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The state of nuclear power two years after Fukushima – The ASEAN perspective

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HIGHLIGHTS

- This paper provides a holistic analysis on the importance of nuclear power.
- This paper examines the drivers for nuclear power post-Fukushima.
- This paper studies the responses towards "safer nuclear".
- Nuclear remains a reliable and clean base-load technology.
- Pronouncing the demise of nuclear power will not be sustainable.

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ABSTRACT

Given the need to rein in the rise in the global average temperature, decarbonizing the electricity sector, which accounts for nearly 50% of global greenhouse gas (GHG) emissions, is crucial. The suitability of nuclear power as a base-load technology and its relatively negligible GHG emissions raised expectations of a nuclear renaissance, until the Fukushima disaster brought discussions about nuclear power's potential to a standstill. However, completely ruling out nuclear may not be sustainable owing to the realities of rising energy demand, climate change considerations, and the need for reliable base-load supply technology, especially in the case of fast growing economies in the Association of South East Asian Nations (ASEAN). The Fukushima disaster was a wake-up call for both governments and the nuclear industry. Led by the International Atomic Energy Agency, the more advanced economies conducted stringent reviews of safety standards and emergency response procedures in the event of a catastrophe. Meanwhile the industry responded with strong commitments towards "Fukushima proof" designs, alongside other advancements towards "safer" fission power. In the ASEAN context, we argue in this paper that in addition to the economic advantage, nuclear power can help address the twin objectives of energy security and mitigating climate change effects. In ASEAN, there is still a strong momentum towards nuclear power development due to strategic considerations. In this paper, we reviewed in a holistic approach the various factors influencing decision making on nuclear power. Using ASEAN as a case study, we argue that nuclear power remains an important option and should be taken up rapidly if decarbonizing electricity generation is a grave concern. We also provide some recommendations towards the "safer nuclear" for ASEAN at the end of this paper.

1. Introduction

Despite rising global surface temperatures [1,2] and the need to address the increase of greenhouse gas (GHG) emissions to mitigate global warming [1,3,4], anti-nuclear sentiments have thwarted policymakers' attempts expand the use of nuclear technology. Whilst several studies have shown that nuclear power is an economically competitive base-load power source producing negligible GHG emissions [5], many countries and societies have turned strongly against fission power. Global anti-nuclear sentiments peaked in the aftermath of the March 11, 2011 event and the ensuing problems at the Tokyo Electric Power Company (TEPCO) Fukushima Daiichi nuclear power station. In Germany, following the anti-nuclear protests of more than 200,000 people [6], the country is now on track to completely phase out nuclear power with 8 reactors already being decommissioned since 2011 [7]. At the G-8 Summit, there were mixed reactions in which France, Russia, US, and the

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Nomenclature

ACR	Advanced CANDU Reactors
ADB	Asian Development Bank
ASEAN	Association of South East Asian Nations
ASEANTOM	ASEAN Network of Regulatory Bodies on Atomic Energy
BAU	Business-as-usual
BWR	Boiling Water Reactor
EMA	Energy Market Authority
EPR	European Pressurized Reactor
EPRI	Electric Power Research Institute
ESBWR	Economic Simplified Boiling Water Reactor
FPP	fission power plant
GHG	greenhouse gases
Gt	Giga-ton
GWe	Gigawatt of electricity
GWh	Giga-Watt-hour
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IGCC	Integrated gasification combined cycle
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilo-Watt-hour
LEU	Low-Enriched Uranium
LNG	Liquid Natural Gas
MCFPD	million cubic feet per day
Mt	Megaton
MTI	Ministry of Trade and Industry
MTOE	megaton of oil equivalent
MTR	Material Test Reactor
NEA	Nuclear Energy Agency
O&M	Operations and maintenance
SMR	Small and Medium Reactor
TEPCO	Tokyo Electric Power Company
TOR	Terms of References
TWh	Tera-Watt hour
U.S.NRC	United States Nuclear Regulatory Commission
WNA	World Nuclear Association

UK remained committed to new builds while Italy placed a one year moratorium on its plans to revive nuclear power [8] and Switzerland decided to abandon plans for new builds and scheduled the phasing down of current reactors by 2034 [9]. Even though committed to new builds, the US wanted major changes in nuclear power plant rules to enhance the safety of reactors [10].

