MILITARY GREEN 2012

EUROPEAN DEFENCE AGENCY

Conference-Exhibition-Demonstration

Proceedings

19 – 20 June 2012 Brussels, Belgium

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Coming Together On Energy and Environment

Dinesh H C REMPLING (European Defence Agency)
Antoine VINCENT (European Defence Agency)

The first of its kind, Military Green 2012 has sought to establish a common understanding how the defence and crisis management community can contribute to sustainable development while enhancing Europe's defence and crisis management capability. Gathering a good mixture of civilian and military expertise at all decision-making levels the event has strived to:

- Showcase high level visions on Energy and Environment and how the defence and crisis management domain can collectively and effectively deliver contributions to the overall EU goals for 2020 and beyond
- Exhibit and demonstrate the technological solutions of today as well as shed light on the technological opportunities in the long term
- Provide insights into how new business models can support implementation of "green" solutions

There is a growing consensus that energy and environment are integral to resilience and affordability. This is reflected in EDA's overall approach under the umbrella Military Green. Together with the European Union Military Staff's work on a Military Concept for Environmental Protection, this aims at increasing energy and environmental responsibility in order to enhance capabilities in terms of safety, survivability, effectiveness, cost and environmental impact. With a through-life perspective increasing awareness plays an important role and this is where Military Green 2012 fits in.

Organised by the European Defence Agency (EDA) as part of the European Commission's EU Sustainable Energy Week (EUSEW) the event gathered approximately one hundred and fifty stakeholders over two days to try and get a better grasp of the complexity of energy and environmental issues and its particularities in the context of defence and crisis management. Policy, technology, knowledge and incentives all need to interact in order to achieve results and this is what Military Green 2012 attempted to show.

These proceedings try to capture what took place on 19 and 20 June at the Royal Military Academy in Brussels. While the documentation of the discussions and debate of the High Level Conference only exists in the form of audio recordings, the essence is reflected in the Event Summary and the article "Examining Sustainability in Defence". Technical Papers and brief descriptions of the exhibits and demonstrations have been compiled to show expert views on state-of-the-art and beyond. Overall, the proceedings provide a good platform to increase awareness on the challenges and opportunities that lie ahead.

Speakers, exhibitors and demonstrators who spent time and money to come and share their insights, without you the event would not have been what it was – many thanks to all of you. Also, thank you to all in the audience who contributed to the discussions and networking.

Further gratitude needs to be expressed to the Royal Military Academy of the Belgian Ministry of Defence as well as GOPA Catermill for helping with the infrastructural complexities.

The EDA will continue its efforts on energy and environment as part of Military Green, guided by the output of the event. In doing so, EDA will attempt to draw on the network of experts present during Military Green 2012.

Military Green 2012 – Event Summary

Dinesh H C REMPLING (European Defence Agency)

Brussels in shades of early summer was the backdrop for Military Green 2012, a unique event held right in the heart of Brussels at the Royal Military Academy. High level policy makers, experts on climate change, industrial technology suppliers and pioneers in research all gathered to address different aspects of Energy and Environment in the context of Defence and Crisis Management. Organised by the European Defence Agency under the framework of the European Sustainable Energy Week, the event consisted of three main elements

- High Level Conference dedicated to address policy beyond 2020, its impact on Defence and Crisis Management as well as promoting technological solutions
- A Technical Conference dedicated to exploring current and future technological opportunities
- A combined Exhibition and Demonstration aimed at showcasing what is possible today

High Level Conference

Opening the event saw EDA's Chief Executive Ms Claude-France Arnould provide her views on the role of energy and environment in sustainable Defence and Crisis Management and how EDA's Military Green umbrella effort can contribute to this. While H.E. Tomas Kovacs, the Hungarian Ambassador, provided a national perspective MEP Indrek Tarand member of the European Parliament's Subcommittee for Defence and Security spoke about the findings in his recent report dealing with the role of the Common Security and Defence Policy in Climate Driven Crisis and Natural Disasters.

Piloted by Mr Tom Spencer, Vice Chairmen of the Global Military Advisory Group and Conference Chair, five sessions followed. The first saw a panel consisting of Ms Marie Donnelly (European Commission), Dr Andrew Barrett (IHS CERA), Mr Karl Hallding (Stockholm Environment Institute), Dr Jason Blackstock (Oxford University), Professor Marcel Leroy (UN University for Peace) and Peter Olajos (Green Player). Discussions revolved around a number of different topics including the effectiveness of European policy so far, the challenges of decarbonising the world and the pros and cons of climate engineering.

The second panel consisted of H.E Gabor Iklody (NATO), RAdm Bruce Williams (EUMS), Col Romas Petkevicius (Energy Security Centre), Mr Paul Johnson (UK MoD – DE&S) and Brig Jon Mullin (EDA). Topics covered revolved mainly around the increasing importance of energy and environment in future Defence and Crisis Management. This included showcasing examples of current proactivity with regard to energy security.

Two presentations, one from Ivan Blazevic (UNEP) and one from Col Georgios Drosos (Greek MoD) provided insights into benchmarks achievements.

Following lunch and a tour of the Exhibition and Demonstration area a video-link was established with Rio de Janeiro where the UN Conference on Sustainable Development was taking place. Former President of Costa Rica, currently President of the Carbon War Spoke, Mr Jose Maria Figueres Olsen spoke about the urgency of making sure our planet is in good health.

The last panel of the High Level Day gathered Mr Jean Perrot (EADS France), Mr Alexis Hammer (UK MoD – Dstl), Mr David Muchow (Power Anywhere) and Christian Breant (EDA). Topics covered here were the proven rationale to go for green solutions, corporate perspectives on responding to these needs and the short and long term role of research.

Technical Conference

The Technical Conference brought engineers and researchers from MoDs, industry and academia to share their views on what technology has to offer today and what it could potentially offer in the future through presentations supported in many cases by Technical Papers. Conducted over a day the full agenda was split into a number of sessions, some running in parallel, covering:

- Systems and architectural design
- Management of munitions and hazardous substances
- Energy efficiency and consumption
- Generalities such as legislation, international cooperation and future trends

Al lot of interesting ideas surfaced as a result of the presentations and the small talk during breaks, ideas that the EDA hopes to be able to incorporate into its work streams.

Exhibition and Demonstration

Ten brave exhibitors and demonstrators spent two days adding a much needed dimension to the event. As a break from presentations and attendants were offered the treat of viewing the latest that technology has to offer. Primarily small and medium sized enterprises, as often associated with novelties, were thus put centre stage:

- Geoter
- Fraunhofer
- Sleebreeze
- Unat Solar
- Sunbird
- Skybuilt
- Ampair

- Windtronics
- Conteno

Conclusions

Military Green 2012 marks the EDA's first attempt to try and gather all stakeholders involved in energy and environment for Defence and Crisis Management. The purpose was to try and get a common understanding of what the future may hold policies and potential threats as well as what responsibility the community has in terms of contributing to the civilian goals and what opportunities there are for technology to help us get there. This ambitious undertaking resulted in an interesting two-day programme with presenters from EU institutions, international organisations, Governments, academia and industry. In addition the event provided exhibits and demonstrations of readily available novel technologies. Organised as part of the EU Sustainable Energy Week, Military Green 2012 this stood out as probably one of its most comprehensive events. In doing so it

Examining Sustainability in Defence

Tom WEIN (European Defence Agency)

The European Defence Agency has been reflecting on the role of the military in environmental sustainability. At a conference scheduled to coincide with the EU's Sustainable Energy Week, high level speakers made a powerful call for the military to shoulder its responsibilities in this domain – and technical experts plotted ways to do so.

