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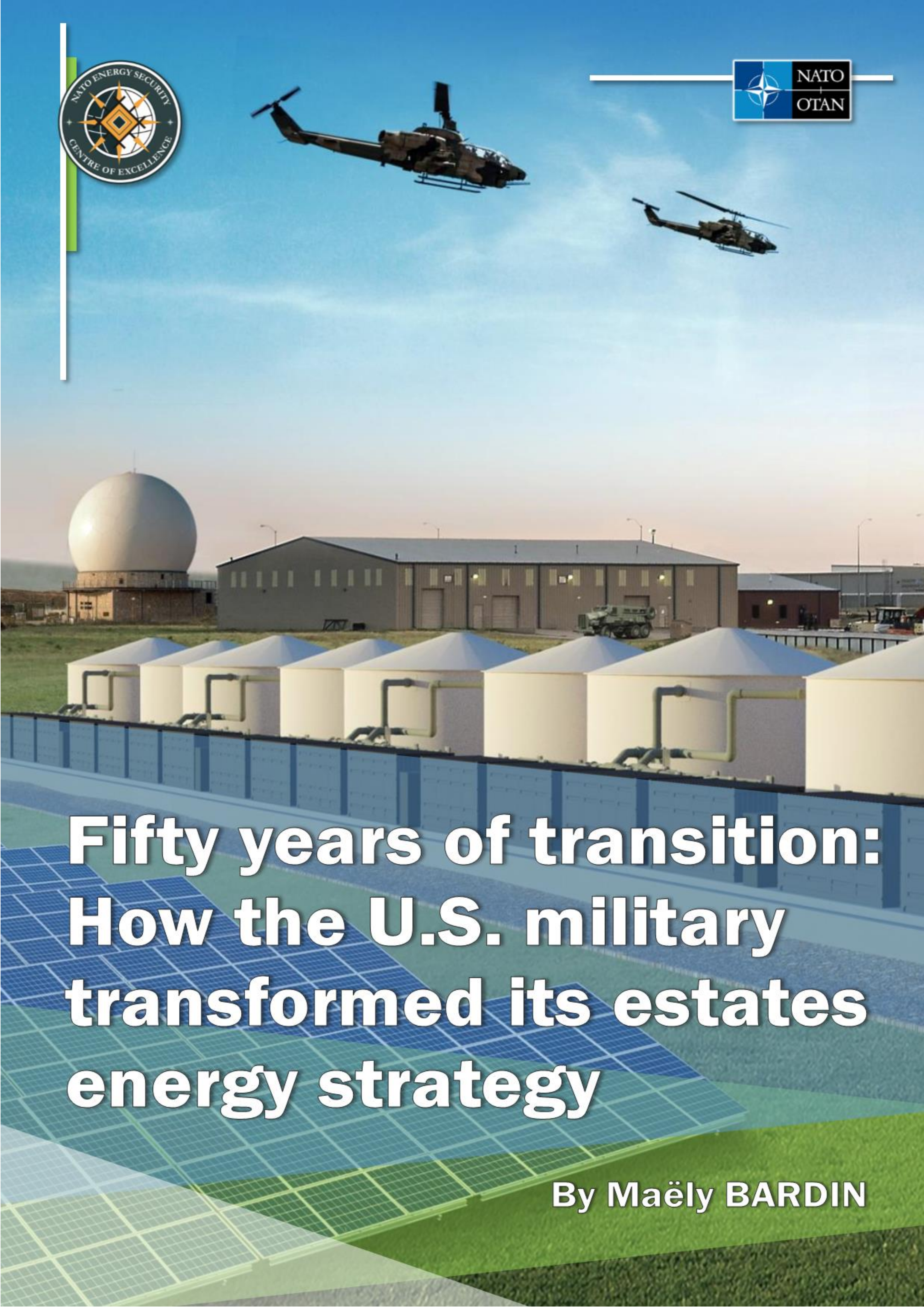


Fifty years of transition: How the U.S. military transformed its estates energy strategy

By Maëly BARDIN

FIFTY YEARS OF TRANSITION:
HOW THE U.S. MILITARY TRANSFORMED ITS ESTATES ENERGY STRATEGY

By Ms. Maëly BARDIN Energy Security Internship 2024

This analysis was conducted in 2024, prior to the inauguration of Donald Trump as the 47th President of the United States. It therefore reflects the climate policy positions of preceding administrations.

