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Research Article

Energy Security Challenges for Countries and Military Forces in the 21st Century

Political Science

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Ruzhdi Rustemi

Ministry of Defense. Albania.

Abstract

Before 1990 the national security was dependant only on military power. Energy security was one of the fields added to the concept of security after 1990. With the end of Cold War the security concept was extended with new concepts such as economic security, social security, human security, environmental security etc. Soon, the energy security became too important and closely related to other new security fields. They are interrelated because they influence reciprocally each-other. Actually the national and global economies are still dependent on fossil fuels and gas. But they are definite resources. Also NATO countries during their daily operations are dependent on energy supply to carry out their missions. In this article I am going to present some energy security challenges facing countries and military forces in the 21st century.

Introduction

Because most of the world's oil and natural gas resources are concentrated in a small number of countries, many nations have economic, social, and geopolitical concerns about energy dependence. Many countries have explored options for improving energy security, e.g., the use of domestically available alternative or renewable energy sources. The International Energy Agency (IEA) defines energy security as the uninterrupted availability of energy sources at an affordable price. Energy security has many aspects: long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs. On the other hand, short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance. "Energy security" is not "energy independence" in the sense that all of the energy used in the country comes from within its borders without international trade. This is neither obtainable nor desirable in a globalized world. Energy security does not depend on the percentage of supply that is imported. In a world of globally traded commodities, it is no longer possible to be truly energy independent, even domestically produced energy sources are subject to fluctuations in global commodity markets.

Energy security is about countries ability to meet the energy needs of the population, both in the short and long term. Improving a country's energy security is important to minimize blackouts, brownouts and shortages of liquid fuels or gas which cause significant disruption. Activities to support better energy security include minimizing and managing energy supply shortages and protecting country from loss of critical energy infrastructure, such as power stations and oil refineries. In the country's policy context, energy security is defined as the adequate, reliable and competitive supply of energy across the electricity, gas and liquid fuel sectors. Adequacy is the provision of sufficient energy to support economic and social activity; and reliability is the provision of energy with minimal disruptions to supply, and competitiveness is the provision of energy at an affordable price. And the NATO as the most powerful political-military Alliance is effected and effects on energy security issues. The energy security influences on the effectiveness of its operations and NATO operations help to protect critical infrastructure and energy resources.

Methodology

The methodology used in this article is descriptive and comparative, based on the contemporary literature and the experience gained from some advanced countries and intergovernmental organizations dealing with energy security.

Results

The energy market, especially the sale of oil and gas is profitable. So, the countries that own oil and gas are blessed and because of that they are rich and have an important geopolitical position. The other countries are dependent on the supplies from them. They have possibilities to develop their national economies but at the same time to make money. Always there has been a struggle between countries having energy resources and countries wanting to have them. In many times it has lead to debates, disagreement and conflicts.

Discussion

Today energy security has become a top priority issue for the all the countries around the globe. But, what does the term "energy security" really mean? The term is a composition of two terms "energy" and "security". Because of the term "security" which is not unified and accepted as one definition, because of the different approaches and viewpoints to security, there are too many definitions of the term "energy security". For many it is assuring the safe supply and transport of energy as a matter of national security. For others it is developing and moving toward sustainable and low-carbon energy sources to avoid environmental catastrophe, while still others prioritize affordability and abundance of supply. The demand for energy has ramifications in every part of the globe, from growing demand in Asia, to the pursuit of reserves in Latin America and Africa, to the increased clout of energy-producing states such as Russia and Iran. Yet the fact remains that the vast majority of global energy production still comes from fossil fuels, and it will take a thorough understanding of the interrelationships of complex challenges, finite supply, environmental concerns, political and religious conflict, and economic volatility, to develop policies that will lead to true energy security. Brookings scholars present a realistic, cross-disciplinary look at the global quests for energy security within the context of these geopolitical, economic, and environmental challenges. For example, Carlos Pascual and his colleagues examine delicate geopolitical issues. Suzanne Maloney addresses "Energy Security in the Persian Gulf: Opportunities and Challenges", while economist Jason Bordoff and energy analyst Bryan Mignone trace the links between climate policies and energy-access policies. Assuring long-term energy security remains one of the industrialized world's most pressing priorities, but steps in that direction have been controversial and often dangerous, and results thus far have been tenuous.