Day 1 of the conference focused on the politics of military sustainability. In a series of panel discussions, speakers reflected on the military's role in green action, from reducing emissions to improving recyclability. Big questions were asked: where is energy and environmental policy going? What will be the impact of those policies on defence and crisis management? What has been achieved so far? And how can the military and defence world comply with current policy, while enhancing its capabilities?

The overall message that emerged was one of tempered hope. There was a clear consensus that the military has a role to play in this field, a role which goes beyond merely complying with legal obligations – though that in itself is a challenge to be tackled. Mr Jose Maria Figueres, the former President of Costa Rica, and now President of the Carbon War Room, addressed the conference on a videolink from Rio de Janeiro. Speaking with passion and detail, he reminded attendees of the big picture; the imperative incumbent on all of us to move to a low-carbon economy.

Building on that message, the UK MoD's Alexis Hammer led the way in proposing solutions, explaining the importance of framing action as producing concrete benefits in lives and money saved, rather than abstract common goods. Numerous speakers concurred, proffering statistics that included that every penny increase in the cost of fuel impoverishes the UK MoD by £13 million a year, while US convoys took one casualty for every 24 convoys they operated in Iraq.

This consensus opened the way for a focused debate on the solutions available. David Muchow of Power Anywhere said of the technology for reducing fuel consumption: "It's real, it's here now", and that was on display in the exhibitions by representatives from industry. Though all showed off innovative products, Belgian company ContenO, which produces mobile water purification & packaging systems, was singled out for a special award for their novel and promising offering.

On Day 2, then, technical experts debated how to fulfill the military's sustainability obligations. Drawing on a number of technical papers, they considered three major areas: systems and architecture; responsible management of munitions and hazardous substances; and improving efficiency and reducing consumption. Paul Johnson recounted his experience in constructing the experimental Power Forward Operating Base to test power-generation technologies, while the EDA's Tarja Jaakkola offered a European perspective on complying with the Commission's REACH directive in defence.

Jean Perrot, representing EADS France, offered three principles that might summarize the conference. With long timescales, costly equipment and lives on the line, any military sustainability initiative must march to the beat of three words: anticipation, transparency and communication. In the coming months, the European Defence Agency will move forward with its Military Green initiative, helping build consensus and standards among European militaries in support of sustainability. As it does so, it will bear these precepts in mind.

Conference Programme

Programme High Level Day – 19 June 2012

Accreditation 08:00 – 09:00 Building I – Foyer		
Opening Session 09:00 – 09:30 Building I – Auditorium		
Welcome Address	Ms Claude-France ARNOULD	Chief Executive, EDA
Opening Remarks	H E Dr Tamás Ivan KOVÁCS	Ambassador of Hungary to Kingdom of Belgium and Grand Duchy of Luxembourg
	Mr Indrek TARAND	Member of European Parliament
Session A: Panel Discussion – Energy and Environmental Policy Beyond 2020 09:30 – 10:30 Building I – Auditorium		
Chair	Mr Tom SPENCER	Vice Chairman, Global Military Advisory Council
Panelists	Ms Marie DONNELLY	Director for New and Renewable Sources of Energy, Energy Efficiency and Innovation, DG Energy, European Commission
	Dr Andrew BARRETT	Senior Advisor, IHS CERA
	Mr Karl HALLDING	Senior Research Fellow, Head of China Cluster, Stockholm Environment Institute
	Dr Jason J BLACKSTOCK	Institute for Science, Innovation and Society, Oxford University and CIGI Strategic Advisor
	Dr Marcel LEROY	Senior Researcher, Africa Programme, UN-mandated, University for Peace
	Mr Peter OLAJOS	Managing Director, GreenPlayer Ltd
Coffee Break & Tour of Exhibition/Demonstration 10:30 – 11:00 Building I – Foyer/ Grote Koer		

Session B: Panel Discussion – Impact on Defence and Crisis Management 11:00 – 12:00 Building I – Auditorium		
Chair	Mr Tom SPENCER	Vice Chairman, Global Military Advisory Council
Panelists	H E Gabor IKLODY	Ambassador and Assistant Secretary General for Emerging Security Challenges, NATO
	RAdm Bruce WILLIAMS	Deputy Director General, EU Military Staff
	Col Romualdas PETKEVICIUS	Deputy Director, Energy Security Centre, Lithuanian Ministry of Foreign Affairs
	Mr Paul JOHNSON	Logistic Systems & Operational Energy Management – Section Head, Director Technical – Technology Delivery, DE&S, UK Ministry of Defence Ministry of Defence
	Brig Jon MULLIN	Capabilities Director, EDA
Session C: Interventions – Benchmark Achievements 12:00 – 12:45 Building I – Auditorium		
Chair	Mr Tom SPENCER	Vice Chairman, Global Military Advisory Council
Greening the Blue Helmets	Mr Ivan BLAZEVIC	Programme Director Environmental Cooperation for Peacebuilding, Post-Conflict & Disaster Management Branch, UNEP
Environmental Policy of Hellenic Ministry of National Defence – Development and Implementation	Col Georgios DROSOS	Director of Department on Infrastructure and Environmental Protection, Hellenic Ministry of Defence
Lunch & Tour of Exhibition/Demonstration 12:45 – 14:30 Building K – Patio / Groete Koer		
Session D: Panel Discussion – Rio +20 (live from Rio de Janeiro) 14:30 – 15:15 Building I – Auditorium		
Chair	Mr Tom SPENCER	Vice Chairman, Global Military Advisory Council
Panelists	Mr Jose Maria FIGUERES	President, Carbon War Room (former President of Costa Rica)

Session E: Panel Discussion – Complying With Policy While Enhancing Capabilities 15:15 – 16:15 Building I – Auditorium		
Chair	Mr Tom SPENCER	Vice Chairman, Global Military Advisory Council
Panelists	Mr Jean PERROT	Vice President, Head of R&T Institutional Affairs, EADS France
	Mr Alexis HAMMER	Domain Leader Acquisition Policy, Dstl, UK Ministry of Defence
	Mr David MUCHOW	President and CEO, Power Anywhere, LLC
	Dr Christian BREANT	Research and Technology Director, EDA
Coffee Break & Tour of Exhibition/Demonstration 16:15 – 16:45 Building I – Foyer/ Grote Koer		
Closing Session 16:45 – 17:15 Building I – Auditorium		
Closing Address	Ms Claude-France ARNOULD	Chief Executive, EDA
Military Green 2012 VIP Reception 17:30 – 19:00 Building K – VIP Room		
Host	Ms Claude-France ARNOULD	Chief Executive, EDA

