DOI 10.15302/JSSCAE2020.01.019

Application History and Enlightenment of Very Small Modular Reactor for Land Battlefield Energy Supply

Chen Rongjiang

Joint Service College, National Defense University PLA China, Beijing 100036, China

Abstract: Very small modular reactors (vSMRs) have received considerable attention owing to its significant potential in land battlefield energy supply. They offer advantages of flexible mobility, rapid energy supply, low cost, and high safety. Significant fuel consumption, resupply difficulties, high costs, and risks in the Iraqi and Afghan battlefields have motivated the US military to re-examine the use of vSMRs in operational energy supply. This article begins with the historical process of the US Army's development of vSMRs, and representative types of current vSMRs are introduced. Subsequently, the application scenarios, use mode, main advantages, and challenges of mobile nuclear power plants are analyzed based on vSMR technology. The findings suggest that China should actively pursue military applications of vSMRs and investigate their use modes in different areas, such as fixed installations, mobile battlefields, and overseas operations based on national conditions and military conditions. Furthermore, China should strengthen the military−civilian coordination in addressing key problems and accelerate the application of vSMR technology.
Keywords: reactor; very small modular; land battlefield; energy supply; apply history; US Army

1 Introduction

During the wars in Iraq and Afghanistan, the fuel supply lines of the US army became the main target, and the fuel delivery convoy to the forward operating bases (FOBs) was often attacked by the enemy. From 2003 to 2007, more than 3000 military personnel were killed or injured because of the attack on the fuel supply convoy [1]. While casualties occur, fuel supply costs continue to increase. It is estimated that [2] the cost of delivering fuel to FOBs by land transport can reach 50 USD per gallon (1 gallon ≈ 3.785 L), and the cost of delivering fuel to remote outposts by helicopter airdrop can reach as high as 400 USD per gallon. The battlefield energy security represented by fuel supply has become a major problem affecting the US military's overseas operations as well as combat effectiveness. In recent years, China's army's information technology level improved continuously, new weapon systems have been fielded, and the reach of forces has continued to expand. In the future, the power demand of battlefields will increase significantly. Hence, prominent problems such as high fuel pressure and unreliable power supply will be encountered.

To solve these problems, the military forces of various countries have adopted measures to improve energy efficiency and promote renewable energy and alternative fuel oil applications. However, these are insufficient to eliminate the issue of land battlefield energy security. Therefore, nuclear energy has become an important option

Received date: October 25, 2019; **Revised date:** December 05, 2019
Corresponding author: Chen Rongjiang, doctoral candidate of Joint Service College of National Defense University PLA China. Major research field is military energy development strategy; E-mail: E-mail: ywlei9@163.com
Chinese version: Strategic Study of CAE 2020, 22 (1): 146–152
Cited item: Chen Rongjiang. Application History and Enlightenment of Very Small Modular Reactor for Land Battlefield Energy Supply. S*trategic Study of CAE*, https://doi.org/ 10.15302/JSSCAE2020.01.019

for land battlefield energy security because of its unique technical advantages. Very small modular reactors (vSMRs), which afford high output power, strong adaptability to the power grid, and flexibility in maneuverability, have broad application prospects in new radar systems, directional energy weapon systems, and FOBs; therefore, they have garnered significant attention from military powers. Currently, a standard definition has not been formed for vSMRs. However, they exhibit three basic characteristics: the maximum power generation capacity of each reactor module is approximately 10 MW [2]; the entire system is assembled before leaving the factory; the entire system can be transported by sea, land, or air.

Regarding vSMR research, most domestic experts and scholars focus on analyzing the current state of technology, development trends, and application needs from the perspective of economic and social development; however, they rarely delve into the energy protection of battlefields [3–6]. Foreign research institutions and experts discussed the feasibility of using vSMRs in land battlefield energy supply from multiple application perspectives, such as fixed installations and front-line bases. The US National Defense Science Board (DSB) and the National Laboratory of Idaho have proposed using vSMRs in FOBs for energy supply and analyzed the special requirements of and risk challenges encountered by FOBs. [2,7]. The United States Nuclear Energy Research Institute (NEI) fully demonstrated the feasibility of vSMR deployment at US military bases and established a time roadmap [8].