Introduction:

Energy has always been the lifeblood of military operations, powering everything from vehicles and equipment to the infrastructure that supports military personnel. In recent decades, there has been a visible shift in how estates and facilities use energy. More carbon intensive fossil fuels have begun to play a smaller role, with greater electrification also powered by greater renewable generation. As the world grapples with the dual challenges of climate change and evolving geopolitical tensions, the military faces two (sometimes competing) demands: developing the resilience of its infrastructure, and contributing to climate goals by reducing its carbon intensity. Nonetheless, this shift is not solely about addressing environmental concerns, but also about securing the military's long-term operational capacity and supporting broader national and global security goals, regardless of the type of energy it consumes.

The U.S. military, as the largest Allied force, offers a useful case study. The story of the transformation of their estates energy begins in the oil-dominated 1970s. The energy crises of that decade highlighted the dangers of dependence on external resources, leading to an urgent need for diversification. Over the years, natural gas emerged as a less carbon intensive, more flexible alternative, gradually replacing coal and oil as the largest primary energy source. However, reliance on globally-traded fossil fuels brought its own vulnerabilities, from price fluctuations to environmental consequences. These pressures paved the way for the military’s ambitious shift to renewable energy.

While renewables offer the promise of sustainability and resilience through independence, they also introduce new challenges. The increasing reliance on digital infrastructure to manage new systems and microgrids creates vulnerabilities to cyberattacks. The intermittent nature of solar or wind power requires significant advances in energy storage technology to ensure stable supply. Moreover, the transition to renewables depends on scarce resources like lithium – essential components in the technologies which support the transition - often controlled by non-allied countries, raising concerns about geopolitical tensions along the energy supply chain. Finally, climate change itself threatens renewable systems designed to mitigate environmental risks.

The military’s ability to maintain readiness in the face of these challenges is critical. Can the U.S. military ensure its resilience as vulnerabilities introduced by new energy technologies arise? Will the shift to renewable energy compromise its ability to respond to emergencies or increase its dependence on foreign supply chains? These questions make up a complex narrative of adaptation.

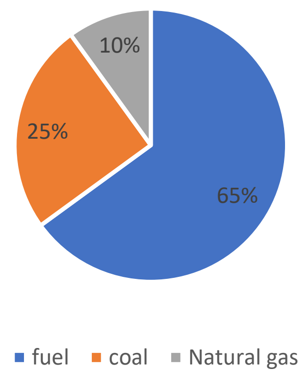
As we explore half a century of transformation within the U.S. military, we’ll uncover lessons learned from its early reliance on fossil fuels and its current shift toward renewable energy. Along the way, we’ll examine how the military is managing technological, geopolitical, and environmental risks. We want to understand what their efforts reveal about the future of energy security in an increasingly volatile world.

1. Historical and Strategic Context of Energy in the US Military's Estates

Fuel Oil's Waning Domination (1975-1990)

Available data from the Department of Energy provides a view of the US Department of Defense's facilities energy consumption back to 1975. The 15 years to 1990 saw fossil fuel consumption undergo significant changes as energy consumption patterns evolved. It is noted that in the 1970s, fuel oil was the dominant energy source, making up 65% of primary energy needs. Coal accounted for 25%, while natural gas played only a minor role with 10% of total primary energy demand. During this time, fuel oil served as a reliable source of energy to dispersed estates, either as fuel for generators, or as direct feedstock for oil-fired boilers.

Figure 1: Primary Energy Mix of US DoD Facilities in 1975



This heavy dependence on oil, however – which, at the time, was produced domestically but also imported in great quantities - made the US military quite vulnerable to the global oil shocks of the decade. Arguably, this looming vulnerability prompted a rethink in how the military secured its energy.

