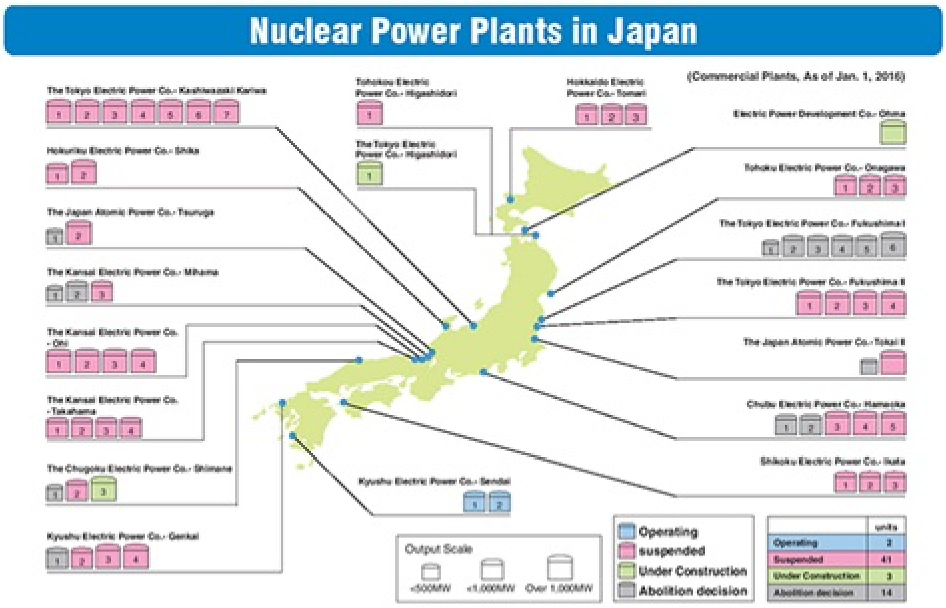
JAPAN’S POST-FUKUSHIMA CHOICE: FUTURE NUCLEAR FUEL CYCLE PATHS AND THEIR IMPLICATIONS



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DAVID VON HIPPEL AND PETER HAYES

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I. INTRODUCTION

In this essay, David von Hippel and Peter Hayes address the vulnerability of Japan's spent fuel to non-state attack by evaluating three “paths” for the future of the Japanese nuclear energy sector and management of spent nuclear fuel. The minor differences between the paths in terms of nuclear energy sector or overall electricity generation costs, or even greenhouse gas emissions, are not, however, significant in determining the best policy direction to reduce the vulnerability of Japan’s nuclear sector to accident or terrorist attack.

The full report in PDF format (1.6 MB) is found here.

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Readers should note that Nautilus seeks a diversity of views and opinions on significant topics in order to identify common ground.

Banner image: Color-coded map identifies potential nuclear power plants in Japan and their status as of early 2016, from here

II. NAPSNET SPECIAL REPORT BY DAVID VON HIPPEL AND PETER HAYES

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Spent fuel in Japan and elsewhere is vulnerable to attack by non-state actors. Following the March 11, 2011 catastrophe at the Fukushima Daiichi nuclear power plant, all of Japan's reactors were shut down for extended safety reviews. Since 2011 policy analysts have discussed not only the impact of the Fukushima catastrophe on Japan's power supplies and future level of nuclear power, but also on the disposition of spent fuel, including fissile material either separated from or stored in various ways as spent fuel. This Report addresses the vulnerability of this spent fuel by evaluating three "paths" for the future of the Japanese nuclear energy sector and management of spent nuclear fuel. These are:

- **Path 1: Return to Pursuit of Closed Nuclear Fuel Cycle**, which includes the restart of most existing light-water reactors in the next five years, extension of reactor lifetimes, the addition of 10 new reactors, and the resumption of domestic reprocessing of spent fuel use of mixed-oxide fuel (MOx);
- **Path 2: Slower Return to Pursuit of Closed Nuclear Fuel Cycle**, in which the return to a closed nuclear fuel cycle path proceeds at a slower pace than in Path 1, but is otherwise similar to Path 1; and
- **Path 3: Limited Reactor Restart with Once-through Fuel Cycle**, in which only 10 reactors are restarted, MOx is used in about half of restarted reactors, limited life extension is applied, all existing dense-packed spent fuel pools are converted to non-dense-packed operation, and reprocessing is pursued.

These paths have different, and sometimes offsetting, types and levels of vulnerabilities to terrorist attack on nuclear facilities or diversion of nuclear materials.

Cumulative 2015 through 2050 spent fuel arisings in Path 1 are about 40 percent higher than in Path 2, and three times those in Path 3.

Paths 1 and 3 essentially use up (via MOx fuel fabrication and irradiation) Japan's current stockpile of plutonium (Pu) by 2050, whereas on the order of 40 tonnes of Pu remain by 2050 in Path 2, and thus remain vulnerable to diversion or attack.

Conversely, Paths 1 and 2 temporarily increase Japan's aggregate stockpile of Pu (via reprocessing) by 10 to 20 tonnes and require total Pu throughput (and thus handling) for MOx fabrication that is five and three times higher, respectively, than in Path 3 over 2015-2050, thus creating higher vulnerability to attack or diversion.

Path 3 reduces the vulnerability of spent fuel pools to attack by shifting to non-dense-packed configurations and through more rapid decommissioning of reactors, but also requires more spent fuel handling and transfers to dry cask storage earlier than in the other paths.

Path 1 and, to a lesser extent, Path 2, include more reactors with fuels cores that have higher thermal and radiation loads than in Path 3, and thus pose more of a risk of attack on reactors themselves.

To understand the risks arising from malevolent non-state actors, Nautilus also evaluated three scenarios of the potential radiological impacts of an accident or attack at the Hamaoka nuclear power plant. These scenarios indicated potential exposures resulting in near-zero to hundreds of thousands of early cancer deaths, with potential health-related damages from low levels to trillions of dollars, depending on which nuclear plant components are involved in the accident or attack, and on which direction prevailing winds are blowing. This enormous range represents the true uncertainty and unpredictability of such extreme events, the probability of which cannot be determined except to say that it is finite and should therefore be managed, not ignored. The evaluation also includes each path's 2015 through 2050 estimated cumulative nuclear energy sector costs, overall cost in terms of electricity generation, greenhouse gas emissions, and other qualitative and quantitative "energy security" (broadly defined) attributes.

Nuclear fuel cycle costs, measured per unit of electricity output, were substantially lower in Path 3, which does not include reprocessing.

The minor differences between the paths in terms of nuclear energy sector or overall electricity generation costs, or even greenhouse gas emissions, are not, however, significant in determining the best policy direction to reduce the vulnerability of Japan's nuclear sector to accident or terrorist attack.

III. NAUTILUS INVITES YOUR RESPONSE

The Nautilus Asia Peace and Security Network invites your responses to this report. Please send responses to: nautilus@nautilus.org. Responses will be considered for redistribution to the network only if they include the author's name, affiliation, and explicit consent

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