EURODEFENSE

Federation of European Defence Technology Associations

Energy Transition as an Operational Advantage for the Military

EDTA / EURODEFENSE Working Group (EWG26)

Preamble

This report focuses on the policies, need and options for use of sustainable[1] energy in major military combat systems like naval vessels, aircraft, vehicles and in military compounds, especially during operations. Energy transition could be a **necessity** to adapt to in a new fossil fuel free society and an **opportunity** to achieve a smaller logistical footprint or more effective military capabilities.
It is <u>not</u> our intention to drag our armed forces into the debate on climate change. Nor do we intend to prioritise the goals of the Paris agreement in any general or particular way over the need to defend our security.

This report consists of two chapters and five annexes:

Executive summary

Energy transition is discussed worldwide on a daily basis, except in most Ministries of Defence (MoD) and the military. Currently, military capabilities are being built running on regular diesel fuel with an intended service life of 40 years. However, when energy transition continues at the current pace, availability of fossil fuels could be an issue in less than 20 years. Time for action!

EDTA-EURODEFENSE provides five **recommendations** for the energy transition in European defence. In short these are:

1. Each Member State to consider Energy as a physical environment like sea, ground, air and cyber,
2. Each Member State to establish a national governance in charge of energy transition and promote it in military circles as an opportunity for an operational advantage,
3. Actively monitor and select civilian energy transition technologies suitable for major military capabilities at DG ENER in cooperation with EDA,
4. Coordinate defence related research and implementation of long-term solutions at EDA,
5. Use the opportunity of the European Defence Fund (EDF) and require an Energy Transition paragraph in each proposal.

Continue reading for more details and reasoning for these recommendations.

[1] The term sustainable energy is avoided, as “sustainability” is defined in the military as the extend in time and distance a military operation can be executed. The endurance of an operation.

I. Reason for this report and main goals

Energy transition is discussed worldwide on a daily basis. Many nations and industries are taking action and invest large sums to develop alternative energy solutions in an endeavour to reduce or abandon the use of fossil fuels. Except in the military.
Very often, energy transition for defence seems to be a non-issue based on the assumption that any energy source needed will always be available for the military in wartime conditions. Also, the amount of pollution in wartime is not considered relevant.

As mentioned in the preamble this document is not intended to prioritise sustainability goals over the military needs for our defence and security. We neither want to debate the extent of the legal means available to governments to just claim all resources they need in a crisis situation. However, claiming fuel is viable only when fossil fuels of the right type and quantities are available. When energy transition in society continues at the current pace the actual availability of fossil fuels could be an issue in 20 years. Maybe there is nothing to claim at all!

Now and in the near future, European military forces are procuring new capabilities with a forecasted lifespan of 30-40 years after delivery, while development and production may take up to 10 years. This means we are now taking technical decisions about systems that are intended to be in-service until 2060 - 2070. As the first relevant factor, **by that time fossil fuels may have become very scarce worldwide.** An official claim to get fuel will not change that. This does not mean we have to implement fuel technology of the 2050's right now, but we need to prepare capabilities for important changes in their sources of power, taking into account future equipment programs and future facilities, permanent and non-permanent. Built-in fuel flexibility is a necessity for systems that last.

> **GOAL 1:**
> **Build fuel flexibility into new major capabilities to be adaptable to changes in supply and overcome lack of fuel in the future.**

A second relevant factor is the immense amounts of new energy technology that is being developed in Europe and elsewhere to support the worldwide energy transition. Many of these technologies are very promising and provide options to save energy and/or to replace fossil fuels for other power sources.

Using energy-saving technologies could reduce the logistic footprint of our forces drastically. It could also reduce the current cost and effort to transport huge quantities of high standard fuels to mission areas. Cost of transportation not only in terms of money but also in the loss of lives during transport in risk areas. **Hence, applying new sources of energy could bring our forces a logistic and operational advantage**.

