DEFENCE ENERGY STRATEGY

Energy Working Group Report
2020

Ministry for
the Armed Forces

Table of Contents

Introduction

The Ministry for the Armed Forces is responsible for ensuring the superiority of the French armed forces over its current and future adversaries, but also for carrying out its requisite responsibilities concerning the national policy of energy transition. This two-fold requirement, which was at times in the past considered incompatible, now on the contrary is considered a major and converging strategic theme that aims to guarantee the armed forces' access to the energy it needs at a reasonable price, in order to maintain its capacity for action in all circumstances.

While the global energy situation is undergoing profound changes, and we are witnessing competition for access to resources that is more complex and more global than in the past, the Covid-19 crisis demonstrated the extreme volatility of the oil markets, as well as its negative impacts on economic health and the political and social stability of the oil-producing countries. The issue of security of the oil supply is in this way of a longer-term perspective. Tensions of both a geoeconomic and geopolitical nature that are shaking up the global oil market confirm the necessity for exploring all disruptive energy sources (biofuels, hybridisation, hydrogen) in order to break free from dependence on solely oil in terms of mobility, both at a tactical and strategic level.

The primary objective of this defence energy strategy consists of making the energy transition an operational advantage in order to increase performance and to reinforce the Ministry's resilience. To that end, we begin by seeking energy efficiency by using new energy technologies and optimising consumption. A detailed knowledge of energy consumption, linked to both mobility and stationing, will make it possible to anticipate future needs and to control growth. The reduction of the carbon footprint that results from implementing these actions will result, in concrete terms, in a commitment of the Ministry for the Armed Forces to the national efforts towards energy transition.

The Covid-19 public health crisis also demonstrated the fragility linked to our technological and industrial dependence, and reminds us of the need to strengthen the strategic autonomy sought out in the last strategic review. As such, outside of reducing the carbon footprint of the Ministry, the use of alternative energy sources combined with the support of national or European industrial sectors could strengthen its energy autonomy. This means accounting for the strategic dimension of energy, and coordinating actors at both the national and European scale. Cooperation should be strengthened with European and allied partners in order to have indispensable advantages for maintaining our operational superiority (including collaboration in legal, scientific, technical, and academic domains).

Lastly, this ministerial strategy has to be steered by specific, robust governance to improve the circulation of information and coordination of ministerial actors. This means facing the numerous challenges of the energy sector in a cross-cutting and consistent manner, and in so doing, allowing the implementation of a global energy policy. To accomplish this, the Ministry must be configured to develop full knowledge of the challenges, restrictions, opportunities, and economic factors linked to energy concerning changes in the geostrategic context.

The topic of nuclear energy as propulsion or in the theatre of operation is not covered in this study.

1. Energy in the 21st century: globalised resources, energy transition and defence challenges

The global energy context is undergoing profound change. The growth and increase in complexity of geopolitical and geoeconomic tensions surrounding energy and mineral resources makes energy security an essential element of State policy. The high volatility in the price of raw materials, including oil, accentuates the instability of the regions producing them. Rivalries between powers for the control of strategic transfer points (straits, canals) and access to production zones contribute to the increase in tensions and conflicts, reinforcing the militarisation of maritime spaces and unstable regions. The question of controlling resources and the security of energy supply streams comes forcefully to the fore again in national affairs[1]. At the same time, the efforts to fight climate change and the challenges related to energy transition complicate the energy landscape. The global energy mix is transforming with the electrification of energy usages and digitalisation. The sector referred to as "low-carbon" [2] is a new field of competition in terms of the economy, technology, and norms. In that area there are new power relationships concerning access to critical metals, controlling industrial value chains, definition and distribution of norms, storage and processing of data, etc.

Concerning these changes, both France and the European Union (EU) must elaborate a strategic approach on issues of strategic autonomy, sovereignty, and energy security. This assumes choosing the origin of energy source streams and being able to physically secure them, to anticipate the potential exhaustion of conventional oil resources and the crises that can result from such exhaustion, and lastly to become aware of new economic and industrial dependence brought about by energy transition.

1.1 A global energy context that is changing and tense

1.1.1 An economic model that is persistently carbon-heavy and energy-intensive

Buoyed by demographic and economic growth of developing countries, particularly in Asia, global energy consumption may grow by around 30% by 2040. According to the International Energy Agency (IEA), in 2020, the global energy system should see a downturn in energy consumption of about 6% due to the Covid-19 epidemic[3]. Energy consumption is directly correlated with economic growth, a phenomenon further exacerbated by the progress of globalisation of the past decades, which caused an increase in trade and streams at a planetary level (commercial, energy, financial, and data streams, and streams of technical and technological know-how). The energy-intensive ways of living remain a central challenge for the proper functioning of companies, and the supply of energy often has a considerable effect on growth perspectives for economic actors, from governments to businesses. Despite the rapid development of renewable energy, fossil fuel-based energy sources should continue to be the majority, and represent more than 80% of the global energy mix by 2040[4]. Oil remains important for economic exchange, and represents 92% of the energy consumed by the transportation sector on a global scale.

"Conventional" sources of oil, those that are the most accessible and the least costly to exploit, have already been discovered. Yet the production of existing sources is falling, to the tune of about 3 to 4 million barrels per day, or 4% of global consumption, creating fear of a global production peak around 2030, according to recent studies[5]. "Unconventional" sources are increasingly being used to meet global demand (shale oil extraction in the US and in Canada, reserves in the Arctic), and profitability of these sources depends on a sufficiently high per-barrel price (around $55). However, the fall in prices due to the Coronavirus crisis demonstrated the vulnerability of the shale oil industry to oil market fluctuations, which are themselves particularly sensitive to political and economic events. Concerning the interdependence of the oil and gas markets and the significant dependence of low-carbon innovation on the price of oil, long-term impacts of the crisis on the other energy sectors should be expected.

1 Speech by the President of the French Republic on deterrence on 7 February 2020.

2 Referring to the French national low-carbon strategy (SNBC) as amended in March 2020.

3 *Global Energy Review*, International Energy Agency, 30 April 2020.

4 World Energy Outlook 2019, International Energy Agency

5 The European Union runs the risk of seeing significant constraints on oil supply by 2030 – Prudential prospective analysis, The Shift Project, 2020; World Energy Outlook 2019, International Energy Agency; Rystad Energy; IFP Energies Nouvelles.

In the context of energy transition, natural gas – the least polluting of all fossil fuel energy sources – constitutes an abundant and sought-after fossil fuel energy source that is increasing in importance in the global energy mix. Over the past decade, new importers and exporters have emerged, changing the geography of trade and contributing to the globalisation of markets that were originally regional in nature. Within the EU, we are seeing increased competition between Russia and the United States to gain market share on the European gas market. Based on its production of shale gas, the United States seeks to affirm itself as one of the largest exporters of liquefied natural gas (LNG). As for Russia, it is implementing an energy policy that seeks to diversify its opportunities and to balance out its instances of dependence. Lastly, China is developing a diversified investment strategy for energy sectors in Europe, Asia and Africa, as part of support for the "New Silk Road" project.

1.1.2 Volatility of production zones and transit

The extreme volatility of the oil markets makes the changes in oil prices over the short- and medium-term uncertain, and risks the investments of major actors in the sector (exploration, production), reinforcing the economic and political uncertainty of the oil-producing nations. The large oil-producing regions, which are already subject to strong internal tension and regional geopolitical rivalries, could suffer the cumulative effects of the public health and economic crisis, and see the fall in their production pick up speed. Consequently, the tightening of the global oil supply is becoming an issue in terms of future supplies for EU countries[6].

Though Saudi Arabia imposes itself today as a regulator of the global oil market and oil prices, the tension that came about during the Covid-19 crisis between Russia, Saudi Arabia, and the United States on the sharing of global oil production contributed to destabilising the oil market and increasing price volatility. This crisis does not seem strong enough to compromise the strategic partnership between Riyadh and Washington, but could prejudice a reconfiguration of global oil alliances. The worsening of the security situation in the Persian Gulf, a crucial region for oil supply for France and the EU, would directly impact European and Asian energy security.

More than 60% of global trade in oil is carried out by sea, and the LNG market, also traded by sea, is booming. Securing maritime routes and maritime transport hubs is also of strategic importance. Most of these streams transit through the following straits:

- Hormuz: largest transportation passage for oil (21 million barrels/day, 1/3 of all oil transported by sea per year, 20% of global consumption), located in a region that is chronically unstable and threatened by growing regional and global tension;

- Malacca: 2nd largest transportation passage for oil in the world (15.7 million barrels/day), at the core of strategic concerns for China (the world's largest energy consumer), and situated in an increasingly militarised zone, that is also subject to infringements on the freedom to navigate;

- Bab-el-Mandeb / Suez Canal: considered respectively as the third and fourth largest transfer points in oil transport (5.5 and 4.6 million barrels/day), threatened by piracy, terrorism, or armed conflict (Yemen);

- Mozambique Channel: major maritime transport route for goods (700 million tonnes/year, 30% of global production), oil and gas discoveries offshore have increased its strategic importance.

In an economic context that is favourable to exploiting resources that are difficult and costly to access (unconventional, offshore), the recent discovery of zones that are rich in hydrocarbons (western Mediterranean, Mozambique Channel, the Arctic) could, over the longer term, significantly modify the supply allocations and zones of production and transit to be secured.

6 Europe is the largest importer of oil before China and the United States, at more than 13 million barrels/day. Its largest suppliers, Russia and all of the former USSR (more than 40% of the oil for the EU), Algeria or Angola (more than 10% of the EU oil supply) could see their production fall in the years to come.

1.1.3 Energy transition and new instances of strategic dependence

Faced with the effects of climate change (extreme climate events, ecosystem vulnerability, displacement of populations, etc.), political authorities, pushed by civil society, seek to promote sources of energy that emit fewer greenhouse gases and that are renewable. The diversification of the global energy mix is characterised by the rise in renewable energy sources (EnRs), and strong growth in demand for electricity driven by the electrification of ways of living: transportation, digital tools, communication, etc. According to ADEME, in 2018, the Internet represented the third largest consumer of electricity, behind China and the United States.

Energy transition and digital transformation are speeding up the displacement of instants of dependence to new energy sources (renewables) and storage (batteries). They create new tension for other types of resources (rare earth metals[7], lithium, cobalt, etc.), indispensable for building low-carbon technology and digital equipment (batteries, solar panels, wind turbines and digital objects, etc.) The quasi-monopoly that China has on the global reserves of rare earth metals, their refining, and the production of components puts the EU and the rest of the world in a position of significant dependence on China.

As a vector of dependence and an issue of sovereignty, access to strategic ores[8] is indispensable for industrial activities both in the energy sector and the defence sector. The increase in the needs of the defence industry for critical ores brings up the question of availability and securing their sources.

Securing supply can be composed of several distinct elements: diversification of supply or developing inventories for some of these materials.

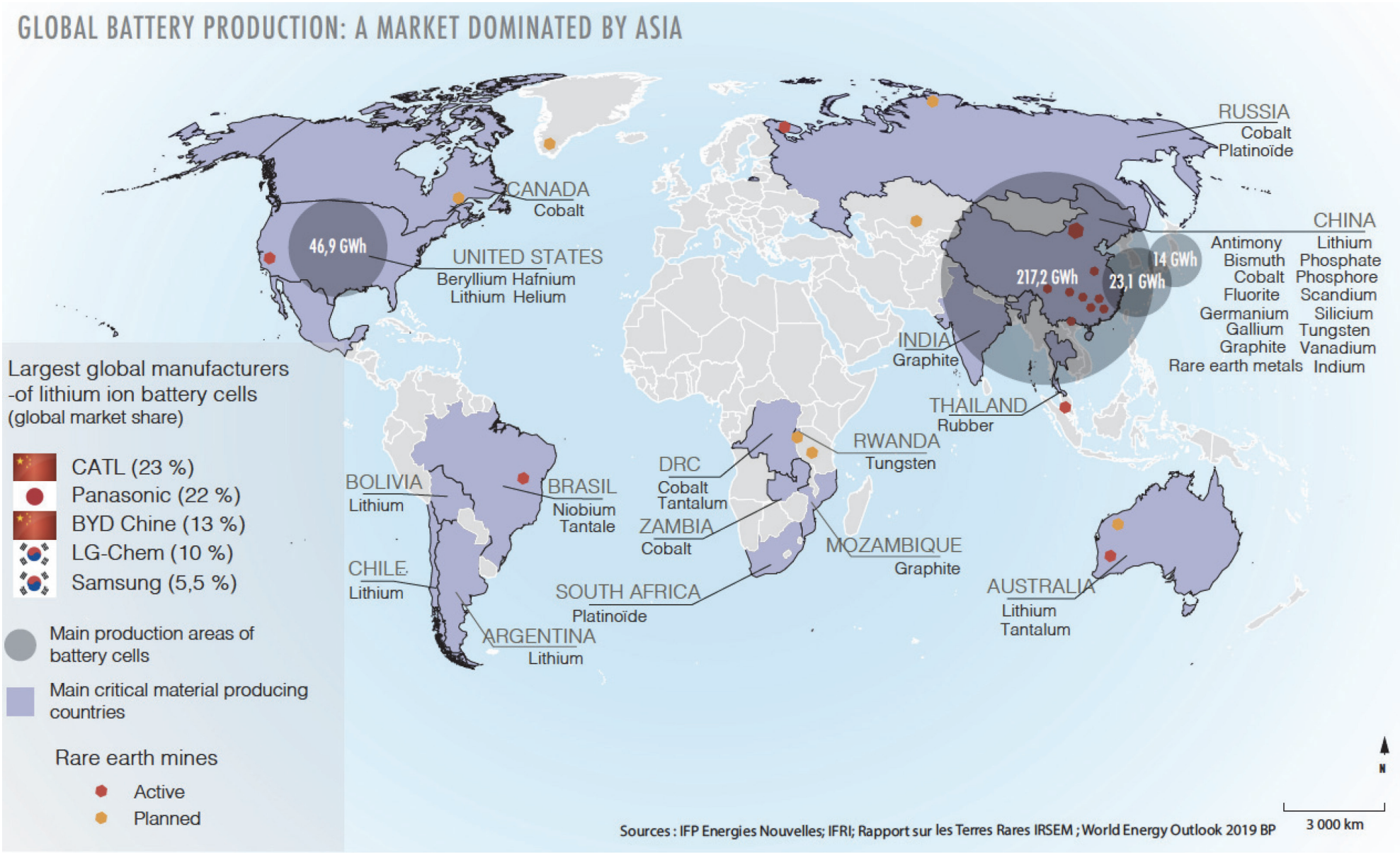
In combination with the substitution or reduction of quantities of metals used, recycling these metals could constitute a complementary method for reducing vulnerabilities based on securing supply. The streams and sources of waste of the defence sector could contribute to targeted industrial recycling sectors (batteries, permanent magnets, electronic equipment, networks, etc.) and therefore constitute opportunities in terms of the securing of related supply (rare earth metals, tantalum, copper, etc.) but also of recycling other resources in the territory (tungsten, lithium, etc.).

R1 - Map the sources and sectors in the strategic ores sector for January 2021.

7 The term «rare earth metals» is a collective name given to a group of 15 to 17 metallic elements that are on Mendeleev's periodic table. These chemical elements are not in reality rarer, in the sense that they are rather abundant in the Earth's crust, but their significant dispersion in ores makes extracting and separating them difficult and costly.

8 For the defence industry, about thirty metals and rare earth metals have «strategic» or «critical» importance. The notion of criticality is linked to the amount of a metal in the production chain, its level of rarity, and its geographical location. Considering these different criteria, its strategic dimension is variable over time, according to technical applications for which it is used, the changes in supply, and the geopolitical tensions that producing countries may occasionally encounter.

GLOBAL BATTERY PRODUCTION: A MARKET DOMINATED BY ASIA



Sources : IFP Energies Nouvelles; IFRI; Rapport sur les Terres Rares IRSEM ; World Energy Outlook 2019 BP

1.2 Promote a strategic approach to energy security on the European scale

1.2.1 Towards strengthening European interdependence

Energy supply for France is currently part of a European framework, both from a normative standpoint and a hardware standpoint. The interconnection of the energy transmission networks causes sector interdependence that is a vector of solidarity and resiliency, but also of vulnerability. Since the 1990s, European Member States and the European Union share the power of determining energy policy, and in that framework energy has been the subject of European integration policies that concern standards, networks, and markets. Since the 2000s, transition policies linked to environmental targets round out this system. They aim to achieve the three objectives of the EU: securing supply, competitive markets, and sustainability.

Like all other Member States of the EU, France has progressively deregulated the hydrocarbons market since the 1980s. The European deregulation policy separated production, transportation, and distribution activities, which were historically integrated in France. Excluding a capacity to mobilise strategic oil stocks (90 days of consumption in case of a crisis situation) and gas stocks (regulated by the French commission on the regulation of energy (*Commission de Régulation de l'Energie, CRE*) in case of a crisis situation, France and the EU rely on the global market to ensure their supply. Concerning technical aspects, common European norms, developed by network administrators9, aim to construct cooperation mechanisms in case of a crisis situation, and to establish a common vision of the integrated European networks. The policy choices of the other European Member States10, particularly those on the borders of the European Union, therefore impact the French systems, whether it be in terms of the price of energy or seasonal balancing.

In the electricity sector, interdependence is growing. The EU has the goal of developing a large integrated European network, allowing each Member State to exchange 15% of its national electricity production with its neighbours; this is done in order to generate economies of scale, to allow competition between energy sources, and to regulate the use of electricity from renewable sources, which have very variable volumes.

1.2.2. France facing the challenges of energy security

Changes in the French energy mix

The portion of new renewable energy sources (EnRs) must be increased to 33% of the French energy mix by 2030[11] (Act 2019-1147 of 8 November 2019 relating to energy and the climate, and the update of the multiannual energy policy[12]). However, even if we see a downturn in the proportion of carbon-based energy sources, particularly oil products, these will continue to occupy a significant place in the French energy mix.

By 2040, electricity will represent almost 40% of the end-user energy demand in France, compared to 25% today. The period from 2020-2025 therefore constitutes a key period for the French electrical system, which has seen a strong diversification of its primary energy mix: acceleration of development of renewable energy sources, closure of 5 gigawatts of electric production capacity[13], delays in the commissioning of the EPR reactor at Flamanville, and lastly the ten-year review programme of French nuclear facilities (58 reactors commissioned between 1977 and 1992). The development of EnRs would likely be insufficient to compensate for expected decreases in capacity[14], thus accentuating the vulnerabilities of the national electric network, to which the defence infrastructure is attached.

9 Under control of the European regulatory authority (ACER) and the Commission.

10 Germany's nuclear energy phase-out, Brexit, Polish desire for energy independence relating to Russia.

11 Fossil fuel-based energies represent 70% of the French energy mix in 2020 (45% oil, 20% gas, and 2.5% coal). As for electricity, it represents 24.3% of end-user consumption, 71% of which comes from nuclear sources, 17.9% from renewable energy sources (hydroelectric: 10%, wind: 4.4%, and solar: 1.7%), and 11.2% from fossil fuel-based thermal power stations.

12 Decree 2020-456 of 21 April 2020 relating to the multiannual energy programme.

13 1.8 GW of nuclear power with the closure of the Fessenheim plant, and 3 GW for the coal-fired power plants in Saint Avold, Gardanne, Le Havre and Cordemais.

14 Source RTE 2019.

In terms of energy infrastructure security, outside of problems of obsolescence, refineries, storage infrastructure, oil and gas terminals, thermal and nuclear power plants, as well as electricity networks are subject to many physical risks. Threats that would seem anecdotal a few years ago have now become major strategic issues, such as terrorism or cyberattacks. Other threats that are beginning to appear today could follow the same path, such as massive and coordinated drone attacks. Despite their current speculative aspect in Europe, they should be observed and taken into account in current discussions, particularly since they have already occurred at large enough scales that they should no longer be considered a possible threat (attack on the Aramco site in Saudi Arabia on 14 September 2019).