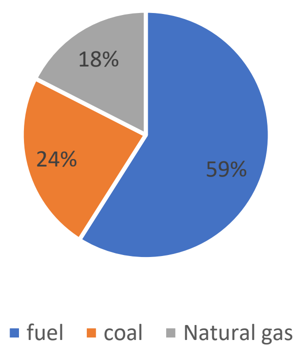


Figure 2: Primary Energy Mix of US DoD Facilities through the 1980s

In the 1980s we started to see a shift: natural gas started to play more of a part in the military's estates energy portfolio. Its share of usage, which had been 10% in the previous decade, increased to 20-25% thanks to its cost effectiveness and cleaner profile compared to oil. Consequently, the dominance of fuel oil began to decline, decreasing to 58%. At the same time, we also saw the use of coal start to decline. Not only did the market influence this change, the number of environmental regulations aimed at addressing concerns about pollution were increasing. Coal's relatively large role in the energy mix and its use had to be reduced to align with new policies.

This period marked the beginning of a gradual shift towards diversification of energy sources but also reduction of dependence on conventional fossil fuels.

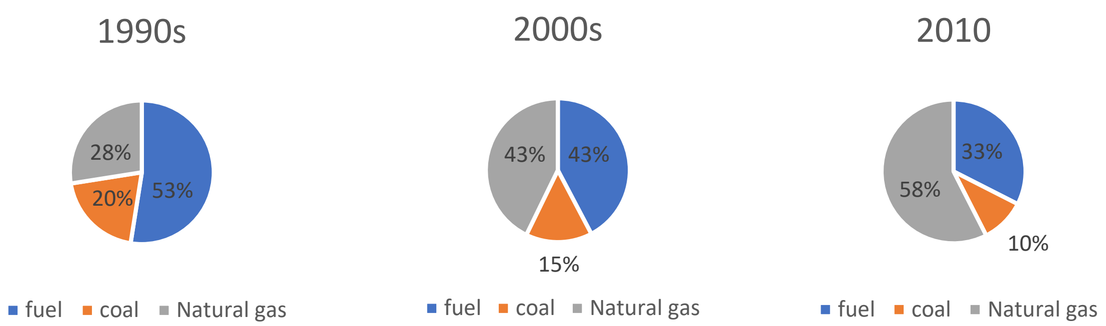
The Shift Towards Cleaner Energy Sources (1990-2010)

In the two decades that followed, the facilities' energy consumption reduced the carbon intensity of the supply mix by increasing its use of natural gas. In the 1990s, natural gas consumption became more prevalent, reaching 30% usage in 1995. Indeed, the military, seeking to improve its energy security while reducing its costs, moved away from fuel oil and coal as the default, while keeping them for specific uses.

The trend accelerated in the 2000s with natural gas becoming the dominant primary energy source. By 2005 it accounted for 45% of consumption, surpassing fuel oil which accounted for 40% of consumption. Efforts to reduce the carbon footprint of military bases have been growing over time. This is illustrated by initiatives such as the Net Zero program, which, while not explicitly focused on natural gas as a transitional energy, has contributed to its growing adoption. In the late 2000s, on-site renewables generation starts to play a more significant part in the primary energy mix.

In the decade that followed, military bases continued their progress towards sustainable consumption. Natural gas constituted 55% of primary energy consumption through the 2010s, and the role of coal had considerably decreased to just 10%. These changes marked a decisive step towards the diversification of energy sources, but also in the adoption of cleaner and more sustainable energy practices.