Most of the technologies being developed worldwide focus on changes of power sources from fossil to electrical. In the next decades, we will see the improvement of natural gas and LNG, renewable power, biofuels, (powdered) hydrogen or other alternative sources of energy. Even small-scale nuclear plants could be an option when (NATO) standard fossil fuels are less or not available anymore. And using aerostats for producing electricity with photovoltaic solar platforms is a possible option in support of forward operational bases.

Many more options will become available in the near and more distant future. Due to the nature of activities in energy transition, most of these are focussed on the short to medium term and may be outdated by 2040 or beyond. Consequently, it will be necessary to develop effective new technologies for major defence capabilities that will be used until 2060 and beyond.

GOAL 2:
Use newly developed energy transition technologies when they become available in Europe to improve the effectiveness of major military capabilities in the long term. Actively develop technologies needed to sustain major capabilities until 2060 or 2070 and increase their effectiveness.

II. Recommendations

Energy transition is daily 'business' in the European societies and economy. It is, or should be, of growing importance for our armed forces to adapt to a future reality. Based on the goals in chapter I of this document and the survey in annexes we have derived five recommendations for the Member States, European Defence Agency (EDA) and the European Commission (EC).

RECOMMENDATION 1.
For each Member State, to consider Energy as a full physical environment like air, ground, sea or cyber areas. Energy security, through the energy transition constraints, should be considered to ensure at any time and in any location the effectiveness of the armed forces.
In operations, new technologies could reduce the logistic footprint and fuel transportation requirements. Hence, they could save lives and reduce costs of military operations. At home, new energy sources must be adopted in the future compounds to replace energy fossils sources and save money.

Based on this statement, from the beginning, every project, equipment or infrastructure, permanent or non-permanent, must consider energy issues as a specific chapter. During the preparation of a future operation, during the planning phase, energy supply aspects must be analyzed through the operational effectiveness requirements, the local energy resources capabilities and the pollution impact, especially on the local population. Energy supply has to become a specific chapter of Concept of Operations (CONOPS) and Operations Plan (OPLAN).

RECOMMENDATION 2.
In each Member State at the MOD level to establish a national governance being in charge of considering all energy transition aspects including concepts, standards, training, infrastructures, equipment, support, personal (best practices), pollution reduction, ... and create a permanent experts network at European level.

Under a unique authority, to create a group of national coordinators composed of experts in the following capability areas: operations, armament, infrastructure and Research & Technology (R&T). This group of national experts will contribute at the national level to the development of an energy security strategy and implementation plans in the different capability areas. This group will actively participate in EDA and Commission activities in the energy area. EDA, in turn, should promote the energy transition in military circles as an opportunity to improve resilience and operational effectiveness. EDA rule should encompass best practices, training, the definition of standards and risk analysis.

RECOMMENDATION 3.
Create a "technology watch" at Directorate-General for Energy of the European Commission (DG ENER) in cooperation with EDA to monitor civilian energy transition technology developments and search for technologies particularly suitable for major defence capabilities. All over Europe and also in small and medium enterprises (SME).

Transitioning from well-known fossil sources to other sources of energy is both a need and an opportunity for major military combat systems that will be used (far) beyond 2050.
Energy transition technologies, however, are not a natural business area of the defence industry, but it is core business in many other sectors of the economy. Consequently, the search for suitable technologies should not start in the defence industry, but elsewhere. Of course, the defence sector should be involved to assess and implement these technologies.

Example: watch for (1) solar cell technology capable to withstand extreme environmental conditions, (2) electrical energy storage suitable for use in mission areas

RECOMMENDATION 4.
Create a steering committee at EDA to coordinate research and implementation of long-term solutions for major defence capabilities. Participation by member states should be encouraged in order to avoid duplication and to create advanced energy transition technology standards throughout the Union.

Some capabilities under development will need technologies that are not available in the foreseeable future. To operate these capabilities for 30-40 years development of new technologies is unavoidable. EDA could, similar to their Capability Development Plan (CDP) process, create a list of technologies needed and coordinate the development of these technologies. Standards for application throughout the Union could be derived from requirements and new technologies. This would avoid duplication of Research and Development (R&D) and, more importantly, improve interoperability to future energy sources.