Diversified energy supplies

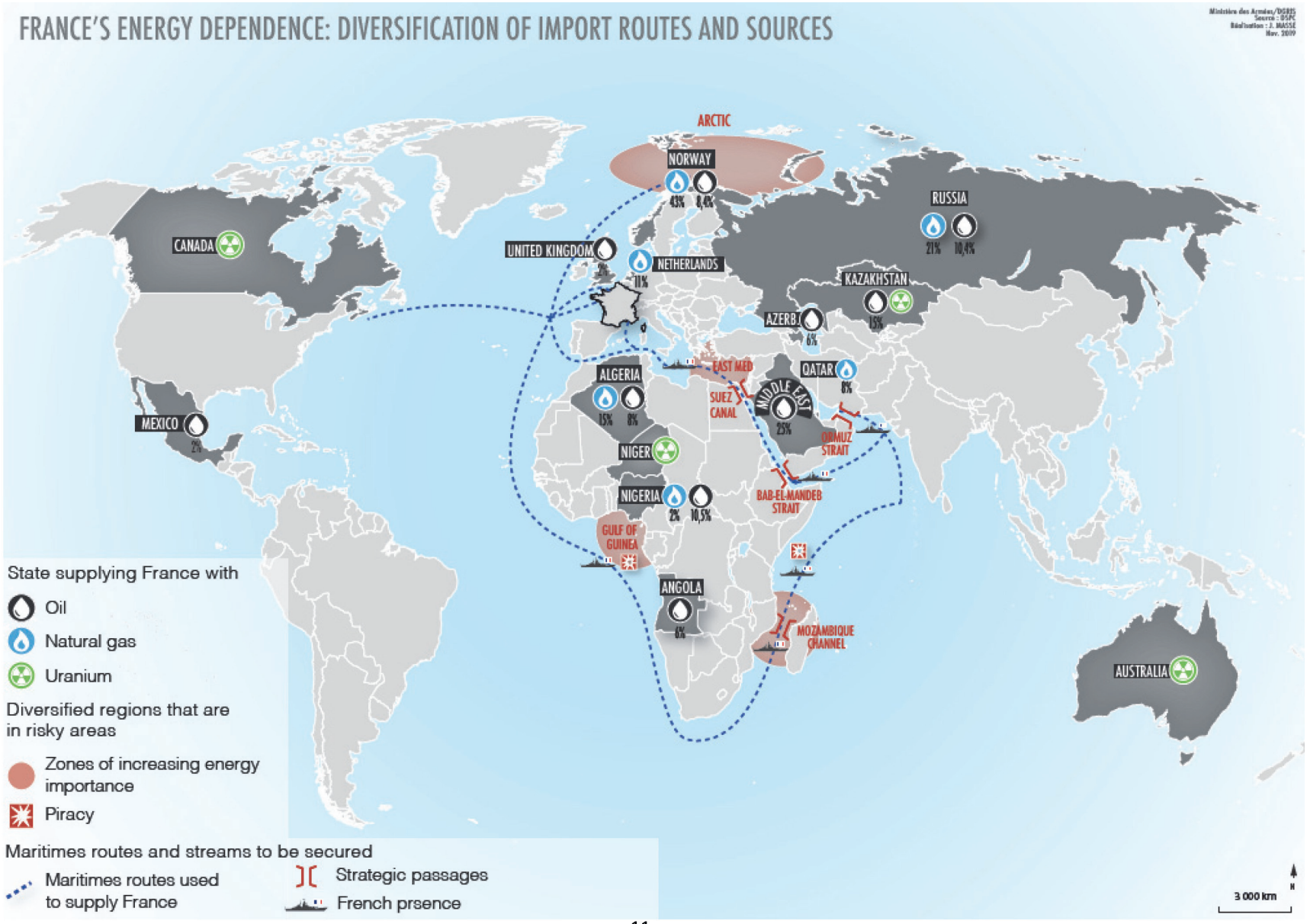
France imports most of its oil by sea, and has seven refineries spread out over the continental territory, and one refinery in the French West Indies. None of its suppliers provide more than 15% of the goods consumed. However, the French refining capacity only covered 70% of national needs in 2017 (compared to 93% in 2008), with a particular shortfall in the diesel fuel and jet fuel sectors.

In the gas sector, interdependence with the rest of the EU is strong. France imports around 40% of its gas from Norway, 20% from Russia, and the rest comes from Northern Africa and the Persian Gulf. However, even if it is sometimes impacted by tension between suppliers and transit countries (Russia-Ukraine conflict), France has a degree of resilience when faced with crises[15]. It has a large storage capacity (26% of its annual consumption), it has benefited from the reform of gas storage carried out in 2018 that encourages suppliers to purchase these capacities, and it maintains significant maritime LNG import capacities (from Qatar, Russia, or the United States).

As for nuclear fuel, France consumes almost 9,000 tonnes of uranium from Kazakhstan, Australia, Niger, and Canada to fuel its 58 reactors.

The significant dependence of France and the EU on non-European third parties for the supply of energy or materials necessary for the production of energy must be minimised in that it constitutes a source of vulnerability for their energy security, their sovereignty, and their autonomy of action and of decision. France and Europe must therefore implement or consolidate diversification strategies that are supported and proactive.

15 France has a large underground storage capacity. Combined with importing LNG, these capacities help to face the winter peak in usage.


FRANCE'S ENERGY DEPENDENCE: DIVERSIFICATION OF IMPORT ROUTES AND SOURCES
ARCTIC
NORWAY
43% 8,4%
RUSSIA
21% 10,4%
CANADA
UNITED KINGDOM
2%
NETHERLANDS
11%
KAZAKHSTAN
15%
AZERBJ.
6%
EAST MED
SUEZ CANAL
QATAR
8%
ALGERIA
15% 8%
MIDDLE EAST
25%
ORMUZ STRAIT
MEXICO
2%
NIGER
NIGERIA
2% 10,5%
BAB-EL-MANDEB STRAIT
GULF OF GUINEA
ANGOLA
6%
MOZAMBIQUE CHANNEL
AUSTRALIA
State supplying France with
Oil
Natural gas
Uranium
Diversified regions that are in risky areas
Zones of increasing energy importance
Piracy
Maritimes routes and streams to be secured
Maritimes routes used to supply France
Strategic passages
French prsence
3 000 km

1.2.3 The role of the armed forces in securing energy streams

Securing energy streams and maritime routes, as well as critical energy infrastructure (oil terminals, power plants, etc.) is the subject of constant review by the armed forces. As such, through the missions they carry out as constant positions of backup and safety, the armed forces contribute to the reduction of risks and threats.

The multiple challenges and the immensity of the zones to cover involve complementarity of resources: intelligence, surveillance (vessels, satellites, radars, aircraft, drones), and knowledge of global traffic and operations. The presence of sovereignty forces (Djibouti, Abu Dhabi, Côte d'Ivoire, Gabon) and forces of presence overseas participate in the prevention of crises or malevolent actions in production zones or involving supply streams. In addition to points of support, the deployment of permanent or circumstantial military resources (Agénor, Pégase) contribute to ensuring the security of energy supplies:

the permanent presence of a frigate in the Indian Ocean and in the Mediterranean, regularly reinforced by other deployments (naval air group, maritime air patrol, mine warfare group, etc.) is part of other actions in this framework of securing streams;

- the permanent presence of amphibious helicopter carrier-type vessels (Corymbe mission) and a maritime surveillance aircraft in the Gulf of Guinea supports a proactive policy of cooperating with neighbouring navies, relying on the Yaoundé process;

- the permanent presence of ground forces on the Scattered Islands in the Mozambique Channel (Europa and Juan de Nova);

- the implementation of the European maritime surveillance mission in the Strait of Hormuz (Agénor), while not having a priority of responding to the objective of securing energy streams, contributes to the creation of a navigational environment that is safer;

- the demonstration by the French air force of the rapid projection capacity of a large air force system (Pégase mission), demonstrating our strength (several fighter planes refuelled, projected into the South Pacific), also show the capacity of the armed forces to produce this effect of prevention, in order to protect zones and streams.

These installations and deployments are rounded out with partnerships with actors in the private sector, following the example of the implementation of a voluntary naval cooperation structure steered by the MICA Center[16], carried out under agreements between the French Navy and French shipowners for situation reports and exchange of security information in certain risky zones.

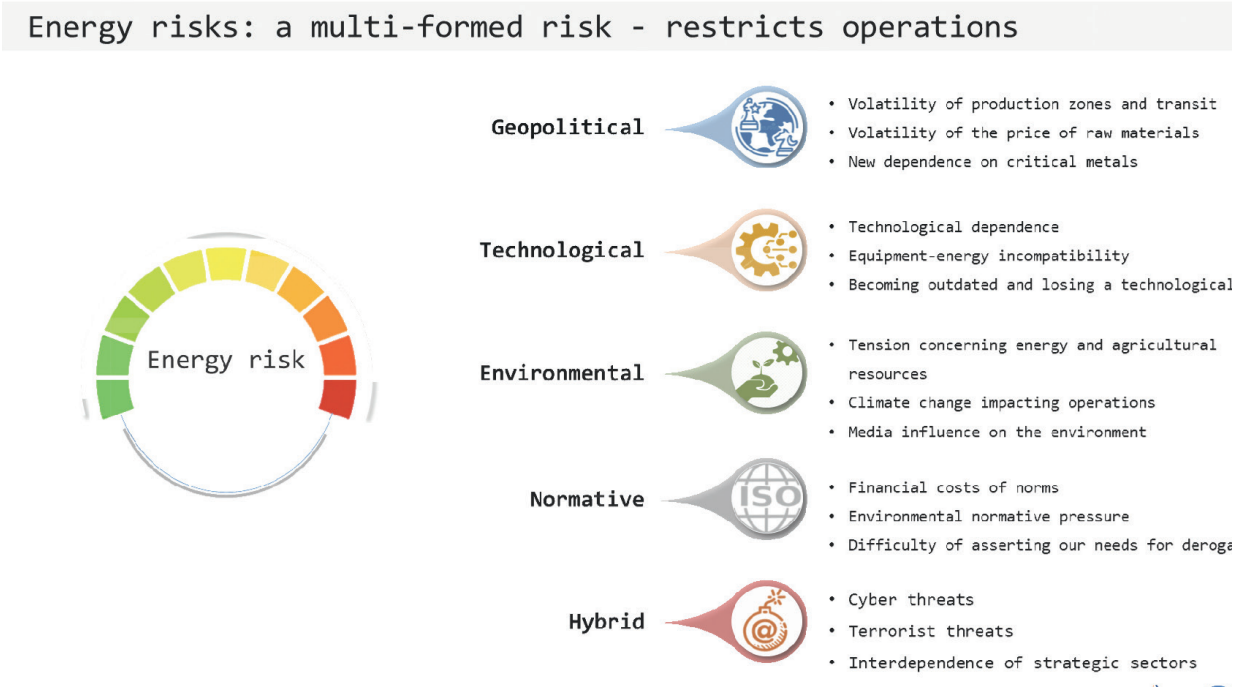
Lastly, in case of a crisis, the armed forces can participate in the evacuation of expatriate employees of French energy companies that are present in sensitive regions of the world.

R2 – In order to secure streams, analyse geostrategic changes and their impact on the energy sector and adapt the system accordingly.

16 Maritime information, cooperation and awareness

2. The Ministry for the Armed Forces facing the challenges of energy transition

The international awareness of the risks linked to climate change caused an irreversible change in mentalities and ways of consuming. The energy transition, accompanied by a digital revolution, and the civil technological innovations that it is causing, obliges changes in the defence sector, and is causing changes in both equipment and in methods of military action. These changes in society, technology and regulations push the armed forces to change mentalities and begin a process of streamlining energy resources. The challenges that the armed forces have to face are numerous and cross-cutting. They simultaneously concern regulations, technology, logistics, and behaviour, and they require an effort of forethought in order to face new threats (linked to climate, cyberattacks, and the strategic context of data).



2.1. Identify the specificities of defence in a context of strengthening of the European and national normative framework

To anticipate the changes in the national and European normative context concerning the environment, the Ministry for the Armed Forces must characterise its specificities to support its operational performance and its resilience. In particular, it will need to make sure that technology used to meet these needs remains accessible and does not, over time, lead to society calling into question the acceptability of the missions of the armed forces.

2.1.1. The fight against climate change, an engine of normative change

France and the EU are signing parties of the Paris Agreement on climate change (2015) which sets a goal of reducing emissions of GHGs by at least 40% by 2030 for the EU (compared to 1990 levels). The energy and climate law[17] transposes these provisions into French law. Specifically, it aims to reduce end-user energy consumption by 7% in 2023, 20% in 2030, and 50% in 2050, compared to 2012, to increase the portion of renewable energy sources to 33% of the energy mix by 2030, to lower the consumption of fossil fuel-based energy by 40% by 2030, and to renovate facilities. The limitation of emissions of GHGs impacts sectors that include construction, transportation, waste management, and energy production.

17 Act No. 2019-1147 of 8 November 2019

In December 2019, the European Council approved the goal of carbon neutrality by 2050, presented by the Commission in its release on the *"European Green Deal"*18. It foresees including environmental and climate objectives in all sector policies of the EU. The support measures dedicated to financing this objective should represent a non-negligible portion of the multiannual financial framework (2021-2027), for which negotiations are in progress. The current Covid-19 public health crisis could however cause some of these objectives to be revised.

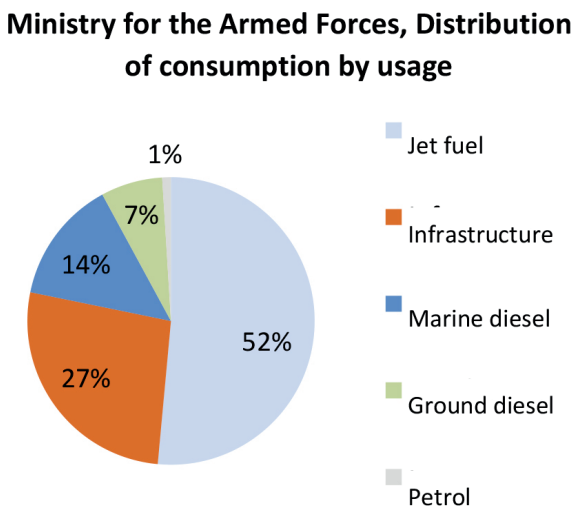
The application of the Green Deal in most of the European policies, as well as the revision of the March 2020 national low-carbon strategy (*Stratégie Nationale Bas Carbone*), published in April, will partially apply to the Ministry for the Armed Forces. It reinforces the scope of the sector19 covered by the emissions quota exchange system, as well as the quantified targets for reduction of GHG emissions, introduces regulations into new sectors such as the production of batteries20 and will have an impact in terms of energy and tax costs.

This normative framework could concern certain activities of the Ministry for the Armed Forces, in the infrastructure and equipment sectors, and even in its operations. However, when they are properly justified, the Ministry is able to obtain exemptions or derogations from ordinary law. It seems necessary to adapt, when possible, to national, European, and international norms. An incompatibility with certain defence practices and norms of ordinary law can arise: the EURO 6 European standard for fuels is, for example, incompatible with performance and indispensable operational use of ground equipment, restrictions for access to certain maritime areas (Emission Control Areas, or ECAs) or certain ports could also be imposed on certain vessels of the French navy; reducing carbon in fuels could become, over time, impossible for certain military equipment that has a useful life that is longer than that of civil equipment.

2.1.2. To be sure that the European legislator takes into account defence issues

In cases where European rules concerning energy, the environment, or the digital domain are applied unequivocally and in an undifferentiated manner, this could present a risk for the security of supply, of infrastructure, of military equipment and of operational commitments. It would be preferable to keep a watch on maintaining existing exemptions and derogations[21] in place for the armed forces.

To better look after its interests and demonstrate the unique nature of its missions, the Ministry must carry out significant work to support institutional actors, inter-ministerial work, as well as work with European authorities. Maintaining a legal watch is indispensable to allow the Ministry for the Armed Forces to intervene sufficiently beforehand to guide the content of a normative text that is being drafted. This monitoring work is active by necessity, and it must allow for carrying out lobbying missions that are targeted and regular with the actors that are tasked with designing normative texts that may concern the Ministry for the Armed Forces.



The challenge for the Ministry for the Armed Forces is to evaluate the potential impact of new environmental regulations that are adopted, through regular exchanges with its legal affairs department and its network of experts in the different general staff, departments

18 Decision of the European Council of 12 and 13 December 2019.

19 Maritime, road transport, and construction sectors.

20 Only battery recycling is subject to a European directive (Directive No. 2006/66/EC). The design of batteries, however, is not yet covered by European normative provisions.

21 It should be noted here the distinction between an exemption, from the scope of application of a text or one of its chapters, which does not have a legal effect on the activities of the armed forces as a whole, and that of a derogation, which allows the non-application of one or several articles, under certain conditions.

and services in the various areas (carrying out operations, equipment, fuel, assets, infrastructure). Prior to texts being negotiated, this means determining on a case-by-case basis if, given their operational imperatives, the armed forces will be able to apply the proposed provisions. The Ministry should also rely on industrial actors in the defence sector to research technologies, products and substitution formulas that are necessary over the short- and medium-term.

The network of directors of legal affairs of the European defence ministries could itself propose new legislative initiatives that would constitute the "European Green Deal" and imagine common actions to recall the military interests and challenges.

As well, DEFNET (Defence Network), composed of expert legal scholars and armament engineers from the European ministries of defence, can be a space for exchange and lobbying on the European normative process. It consists of almost all of the Member States of the European Union, as well as the United Kingdom and the United States, and provides a forum for exchange on European norms related to defence, the environment, and energy. DEFNET is also a stakeholder in the European conference on defence and the environment, an event that is organised every two years, attended by European experts on questions related to defence and the environment. The department of legal affairs will organise this technical conference in Paris in the spring of 2021 to better communicate on the challenges faced by the armed forces related to European environmental law, and to identify new points of influence.

R3 - Ensure normative and regulatory monitoring within the Ministry to identify texts that need to be modified for the needs of defence-related activities.

2.2. Control energy consumption

The consumption of energy by the armed forces has only increased since the advent of modern warfare, and forecasts confirm that this trend will continue. The arrival of new, energy-intensive systems translates into an increase in needs for fuel for ground equipment (about 30%) and increasing dependence on electricity (Scorpion, A 400M and Rafale). Energy needs are a source of financial and logistical expense, both in training and in operations, and the energy dependence associated with the supply lines generates risks.

2.2.1. Breakdown of consumption for the Ministry for the Armed Forces

For 2019, the Ministry for the Armed Forces consumed 835,000 m3 of oil products, for a financial cost of €667 million, and more than 2.6 TWh of energy was delivered to defence infrastructure for a cost of €222 million. In the construction sector, annual emissions of GHGs amount to 455,000 tonnes of CO2 eq, or 0.5% of national emissions.

The portion used for mobile energy required for operations is significant, at nearly 73% of the Ministry's consumption, compared to 27% for the energy necessary for infrastructure. Concerning mobility, the main fuel used is jet fuel for aviation use. Aviation use represents half of the consumption of fuel, and marine use represents almost a quarter, compared to a fifth for ground use. The portion of the Ministry for the Armed Forces' use of oil products at the national scale is 0.8%, 0.2% of which is for ground vehicle use, 5% for diesel fuel for marine navigation, and 7% for jet fuel.

Excluding fuels, the energy mix consumed by infrastructure of the Ministry is mainly composed of electricity (44%) and gas (41%), the remaining 15% being distributed between fuel oil (6%), heat from urban heating networks (RCUs), 4% from other energy sources such as coal, thermal solar or biomass. The predominance of electricity for infrastructure should further increase, with computerisation that is ever more energy-intensive (servers to host data), the development of simulation, and new usages such as electromobility.

We nevertheless note that the total consumption of the Ministry's facilities has decreased by more than 20% since 2010, arriving at 2.6 TWh of end-user energy. At the same time, the consumption of fossil fuel-based energy and the associated GHG emissions were reduced by almost 30%. To reach the goal of carbon neutrality by 2050, all of the new infrastructure operations are now designed according to their performance and to energy transition.