Figures 3, 4, 5: The Evolution of the Primary Energy Mix in US DoD Facilities, Decade Averages

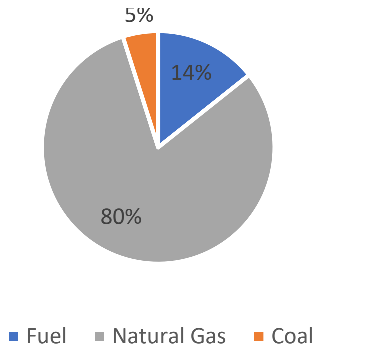


Source: US Department of Energy Federal Facility Reporting Data (8)

<u>New Priorities for the 21st Century</u>

By 2020, natural gas had consolidated its dominance in the military estate's energy portfolio, with a 70% share of total primary consumption, while fuel oil's share had fallen to 25% and coal's to just 5%. This strong dominance of natural gas reflects a clear policy shift. Alongside this transition to cleaner energy sources, the military has undertaken a major modernization of its infrastructure to continue reducing its reliance on fossil fuels in order to improve its energy strength. Among the key initiatives that have been adopted is the development of microgrids, localized energy networks capable of operating independently of national distribution systems.

Figure 6: US DoD Facilities Hydrocarbon Consumption Mix, 2020s



By 2022, we are seeing increasingly concrete results, with approximately 45% of the electricity on military installations being produced from renewable sources, with the majority produced by solar and wind installations. These new restructurings do not stop after their first results - the Army outlined an aim to install microgrids in all its installations by 2035, thus reinforcing its commitment to sustainability and energy security.

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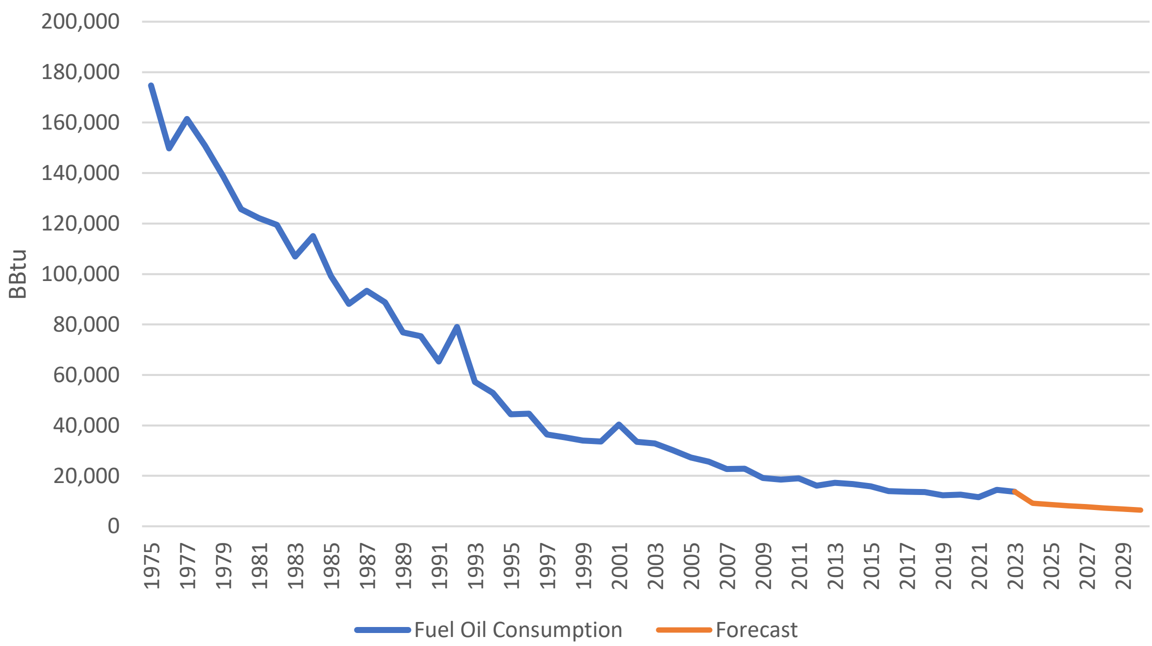
2. Energy Transition: Towards Cleaner Energies

Natural Gas as a Transition Fuel

The focus on natural gas as a transition fuel reflects a strategic approach to achieving a cleaner energy mix while maintaining stability and flexibility. Natural gas is less carbon intensive than coal and oil and provides immediate emissions reductions gains. Natural gas is a despatchable resource which can quickly generate electricity on demand to support peaks and troughs of renewable generation. As a result, it facilitates the development of renewable infrastructure to support a transition over the long term.