Programme – Technical Conference 20 June 2012

Accreditation 08:00 – 08:45 Building I – Foyer	
Keynote Session 08:45 – 09:30 Building I – Auditorium	
Chair	Brig Jon MULLIN Capabilities Director, EDA
Improving Shipping Efficiency	Mr Alisdair PETTIGREW Senior Advisor, Shipping Operation at Carbon War Room
Session A: Systems and Architecture Part 1 09:30 – 10:-45 Building I – Auditorium	
Chair	Mr Dinesh REMPLING Technical Project Officer R&T, EDA
Sustainable Design and Procurement	Mr Dinesh REMPLING Technical Project Officer R&T, EDA
Land Open System Architecture (LOSA)	Mr Paul JOHNSON Logistic Systems & Operational Energy Management – Section Head, Director Technical – Technology Delivery, DE&S, UK Ministry of Defence
Environmentally Friendly Solutions in Military Applications	Mr Jörn BRAUER Principal Development Officer, NATO Maintenance and Supply Agency

Coffee Break & Tour of Exhibition / Demonstration 10:45 – 11:15 Building I – Foyer / Grote Koer			
Session B1: Systems and Architecture Part 2 11:15 – 13:-00 Building K – Auditorium		**Session B2: Responsible Management of Munitions and Hazardous Substances** 11:15 – 12:45 Building I – Auditorium	
Chair	**Mr Antoine VINCENT** Technical Project Officer R&T, EDA	Chair	**Dr Adam S CUMMING** Principal Consultant Energetics Technology, Dstl, UK Ministry of Defence
Dependencies on Fuel and Alternative Options for Crisis Management Operation	**Mr Antoine VINCENT**, Technical Project Officer, EDA and **Mr Cesar GONZALEZ**, ISDEFE	**Environmentally Responsible Munitions – An EDA programme for the future**	**Dr Adam S CUMMING** Principal Consultant Energetics Technology, Dstl, UK Ministry of Defence
Power Forward Operating Base (Power FOB)	**Mr Paul JOHNSON** Logistic Systems & Operational Energy Management – Section Head, Director Technical – Technology Delivery, DE&S, UK Ministry of Defence	**Safe and Ecological Destruction of Ammunition**	**Ms Olga DOBROWOLSKA** Project Manager, JAKUSZ Security Systems
Naval Economy and Flexibility	**Mr John BUCKINGHAM** Chief Mechanical Engineer, BMT Defence Services Limited	**Hazardous Substance Management in Military Operations – How Integrated Software can Enhance Safety for People and the Environment**	**Prof Dr Martin HILL** Vice President, Head of the Center of Excellence Sustainability EMEA, SAP
Military Engine and Propulsion Systems Going Green	**Mr Thomas VON RETH** Director Business Development Military Applications	**Complying With REACH in Defence – A European Approach**	**Ms Tarja JAAKKOLA** Assistant Director Industry and Market, EDA
Drinkable Water Anywhere: A Logistical and Costly Nightmare	**Mr Christophe Van Steen** Managing Director, ContenO		

Lunch & Tour of Exhibition / Demonstration

13:00 – 14:15
Building K – Patio / Grote Koer

Session C1: Improving Efficiency and Reducing Consumption Part 1 14:15 – 16:00 Building K – Auditorium		Session C2: The Bigger Picture 14:30 – 16:00 Building I – Auditorium	
Chair	**Mr Antoine VINCENT** Technical Project Officer R&T, EDA	Chair	**Mr Dinesh REMPLING** Technical Project Officer R&T, EDA
The Role of ICT in Energy Efficient Military Camps, Civil Business Cases and Model Examples	**Dr António BENTO** ISA - Intelligent Sensing Anywhere	**Sustainable Development, Defence and the EU Law Making Process**	**Mr Gilles LELONG** Head of European Legal Affairs, SGA, French Ministry of Defence
Renewable Energies in Combination with Energy Storage Systems for Military Field Camps	**Dr Karsten PINKWART** Vice Head of Department Applied Electrochemistry, Fraunhofer Institute for Chemical Technology	**DEFNET – A European Network of Environmental Experts**	Dialogue via Video Link with Copenhagen
TSS Habitat Systems: Supporting and Sustaining Life in Remote Locations	**Ms Kris VANCOMPERNOLLE** Thermal Storage Systems Inc	**Developing a European Environmental Protection Concept**	**Cdr Henning FALTIN** Concepts Branch, EU Military Staff
Demonstration of Hydrogen Fuel Cell Technology for German Land Forces	**Dr Karsten PINKWART** Vice Head of Department Applied Electrochemistry, Fraunhofer Institute for Chemical Technology	**The End of Heavy Armour? – Energy Security Will Change Warfare**	**Capt (N) (ret) Marcel HENDRIKS VETTEHEN** Consultant, Energie Voor Inzet
Methanol Steam Reformer – High Temperature PEM Fuel Cell System Analysis	**Dr Stanko HOCEVAR** Mebius d.o.o.	**International Forces in Operation – Policies and Measures to Reduce Energy Costs**	**Dr Sabine MUELLER** Fraunhofer Institute for Technological Trend Analysis

Comfort Break

16:00 – 16:10

Session D: Improving Efficiency and Reducing Consumption Part 2 16:10 – 17:10 Building K – Auditorium	
Chair	Mr Antoine VINCENT Technical Project Officer R&T, EDA
Cooling People, not Places. Recycling 20th Century Defence Science to meet 21st Century Challenges.	Mr Andy BUXTON Managing Director, Sleepbreeze Ltd
Sustainable Energy for Crisis Management	Mr Juan Antonio DE ISABEL GEOTER and Clysema AIE
Solar Energy from Space – Challenges and Opportunities	Dr Aleksander ZIDANŠEK Josef Stefan International Post Graduate School
Closing Session 17:15 – 17:30 Building K – Auditorium	
Closing Remarks	Mr Antoine VINCENT Technical Project Officer R&T, EDA Mr Dinesh REMPLING Technical Project Officer R&T, EDA

Photographs


















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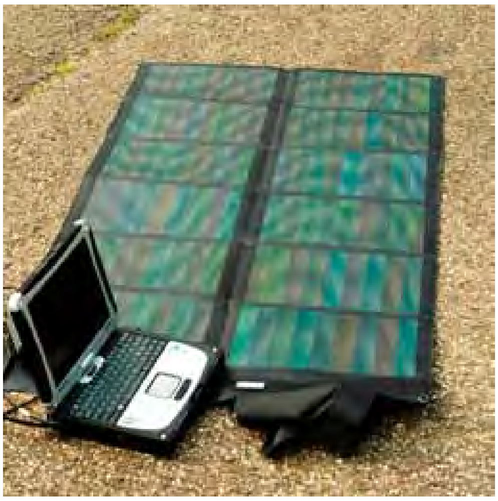
EU SUSTAINABLE
ENERGY WEEK
-22 JUNE 2012






sleepbreeze

Mobile Bottling Plant


Technical Papers (click on the titles)

Sustainable Design and Acquisition in Defence and Crisis Management

Dinesh H C REMPLING (European Defence Agency)

Abstract – The phenomenon of Sustainable Design has in the past few decades seen an ever increasing presence in civilian products. Under the monikers such as eco-design and environmental design it aims at methodically reducing the multifaceted issue of environmental impact through better designs. There is a wealth of principles, tools and services available to support responsible design of equipment and facilities. Having been in use for several years, can these be applied to achieve more responsible defence and crisis management? In fact they already are. Civilian principles have been adapted to be able to work effectively in the constrained environment of Defence and Crisis Management. This paper tries to capture the essence of existing policies relating to sustainability and attempts to present the findings in a comprehensive way.