Within the Ministry, energy is delivered and managed by two main operators: the Petrol, Oil and Lubricant Services (SEA) for mobile energy (fuels for transport and for electricity production for emergencies or for operations) and the Defence Infrastructure Service (SID) for energy for infrastructure.

2.2.2. Measure, know, and optimise consumption

Elaboration of an energy policy is based on a prior knowledge of consumption in order to set goals for progress in terms of energy efficiency, both for systems and for facilities and mobility. The indispensable control of energy passes through several successive and complementary stages: the precise measurement of consumption by usage, their analysis, and the implementation of an improvement and optimisation strategy for energy performance.

The emergence of digital technology gives a glimpse of new perspectives of optimisation of energy use. Sensors and algorithmic analysis allow for close monitoring and precise management, while modelling and using energy data offer the opportunity for predictive analysis, and thus energy optimisation. The Ministry for the Armed Forces must be able to evaluate its future energy needs in order to better anticipate them.

Controlling energy streams through active building management[22]

Since 2019, within the Labo-BI of the steering support mission (MAP), the Ministry has been developing analytical and forecasting tools by processing big data.

In the field of managing data related to energy, the purchasing mission (Directorate of Financial Affairs, DAF) and the energy purchasers (SID) launched DataNRJ360 in order to streamline and improve purchasing of electricity and gas, by modelling acquisition clusters, or by simulating penalties according to problem scenarios.

By the end of the year 2023, an updated DataNRJ360 tool with extended functions will replace the water and fluids module (Eau&Fluides) of the SID's technical management tool. It will offer optimised management and adapted communication for user training and command.

This means developing collection of data, and making all data available (data from counter sensors, sensors for confirmed presence and forecast presence, but also climate data, data on energy efficiency of works, etc.) in order to implement cross-sectional analysis and to have alert systems.

R4 – Before the end of 2021, deploy a measurement and analysis tool for consumption of energy streams in order to optimise them for all of the Ministry's facilities.

Implement a policy of digital sobriety[23]

Digital sobriety is an element that is simultaneously a cross-cutting element and a structural element of the information system of the French State and the armed forces. This work is central to the current context of seeking a form of autonomy, strengthened ethics, and respect for the environment in the digital domain. As is the case for the French State as a whole, the Ministry for the Armed Forces is committed to carrying out a study on the subject in order to be able to encourage good practices. Integrating the ecological element to the process of digital transformation of the Ministry for the Armed Forces, as well as to the existing information systems and digital systems, takes priority through approaches used for equipment, approaches used for digital services, and the creation and update of indicators to measure the impacts and progress.

In ecological terms, measures, even very small ones, have tangible impact on the cost of data centres, their energy consumption, and the energy and environmental footprint of the Ministry in general. Priority attention must be given to the data centres. Then the sharing of data centres between the branches of the armed forces, departments, and services, rounded out by the use of private/sovereign Cloud services (type C2) must be given particular attention, in order to find the right balance between cost optimisation and the risks linked to a co-localisation in case of a problem or if any incidents occur.

22 See Appendix 6 - Towards low-carbon facilities by 2025

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The most well-known environmental corollary concerning data centres is consumption of electricity. The latter is linked to the energy consumed by servers, but also by the various cooling and ventilation systems. Since this situation has been noted for several years, many suppliers look for ways to recycle or transform the heat created by server rooms. The overall idea is to be able to limit the ecological impacts in such a way that the data centres are not destined to downsize from a digital standpoint, but very much the opposite. The problem related to data centres concerns both the initial sorting of data – meaning what data must be stored or destroyed, and where it should be hosted – and the ecodesign of the data centre itself.

Even though the Cloud has long been considered a major source of pollution due to the energy used by data centres, less energy-intensive solutions are now emerging. Several providers offer Cloud and hosting solutions that have smaller ecological footprints. As part of the Cloud strategy of the Ministry for the Armed Forces, ecodesign clauses will be proposed concerning the choice of data centres.

R5 - Starting in 2020, define and implement a digital sobriety policy:

1. Monitor the consideration of the environmental footprint in the choice of internal and external hosting solutions for the Ministry for the Armed Forces;
2. Future data centre renovations or constructions will be carried out integrating the systematic recuperation of the heat emitted by the equipment;
3. Foster ecological information system development, both internally and externally, by favouring the ecodesign of software, and by introducing this criterion into contracts in order to influence construction companies and publishers;
4. Integrate the GreenTech dimension into the training offer of the digital academy (Académie du numérique) and promote this dimension within the Ministry.

Control the energy review of systems

In all areas, electrical consumption of armaments is constantly growing: increased mobility, electrification and automation of equipment, management and control of systems, surveillance of the environment, better performing information and communication systems, better performing weapons and sensors, without forgetting the climate control necessary for systems that are increasingly automated, including storage units to collect, store, and exploit data. Combatants themselves can now be equipped with more and more energy-dense equipment (FELIN (*Fantassin à Équipement et Liaisons Intégrés*, Integrated Infantryman Equipment and Communications) equipment: night vision glasses, FELIN batteries, etc.) to see, shoot, and communicate more effectively. The coming wider application of drones and other robots in theatres of operation will increase energy needs further.

Modern armed forces now face a contraction of their manpower. As well, they are resolutely committed to large-scale digitalisation: robots, ground/naval/airborne drones. By supporting the combatant in the theatres of operation, the robots will also revolutionise logistics by having a larger destabilising impact on the types of needs in terms of supply.

In order to control the overall energy use of the current and future systems, and to verify the achievement and maintenance of the objectives that are set, the specifications of energy needs of the platforms and equipment need to be adapted to the changes taking place now. The studies planned in the short term, such as the GENOPTAIRE defence technologies project, should allow for the characterisation of energy efficiency indicators specific to the domain of defence, and to define the data to collect in consideration of the specificities of the military missions. The development of smart grid-type steering systems or steering support systems will also help to optimise the use and storage of electricity, to better manage the electric network of the platforms, and to reduce the consumption of primary energy.

R6 - Launch the GENOPTAIRE study at the end of 2020 in order to adapt energy optimisation methodologies to military specificities with integration into the programmes for the three areas starting in 2022.

Use simulation to a greater degree as a complement to training forces

Even if it does not replace the indispensable activity of training combatants in real-world conditions, simulation of training in virtual environments or in augmented reality rounds out operational preparation of forces in all areas. The use of shooting, driving, flight and combat systems operation simulators is widespread and allows, in terms of a favourable energy balance sheet, to increase the quality of training in order to maintain the required level of performance.

Innovative solutions (embedded or distributed simulation) that are currently being implemented within the armed forces at least partially respond, and as a complement to real-world exercises, to the need for training, including in the context of collaborative combat, which tends to make operational situations more complex (increase in air traffic, increase in combat vectors, in type and volume, increasing complexity of operational environments). As such, from the outset, the SCORPION programme takes into consideration an operational preparedness system (*system de préparation opérationnelle, SPO*) based on embedded simulation. The tactical trainers, with lower performance than certified simulation systems, help strengthen (depending on their level of reality) the capacity of forces in terms of doctrinal learning and collective training.

It will nevertheless be essential to preserve the energy resources necessary to train operators (maintaining activity at standards level in terms of flight hours, for example), all the while increasing the quality of training, to allow combatants to reach and maintain a certain level of required performance. Effective, high-performance measures should be put in place, and plans should be made, for example, to implement tools that simulate the implementation of autonomous and remotely guided systems in order to carry out training of human operators (for example, the Companion Trainer concept, a training aircraft that simulates all surrounding non-piloted vectors and opposing forces).

R7 - Increase the portion of virtual simulation in training, as a complement to real-world activity, to optimise the use of energy resources and increase the level of realism, all while maintaining the level of operational performance.

2.3. New types of risks to take into account

Climate change is considered as something that multiplies threats. It impacts all sectors and human activities. To fight against the worsening of climate phenomena, development of low-carbon technologies favours the use of digital technology, creating new types of risks (cyberattacks, data capture). The vulnerability of the energy sectors, in particular the electric sector, to these new risks and threats needs to be taken into consideration by the Ministry for the Armed Forces.

2.3.1. Preparing for the impacts of climate change on the armed forces' needs and energy systems

The increase in the intensity and the simultaneous nature of extreme climate events creates tension linked to access to natural resources, generating geopolitical instability, and amplifying the seriousness of humanitarian crises and climate migration. We are witnessing a growing mobilisation of military forces to support civil security forces in continental France and in the French overseas territories, for example, the operation carried out in the French West Indies following hurricane Irma.

As aggravating factors, changes in climate increase the vulnerability of infrastructure: military ports and their installations, air bases, civil airport platforms used by the armed forces, military camps, sensitive/critical installations such as munitions or fuel depots, etc. The usual areas of intervention or the support points can be found in areas subject to climate change. This means re-evaluating the resilience of all support points and reviewing the specifications of certain equipment.

The increase in temperatures and the disturbances it causes weigh on both operational activities and energy consumption (increasing need for controlling temperature for equipment and for personnel). As an example, the source of cool air for vessels of the French navy is sea water: its increase in temperature diminishes the performance of the heat exchangers and leads to a deterioration in the performance of climate control or refrigeration equipment. Defence activities must necessarily integrate the impacts of climate change.

2.3.2. Evaluate cyber risks and protect against them

The energy sector, both for infrastructure and for logistics and telecommunications, currently constitutes a target of choice for cyberattacks, in order to sabotage or to collect information, with attackers seeking targets in both the military and civil sectors. For example, Ukraine is subject to regular attacks seeking to sabotage (critical infrastructure targeted by malware that caused a blackout in Kiev in 2016), and the logistics chain of fuel for the French navy was targeted in 2017. Infrastructure and equipment implemented or managed within the Ministry are now at the heart of this targeting.

The optimised management of infrastructure energy exposes it to cyberthreats by virtue of its digitalisation, carried out in particular through the spread of the remote measurement, supervision, and equipment steering capacities. Its increasing dependence on the internet and global positioning navigation systems such as GPS or Galileo, the interconnection of the Ministry's information system networks and the increase in exchanges of data make defending the energy function in cyberspace more complex. Tracking and steering systems for energy streams require strengthened technical and cyber architectures, and maintenance of secure conditions and of functional capacity in a degraded state.

The chain of cyber defence regularly participates in exercises on this topic, with partners or via the NATO Cooperative Cyber Defence Centre of Excellence in Tallinn, Estonia. The scenario of the "Lockedshield 2018" exercise targeted fuel reserves in order to cause environmental damage.

Moreover, steering of these infrastructure information systems (*systèmes informatiques d'infrastructure, S2I*) must be integrated into the governance of all of the information systems, as is the case with SIOC, SIAG, and SIST24. Energy installations must be handled at the same level as other systems of the Ministry, particularly weapons systems, for which they provide indispensable services. Compliance with the rules issued by the ANSSI and the qualification of the systems is an indispensable line of defence for these energy installations.

R8 - Continue cybersecurity actions within the Ministry for the Armed Forces for digital systems directly linked to energy:

Mapping, application of information system hygiene rules, and maintenance of the implementation of security supervision for the most critical elements;
Accelerate the cybersecurity approach in the energy digitalisation projects (smart grid, etc.).

2.3.3. Take the strategic dimension of energy data into consideration

Balancing of energy networks by administrators, purchasing by suppliers and the improvement of energy performance are founded on the collection of measurement data on a grand scale. Yet, their exploitation by an adversary could lead to a reconstitution, or even the anticipation of the activity of armed forces. The data could be used for advanced analysis with a view to malevolent acts or obtaining information. These effects are accentuated by the spread of access to energy data on shared databases.

In terms of capacity, the development of optimised energy management systems and energy steering systems, and the spread of objects with sensors, processing systems and connected effectors bring up the issue of storage and processing of data. This data is part of our assets, and its value and associated risks

24 SIOC: (systèmes d'information opérationnels et de communication) - information systems for operations and communication; SIST: (systèmes d'information scientifiques et techniques) - scientific and technical information systems; SIAG: (systèmes d'information, d'administration et de gestion) - information, administration, and management systems.

should be assessed. The growing amount of data generated by military systems involves significant effort concerning energy efficiency of these new energy-intensive systems, but also concerning the cybersecurity of platforms and protection of communication protocols. The issue therefore lies in the control of data and its value chain – some elements of which come from the civil sector[25].

R9 - Implement an energy (NRJ) hackathon after summer vacation in 2020 in order to uncover any possibly undetected risks

3. Make energy an operational advantage

Concerning new energy issues and the arrival of new types of risks, the Ministry's ambition to equip itself with a defence energy strategy requires a renewed approach in the energy sector overall. This revolution must result in better individual and collective accounting for the new energy issues and energy usages, as well as an integrated energy approach in internal and operational activities. In particular this results in the adoption of the concept of operational energy, which designates energy as indispensable to the completion of operational contracts, and sets out a dedicated policy. The wider use of new energy technologies and disruptive fuels, both for mobility and for stationing, will provide for better operational performance, as well as increased energy resilience. By controlling and optimising consumption, the Ministry will reduce not only its energy and logistical footprint, but also its environmental footprint.

3.1. A renewed approach to energy issues

The old approach to energy was from the viewpoint of a logistical and technical contingency. However, it is now an element that is indispensable for operating the Ministry's systems, for its functioning, and for its bases of operation. This approach is now outdated, and requires a profound transformation that cannot be based solely on replacing old inefficient equipment with more efficient models, or reducing energy consumption. First and foremost, it requires a change in perception, a better grasp of consumption, and an overall energy policy applicable to the Ministry.

3.1.1. Change mentalities and reinforce skills

Having a global and optimised control of energy for mobility and stationing (whether permanent or on deployment) must be accompanied by a change in the mentalities of all of the end users of energy in operations, and making all actors accountable, whether or not they are specialists in the field.

The feedback of allied armed forces (United States and United Kingdom) shows that behavioural changes have a very significant effect on consumption[26]. Making personnel aware, managing consumption (gathering statistical data, analysis, and adaptation) and taking into account the energy dimension in operational decisions all constitute decisive areas of action to optimise the use of energy in mobility and stationing (whether permanent or on deployment).

Both on the national territory and in external operations, making progress in the energy transition indeed requires adapting to the relevant new technologies, but also entering into a culture of energy sobriety and "low-carbon" elements, by giving priority to new design and operation methods, and methods of use. It would include applying the ISO 50001 approach to operations, as it has been implemented in the Ministry's national facilities. This international standard defines a framework of requirements (setting targeted objectives in terms of energy efficiency, measurement of results) and ensuring their implementation by an energy management system.

For example, the officers in charge of energy in operations are only currently accountable for the functioning of stream logistics and inventory logistics. Yet, for the armed forces, seeking energy efficiency is both a means of reducing risk exposure, and of improving resiliency. Following the example of what was implemented by the SID on defence bases on national territory, the officers in charge of improving

25 Berthier, T., Mazzuchi, N., «Défense et changement climatique : quel modèle pour les armées de demain ?» , The Conversation, 15 December 2019.

26 ENSEC COE could carry out benchmarking of energy usages in the NATO armed forces.

energy efficiency could therefore be put in place in operations. The coordination of actors and efforts will contribute to the general adoption of ecoresponsible behaviour (sober behaviour and use, monitoring of excesses, etc.), and for determining and expressing energy needs. This therefore ensures the continuity of activity, and purchasing that guarantees energy supply over the long term, in terms of quantity, quality, and at a controlled cost.

High levels of skill are required for designing, managing, and implementing systems and technologies related to energy production and optimisation. A mapping of the skills that are indispensable to have or to acquire, whether internally or through partnership, remains to be established. The source of skills has to be maintained through an initial or continuous training effort, or using targeted recruitment.

In parallel, the accumulated feedback leads to planning for:

- either evaluating specialised skills that are indispensable to have or to acquire, whether internally or through partnership with energy providers and industrial actors, including in relation to maintenance of operating conditions and limiting the externalisation of certain tasks such as complex repair services on electrical plants;

- or to reconsider the concept of equipment with standard exchanges for repair behind the lines.

Reinforcing the source of experts is in progress. In order to steer and implement this renewed effort, more attractive professional pathways need to be defined, and they are a major issue for skills, autonomy, and success. This capacity is indispensable to ensure that the actors in the energy sector steer energy in a way that is firm and resolute, as well as ensuring that developments in the sector are integrated.

R10 - Favour evolution of mentalities and practices towards a culture of sober energy use that is in line with operational imperatives:

1. broaden the application of the ISO 50001 approach and encourage user adoption of ecoresponsible behaviour in their daily lives;
2. implement a training programme related to energy issues and usages, in the armed forces' schools, and in preliminary and continuous training centres.

R11 - Establish a mapping of specialised skills that are indispensable to have or to acquire, internally or through partnership, with energy producers and industrial actors.

3.1.2. Consider energy as a full-fledged capacity on its own

Up until recently, energy was essentially accounted for as a technical factor in operational performance (autonomy, reliability, etc.), in the definition of energy consumption by military equipment and systems, consistent with the single fuel policy in place within the NATO Member States. The changes in the global energy context are leading the Ministry for the Armed Forces to change this approach. This means reducing its dependence on oil products for mobility in its systems, and adapting to the energy transition by monitoring the changes of related regulations. Now it is indispensable to go beyond using solely the technical approach that has worked until now, in order to develop a truly capacity-related approach to energy27. From now on, the consideration of the role of energy in programmes will be carried out along six major themes:

- develop more prior to the inclusion of ecodesign28 and energy efficiency requirements, for each armament operation;

- audit industrial general contractors that have contracted with the Ministry for the Armed Forces, relating to their consideration of ecodesign and energy efficiency in their works and products;

27 The changes in constraints related to climate change on equipment and systems is taken into account, among other methods, in the EMA/COCA-DGA/SASD reinforced capacity approach.

28 "Ecodesign" means designing conforming to the principles of sustainable development and respecting the environment.

- analyse system life cycles and estimate their environmental impact in the different phases of an armament operation;
- measure energy consumption of systems both in operation/training as well as in stationing;
- take forecast energy consumption of systems into account in the programming approach (for example, in the functional analysis phase or in the contractual phase);
- take energy into account in capacity development from doctrine up to training and support, including organisation, implements and equipment.

This renovation of the energy perspective in armament programmes must be broadened to the defence industrial and technological base (BITD).

R12 - Make accounting for the "energy" portion systematic in the preparation and steering of armament operations and over the entire life cycle:

1. Broaden the inclusion of ecodesign and energy efficiency requirements to all armament operations, and make them a criterion of choice within the Ministry;
2. Audit industrial general contractors that have contracted with the Ministry for the Armed Forces, relating to their consideration of ecodesign and energy efficiency in their works and products;
3. Deploy the approach on new programmes, including the 4/6 tonne truck programme, and the *Patrouilleur Océanique* programme.
4. Integrate a theme linked to energy optimisation into cooperation programmes as started with our German partners on the NGF and the MGCS.

3.1.3. Define a global energy policy

In order to respond to environmental and economic issues, control identified risks and secure supplies for stationed forces, the Ministry first aimed to handle energy performance in its facilities, which constitute a source of environmental gains that can be acted on immediately. Even so, the implementation of a global policy takes place through the consideration of the issues linked to operational energy, indispensable for carrying out operational contracts. Operational energy is the energy that allows for the implementation of all of the means that meet the needs that support operational commitments. Achieving established military objectives and responding to tactical, operational, and strategic requirements are impacted by the availability and accessibility of operational energy.

Implement SMPE for infrastructure and non-operational mobility

The Ministry's strategy for energy performance (*Stratégie Ministérielle de Performance Énergétique, SMPE*)[29] as recently updated (March 2020) breaks down the details of these objectives. To reduce its energy consumption, giving priority to reducing consumption of fossil fuel-based energy, and limiting its greenhouse gas emissions, the Ministry for the Armed Forces is committing to moving toward clean mobility, to improving the energy efficiency of its defence bases, and over time to have tertiary and residential facilities that are energy efficient.