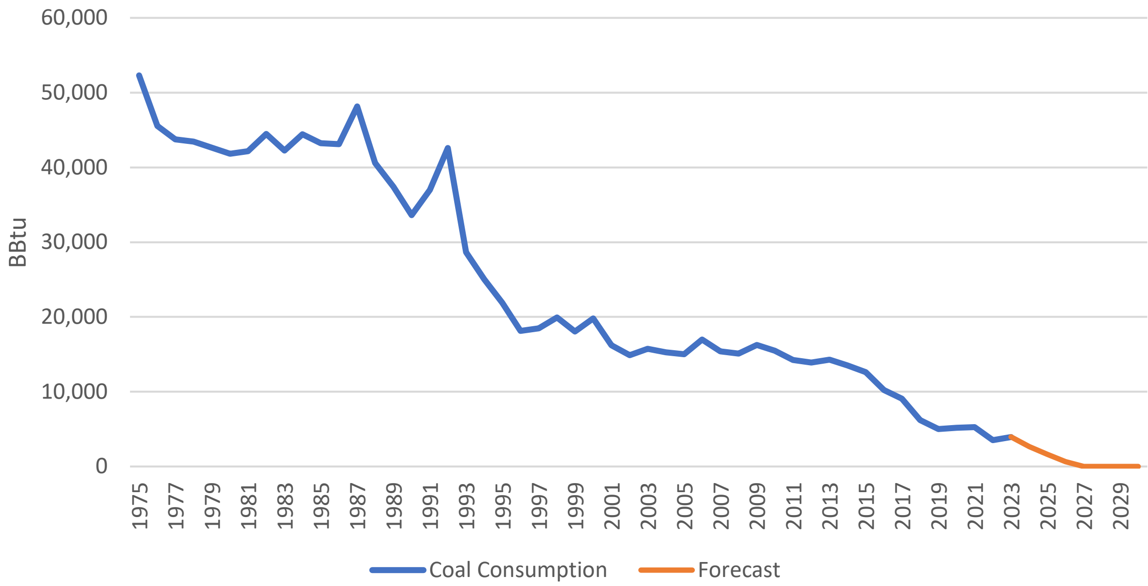
Looking at the historic consumption data, it is possible to provide an indication of what the future might look like. By finding the best pattern previous data displays, it is possible to apply it to coming years. This is not a model, but demonstrates that – if the historic pattern holds – we can expect a continued reduction in fuel oil consumption and a possible completion of the phase out of coal.

Figure 7: US DoD Estates Fuel Oil Consumption & ETS Forecast



Source: Own Analysis of US Department of Energy data (6).

Figure 8: US DoD Estates Coal Consumption & ETS Forecast



Source: Own Analysis of US Department of Energy data (6).

