New Jersey nuclear plant; the alert ended after 47 hours when the water level dropped.[6]
- In August 2012, Dominion Resources shut down one reactor at the Millstone Nuclear Power Station in Connecticut because the temperature of the intake cooling water, withdrawn from the Long Island Sound, was too high. Water temperatures were the warmest since operations began in 1970. No power outages were reported but the two-week shutdown resulted in the loss of 255,000 megawatt-hours of power, worth several million dollars.[1]
- In August 2012, Entergy's Waterford 3 reactor, Louisiana, was temporarily shut down as a precaution due to projected high winds (Hurricane Isaac).[6]
- In July 2012, four coal-fired power plants and four nuclear power plants in Illinois requested permission to exceed their permitted water temperature discharge levels. The Illinois Environmental Protection Agency

granted special exceptions to the eight power plants, allowing them to discharge water that was hotter than allowed by federal Clean Water Act permits. [1]

- In July 2012, the Vermont Yankee had to limit output four times because of low river flow and heat; and FirstEnergy Corp's Perry 1 reactor in Ohio dropped production because of above-average temperatures.[2]
- In September 2011, high temperatures and high electricity demand-related loading tripped a transformer and transmission line near Yuma, Arizona, starting a chain of events that led to the shut down of the San Onofre nuclear plant with power lost to the entire San Diego County distribution system, totaling approximately 2.7 million power customers, with outages as long as 12 hours. [1]
- On 27–28 August 2011, Hurricane Irene affected 24 nuclear power plants along the East Coast. Eighteen reactors remained at or near full power throughout the storm. Power output from four reactors was temporarily reduced as a precaution. One plant temporarily shut down as a precaution – Constellation Energy declared an unusual event when the Calvert Cliffs 1, Maryland, reactor automatically shut down due to debris striking an external electrical transformer.[6]
- On 27 April 2011, three Browns Ferry reactors, Alabama, automatically shut down when strong storms knocked out off-site power. Emergency diesel generators were used for just over five days.[6]
- On 16 April 2011, Dominion Resources' two Surry reactors, Virginia, automatically shut down after a tornado damaged a switchyard and knocked out off-site power.[6]
- In the Summer of 2010, the Hope Creek nuclear power plant in New Jersey and Exelon's Limerick plant in Pennsylvania had to reduce power because the temperatures of the intake cooling water, withdrawn from the Delaware and the Schuylkill Rivers respectively, were too high and did not provide sufficient cooling

for full power operations. [1]