The Ministry for the Armed Forces aims to have an administrative vehicle fleet composed at minimum of 50% of low-emissions vehicles in 2030. It will define the low-emissions vehicle deployment plan, and plan for the installation of the related electric charging infrastructure. Concerning defence infrastructure, the SMPE is based, among other things, on the elimination of the forms of energy that are the biggest polluters (coal, fuel oil), and aiming to use renewable energy sources (photovoltaic panels, biomass, geothermal energy, green gas, connections to urban heating networks, etc.). As such, the existing and future facilities will be renewed, according to energy efficient and low-carbon emissions standards, including an approach involving the systematic analysis of the life cycle. This integration of the Ministry's facilities into a decentralised energy model that is closer to the territories responds to the changes in the national model

29 Ministry's strategy for energy performance from 2020 to 2023.

set by France's multiannual energy policy. Use of global contracts for energy performance[30] continues in order to optimise the energy consumption of the Ministry's facilities that are the largest consumers of energy or that emit the greatest amount of pollution.

Adopt a ministerial operational energy policy

Adopting an operational energy policy will help unify the efforts of actors involved in the field of operational energy. This policy, which aims to meet the energy needs of operations and operational contracts, must define principles that consider energy as a path to performance and superiority.

R13 - Create a dedicated operational energy division within the EMA, which will be in charge of:

1. Development of a sober energy culture;
2. Training for taking into consideration the issues and usages of energy;
3. Reinforcement of resilience and continuity of operational activities;
4. Planning and deployment of innovative energy capacities in operations;
5. Preservation of the single fuel policy;
6. Implementation of a specific organisation relying on a network of key persons;
7. Opening up energy information and forecasting to develop operational methods of action which are both offensive and defensive in nature.

3.2. Secure operational energy

Permanence and availability – in quantity and in quality – of energy that influence how operations are carried out, such as the preparation of forces. The security of operational energy access therefore constitutes a major issue, while its availability is founded on the securing, reliability and resilience of the means of production, distribution, storage, and steering. Moreover, fluctuations in the cost of energy that are sometimes significant, and sometimes quite rapid, may have an impact on the financial situation of the Ministry.

3.2.1. Strengthening the resilience of critical infrastructure and operational functions

The predominance of electricity within the Ministry should continue to grow with the development of simulation, computerisation that is ever more demanding in terms of energy (data centres) and new usages of electricity, including electricity-based mobility. The ever-increasing usage of electricity linked to new technologies therefore causes a strong dependence on electricity, bringing up the issue of the continuity of the supply of this energy within the operational infrastructure. Yet, various external factors make these networks more vulnerable: digitalisation, increasing interconnection of electricity delivery networks on a continental or regional scale, entryism of actors external to the European Union, new usages of electricity, liberalisation of markets, power supplied and volatility. Vigilance is therefore necessary for the security of energy supply, and the reliability of the recovery capacities of the Ministry's facilities.

Secure the electrical supply for sites

While external operations use their own supply approach, partially independent of networks and national sources of electricity, this is not the case for sites on the national territory that are mostly, or with rare exceptions, supplied by the national civil network.

On the national territory, the quality and reliability of the delivery of energy via networks are ensured by the electricity and gas distribution and transmission operators, and locally for heat, through local urban heat networks. However, a one-off failure of the national electricity network cannot be totally ruled out, whether it results from a general cyberattack, a labour strike, a major climate event, a significant imbalance in the European electricity network or a major hypothetical cut in power resulting from an attack on the territory. Being able to have energy when the national supply has failed requires the availability of autonomous production and distribution capacities, and that they be maintained for operational functioning. While

30 The CPE taking the form, as of the renovation of infrastructure, of a modernisation of insulation and "greening" of the energy production mix (biomass, heat networks, renewable energy sources (EnRs).

the risk of supply interruptions from the public network remains low, partial load-shedding and internal backup power capacity for the vital functions of the Ministry must be maintained and updated.

Based on functional priorities established by the command, then technical audits of internal installations for production and distribution, it is recommended that the most strategic sites be provided with backup production solutions, and consequently, to establish guidelines for updating critical infrastructure. Outside of the update of critical installations, it would also mean working to maintain internal skills for maintaining operating conditions (MCO) of these installations.

Concerning maintaining the continuity of activity, including during load shedding31, the national electricity distribution network ensures supply to priority sites. The backup systems generally are diesel fuel-based, which therefore needs to enter into consideration as an energy source that is necessary for certain operational functions. Since diesel dedicated to fuelling generators was not accounted for in strategic stock, it will therefore be necessary to integrate backup energy sources into the calculation of the security stocks of the armed forces.

The resilience of backup systems should be regularly tested using "crisis" scenarios (extended labour strikes, attacks, pandemics, technical incidents, etc.), taking into account the operational missions attributed to these sites. This involves precisely evaluating the vulnerabilities and reliability of the systems:

- identify the priority subscribers on the sites (priority defence installations (IPDs)/vitally important points (PIVs)/sensitive military installations (IMSs)) and assert the priority of MinArm sites with distributors;
- for each operational site, define the rules for load balancing or passing into backup power in case of an outage (power cut upstream)
- study the adaptation of network architecture that does not fulfil the supply security objectives;

by considering that:

- external sourcing of electricity can be interrupted, despite priority systems;
- subcontracting personnel that are supposed to be ensuring electrical installation operations on sites could be absent (public health crisis, labour strike, etc.);
- oil supplies could be insufficient in the event of a general problem occurring in a region.

R14 - Develop an overall policy for energy resilience by initiating an evaluation of sites starting in 2020 for solutions put in place in 2025:

Establish a mapping of vulnerabilities for end-of-year 2021;

For end-of-year 2022, consolidate existing concepts concerning resilience, evaluate them, and validate them through testing with "crisis" scenarios, taking into account operational missions that could be requested of armed forces operating in continental France (politically sensitive persons, dissuasion, national emergency response unit (échelon national d›urgence, ENU)), strengthening platforms in OPEX, specifically airborne forces). Lessons learned from the Covid-19 crisis will be taken into account;

For end-of-year 2022, define the energy needs of the most critical infrastructure, and develop resilience and continuity criteria for activities, and broaden the scope of the communication of requirements to all armed forces, directorates and services (ADSs); these elements will constitute a foundation to establish steering guidelines for update;

Identify new emerging skills to have internally or within the BITD for maintaining our critical installations in operating condition.

31 Decree of 5 July 1990 defining the general guidelines for load balancing on electrical networks, updated on 13 January 2016.

Test self-consumption of sites and develop new models of resilience

Reducing consumption and transitioning to more sustainable energy sources favours less energy dependence by reinforcing the resilience of each defence facility. The development of self-production capacities, parallel energy autonomy, and self-consumption will be built on interconnected energy production, storage, and management equipment. As part of the SMPE, twelve energy performance contracts[32] are in progress, for example on the base at Mourmelon, which involves eliminating all of the fuel oil and coal boilers by 2023.

As part of the works[33] launched by the European Defence Agency (EDA) with the support of the General Energy Directorate of the European Commission, the ENSSURE (ENergy Self SUfficient REsilient military base) project, under the direction of the SID thus aims to implement a military site demonstrator that integrates solutions to the energy issues of the future: resilient, self-sufficient and carbon free. This pilot project will rely on a consortium of civil and military skills, and will test almost total decarbonisation of energy needs on a typical military site in continental France, while still preserving operational capacity in case of interruption of the supply of electricity or in case of cyberattacks on installations.

More than just a simple energy performance contract, the project should also combine the production of different sources of renewable energy and the utilisation of multiple energy storage solutions within an intelligent micro-network. The aim is to ensure permanent functional capacity of critical installations of the site and shared installations in case of interruption of supply from the public electricity network, using "smart" communication systems that also meet the Ministry's requirements in terms of cybersecurity. The project should also define a technical-economic model through a feasibility analysis of various technological solutions that are tested.

R15 - Integrate disruptive energy sources or renewable energy sources that allow for increased energy self-production capacity in facilities, and thus increasing the resilience of the armed forces, following the example of the ENSSURE project and energy performance contracts.

3.2.2. Ensure fuel support and control its risks

Each operation requires implementing a specific fuel support system: there is no default dimensioning or notion of proportionality from one theatre of operation to another. As part of operational commitments, the design of fuel support systems always depends on supply security issues.

The growing energy needs require a wider degree of logistical manoeuvring, exposed to actions on the part of opposing forces and therefore constituting a factor of vulnerability. The main issue therefore consists of meeting a growing energy need for systems and equipment, while controlling consumption of fossil fuel-based energy, and as such the environmental and logistical footprint.

The engagement of the armed forces is most often over the long term, and the weapons systems must therefore have range, be durable, be flexible in use, and be resilient. The footprint of energy logistics in OPEX must be limited. The implementation of the single fuel policy (reduction of supply to jet fuel only) contributes to this requirement, among others. Under these conditions, any optimisation of consumption and availability of energy that is produced or locally accessible will reduce logistical expense, improve durability, and free up protection resources for other missions. The same logic is present in managing water and waste, where the issue of a reasoned and efficient approach is the main challenge with which logistics will be confronted in the coming years.

Plan operations beforehand

Any operational engagement requires a supply of energy, indispensable both for mobility and for electricity production at camps and bases. The provisions related to supplying oil products to the armed forces are planned during peacetime. They include finding commercial solutions and prior establishment of bilateral or multinational support arrangements in order to secure supply.

At the strategic level, the SEA participates, along with the CPCO, in the design and planning of fuel support in operations. For fuel support, the strategic level corresponds to actions implemented by the SEA to

32 See Appendix 6 - Towards low-carbon facilities by 2025.

33 As part of the Consultation Forum for Sustainable Energy in the Defence and Security Sector initiative.

acquire the resource and supply it to the armed forces in a secured manner, by relying on security stocks constituted by external operations, overseas and on national territory. These actions are made possible by thorough knowledge of the oil sector, maintained by the SEA and with oil companies and allied forces.

During the planning of an operation, the SEA studies the needs expressed in order to adapt its system and to develop the fuel support manoeuvre. This includes defining the volumes of fuel that will be used. Today, this analysis is essentially empirical, and is based on NATO standards (STANAG 1333), and above all on its operational experience. The detailed anticipation of needs is carried out using precise knowledge of usages and consumption by mission profiles. Fuel support remains contingent on the operational context of the use of force, which defines the policy of energy in operation[34], average daily consumption, and desired autonomy.

The planning of fuel support outside of continental France is determined by many interdependent factors, including the capacity of host nations to compete for the fuel support of deployed forces. The issues are the availability of the fuel resource, in quality and in quantity, the location and access to the fuel resource, as well as the methods of supply. Oil supply will be carried out in priority from national stocks, from those of the host nation (host nation support (HNS)), allied armed forces, international agencies or, if applicable, through private companies, according to the availability of resources and the level of accepted risk.

The availability of local oil resources is a determining factor of the autonomy and resilience of the force. It orients the choice of logistics entry zones in the theatre of operations for the armed forces, and the diplomatic actions to support the supply priorities of the armed forces.

R16 - Integrate energy into operational planning:

1. Implement the energy coordinator function into the operational chain, in order to have a global vision of energy, and to ensure that energy needs are met in a coordinated fashion between all actors;

2. Develop and operate a robust planning and decision-making support tool, in order to estimate consumption.

Preserve the single fuel policy

For the armed forces, as part of engagements external to the national territory, it is fundamental to know the availability of fuel resources, and this availability is also a factor of dependence and of risk. Energy support during deployment is largely based on fossil fuel-based energy sources that are required for mobility and for installations for stationing armed forces.

The supply principles are the following:

- in operations, the main source of fuel for ground and air components is based on F-34 or F-35 jet fuel, and F-63 jet fuel for ground applications;

- the French Navy mainly uses dedicated fuels (F-75/F-76, XF-80 marine diesel, and F-44 high-flash-point type jet fuel);

- the use of other fuels such as F-18 jet fuel, F-54 diesel and F-67 superfuel must also be considered for equipment that is incompatible with the single fuel policy (SFP), including certain drones.

In situations where locally available fuels are of poor quality or of insufficiently available volume, for instance during operations, the armed forces use the NATO single fuel policy. This approach consists of supplying all internal combustion equipment, including ground vehicles and electrical generators, with aviation-type fuel that guarantees strict quality standards that are applied everywhere. The single fuel policy is therefore important for operational efficiency because it gives access to a resource in both quantity and quality anywhere in the world, while also streamlining logistical chains.

34 Implementation of the single fuel policy, assuming partial or total responsibility for fuel support during a multinational operation, which can be assumed in the form of Lead Logistics Nations (LLNs) or Lead Role Specialist Nation, or of deployment of Modular Combined Petroleum Units.

This policy is satisfactory during operations, it would be best to continue it.

R17 - Preserve the capacity of the armed forces to operate using a single fuel in order to meet requirements in terms of mobility and the intervention of armed forces.

Risks linked to the externalisation of fuel support

The increase in the armed forces' needs in relation to the capacities managed by the SEA requires that a portion of the fuel support for operations be externalised, depending on the reliability of local oil operators. This dependence on the civil sector is not free from risk, but externalisation makes it possible to limit the fuel support system strictly to the operational needs of the armed forces.

Currently, operational contracts already include a portion of externalisation that should increase significantly. To improve the resilience of supply and externalisation solutions, the search for several candidates that are considered reliable is carried out as part of the calls for bids issued by the SEA. This reliability is determined using oil company monographs maintained by the SEA on the regional oil industry. They evaluate the capacities of a region to meet military needs without destabilising the usual economic activity. They help to measure the criticality of oil infrastructure used by the armed forces (oil installations, roads, pipelines, etc.) and analyse the available information on the regional oil actors.

Size the oil security stocks

On the national territory, the oil logistics of the Ministry for the Armed Forces relies on the network of civil oil infrastructure, SEA storage depots, and the security stocks maintained by the SEA. The volume of these stocks that is exclusively for Ministry use is defined by the EMA. They are mainly made up of jet fuel for airborne and ground forces, and diesel fuel for marine navigation, and high-flash-point jet fuel for the French navy. They are broken down into:

- Strategic stocks, meant to help face an international supply crisis;
- Stocks in case of a crisis ensure the continuity of operations during major national logistical disturbances in oil supply.

However, these stocks do not take the likely increase in future needs into account. They will increase under the effect of the increase in estimated needs for airborne[35] and ground[36] branches. A forecast for 2030 indicates that an increase of 60,000 m^3 would be necessary, representing an additional fuel purchase cost of €10 million, and €750 thousand per year in rental expenses for storage capacity[37]. Taking these needs into account should not require additional infrastructure investments by 2030, as the additional volumes identified[38] would be able to be absorbed by existing capacity (SEA and the CEPS pipeline), or already planned (storage at sea).

Moreover, the functional supervisory role carried out by the SEA for the service stations of the armed forces logistical services administration [Direction du Service du Commissariat des Armées] (taken over by the SEA by 2023) also allows for it to know the level of their fuel stocks.

In external operations, developing stocks of fuel is subject to a decision of command that takes into account the capacities offered by the Host Nation, the operational needs, and the risks posed to oil logistics.

R18 - Size security stocks by taking into account consumption that can be forecast, linked to the arrival of new equipment and to changes in activity:

35 +37% of jet fuel by 2030 for the French air force and +11,000 m3/year for the French army, consumption of high-flash-point jet fuel in 2035 at 5,900 m3/year instead of the current 3,600 m3/year for the carrier-based airborne group.

36 +25% with the SCORPION programme starting in 2020.

37 Central Europe Pipeline System.

38 52,500 m3 of jet fuel and 8,000 m3 of high-flash-point jet fuel.

For the 2020-2025 period, this means increasing security stocks of fuel for the armed forces by 60,000 m3 for a cost of €14 million.

Diversify the oil supply

In order to guarantee the security of its supplies and to control fuel costs, the SEA adopts a purchasing strategy based on diversifying its supply methods: major purchase of jet fuel via annual contracts, bulk purchase of products other than jet fuel, charge cards, etc. It implements various financial systems in order to ensure that the armed forces have a purchase price that fluctuates less than the price of oil (pricing based on the weighted average unit cost, system for hedging risks).

Use of externalisation, already mentioned in operations, is also implemented on the national territory for supplying the SEA's oil depots. A capacity for resilience is maintained in order to compensate for shortcomings on the part of external operators (intervention of fuel support companies of the inter-armed forces oil base, calling on the refuelling squadrons of the French army's logistics, transport and support arm (TRAIN), etc.). This capacity was already implemented on several occasions during oil crises in the country.

3.3. Minimise the energy footprint to increase operational performance and resilience

As they are often complex, weapons systems have long life cycles that require initial margins related to design that makes future modifications possible. With this perspective, the energy aspects have their rightful place across the entire equipment life cycle: reduction of the energy footprint, decarbonisation of energy sources, improvement of performance, integration of the constraints related to the energy transition, etc. Moreover, these advances will likely generate operational gains: increased stealth, resilience, autonomy, the possibility of integrating new weapons that are highly energy intensive (railguns, directed-energy weapons, etc.). These considerations are largely shared, but are carried out in different ways according to where they are used.

3.3.1. Take advantage of civil technological advances

Technological innovations in energy are essentially the product of research in the civil sector. Monitoring must be maintained on these activities, but also with a forward-looking perspective, to identify technology from the civil sector that is best suited to being adapted to the constraints of military usage, and the performance required by the armed forces (mechanically reliable, safe functioning, autonomy, functioning in degraded mode, etc.).

The Ministry for the Armed Forces aims to use technology from the civil sector or technology derived from it, in such a way that it can benefit from economies of scale and the dynamics of the commercial market, as well as maintaining operating conditions at a controlled cost.

Developments that are specifically military will however be necessary for certain applications. This is the case, for example, with high-power pulsed-energy generation and storage systems for directed-energy weapons, railguns, or batteries for complex munitions (missiles or torpedoes).

Taking the different military specificities into account should not result in too large a gap between the civil and military sectors which would require maintaining a large variety (likely unsustainable) of specific and unique technologies, generating cost overruns, loss of skills, even obsolescence and unavailability.

In the 2020 edition of the defence innovation guidance document (Document d'orientation de l'innovation de défense, DOID), the "Energy" topic is integrated as a new field of action for the Ministry for the Armed Forces in terms of innovation. It is identified as a priority and cross-cutting area, and the effort is focused on detecting, collecting, and selecting innovation, and then supporting it.

R19 - Take advantage of innovations in the civil sector, by adapting them to military usage cases:

1. Launch three innovation acceleration projects in 2021 (alternatives to diesel electrical generators, cleaning of photovoltaic panels in restrictive environments (sand), hydrogen in camps;

2. For the 2020-2025 period, €23 million will be invested in open innovation.

3.3.2. On the ground: increasing electrification for operational contribution

Towards hybridisation of vehicles

In a context of energy transition, the civil automotive fleet is moving towards electrification of its power trains (hybrid and/or fully electric). Military ground vehicles still consume more and more electricity, to the point of having reached the technological limits of the alternators producing electrical energy on board39. Hybridisation of powertrains, along with optimised energy management appear to be a solution to this technological limitation.

The feasibility and the interest of hybridisation depend on the type of vehicle and its mission profile. For each of the vehicles and the related missions, the planning approach, through an analysis of the energy component, should help define the best technical and economic compromise. If hybridisation does not adequately cover all military needs, the first promising studies show its promise in certain configurations or usages. Hybridisation not only brings operational gains, including increased electrical power for forward crossing and greater stealth, but also, in certain cases, provides gains in fuel economy that can reach 10 to 15%.

The hybridisation of the civil sector cannot be directly applied to the military sector. This concerns the risks linked to the use of Li-ion batteries (fire or explosion hazard in a ballistic environment, thermal runaway in extreme temperatures, premature ageing of batteries) or those linked to the specifically military functions of this equipment. Covering these risks will necessarily be via technological studies and the development of a hybrid armoured vehicle demonstrator in the coming years. The actual production can be imagined for the next generations or standards for armoured vehicles for 2028-2030.

R20 – Starting in 2022, develop a hybrid armoured vehicle demonstrator in order to provide powertrain choice criteria for the Griffon and VBCI in 2025.

Study the use of alternative fuels[40]

While we are seeing that fuels are being diversified in the civil sector, in order to decarbonise mobility, the use of alternative fuels (biofuels, hydrogen) is being studied within the Ministry for the Armed Forces.