The research status at home and abroad indicate that China is still in the embryonic stage in the research pertaining to using vSMRs in the energy supply of land battlefields, and that China's relevant progress is lagging behind compared with other countries. This paper analyzes the research history of vSMRs in the US army; introduces the current development status of vSMR technology in the United States; elucidates the practical foundation, main advantages, challenges and specific scenarios of the current application of vSMRs on land battlefields; and analyzes the feasibility and development path of the application of vSMR technology in the Chinese army.

2 History of US Army's research on vSMR

The energy supply problem on battlefields is not new to the US military. As early as World War II, the Korean War, and the Vietnam War, the US military has already used mobile power stations (such as power barges and large diesel generators) on a large scale to provide electrical support for combat forces. In 1954, the US army launched the army nuclear energy program (ANPP) under the requirements of the Joint Chiefs of Staff Act. The goal was to use nuclear energy to supply energy to remote bases and FOBs, thereby shortening the supply chain of electricity, fuel, and water [9]. From 1957 to 1977, the US army developed and operated eight nuclear reactors, five of which were portable/mobile (Table 1), all operating successfully in test and practical environments [7]. The output power of these five reactors belonged to the category of vSMRs, but their technical status and application mode were not up to the modular level of assembly.

Table1. Portable/mobile reactor systems in US army reactor program [9].

Program	Operating location	Net power (MW)	Activation date (Year)	Deactivation date (Year)
PM-1	Sundance Air Force Station, Wyoming, U.S.	1.25	1962	1968
PM-2A	Camp Century, Greenland ,Denmark	1.60	1960	1963
PM-3A	McMurdo Navy Base, Antarctica	1.50	1962	1972
ML-1	(Developmental Testing)	0.30	1962	1966
MH-1A	Panama Canal	10.00	1968	1977

(1) PM-1 has been supplying power to the Sundance Radar Station in Wyoming since 1962. This radar station is located on the top of a mountain and cannot be connected to a commercial power grid. The road conditions are poor and fuel supply is difficult. PM-1 has an output power of 1.25 MW and can be categorized into 27 components when it is delivered from a factory. It is transported to near a radar station by freight plane and utilized after trans-shipment and assembly [10].

(2) PM-2A began to provide electricity and heat for the Century City military base in Greenland, Denmark in November 1960, becoming the first nuclear power plant to be used in a remote and independent military base [11]. PM-2A was disassembled and transported to a target base. After a successful on-site assembly, it validated the feasibility of assembling nuclear power plants with prefabricated components [9].

(3) PM-3A is a nuclear power station built by the Army and used by the Navy; furthermore, it is the Navy's first ground nuclear power station [11]. It has provided energy support for naval bases in Antarctica since 1962. Since

DOI 10.15302/JSSCAE2020.01.019

its decommissioning in 1972, PM-3A has produced more than 7.8×10^7 kW·h of electricity and used excess steam from a desalination plant to produce 4.92×10^7 L of fresh water [12].

(4) ML-1 is the Army's first mobile modular miniature reactor for battlefield applications. It was built in 1961 and is mainly used to provide power for command and communication centers, battlefield hospitals, radars, and weapon systems [11]. The total mass of ML-1 is approximately 38 tons, and various components are disassembled and placed in four containers, which can be transported by air, road, or rail [13]. After several major improvements and hundreds of hours of operational testing, the ML-1 did not perform at the intended level. Furthermore, owing to the financial tension caused by the Vietnam War and the reliability problems of its own system, its development halted in 1966 [13].

(5) MH-1A, as a barge-type nuclear power plant, was converted from a warship during World War II. It began operation in 1968 and mainly provided electricity and fresh water for military operations in the Panama Canal Zone [11].