Examples are: Diesel engines that can be (dis)assembled in small parts to move in- and out small and mid-size diesel-electric submarines. Use flexible fuel engines adaptable to 100% bio-fuel. Design ships so that fossil fuel engines and generators are replaceable by a large battery or hydrogen fuel cells.

RECOMMENDATION 5.
Use the opportunity of the European Defence Fund and require an Energy Transition chapter in each proposal. Both in the R&D and capability window. Add "*Relevance for military Energy Transition*" as selection criterium.

Research and new development activities for defence should be aware of the changed 'environment' for future major capabilities and adapt where necessary. For this reason, it would be effective to require an "energy transition" paragraph in each proposal for the European Defence Fund (EDF). This will force applicants to address the topic in their proposals and provide the EC with an option for selection.

Example: Never build direct driven capabilities, but always use a diesel-electric option to be adaptable for future changes to hybrid or all-electric solutions.

Annex 1. Survey in the European military sector

EDTA and EuroDéfense conducted a brief survey among their member associations and other specialists in the defence sector. In this survey three questions were asked: (1) are energy transition activities on-going in defence procurement or development of major capabilities, (2) are energy transition policies for defence in development or active, (3) is suitable energy transition technology for major capabilities available or could this developed.

In the following paragraphs, the main results of the survey are given. More details can be found in annexes 2 - 4 of this report.

Q1. Are energy transition activities on-going in European nations for defence procurement or development of major capabilities.

1A. A few scattered energy transition activities are being conducted throughout forces in the European Union. Only in Spain and the Netherlands some promising and focussed projects are on-going.

1B. Co-ordination throughout the EU is non-existent, except for the announcement of a new EDA conference to generate ideas.

Q2. Are energy transition policies for defence active or in development in European nations.

2A. In a few European nations an Energy Transition policy exists. An approved policy, however, does not guarantee that actual activities are being conducted. Monitoring of policy execution seems absent except in Spain and the UK.

2B. The military does not worry about energy transition or a future lack of fuel availability.

Q3. Is suitable energy transition technology for major capabilities available or could this be developed.

3A. Several interesting future options for future technologies are visible now, but the technical focus of industry is merely on the short to mid term. As major capabilities with a lifespan until 2060 and beyond are being developed now, it is necessary to ensure future technologies can be retrofitted when availability of fossil fuel recedes.

3B. Technological developments in civil energy transition should be monitored for future use in military capabilities. In particular reliable and safe electrical energy generation and storage. These developments typically occur in SME companies throughout Europe not primarily focussed on the defence market.

3C. Some technologies of interest for military capabilities are not expected to be the focus of civil developments. R&D and product development using these technologies could be stimulated for future use in military systems. Examples are Hydrogen fuel cells, small nuclear plants, solar power for HALE UAVs and local area smart grid.

Annex 2. Current technological activities in Europe

In this annex current energy transition activities by MoDs and armed forces throughout Europe are reviewed, in particular cross-cutting technologies for major capabilities that would enable military units and missions to cope with reduced or no availability of fossil fuels.
Easy energy reduction solutions currently available, or in the near future are not relevant from the perspective of this paper.

Answers to our questionnaire were scarce. Some activities seem to be on-going in barracks and establishments following civilian policies and using civil products, in particular in France. In the Netherlands and Italy initiatives to partially use biodiesel in Navy ships are on-going. In Germany, scattered activities are on-going throughout the armed forces. As these do not seem to be co-ordinated no details can be given.
Unfortunately the GO-GREEN project, an interesting initiative of EDA, that could have made a difference in many of the larger military bases and exercise grounds throughout Europe, has been terminated due to limited interest in the Member States.

The only known activities for major capabilities are in the **Netherlands, Spain** and probably by **EDA**.

- In the **Netherlands** an active programme exists to develop sustainable technologies for military compounds. The intention is to make compounds less dependent on logistics, in particular on fuel transports to distant bases in disputed areas.
- In **Spain**, new systems for storing electrical energy are being developed as well as small-scale energy systems for the capture of environmental energy and energy reduction measures are being implemented in a broad range of areas.
- **EDA** has held two informative conferences on energy transition in 2018. A third conference will be held on 25-27 February 2019 in Cyprus to develop project ideas in three areas: Energy management and efficiency; Renewable energy and Protection of energy infrastructure.
  The focus is however not on major Military capabilities.