Biodiesel is already produced and sold in the civil sector in France and abroad. The potential of these biofuels is interesting, and is currently being evaluated for ground equipment. The evolution of the ground-based biofuels market is partially linked to the market of the aviation biofuels market that is developing (see paragraph on the "aviation sector"). They are therefore already in use by the armed forces, either when they source from the civil sector by credit cards, or in DSCA service stations that have supplies of ground fuels.

However, the use of aviation biofuel, such as diesel jet fuel, within the single fuel policy, should be confirmed. This analysis should make it possible to ensure the compatibility of biofuels with the single fuel policy, and to evaluate the impact on the Ministry's supply chain.

Hydrogen also offers a good perspective as a new mobility fuel. Vehicles and equipment with diverse usages, fuelled by hydrogen fuel cells, are now appearing in the civil sector. This technology offers the

39 The capacity of the front-line armoured vehicle (VAB) alternators in 1976 and of the armoured infantry combat vehicle (VBCI) in 2008 went from 50 to 300 amperes. The capacity of the Griffon is 600 amperes, which is the current technological limit of alternators in ground equipment.

40 See Appendix 5 - Biofuels, vectors for decarbonising mobility.

advantage of only emitting water, and the silence of the electric motors is an interesting factor for the acoustic stealth of equipment.

However, this technology is not without its flaws, and its application to military usages cannot be broadened in the short term. For example, the fuel tank is quite voluminous, and the system has to be combined with a battery to absorb power peaks. The storage and transport of hydrogen in pressurised tanks or in liquid form at very low temperatures complicate logistics, without taking into account risks in theatres of operation or in enclosed spaces. Moreover, the production of hydrogen is itself particularly energy intensive.

Therefore, it is evident that, even if the potential of this technology is interesting, its technological and practical adaptation to military mobility is not yet mature. But this possibility should be examined over the long term, monitoring the development of civil projects (captive fleets). Adaptation to military constraints, as well as the logistics aspect (production, storage, transport and distribution) should also be studied.

Currently, three hydrogen-based projects have been launched within the Ministry by the DGA and the AID, and concern low- to medium-voltage systems: two fuel cells for the FELIN infantry and for a mini-drone Additional technical and operational studies should be launched to determine the interest and feasibility of such systems in relation to military constraints (production, storage, transport). In parallel, the SID is conducting a study for using hydrogen for high-power electrical generation for stationing use (camps, barracks, etc.).

R21 - Launch an ENERTOP technical and operational study starting in 2020 to study the interest and feasibility of integrating new energy technologies, specifically hydrogen, on ground platforms, from the perspective of military constraints and related logistical impacts (production, storage, transport, distribution) and carry out the related technological studies.

R22 - As long as no other replacement technology has been developed, ensure that the ground systems are compatible with aviation biofuels that are certified, or in the process of being certified, and define the related conditions of use as part of the implementation of the single fuel policy.

3.3.3. In the naval area: improve energy efficiency of vessels to respond to operational challenges

From the design phase of a vessel, energy is taken into consideration and has an effect on architecture, propulsion, electricity generation, and combat systems. The FREMM programme is an example of mixed propulsion systems that were chosen (diesel-electric with gas turbine). Outside of these architectural considerations, the DGA integrates into its steering of its armament programmes the analysis of the best technical and economic compromise for energy on the platforms (recent example of the programme-based approach to reducing fuel consumption from the design phase for the offshore patrol vessel (Patrouilleur Outre-Mer), which is planned to consume 30% less diesel).

Reduce the consumption of fossil fuel-based energy and meet the growing need for embedded electricity

The naval area is distinguished by an increased need for autonomy and endurance. The concentration of numerous types of equipment on the same vessel (propulsion, auxiliary, daily life on board, armament, sensors, etc.) involves significant levels of electric power (several tens of MW on a frigate).

Excluding aircraft carriers and submarines whose primary source of energy is nuclear, meeting the energy needs of military vessels is at this time based exclusively on marine diesel fuel (F-76 and DMA). The energy performance of future vessels will be the focus of improvements (hydrodynamism[41], adapted electric consumption, production capacities that are more streamlined, and an optimised distribution network), without losing sight of the necessary redundancy of equipment and power reserves that are indispensable for a combat vessel.

Firstly, this means limiting or reducing vessel consumption of fossil fuel-based energy, while meeting the growing energy needs on board. Embedded equipment requires more and more energy, and the

41 In terms of hydrodynamism, innovative solutions must be sought and tested (skeg on the rear platform, form of the hull lines or bow, covering of the hull, etc.).

implementation of future systems (directed-energy weapons, radar, electromagnetic catapults, marine-based refuelling systems, etc.) require storage of high-power energy. The development and control of this new equipment is key to operational superiority for combat vessels.

Moreover, even if civil environmental regulations do not apply to military vessels (MARPOL agreement), bringing them closer to compliance with these regulations by reducing atmospheric emissions (CO2, NOx, SOx, small particulates) is necessary, in order to limit pollution and avoid potential prohibition of access to certain waterways or ports that could be used as logistical support points.

Fuel for naval vessels: rapid changes in the civil sector that should be monitored[42]

Even though the French navy mainly consumes marine diesel, with a low sulphur content but a high energy density, the civil sector is gradually moving towards the use of LNG (liquefied natural gas), a fuel that meets the technical requirements of the naval anti-pollution standards (35% reduction in CO_2 emissions, NOx emissions that are seven times lower, small particulate emissions that are 20 times lower compared to marine diesel). This mainly concerns large transport vessels (ferries or merchant vessels) whose trips are well defined and regular in nature, and for which the LNG supply points are well defined.

The studies carried out by the Ministry43 led it to eliminate LNG as a potential fuel for the French navy. This technology involves operational limitations and does not provide sufficient guarantees in terms of security and supply. The LNG refuelling points are actually not as widespread as those that deliver DMA. To that can be added the low energy density of this fuel, that would impose significant constraints on architecture. By nature of their activity, combat vessels are significantly less subject to commercial shipping routes, and they are more likely to find themselves in unusual situations, such as exchange of fire. Using LNG could possibly be imagined for a captive fleet that is less exposed (in-harbour vessels, for example). In this case, supply of LNG should arguably be externalised in order to avoid too large an investment in infrastructure and implementation, and then the maintenance of very specific skills carried out by a small number of personnel. As for the use of marine biofuel, it can only be planned and authorised after a precise evaluation of its technical and operational impact (engine functioning, storage in holds, filtering, etc.).

Other innovative methods of propulsion are also tested, including for service fleets. Since 2018, a multi-mission scow, the first vessel using diesel-battery hybrid propulsion, is now part of the French navy. There were positive results in this usage case, feedback shows 70-80% of functioning in electric mode, with recharging of batteries when in port or at sea. Other propulsion solutions (electric motor based on superconductors, turbosails, foils, ammonia, etc.) could also be envisioned but their maturity is insufficient and their conditions for use are too restrictive for military use in the medium term.

The reduction in emissions of small particulates and nitrogen oxides in the exhaust of vessels must be studied. The vessels of the French navy currently comply with the TIER2 standard, and must aim for the TIER3 standard for future generations of motors without compromising operational performance of systems. Lastly, as for the ground and airborne areas, the development of biofuels is starting to appear in the naval area, and seems to be an interesting solution in the short and medium term.

R23 - Ensure monitoring of different marine fuels and of different solutions for naval propulsion, as well as their availability and supply in the defence context (for example: hydrogen fuel cells, electric motors) in order to anticipate changes and maintain deployment capacity.

Optimise energy on board and explore innovative electric techniques

Optimisation of energy consumption is particularly well suited to vessels exceeding 3,000 tonnes. An objective of 20% improvement in fuel economy seems attainable according to studies that help:

- to better know and control the energy situation of the vessel and its equipment;
- to improve the architecture of electrical networks, taking the usage profiles of military vessels into account;

42 See Appendix 5 - Biofuels, vectors for decarbonising mobility.

43 Technical and operational study of the use of liquefied natural gas by the French Navy, 2016-2017 (Etude Technico-Opérationnelle de l'utilisation du gaz naturel liquéfié pour la Marine nationale (ETO GNLMN), 2016-2017).

- to vary the sources of energy on board, with energy storage and energy recuperation systems;
- to develop smart grid-type energy steering systems;
- to develop energy systems that can evolve over the life of the vessel.

The gains offered by these latest technological advances to improve the architecture of electric networks (using direct current, energy storage systems, smart grid-type automatic network management systems, voltage conversion, etc.) must be examined, taking into account the very specific usage profiles of military vessels. Energy sobriety while docked is also an issue for the proper sizing and resilience of the network of support bases.

The diversification of energy sources on board offers an interesting solution, already implemented but which could still be further developed by studying the opportunities offered by energy storage systems. That would allow for adjusting the electricity production capacity, to better target energy loss points, and later to feed pulsed-energy systems when they are mature.

In the continuity of previously launched studies for vessels larger than 3,000 tonnes[44], it is suggested that the advantages of direct current be confirmed, specifically in terms of performance, volume, stealth, and the quality of the energy delivered. This technology helps to diminish energy loss by the joule effect, as well as contributing to greater stealth, and to delivering more electrical power on board.

Moreover, exploratory studies and technology monitoring on superconductor motors aim to reduce the size of motors and their consumption at a given power level.

Lastly, the integration into a contained volume of technologies that are already mature in the civil domain (heat recovery systems, power tiering and regulation of ventilation and air conditioning systems, etc.) may help reduce energy consumption in a way that is adapted to the operational goal. Such technologies do not require development but must be provided for from the design phase (integration into vessel specifications). For example, R&T studies plan to analyse the existing energy generation architecture, the distribution and consumption of various equipment, then to propose alternative solutions to improve optimisation of energy consumption on future naval platforms.

R24 - Optimise, on a case-by-case basis, the propulsion and architecture of new vessels based on their size and their use, giving priority as soon as possible to "all-electric" architecture.

1. Starting at the vessel design phase, the offshore patrol vessels (*Patrouilleurs Outre-Mer*) programme integrates the energy performance aspect, an aspect which will be verified in 2022.
2. The ocean patrol vessel (Patrouilleur Océanique) programme plans to incorporate energy into the choice criteria as part of the value analysis to come, seeking optimal design.

3.3.4. The aviation sector: take advantage of civil developments and adapt to integration constraints

Rely on the increasing use of biojet[45]

Liquid fuel remains the sole option for the medium term in the domain of military aviation. Synthetic fuels therefore seem like a transitory solution between conventional oil-based fuels and disruptive energy sources (hydrogen, etc.). They offer the advantage, under certain conditions, of being able to be mixed with conventional fuels and being able to be used in internal combustion engines, as well as in existing turbojet engines without technical modification (drop-in fuels).

44 Following the example of the PEA SECU HT started in 2018.

45 See Appendix 5 - Biofuels, vectors for decarbonising mobility

Biofuels represent an important lever to significantly decarbonise jet fuels. Even though the technologies are mature, the availability of synthetic jet fuel will essentially depend on the maturity of the civil market and the cost of the supply. The price of biojet is still currently 3 to 4 times higher than conventional jet fuel.

Today there are six sectors of biofuels that are certified, which allows us to imagine, for the most part, adding in up to 50% for standard aviation usage.

A national roadmap was drafted by the MTES for deployment of sustainable aviation biofuels as part of the commitment to green growth (Engagement pour la Croissance Verte, ECV) signed in 2017: the proposed trajectory is to add jet fuel from the biofuel sector for up to 0.05% in 2020, 2% in 2025, 5% in 2030, 50% in 2050. The Ministry commits to the 2050 objective and will define its trajectory to reach that goal.

Despite a cost that is currently not very competitive, studies show that biojet fuels seem like the only medium-term option that allows decarbonisation of the aviation sector. The Ministry will use these fuels on the current fleets and the engines of future programmes, such as the FCAS, which will be certified.

R25 - Prepare for using alternative fuels (biofuels), including in logistics, according to their technical, economic, operational, and environmental interest, consistent with developments in the civil domain. This means meeting defence needs and military characteristics with biologically sourced fuels through the aviation biofuels sector and between ministries.

The MINARM is committed to the national effort to decarbonise by ensuring minimal consumption of biojet fuel, and to work towards carbon neutrality by 2050 for the aviation sector. Adapt to integration constraints

Civil aviation continues to improve engine performance and to hybridise propulsion, seeking to reduce greenhouse gas emissions and to comply with different normative constraints. These projects are financed by the French civil aviation authority (Direction Générale de l'Aviation Civile, DGAC) (SPHERE convention), at the European level (CleanSky project) as well as by future investment plans (Plans d'Investissement d'Avenir, PIA).

For combat aircraft, the high level of operational performance required, combined with substantial integration constraints, has already led to strong optimisation of the propulsion element. This approach should also take into account the electrification of on-board equipment, as well as the optimisation and sizing of future engines. Moreover, work is carried out to identify new technology, such as superconductor motors applied to aviation46.

Explore innovative solutions in terms of electrification

Optimising electric energy on board of aircraft, as well as electrifying hydraulic, pneumatic, and mechanical functions is also being studied in the civil sector. However, the complexity of combat aircraft and their weapons systems brings about considerable contradictory constraints. For example, the simultaneous use of energy-intensive equipment (radar, electronic warfare, data connections) generates electrical consumption that is uneven (peaks) that encourages more significant sizing, which leads to too much weight and reduced range. This means for example, for certain missions, studying innovative low-carbon platforms, such as HAPS (High Altitude Pseudo Satellite) and MAPS (such as Solar Impulse - Skydweller) which seem promising as information, surveillance and intelligence vectors (Information, Surveillance et Renseignement, ISR) and communication relays.

46 RAPID RESUM, RAPID CRYO SUPRA

R26 - Furnish technical expertise to the DGAC on the national roadmap for powertrains for civil aircraft, whether in propulsion or not, and monitor the taking into account of the Ministry's energy issues in future programmes:

1. Integrate civil developments into the preparation of military programmes
2. Explore solutions that will help guarantee provision of the energy needed (for example, to power the Rafale's AESA NG radar);
3. Study the modernisation of electricity generation in aircraft in order to have more power available compared to existing sizing and at a constant level of security;
4. Study the possibilities of storing energy on board by optimising energy produced by alternators.

Specificities of missiles

In the very specific domain of missiles, energy is a primary factor in terms of performance and cost. This domain is therefore the focus of many studies on higher performance thermal batteries, solid propulsion, consideration of regulatory changes (for example, REACH regulations), or new energy materials (at a very low level of technological maturity).

3.3.5. Stationing: accelerate the implementation of decarbonised solutions

Optimised management and storage are the two major themes of current development that are considered for the energy needs related to stationing armed forces. These development paths are based on civil technology, such as lithium-ion batteries, fuel cells, or network management systems. With systems that are more economical in terms of energy and water use, armed forces will be able to preserve their capacity for action while having better support for an equivalent cost. Specifically, alternative methods of producing energy in operations reduce the carbon footprint of the armed forces, and increase their resilience.

Broaden the application of the eco-camp concept in operations[47]

Any operation undertaken in external theatres is based on ad hoc sites. The SID carries out the design, operation, and maintenance in operating conditions of the infrastructure and equipment necessary for functioning, whether for daily life, technical support, or preparation for operations.

This support is highly dependent on external streams (fossil fuel-based energies, potable water and waste water services, waste management) that generates material logistical costs, significant dependence, sources of potential accidental pollution, noise and odour nuisances (electric generators), and even vulnerabilities. The necessary electrical energy is produced exclusively by electric generators that run on fuel, which is therefore of critical importance.

Several entities of the armed forces and foreign armed forces are discussing and participating in setting up innovative installations, including using renewable energy sources. However, solutions have not yet been seen that deploy measures that are overarching, sustainable, secure, and systematic that would give camps a sufficient increase in energy autonomy. Moreover, it becomes necessary to take the environmental aspect into account as soon as a camp is set up, in order to control its footprint during and after the operation.

To meet needs and respond to energy transition issues, the SID is studying the Eco-Camp 2025 concept, which seeks to ensure better autonomy, while maintaining the same level of support provided to deployed forces. The key idea is to aim for camp autonomy during operations in order to diminish their vulnerability in day-to-day operations, and to increase their resilience.

This target will be reached via the following efforts:

- reducing consumption (water and energy), while integrating the new needs of the armed forces;
- alternative production of water and energy;
- optimising new equipment by looking for synergies between the different infrastructure equipment: waste from one source could make energy for another.

47 Appendix 7 - Eco-Camp 2025

The Eco-Camp 2025 project and its objectives will make it possible to lower consumption of fossil fuel-based energy in stationed camps (for the part related to infrastructure), decreasing by 40% in 2030, by using renewable energy sources and by increasing the energy efficiency of production equipment and terminals. This reduction goal is comparable to the objectives and trends of the climate plan.

R27 - Once testing is finalised, broaden the application of the Eco-Camp 2025 project, which seeks to reduce consumption and increase energy autonomy of deployed camps in operation:

1. Develop camp technological building blocks (hybrid electrical generator, photovoltaic cells, building performance) aiming for water and energy autonomy by relying on civil technology between 2020 and 2022;
2. Test these systems in external operations between 2023 and 2025;
3. Have a digital version of this camp model available to allow for prospective planning of deployment and operational maintenance of deployed camps by 2028.

Optimise energy management and decarbonise stationing

Outside of the Eco-Camp 2025 project, other optimisation approaches are being explored. The results of testing carried out by the air force on the proposed H5 base in Jordan, and of the PEA GENALT (demonstrator of electric energy management in large OPEX camps[48]) have demonstrated the usefulness of integrating low-carbon technologies (smart grids, renewable energy sources, electricity storage). A 15% fuel economy was noted, but the difficult usage conditions in OPEX (temperature, sand) currently limit their wider application.

Moreover, technological building blocks are tested following the example of the ENSSURE project (self-sufficiency and resilience of a military site), SOLTHAIR (thermal solar concentration plant that can be deployed in OPEX), or OPERASOL (photovoltaic panels made of composite materials that can be deployed on tent roofs.

For its part, the army, in cooperation with the DGA, is carrying out the innovative ARPEGE[49] project, seeking to homogenise the fleet of electric generators based on a unified system (production – management – distribution) using modern technology. It will help to improve the flexibility of use and support, as well as the autonomy of the deployed units. It may also be used as a backup on national territory. Lastly it can integrate energy hybridisation consisting of combining different sources of energy to offer an autonomous solution that is economical and easy to use.

Using hydrogen as an alternative energy in camps is also being studied by the SID, as is the use of hybrid electric generators that link to photovoltaic cells and storage.

These various technological innovation blocks may be integrated into optimised energy production systems for planned bases, as well as for Ministry facilities on the national territory.

The small modular reactor (SMR) and micro modular reactor (MMR) technologies, studied by the US Army in particular, offer opportunities to decarbonise the stationing of armed forces, but also impose considerable security constraints, as well as operational risks. As the nuclear energy issue has been dealt with elsewhere, this technology was not taken into account within the framework of this study. However, this will mean ensuring that the changes and developments abroad in this technology are monitored.

R28 - Starting with testing carried out on the national territory, study the integration of renewable energy sources (EnRs), the replacement of generators, and the use of hydrogen in facilities and in operations:

1. Launch testing of a hydrogen-photovoltaic electric generator in the Glorioso Islands for the second half of 2020;
2. Launch testing of a photovoltaic-diesel electric generator in French Guyana for the second half of 2020;

48 >200 persons

49 Distribution equipment for electricity production and energy management.

4. Adjust our level of strategic autonomy to exact operational needs

Raw materials, technology, innovation, and capacities for production, transformation, and transport lie mostly outside of the national and European spheres. Seeking strategic autonomy, it is recommended that we closely analyse the degree of dependence, and that we identify issues linked to national sovereignty or elements of mutual dependence that can be agreed on with our partners, which would require specific vigilance concerning strategic civil domains, and lastly, we should identify elements that do not present any specific issues of autonomy.

The increasing importance of the energy domain justifies carrying out an analysis for the defence industrial technological base (BITD) from this perspective. This means identifying, and if applicable, promoting or supporting actors, sectors, and existing skills linked to defence needs. When the necessary investments exceed the financial capacities of national companies, European partnerships will be sought out in order to mutualise the efforts. Partnerships will also be developed to respond to operational needs, particularly within NATO.