After nearly 20 years of practical exploration, the US Army concluded that under the technical conditions at that time, nuclear reactor maintenance was complex, research and development costs were high, safety risks were inevitable, diesel generator technology gradually matured, and oil prices continued to decrease. Owing to these circumstances, the scale of the ANPP development decreased gradually. In 1977, the MH-1A in the Panama Canal Zone ceased operation, and the US Army's application of nuclear energy halted since then.

3 Status of US vSMR technology

After decades of development, nuclear energy technology has provided a clean energy guarantee for human society. However, large- and medium-sized nuclear power plants, which have long construction cycles and high costs, are not suitable for small-scale power requirements. Hence, vSMR technology has regained attention. Many organizations believe that it will become an effective supplement for large- and medium-sized nuclear power stations; therefore, the application of vSMRs has gained attention again.

Currently, the United States is the world leader in vSMR technology and is actively developing a new generation of vSMR prototype systems. Typical examples of these systems include the Holos system developed by the University of Maryland, College Park and the MegaPower system developed by Los Alamos National Laboratory.

3.1 Holos system

Holos is fueled by enriched uranium with 8% enrichment. It can operate for 10 to 20 years with one charge. It is designed in two models [9]: a 3.3 MW model, which can be installed in a 20 ft. (1 ft. = 0.3048 m) ISO transport container; and a 13 MW model, which can be installed in a 40 ft. ISO transport container and the total mass of the system does not exceed 40 t. Holos is designed with a compact overall layout, with an integrated outer envelope of all components within an ISO transport container (Fig. 1), enabling fast, mobile, and safe transportation. The commercial waste/spent fuel disposal storage tank solution can be adopted in the system module to further reduce the decommissioning cost [2]. The system uses the plug-and-play mode and can be directly connected to the power grid.

Fig.1. Holos system transport configuration.

3.2 MegaPower system

The nuclear fuel for MegaPower is uranium oxide enriched up to 19.5% in uranium 235. From the perspective of nuclear non-proliferation, this type of nuclear fuel has a low level of enrichment and belongs to the "non-weapon grade." The total mass of the MegaPower system is approximately 35 tons, which can jointly supply 2 MW of electricity and 2 MW of heat, and one charge enables a continuous operation for 12 years [2]. Similar to Holos, to improve safety and ease of transport, an overall layout that encapsulates all components in a special armor is adopted in MegaPower (Fig. 2). The MegaPower system design plan has been determined and technical integration verification is being performed. The DSB predicts that the system will be prototyped around 2021 [2].

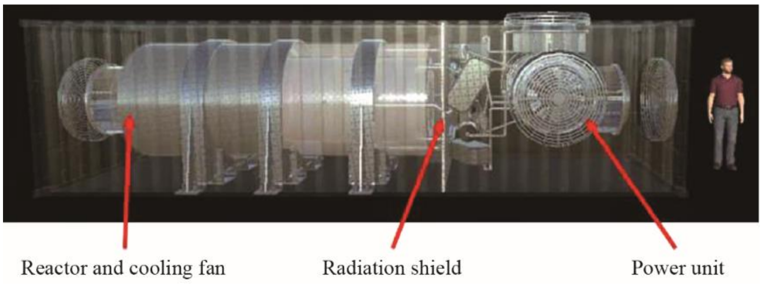

Fig. 2. MegaPower system main structure.

4 US Army vSMR application scenario

Motivated by multiple factors such as large fuel consumption on battlefields, difficult resupply, high costs, outstanding risks, and the maturity of new-generation vSMR technology, the US Army has begun to study the feasibility of applying nuclear energy on battlefields. In 2016, the DSB reported that vSMRs will be a disruptive technology that changes the paradigm of energy support in battlefields, and is expected to realize a significant transformation in battlefield energy from scarcity to abundance [2]. In 2018, the US army proposed the mobile nuclear power plant (MNPP) project using vSMR technology in ground operations but did not disclose the deployment application roadmap and time plan [9].