- On 6 June 2010, DTE Energy's Fermi 2 reactor, Michigan, automatically shut down after a tornado knocked out off-site power to the site. The tornado caused some external damage.[6]
- On 1 September 2008, Entergy's River Bend reactor, Louisiana, was manually shut down ahead of the approach of Hurricane Gustav. The shut down proceeded safely as designed but the hurricane caused some external damage.[6]
- In 2007, 2010, and 2011, the Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant in Athens, Alabama, had to reduce power output because the temperature of the Tennessee River was too high to discharge heated cooling water from the reactor without risking ecological harm to the river. TVA was forced to curtail the power production of its reactors, in some cases for nearly two months. While no power outages were reported, the cost of replacement power was estimated at US\$50 million. [1] From August 5–12, 2008, the TVA lost a third of nuclear capacity due to drought conditions; all three Browns Ferry reactors were idled to prevent overheating of the Tennessee River.[2]
- On 20 August 2009, lightning struck transmission lines knocking out off-site power to the Wolf Creek reactor, Kansas, and the plant automatically shut down.[6]
- In August 2006, two reactors at Exelon's Quad Cities Generating Station in Illinois had to reduce electricity production to less than 60% capacity because the temperature of the Mississippi River was too high to discharge heated cooling water. [1] The Dresden and Monticello plants in Illinois cut power to moderate water discharge temperatures from July 29 to August 2.[2]
- In July 2006, one reactor at American Electric Power's D.C. Cook Nuclear Plant in Michigan was shut down because the high summer temperatures raised the air temperature inside the containment building above 48.9°C, and the temperature of the cooling water from Lake Michigan was too high to intake for cooling. The plant could only be returned to full power after five days. [1]
- On 28 August 2005, Hurricane Katrina knocked out off-site power to Entergy's Waterford 3 reactor, Louisiana, and a manual shut down proceeded. Emergency diesel generators were used for 4.5 days. [6]
- On 24 September 2004, Hurricane Jeanne prompted a manual shut down of NextEra Energy's St. Lucie 1, 2 reactors, Florida, then caused loss of off-site power. Emergency diesel generators functioned as designed.[6]
- In 2003, Hurricane Charley led to a shut-down of the Brunswick 1 reactor in North Carolina due to loss of off-site power because of a trip of the station auxiliary transformer. The transformer trip was due to an electrical fault on a transmission system line. Operators manually shut down the reactor.[7]
- On 24 June 1998, FirstEnergy's Davis Besse reactor, Ohio, received a direct hit by an F2 tornado. The plant automatically shut down and emergency diesel generators (EDG) provided back-up power.[6] One EDG had to be started locally because bad switch contacts in the control room prevented a remote start. Then, problems due to faulty ventilation equipment arose, threatening to overheat the EDGs. Even with the EDGs running, the loss of offsite power meant that electricity supply to certain equipment was interrupted, including the cooling systems for the onsite spent fuel pool. Water temperature in the pool rose from 43°C to 58°C. Offsite power was restored to safety systems after 23 hours just as one EDG was declared inoperable.[7]
- On 24 August 1992, Category 5 Hurricane Andrew knocked out off-site power to NextEra Energy's Turkey Point 3, 4 reactors, Florida, and damaged electrical infrastructure. Manual plant shut down proceeded and emergency diesel generators were used for six days, 10 hours.[6] All offsite communications were lost for four hours during the storm and access to the site was blocked by debris and fallen trees.

shutting down reactors. The nuclear power station's fire protection system was also destroyed.[7]

- In 1988, drought, high temperatures and low river volumes forced Commonwealth Edison to reduce power by 30% percent or in some cases shut down reactors at the Dresden and Quad Cities plants in Illinois. "That was the first wake-up call that plants would be vulnerable in a climate-disrupted world," said David Kraft, director of the Nuclear Energy Information Service.[2]

Of course, the problems are not unique to the US. A few examples:

- In July 2009, France had to purchase power from the UK because almost a third of its nuclear generating capacity was lost when it had to cut production to avoid exceeding thermal discharge limits.[2]
- In 2003, France, Germany and Spain had to choose between allowing reactors to exceed design standards and thermal discharge limits and shutting down reactors. Spain shut down its reactors, while France and Germany allowed some to operate and shut down others.[2] The same problems occurred in the Summer of 2006.[3]
- On 8 February 2004, both Biblis reactors (A and B) in Germany were in operation at full power. Heavy storms knocked out power lines. Because of an incorrectly set electrical switch and a faulty pressure gauge, the Biblis-B turbine did not drop, as designed, from 1,300 to 60 megawatts, maintaining station power after separating from the grid. Instead the reactor scrambled. When Biblis-B scrambled with its grid power supply already cut off, four emergency diesel generators started. Another emergency supply also started but, because of a switching failure, one of the lines failed to connect. These lines would have been relied upon as a backup to bring emergency diesel power from Biblis-B to Biblis-A if Biblis-A had also been without power. The result was a partial disabling of the emergency power supply from Biblis-B to Biblis-A for about two hours. Then, the affected switch

was manually set by operating personnel.[7]

A study by researchers at the University of Washington and in Europe, published in *Nature Climate Change*, found that generating capacity at thermoelectric plants in the US could fall by 4.4–16% between 2031 and 2060 depending on cooling system type and climate change scenarios.[4]

Prof. Dennis Lettenmaier, one of the authors of study, told *InsideClimate News* the problems will be two-fold. [5] First, water temperatures will be higher because of raised air temperatures, and will be too high at times to adequately cool the plant. Secondly, there may simply not be enough water to safely divert the flow and return it to the waterway. Climate models project a greater probability of low river levels

due to a more variable climate. Lower river or lake levels would mean there would be less water available to diffuse the warmth that is returned. Plants currently have discharge restrictions to prevent ecological damage from downstream thermal pollution. With lower water levels, the plants would be forced to shut down more often.