Conclusions Q1

1A. A few scattered energy transition activities are being conducted throughout forces in the European Union. Only in Spain and the Netherlands some promising and focussed projects are on-going.

1B. Co-ordination throughout the EU is non-existent, except for the announcement of a new EDA conference to generate ideas.

In this annex <u>currently active policies</u> for energy transition of armed forces in Europe are listed.

Our research through 11 EDTA and 14 EuroDéfense associations, EDA, NATO and several other sources revealed that only the UK, Spain and the Netherlands have policies in place for energy transition related to major capabilities.

In the **Netherlands**, an Operational Energy Strategy is in place since 2016. This strategy calls for a reduction of the use of fossil fuels compared to 2010. The reduction should be 20% in 2030 and 70% in 2050. The strategy will be implemented using a detailed implementation plan. This plan, however, is still under development.

In **Spain**, a “State Plan for Scientific and Technical Research and Innovation 2017-2020” is in place aimed at reducing by 30% the energy consumption of the Armed Forces facilities and installations and progressively introducing new renewable energies.

In the **United Kingdom** a Sustainable Energy Steering Group is active and chaired by a 4* Vice Chief of Defence Staff and an overarching policy document “Sustainability Strategy 2015-2020”. The UK MoD does seem to be taking this issue seriously today, which is a relatively new development and good energy practice seems to be being promulgated and encouraged widely throughout the Armed Forces.
Two important strategic objectives are:

1. *We will increase our energy efficiency and reduce our dependency on fossil fuels to lower their associated risks to business and capability.*
2. *We will adapt and prepare our activities, infrastructure and equipment assets, to become resilient to the impacts of current and future climates.*

In **France,** the Ministry of Defence adopted in 2012 the" Ministerial strategy for energy performance" (the "Strategy").
According to the Strategy and considering the rapidly developing energy sector, the MoD has to make following important efforts regarding energy supply and consumption:
- to secure access to energies;
- to ensure an adequate quality of service;
- to control its expenses and its consumption;
- to restrain the environmental impact.

Energy, in all its forms, which conditions the normal functioning of the Ministry and the carrying out of operations and support activities, becomes a primary concern affecting all of the department's policies.

Main goals mentioned in the Strategy are aligned, regarding infrastructures, with the "Grenelle I" law.
Objectives by 2020 applying as well to permanent and non-permanent <u>military bases</u> are to reduce the energy consumption by at least 40%, greenhouse gas emissions by 50% and to increase the share of renewable energies up to 23%.

In the same time, the General Staff of Armed Forces (EMA) charged the working group "Energy transition and armies" under the auspices of the "Group of military strategic orientation" to develop the operational strand of the Strategy. Its conclusions will be announced by the middle of 2019 and will be followed by the development of the "Strategy of the Operational energy". The most important bodies of three armies will participate in its redaction aiming to improve the resilience of armed forces.

France actively takes part in works on energy transition notably the project Energy Operational Function (EOF) within the Permanent Structured Cooperation and participates in the Energy and Environment Working Group within the European Defence Agency.

Other European nations do not seem to have a clearly formulated defence-wide policy.

The **European Defence Agency (EDA)** assembled 140 sustainability experts from 27 European countries and more than 30 different institutions and organisations in a 2nd consultation conference in October 2018. The goal is to establish a consultation form. A follow-on conference will be held in February 2019, where practical proposals will be developed in a workshop setting. The agency also has two or three capability managers active in this area. The focus is on gathering information.

NATO monitors developments from their Energy Security Centre of Excellence (ENSEC COE) in Vilnius, Lithuania. The organisation has knowledge on the subject and has published two studies:
"Energy efficiency: Cultural Change" (for the military), 2016.
"Recommendations on the importance of critical energy infrastructure stakeholder engagement, coordination and understanding of responsibilities in order to improve security", 2018.
The COE also published "Operational Highlights" magazines between 2013 and 2016.
No information on breakthrough energy transition for major military capabilities could be found in their publications.