4.1 Basic application assumption

An MNPP is a small mobile power system that generates electricity through nuclear fission. Compared to ML-1 from the 1960s, the battlefield application concept is basically the same. However, because the current vSMR technology is more mature, smaller, and more stable in operation, the MNPP has become a power option for land battlefields. According to an assumption [9], the MNPP includes a vSMR module and an ancillary equipment equipped with nuclear fuel. The entire system is placed in a standard container that has good battlefield mobility and transport diversity. The MNPP's modular design and application method enables multiple vSMR modules to be assembled, providing flexibility to satisfy greater power requirements.

4.2 Application scenario

Considering vSMR security protection issues, the US Army adheres to the principle of combining safety and practicality when planning the main application scenarios of MNPPs, focusing on deploying them in major ports, airports, and FOBs where troops land. The demand for electricity in these key parts is significant, and the intelligence collection and safety protection abilities are strong, thereby ensuring the security protection of MNPPs. In addition, energy-intensive systems with demanding power requirements, such as large radars, as well as remote military bases that cannot easily access the public grid have become important application scenarios for MNPPs.

4.3 Primary application method

According to plan, after the factory pre-installation, critical testing, and trial operation of the reactor, the MNPP will be transported to different battlefields as required to ensure a reliable system operation. The MNPP system is small and light, affording flexible transportation. The typical application method is described in [9] (Fig. 3): the MNPP will be transported from the United States to a theater by air and then transported by road to FOBs; after an on-site assembly and security protection, it begins to provide energy for the base and operates continuously for a

DOI 10.15302/JSSCAE2020.01.019

significant amount of time. When the refueling cycle (estimated 10–20 years) approaches, the MNPP will be returned to the United States for refueling, reuse, or decommissioning.

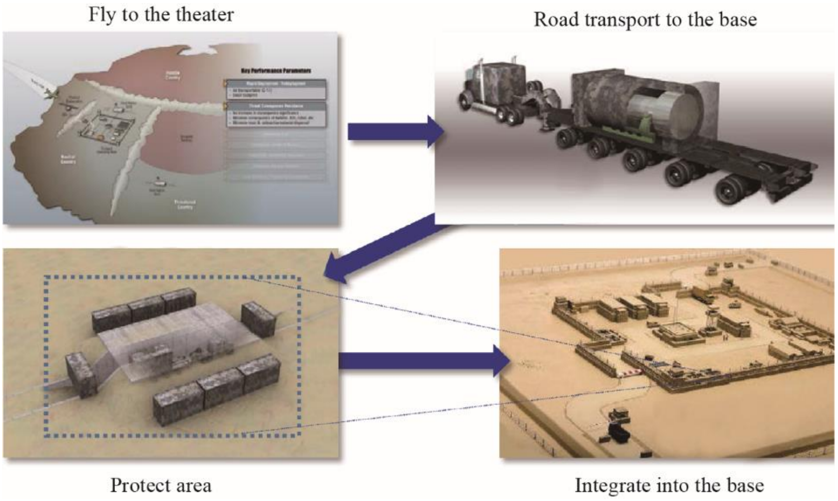

Fig. 3. MNPP battlefield application mode.

5 US Army vSMR application analysis

5.1 Advantages

5.1.1 Support advantage

The first advantage is improved Army combat capabilities. Battlefield practice shows that transporting liquid fuel from the air and the ground is risky and incurs a significant cost. By applying vSMRs to supply energy on battlefields, one charge enables a continuous operation for 10 to 20 years, thereby significantly reducing the power supply demand for diesel generators. This can not only significantly reduce the frequency of troops escorting fuel supply convoys, but also conserve more fuel to support the main battle equipment, thereby expanding the operational reach and enhancing the continuous combat capability.

The second advantage of vSMRs is their flexibility and ability to quickly provide energy supply. Although diesel generators have been used to supply power on battlefields for one century, their inherent thermal/acoustic characteristics render them easy to be identified and targeted. The target characteristics of vSMRs are relatively weak, and they cannot be identified and located easily by the enemy. After a mobile deployment, they can quickly provide energy for the reconstruction of critical infrastructure, such as the attacked airport and port.