Post Fukushima, many have casted doubts about the future of nuclear industry as seen in [11]. However, one should not forget that nuclear power plays an important role in the "BLUE Map Scenario" [12] developed by the International Energy Agency (IEA). In the latest IEA's projection, all CO_2 emissions permitted in the IEA's "450 Scenario" would be "locked-in" by power plants, factories, buildings, and other infrastructure by 2017 without further urgent actions [13]. Since the electricity sector contributed to approximately 40% of GHG emissions globally [14], decarbonizing electricity generation is crucial.

In this paper, we asked whether Fukushima had brought about the demise of the nuclear industry or merely delayed the previously heralded "nuclear renaissance" [15]. Despite strong anti-nuclear sentiments following the Fukushima disaster, there was an increase in the share of nuclear power in most of the countries as reported in [16–18]. Updating the information with [19], very few countries altered the share of nuclear power in the electricity fuel mix as seen in Fig. 1. Globally, as of the end of 2012, there were 437 reactors totaling 373 GW generating capacity in operation, 1 reactor in long-term shutdown, 67 reactors under construction, and total electricity supplied amount to 2346.2 TWh [19]. Compared with 441 reactors in operation (as of end of 2010), the net reduction in reactors came primarily from the following countries: Japan (4 units), Germany (8 units), UK (1 unit). Meanwhile, several Asian economies, such as China, Kazakhstan, South Korea, and Pakistan, and Russia added new reactors to the grid. As of December 2012, China, Russia, and India were leading the construction of fission power reactors with China having 26 reactors under construction, Russia having 10, and India having 7. South Korea was constructing 4 reactors as of end of 2012. Among the member countries of the Associate of South East Asian Nations (ASEAN), Vietnam has 2 confirmed reactors by Russian design and 5 others in the planning stage [20].

According to China's 12th Five-Year Plan, the country will be aggressively promoting nuclear, natural gas, and renewables to achieve its Copenhagen pledge of 40–45% carbon emission reductions below 2005 levels by 2020 [13]. This target was consistent with [20], which reported the Chinese government's plan to increase its nuclear capacity by 5 to 6-fold to 60 GWe by 2020, 200 GWe by 2030, and 400 GWe by 2050.

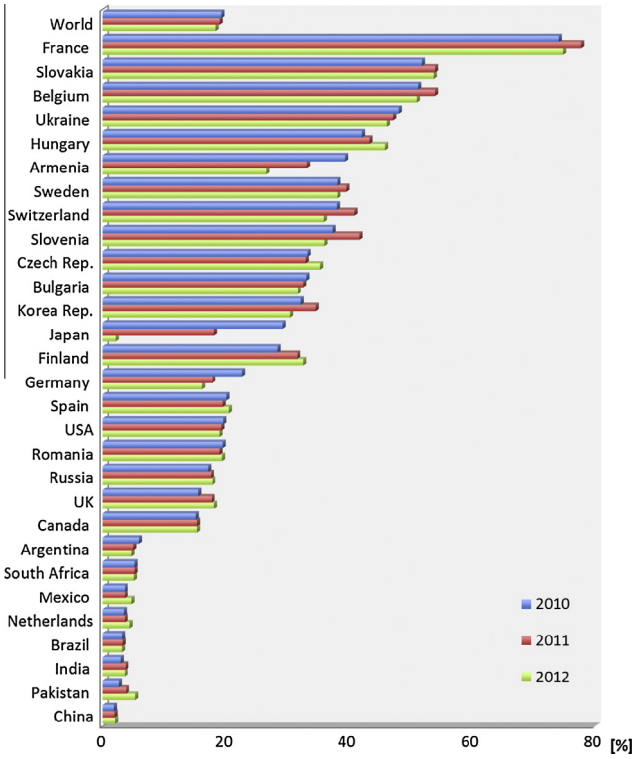

Fig. 1. Change in the share of nuclear power by country from 2010 to 2012.

Arguably, the unsuitability of renewables to supply base-load electricity, compounded by the ever-increasing energy demand left little room for maneuver to combat the dire Business-as-usual (BAU) projections by the IEA. Against the background of addressing the twin objectives of improving energy security and mitigating climate change, there is an important set of policy questions ahead: what is the role of nuclear energy in a low carbon future? What are the policy and technical considerations for evaluating nuclear power as an option post-Fukushima? How can the nuclear

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