Since the oil price crises of the 1970s, the risk of absolute supply shortages has been reduced significantly. The creation of the IEA and its requirement that all member countries hold oil stocks capable of replacing 90 days' worth of imports acts as a buffer against disruptions in oil supplies. Obtaining energy security actually does not come from increased domestic production alone: it comes from flexibility, competition, and redundancy. If a source of energy supply is easily replaced by either a different fuel type or a different source, then a country is insulated from supply shocks. A country's foreign policy should be determined by its interests, not by how it generates its energy.

Energy Security Challenges for Europe

Actually there are a lot of discussions in EU about the construction of Nord Stream 2 gas pipeline. Kyiv wants to stop the construction of Nord Stream 2 gas pipeline, 800 mile-long, which aims to transport Russian gas directly to Germany, across the Baltic Sea, bypassing Ukrainian territory. It is a geopolitical project and represents a significant loss of income for Ukraine. Meanwhile, the European Commission has many times repeated that they do not consider Nord Stream 2 to be strategic for the EU energy security. Germany's energy relationship with Russia has long frustrated Washington and Eastern Europe, who fear that Nord Stream 2 pipeline could be used to cut them off from crucial energy supplies. Former German Chancellor Gerhard Schroeder is a top executive at the Russian government controlled company that runs the pipeline. Trump has promoted exports of US natural gas to Europe as an alternative to Russia as a supply source, although US gas is far more expensive of shipping costs. Even Stoltenberg, former Norwegian prime minister who has cultivated a positive relationship with the president, appeared reduced to spluttering as Trump cut him off after he started to explain that allies traded with Russia even during the Cold War. Earlier in the exchange, Trump demanded credit from Stoltenberg for forcing an increase of NATO defense budgets.

Germany is indeed Russia's biggest export market in Europe for gas, with a dependency that may grow further once Nord Stream 2 is finished. The project would roughly double Russia's export volume via the Baltic route that goes through the original Nord Stream pipeline. Over the next few decades Europe's own gas resources, which accounted for more than a third of its supplies in 2016, are expected to gradually disappear. Britain, Norway and the Netherlands are Western and Northern Europe's biggest producers, primarily relying on natural gas fields in the North Sea. As Europe's own supplies are running out, the US is hoping to gain access to a profitable market with growing demand. But US economic interests only partially explain why the pipeline conflict is now emerging as a key point of contention. German Chancellor Angela Merkel has not shown any willingness to halt the controversial pipeline project, but at times she has indicated at least some skepticism, acknowledging that the project was not an entirely economic one but also of political significance. That already stood in strong contrast to her predecessor, Gerhard Schroeder, who long championed the gas connection. At the time, the German government said it was pursuing the offshore pipeline between Russia and Germany to cut energy costs and establish a reliable supply route. So far, Nord Stream 2 has only had one real impact: driving a wedge between Germany and other Western nations.

About 25% of European Union's natural gas demands are met by Russia alone. With 24% of the world's proven reserves the country tops the list of countries with highest natural gas reserves. At the last NATO Summit, held in July 2018, the President Donald Trump criticized Germany for dependence on Russian gas. "Germany, as far as I'm concerned is captive to Russia because it's getting so much of its energy from Russia", Trump told NATO Secretary General Jens Stoltenberg, speaking on camera. "We have to talk about the billions and billions of dollars that's being paid to the country we're supposed to be protecting you against". "It is not only bad, it is catastrophic". Merkel told reporters as she entered NATO headquarters "We decide our own policies and make our own decisions". But the issue seems not so simple. Some of the questions are: what Germany and other countries will do if the Russia interrupts gas supply? Do they have other alternatives, to change the source of supply or to change the fuel type? How long does it take and what will be the consequences on their economies? Why not to give that money to other countries which are NATO friendly?