In **military circles**, the question of a need for any policy was most often answered in a negative sense. There is no need for alternative energy sources in the foreseeable future. Fossil fuel will remain available in sufficient types and quantity until the end of this century. If not, our respondents said, we will claim all fuel required.

Conclusions Q2

2A. In a few European nations an Energy Transition policy exists. An approved policy, however, does not guarantee that actual activities are being conducted. Monitoring of policy execution seems absent except in Spain and the UK.

2B. The military does not worry about energy transition or a future lack of fuel availability.

In this annex several <u>promising</u> energy transition technologies and lines of technological approach are mentioned. In particular technologies for major capabilities that would provide an *operational advantage* to our forces without losing combat power. An operational advantage could be a smaller logistical footprint, increased military sustainability of less dependency on particular supplies.

Easy energy reduction solutions available currently or in the near future are not mentioned. An example of not-mentioned technologies is the use of biodiesel, regular solar power and wind energy.

Early research suggests that the following lines of thought and practical examples could be considered as potential opportunities to nurture and support. These could fit the principles mentioned above and, by default, thereby impact the goals of the energy transition and other environmental factors.

Alternative Fuels

<u>Hydrogen</u>.
Hydrogen is one of the least polluting fuel alternatives. It is also suitable and fuel efficient for future military applications. However, production in necessary quantities will be a problem for the military unless it is widely adopted in the civilian market which current trends suggest is not likely in the near future. Also safe storage and transportation of compressed hydrogen to and on the battlefield would be problematic and present an additional fire hazard to vehicle crews in combat compared to diesel. A suitable alternative to compressed hydrogen could be hydrogen captured in sodium borohydride ($NABH_4$). This powder can be used in a fuel cell to produce electrical energy. After use spent fuel can be recycled and used over and over again. A Netherlands company H2Fuel is developing this product for the Netherlands armed forces and other users.

<u>Nuclear</u>
Nuclear power supplies are already used extensively in naval ships and submarines. Miniaturisation for use in land vehicles is a possibility being pursued in the US in particular. The theoretical advantages are considerable with vehicles requiring no fuel resupply on the battlefield at all and an occasional replacement of fuel rods being able to be undertaken at scheduled times well away from combat areas. However, their development will be a major technical challenge and the peacetime political implications of the widespread deployment of nuclear vehicles, their use in peacetime training and subsequent disposal would be even more challenging.
A practical option for small scale use of nuclear energy could be technology like the NEREUS project. This is a **N**aturally **s**afe, **E**fficient, **N**uclear reactor, **E**asy to operate, **U**ltimately simple and **S**mall power plant suitable for unmanned engine rooms and power plants. It uses a nuclear High Temperature Reactor, combined with a compressor/hot Air Turbine HTR-AT

Land forces

Electrical energy storage

Wind energy and solar power are attractive sources of power for out-of-area military bases. Important downside is the lack of energy storage solutions needed for reliable and effective operations on a 24/7 bases. When electrical energy could be stored for a reasonable period of continuous operation (depend on application and location) wind- and solar power can be used.
A lot of development work is being done throughout the EU and beyond. An example of a military safe and reliable storage system suitable for use in army compounds has been developed in Norway by the company Energy Nest. Their thermal batteries store vast amounts of energy in concrete and steel.

Electrical energy smart GRID

For large long-stay military compounds the use of high voltage grids could be considered. These grids enable sharing of energy between multiple systems and using surplus amounts of energy at the time it becomes available. An example is to start laundry machines at sunrise when solar panel energy comes on-line and pause these systems at peak times of high kitchen and air conditioning demand. However there are considerable costs involved and certified personnel is required to operate high voltage grids.
The Netherlands Army is cooperating with 250 SMEs and other companies to develop smart solutions for future compounds in their “Field Lab Smart Base”. Smart grid solutions are among the innovations pursued.

