Professor Ileana Porges –West
Nulear Power
EAP1620

Preparation:

1. Students in an advanced ESL Reading Class Listen and Read to what happened in two different nuclear accidents in Japan and Russia. Lovins article will be read and discussed in class. Students will summarize *Economist* article for homework and prepare vocabulary cards for 10 new words to be used in a class Jeopardy game on vocabulary covered in the article.

2. Students will have a session with the Research Librarian to learn how to locate information on library databases and films on FRG.

3. Students will work with a group to pick a country to report on the use of nuclear power and prepare PPT's on what governments are doing and how citizens are reacting to the current situation in view of their own investment in nuclear energy or alternative sources of energy.

4. Students will discuss the unknown future human costs based on the disasters in Japan and Russia.

Learning Outcomes:

Student understands the relationships among science, technology, society, and the individual. Knows ways in which social and economic forces influence which technologies will be developed and used; Knows that alternatives, risks, costs, and benefits must be considered when deciding on proposals to introduce new technologies or to curtail existing ones; Knows examples of advanced and emerging technologies.

Competencies: Collaboration, synthesis and critical thinking

Assessment: Students will be given a rubric that will be used to assess their presentation based on six categories. Students will grade themselves and one other group for 1/3 of grade, faculty will provide final 2/3 of points for the assignment.

Learning Outcomes of MDC covered in this activity:

Communicate effectively using listening, speaking, reading, and writing skills.

Solve problems using critical and creative thinking and scientific reasoning.

Formulate strategies to locate, evaluate, and apply information.

Create strategies that can be used to fulfill personal, civic, and social responsibilities.

Demonstrate knowledge of ethical thinking and its application to issues in society.

Use computer and emerging technologies effectively.

Describe how natural systems function and recognize the impact of humans on the environment.

Resources:

Students will watch videos on the Chernobyl and Japanese nuclear power accidents

Japanese Nuclear Plant in Jeopardy
http://www.nytimes.com/interactive/2011/03/16/world/asia/reactors-status.html

Students will watch videos on the Chernobyl and Japanese nuclear power accidents

http://digital.films.com/PortalViewVideo.aspx?xtid=42676&loid=95494

Students will read Amory Lovins on Japan
http://www.pbs.org/wgbh/nova/insidenova/2011/03/nuclear-lovins.html

Nuclear power

When the steam clears Mar 24th 2011 | *LONDON, NEW YORK AND TOKYO* | from the print edition
http://www.economist.com/node/18441163?story_id=18441163

The Fukushima crisis will slow the growth of nuclear power. Might it reverse it?

FEAR and uncertainty spread faster and farther than any nuclear fallout. To date the crisis at the Fukushima Dai-ichi nuclear plant in Japan, laid low by the tsunami of March 11th, seems to have done little if any long-term damage to the environment beyond the plant's immediate vicinity or to public health. In fits and starts, and with various reverses, the situation at the plant has come closer to being under control.

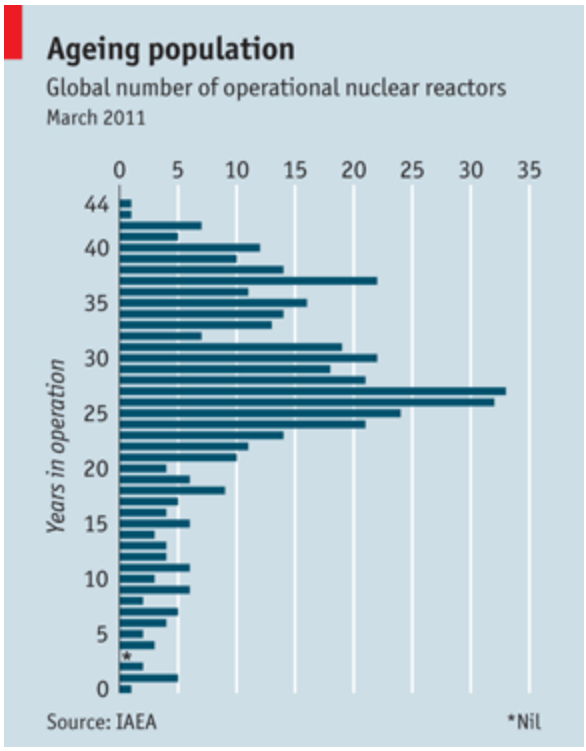
But the immediate crisis is far from over. The temperature of the three reactors with damaged central cores still fluctuates and water systems for the spent-fuel pools are jury-rigged at best. Contaminated food has been found a disconcertingly long way away, although it seems to be being kept out of the food chain. There are worries about tap water in distant Tokyo.