Recent events in Ukraine and Russia's anti-Western rhetoric and military posture force European energy consumers to look for alternatives for Russian hydrocarbons. One of the possible suppliers of both oil and gas could be Kazakhstan, which boasts the largest hydrocarbon resources in the oil-rich Caspian basin. Kazakhstan is among the top 15 countries in the world, having 3% of the world's total oil reserves. Kazakhstan, wedged between China and Russia, is seeking economic opportunities that cannot be found in cooperation with Russia alone. The country is happy to develop its massive oil and gas reserves, but is seeking to develop industrial production and post-industrial services. Calculus of Astana is pretty reasonable according to the Kazakhstan Ministry of Oil and Gas, proven hydrocarbon reserves; both onshore and offshore, are estimated to amount to 4.8 billion tons, or more than 30 billion barrels. Not all of the reserves are fully prospected. Many experts believe that there are probably more reserves of oil and gas in fields located in the Kazakh section of the Caspian Sea, with additional 17 billion tons or 124.3 billion barrels there. Given these impressive reserves as well as the ever-increasing production volumes, in the foreseeable future, Kazakhstan is much likely to remain among top global oil producers.

Another alternative is the construction of Trans Adriatic Pipeline (TAP) a pipeline project to transport *natural gas*, starting from *Greece* via *Albania* and the *Adriatic Sea* to *Italy* and further to Western Europe. The pipeline would be supplied by natural gas from the second stage of the *Shah Deniz (Azerbaijan)* gas field development in the Azerbaijani section of *Caspian Sea* through the *South Caucasus Pipeline* and the planned *Trans Anatolian Pipeline (TANAP)*. Since it will enhance *energy security* and diversify gas supplies for several European markets, the TAP project is supported by the European institutions and seen as a "Project of Common Interest" and a part of the *Southern Gas Corridor*. The total length of the pipeline will be 878 kilometers. TAP also plans to develop an underground natural gas storage facility in Albania and offer a reverse flow possibility of up to 8.5 billion cubic meters. These features will ensure additional energy security for the *Southeastern Europe*. The construction of the TAP is in process and will be operational in 2020.

But, who is responsible for energy security? The adequate, reliable and competitive provision of energy is a shared responsibility between governments, market institutions and energy businesses. Some countries have established strong government-business partnerships across the country to address energy security challenges. The national Ministries and Departments of Energy supports the security of domestic and international supply chains for electricity, gas and liquid fuel through these core activities.

NATO and Energy Security

The disruption of energy supply could affect the security of Allies and have an impact on NATO's military operations. While these issues are primarily the responsibility of national governments, NATO continues to consult on energy security and further develops the capacity to contribute to energy security, concentrating on areas where it can add value. To this end, NATO seeks to enhance its strategic awareness of energy developments with security implications; develop its competence in supporting the protection of critical energy infrastructure; and work towards significantly improving the energy efficiency of the military.

NATO's role in energy security was first defined in 2008 at the Bucharest Summit and since then has been strengthened. Energy security is a vital element of resilience and has become more important in the past years due to the new security context. Energy efficiency is important not only for logistics and cost-saving in theatres of operation, but also for the environment. While NATO is not an energy institution, energy developments, such as supply disruptions, affect the international security environment and can have far-reaching security implications for some Allies. As a result, NATO closely follows relevant energy trends and developments and seeks to raise its strategic awareness in this area. In May 2012 at NATO Summit held in Chicago, leaders officially endorsed the creation of a new NATO Energy Center of Excellence.

This includes consultations on energy security among Allies and partner countries, intelligence-sharing, as well as organizing specific events, such as workshops, table-top exercises and briefings by external experts. The North Atlantic Council's annual seminars on global energy developments, as well as the first Energy Security Strategic Awareness Course are of particular importance in this regard. All countries are increasingly reliant on vital energy infrastructure, including in the maritime domain, on which their energy security and prosperity depend. Energy infrastructure is also one of the most vulnerable assets, especially in areas of conflict. Since infrastructure networks extend beyond borders, attacks on complex energy infrastructure by hostile states, terrorists or hack activists can have repercussions across regions. For this reason, NATO seeks to increase its competence in supporting the protection of critical energy infrastructure, mainly through training and exercises.

Protecting energy infrastructure is, however, primarily a national responsibility. Hence, NATO's contribution focuses on areas where it can add value, notably the exchange of best practices with partner countries, many of which are important energy producers or transit countries, and with other international institutions and the private sector. By protecting important sea lanes, NATO's counter piracy operations also make an indirect contribution to energy security. Moreover, NATO is also supporting national authorities in enhancing their resilience against energy supply disruptions that could affect national and collective defense. Enhancing energy efficiency in the military focuses on reducing the energy consumption of military vehicles and camps, as well as on minimizing the environmental footprint of military activities. Work in this area concentrates on bringing together experts to examine existing national endeavors, exchanging best practices, and proposing multinational projects. It also includes studying the behavioral aspects of saving energy in exercises and operations, as well as developing common energy-efficiency standards and procedures.