The third advantage of vSMRs is that their high power density can satisfy the energy requirements of new weapons. With the development of new high-energy weapons technologies such as directed-energy weapons and electromagnetic guns, the energy demand for land battlefields will continue to increase in the future. vSMRs offer the natural advantage of high power density, and they can continue to provide more electrical energy for new weapon equipment in the same volume.

The fourth advantage of vSMRs is that they can provide heat-power coordinated supply to satisfy the multifaceted requirements of FOBs. Furthermore, vSMRs can provide electricity and thermal energy, as well as provide fresh water for mobile bases in the far sea in combination with seawater desalination technology to satisfy the energy demand of weapons and equipment in the base and support the living demand of personnel in the base; clearly, they are conducive to improving the comprehensive support capacity of mobile bases.

5.1.2 Cost advantage

The MNPP project of the US Army compared the economic benefits of a 13 MW Holos system with those of diesel generators powering remote outposts at FOBs [9] (Table 2). When the fuel price was 2.25 USD/gallon under a 75% capacity factor, the Holos power cost was 44.4% that of diesel generators. When the fuel prices increased to 7 USD/gallon, Holos' power costs remained unchanged at 14.8% of the cost of diesel generators. The comparison shows that the power supply cost of diesel generator is significantly affected by the fuel price and the comprehensive cost is higher. Although the power supply cost of Holos is significantly affected by the capacity factor, its comprehensive cost under medium and high load conditions is only 1/5–1/3 the comprehensive cost of diesel generators. Holos' cost advantage is expected to be more significant as poor transport conditions result in higher fuel prices.

Table 2. Comparison of power generation costs under field application conditions. USD/(kW·h)

Capacity factor	Diesel generation costs under different fuel costs			Holos system costs
	2.25 USD/gal	3.5 USD /gal	7 USD /gal	
25%	0.23	0.35	0.67	0.21
50%	0.19	0.29	0.56	0.11
75%	0.18	0.28	0.54	0.08
100%	0.19	0.28	0.55	0.07

5.1.3 Environmental advantages

For a significant time period, owing to the particularity of military operations, environmental pollution on battlefields was unclear for environmental governance in various countries. According to estimates [14], during the Iraq War from 2003 to 2010, the annual CO_2 equivalent of all military operations in the country was 2.5×10^8–6×10^8 t, which is directly related to the consumption of large amounts of traditional fossil energy on battlefields. By contrast, nuclear energy is clean energy, and vSMRs can achieve zero pollutant emission. Even if nuclear waste disposal issues are involved, vSMR fuel is only replaced once every 10 years or more, and nuclear waste involves a special treatment mechanism that is of minimal environmental concern.

5.2 Challenges

5.2.1 Supervision and licensing

Although the US army has developed and demonstrated small mobile reactors in the 1960s and 1970s, current commercial reactor design codes and application concepts, nuclear energy management systems, and local and international transportation systems do not directly apply to vSMRs. Currently, regulatory authorities are focused on large nuclear power plants (based on traditional nuclear technology, i.e., fixed and immovable). Promoting the application of vSMR technology in the US military requires coordination between the US Department of Defense and multiparty agencies to complement and improve the existing nuclear regulatory system; this will be a complicated and long process. In addition, owing to the lack of internationally accepted licensing standards, the US military are implementing global operations in which parties that wish to apply vSMRs in different countries must obtain permission from the partner country in which it is stationed. However, different countries have different attitudes toward the application of nuclear energy, and vSMRs will be affected by various complicated licensing approval procedures in supporting the US military's global military operations.

5.2.2 Production capacity

As a nuclear power, the United States should not be affected by its production capacity in supporting the development of vSMRs. However, the United States has not built a new nuclear reactor for many years, and the domestic nuclear enterprise's equipment manufacturing capacity has decreased significantly, rendering it difficult to form mass production capacity in a short time. With regard to the supply of nuclear fuel, it was evaluated through the MNPP project that if an MNPP is deployed within 5 to 10 years, a large amount of low-enriched uranium will be required. Currently, only one manufacturer in the United States is engaged in commercial nuclear fuel enrichment. To satisfy the potential demand for MNPP fuel, it is necessary to upgrade existing equipment and re-acquire the US Nuclear Regulatory Commission license, which requires approximately 5 years [9].