Lettenmaier said the study's findings might discourage operators from applying for relicensing of ageing facilities, because of the expensive upgrades that would be required. "That could be the last nail in the coffin," he said. (For example the the Oyster Creek (NJ) plant will close in 2019 in part because the utility prefers closure instead of installing a state-mandated cooling tower to minimise damage to Barnegat Bay.) Plants using cooling towers rather than once through coo-

ling will also be affected by climate change, but not nearly as much.

The impacts of climate change could be even bigger in Europe, according to the *Nature Climate Change* study. Power production in European thermoelectric plants could drop by 6.3–19% between 2031 and 2060 due to increased shut-downs.

The *Nature Climate Change* article states: "In addition, probabilities of extreme (>90%) reductions in thermoelectric power production will on average increase by a factor of three. Considering the increase in future electricity demand, there is a strong need for improved climate adaptation strategies in the thermoelectric power sector to assure future energy security."

References:

- 1 Department of Energy, July 2013, 'U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather' <http://energy.gov/downloads/us-energy-sector-vulnerabilities-climate-change-and-extreme-weather>
- 2 Robert Krier, 15 Aug 2012, 'Extreme Heat, Drought Show Vulnerability of Nuclear Power Plants', *InsideClimate News*, <http://insideclimatenews.org/news/20120815/nuclear-power-plants-energy-nrc-drought-weather-heat-water>
- 3 Susan Sachs, 10 Aug 2006, 'Nuclear power's green promise dulled by rising temps', www.csmonitor.com/2006/0810/p04s01-woeu.html
- Michelle T. H. van Vliet et al., June 2012, 'Vulnerability of US and European electricity supply to climate change', *Nature Climate Change*, Vol.2, pp.676–681, www.nature.com/nclimate/journal/v2/n9/full/nclimate1546.html
- 5 Robert Krier, 13 June 2012, 'In California, No Taboos Over Coastal Climate Threats', *InsideClimate News*, <http://insideclimatenews.org/news/20120613/nuclear-power-plants-united-states-climate-change-global-warming-water-scarcity>
- 6 Nuclear Energy Institute, 'Through the Decades: History of US Nuclear Energy Facilities Responding to Extreme Natural Challenge', www.nei.org/Master-Document-Folder/Backgrounders/Fact-Sheets/Through-the-Decades-History-of-US-Nuclear-Energy-F
- 7 Hirsch, Helmut, Oda Becker, Mycle Schneider and Antony Froggatt, April 2005, 'Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century', Report prepared for Greenpeace International, www.greenpeace.org/international/press/reports/nuclearreactorhazards

Further reading:

Section D.2 of the Greenpeace report cited immediately above addresses the following topics:

- Consequences of Climate Change for NPP Hazards
- Examples of Flooding
- Examples of Storm Events
- Vulnerability of Atomic Power Plants in the Case of Grid Failure
- Vulnerability of Atomic Power Plants in the Case of Flooding
- Vulnerability of Nuclear Power Plants by Other Natural Hazards
- Possible Counter-measures

'Hot water' documentary

(Abridged from *YourGv.com*, 8 July 2013.)

Hot water is an 80-minute documentary exposing the long-term devastation wrought by uranium mining and the nuclear industry.

770.4345 It follows the investigative journey of Liz Rogers, the 'Erin Brockovich of Uranium', as she travels around the US exploring the impact of uranium mining, atomic testing and nuclear plants on the drinking water of 38 million people.

The documentary is described as a "powerful film that exposes the truths behind how the ground water, air and soil of the American Southwest came to be contaminated with some of the most toxic substances and heavy metals known to man due to the mining of uranium and the health and environmental impacts that followed."