National militaries that make up the Alliance have a strategic weakness in their energy supply chains and energy usage. NATO convoys regularly came under lethal attacks in Afghanistan while delivering fuel to operate inefficient vehicles and inefficient diesel generators used to power inefficient devices. The fully-burdened cost of fuel, not the price paid to the wholesaler, but the true price of getting that fuel to the frontlines of the battlefield, is an excess that no military expecting combat can easily afford as national budget across the Alliance tighten. NATO should catalyze cooperation throughout the Alliance to identify and implement the means by which our militaries can be made stronger by becoming more energy efficient and less reliant on lengthy fuel supply chains.

A significant step forward in this area is the adoption of NATO’s “Green Defense” framework in February 2014. It seeks to make NATO more operationally effective through changes in the use of energy, while saving resources and enhancing environmental sustainability. Finally, NATO is also instrumental in showcasing energy-efficient solutions in military exercises and exhibitions. At the Bucharest Summit in 2008, Allies noted a report on “NATO’s Role in Energy Security”, which identified guiding principles and outlined options and recommendations for further activities. These were reiterated at subsequent summits, while at the same time giving NATO's role clearer focus and direction.

The NATO acknowledged the potential impact of energy security issues in the 2010 Strategic Concept and, more recently, in the Chicago Summit Declaration, which underlined the need to integrate, as appropriate, energy security considerations in NATO’s policies and activities, concentrating on areas where the Alliance can add value and make a difference. Efforts directed towards a significant improvement of the energy efficiency of NATO's military forces, and at the same time reducing their impact on the environment, were identified as areas to explore.

The 2010 Strategic Concept, the setting up of an Energy Security Section at NATO Headquarters that same year, and the accreditation of the NATO Energy Security Centre of Excellence in Lithuania in 2012 were major milestones in this process. The decision of Allies to "integrate energy security considerations in NATO's policies and activities" (2010 Lisbon Summit Declaration) also meant the need for NATO to reflect energy security in its education and training efforts, as well as in its exercise scenarios. Since then, several exercises have included energy-related developments, and several training courses have been stood up, both nationally and at the NATO School in Oberammergau, Germany.

In the years to come, NATO will seek to further enhance the strategic dialogue, both among Allies and with partner countries, offer more education and training opportunities, and deepen its ties with other international organizations, such as the International Energy Agency, academia, and the private sector. Work on enhancing the resilience of energy infrastructure, notably in hybrid scenarios, will be given greater attention. With increased awareness of energy risks, enhanced competence to support infrastructure protection, and enhanced energy efficiency in the military, NATO will be better prepared to respond to the emerging security challenges of the 21st century.

Several strands of work in this domain are currently being pursued by many NATO committees and organizations, one of the most active being the NATO Science & Technology Organization (STO). The STO has been active over the last years in undertaking research activities, mainly through its collaborative network, to support the global effort on energy efficiency and environmental preservation, nowadays also referred to as "Smart Energy". The main current activities are addressing the following areas: power and energy in NATO operations; fuel cells and other emerging man-portable power technologies; electric military vehicles and large battery packs: the hybrid electric technology is approaching a level of maturity which will allow fielding military hybrid electric vehicles in the near future. Use of large battery packs is currently being investigated; greener munitions: several studies focus on how to design and apply "greener" munitions, monitor their "health" during the lifetime, and adopt advanced technologies for the disposal and for the mitigation of the contamination of proving ranges; environmental noise: the current efforts are focused on aircraft noise reduction, improved modeling and management of noise, to address current trends in environmental regulations which will make it more costly to operate military platforms without minimizing the effects of the noise they generate; reduction of fossil fuels consumption: the research is focused on opportunities and threats for vehicles (air, land, and naval), associated with the introduction of synthetic fuels.