5.2.3 Safety protection

Safety is crucial in the application of nuclear energy. The US army has developed a series of safety measures to ensure the safety of vSMR core components, such as the use of low-concentration nuclear fuel, use of integrated design, passive safety system design, and armor protection. However, nuclear safety remains one of the major challenges in promoting the military application of vSMRs. For the US army, vSMRs placed on a forward/remote operating base will become a target of the enemy; this will result in potential nuclear contamination and disposal issues.

DOI 10.15302/JSSCAE2020.01.019

6 Preliminary considerations on development of vSMR technology in China

6.1 The next 10 years will be a crucial period for the development of vSMRs and vSMRs should be actively promoted to fully utilize energy support technology on battlefields

Based on public information, the United States has used vSMRs as an important alternative to traditional land battlefield energy supply. In October 2018, the NEI released a roadmap for the deployment of small reactors in US military bases; it plans to deploy the first small reactor by the end of 2027 [8]. The proposal of the MNPP project for ground operations indicates that the US military has conducted systematic research on the application of vSMRs on land battlefields. vSMR technology presents important strategic significance for upgrading military equipment and improving combat capabilities.

Currently, China has not conducted research on the application of vSMRs in land battlefields. Whether a small fixed reactor used in a camp or a mobile vSMR used in battlefields, a significant amount of time is required to complete demand demonstration, technology research and development, demonstration site selection, environmental assessment, installation, and deployment. The current main trend of the development of land battlefield energy support technology should be analyzed, beginning with the top-level design, followed by the basic ideas of a camp (and then a battlefield), for domestic and then overseas cases; this is to demonstrate the development of vSMR technology development and the military application development roadmap such that energy support technology can be fully utilized in future battlefields.

6.2 With the increasing number of overseas interests and international peacekeeping operations, new requirements are proposed for military energy security, and the feasibility of overseas application of vSMR should be demonstrated in advance

It is clear from US military studies that overseas military bases are important to vSMR military applications. As China's overseas interests continue to expand and national participation in international affairs continues to increase, overseas military operations will become more frequent, and military forces are urgently required to perform overseas; consequently, the demand for overseas energy supply will increase.

Different countries have different energy infrastructure conditions, and the energy quality and difficulty of financing vary significantly. This has resulted in many hidden dangers to overseas energy supply. Therefore, vSMRs should be further developed to achieve independent, safe, and efficient energy support for overseas operations. While conducting key research regarding nuclear technology, the issues of vSMRs' political impact, international consultation, policy systems, and operating mechanisms should be demonstrated, and the feasibility of vSMR application for overseas operations should be clearly defined the soonest possible.

6.3 Organize propaganda and education of nuclear energy timely, overcome fear of nuclear energy, and eliminate ideological barriers for vSMR to be used in military energy support

The disastrous consequences of the Hiroshima and Nagasaki nuclear explosion, the Chernobyl nuclear accident, and the Fukushima nuclear accident have caused a deep awareness regarding the formidable nuclear energy, and the fear of nuclear energy has been deeply ingrained. To promote the application of vSMRs for land battlefield energy supply, we must not only achieve key technological breakthroughs and systemize supporting resources, but also perform early preparations in terms of cognition. Nuclear energy publicity and education should be organized actively using nuclear-powered aircraft carriers and submarines as examples. Furthermore, military personnel should understand the operating principle, protection mechanism, application advantages, and development trends of nuclear energy; subsequently, they should be guided to establish a correct nuclear energy concept.

6.4 Fully exploit the respective strengths of the military and localities, form a development momentum through collaborative cooperation, and quickly advance vSMR technology research and demonstration applications

To promote the military application of vSMRs, the respective advantages of the military and the land should be fully exploited: the military should comprehensively study the application scenarios and potential problems of land battlefield energy supply, formulate timely response strategies, and perform well in demand demonstration.