4.1. Identify and control technological and industrial dependence

Given the dynamism and the size of the market, defence equipment and infrastructure rely as much as possible on technologies that come from the civil energy sector. However, certain exceptions focus on developments that benefit defence directly, such as nuclear propulsion, thermal batteries, seawater batteries, or other specific types of batteries, combat aircraft engines, and pulsed-energy technology for directed-energy weapons or the railgun. Even so, currently there is no "defence industrial technological base for energy" (BITD de l'énergie) that is formally identified by the DGA. From time to time, these technological domains specific to defence can in turn contribute to the civil sector, for example the hot section components for jet engines.

Access to energy technology needed for equipping the armed forces and, if applicable, their export conditions, are a critical issue for the Ministry. Depending on how open the market is, the level of performance required, and the potential applications of these technologies, a national control (for example thermal batteries) or European control (for example ground propulsion), or a dependence on the international market (for example high power electronic components) are sought out or consented, depending on the case, with a constant consideration of the security of supply.

Sovereign core

In order to control access to civil energy technology, tools were implemented to monitor foreign investment and export. Thus, the Ministry for the Armed Forces provides opinions on the monitoring of foreign investment through inter-ministerial exchanges conducted by the Directorate General of the Treasury (DGT). Moreover, certain technologies, such as high-capacity batteries50, are subject to control of dual-use goods and are only able to be circulated freely within the EU and the Western countries. Lastly, other technologies, such as high-power-density batteries, are considered armament technologies and require authorisation in order to be exported.

European partnerships and mutually agreed dependence

Batteries represent a market that is dominated by Asia and driven by the civil sector, due to the large supply volumes necessary for various applications, particularly in the civil development of electric and hybrid vehicles. But initiatives are being put in place at the European level with the European Battery Alliance project, in which the leading French battery company, SAFT, participates.

Technologies that require control at the European level include those used for propulsion of equipment and platforms. The diesel engines of military ground vehicles are developed from civil engine models, mostly supplied in Europe[51] then adapted to military fuel through configuration of their injection systems. Combat aviation, which has sovereign needs, also relies on a European scope. In the meantime, the Rafale engine, the NGF engine and the missile jet engines are produced by SAFRAN.

50 >350 Wh/kg

51 Main suppliers: PSA, Volvo, Scania, Cummins, Iveco, Ford.

Moreover, the European Defence Fund represents a significant opportunity for projects striving to create a European sector for future technologies of military interest, such as powering directed-energy weapons or the development of direct current high-voltage electric networks on vessels. The development of civil technology that can be adapted to military use such as biofuels, superconductor motors, or hydrogen-based technologies, will also make it possible to develop new French or European sectors that are state of the art on the global markets.

R29 - In domains identified as strategic, ensure the national control of energy technologies used in the military domain by maintaining a BITD that is accessible via:

1. Support of French BITD businesses that are active in the energy sector, including as part of foreign investments in France;
2. A variety of suppliers for dual-use technologies;

Relying on our European partners.

4.2. Develop strategic cooperation

The Ministry for the Armed Forces is not by itself able to develop French companies in the energy sector and make them profitable. Setting up cooperation arrangements with our partners and within the organisations and institutions (EU and NATO) is therefore indispensable. The need for interoperability also requires constant efforts to create standards and norms for the energy sector.

4.2.1. Support European centres to develop cooperation in the field of operational energy

Since 2017, reinforcement of European defence has been accompanied by several Member State and European institutional initiatives, some of which serve to support cooperation in the energy domain.

Take advantage of France's steering role in the Energy Operational Function project

The Permanent Structured Cooperation (PESCO), launched in December 2017 by 25 Member States of the EU, is a priority vector of cooperation in the defence domain. In this framework, France steers the Energy Operational Function (EOF), with the participation of Spain, Italy and Belgium. It involves developing an operational approach to energy in order to increase autonomy and resilience of armed forces and to increase their operational performance. Three development themes are specifically identified:

- **energy efficiency of deployable camps:**
  - lower energy consumption without impacting the service level;
  - develop common European standards and favour interoperability (including with NATO).

The French Eco-Camp project presented previously will be proposed to federate the partner and observer country discussions on this subject.

- **the standardisation of batteries for operational mobility:**
  - propose European standards for batteries for ground vehicles deployed in operations;
  - develop a sustainable European industrial organisation in this field;
  - study the relevance of a demonstration phase based on prototypes;
- **development of a common support tool for operational energy planning:**
  - develop a simulation tool that helps optimise the energy mix in operations to reduce energy consumption and guarantee the resilience of the armed forces.

Ensure the monitoring of energy projects developed within the European Defence Agency

The European Defence Agency (EDA) favours calls for projects published within the EU, based on capacity needs that are jointly identified between Member States.

In the research domain, the Overarching Strategic Research Agenda (OSRA)[52] seeks to identify future areas of European cooperation, broken down into Technological Building Blocks (TBB). The OSRA is constantly consolidated based on the work of the Member States and companies, with the support of the European Defence Agency. Thus, France is committed to TTB no. 1 - Alternative fuels and drive - propulsion systems - the objective of which is to examine the direct and indirect impacts of the use of alternative fuels (drop-in fuels or disruptive fuels) in military equipment (performance in use in harsh conditions, acoustic discretion, related logistics, handling during long-term storage, bacterial and microbial contamination issues, compatibility with the single fuel policy, etc.) and to evaluate if future fuels could improve engine performance.

Moreover, the Agency coordinates a specific working group that is dedicated to energy management and the energy efficiency of buildings. This enabled the creation of a community of interest around the ENSSURE project related to the energy autonomy of a military site, and France participates in this community. This project will be proposed to be financed by European Union funds.

In its role as an interface between the Member States and at the request of the European Commission, for issues concerning defence, the European Defence Agency also coordinates the Consultation Forum for Sustainable Energy in the Defence and Security Sector, CF SEDSS. Launched in 2015 on the initiative of the European Commission as part of the Horizon 2020 framework programme for research and innovation, the CF SEDSS is now going into its third phase, with the objective of identifying available financing for research and innovation efforts in the defence energy sector.

Foster and support projects as part of European programmes

- **The European Defence Fund (EDF):**

In 2016, the European Commission proposed the creation of a European Defence Fund, potentially provided with a budget of 13 billion euros over the 2021-2027 period, in order to strengthen cooperation in research and development in the defence sector. France played an active role in the negotiations of the terms for the establishment of this fund, and proposed several projects as pilot programmes, which are the preparatory action for research in defence (Action Préparatoire pour la Recherche en matière de Défense, APRD) and the European Defence Industrial Development Programme (EDIDP). The "energy" element, as soon as these preparatory actions were undertaken, was taken into account, for example through the PILUM project to develop a railgun demonstrator (awarded to the Institut Saint Louis), chosen as part of the APRD.

The Ministry is actively involved in seeking the integration of actions that are useful for the armed forces in the energy sector into the works programmes of the European Defence Fund.

- **Horizon Europe:**

The framework programme of research and innovation of the EU for the 2014-2020 period, "Horizon 2020", devoted 5.9 billion euros to research on sustainable energy. This budget may be raised to 94.1 billion euros in the next framework programme for the 2021-2027 period, Horizon Europe. This programme should include two missions that directly concern energy.

If the projects with a defence interest are proposed for financing by the European Defence Fund, the Ministry for the Armed Forces will actively monitor the energy projects chosen as part of Horizon Europe, given the importance of civil technology in the Ministry's energy strategy. To do this it will rely on a reinforced dialogue with the Ministry of Higher Education, Research and Innovation (Ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation, MESRI), and it will report to that Ministry the sectors in which it is interested and the specific details of those sectors.

52 Overarching Strategic Research Agenda

Propose a project for a central oil purchasing agency at the European level

Relying on the expertise and experience of the SEA in terms of purchasing oil products abroad, France will propose a study on a central oil product purchasing agency to benefit the EU armed forces, thus supporting the construction of a European defence structure. The objective of the central purchasing agency is to allow bulk purchases in order to reduce product costs, and to provide European armed forces with a structure that is reactive and adapted to provide energy support to the armed forces. This entity may also include Great Britain. Its main missions would be:

- seeking the fuel resources necessary to maintaining efficient activities of EU Member States and Great Britain until they are made available;
- advising, without supplying resources (HR and equipment) to client nations.

The study would cover the following points:

- identify the Member States that would like to participate in this project;
- determine the legal status of the agency, its legal capacity to acquire and sell oil products in European territories to foreign clients on their own territory (internal consumption);
- determine the purchasing segment (marine fuels distributed in the civil sector – port supply), credit cards for service station networks and aviation refuelling;
- determine the financial support of the agency;
- determine the operating costs and total payroll, and operating methods.

Creating such an agency is an opportunity for France to position itself as a driver of development in European defence. If the SEA offers numerous assets for steering this project (oil product purchasing expertise, existence of the State's trade account), it must however measure the potential supply risks for the French armed forces.

R30- Support the development of cross-cutting or capacity projects in energy within the European Union as part of the Permanent Structured Cooperation (PESCO) and the European Defence Agency (EDA), by searching for financing from the European Defence Fund (EDF) and Horizon Europe:

1. Starting in 2020, coordinate the PESCO *Energy Operational Function (EOF)* project and favour PESCO to steer all European works in the energy sector:
2. Energy in camps,
3. Adapting batteries to the military context,
4. Operational planning tool;
5. Since 2018, participating in the EDA actions in the energy sector (R&D and capacity) and in the EDA's Consultation Forum for Sustainable Energy in the Defence and Security Sector;
6. Host a Consultation Forum on energy in France during the French presidency of the EU in 2022;
7. Support the approach initiated with the commission to see the energy topic fully integrate the EDF.

R31 - Study a joint purchase project for oil products to benefit European defence ministries by 2030.

4.2.2. Strategic and operational cooperation within NATO

Energy security policy within NATO

Outside of its historic role in standardisation, NATO has progressively been referred to on issues linked to energy in the defence sector by:

- defining its role in terms of energy security during the Bucharest Summit in 2008;

- the creation of the Energy Security Centre of Excellence (ENSEC COE) in Vilnius in 2012;
- the adoption of the framework for green defence in February 2014.

However, even if NATO does not have significant means in the research sector and that few projects are carried out at ENSEC COE, its research approach is based on three pillars:

- Enhancing Strategic Awareness, which promotes a better exchange of information and intelligence between member states of the Organization, as well as strengthening institutional ties;
- relying on protection of critical infrastructure which includes exercises, sharing best practices, training, and review of support resources;
- strengthening the efficiency of military forces by lessening their dependence on fossil fuels, using alternative and clean energy sources, simplifying and standardising fuels, as well as diversifying energy suppliers.

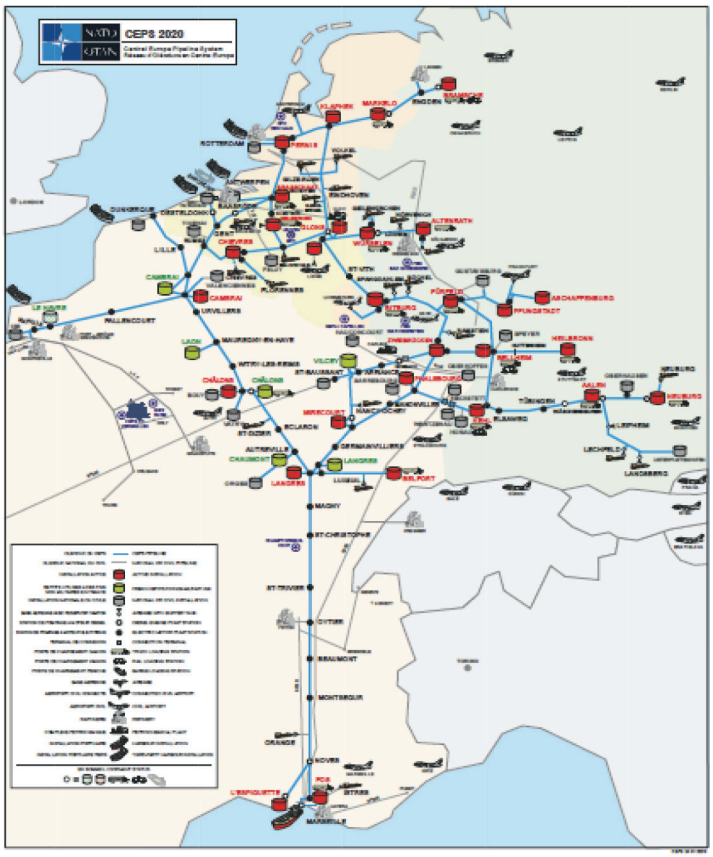
Strategic capacity of NATO's Central Europe Pipeline System (CEPS)

The CEPS is managed by the host nations and the United States. It provides military bulk transport capacity for refined oil products (5,314 km of pipeline network spread over five countries[53]) and bulk jet fuel storage capacity (1.2 million m^3). This military network, which is the only one of its kind in the world (linked, multinational, functioning as a fuel bank for jet fuel[54], reversible, extended capacity) is a strategic capacity for supporting NATO operations in Europe and French forces, as well as for resilience of fuel support, both for the benefit of the armed forces and for the French economy.

The CEPS is a supply method that is secure ar
other transport methods[55]. It contributes to
benefit of the French economy, and in suppor

This network makes it possible to set up strateg
with major support capacity and resilience in

The CEPS is vital for fuel support for an opera
the airborne operations of NATO against Serb



Multinational fuel support (Modular Combined Petroleum Unit (MCPU))

Modular multinational fuel support units come from a project involving the cooperation of nine nations[56] for providing energy support to a multinational force. This project comes from a 2016 NATO smart defence project. This capacity allows for sharing resources for the deployment of a complete fuel support chain to support a high intensity operation, under the leadership of a framework nation. The standardisation of the procedures and organisation of the MCPU[57] guarantee an implementation that is reactive and efficient. This capacity was deployed during NATO exercises (Trident Juncture in Norway

53 France, Germany, Netherlands, Belgium, Luxembourg

54 Functioning as a fuel bank: all CEPS clients can obtain jet fuel at every CEPS point thanks to the fuel bank system, as long as the client later restores the volume taken out of the network via one of the entry points.

55 Transport by pipeline generates three times less greenhouse gases than barge transport, four times less than rail transport, and five times less than road transport in tank lorries.

56 (FR/US/UK/DE/ES/IT/LU/TU/BE)

57 STANAG 7237 in the process of being ratified

and Spain, Capable Logistician), and in operations in Mali. It will ensure the support of the NRF (NATO Response Force) alert[58] in 2022.

The MCPUs are an efficient integration framework for fuel support resources, and they help in the sharing of efforts within a coalition, and they develop interoperability, training and fuel know-how between allies.

This integration role could be extended to alternative energy sources, including those needed for operations of camps on deployment, and as such could contribute to promoting innovations in terms of renewable energy and energy efficiency as part of a multinational operation.

Cooperation coordinated within the NATO Petroleum Committee

The NATO Petroleum Committee is the benchmark entity in terms of fuel support policy and standardisation of fuels and oil equipment. This committee, essentially focused on fuels, offers a privileged space for exchange between States on issues of interoperability, operational support, and on cooperation projects (i.e. MCPU, CEPS, NATO exercises, etc.).

The energy transition and its consequences for the armed forces are generally dealt with by sector (environment, infrastructure, energy security, logistics, etc.). Even so, the opening up of discussions seems indispensable in order to control the transition and to ensure that its operational application is efficient and coordinated.

NATO could put together a relevant forum to promote the overall operational energy approach, to which the Ministry for the Armed Forces could commit. France could thus support the widening of the scope of responsibility of the Petroleum Committee to alternative energy sources by proposing, for example, the development of energy efficiency projects for operations, and by coordinating discussions on alternative energy sources and interoperability. This means focusing actors around interoperability issues linked to new energy sources (alternative energy sources, batteries, smart camps, etc.) and to managing energy in operations. It will rely on ENSEC COE[59], Allied Command Transformation (ACT), and a Petroleum Committee with widened competencies and strengthened influence. The latter could for instance focus on:

- the promotion of alternative energy sources in order to improve operational performance (autonomy, flexibility, mobility) and develop standards relating to energy transition;
- the storage of electricity for stationing and mobility, as well as the related logistical support;
- contribution to the implementation of the NATO energy roadmap dedicated to NATO's role in the military aspects of energy security.

France has several advantages, including recognised expertise within the committee and in-depth knowledge of the NATO command energy network structure, which can be a good vector of influence and information.

R32 - Promote operational energy within NATO:

1. support normalisation and standardisation works on operational energy at NATO headquarters, and widen the scope of responsibility of the Petroleum Committee to alternative energy sources by proposing, for example, the development of energy efficiency projects for operations, and by coordinating discussions on alternative energy sources and interoperability.
2. support the concept of Modular Combined Petroleum Units (MCPUs) and offer to organise a cooperation exercise on operation energies that integrate Eco-Camp 2025-type blocks.
3. Support ENSEC COE in Vilnius, Lithuania with energy expertise in order to extend its scope of action to the support of operational energy.

58 NATO Response Force.

59 Energy Security Centre of Excellence (located in Vilnius), for which France holds the position of deputy director.

Bilateral cooperation with our European partners

Future systems such as FCAS or the future MGCS tank for which hybridisation of the power train is being studied, represent privileged thematic areas of cooperation with our European partners on these programmes in terms of reducing the carbon impact of our systems.

These cooperation efforts with Germany round out cooperation related to energy, which already exists for example with the Franco-German Institut Saint-Louis (ISL). As part of its work on railguns, the ISL, the European leader in the sector, carries out cutting-edge research on compact, high-power pulsed electricity sources, with a view to future integration on military platforms. The research conducted by ISL on embedded processing for sensors will also contribute to lowering electric consumption of weapons systems.

R&T works in cooperation with the United Kingdom were implemented for the FCAS TDC project, and a discussion is in progress to strengthen cooperation in the energy sector, given the shared issues that are present in this area.

Lastly, the shared works with Italy, that include the naval sector, should take into account the issue of optimising energy consumption on naval platforms, as part of shared R&T.

Bilateral cooperation with the US

Bilateral agreements with the US are formalised under a Data Exchange Agreement (DEA) to allow for the exchange of information on projects in progress and to identify possible areas of interoperability.

As well, France takes part in discussions at the ASTM for the certification of biofuels for the aviation sector. As of the date of this report, 5 biofuel sectors (FT-SPK, HEFA-SPK, SIP, FT SPK/A and ATJ-SPK) have been certified by the ASTM (ASTM D7566) allowing for adding up to 50% into fuel for aviation use.

R33 - Make energy, both in its operational and capacity elements, a thematic area of cooperation in our bilateral exchanges with our allies.

5. Adapt energy governance to the Ministry's ambitions

A non-organic and cross-cutting sector by nature, energy is currently understood by each of the services of the Ministry in a way that is scattered and in silos, each one in their sector of competence. Infrastructure energy is handled by the SID (SGA), and oil logistics by the SEA (EMA), while armament programmes are under the responsibility of the DGA. For the Ministry to take into account the global changes in terms of energy, it needs to increase coordination of organic works, as well as operational works and capacity works, including linking these to strategic considerations.

This approach is crucial for facing the issues of energy transition and the increasing restrictions in the sector. In order to open up discussion and coordinate the actors, to make sure that the objectives of the current strategy are well taken into account, a global system of governance must be implemented.

This governance would have three levels: a COMEX, an energy committee, and four pillars (covering operational energy, infrastructure energy, international and strategic relations, capacity, and innovation).

5.1. Level 1: A decision-making executive committee

Chaired by the Minister, an Executive Committee (COMEX) meets once a year, or by decision of the Minister, to make the decisions necessary for implementing the defence energy strategy.

5.2. Level 2: A single ministerial committee in charge of energy

The ministerial energy committee (Comité Ministériel Energie, CME) coordinates and organises the implementation of the defence energy strategy. It meets once or twice a year. Secretariat is provided by the operational energy (EO) department of the EMA and the senior civil servant with responsibility for the ministry's sustainable development (HFDD) so as to foster interactions between all components that deal

with energy within the Ministry. It includes representatives of the major subordinates of the minister (CEMA, DGA, SGA, DGRIS), as well as the heads of the thematic pillars (presented later in this document). The legal affairs department (Direction des Affaires Juridiques, DAJ), as well as relevant occasional participants (for example, the DPID) provide their expertise.