Film-makers Liz Rogers and Kevin Flint begin in South Dakota witnessing communities exposed to uranium

from local mining interests. They take samples showing that radioactive material is seeping toward the nation's breadbasket.

Rogers and Flint follow the story to Oklahoma to explain the economic model of the industry. Private companies mine the uranium for a massive profit. Local workers and residents are made promises, but when finally forced to admit the environmental and health impact of the mining, the companies take their profits, declare bankruptcy and saddle the American taxpayer with hundreds of billions of dollars in clean-up costs, according to the documentary.

"I don't know who started calling me the Erin Brockovich of uranium. Maybe

I am the old and fat Erin Brockovich with a trucker mouth," said Rogers. "I took this journey because I was pissed off. I felt like an idiot because I believed the lies. I believed we were safe. I made this film because people need to know the truth."

The producers of Hot Water are completing a distribution agreement and will soon have the film on NetFlix and other VOD streams.

Youtube trailer: <http://tinyurl.com/water-hot>

Web: www.zerohotwater.com

Email: Liz Rogers liz@regroupfilms.com

Twitter: @ZeroHotWater

Facebook: www.facebook.com/ZeroHotWater

Flooding of nuclear plants

The risks associated with flooding of nuclear plants are as follows [1,2]

770.4346

- The presence of water in many areas may be a common cause of failure for safety related systems, such as the emergency power supply systems or the electric switchyard, with the associated possibility of losing the external connection to the electrical power grid, the decay heat removal system and other vital systems.
- Considerable damage can be caused to safety related structures, systems and components by the infiltration of water into internal areas of the plant. Water pressure on walls and foundations may challenge their structural capacity.
- The dynamic effect of the water can be damaging to the structure and the foundations of the plant as well as the many systems and components located outside the plant.
- A flood may transport ice floes in very cold weather or debris of all types which may physically damage structures, obstruct water intakes or damage the water drainage system.
- Flooding may affect the communication and transport networks around the plant site. The effects may jeopardise the implementation of safety related measures and emergency planning by making escape routes impassable and isolating the plant site in a possible emergency, with consequent difficulties in communication and supply.
- Flooding can contribute to the dispersion of radioactive material to the environment.

A 2005 Greenpeace International report lists examples of flooding of nuclear plants[1]:

- India, 2004: Kalpakkam-2, also known as Madras Atomic Power Station (MAPS), was operating at nominal power when the December 2004 tsunami sent seawater into its pump house. Operators brought the unit to safe shut-down. The tsunami swept away 59 people from Kalpakkam town, including five employees of the nuclear plant.
- France, 2003: EDF shut down two

reactors at Cruas in December 2003 in response to torrential rainfall along the lower Rhone River, prompting French nuclear safety authority DGSNR to activate its emergency response centre. Filters on heat exchangers between the component cooling system and the essential service water system at Cruas 3 and 4 were clogged, hindering operation of the residual heat removal system. At the nearby Tricastin site, clogging of filters on the conventional site caused two more power reactors, Tricastin 3 and 4, to scram.

- Ukraine, 2000: reactor 3 at Chernobyl was shut down due to flooding caused by a storm. Workers had to pump water out of the reactor building.
- France, 1999: The electricity grid was hit hard by storms on December 27. One of many problems was the loss of auxiliary power for the four reactors at Blayais as well as a loss of the 400 kV power grid at Blayais units 2 and 4. The load shedding design that allows the units to self-supply with electrical power after disconnection from the grid failed. This led to an automatic shut-down of these two units. The diesel generators were started and functioned until the connection to the 400 kV power grid was restored, after about three hours. Furthermore, a flood resulted in the partial submergence of the Blayais site. Invading the site through underground service tunnels, water flooded the pumps of the essential service water system to unit 1, and one of the two trains (with two essential service water system pumps each) was lost because the motors were flooded. Other facilities were also flooded, including rooms containing outgoing electrical feeders (indirectly leading to the unavailability of certain electrical switchboards); the bottom of the fuel building of units 1 and 2 leading to the unavailability of safety-critical pumps (arising from a breach of French safety standards).
- In July 1993, the operator of the

Cooper nuclear power plant on the Missouri River, Nebraska, was forced to shut down the reactor as dykes and levees collapsed around the site closing many emergency escape routes in the region. Below grade rooms in the reactor and turbine buildings had extensive in-leakage with rising water levels. The NRC inspectors noted that plant personnel "had not established measures to divert the water away from important components".