There will certainly be more durable effects too. Years of clean-up will drag into decades. A permanent exclusion zone could end up stretching beyond the plant's perimeter. Seriously exposed workers may be at increased risk of cancers for the rest of their lives (which may nevertheless be long). A concern for the long term, like uncertainty and fear, is one of the things that nuclear power invariably brings to discussions of future energy.

To a lot of environmentalists, the priority is to get nuclear power out of those discussions once and for all. Simply put, you can't trust the stuff. Somewhere, eventually, reactors will get out of control. One did at Three Mile Island in Pennsylvania in 1979. One did at Chernobyl in 1986. Now three have done so again, and an argument that had seemed to be running short of puff (Chernobyl's 25th anniversary comes up in April) is revived. Though this disaster has been nothing like as bad as Chernobyl, it is in some ways a lot worse than Three Mile Island—a bit like three Three Mile Islands in a row, with added damage in the spent-fuel stores.

Fukushima Dai-ichi, it is true, was swamped by a natural catastrophe of biblical proportions. But this argument cuts both ways. Nuclear planners clearly did not appreciate how bad things could get on a low-lying coast in a seismic zone; and poor planning is part of the problem. One reason why Japanese confidence in nuclear power had been growing in recent years was that past scandals led to resignations and the prospect of reform among planners, power companies and regulators. Whereas in 2005 only a quarter of people felt nuclear energy was safe, by last year more than 40% did, according to a survey by Japan's Cabinet Office. Finding sites for new reactors was not proving easy—and old reactors stayed online as a result—but it did not seem impossible.

Elsewhere, too, the industry was reviving. Figures from the World Nuclear Association, a trade body, have shown more capacity planned and proposed than on the ground. Now much of this expansion looks likely to be curtailed. Even the replacement of reactors may be in question.



When last year a volcano closed the skies over Europe and a blown-out oil-rig turned the Gulf of Mexico black, there was no widespread enthusiasm for giving up oil or air travel. But nuclear power is much less fundamental to the workings of the world than petrol or aeroplanes. Nuclear reactors generate only 14% of the world's electricity, and with a median age of about 27 years (see chart) and a typical design life of 40 a lot are nearing retirement. Although the world is eager to fly and thirsts for oil, it has had little appetite for new nuclear power for the past quarter of a century.

This is not just the direct result of Chernobyl. New nuclear plants cost a great deal of money. After Fukushima they are likely to cost even more, thanks to extra uncertainty in licensing and approval if nothing else. Another problem now made manifest is that if operator error or shoddy construction causes a reactor of the same design as yours halfway round the world to go wrong, yours may be shut down too. This is not a merely theoretical possibility. Seven German nuclear reactors which were officially safe until mid-March have been shut down. It is widely thought that at least some will not open again.