The participation of all of the actors favours interactions and dealing with cross-cutting issues. The consensus rule also guarantees that the specificities and the prerogatives of each actor are properly taken into account. Lastly, the energy committee sets the agenda of the COMEX and consequently coordinates the works of the different pillars.

5.3. Level 3: Four pillars with clear responsibilities

Four pillars are built around different sectors that concern energy: operational energy, infrastructure energy, international and strategic relations, capacity, and innovation. The mission of each pillar allows it to ensure that the theme is well taken into account within the Ministry. Each pillar can carry out discussions and works on issues that the Ministry must take into account in the years to come.

Each pillar mobilises all of the skills required and is steered by an actor who heads the area:

- The "International and Strategic Relations" pillar is steered by the DGRIS;
- The "Operational Energy" pillar is steered by the EMA/EO Division;
- The "Capacity and Innovation" pillar is steered by the DGA and the AID;
- The "Infrastructure Energy" pillar is steered by the DCSID.

The "International and Strategic Relations" pillar is steered by the DGRIS

The International and Strategic Relations pillar, steered by DGRIS, produces strategic analyses on geopolitical issues relating to the energy sectors in order to identify and prioritise the geographical areas where energy is a structural factor (securing streams).

In terms of cooperation, its mission is to:

- Identify with the relevant services beforehand the States and themes to approach in terms of cooperation;
- Coordinate all of the interactions with the actors abroad: cooperation involving the EU (including EDA), NATO, and bilateral cooperation, and support the competent services regarding their responsibilities (DGA for the EDA, the European Defence Fund, armament cooperation; EMA for the NATO portion, PESCO);
- Monitor that the Ministry for the Armed Forces' specificities are taken into account in the policy initiatives taken within the EU concerning energy, climate/defence, and the environment.

The "Operational Energy" pillar led by the EMA/DivEO

The mission of the operational energy pillar is to deal with issues related to energy necessary for operational functioning (excluding the nuclear sector) and for carrying out the operational contract of the armed forces.

It coordinates the actions of all actors involved with a view to:

- Elaborating, steering, and implementing the operational energy policy, and to monitor its results;
- Determining needs and the guidelines for resilience, and to develop the test scenarios for them;
- Determining and satisfying energy load-balancing needs for operations;
- Contributing to planning of operations by developing energy situation tools for theatres of operations;
- Developing the operational energy theme within NATO;

- Contributing to energy choice in programmes;

- Steering the operational energy function of PESCO.

"Capacity and Innovation" pillar steered by the DGA-AID

This Capacity and Innovation pillar develops choices in terms of energy in the preparation and steering of armament operations. It contributes to the consistency of actions and cooperation dealing with energy in plans and programmes related to armament, research, technology, and industry, as well as orientations in relation to infrastructure and mobility energy.

It monitors the consistency of activities linked to energy with the Ministry's innovation policy, and favours innovative actions for all related new energies and technologies. It also ensures monitoring of cooperation efforts in relation to armament and research and technology in the energy sector.

Lastly, this pillar participates in inter-ministerial actions that are related to equipment and systems (certifications, technology, regulations, etc.) and ensures monitoring of civil technology. It also monitors foreign investments in industry, in cooperation with the DGT.

"Infrastructure Energy" pillar steered by the SID

For the continuity of its missions carried out since 2013, this Infrastructure Energy pillar covers all of the issues related to energy consumed by Ministry facilities and their equipment. Its main missions are:

- Proposing the Ministry's energy policy, aiming to make high-performance infrastructures that meet operational objectives available to the armed forces, administrations and services.

- Steer and carry out ministerial strategy actions for energy performance, reducing consumption, reducing emissions of greenhouse gases, and reporting on these actions

- Steer the actions of the actors of the Energy function of infrastructure within the Ministry and inform them of changes in the regulatory context for stationed units,

- Monitor consumption and usage made of energy, excluding operational fuels, paying special attention to the security of data coming from infrastructure energy management systems

- Determine skills needs and adapt the activity sectors within infrastructure energy within the Ministry

For these missions, the pillar mainly relies on an infrastructure energy and water committee that is chaired by the central director of the SID. At the level of defence bases, the local combined energy-water committee (comité mixte énergie-eau local, CMEEL) ensures continuity at the level of supported units.

R34 - Provide for integrated ministerial governance that guarantees an open and consistent approach to the energy function within the Ministry and in interaction with the civil sector and foreign partners.

Glossary

EDA: European Defence Agency

AID: Defence Innovation Agency

IEA: International Energy Agency

ANSSI: French National Cybersecurity Agency

APRD: Preparatory action for defence-related research

ARPEGE: Distribution equipment for electricity production and energy management

BITD: Defence industrial technological base

CEPS: Central Europe Pipeline System

CF SEDSS: Consultation Forum for Sustainable Energy in the Defence and Security Sector

CMEEL: Combined local energy-water committee

COMEX: Executive Committee

CPCO: Operations steering planning centre

PESCO: Permanent Structured Cooperation

DAF: Directorate of Financial Affairs

DEFNET: Defence Network

DGA: Defence Procurement Agency

DGAC: Civil Aviation Authority

DGT: Directorate General of the Treasury

DMA: Marine gasoil

DOID: Defence innovation guidance document

DRM: Directorate of Military Intelligence

ECA: Emission Control Area

ECV: Commitment for green growth

EMA: Joint Staff

EnR: Renewable energy sources

ENSEC COE: ENergy SECurity Centre of Excellence

ENSSURE: ENergy Self SUfficient REsilient military base

EO: Operational energy

EDF: European Defence Fund

EOF: Energy Operational Function

FREMM: Multi-Mission Frigate

GHG: Greenhouse gas

LNG: Liquefied natural gas

HAPS: High Altitude Pseudo Satellite

HFDD: Senior civil servant with responsibility for the ministry's sustainable development

ISL: Institut Saint-Louis

MAP: Steering Support Mission

MAPS: Medium Altitude Pseudo Satellite

MARPOL: Marine pollution (International Convention for the Prevention of Pollution from Ships)

MCO: Maintenance in operational condition

MCPU: Modular Combined Petroleum Units

MESRI: Ministry of Higher Education, Research and Innovation

MGCS: Main Group Combat System

MMR: Micro Modular Reactor

MTES: Ministry for the Ecological Transition and Solidarity

NSPA: NATO Support and Procurement Agency

OPEX: Overseas operations

OSRA: Overarching Strategic Research Agenda

NATO: North Atlantic Treaty Organization

EDIDP: European Defence Industrial Development Programme

R&D: Research and development

R&T: Research and technology

RCU: Urban heat networks

REM: Frame of reference for ministerial jobs and professions

S2I: Infrastructure information systems

SCA: Administrative, General Support and Legal Service

FCAS: Future Combat Air System

SEA: Petrol, Oil and Lubricant Services

SFP: Single fuel policy

SGAE: General Secretariat for European Affairs

SIAG: Information, administration and management systems

SID: Defence Infrastructure Service

SIOC: Operational information and communication systems

SIST: Scientific and technical information systems

SMPE: Ministerial energy performance strategy

SMR: Small Modular Reactor

SPO: Operational preparedness system

SWAP: Size, Weight And Power

TBB: Technological Building Blocks

EU: European Union

Appendices

Appendix 1 – Summary of recommendations

1. Energy in the 21st century: globalised resources, energy transition and defence challenges	
1.1. A global energy context that is changing and tense	
R1	Map the sources and sectors in the strategic ores sector for January 2021.
1.2. Promote a strategic approach to energy security	
R2	In order to secure streams, analyse the geostrategic changes and their impact on the energy sector and adapt the system accordingly.
2. The Ministry for the Armed Forces facing the challenges of energy transition	
2.1. Identify the specificities of defence in a context of strengthening of the European and national normative framework	
R3	Ensure normative and regulatory monitoring within the Ministry to identify texts that need to be modified for the needs of defence-related activities.
2.2. Control energy consumption	
R4	Before the end of 2021, deploy a measurement and analysis tool for consumption of energy streams in order to optimise them for all of the Ministry's facilities.
R5	Starting in 2020, define and implement a digital sobriety policy: Monitor the consideration of the environmental footprint in the choice of internal and external hosting solutions for the Ministry for the Armed Forces; Future data centre renovations or constructions will be carried out integrating the systematic recuperation of the heat emitted by the equipment; Foster ecological information system development, both internally and externally, by favouring the ecodesign of software, and by introducing this criterion into contracts in order to influence construction companies and publishers; Integrate the GreenTech dimension to the training offer of the digital academy (*Académie du numérique*) and promote this dimension within the Ministry.
R6	Launch the GENOPTAIRE study at the end of 2020 in order to adapt energy optimisation methodologies to military specificities with integration into the programmes for the three areas starting in 2022.
R7	Increase the portion of virtual simulation in training, as a complement to real-world activity, to optimise the use of energy resources and increase the level of realism, all while maintaining the level of operational performance.
2.3. New types of risks to take into account	
R8	Continue cybersecurity actions within the Ministry for the Armed Forces for digital systems directly linked to energy: Mapping, application of information system hygiene rules, and maintenance of the implementation of security supervision for the most critical elements; Accelerate the cybersecurity approach in the energy digitalisation projects (smart grid, etc.).
R9	Implement an energy (NRJ) hackathon after summer vacation in 2020 in order to uncover any possibly undetected risks

3. Make energy an operational advantage	
3.1. A renewed approach to energy issues	
R10	**Favour evolution of mentalities and practices towards a culture of sober energy use that is in line with operational imperatives:** Implement a training programme related to energy issues and usages in the armed forces' schools, and preliminary and continuous training centres. Broaden the application of the ISO 50001 approach and encourage user adoption of ecoresponsible behaviour in their daily lives;
R11	**Establish a mapping of specialised skills that are indispensable to have or to acquire, internally or through partnership, with energy producers and industrial actors.**
R12	**Make accounting for the "energy" portion systematic in the preparation and steering of armament operations and over the entire life cycle.** Broaden the inclusion of ecodesign and energy efficiency requirements to all armament operations, and make them a criterion of choice within the Ministry; Audit industrial general contractors that have contracted with the Ministry for the Armed Forces, relating to their consideration of ecodesign and energy efficiency in their works and products; Deploy the approach on new programmes, including the 4/6 tonne truck programme, and the Patrouilleur Océanique programme. Integrate a theme linked to energy optimisation into cooperation programmes as started with our German partners on the NGF and the MGCS.
R13	**Create a dedicated operational energy division within the EMA, which will be in charge of:** Development of a sober energy culture; Training for taking into consideration the issues and usages of energy; Reinforcement of resilience and continuity of operational activities; Planning and deployment of innovative energy capacities in operations; Preservation of the single fuel policy; Implementation of a specific organisation relying on a network of key persons; Opening up energy information and forecasting to develop operational methods of action which are both offensive and defensive in nature.
3.2. Securing operational energy	
R14	**Develop an overall policy for energy resilience by initiating an evaluation of sites starting in 2020 for solutions put in place in 2025:** Establish a mapping of vulnerabilities for end-of-year 2021; For end-of-year 2022, consolidate existing concepts concerning resilience, evaluate them, and validate them through testing with "crisis" scenarios, taking into account operational missions that could be requested of armed forces operating in continental France (politically sensitive persons, dissuasion, national emergency response unit (échelon national d›urgence, ENU), strengthening platforms in OPEX, specifically airborne forces). Lessons learned from the Covid-19 crisis will be taken into account; For end-of-year 2022, define the energy needs of the most critical infrastructure, and develop resilience and continuity criteria for activities, and broaden the scope of the communication of requirements to all ADSs; these elements will constitute a foundation to establish steering guidelines for update; Identify new emerging skills to have internally or within the BITD for maintaining our critical installations in operating condition.

R15	**I**ntegrate disruptive energy sources or renewable energy sources that allow for increased energy self-production capacity in facilities, and thus the resilience of the armed forces, following the example of the ENSSURE project and energy performance contracts.
R16	Integrate energy into operational planning: Implement the energy coordinator function into the operational chain, in order to have an overall vision of energy, and to ensure that energy needs are met in a coordinated fashion between all actors; Develop and operate a robust planning and decision-making support tool, in order to estimate consumption.
R17	Preserve the capacity of the armed forces to operate using a single fuel in order to meet requirements in terms of mobility and the intervention of armed forces.
R18	Size security stocks by taking into account consumption that can be forecast, linked to the arrival of new equipment and to changes in activity: 1. For the 2020-2025 period, this means increasing security stocks of fuel for the armed forces by 60,000 m^3 for a cost of €14 million.
3.3. Minimise the energy footprint to increase operational performance and resilience	
R19	Take advantage of innovations in the civil sector, by adapting them to military usage cases: Launch three innovation acceleration projects in 2021 (alternatives to diesel electrical generators, cleaning of photovoltaic panels in restrictive environments (sand), hydrogen in camps; For the 2020-2025 period, €23 million will be invested in open innovation.
R20	Starting in 2022, develop a hybrid armoured vehicle demonstrator in order to provide powertrain choice criteria for the Griffon and VBCI in 2025.
R21	Launch an ENERTOP technical and operational study starting in 2020 to study the interest and feasibility of integrating new energy technologies, specifically hydrogen, on ground platforms, from the perspective of military constraints and related logistical impacts (production, storage, transport, distribution) and carry out the related technological studies.
R22	As long as no other replacement technology has been developed, ensure that the ground systems are compatible with aviation biofuels that are certified, or in the process of being certified, and define the related conditions of use as part of the implementation of the single fuel policy.
R23	Ensure monitoring of different marine fuels and of different solutions for naval propulsion, as well as their availability and supply in the defence context (for example: hydrogen fuel cells, electric motors) in order to anticipate changes and maintain deployment capacity.
R24	Optimise, on a case-by-case basis, the propulsion and architecture of new vessels based on their size and their use, giving priority as soon as possible to "all-electric" architecture. Starting at the vessel design phase, the offshore patrol vessels *(Patrouilleurs Outre-Mer*) programme integrates the energy performance aspect, an aspect which will be verified in 2022. The ocean patrol vessel (*Patrouilleur Océanique*) programme plans to incorporate energy into the choice criteria as part of the value analysis to come, seeking optimal design.

R25	Prepare for using alternative fuels (biofuels), including in logistics, according to their technical, economic, operational, and environmental interest, consistent with developments in the civil domain. *The MINARM is committed to the national effort to decarbonise by ensuring minimal consumption of biojet fuel, and to work towards carbon neutrality by 2050 for the aviation sector.*
R26	Furnish technical expertise to the DGAC on the national roadmap for powertrains for civil aircraft, whether in propulsion or not, and monitor the taking into account of the Ministry's energy issues in future programmes: Integrate civil developments into the preparation of military programmes Explore solutions that will help guarantee provision of the energy needed (for example, to power the Rafale's AESA NG radar); Study the modernisation of electricity generation in aircraft in order to have more power available compared to existing sizing and at a constant level of security; Study the possibilities of storing energy on board by optimising energy produced by alternators.
R27	Once testing is finalised, broaden the application of the Eco-Camp 2025 project, which seeks to reduce consumption and increase energy autonomy of deployed camps in operation: Develop camp technological building blocks (hybrid electric generator, photovoltaic cells, building performance) aiming for water and energy autonomy by relying on civil technology between 2020 and 2022; Test these systems in external operations between 2023 and 2025; Have a digital version of this camp model available to allow for prospective planning of deployment and operational maintenance of deployed camps by 2028.
R28	Starting with testing carried out on the national territory, study the integration of renewable energy sources (EnRs), the replacement of generators, and the use of hydrogen in facilities and in operations: Launch testing of a hydrogen-photovoltaic electric generator in the Glorioso Islands for the second half of 2020; Launch testing of a photovoltaic-diesel electric generator in French Guyana for the second half of 2020;
4. Adjust our level of strategic autonomy to exact operational needs	
4.1. Identify and control technological and industrial dependence	
R29	In domains identified as strategic, ensure the national control of energy technologies used in the military domain by maintaining a BITD that is accessible via: Support of French BITD businesses that are active in the energy sector, including as part of foreign investments in France; A variety of suppliers for dual-use technologies; 1. Relying on our European partners.

4.2. Develop strategic cooperation	
R30	**Support the development of cross-cutting or capacity projects in energy within the European Union as part of the Permanent Structured Cooperation (PESCO) and the European Defence Agency (EDA), by searching for financing from the European Defence Fund (EDF) and Horizon Europe:** Starting in 2020, coordinate the PESCO *Energy Operational Function (EOF)* project and favour PESCO to steer all European works in the energy sector: - Energy in camps, - Adapting batteries to the military context, - Operational planning tool; Since 2018, participating in the EDA actions in the energy sector (R&D and capacity) and in the EDA's Consultation Forum for Sustainable Energy in the Defence and Security Sector; Host a Consultation Forum on energy in France during the French presidency of the EU in 2022; Support the approach initiated with the commission to see the energy topic fully integrate the EDF.
R31	**Study a joint purchase project for oil products to benefit European defence ministries by 2030.**
R32	**Promote operational energy within NATO:** Support normalisation and standardisation works on operational energy at NATO headquarters, and widen the scope of responsibility of the Petroleum Committee to alternative energy sources by proposing, for example, the development of energy efficiency projects for operations, and by coordinating discussions on alternative energy sources and interoperability. Support the concept of Modular Combined Petroleum Units (MCPUs) and offer to organise a cooperation exercise on operation energies that integrate Eco-Camp 2025-type blocks. Support ENSEC COE in Vilnius, Lithuania with energy expertise in order to extend its scope of action to the support of operational energy.
R33	**Make energy, both in its operational and capacity elements, a thematic area of cooperation in our bilateral exchanges with our allies.**
5. Adapt energy governance to the Ministry's ambitions	
R34	**Provide for integrated ministerial governance that guarantees an open and consistent approach to the energy function within the Ministry and in interaction with the civil sector and foreign partners.**

Appendix 2 – Working group mandate

MINISTRY FOR THE ARMED FORCES

Paris, 24 September 2019

No. 5300/ARM/CAB/CC5

Ministry for the Armed Forces

to

Distribution list attached

SUBJECT: Energy Working Group Report

Energy is at the core of contemporary issues: growing needs for mobility and the digital world, tensions over resources, development of alternative energy resources, opposition to nuclear energy, global warming, energy transition, etc. The armed forces, and the defence sector in general, are no exception, and are directly concerned, whether in terms of operational efficiency (operations, training, and equipment) or stationing of forces. To meet these challenges and to adapt to these new balances, the Ministry for the Armed Forces must structure its study and build a strategic plan to adapt to this context undergoing profound change.

Work has already been carried out, either by support services (SEA and SID) directly concerned by energy issues, or by the joint staff of the armed forces as part of the general military strategy orientation group (GOSM), or by the directorate general of armament as part of its prospective work, and more generally while armament programmes are carried out. Without calling these studies into question, this means ensuring that they are well coordinated and that the Ministry's energy future is well prepared, in a context that is rapidly changing.

Consequently I decided to launch, under the direction of my civil and military office director, a ministerial working group that will cover this issue comprehensively, in order to define a defence strategy on energy.

In order to cover all of the areas of the subject, the work will be organised according to four major themes: an overall review of the current conditions, changes in the defence energy sector, capacity-related strategies, and lastly, guidelines for a ministerial energy policy. Each theme will be the subject of proposals validated as the study progresses, during steering meetings with the office director. Work sessions will precede these meetings, steered by my office under the responsibility of my industrial affairs advisor.

The EMA, including the SEA, the DGA, the SGA, including the SID, the joint staff of the armed forces, the DGRIS, and the AID will participate in this study. Additional actors may be brought in as needed, coming both from the Ministry and from the civil sector, public organisations, research organisations, or businesses in the sector.

The work schedule must provide for the coverage of one theme each month, in order to finish the works by the end of the month of March 2020. I am counting on everyone's commitment to carry out this study and to support the ministerial approach to this issue, which is critical for our future.