Introduction

Sustainable Design is an approach and philosophy that advocates designs that do not affect the environment negatively while taking into account social and economic aspects. It has emerged in later years as a contributor to Sustainable Development and can be defined as follows:

> *"Sustainable Design is a design philosophy that seeks to maximise the quality of the built environment, while minimising or eliminating negative impact to the natural environment" [1]*

A comprehensive and transversal topic, it covers among other things:

- Maximising recyclability and reusability
- Optimising waste properties
- Conservation of water
- Minimising use of hazardous substances and materials
- Increasing energy efficiency and reducing consumption
- Reducing hazardous emissions

It has also made its way into the Defence and Crisis Management domain and as a consequence many countries now have high level policies on sustainability that are incorporated into the acquisition process. With policies and approaches varying from country to country, this paper tries to capture the essence of what sustainability implies for the design and acquisition while attempting to develop and present it in a comprehensive way.

It should be state that the views and ideas presented in this paper are those of the author and do not necessarily represent those of the European Defence Agency.

Particularities of Modern Defence and Crisis Management

Defence and Crisis Management has seen big transition in the past decades. With the Cold War long gone, the dynamics of the world have changed, in particular with regard to international security. As a result the types of capabilities needed are significantly different and are expected to be delivered in quite challenging circumstances.

Evolution of Tasks

Modern Defence and Crisis Management goes far beyond what used to be associated with territory. Defending the home still accounts for an essential task but Ministries of Defence have to be prepared intervene internationally to support crisis management, the scope of which is much wider than war fighting. This incorporates conflict prevention as well as post-conflict reconstruction and support to law enforcement. It also covers interventions in the case of natural disasters. Therefore there is a need for a flexible and adaptable organisation that draws on many types of skills and equipment.

Shrinking Budgets

Budgets are no longer what they used to be. Ministries of Defence across Europe experience the challenge of having to ensure sufficient capabilities and a level of preparedness to handle a number of tasks while at the same time having to tackle legacy in terms of organisation and equipment.

Legislation and Policies

The Defence and Crisis Management community have in the past enjoyed certain exemptions to legislation to avoid compromising a capability’s effectiveness. Today exemptions are becoming rarer and compliance is a necessity to ensure the availability of a capability in the long term.

Energy and Environment

There is a growing consensus globally that energy and environment have key roles to play in Defence and Crisis Management.

Energy is essential to being properly prepared for operations as well as for carrying them out. At home energy stems from both the electricity grid and fossil fuels. In theatre the energy supply is almost entirely dependent on fossil fuels, which are brought in by convoys. An Achilles heel, these are targeted by adversaries in order to disrupt the energy supply. This results in unnecessary casualties and reduces the effectiveness of the operation. Increasing energy efficiency and reducing energy consumption reduces the number of fuel convoys, hence lives are saved. Resources used to protect the convoys can be used for other tasks in the operation. Costs are reduced, both in theatre and at home.

Effective munitions, water and waste management further reduces the environmental impact, which contributes to the overall long term sustainability both at home and in theatre.

Lifecycles

Defence and Crisis Management product lifecycles differ from conventional ones. Two types of life-cycles should be considered.

- The Operations Life-Cycle has a varying time-frame and ranges from a few months to more than a decade. It is typified by the initial urgency and by a through-life uncertainty in terms of how it will evolve. Planning is therefore challenging.
- The Materiel Life-Cycle looks at the longer time-frame, in the past often around thirty-years. It is characterised by rigorous planning before acquisition.

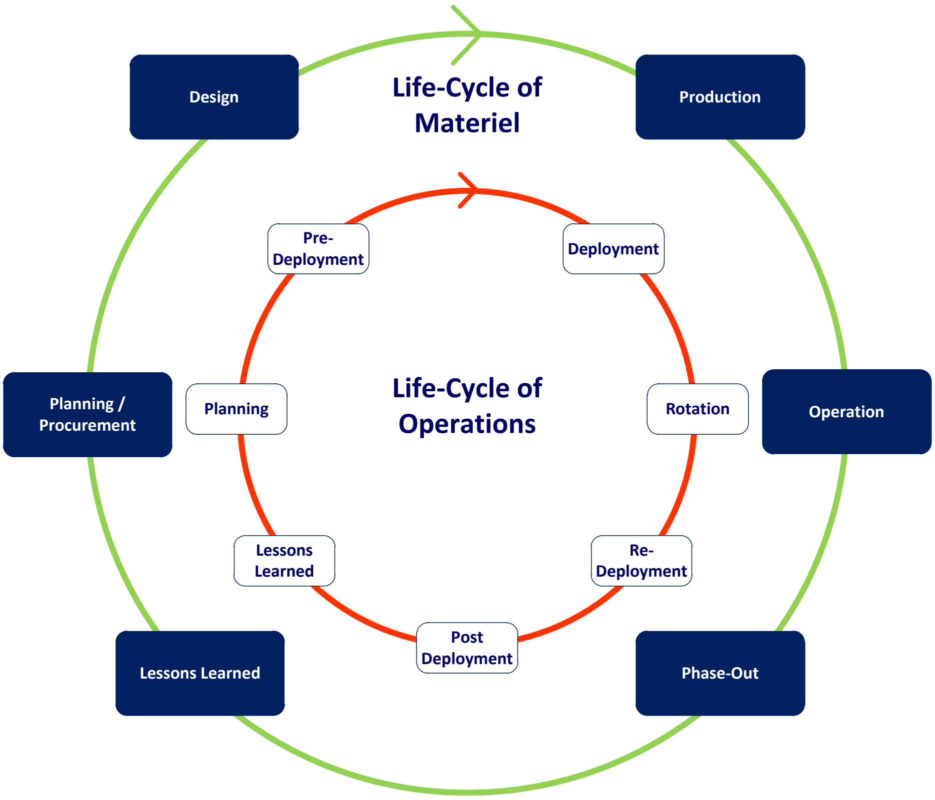


Figure 1: An illustration of the materiel and operations life-cycles and their respective phases

Sustainable Design and Acquisition Parameters

So how does sustainable design translate into a defence and crisis management context with all its particularities? The approach needs to be comprehensive and needs to take into account:

- Environmental considerations
- Livelihood of the domain
- The domain's purpose and credibility

Below is an attempt to develop these aspects into parameters that affect the requirements and choices in the design and acquisition process.