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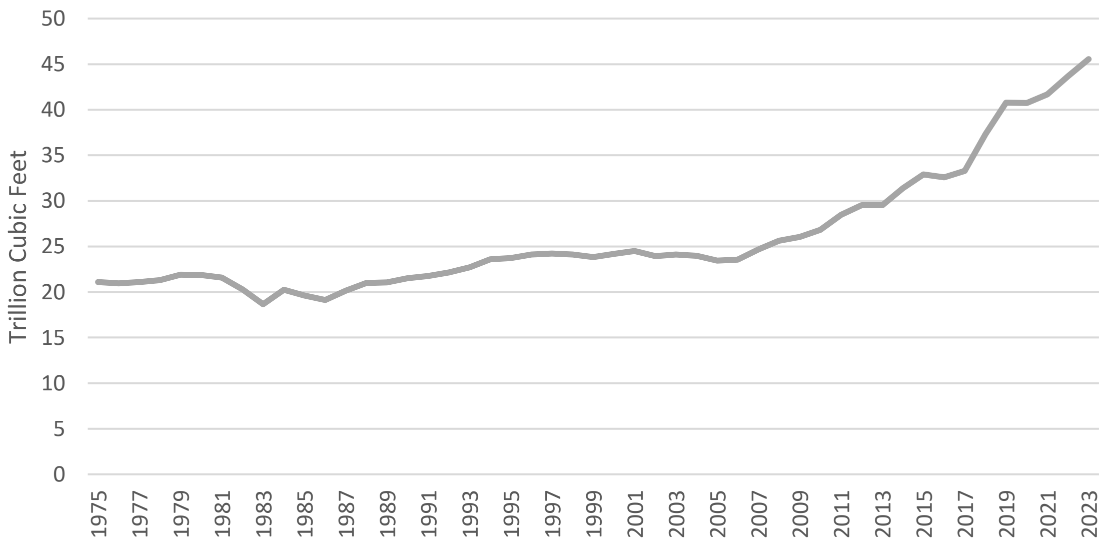
Natural gas' utilization as a transition fuel has been motivated by the expansion of domestic production. This was made possible by advanced technologies utilized within oil & gas industry such as hydraulic fracturing. This owes much to George P. Mitchell, considered pioneer of its commercial development in the 1980s, allowing gas to be extracted from shale formations. Consequently, the United States avoided increasing its dependence on imports, which looked increasingly likely after domestic production peaked in the early 1970s and began to decline. This has safeguarded energy independence.

Figure 9: U.S. Natural Gas Gross Withdrawals, 1975 - 2023



Source: U.S. Energy Information Administration

Beyond Natural Gas: Renewables & Efficiency

Noticing that natural gas can only support the transition, the US has implemented measures to mitigate its negative impacts while also bolstering alternate source. These include regulations on methane emissions, such as leak monitoring and limiting emissions from oil and gas operations, which are essential to minimizing climate impacts. Under the administration of President Joe Biden, additional reforms encouraged investment in renewable energy while redefining tax incentives in the oil industry to support companies committed to reducing their carbon footprint. These reforms were built on previous measures, such as the Clean Transportation Plan implemented in 2015 by the administration of former President Barack Obama, which allocated $10 billion per year to transform regional transportation infrastructure to clean energy infrastructure, thereby reducing carbon emissions.

In addition to these measures, policies were also targeted at the Department of Defense's energy use. Such as Executive Order n°14057, which directed the federal government to lead by example in adopting clean and resilient energy solutions. This mandate aimed at achieving 100% carbon-free electricity for federal operations by 2030, with at least half of the energy supplied locally to meet demand 24/7. To achieve this, the government collaborated with utilities, developers and other partners, to source electricity from solar, wind and other carbon-free sources. This initiative was expected to drive the development of at least 10 gigawatts of new clean energy capacity in the United States by 2030, supporting job creation and advancing the goal of a carbon-free electricity sector by 2035.

With the significant need to diversify supply sources, the US DoD had to adapt technologically. In recent years, they have invested heavily in renewable energy projects to improve the energy resilience of installations. A key element of this is the development of autonomous energy systems, which reduce dependence on traditional electricity grids, while strengthening energy security. However, the intermittency of renewable energy sources is a significant challenge, requiring the use of advanced energy storage technologies – or despatchable generation like natural gas - to provide stable and continuous power supply, particularly for critical operations.

Fully capturing the benefits of renewables is contingent on progress in acquiring efficient technologies, especially on the issue of energy storage to be able to cope with the variability of renewable energy and to ensure a reliable energy supply in the long term. These technological advances will be essential to support the military's transition to a more sustainable and resilient energy future.

Reference:
15.16.17.18.19.20.21.22

3. New Risks Linked to the Energy Transition

Technological and Cybersecurity Risks

The energy transition is made possible in part by technological innovations over time. However, these do not come without risks. The transition to renewable energy systems or to micro-grids adds in the risk vector of cybersecurity for of military installations. Increasing use of digital technologies for the management of modern infrastructures increases vulnerability to cyber-attacks. While technological advances improve energy autonomy, they also expose military installations to potential disruptions in energy distribution of a new kind, which can compromise military operations in critical ways.