Energy support for military operations

Military operational energy is defined as the energy required for training, moving, and sustaining military forces and weapons platforms in operations. It also includes the energy demand from tactical systems and generators in operational bases. The demand and cost of military operational energy have increased considerably over recent decades, creating several logistical challenges in the battlefields. Indeed, increased operational energy demands drive thicker logistics tails that can slow operations, limit maneuverability and deploy ability, tie up force structure in combat support, create untenable force protection requirements, expose personnel to serious and unnecessary risks, and reduce the likelihood of mission success. For example, fuel delivery convoys along vulnerable lines of communication have often been prime targets for insurgent forces. Protecting these convoys imposes a high logistics burden on combat forces by diverting combat units from direct engagement to force protection missions. Reducing the need for operational energy can have significant benefits; both for force deploy ability and sustainability.

One of the fastest ways of reducing the operational energy demand, especially fuel demand, would be to optimize current energy usage patterns. This could be achieved through cultural changes and operational efficiency initiatives. From a culture change perspective, it is important to increase the awareness of energy issues in operations and to understand the human factor aspects of decision-making pertaining to avoid wasting energy. From an operational efficiency perspective, it is important to take initiatives to optimize the energy usage in operations. This includes the installation of energy efficient structures in camps, the use of tactical intelligent power management systems tapping on local energy sources, as well as the increased use of simulators for training.

In the longer term, operational energy demands and costs could be reduced through various technology insertion programs. These could include the development of energy efficient platforms, the use of mature and emerging renewable energy sources for deployed camps, and alternative fuels for mobility systems. In addition, it is important to factor properly energy logistics in the acquisition-decision trade space to reduce life-cycle operations and sustainment costs.

In military operations, energy demand data can be used to develop realistic sustainment plans and to allocate appropriate fuel delivery resources in theatre. From a process perspective, energy demand data is essential not only for budget planning and reporting expenditures, but also for strategic level analysis and decision-making related to the defense operational role, such as force development, strengthening operational readiness, and building a more efficient and resilient force. While energy usage data for domestic infrastructure and operations would be easily collected, little information about energy data for expeditionary operations is available. To address the data availability issues, modeling and simulation methodologies could be used to determine the expected energy consumption in expeditionary operations. A methodological framework for forecasting fuel consumption in military operations has been developed by the study group. Fuel requirements in military expeditionary operations could be simulated using the Monte Carlo simulation methodology. This methodology establishes a common set of parameters describing a set of deployment scenarios; within each scenario, individual parameters such as composition of the task force, locations and duration of deployments, frequency of sustainment flights, fuel consumption rates, etc., are then generated stochastically. To allow for meaningful statistical evaluation, fuel consumption data should be simulated and collected for a large number of randomly generated deployment scenarios. Each operational scenario would involve land, air and maritime operations and fuel consumptions are calculated for the three operations.

For land operations, fuel requirements in a given scenario are mainly determined by the daily consumption of ground vehicles and power generation systems of the task force. Key input data into an energy demand simulation model would include distances travelled by ground vehicles, number of vehicles, number of generators, operating hours of generators, and consumption rates.

Air force operations would involve airlift activities as well as tactical air operations. For lift activities, fuel requirements are mainly determined by the consumption of the lift assets during the deployment, sustainment and redeployment operations. For tactical air operations, fuel consumptions are driven by the tactical asset activities. Key input parameters into an energy demand simulation model would include number of aircraft sorties, average sortie length, aircraft speed, aircraft consumption rate, helicopter consumption rate, etc.

For naval operations, key input data would be the number of days that each platform spends in each of a set of activities including: pre-deployment, transition, deployment, and post deployment. For each activity the minimum and maximum speeds are defined. The input data will be used to determine the total scenario consumption based on activity per day.

The NATO war fighter of today has become increasingly dependent on electronic devices to achieve battle superiority. The use of these devices requires the production of electricity which can range from the utilization of small batteries to large diesel generators. However, reliance on these forms of power generation is becoming increasingly problematic. The use of diesel or gasoline internal combustion engines to power a generator or for propulsion generates noise, is maintenance intensive, and consumes large amounts of fossil fuels. Non-rechargeable batteries create a large logistical footprint, are expensive, and create environmental disposal issues. The use of rechargeable batteries is somewhat less costly with a smaller overall logistics footprint but requires an energy source for recharging.