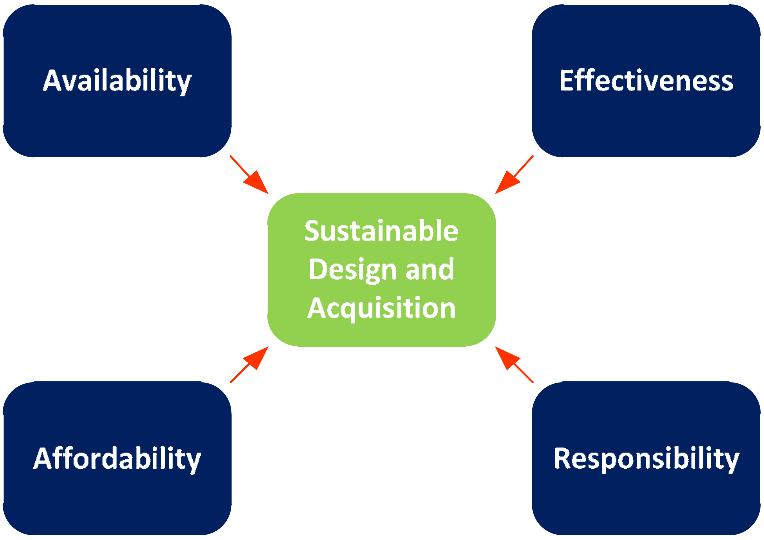


Figure 2: Parameters associated with Sustainable Design and Acquisition

- Availability:
    - Maturity - Often associated with Technology Readiness, maturity needs to include not only the current state of technology but also how much the end-product actually will contribute to the overall the capability.
    - Likelihood of Implementation – Although a technology is mature or well underway in terms of development, it might not be a given that it will be implemented. There could several reasons for this. For example, if the technology has been developed in a completely different domain, there might not be a natural mechanism for it to make its way into the context of defence and crisis management.
    - Operational Availability – Reliable equipment is always a big concern in defence and crisis management but in actual fact it is the Availability of a system that is the most relevant measure to consider. Defined as the ratio between the time a system is up and running and the total time, Availability takes into account the reliability of all the ingredients in the system as well as other aspects such as time needed for preventive and corrective maintenance. Designs therefore need to take into the configuration of the system, where means of increasing Availability look at for example including back-ups and readily accessible spare parts.
    - Supply Chain – Designing a system with the supply chain in mind is essential from a through-life perspective. This is particularly relevant to subsystems, components and materials that are critical as well as where the actual supply sources are few.

- Skills and Knowledge – Associated with supply chain are the aspects of skills and knowledge. While financial constraints often lead to outsourcing of not only production of equipment but also equipment design, it is important to identify and retain key skills sets and know-how. For long term sustainment this comes with the need to invest in for example educational and research infrastructures.

- Effectiveness:
  - Effect – The purpose of an operation is to achieve effect. Understanding what the requirements are enables providing appropriate equipment. Systems Engineering is therefore key.
  - Autonomy – More autonomy in a system requires more intelligence to be embedded. This of course comes with a price tag. More autonomy has the advantage that it can put humans out of harm's way and let the equipment be subjected to the risks in operations. It also reduces the human presence in the loop and at its most extreme there is no human presence at all. Although this is still a long way ahead, confidence and trust in the system are necessities.
  - Endurance – Sustainment is a feature that is also important to an operation's effectiveness. Enduring different types of natural and induced conditions over long periods of time imply tough requirements on equipment.
  - Mobility and Agility - Two other important aspects of effectiveness are Mobility and Agility. In a systems context this also implies tough requirements. It can also imply a compromise in terms of payload.
  - Readiness and Deployability – With the globe as the scene for interventions systems need to be easy to deploy. This is a parameter that is strongly connected to Operational Availability.

- Affordability:
  - Development – If the technology is not yet mature there is a cost associated with the development. Since it precedes the Initial cost of acquisition it is not as visible. It is perhaps also quite challenging to measure since contributors can come several lines of research and development. Development comes in addition with lead time that also needs to be taken into account.
  - Initial – The initial acquisition cost carries a lot of weight when selecting a design. Although through-life costs are used to a great extent today in the evaluation process the business models are often still based on the initial cost. Low initial costs are dependent on high volume. Established designs have therefore the upper hand and it makes it difficult for new designs to enter into the market.

- Through-Life – Often associated with a different budget line than that of the initial cost, the through-life cost affects the sustainment of an operation as well as preparedness for future operations. It is essential to give this a more prominent role in acquisition through new business models.
- Replacement – When equipment is in use in theatre it is subjected to risks which might result in destruction. The more expensive a piece of equipment is the more it financially hurts to lose it and subsequently replace it. This acts as an additional incentive to go for less costly solutions.

- Responsibility:
  - Safety and Survivability – Safety and survivability are cornerstones in doctrine. This is something that cannot be compromised.
  - Environment – Each phase of both the Materiel and Operational Life-cycle comes with an environmental footprint. The environment includes aspects pertaining to climate change, biodiversity and cultural heritage. Understanding the impact of the footprint allows for implementing measures to reduce it. The planning phase plays an important role and can have effects that can be seen as far as thirty years later. New business models are also important in this context in order to catalyse more environmentally responsible solutions.
  - Socio-Economics – A political parameter, socio-economics has an impact on design and acquisition in Defence and Crisis Management. With contracts still being relatively big and for long periods of time, the well-fare of not only an industry but an entire region can depend on these.
  - Ethics: Requirements on ethical aspects concerning for example the exploitation of labour are integral to collective social responsibility.

A Sustainable Process

How these Parameters are implemented and to what extent vary from country to country. What can be said is that in order to achieve the full effect they need to be present during the entire process. Awareness among the stakeholders involved is therefore essential (end-user, acquirer, supplier and society). Depending on the objective and scope of the acquisition each parameter will carry a different weight in the requirements definition phase.

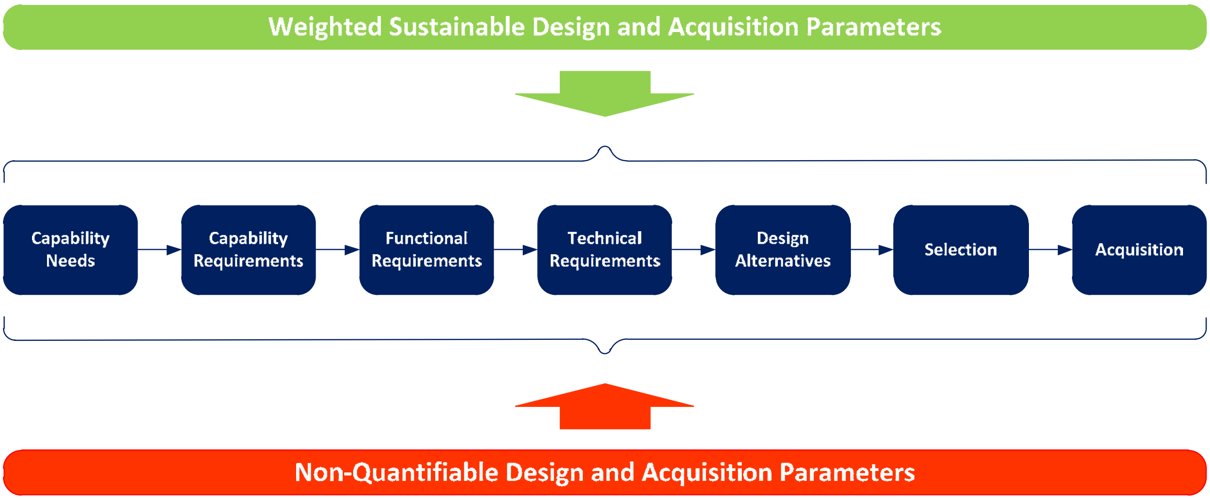


Figure 3: The role of the Design and Acquisition Parameters in the Process

In this context it is also important to acknowledge that there a number of Non-Quantifiable Design and Acquisition Parameters that will play a part as well, albeit not necessarily explicitly.