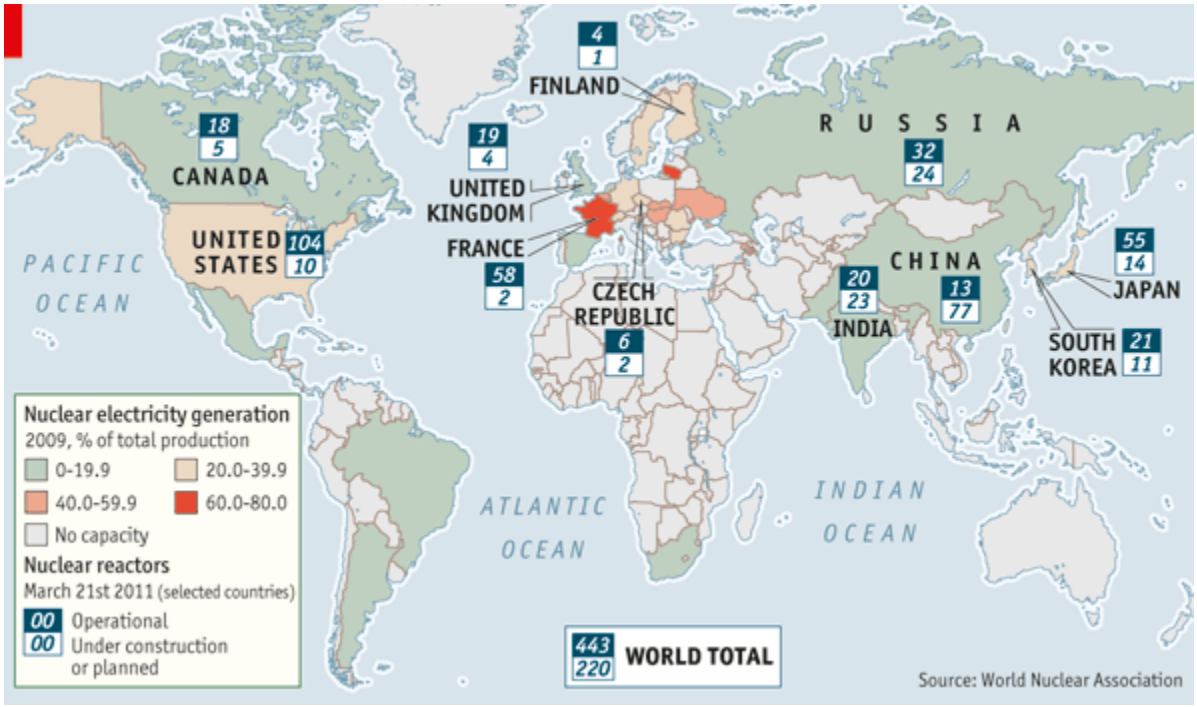
And if that happens, Germany will not suffer much. While the nuclear industry has stalled since Chernobyl, natural gas and renewables have come on impressively. German electricity prices would probably go up, depending to some extent on the price of gas and carbon, because although new nuclear plants are expensive, old, depreciated ones make cheap electricity. But it would not be the end of the world.

The 14% solution

Nuclear power thus looks dangerous, unpopular, expensive and risky. It is replaceable with relative ease and could be forgone with no huge structural shifts in the way the world works. So what would the world be like without it?

The most obvious answer is: a bit warmer. In 2009 the world's electricity generators emitted about 9 billion tonnes of carbon dioxide, out of an industrial total of 30 billion tonnes and a grand total, including deforestation and the effects of other gases, equivalent to some 50 billion. Without nuclear power and with other fuels filling in its share pro rata, emissions from generation would have been about 11 billion tonnes. The difference is roughly equal to the total annual emissions of Germany and Japan combined.

To put that in perspective, in 2010 the UN Environment Programme estimated that for the world to have a reasonable chance of limiting global warming to less than 2°C, carbon-dioxide emissions should be reduced to 44 billion tonnes by 2020. With business as usual, emissions would be between 54 billion and 60 billion tonnes. If countries took the most ambitious of the courses of action that they have outlined to the UN, the figure comes down to about 49 billion tonnes, leaving an "emissions gap" of 5 billion tonnes that seems highly unlikely to be bridged. So the 2 billion tonnes saved by nuclear power is not vast, but it is significant.



That said, a complete withdrawal from nuclear energy is not on the cards. Though China, which has 77 reactors at various stages of construction, planning and discussion, has said it will review its programme in the aftermath of Fukushima, few expect it to stop entirely. China has a great appetite for energy, which will continue to grow. For now its energy sector is highly concentrated on coal, but so that the country can both diversify and clean its air China's latest five-year plan aims for growth in all sorts of non-coal energy, including wind power, gas and

nuclear. Adverse public opinion and the additional cost of capital caused by uncertainties over regulatory approval have much less salience in China than elsewhere.

