GET1024/GEC1036: Radiation – Scientific Understanding and Public Perception

Tutorial 4

Notes from the lecturer

a. *This tutorial is based on lectures on Nuclear Power Plant. You will be required to read the article that appeared in Straits Times on 15 March 2017 proposing that Singapore should go nuclear. More specifically, the writer suggested a floating platform as the way forward.*
b. *The tutors will also take the opportunity to discuss some of the questions in Term Test 1 which many students may have found difficult or confusing.*

Your Tasks

1. Read the article published in Straits Times in 2017 on the proposal for Singapore to go nuclear at http://www.straitstimes.com/opinion/time-for-spore-to-say-yes-to-nuclear (and extracted below) using floating nuclear power plants.

2. Examine all the figures (e.g., amount of electricity generated worldwide, dose in Tokyo, per capital electrical energy consumption, "energy density" of nuclear fuel, etc.) given in the article. Are they reasonable? Are there any figures that differ significantly from what we have given in our lectures or from what you can find in the Internet?

3. Are there any factual statements in the article that are not precise (or even inaccurate) or should be qualified, for example

    i. the causes of the three nuclear accidents mentioned,
    ii. the production of hydrogen in a nuclear power plant,
    iii. small footprint of nuclear power plant (or more productive use of land),
    iv. lifetime of spent fuels kept in a pool of modest size.

4. The author stated: "Without radioactive emissions, we would all be dead. The human body is radioactive and much of our food is naturally radioactive. Many medical procedures are radiation-dependent." Do you agree? Are they essentially true, partially true, or essentially false?

5. The author provided "compelling" reasons for Singapore to consider nuclear power and the solution of moving the power plant away should an accident happen. Can you think of possible reasons (scientific, political or otherwise) why such a solution of moving away "a distressed power plant" cannot easily work?

6. What would your recommendations be for Singapore when the fossil fuels run out? Among the different types of reactors discussed in the lectures, could any of these be suitable for deployment in Singapore?

7. If you are interested, research further on reactors on floating platform that are currently being built or will be deployed in the near future and the amount of electrical power needed in Singapore.

    i. How many of such plants would we need to replace fossil fuel power plants?
    ii. Look at the map of Singapore. Can you suggest the locations for deploying these plants? Take in consideration factors such as shipping lanes, minimum distance from populated areas (you may decide how far this should be), security from terrorists, etc.
    iii. Conclude whether nuclear power plants on floating platform is a viable solution for Singapore.

Time for Singapore to say 'Yes' to nuclear

A floating nuclear power plant mitigates risks and offers economic advantages

Lim Soon Heng For The Straits Times
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The Fukushima nuclear accident dealt a blow to the emerging "nuclear renaissance" just when the world was close to putting Chernobyl behind it.

In its aftermath, several countries, including Japan and Germany, put aside, under public pressure, plans to build nuclear power plants (NPPs).

Six years after Fukushima, 61 new nuclear plants are under construction, in Britain, China, India, Russia and even the United States, where lobbyists from the oil and gas industry ply the corridors of power. France, undeterred, continues to keep its economy humming, with 77 per cent of its energy needs coming from nuclear fission. Scandinavian countries opt for nuclear rather than dam up their stunning fjords. Vietnam pushes ahead with its plan to build the first NPP in Asean.

But Singapore continues to vacillate, despite its strategic vulnerability, with its 95 per cent dependence on natural gas flowing from Indonesia and Malaysia for as long as goodwill on the other side prevails.

Natural gas is expensive and pollutive. Regular replenishment is needed or the economy halts. Gas-fired power plants require additional land for unloading terminals, tanks, regasification units, flue gas treatment plants and kilometres of pipelines. Carbon sequestration looms in the future.

Each year, 25 million gigawatt hours of electricity are generated worldwide. Studies by the University of Wisconsin-Madison conclude that 944.4 tonnes of CO_2 (if coal-fired) and 564.3 tonnes (if gas-fired) are released for each gigawatt hour.

Singapore, on a per capita basis, is a significant polluter.

This is not to deny the risks from NPPs. One commonly cited risk is radioactive particle leaks, which is possible. But radioactivity is not as deadly as naysayers proclaim.

Without radioactive emissions, we would all be dead. The human body is radioactive and much of our food is naturally radioactive. Many medical procedures are radiation-dependent.