- Experience from having used or designed similar systems
- References from others using similar types of systems
- The outcome of Test and Evaluation of similar types of systems
- Taste and gut feeling among end-user, acquirer and supplier

These Non-Quantifiable Design and Acquisition Parameters cannot easily be controlled and some can be seen as subjective. On the other hand these represent aspects that raise the level of confidence in the system among the stakeholders – clearly this must be a considered a contributor to sustainability as well.

Seeing that the Sustainable Design and Acquisition Parameters cover a wide range of issues it is not an easy task to ensure that they are implemented appropriately. One approach could be to centre the process on the Functional Requirements. Two iterative loops reverse engineer the high level capability needs and develop the technical requirements respectively. This could make it easier to understand the impact of the Sustainable Design and Acquisition Parameters and allow for some experimentation in order to fine tune the requirements to achieve the desired outcome.

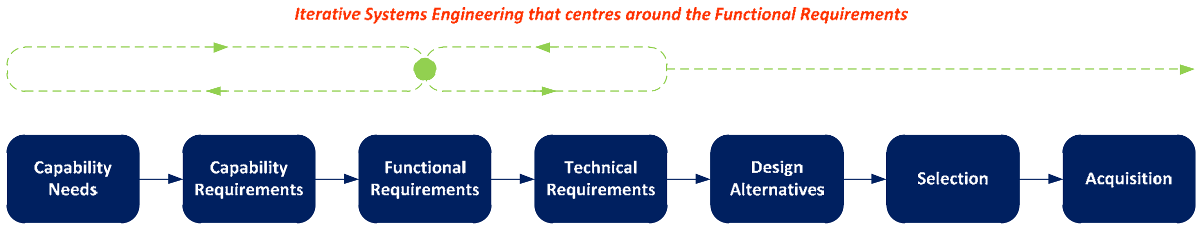


Figure 4: An illustration of how Systems Engineering can be handled in a more pragmatic way to ensure that the Sustainable Design and Acquisition Parameters are taken into account properly

Conclusions

This paper has attempted to translate the civilian principles of sustainable design into a Defence and Crisis Management Context. Looking specifically at the design and acquisition process, the paper has attempted to extract the essence of existing national approaches and develop them further. Sustainable Design and Acquisition Parameters have been defined and their role in in the process has been described.

In conclusion it can be said that Sustainable Defence and Acquisition is complex and touches on a number of different topics. All of these carry different weight depending on the acquisition project. The important thing is to understand their implications early on in the requirements definition phase. Awareness among the stakeholders involved is thus crucial. It is encouraging to see that many countries already have policies in place attempting to tackle this issue (a simple search on the Internet reveals this fact). They do vary in terms of scope and therefore there is an opportunity for international harmonisation.

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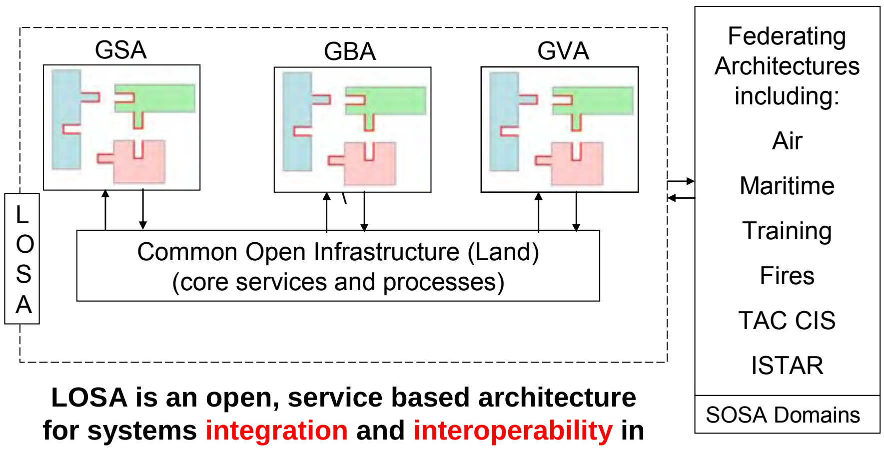
Land Open System Architecture (LOSA)

Paul JOHNSON (Defence Equipment and Support, UK Ministry of Defense)

Background

The requirement for a Land Open Systems Architecture (LOSA) is based on the integration and interoperability of systems within a deployed brigade. LOSA partitions the problem space in terms of force elements into 3 platform views (soldier, vehicle and operational base or headquarters) based on a common model that includes a defined core infrastructure and core processes such as System Information Exploitation (SIE).

While architectures and standards have been or are being produced for the 3 platform types (Vehicles, Base and soldiers), LOSA provides the next higher level of interfaces to be managed, internally for platform interoperability and externally for LOSA to federate with other architectures, and for the implementation of core processes:



LOSA is an open, service based architecture for systems integration and interoperability in the land domain in order to deliver coherent Force Elements.

Objective

The vision for LOSA is one where, through the use of defined open system architectures and mandated standards developed in conjunction with industry, the ready integration of systems on platforms and interoperability between platforms is achieved in such a way as to maximise the operational agility of force elements to respond to change while reducing the cost of ownership.

This will be achieved when dismounted soldiers can share data and power seamlessly and transparently with a vehicle or base, particularly when on board, and, similarly, soldiers and vehicles with the base infrastructure, thereby providing integrated and interoperable force elements.

Approach

The basic LOSA model has a number of functions1 which are delivered, to a greater or lesser extent according to role, as services by a single platform (soldier, vehicle or base) or grouping of platforms (a force element) in order to deliver a given capability. These functions or services are delivered by systems and integrated through the use of common, standardised interfaces. The basic unit of capability in the Land domain is a brigade.

With its emphasis on the interoperability of the systems that provide these services, LOSA affects and provides benefit across all DLODs, where reducing the training burden and the manpower to manage and maintain them are seen as key benefits.

The common core infrastructure, therefore, is applicable across the Land domain and is key to integration and interoperability. The boundaries and interfaces to it are open2 and use open standards defined, maintained and mandated by the MoD as Defence Standards. This provides the MoD with control over the integration and interoperability aspects while allowing industry the freedom to provide system solutions to meet specific requirements.

Impact

The high level benefits being sought by the development of LOSA are:

a) Increasing operational effectiveness:

- Enabling the exchange of data between platforms.
- Enabling the exchange of data with systems external to the Land domain.
- Enabling integration between base, vehicle and soldier.
- Improved acquisition processes through early engagement with industry and rapid prototyping.

b) Reducing whole life costs:

- Improving ways if working within and without the Land domain.
- Reducing and simplifying system requirements.
- Enabling simpler integration of new or altered processes and equipment.
- Enabling decisions based on accurate and consistent data provided through the SIE process.

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[1] Command and Battlespace Management, Situational Awareness, Lethality, Mobility, Survivability, Sustainability and Special to Role.

[2] Open standards are those that are publicly available, controlled by a recognised non-commercial standards body, are royalty-free and encourage 3rd party participation.