(signature)

Florence Parly

DISTRIBUTION LIST:

- Chief of staff of the armed forces;
- Delegate general for armaments;
- Secretary general for the administration;
- Director general of international relations and strategy;
- Chief of the general control of the armed forces;
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- Air force general, Chief of staff of the Air Force;
- Admiral, Chief of staff of the Navy;
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- Europe and Africa advisor;
- Colonel, Chief of the reserve office;
- Naval captain, "navy" deputy;
- Colonel, "air force" deputy;
- Colonel, chief of the "preparation for the future" unit;
- Colonel, chief of the "international" unit.

Appendix 3 – List of interviews and visits carried out

Ministry for the Armed Forces

GAL FERRE Jean-Charles	SEA
VA CHAINEAU Jean-Philippe	DPID
CA JAOUEN Patrice	DIRISI
Mme FAURE Camille	DAJ
Mme PLIER Valérie	SGA MAP
Mme PRIN LOMBARDO Julie	DGNUM
M. BOMBAL Sébastien	COMCYBER

SGDSN

Laurent Ducamin

SGPI

Karine Vernier

ANSSI

Henri Hémery

Ministry for the Ecological Transition and Solidarity

Aurélie Lecureuil	DGALN
Anne-Fleury Coron	DGEC
Aurélien Louis	DGEC
Nicolas Morin	DGEC
Antoine-Tristan Mocilnikar	SDSIE

Ministry for Europe and Foreign Affairs

Vanessa Salas-Pouget	DGM
Pierre Dubouchet	ASD
Yann Rivoal	ASD

Ministry of the Economy, Finance and Recovery

Marc Rico	DGE

Representing France

Julien Daemers	EU PR
ICETA2 Jean-Sébastien Vautier	NATO PR

Research centres

Hélène Burlet	CEA
Stéphane Sarrade	CEA
Pascale Lehman	Institut Saint-Louis
Christian de Villemagne	Institut Saint-Louis
Nicolas Mazzuchi	FRS
Marc-Antoine Eyl Mazzega	IFRI
Berengère Mesqui	France Stratégie
Sylvie Matelly	IRIS
Christophe-Alexandre Paillard	CNRS

Agencies

Yasmine Arsalane	IEA
Frédéric Boissier	ADEME

Companies in the energy sector

Antoine Nogier	Sun'R
Matthieu Soulas	Total
Julien Pouget	Total
Nils Joyeux	Zephyr&Borée
Marc Bussieras	EDF
Xavier Carton	RTE
Steve Arcelin	Akuoenergy
Jean-Michel Germa	Soper
Anne-Laure de Chammard	Engie
Julia Maris	Engie
David Reulier	SAFT
Paul-Edouard Niel	Air Liquide
Alexis Duval	Tereos

Companies in the transportation sector

Jacques Gerault	CMA-CGM
Nathalie Simmenaur	Air France

Industrial companies in the defence sector

François Deloumeau	Arquus
Charles Maisonneuve	Arquus
Eric Papin	Naval Group
Guillaume Rochard	Naval Group
Victor Bouissou	Naval Energies
Marie-Colombes Célérier	Naval Energies
Jean-Michel Remblière	Nexter
Alexis Mabile	Nexter
Thierry Rouge-Carassat	Safran
Grégoire Aladjidji	Safran
Nicolas Jolen	Safran
Bruno Stouflet	Dassault
Henry Michel	Dassault

Appendix 4 - NATO single fuel policy

The single fuel policy (SFP), started by NATO in the 1970s, was adopted by the French armed forces at the end of the 1990s.

The principle of the SFP is the use of one and only one fuel, jet fuel for aviation jet engines with anti-icing additive (F-34) on the battlefield and for airborne operations.

France has however chosen to only use F-34 in emergency situations, and prioritise diesel jet fuel, referred to as F-63, a jet fuel that is mixed with an additive that improves its cetane index and lubricity prior to it being used in a diesel engine.

Nevertheless, this policy only applies to military resources for operational use. Recent vehicles in the commercial range, which have pollution control systems that meet recent European emissions standards (starting with Euro 5) should not use F-63, as that fuel's sulphur content would impact the exhaust gas treatment systems in those fleets. Deployable equipment and vehicles must therefore be able to use "exotic" diesel fuels, as well as F-63. Therefore, since 1996, the DGA designs operational equipment that can continuously function on jet fuel, without a loss in performance.

A fuel that is of consistent quality, around the world

The jet fuel used by civil and military aviation meets very stringent international specifications that are all equivalent. Its quality is the same wherever it is available, which is not the case for diesel, the quality of which in certain theatres of operation can be very much removed from the quality found in Europe.

In operations, using F-63 can avoid problems linked to using poor quality diesel fuel.

Managing a single product during operations, a source of savings

Using only F-63 in a theatre of operations is a source of savings because it lowers personnel, infrastructure, transportation, and storage needs.

Improvement of the security of supply

Implementing the SFP supports simplifying the deployment of armed forces and guarantees their energy independence during operations. Around the world, jet fuel is immediately available on aviation platforms, which are generally used as the point of entry for overseas operations. Defuelling of transport aircraft also provides an initial supply to armed forces in isolated zones.

Operational advantages

In certain theatres of operations, weather conditions require the use of fuels that remain fluid at very low temperatures. Diesel that fulfils this requirement requires specific refining methods and supply chains, and dedicated storage facilities. Its availability is not ensured, including in entry to the theatre of operations. Using F-63, given its excellent performance in low temperatures, overcomes these constraints.

Moreover, using only F-63 reduces the logistical footprint, and also makes it possible to increase fuel logistics reactivity and the potential for sharing fuel resources between allied forces.

A prerequisite for operations between allies

The SFP is implemented by most of our allies, including the United States Army. In order for France to be able to participate in operations with allied forces, it has to have equipment that is compatible with F-63.

Considerable experience in operations

Since operation DAGUET, France has implemented the SFP on many occasions, including during MINPRENUC (Cambodia, 1991), ORYX (Somalia, 1992), TURQUOISE (Rwanda, 1994), PAMIR (Afghanistan, 2002), ARTEMIS (DRC, 2003), BERYX (Indonesia, 2005), BARAL (Pakistan, 2006), and EUFOR (Chad, 2008).

Lastly, the SFP is currently implemented for the entire BARKHANE operation in the Sahel.

Appendix 5 - Biofuels, vectors for decarbonising mobility

Synthetic fuels seem like a transitory solution between oil-based fuels (which we refer to as conventional fuels) and disruptive energy sources (hydrogen, etc.). They offer the advantage of being able to be mixed with conventional fuels and being able to be used in internal combustion engines, as well as in existing turbojet engines without technical modification (drop-in fuels).

Aviation biofuels

Today there are six sectors of biofuels that are certified by the ASTM (ASTM D7566) which allows us to add in up to 50% for aviation usage.

In France, the HEFA sector (hydroprocessed oils) is the most developed (the TOTAL hydroprocessing plant in La Mède, with an annual production capacity of 500,000 tonnes). Even though the cost of HEFA plants is moderate, the raw material is very costly and lacking in availability, since it is usually in competition with usage in foodstuffs. This is why TOTAL planned to use palm oil, which has the lowest cost price, but is not authorised to be marketed in France.

Over the medium term, gasification plants for the raw material (using the Fischer-Tropsch (FT-SPK method) will likely develop because the technology is already mature.

In particular, the BioTfueL project should be noted, which aims to thermochemically convert lignocellulose biomass (straw, forestry residue, dedicated agriculture, etc.) into biofuels, in order to develop a complete chain of processes to produce biodiesel and second-generation biokerosene (Axens, Total, CEA, IFP Energies Nouvelles, Avril, Thyssen Krupp Industrial Solutions).

Contrary to the HEFA process, FT plants are very costly, but the raw materials used are inexpensive and diverse (forestry residue, agriculture residue, wood, paper, and unrecycled cardboard, household waste, etc.).

Resources (biomass) for this sector seem available and of sufficient quantity to meet the needs of the French aviation fuel production sector. However, thought needs to be given to the means of collection and transport of these raw materials to the production plant.

Over the longer term, the Alcohol-to-Jet Fuel (ATJ) sector also has promise, specifically when the alcohol is produced from biomass (Futurol Project – IFP, Axens) – it can also come from the conventional bioethanol market. For this sector, R&D efforts are still needed in order to bring down costs.

It should be noted that the processes for synthesising fuel using renewable sources of electricity or thermal solar resources (processes called "Power to Liquid", "Sun Fuels" or "e-fuels") are currently being studied in detail by most of the ground transport and air transport actors. These processes make it possible to create liquid fuels, chemical intermediaries, or methane using water and CO_2, captured from the atmosphere or from industrial emissions.

The "Power to Liquid" process uses electricity for this, to carry out on the one hand the electrolysis of water to produce hydrogen, and on the other to capture CO_2 and reduce it to CO. The synthetic gas that is obtained from this can fuel a Fischer-Tropsch-type chemical reactor, and therefore possibly produce drop-in jet fuels. Another process, called "Sun to Liquid" uses solar energy to carry out reactions using thermal means.

These processes present strong potential for growth, for their synergy with the functioning of intermittent renewable energy (solar, wind), their capacity to produce drop-in fuels and their synergy with Fischer-Tropsch-type sectors developed also for exploiting biomass. However, a certain number of points remain that need to be validated, such as the efficiency of CO_2 capture or the reduction reaction used to reduce this CO_2 to CO (Reverse Water-Gas Shift). The German/Swiss actors are particularly well positioned in this sector (Sunfire, ETH), but the CEA is currently developing an interesting expertise in the sector.

In any case, the development of these sectors requires incentive schemes, given the higher cost of biofuels compared to conventional fuels.

A government roadmap was drafted by the Ministry for the Ecological Transition and Solidarity (MTES) for deployment of sustainable aviation biofuels as part of the commitment to green growth (ECV) signed in 2017: the proposed trajectory is to add jet fuel from the biofuel sector for up to 0.05% in 2020, 2% in 2025, 5% in 2030, and 50% in 2050. The last inter-ministerial meeting on the subject (inter-ministerial meeting of 29/10/2019) confirmed that no financial penalty mechanism (in case of not using biofuels) was planned at this point and that it would be the subject of a call for interest with sector actors (refining companies and aviation companies).

Ground and marine biofuels

The technologies mentioned previously also apply to the production of biofuels for ground or marine use. Biodiesel is already produced and marketed in several European countries and in the United States. It is also starting to emerge for marine applications.

While it could be promising for the MINARM to promote the development of biofuels in the aviation sector, and possibly in the marine sector, the ground transport biofuels market will impose itself naturally in the French oil landscape.

Concerning liquefied natural gas (LNG) for marine use, it is suggested at this stage to eliminate development perspectives in this fuel for the armed forces: this technology does not offer sufficient guarantees in terms of security to be used on French navy vessels.

Supply of LNG in the case of limited use in a captive fleet (in-harbour vessels, for example) would be externalised in order to avoid significant investment, including in terms of infrastructure and skills acquisition. Use of electric motors is therefore a priority.

This technology is developing globally and will partially replace marine gasoil (DMA), it is suggested that DMA capacities be actively monitored in order that the fuel remain available for refuelling of vessels.

Appendix 6 - Towards low-carbon facilities by 2025

The national low-carbon strategy (SNBC) that was established in 2015 describes France's roadmap to reduce greenhouse gas emissions by 2050.

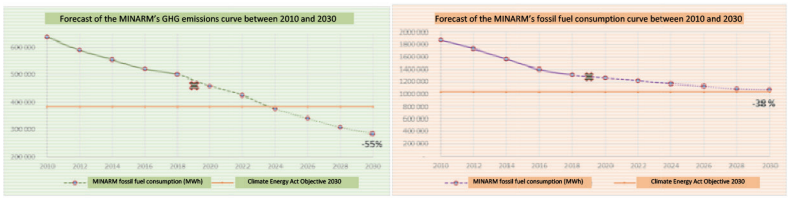
This strategy simultaneously involves a drastic reduction in energy consumption, giving priority to reducing the use of the most carbon-dense energies, by the use of new technology, as well as by changing behaviour.

The French multiannual energy policy (PPE) stipulates that the construction sector should resolutely turn to building high-performance buildings and renovations, which also integrate renewable energy sources.

Since construction is the largest consumer of energy at the national level, reducing the sector's consumption is therefore a key issue. The Ministry, with its more than 30 million m^2 of assets, or more than 26% of the built assets of the nation, must be proactive, while ensuring the total maintenance of its operational capacities, to make the governmental policy principles its own, meaning ending the use of carbon-based energy, building new construction that is high-performance, carrying out the renovation of existing facilities, and using renewable energy sources in construction.

To meet these multiple objectives, a Ministry strategy for energy performance for infrastructure and non-operational mobility has been established.

The implementation of the SMPE established for the period of the PPE (2019-2023) makes it possible to reach the current overall national objectives of the construction sector updated by the plan for energy and climate, i.e. end energy consumption decreased by 20% in 2028 (graphic on the bottom left), fossil fuel-based energy consumption decreased by 40% in 2030 (graphic in the centre) and greenhouse gas emissions lowered by 54% in 2030 (graphic on the right). These efforts will be continued and integrated into the upcoming versions of the applicable strategy.



These decreases are the result of the implementation of 18 supplementary actions that support 6 objectives:

Commitment no. 1: *reduce energy consumption*

- **Objective no. 1:** move towards clean mobility
- **Objective no. 2:** improve the energy efficiency of defence bases
- **Objective no. 3:** have tertiary and residential facilities that are energy efficient

Commitment no. 2: *develop renewable energies (EnR)*

- **Objective no. 4:** Place au Soleil (2,000 ha used for PV)
- **Objective no. 5:** give priority to connections to urban heating networks (RCU)
- **Objective no. 6:** test self-consumption for EnRs

Monitoring of these objectives and the progress of the actions are presented by each pilot in the Energy-Water committee meeting chaired by the central director of the SID.

The path to low-carbon buildings for each defence base will be gradually extended in an appendix, called the green appendix, inserted into its building guidelines.

Objectives	Actions of the 20-23 SMPE	
No. 1: move towards clean mobility	1	By 2030, have a fleet of administrative vehicles that is composed of at least 50% vehicles that emit low amounts of carbon dioxide (CO_2) and air pollutants, according to a trajectory that has milestones set at 20% in 2023, and 25% in 2025 (pilot: EMA)
	2	For the 2019-2023 period, gradually provide each defence base with a "clean mobility" plan (pilot: EMA)
No. 2: improve energy efficiency of defence bases	3	Award twelve energy performance contracts (CPEs) for the 2020-2025 period (pilot: SID)
	4	Deploy operating/maintenance contracts for heating, ventilation and air conditioning installations with incentive clauses on energy-heavy sites for which a CPE is not justified, according to an overall plan to be established, as a first version, in 2020 (pilot: SID)
	5	By 2023, implement an ISO 50001-compliant energy management system in at least one major site of each of the 15 highest-consuming defence bases (pilot: SID)
	6	Over the 2020-2031 period, plan for the replacement of all heating systems using coal or fuel oil, excluding backup heating systems, with heat production systems that are less polluting and that use less energy, according to an energy transition plan to be established, as a first version, by March 2020 (pilot: SID)
No. 3: have tertiary facilities that are energy efficient	7	Excluding an exception justified by considerations linked to activities that are specific to defence, apply the obligations to reduce end energy consumption of tertiary facilities, as soon as the heavy remodelling of existing facilities is decided and committed (pilot: SID)
	8	Establish a prospective 10-year implementation plan for the Decree of 23 July 2019 relating to the obligation to act to reduce end-user energy consumption in existing tertiary facilities (pilot: SID)
	9	Carry out, every time it is possible to do so, all new construction of tertiary facilities according to "positive energy" standards and according to "high environmental performance" standards (pilot: SID)
	10	By 2038, carry out the energy renovation of residential facilities that are useful to the Ministry for the Armed Forces (pilot: DPMA)
	11	In 2023 at the latest, complete the implementation of the fluid monitoring tool (OSF) and the DATANRJ360 tool for measuring and analysing current consumption of Ministry for the Armed Forces infrastructure (pilot: SID)
	12	Establish all of the technical requirements according to the energy efficiency certificates (CEE) and renew the system starting in 2021 (pilot: SID)
No. 4: by 2022, mobilise 2,000 hectares of land for photovoltaic power plants as part of the "Place au soleil" plan	13	Carry out, while ensuring that obligations are met and without impeding the development of facilities and the installation of operational systems, the calls for projects necessary for renting approximately 1,800 hectares of available land to photovoltaic power plant operators (pilot: SID)
	14	Carry out land sales, representing a cumulative surface area of approximately 200 hectares to local authorities that will install photovoltaic power plants on that land (pilot: DPMA)
No. 5: give priority to connecting facilities to urban heating or cooling networks	15	Give priority to the connection of sites of the Ministry for the Armed Forces to urban heating or cooling networks whenever such a connection is possible (proximity of such a network) and opportune (after studying alternative solutions) (pilot: SID)

No. 6: test self-consumption of renewable energy	16	Continue experimental projects of producing photovoltaic or thermal solar energy for self-consumption purposes, while ensuring that obligations are met and without impeding the development of facilities and the installation of operational systems. As well, seek to progressively spread self-consumption, start and then maintain a count of sites that could potentially host the tested technology (pilot: SID)
	17	By 2023, carry out the testing of a biogas production site at the Coëtquidan camp, and decide on a potential spreading of the process to other camps or sites that offer the same potential of exploiting local biomass (pilots: EMAT and SID for exploiting and using the resource, and using the energy produced).
	18	In 2020, choose a site to test renewable energy production for self-consumption from a small wind turbine farm of low or medium voltage, and carry out the testing starting in 2021 (pilot: SID)

Appendix 7 - Eco-Camp 2025

The Defence Infrastructure Service (SID) designs, develops, purchases, plans, maintains and improves the installation of stationing infrastructure for the armed forces engaged in operations. In this framework the service is charged with producing energy, potable water, and soil decontamination when theatres of operations are closed.

Concerning support of stationing, and in application of DIA 4, it is in charge of, among other responsibilities, monitoring equipment and material technology used to equip deployable camps. Given the societal changes and changes in the construction and public works sector (digitalisation, sustainable environment, alternative energy sources), and in compliance with letter n, paragraph 4.2, last section of D17-005480/ARM/EMA/PERF/BPSO/NP dated 22/09/2017, the SID began a prospective approach that it named Eco-Camp.

Stationing camps are very dependent on incoming and/or outgoing streams to/from outside the camp (fossil fuel-based energies, potable and waste water, solid waste). Electric energy is a crucial point during all phases of the manoeuvre. Currently camps use energy that is exclusively produced by generators that operate on diesel. These incoming and outgoing streams generate:

- a weakness in the security of the armed forces;
- significant logistical costs;
- noise and olfactory pollution (electric generators);
- significant dependence of the camp in relation to the external domain;
- sources of accidental pollution.

Several entities of the armed forces and foreign armed forces are discussing and participating in setting up innovative installations, including using renewable energy sources. However, solutions have not yet been seen that deploy measures that are overarching, sustainable, secure, and systematic that would give camps a sufficient increase in energy autonomy. The need to take the environmental aspect into account, from the moment a camp is set up, is also included. This is for two reasons: societal acceptance of the commitment undertaken, and to reduce costs and delays that occur in terms of rehabilitating the area after the armed forces have departed

The key idea is to aim for camp autonomy during operations in order to diminish their vulnerability in day-to-day operations.

This target will be reached using the main orientations of the Eco-Camp project, which are the foundation of the project carried by the SID expertise centre:

Reduce consumption (water and energy) while integrating the new needs of the armed forces;

Produce potable water and energy differently;

Optimise new equipment. Interactions between infrastructure equipment will be studied. The waste from one element could provide the energy for another.

These orientations seek to meet the resilience objective for operational installations.

The Eco-Camp 2025 project and its objectives will make it possible to lower consumption of fossil fuel-based energy in stationed camps (for the part related to infrastructure) to decrease by 40% in 2030, by using renewable energy sources and by increasing the energy efficiency of production equipment and terminals. This reduction goal is comparable to the objectives and trends of the climate plan.