Case Study: Fort Calhoun

A flood assessment performed by the Nuclear Regulatory Commission (NRC) in 2010 indicated that the Fort Calhoun nuclear power plant in Nebraska "did not have adequate procedures to protect the intake structure and auxiliary building against external flooding events." [3]

In June 2011, Missouri River floodwaters surrounded the Fort Calhoun plant. The reactor had been shut down in April 2011 for scheduled refueling, and has remained shut down ever since for a variety of reasons.

A fire on June 7 caused electricity to shut off in the spent fuel pools resulting in 90 minutes without cooling, and resulting in a partial evacuation. NRC inspectors were concerned that faulty design and faulty maintenance contributed to the fire; workers were unable to quickly get into the electrical room; and plant operator Omaha Public Power District was slow to notify emergency officials. [4,5]

This was followed by allegations that an NRC manager tried to override inspectors' conclusions about the fire and that he misrepresented their findings, and further allegations that senior NRC management made only token efforts to address NRC staff concerns. [6]

On June 23, a helicopter contracted by Omaha Public Power District to survey transmission lines made an unplanned landing 2.4 kms from the plant; reports described it as an unplanned landing but photos showed it on its side in a field. [7]

On June 26, a water-filled rubber flood berm surrounding part of the plant was punctured by a small earth mover and collapsed, allowing flood waters to surround the auxiliary and containment buildings at the plant, and forcing the temporary transfer of power from the external electricity grid to backup generators.[8,9]

On June 30 one of the pumps used to remove seepage caught fire when a worker was refilling it with gasoline. The worker put the fire out with a fire extinguisher but was burned on his arms and face.[10]

NRC whistleblowers

Beyond Nuclear summarises several examples of NRC whistleblower revelations about inadequate protection against flood risks.[11]

In July 2011, with flood waters along the Missouri River rising around Nebraska's Fort Calhoun nuclear power station, David Loveless, a NRC Senior Reactor Analyst, concluded that the reactor would not survive the gross failure of the Oahe dam. Loveless cited analysis that a dam break would hit the reactor with a wall of water knocking out electrical power systems and water pumps vital for reactor cooling.[11]

In September 2012, Richard Perkins, an NRC engineer, accused the NRC of deliberately covering up information relating to the vulnerability of US nuclear power facilities that sit downstream from large dams and reservoirs, and failing to act to correct the vulnerabilities despite being aware of the risks for years.[11,12,13]

Perkins asked the NRC's Office of Inspector General to investigate his allegations that NRC "staff intentionally mischaracterized relevant and noteworthy safety information as sensitive, security information in an effort to conceal the information from the public" where "agency records that show the NRC has been in possession of relevant, notable, and derogatory safety information for an extended period but failed to properly act on it. Concurrently, the NRC concealed the information from the public."

Perkins, along with at least one other NRC engineer, suggested that the real

motive for redacting information was to prevent the public from learning the full extent of the vulnerabilities and to obscure how much the NRC has known about the problems and for how long.[12]

Perkins was the lead author of July 2011 report, "Flooding of U.S. Nuclear Power Plants Following Upstream Dam Failure". The report concluded that the failure of one or more dams sitting upstream from several nuclear power plants "may result in flood levels at a site that render essential safety systems inoperable." Floodwaters could undermine all power sources including grid power, backup generators, and battery backups. The report concluded: "The totality of information analyzed in this report suggests that external flooding due to upstream dam failure poses a larger than expected risk to plants and public safety."[12]