Environmentally Friendly Solutions in Military Applications: NAMSA Initiatives

Jörn BRAUER (NAMSA - NATO Maintenance and Supply Agency)

Abstract – One of the mainstays of providing a safer environment is the demilitarization of surplus munitions, weapons and equipment held in national inventories. NAMSA has safely demilitarized a wide range of items, many of whose components have been actively recycled: plastic mine bodies have been used to make children's toys, recovered metal has been used to produce manhole covers, dangerous chemicals have been turned into fertilizers, white phosphorus has been converted into phosphoric acid and TNT has been recycled to produce quarry explosives.

Another NAMSA initiative in this area is Demilitarization, Dismantling and Disposal (D3). Obsolete military equipment – ships, aircraft, tanks, vehicles, etc. – contain harmful substances such as asbestos, PCBs (polychlorinated biphenyls), lead, chromates, etc. NAMSA's D3 initiative is currently engaged in the environmentally responsible disposal of such systems.

NAMSA General Services Programme (LG)

The NATO Maintenance and Supply Agency (NAMSA) is NATO's principal logistics support management agency. In that capacity, NAMSA provides cooperative logistics services to its customers – the NATO nations and other NATO bodies – while applying three basic principles: consolidation, centralization and competition.

In delivering services to its customers, NAMSA's General Services Programme (LG) is committed to achieving the highest standards. NAMSA LG has recently been certified ISO 14001 compliant, pioneering the Environmental Management System at NAMSA, and is committed to continuously improving its environmental performance while ensuring compliance with all applicable legislation. As part of that effort, the environmental management system implemented by NAMSA LG serves to reduce the environmental impact of its services and activities.

Demilitarization, Dismantling and Disposal

One of the mainstays of providing a safer environment is the demilitarization of surplus munitions, weapons and equipment held in national inventories. Working with NATO's Science for Peace and Security Programme and with national governments, and acting as the executing agent for Partnership for Peace Trust Fund projects, NAMSA has safely demilitarized a wide range of items including anti-personnel landmines, Small Arms & Light Weapons, chemicals, cluster munitions and ammunition containing white phosphorus, depleted uranium and tungsten.

Another NAMSA initiative in this area is Demilitarization, Dismantling and Disposal (D3). Obsolete military equipment – ships, aircraft, tanks, vehicles, etc. – contain harmful substances such as asbestos, PCBs (polychlorinated biphenyls), lead, chromates, etc. NAMSA's D3 initiative is currently engaged in the environmentally responsible disposal of such systems through the newly established

Demilitarization, Dismantling and Disposal (D3) Support Partnership. In the context of Smart Defence – which focuses on capability areas identified as being critical for NATO at the 2010 Lisbon Summit – NATO's Allied Command Transformation (ACT) has now approved the D3 of military equipment as a "Building Capability through Multinational and Innovative Approaches" Project, with NAMSA as lead nation.

Other Initiatives

NAMSA LG also assists nations by providing expertise in reducing their carbon footprint through the recycling, recovery and reuse of their military equipment. ISO 14001 requires materiel to be recycled wherever possible, and many of NAMSA's projects include recycling as part of the overall project plan. Valuable metals have been extracted and resold (and the proceeds paid back to the customers), pesticides and chemicals have been turned into fertilizers, steel from weapons has been re-used in the building industry (manhole covers, piping and reinforcing rods), the bodies of demilitarized SA-4 missiles have been converted into water tanks, explosives have been recycled for alternative uses (e.g. TNT in quarry explosives), white phosphorous has been converted into phosphoric acid for commercial use, and plastic landmine bodies have been used to make children's toys and plastic piping.

NAMSA also takes the nations' responsibility towards future generations into account when procuring equipment today. Military equipment acquired for its customers is tested against stringent national and EU regulations to ensure compliance with environmental standards. Recent acquisitions include environmentally friendly waste incinerators, water and sewage treatment plants, deployable nuclear, biological & chemical (NBC) laboratories and a complete munitions disposal facility that meets all EU environmental regulations. NAMSA LG contractors are required to be compliant with all relevant EU Directives and Regulations, NATO Standardization Agreements (STANAGs), national, regional & local environmental legislation and international conventions. The following NATO STANAGs relating to the environment have been published: 7141, 2510, 7102, 2581, 2582 and 2583.

In addition, NAMSA LG provides nations with support in organizing conferences and exhibitions on environmental solutions in military applications. The goals are to identify civilian renewable energy sources and energy-efficient and environmentally responsible technologies that are applicable to military equipment without loss of combat power in missions and operations, and to raise military awareness of the available technologies. Another aim is to raise the awareness of industry and the scientific community to the fact that there is interest in these technologies on the part of the military. In November 2011, a conference and exhibition themed on Innovative Energy Solutions for Military Applications (IESMA 2011) was organized by the Lithuanian Energy Security Centre with NAMSA LG support. NAMSA LG is currently helping the Luxembourg Ministry of Defence to organize a conference and exhibition in March 2013 themed on "Environmental Solutions for Effective Crises Response / Enhancing Security of Crises Response Actors through Sustainable Solutions / Energy Security" (3E-SEC 2013).

Conclusions

In conclusion, NAMSA has already gained considerable experience in support of its customers, and will certainly build on that expertise to take further initiatives in the area of alternative energies and environmentally friendly solutions.

Dependencies on Fuel and Alternative Options for Crisis Management Operations

Antoine VINCENT (European Defence Agency)

Abstract – Crisis Management Operations led by the European Union in remote locations face numerous logistical challenges. Among them, fuel supply is one of the most prevalent. At the strategic level, the dependence of deployed units on fossil fuel exposes the operations to the risk of rising fuel prices. At the tactical level, fuel supply convoys fall regularly under the attack of insurgents.

In the frame of its capability priority Fuel and Energy, the European Defence Agency commissioned in 2012 to the Spanish defence consultancy company ISDEFE a study on Dependencies on Fuel and Impact of Alternative Options for Crisis Management Operations. The study encompasses the collection of data relevant to energy supply and consumption for Crisis Management Operations, the development of a related parametric model, and the analysis of three case studies for land installations.

Background: Fuel as Strategic and Tactical Factor

Energy is an essential operation enabler and a critical vulnerability. Crisis Management Operations led in remote locations under the European Union banner face numerous logistical challenges. Among them, fuel supply is one of the most prevalent: the long logistic tail limits deployed elements' ability to manoeuvre as an expeditionary force. At a strategic level, the force massive dependence on fossil fuels exposes operations to the risk of constantly fluctuating fuel prices.

In Afghanistan, logistic lines must supply fuel around an area covering more than 380 000 square kilometres, through some of the most hazardous regions of the country. This implies that fuel convoys must be adequately protected, which drives the fully burdened price of fuel in the most remote locations above 75 EUR per litre [1]. Besides, resupply routes are regularly attacked by insurgents, which poses a direct threat to soldier's safety and could have a deep impact on operational effectiveness. Recent reports indicated that, for every 24 fuel convoys in Afghanistan or Iraq, one soldier is killed or wounded. There is therefore a pressing need to identify energy-saving options and alternative power solutions (including renewable energy sources) that can be implemented in support of ever-changing missions.

Fuel and Energy: a Capability Priority

In March 2011, the European Defence Agency's Steering Board identified *Fuel and Energy* as one of its 10 top capabilities priorities [2]. In this context, the European Defence Agency (EDA) has launched an overall initiative to promote Sustainable Energy for Crisis Management Operations (CMO) including:

- definition of policies and strategies

- implementation of novel systems into operations
- logistics & Supply Chain Management
- design and acquisition.