Electrical vehicles

Widespread civilian use of electric vehicles will lead to developments with obvious military application. The difficulty for the military will be the recharging of vehicles in combat conditions. Further, without considerable improvements in the energy density of batteries, the weight of batteries and the need to protect them in an armoured vehicle will restrict their military application perhaps to rear area logistic vehicles. Hybrids are a more likely option but batteries (albeit fewer of them) will still be required along with the resupply of fuel for the hybrid engine. Developments in civilian vehicles will solve this dilemma in the next decade and by 2030 also military vehicles will be able to use battery power. It is necessary to ensure that new vehicles with an intended lifespan of 15 years or more are designed in a way that they can be retrofitted with battery packs and electrical engines.

Vehicle Design

A number of developments are being made in the design of new military vehicles, which should have a beneficial effect on logistic demands and, indirectly, the environment.
Lighter vehicles are in development largely as a result of the use of improved armour materials such as ceramics, nanotechnology solutions etc. which offer more protection at lighter weight.

As in civilian applications, the use of more fuel-efficient conventional engines for military vehicles will continue. Indeed, most engines used in military vehicles (even in tanks) are versions of civilian engines; a notable exception is the gas turbine engine in the US Abrams tank – it is derived from an aero engine and has very high fuel consumption.

Increased automation, more widespread use of autoloaders and other developments. will allow reductions in crew size which should allow for smaller vehicles with improved fuel consumption as a consequence. Unmanned vehicles may not need armour at all. Their reduced weight also implies less fuel consumption. This is relevant for use of fossil fuel, but also for any other source of energy.

Better reliability of combat vehicles should enable a reduction in the provision of battlefield repair and recovery resources which, otherwise, require their own refuelling and resupply effort.

There have always been arguments in the military as to a preference for wheels or tracks for armoured vehicles. If developments for wheeled vehicles could offer the same, guaranteed, cross country performance as for tracked vehicles then advantage could be taken of the better fuel economy that, generally, wheeled vehicles have to offer.

<u>More Efficient Fleet Management</u>
In intense combat involving sizeable military formations it is common practice for higher command to resupply crews, units and formations on a daily, default quantity, basis. This is based on the assumed quantity of ammunition, fuel and rations that will have been consumed the day before by a unit involved in a specified level of operational activity. Unit and formation commanders can request more if consumption has been particularly high: they are less likely to request less. As a consequence there is sometimes significant waste of some commodities; in the heat of battle crews and units are not motivated, understandably, to worry about it or to try to return unused supplies. Further, in the heat of battle, vehicle crews and their units do not welcome the burden of reporting what they have consumed nor do they have an efficient means of doing so. A significant future development is likely to be the automatic reporting to higher authority, by the vehicles themselves from on board sensors and communication systems, of actual fuel and ammunition consumption. This should lead to much more efficient management of resupply. Such systems already exist on a small scale and have been proven but are likely to be much more widely adopted by the military in future.

Aviation

It is difficult, currently, to envisage the effective use of alternative energy sources for military combat aircraft. Future designs will benefit from the developments in reliability, fuel consumption, efficiency etc. of civilian aircraft engines and Air Forces will continue to rely on military versions of civilian aircraft and helicopters eg. A400M, for logistic support. In this area the energy transition will largely follow civilian developments.

A energy transition policy in military aviation that could lead to an operational advantage is the use of alternative platforms. For example, unmanned aircraft like drones would be smaller and thus at least less fuel demanding. In many cases drones also have a much longer endurance that opens up new or improved military use. In addition, other EASA or military safety regulations apply for unmanned aircraft.

A practical example is the idea of the Netherlands Air Force to develop a "Cargoleaper". This is a huge autonomous multicopter capable to transport 20 ft containers of up to 5000 kg over 250 km. Although this aircraft in itself may use quite a lot of fuel, it saves a huge amount of vehicles and helicopters needed to secure manned logistic ground transport. When available, this type of medium range cargo transport in adverse areas could or would have many applications for civilian purposes too. I.e. for NGOs and disaster relief.