"My estimation," Perkins told *The Huffington Post*, "is that if people saw the information that we have, and if they knew for how long we've had it, some might be disappointed at how long it's taken to act, and some might be disappointed that, to date, we haven't really acted at all."[12]

Another NRC engineer told *The Huffington Post* that the Department of Homeland Security had signed-off on releasing the July 2011 report without redactions, undermining arguments made by some NRC officials that certain information should be withheld because upstream dam vulnerability could be exploited by terrorists.[12]

Several nuclear experts have expressed concern about the three-reactor Oconee nuclear plant in South Carolina, which sits on Lake Keowee, downstream from the Jocassee Reservoir. The plant would almost certainly suffer core damage if the Jocassee dam were to fail, according to redacted findings in the July 2011 report. "The probability of Jocassee Dam catastrophically failing is hundreds of times greater than a 51 foot wall of water hitting Fukushima Daiichi," an NRC engineer said.[12]

Nuclear engineer Dave Lochbaum from the Union of Concerned Scientists notes that improvements have

been made at some US plants in the aftermath of the flooding of the Fukushima plant in March 2011.[14] However he questions why the steps were not taken sooner:

"For decades, these design deficiencies left these reactors more vulnerable to floods than necessary. The Fukushima disaster prompted reactions in the United States that found and fix these longstanding impairments. That's good. But what if these reactors had experienced the flood prior to March 2011 that it was supposed to be protected against, but was not? ...

"Why weren't these design problems found in the 2000s, 1990s, 1980s, or 1970s? Lots of people spent lots of time allegedly looking for them. For example, the NRC has inspection procedure 71111.06 titled "Flood Protection Measures" that requires two plant areas to be examined each year. The procedure explicitly guides NRC inspectors to give priority to "Sealing of equipment below the floodline, such as electrical conduits" in "areas that can be affected by internal flooding, including water intake facilities." ...

"Again, why didn't these or other NRC inspections find at least some of these design problems in the 2000s, 1990s, 1980s, or 1970s? It's not a case of one NRC inspector having a bad week – it's a case of a regulatory agency having four bad decades. The NRC should review its inspection efforts in light of all these reports and make changes necessary to improve their effectiveness.

"And the NRC could take a complementary approach. ... The NRC has the authority to fine owners for violating federal safety regulations. The NRC should take its federal safety regulations seriously by sanctioning owners who have violated them for decades."

UK: 12 of 19 nuclear sites at risk of flooding

As many as 12 of Britain's 19 civil nuclear sites are at risk of flooding and coastal erosion because of climate change, according to an unpublished analysis by the UK Department for Environment, Food and Rural Affairs obtained by the Guardian. Nine of the

sites are vulnerable now, while others are at risk from rising sea levels and storms in the future. The sites include all of the eight coastal sites proposed for new nuclear power reactors, and numerous radioactive waste sto-