Some other countries will also go ahead: Russia says it sees no reason to stop work on ten reactors that are in development. But there could still be a widespread withdrawal from the technology by OECD countries, caused by national changes in policy or stiffer local opposition. And grand though China's ambitions are, for now OECD countries produce more than 80% of the world's nuclear electricity.

Analysts at Société Générale, a French bank, argue that if these rich countries built no more reactors and allowed existing ones to close at the end of their planned lives, an extra 860m tonnes of carbon a year would be emitted, on average, from 2010 to 2030. This may underestimate the impact on the system as a whole, because nuclear plants and large dams are the only broadly reliable sources of baseload electricity that do not burn fossil fuels. Although renewable capacity has been added quickly in some countries, you cannot be sure that the wind will blow or the sun will shine to order. A fair part of this can be smoothed out if the various sources are linked into an electric grid that is sufficiently large, robust and smart, but that does not obviate all the need for baseload.

Most studies assume that in a fully decarbonised electricity system the baseload would come either from nuclear or from fossil-fuel plants fitted with carbon capture and storage (CCS) technology. However, CCS has yet to be demonstrated on anything like the necessary scale, so deploying enough of it to replace existing and expected nuclear plants is a tall order. And a public that was turning against hubristic nuclear engineering might also object to the large-scale storage of a potentially asphyxiating gas beneath the ground, which CCS requires. This "numby" (not under my back yard) attitude has already affected some pilot projects.

Damn Vermont Yankee

America, which leads the world in installed nuclear power, may lead the world in turning away from the technology, too. In 2007 Congress agreed to provide loan guarantees for nuclear power; some 28 applications for new stations have since been filed. Barack Obama pledged in his state-of-the-union address in January 2010 to build a "new generation of safe, clean nuclear power plants". Even before Fukushima, though, this was looking increasingly unlikely. The recession hit demand. Ever-more-available shale gas brought a cheap and reliable alternative route to domestically fuelled electricity. And the lack of climate legislation meant there was no price on carbon, which would have favoured nuclear power.

There are just two new American reactors under construction, neither with full regulatory approval (a third, approved under an earlier system and then put on ice, is also under way). Few in the industry expect many more. Applications for around 20 plants to extend their licences are before the government and requests for 15 more are expected shortly. The Nuclear Regulatory Commission has already granted them to 64 plants, most recently on March 21st to Vermont Yankee, which is of the same design and vintage as the Fukushima reactors. This similarity has not been lost on the Vermonters trying with renewed vigour to shut it down. Expect more local opposition in years to come.

In Japan, where nuclear power provides 30% of the country's electricity, the debate may be more complex than outsiders imagine. Japan's nuclear anguish stems more from the way the industry is run than from its technological essence. The Japanese are angry at bureaucrats and TEPCO, the company that owns Fukushima Dai-ichi, for a long record of shoddy safety standards and cover-ups. "*Amakudari* kills," tweeted a well-known reformer recently, referring to the "descent from heaven" of senior bureaucrats to cushy jobs in industries they used to regulate. So although Japan may phase out a lot of older reactors, the public may tolerate nuclear power in the form of new, better plants with management it trusts.

In the European Union Austria, Denmark, Greece, Ireland and Portugal are strongly anti-nuclear, but the EU as a whole is unlikely to go their way. Its response to Fukushima has been to call for "stress tests" of its members' reactors. Britain, the Czech Republic and Finland hope soon to build some more. Finland and France, which produces more of its electricity in nuclear plants than any other big country, each have under construction a plant of the European Pressurised Reactor (EPR) design developed by AREVA, a French industrial group. Plans may be delayed or diminished, but a complete halt to building is unlikely.

France, in particular, seems certain to remain resolutely pro-nuclear. The French nuclear industry may even see Fukushima as an opportunity. The EPR is touted as being especially safe: if concerns about safety could be turned into a regulatory case for building only EPRs in Europe, so much the better. The British, Czechs and Finns, who are all also looking at a design by America's Westinghouse (the Finns are examining a South Korean one, too), would not be keen to be captive customers, but they may choose EPRs anyway.