Furthermore, China should actively conduct the research and development of vSMRs, as well as utilize the results obtained by the China Nuclear Industry Group Co., Ltd. and Tsinghua University to further promote the development of related technologies. Furthermore, we should strengthen the cooperation between local functional departments and research institutes, encourage social science and technology forces to participate in vSMR scientific and technological innovation, and actively undertake relevant technical research and development projects.

Unlike most commercial nuclear reactors in production, the vSMR must be turned on and off several times over its 10 to 20 year life span, as well as maneuvered and deployed through multiple modes of transportation. These application characteristics have resulted in new design requirements and standards. We should fully utilize the rapid development of domestic nuclear reactor technology, gather innovative resources to form a joint research and development force, break through core technologies the earliest possible, eliminate policy obstacles, and perform prototype system construction and demonstration applications to accelerate the application of vSMRs in energy supply on battlefields.

7 Conclusion

The proposal of the US Army MNPP project provides an answer regarding the feasibility of applying vSMRs to land battlefield energy supply from a practical perspective and provides a useful reference for the development of military power equipment. Currently, China is in the early stages of military energy supply transformation. We should combine national defense and military force construction with the demand for energy supply in future wars, organize professional forces to focus on vSMR core technology, develop vSMR prototype systems that satisfy national situations and military requirements, and perform the demonstration project of battlefield energy supply timely. After a thorough study of military application scenarios, application modes, and safety and protection measures, we should develop plans and gradually perform the equipment finalization, mass production, procurement, and assembly of vSMRs to innovate and improve military energy supply capability.

References

[1] Daehner E M, Matsumura J, Herbert T J, et al. Integrating operational energy implications into system-level combat effects modeling, assessing the combat effectiveness and fuel use of ABCT2020 and current ABCT [R]. Santa Monica: RAND Corporation,2015.

[2] Defense Science Board. Task force on energy systems for forward/remote operating bases [R]. Washington DC: U.S. Department of Defense, 2016.

[3] Chen R Z, Wang G. Current status and development tendency of advanced small reactors [J]. Science & Technology Vision, 2018(3): 15–19. Chinese.

[4] Cao Y L, Wang S W, Xiong W B, et al. Features and application analysis of the small modular reactors [J]. Nuclear Electronics &Detection Technology, 2014 (6): 801–806. Chinese.

[5] Liu C, Huang Y. The development prospect and problems of advanced small nuclear reactor [J]. Journal of University of South China (Social Science Edition), 2018, 19(4): 10–14. Chinese.

[6] Chen W J, Jiang S Y. Feasibility study on development of small nuclear power reactors in China [J]. Nuclear Power Engineering,2013, 34(2): 153–156. Chinese.

[7] Griffith G. U.S. forward operating base applications of nuclear power [R]. Idaho Falls: Idaho National Laboratory, 2015.

[8] Nuclear Energy Institute. Roadmap for the deployment of micro reactors for U.S. Department of Defense domestic installations [R]. Washington DC: Nuclear Energy Institute, 2018.

[9] Juan A V, Joseph G L, Charles J J, et al. Study on the use of mobile nuclear plants for ground operations [R]. Washington DC: U.S. Army, 2018.

[10] William R C. Power reactors in small packages [R]. Washington DC: Atomic Energy Commission, Division of Technical Information,1968.

[11] Suid L H. The Army's nuclear power program: The evolution of a support agency [M]. New York: Greenwood Press, 1990.

[12] National Science Foundation. McMurdo station reactor site released for unrestricted use [J]. Antarctic Journal of the United States, 1980, 15(1): 2.

[13] Adams R. ML-1 mobile power system: Reactor in a box [EB/OL]. (2019-02-01) [2019-10-15]. https://atomicinsights.com/ml1-mobile-power-system-reactor-box/.

[14] The Guardian. What's the carbon footprint of the Iraq war? [N/OL]. The Guardian, (2010-11-07) [2019-10-11]. http://www.guardian.co.uk/environment/green-living-blog/2010/jul/08/carbon-footprint-iraq-war.