RSIS S. RAJARATNAM SCHOOL OF INTERNATIONAL STUDIES
Nanyang Technological University, Singapore

RSIS COMMENTARY

www.rsis.edu.sg No. 084 – 26 August 2022

New Developments in NPP

Micro-reactors in the Field of Military Application

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SYNOPSIS

Nuclear reactors are getting smaller in size, leading to an expanding spectrum of civilian applications that range from water desalination to the production of hydrogen as an energy fuel. Technology has advanced so rapidly that in the foreseeable future, nuclear reactors can be used as a standalone energy source to power military bases and equipment, but the use needs to be better regulated to minimise any proliferation concerns.

COMMENTARY

Nuclear energy has been providing electricity and advancing the industrialisation and modernisation of economies since the 1950s. At present, nuclear energy accounts for approximately 10% of total electricity produced globally. In order to reduce carbon emissions, the world is trying to wean itself off fossil fuels such as coal, oil and natural gas, and switching to clean renewables to reduce the effects of climate change.

Policy makers have long been cognisant of the shortcomings of renewables such as solar or wind power, which can be intermittent in nature. In terms of energy security, countries will still require a baseload generation of power that serves as the backbone of their energy demand - not just for pure economic development but more importantly, for modern civilisation.

With the war in Ukraine, many countries in the European Union (EU) have been handicapped by their dependence on Russian gas, but France remains unaffected as its baseload energy is generated by nuclear. France is also an advanced economy that has one of the lowest carbon emissions given that 70% of its electricity produced is from nuclear. In 2022, the EU declared nuclear as a green source of energy.

The push for climate change mitigation, coupled with high oil and gas prices, has certainly swung the pendulum in favour of nuclear power. In 2015, the International Atomic Energy Agency (IAEA) aligned itself to fulfil the United Nations Sustainability Goals. In the private sector, *unicorns* such as Bill Gates and Elon Musk are advocating and working towards a more sustainable future with the development of novel nuclear technologies and their applications in the industry.

One of the areas that would require carbon emission curbing is in military operations. If the world securitises climate change as a global concern, then the military should also play a pivotal role in defending and preserving the security of the environment by reducing its carbon imprint.

RETHINKING ATOMS

Nuclear power has always been at the crossroads of civilian and military applications. The Trinity test, which detonated the first nuclear weapon in 1945, ushered in the moniker 'Weapons of Mass Destruction'. Then-US President Dwight Eisenhower in his 'Atoms for Peace' address paved the way for the establishment of the IAEA in 1957, to promote the peaceful use of nuclear energy in the civilian realm and to serve as an international *watchdog* to safeguard any fissile materials to be used in the military domain.

However, the military application of nuclear energy is not just confined to the development of weapons. For example, due to its high energy efficiency, nuclear submarines are deployed for longer-ranged stealth missions, which provide modern navies with greater force projection advantage. Such submarines can move faster in deeper oceans than diesel-powered submarines, while the latter will be more effective in littoral waters.

Since 1965, the Russians have launched several nuclear-powered reconnaissance spacecraft into space. Compared to spacecraft using solar cells, which operate only in orbits that have a high level of solar flux, nuclear power is still preferred for deep space exploration because the energy source is independent of sunlight. Furthermore, nuclear systems are more compact in design than solar panels and therefore, making the spacecraft lighter and easier to orientate.

Apart from propulsion, military operations nowadays leverage on the Internet of Things for better communication, automation, remote sensing as well as artificial intelligence. All these technological platforms require electricity to power up the systems, such as the charging of drones for long-range reconnaissance missions.

Not only are these technological platforms energy intensive, but from a security aspect, energy supply for military operations needs to be independent, i.e., not connected to the national civilian grid, so that military assets and systems can still function in times of a crisis or war. Presently, there is only one viable source of power that is green and long-lasting – nuclear.

REDESIGNING REACTORS

Global climate change has certainly contributed to the recent nuclear renaissance,

with many countries seeing nuclear power as a strategic solution to make our environment more sustainable to live in. We are also seeing the return to the scene of Small Modular Reactors (SMRs) that are designed with advanced safety features. The IAEA defines SMRs to be in the range of up to 300MW.

Of particular interest is an even smaller class of reactors known as microreactors (MRs), which has a capacity of up to 30MW, enough to power about 10,000 homes non-stop for a period of 20 years. With their small power outputs, the MRs have much smaller footprints compared to the larger conventional reactors that could incur much public resistance.

Both SMRs and MRs can be efficiently manufactured and precisely assembled in factories, thereby defraying the huge upfront capital cost as well as time needed for *in situ* construction of large reactors. These small reactors could be designed as turn-key projects to operate for long periods, usually without the need to refill, and therefore reducing the risks of nuclear proliferation.

SMRs offer the feature of modularity – the ability to scale up the power output by adding more similar units to the grid. MRs, on the other hand, are usually designed to be much smaller in size but are more transportable and can usually be fitted into containers for ease of transportation, by land, sea or air. Indeed, MRs have its genesis in military units, which had the primary objective of deployment to austere military bases and supplying reliable electricity in exceptionally quick time.

ADVANCING REACTOR TECHNOLOGY

In June 2022, the US Department of Defense (DoD) awarded BWX Technologies the project to construct a final MR prototype to be tested at Idaho National Laboratories by 2024. The MR will be a High Temperature Gas Reactor (HTGR), which will incorporate several safety levels of protection. The project, codenamed ‘Pele’, is being undertaken by the Pentagon’s Strategic Capabilities Office.

Critics were quick to reject the US DoD’s justification for deploying a reactor to power remote military bases, arguing that the MR will be a sitting duck in times of war. The recent episode of the war in Ukraine also highlighted the vulnerability of nuclear power plants during a crisis. However, MRs are not open ‘mobile reactors’ that can be targeted easily. Military camps have adequate protective infrastructure to house critical supply lines, such as having the reactor sited entirely underground. MRs are transportable prior to operation (not mobile during operation), which provide an advantage to quickly power up military camps in times of crisis.

While there are promising benefits of MRs using HTGR technology, there are also challenges, such as the safeguarding of the spent fuel to prevent weaponization efforts. Nuclear Weapons States under the Non-Proliferation Treaty are not obliged to comply with any safeguard arrangements, particularly for military activities. For Non-Nuclear Weapons States, safeguards arrangements will have to be made with the IAEA to verify that spent fuel is not transferred to develop any weapons.

CONCLUSION

In modern warfare, military assets are often jointly developed by a consortium that aims to provide equitable capabilities for its group members. For example, the Australia, United Kingdom and United States (AUKUS) arrangement will enable Australia to level up its submarine capabilities to strategically support the missions of the UK and US in the Pacific.

With the advent of the MRs, it will not be surprising to see the military bases, platforms and systems of allied forces powered by nuclear reactors in the future. Afterall, we are fighting a common adversary – climate change. On the other hand, it is necessary to start broader policy engagements to establish relevant rules to safeguard the wider use of nuclear energy and to secure public support for such endeavours.

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