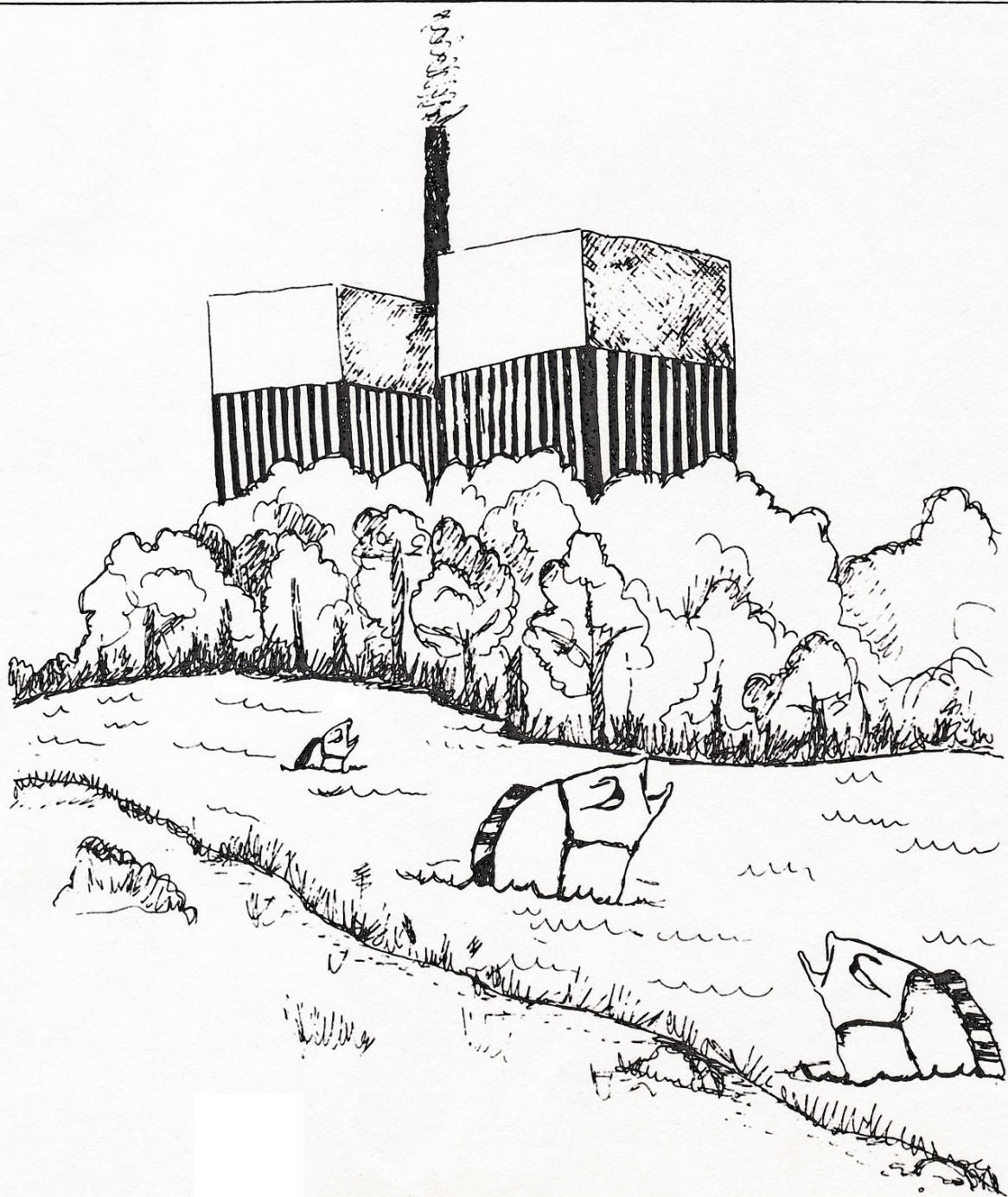
res, operating reactors and defunct nuclear facilities.[15]

A 2007 study by the UK Met Office, commissioned by nuclear firm British Energy, said that “increases in future

surge heights of potentially more than a metre could, when combined with wind speed increases, threaten some sites unless existing defences are enhanced.”[16]

References:

- 1 Hirsch, Helmut, Oda Becker, Mycle Schneider and Antony Froggatt, April 2005, 'Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century', Report prepared for Greenpeace International, www.greenpeace.org/international/press/reports/nuclearreactorhazards
- 2 IAEA, 2004, 'Flood Hazard for Nuclear Power Plants on Coastal and River Sites Safety Guide', <http://www-pub.iaea.org/books/IAEABooks/6731/Flood-Hazard-for-Nuclear-Power-Plants-on-Coastal-and-River-Sites-Safety-Guide>
- 3 NRC, 16 May 2011, 'Licensee Event Report 2011-003, Revision 1, for the Fort Calhoun Station', <http://pbadupws.nrc.gov/docs/ML1113/ML111370123.pdf>
- 4 Nancy Gaarder, 11 May 2012, 'NRC staff criticizes official's handling of Fort Calhoun', www.omaha.com/apps/pbcs.dll/article?AID=/20120511/NEWS01/705119889
- 5 Ryan Tracy, 8 June 2011, 'Nebraska nuclear plant lost cooling system after fire', <http://online.wsj.com/article/SB10001424052702304778304576374011963022284.html>
- 6 Ryan Tracy and Keith Johnson, 9 May 2012, 'NRC Manager Blocked Safety Concerns, Letter Says', <http://online.wsj.com/article/SB10001424052702304070304577394192487886520.html>
- 7 Jodi Baker, 23 June 2011, 'No One Hurt In Emergency Helicopter Landing', www.wowt.com/news/headlines/124434274.html
- 8 Matthew Wald, 27 June 2011, 'Nebraska Nuclear Plant's Vital Equipment Remains Dry, Officials Say', www.nytimes.com/2011/06/28/us/28nuke.html?_r=2
- 9 NRC, 'Event Notification Report for June 27, 2011', <http://nrc.gov/reading-rm/doc-collections/event-status/event/2011/20110627en.html#en46988>
- 10 KETV, 30 June 2011, 'Worker Burned At Nuclear Plant', www.ketv.com/r/28412417/detail.html
- 11 Beyond Nuclear, 11 Oct 2012, 'NRC whistleblowers warn of nuclear accidents caused by dam failures and effort to suppress disclosure', www.beyondnuclear.org/nuclear-power/2012/10/11/nrc-whistleblowers-warn-of-nuclear-accidents-caused-by-dam-f.html
- 12 Tom Zeller, 14 Sept 2012, 'Flood Threat To Nuclear Plants Covered Up By Regulators, NRC Whistleblower Claims', www.huffingtonpost.com/2012/09/14/flood-threat-nuclear-plants-nrc_n_1885598.html
- 13 Richard Perkins, 14 Sept 2012, Letter to the NRC Office of the Inspector General: Concealment of Significant Nuclear Safety Information by the U.S. Nuclear Regulatory Commission, <http://big.assets.huffingtonpost.com/igletter.pdf>
- 14 Dave Lochbaum, 19 February 2013, 'Fission Stories #130: Fukushima's Dividends or Mea Culpas', <http://allthingsnuclear.org/fission-stories-130-fukushimas-dividends-or-mea-culpas/>
- 15 Rob Edwards, 7 March 2012, 'UK nuclear sites at risk of flooding, report shows', <http://www.theguardian.com/environment/2012/mar/07/uk-nuclear-risk-flooding>
- 16 Nick Mathiason, 13 January 2008, 'Nuclear plants 'need better flood protection'', The Observer, www.guardian.co.uk/business/2008/jan/13/nuclear.nuclearpower



Åsa Falkenbert

WISE / NIRS Nuclear Monitor

The World Information Service on Energy (WISE) was founded in 1978 and is based in Amsterdam, the Netherlands.

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.

The WISE / NIRS Nuclear Monitor publishes information in English 20 times a year. The magazine can be obtained both on paper and as an email (pdf format) version. Old issues are (after 2 months) available through the WISE homepage: www.wiseinternational.org

Subscriptions:

US and Canada based readers should contact NIRS for details on how to receive the Nuclear Monitor (nirsnet@nirs.org)
Others receive the Nuclear Monitor through WISE.

	NGO's/individuals	Institutions/Industry
20 Issues for the paper version	100 Euro	350 Euro
20 Issues for the email version	50 euro	200 Euro

Contact the editor via monitor@wiseinternational.org

Contact WISE via *WISE International, Po Box 59636, 1040 LC Amsterdam, The Netherlands*

Web: www.wiseinternational.org / Email: info@wiseinternational.org / Phone: +31 20 6126368 /
ISSN: 1570-4629

WISE/NIRS NUCLEAR

MONITOR

c/o WISE Amsterdam
PO Box 50636
1040 LC Amsterdam
Netherlands

PRINTED MATTER
MATIERE IMPRIMEE



TPG Post

Port betaald