Exposure to radiation becomes hazardous when the subject receives more than 100,000 microsieverts a year for multiple years. To put this in perspective, the radiation recorded in Tokyo 10 days after the Fukushima accident was 0.125 microsievert an hour or 1,096 microsieverts a year. This level is below the threshold and safe.

The accidents at Three Mile Island, Chernobyl and Fukushima, tragic though they were, provided engineers with valuable lessons. The last link in the events leading to the meltdown of the reactors was the loss of cooling water needed to remove the decay heat after the shutdown of the reactor.

The reactor shutdown was accomplished in seconds. However, after the reactor is shut down, the nuclear fuel continues to produce heat, called decay heat.

Cooling water needs to be circulated to keep the temperature of the fuel under control.

In these three accidents, meltdown occurred because of the failure of the cooling water pump. The circulation of the cooling water failed owing to a complete loss of backup power to operate the associated pumps.

To address this, engineers have introduced a passive cooling system, which works by natural convection and will work even when the NPP suffers a total blackout.

And the extensive discharge of radioactive particles in Fukushima was caused by the explosion of hydrogen that resulted from the reaction between the molten uranium and the zirconium cladding of the fuel tubes.

Measures to prevent this are being devised.

It is reassuring that, after previously opposing it, Prime Minister Lee Hsien Loong has said that a nuclear plant is possible in his lifetime and that Singapore "cannot afford to dismiss it".

There are good reasons to seriously consider going nuclear. Natural gas supply can be threatened by political instability or blatant disregard by a party to an agreement to supply it. This would cause havoc to the economy.

With water, Singapore has developed fallbacks should its main supplier abrogate a deal. We should be as resilient with natural gas.

Five countries control 72 per cent of the world's proven reserves of 187,300 billion cubic m.

We must remind ourselves that in 1973, oil prices quadrupled, taking the world by surprise.

What about renewables? For Singapore, this can never meet our base load. And it is only a matter of time before fossil fuels run out.

The way I see it, there is only one option to future-proof our economy: Go nuclear.

This can be done with uranium fission for the immediate future, and possibly thorium or hydrogen fusion for our grandchildren's time.

With the economy trending towards more intensive digital number-crunching, our per capita electrical energy consumption of 8,500 kilowatt hours is likely to rise along with our population. We cannot resolve this conundrum without going nuclear.

NPPs have small footprints because nuclear fuel is 50 million times more energy-dense than gas.

A nuclear reactor does not require gas-fired plants' aforementioned paraphernalia to support it. Its capacity factor is, according to many studies, almost twice that of a gas-fired heat source. This means less downtime for maintenance.

Its lifespan is also longer. The higher capital cost of an NPP is more than offset by its longer life, low maintenance requirements, cheaper fuel and more productive use of land.

Studies have shown that the levelised cost of energy - a way of comparing energy options - is lower than that of fossil or renewable plants, if the cost of funds is less than 4 per cent.

Small modular reactors that can be replicated and scaled up can drive costs even lower.

As for spent fuel, a lifetime of spent fuel can be kept in a pool of a modest size. In fact, 78 per cent of the spent fuel accumulated over five decades from all the NPPs in the US remains in water-filled pools today.

While gas is transported in liquefied natural gas ships or sub-sea pipelines to our shore, uranium can be shipped in boxes at a fraction of the cost.

Hydrogen produced with NPPs could be used in hydrogen fuel cells to power cars cleanly and cheaply. Cheap energy lowers the cost of business and improves our global competitiveness.

One of the biggest obstacles is what to do with a distressed nuclear power plant. If we can move it out of harm's way, there is no need for large exclusion zones.

We can indeed do this, if our NPPs are on floating platforms. Former minister mentor Lee Kuan Yew stated in 2008, when contemplating the prospect of NPPs to serve Singapore's energy needs: "I was thinking at one time about a floating platform. Put a nuclear station there and, if it blows, then we move it a few kilometres away from us."

No one foresaw Singapore becoming a market leader in offshore oil and gas rigs when it delivered its first offshore oil rig. But that market is mature and competition from lower-cost economies is intense. Singapore shipyards are in dire need of innovating and reinventing.

I am convinced that floating assets unrelated to oil and gas are the new horizon and a new area to develop. In particular, floating nuclear power plants are a disruptive technology worthy of the challenge.

What Singapore needs next is the political will to say "Yes" to nuclear.

• The writer is managing director of Floating Solutions LLP.

Extracted from http://www.straitstimes.com/opinion/time-for-spore-to-say-yes-to-nuclear