The most labile European country on matters nuclear has, not surprisingly, been Germany, where great engineering and anti-nuclear sentiment have long coexisted uneasily. In 2002 the then centre-left government said it would phase out nuclear power by 2022. Last year the current, centre-right lot extended the lives of seven ageing reactors by eight years. In response to Fukushima it shut them again, at first for three months.


Explore our **interactive guide** to nuclear power around the world

Getting gas

Some or all of those plants may not reopen. If none did, then according to Stefan Wächter of Point Carbon, a research firm, German carbon-dioxide emissions would increase by 435m tonnes in the decade to 2020. Analysis by Deutsche Bank suggests that at least 23 gigawatts of new gas-

fired capacity would need to be built by the same year. Gas-fired plants are the natural short-term response in part because Germany's grid cannot take much more in terms of renewables (of which the country already has a lot) both because of their peaks and troughs and because some would need to be offshore. That said, demand for renewables elsewhere might increase, as Germany's extra use of fossil fuels pushed up the price of carbon in Europe's emissions-trading scheme.

In its likely switch to gas, Germany reflects the probable post-Fukushima world. In any country where nuclear provides less electricity than had been expected, in the near term gas is favourite to make up the shortfall. Société Générale's analysis suggests that a full withdrawal from nuclear by OECD countries would increase demand for gas by more than 400 billion cubic metres a year by 2045.

In America and Canada the nuclear slack could be taken up by domestically produced gas, Société Générale reckons, reflecting the sheer scale of the shale-gas revolution there. The rest of the world would either buy liquefied natural gas (LNG) or get gas in pipelines, a prospect that relations with Russia have made irksome to some. Energy-security concerns partly explained why Germany decided to delay its phasing out of nuclear plants. Now it and other European countries may buy a lot more Russian gas. To Russia one of the attractions of continuing with nuclear power is that it frees gas for export.

Yet a gassier Europe may not need to worry too much about security of supply. At least in the near term there is plenty of LNG because capacity originally intended to serve America is no longer needed for that purpose. This is good news for Europe and for Japan, which in the short run needs gas and oil to make up for lost production at Fukushima and other nuclear plants closed in the earthquake's aftermath, regardless of its long-term choices.

Some expect this surplus to last throughout the 2010s, as new sources become available. Others fear, or hope, that the market could tighten quite quickly. Paul McConnell of Wood Mackenzie, another research firm, has argued that for China to meet a pledged 40% reduction in the carbon intensity of its economy by 2020 would require a lot more gas than currently expected. If nuclear plants contribute less, that will be truer than ever. But though gas supply may tighten, there is still, by all estimates, a lot of it around for the medium to long term.

In the long term we're not all dead

Gas would be an early winner in a less nuclear world. But renewables might also do well. When cheap and plentiful gas replaces coal in electricity generation, it often reduces emissions much more cheaply than renewables can. But when gas replaces nuclear, it increases emissions. Any country serious about tackling climate change will therefore want more fossil-fuel-free generation elsewhere in the system. Renewables would have a clearer run at that segment of the market.

Distressing though it is, the crisis at Fukushima Dai-ichi is not in itself a reason for the world to change energy policy. The public-health effects seem likely, in the long run, to be small. Coal, with its emissions of sulphur, mercury and soot, will continue to kill far more people per kilowatt hour than nuclear does. But as an opportunity to reflect it may be welcome.

An energy portfolio, like any other, is a basket of risks: of security of supply, cost and environmental damage. Fear and uncertainty, which nuclear fission produces as unavoidably as it does iodine-131, distort people's perceptions of those risks. The long-term outlook which nuclear power also brings with it should clarify them.

Over the next 40 years, four things look clear. The world's people would be healthier and its climate less prone to change if it used a lot less coal; that requires greater energy efficiency, more renewable power and better grids, all of which also allow greater energy security;

significantly more research would help; and the supply of gas is much larger and more reliable than was thought just ten years ago, which will lower the costs of change. Because nuclear power saves carbon, doing without it would make action on climate harder. But because it increases capital costs and systemic risks, it would rarely have grown that much anyway outside a few countries. It won’t go away, but it must to some extent remain a sideshow, however spectacular it looks when it goes wrong.