Recent advances in fuel cell technology have been able to demonstrate that fuel cells can be a source of electricity generation on the battlefield and can minimize or totally eliminate some of the problems associated with traditional sources of energy. When compared to fossil fuelled generators, fuel cells are virtually silent with minimal thermal signatures, thus providing a tactical advantage in some scenarios. They also require less maintenance and because of the low emissions, can conceivable be used indoors. In general, they are more efficient over a wider output range than a standard generator, resulting in less fuel being required for operation. In certain battery operated devices that have a constant drain, a fuel cell can actually replace a battery and most certainly be used as an onboard battery charger. This decreases the logistics burden of constantly transporting non-rechargeable batteries to forward positions (and back for disposal of the toxic materials) or movement of rechargeable batteries to and from charging stations.

The NATO STO Task Group "Fuel Cells and other Emerging Man portable Technologies for the NATO War fighter", established in 2011 and comprising experts from NATO and Partners Nations, conducts assessments for emerging technologies, recommends leveraging of resources serves as subject matter experts and acts as a liaison to other NATO technical teams.

A man wearable application is defined as a piece of equipment that the war fighter wears or carries in his rucksack, such as a radio, whereas a man portable application is something that can be moved without a vehicle, usually limited to what can be lifted by two persons, such as a small generator or battery charger. The investigation of unmanned applications includes ground, air and undersea systems.

Fuel cells offer some significant advantages when compared to other forms of energy generation for the applications mentioned above. A man wearable fuel cell combined with a rechargeable battery into a hybrid configuration can perform as a central power source to all man wearable equipment. Another option is to eliminate the battery portion and have the fuel cell act as a small battery charger, allowing for batteries to be charged while being worn by the war fighter. In either instance the advantages are a reduction in the number of batteries required to complete a mission with the associated reduction in weight carried by the war fighter. Furthermore since the technology is easily scalable, fuel cells are becoming available at power levels below most generators.

When used in unmanned applications fuel cells can replace the battery pack or internal combustion engines. By reducing the weight of the power plant, it results in longer mission times or increased payload capability. This translates into longer loiter times, increased weapon packages or reduced exposure of the operator due to the need to replace a battery pack. Fuel cells have already been tested and used in tactical environments. Fuel cells of various output levels that are fuelled by bottled hydrogen, direct or reformed methanol and propane have been used to a limited extent in military exercises and deployed by various NATO militaries. These have proven to be valuable in providing information for optimizing the design of a given system and providing lessons learned to the developing agencies.

However, before fuel cells can be widely utilized in military weapon systems and support activities, there are several challenges that must be overcome. One of the major obstacles is the ability to operate using standard logistics fuels which would have a strong logistic advantage. The other major obstacles are related to the initial investment and reliability of the systems. Currently even the smallest fuel cells costs tens of thousands of US dollars. This represents a significant investment when compared to the use of batteries or generators, especially in a time of decreasing budgets. This is further complicated by the fact that none of the technologies have been able to demonstrate consistent, long term failure free performance (measured in thousands of hours) in a true tactical environment. In times of restricted budgets, it is difficult for a government to make an investment in an expensive fuel cell technology compared to much less expensive batteries. Nevertheless the multiple logistic, efficiency and tactical advantages that man portable/man wearable fuel cells are able to ensure, would suggest pursuing the research efforts in this field.

Conclusions

As the world moved to 21st century the energy security is becoming a major issue to be resolved. The natural energy sources are finite and after some decades the world will run out of them. The late awareness of the humanity requires finding alternative ways to replace them. Despite their diversity, the description and examples presented here, show how relevant energy efficiency is becoming for the world and to military forces, demonstrating the impact energy efficiency may have in economy and military operations. They also show that a change of culture is required to implement the notion of "green energy", because one has to analyze and balance potentially competing courses of action pertaining to energy considerations and to mission requirements. The true importance of energy availability and efficiency is most likely underappreciated, as for certain military platforms it may become a limiting factor during combat. This is particularly relevant for high-tech soldier systems, as they gradually begin to be fielded by NATO nations, which are more and more reliant on electronics requiring lightweight energy supply devices. The studies conducted show that technical solutions may be available, but they need significant funding to reduce the upfront costs, limiting their affordability to military forces.

Energy related considerations, including their cost, are a real issue to military forces during peacetime, crisis and operations. This requires a new mindset in which scientific evidence-based methods should be used to inform decision makers. The study conducted proposes a model to capture the complete life cycle of fuel in operations, complemented by a methodological framework to determine energy requirements for expeditionary operations.

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