Another challenge, more logistically focused, is the complexity of maintaining renewable energy infrastructure. More modern equipment requires very specific skills for its installation and maintenance, which brings a risk of increased costs and dependence on specially qualified personnel. In the short term, armed forces may have difficulty recruiting enough qualified technicians to manage these systems due to a lack of specialists. The lack of personnel brings a risk of more rapid deterioration of the infrastructure. In the long term, there is a need to maintain the skills of the personnel, which therefore requires continuous training to ensure that the personnel remain competent as technologies evolve.

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23.24.25

Impacts of Climate Change

Climate change poses significant risks at various levels, both for resilience of energy networks and the reliability of renewable energy generation. Indeed, these energy sources are very sensitive to climate fluctuations and are totally dependent on the goodwill of weather conditions. Adverse weather may reduce the availability of energy to military installations. For example, hurricanes can significantly reduce solar energy production, reducing photovoltaic production by 18 to 60% compared to clear days. Their numbers have increased over the years, a phenomenon that may result from climate change. This increases reliance on onsite fossil generation, or on power from a possibly strained distribution grid. In addition, wind power, which currently accounts for 10.2% of U.S. electricity, can be disrupted by hurricanes that change wind speeds, causing fluctuations in electricity production. Indeed, tropical cyclones can impact both wind infrastructure due to their high winds, but also solar, as they can reduce solar radiation by up to 80%, with effects lasting for several days.

This is a dual challenge: carbon emissions intensify weather events which can reduce the efficacy of renewables, which are designed to reduce carbon emissions. This demonstrates the need to transition in a coherent manner, maintaining back-up power for times of stress while reducing annual carbon emissions.

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Geopolitical Dependence, Resource Scarcity and Emergency Management

There is also a major challenge that weighs heavily on the energy issue, political agreements between consumer and supplier countries can sometimes be impacted by conflicts of interest or geo-political disagreements. These complexities lead to major risks that can impact the supply of essential materials for green technologies. Indeed, renewable energy systems or batteries that enable the implementation of energy innovations depend mainly on rare resources such as lithium, cobalt or rare earth which are most often controlled by countries not allied with the United States. This dependence on these states creates a vulnerability that can become problematic in times of international tensions or conflicts. During periods of instability, we could see a limitation or even blocked access to these resources that are essential to the proper functioning of energy infrastructures. A disruption in supply could obstruct the maintenance and development of military infrastructures, which would constitute a significant vulnerability for operational preparations. To overcome this unpredictable risk, the solution would be to work without these materials, but at present few or no alternatives have been found.

Another risk related to both national capacity and the international situation is the assurance of a storage capacity for new energies in the event of an emergency. Indeed, in the event of an emergency, it is necessary to be able to anticipate a good energy operation thanks to reserves, and in such a case, a lack of sufficient fuel reserves could deprive the army of adequate backup solutions. If renewable energy constitutes a sustainable solution in the long term, it is not as easy to store in large quantities, which poses a problem in the context of energy resilience. This risk is aggravated by the low energy redundancy, where limited backup systems may not guarantee a continuous power supply in critical situations, further threatening the army's ability to operate in the event of an emergency. We see in such a case, it is probably necessary to keep stocks of fossil fuels, which are more reliable and easier to store in the long term in the event of a crisis.

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27.28.29.30

4. Resilience and Energy Security: the Challenges of the Future

Improving Security, Resilience and Self-Sufficiency

The need to be constantly adapt to changing energy supply and demand balances is essential to maintain and continually improve resilience. It is essential to strengthen infrastructure, and be able to meet the increasing challenges posed by climate change. This requires modernizing energy systems, including buildings, power lines and support structures, to be able to withstand weather events that are becoming more frequent, with more severe weather. Development of energy efficiency in aging estates also facilities supply security by decreasing total energy need. We have seen innovations such as variable speed wind turbines, or taller designs to facilitate stronger production. These examples illustrate how technology seeks to adapt to new climate challenges, to anticipate fluctuations in weather conditions in a better way.