Solar powered electric flight could be stimulated for military applications based on scientific test flights like the Solar Impulse and others. A promising military application would be High Altitude Long Endurance (HALE) or High Altitude Pseudo Satellite (HAPS) UAVs for reconnaissance, surveillance and intelligence gathering (ISTAR) duties. Worldwide several companies are working on this technology, including Airbus/Qinetic in Europe.

Naval Forces

Major naval vessels use large quantities of energy for their propulsion and household consumption. As already noted, some warship and submarines are already nuclear powered. Most new, non nuclear designs involve the use of fossil fuel engines. These fossil fuel engines usually generate electrical power for use by electric motors which provide the main propulsion. The sheer size of ships compared to land vehicles means that space is available for designers to consider most alternative fuels options and navies will seek to reduce consumption wherever possible to save money, indirectly, be of benefit to the environment. Again they will also benefit from relevant developments in the civilian marine industry.

A complicating issue is that currently new major naval ships and submarines are being developed and build that will remain in use until 2060 or beyond. By that time standard F76 NATO fuel may not be on the market any more. Almost certainly it will not be as easily available as it is now.
For that reason it is important to add fuel flexibility to naval shipbuilding requirement. Fossil fuel gasturbines or diesel engines should not only be able to run on NATO standard F76, but flexible to use any fuel, ranging from sulphurised fossil diesel to 100% biodiesel. Additionally the design of major naval ships should be flexible and modular to accommodate replacement of fossil fuel engines with other means of electrical power generation that could become available in the next 20-30 years.
Using a Integrated Full Electric Propulsion (IFEP) design for major naval vessels is an important first step to accommodate the energy transition for this type of military application. When safe and

reliable hydrogen fuel cell technology becomes available, or small nuclear power plants, both as described above, these could then be retrofitted into these existing ships.

Naval ships like mine-hunters and patrol boats often travel on slow speeds for quite some time. These could benefit from rapid developments in battery technology and use hybrid propulsion. When developing new ships in these categories weight and space for future batteries for hybrid operation should be included. Like in army compounds a local area smart grid could be of interest for these ships too.

Small submarines typically travel for up to one week in regional waters. Research by Delft University (NL) indicates that these types of submarine could run on Li-Ion batteries only. This could be suitable for the navies of Norway, Sweden, Germany, Baltics, Mediterranean, etc.

Conclusions Q3

3A. Several interesting future options for future technologies are visible now, but the technical focus of industry is merely on the short to mid term. As major capabilities with a lifespan until 2060 and beyond are being developed now it is necessary to ensure future technologies can be retrofitted when availability of fossil fuel recedes.

3B. Technological developments in civil energy transition should be monitored for future use in military capabilities. In particular reliable and safe electrical energy generation and storage. These developments typically occur in SME companies throughout Europe not primarily focussed on the defence market.

3C. Some technologies of interest for military capabilities are not expected to be the focus of civil developments. R&D and product development using these technologies could be stimulated for future use in military systems. Examples are Hydrogen fuel cells, small nuclear plants, solar power for HALE UAVs and local area smart grid.

Annex 5. Acknowledgements

This report has been written by a working group of EDTA and EuroDéfense based on contributions received from member associations in France, Germany, Spain, The Netherlands and the UK as well as topical on-line research in NATO, EDA, European Nations and industries.

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About EDTA

The Federation of European Defence Technology Associations (EDTA) was established in 1992 on the initiative of the ministers of the then Independent European Planning Group (IEPG) and aims to enhance cooperation and professional relationships among its members. It does so by information exchange, promotion of conferences and promotion of public interest in defence industry and technology. EDTA is mainly active in the defence technology and defence industry sector.
The federation has 11 member associations in 10 European nations with a total of over 6000 individual and 400 corporate members. For more information: www.fedta.eu

About EURODEFENSE

Established in 1994, the EURODEFENSE network aims to foster the awareness of the common interests of European countries, to develop a greater sense of European defence and to support the implementation of the Common Security and Defence Policy. To achieve this goal, EURODEFENSE is mainly active in the defence and diplomatic sector.
The EURODEFENSE network has 14 national associations in as many European nations.
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