Planners also need to integrate climate data and advanced weather forecasts into energy models. These tools enable a more comprehensive assessment of risks, thereby improving the adaptability of energy systems. In addition, careful siting of energy facilities is essential to minimize their exposure to extreme weather events, and thus limit damage from storms, for example. This can likely ensure a more reliable and robust energy infrastructure in the face of unpredictable climate.

As discussed, military bases may draw their power from the grid. In the event of load shedding on the national or regional electricity distribution system, it is important to ensure the integration of robust backup systems. This demonstrates the value of onsite generation sources, spanning not only hydrocarbons, but also renewables and even hydrogen. Development of these assets are priorities to enable a rapid and effective response in the event of an emergency.

Figure 10: French Military Personnel with a Hydrogen Fuel Cell as Part of NATO ENSEC COE Experimentation

Source: NATO ENSEC COE, 34

Reference:
31.32.33

Enabling Transition without Compromising Capability

One of the main challenges of this transition is the difficulty of storing renewable energy in large quantities, which can pose risks in terms of energy resilience, especially in the event of an emergency as detailed above or in the event of a period of high demand. The development of advanced energy storage solutions, such as the hydrogen fuel cell seen in Figure 9, is therefore an essential subject to be explored in depth to ensure the reliability and stability of maintaining energy supplies during the transition.

Despite these challenges, the transition to renewable energy is a critical step toward a more secure and sustainable energy future. By reducing greenhouse gas emissions, the use of renewable energy also helps reduce climate-related risks, contributing to long-term environmental stability. This transition not only supports global sustainability goals, but also strengthens the Military’s ability to adapt to changing energy demands, while maintaining operational readiness and ensuring energy security.

In the future, the U.S. military plans to increase its use of renewable energy to meet its sustainability and resilience goals. As with the integration of stand-alone energy systems, these investments will reduce the energy dependency that may still exist on traditional grids and will also strengthen the energy security of the latter. However, this will require advances in energy storage technologies to manage the intermittency of renewable sources and ensure a stable energy supply over the long term. But storage is not the only progress that remains to be made. Strengthening security systems must also be seriously considered; with technological advances, the risks of cyber-attacks are greater and pose significant uncertainty for the military. To address this, advanced cybersecurity measures must be implemented to protect energy systems, making the protection of these infrastructures a top priority as technology continues to evolve.

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Conclusion:

The energy transformation of the US military over the past half century reflects a profound strategic shift, showcasing its adaptation to the complex challenges of our time. From an overwhelming reliance on very carbon intensive fossil fuels, this evolution has been marked by the progressive diversification of energy sources, culminating in the significant integration of renewable energy within fixed military infrastructures. This highlights the intersection between energy imperatives, environmental considerations, and national security concerns. Initial efforts to reduce dependence on oil, driven by the oil crises, evolved into an increased adoption of natural gas, viewed as a transitional fuel. This strategy has helped reduce the carbon footprint of military bases while enhancing their energy resilience. In a context where environmental priorities were intensifying, the 2000s marked a turning point with a dramatic increase in the use of renewable technologies such as solar energy.

However, the growing reliance on digital infrastructures has exposed military energy systems to increasing vulnerabilities, particularly in terms of cybersecurity. Moreover, renewable energies, while attractive, are subject to production intermittency and technological constraints, such as storage. These challenges are exacerbated by geopolitical risks related to the supply of critical resources like lithium and rare earth elements, often controlled by non-allied nations. The vulnerability of energy infrastructures to extreme weather events also constitutes a major hurdle. Hurricanes, droughts, and other phenomena linked to climate change the reliability of renewable systems. Yet, far from being a deterrent, these risks underscore the urgency of this transition.

The future of military energy lies in key technological innovations, such as microgrids and advanced storage solutions. At the same time, improved policies, including better coordination with industrial and governmental partners, play a crucial role in accelerating the transition without compromising operational capability. Ultimately, the example of the US military demonstrates that a successful energy transition requires a balance between ambition and pragmatism.

Acknowledgements:

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