This initiative is supported by the Ad Hoc Working Group *Fuel and Energy* under the Integrated Development Team *Sustain* of EDA Capabilities Directorate. This group consists of government representatives from EDA participating Member States (pMS), joined by industry experts during the open sessions.

The preparation of future actions requires a thorough review and analysis of the current state of play. In particular, the determination of the fully burdened cost of energy is essential. A modelling tool specific to energy for expeditionary CMOs is regarded as a prime asset to support decision-makers. Both elements are addressed by the study *Dependencies on Fuel and Impact of Alternative Options for Crisis Management Operations,* commissioned early 2012 by the EDA to the Spanish defence consultancy company ISDEFE.

Collection of Statistical Data

The collection of statistical data is a key task to identify precisely the supply and consumption of energy for EU CMOs and the related costs. The planning of fuel usage may be obtained from example from the NATO Standardization Agreement 2115 *Fuel Consumption Unit*. However, a thorough analysis requires incorporating external costs such as those related to transportation, including the protection of the fuel convoys. Furthermore, energy consumption should also cover the usage of batteries which are extensively used for modernized soldier systems.

In May 2012, a questionnaire was prepared and circulated to EDA participating Member States and to the headquarters of on-going EU Crisis Management Operations. This questionnaire takes the form of a simple Excel template for each operation. The contractor ISDEFE also incorporated available data from comparable non-EU multinational Crisis Management Operations. For land-related operations, the questionnaire collects details on the main energy consumers (Heating, Ventilation and Air Conditioning, cooling…). The answers already received from Member States suggest that the data set will be solid enough to be representative for land-related operations. Further data collection efforts would be necessary for naval and air operations. Besides, the study will include a methodology on how to maintain this comprehensive picture of energy supply and consumption over time.

Fuel-D
Dependencies on Fuels
MISSION FORM

GENERAL
This section aims at establishing the nature of the mission, its current phase and geographical location

CMO TITLE :

LOCATION: COUNTRY: MISSION START DATE (DD/MM/YYYY) :

NATURE OF MISSION: *Please Select One*

Current Phase : Deployment / Sustainment / Demobilization

EVOLUTION OF PERSONNEL
Please indicate the change over time in personnel numbers. The idea is to see if it is possible to map it against the energy consumption over time.

From: (DD/MM/YYYY)	To: (DD/MM/YYYY)	Land (population)	Air (population)	Sea (population)

CONSUMPTION OF FUEL
The parameters below will help show the history of fuel consumption, what types have been used and the associated fully burdened cost.

From: (DD/MM/YYYY)	To: (DD/MM/YYYY)	Fuel Type	Land			Air			Sea		
			Volume (litres)	Fully Burdened Cost	Select Currency	Volume (litres)	Fully Burdened Cost	Select Currency	Volume (litres)	Fully Burdened Cost	Select Currency

Table 1: Extract of the Questionnaire used for the Study

Parametric Model

The study includes the development of a generic parametric model to take into account all aspects of a CMO, and to show the influence of energy supply and consumption. The parametric model shall cover in particular:

- the identification of relevant input and output parameters
- a fully-burdened cost analysis
- life-cycle aspects
- the analysis of the sensitivity to energy of each CMO.

Parameters to be taken into account include:

- the type of assets involved, both static (e.g. military camp) and mobile (e.g. military platform)
- the geographical environment
- the operational environment
- the type of military operation.

This parametric model shall be validated against the data collected previously. To facilitate the use of the model, it will take the form of a simple Excel file.

Test Cases for Land Operations

In general, military platforms have a very long life-cycle due to their high-costs and specificities. By contract, assets for military camps are renewed more frequently and offer more potential for concrete applications of new technologies. For this reason, the study will analyse three test cases for land-related operations:

- one Main Operating Base including an airstrip
- one Forward Operating Base with logistic supply by road
- one Patrol Base in a remote location.

The goal is to compare the relative benefits of a conventional design with a design optimised for fuel efficiency, incorporating energy-efficiency technologies (thermal insulation...) and renewable energy sources (photovoltaic, wind...). The comparison will address issues related to:

- energy consumption
- energy efficiency
- costs: fully burdened cost and investment payback periods
- maintenance.

The optimised design shall be based on a modular approach to accommodate future energy needs in a plug-and-play fashion. Trade-offs involved in the design will be clearly identified and assessed. In particular, the payback period for investments in new materiel will be clearly identified.

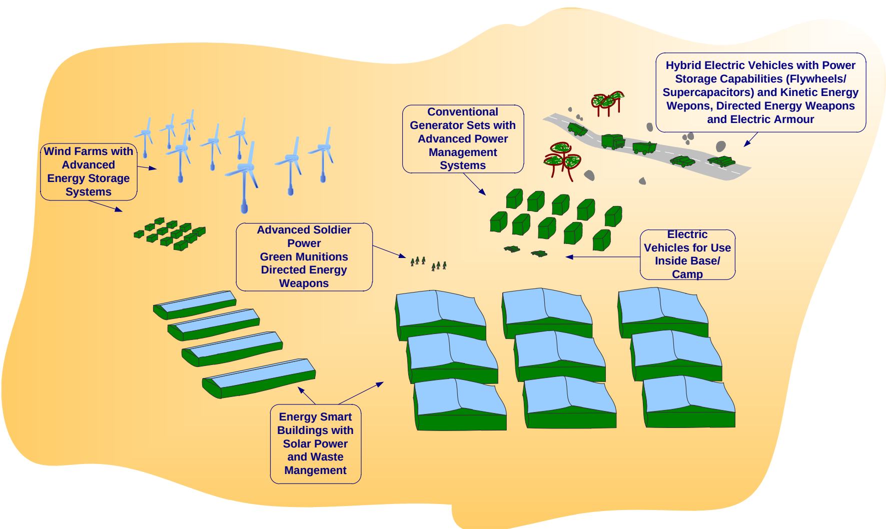

Figure 1: Conceptual View of a possible Optimised Land Installation

Conclusions

This study will inform EDA participating Member States for their decisions regarding energy supply and consumption for Crisis Management Operations. A strong involvement of Member States is a key factor for a robust data collection and validation process. This study will propose short-term improvements for land-based installations. It is expected that the full results will be available by the end of the year 2012.

Acknowledgement

The author would like to thank the European Defence Agency and its participating Member States for supporting this study, and in particular the data collection efforts.

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Power Forward Operating Base (PowerFOB)

Paul JOHNSON (Defence Equipment & Support, UK Ministry of Defence)

Background

The provision of electrical power on deployed operations provides essential support underpinning operational capability but it brings with it a large logistic burden. Power generation in Camp Bastion (largest FOB), for example, consumes around 70% of the non-aviation fuel used in theatre to operate around 250 generators of varying size. This amounts to around 18.2 Million litres of fuel per annum which must be transported overland through high-risk areas. The MoD approach to electrical power generation and distribution has historically been based on local generation using a mixture of equipment solutions and bespoke constructed facilities, almost all of which depend on diesel generators. The result is characterised by complexity and inefficiency.

Objective

PowerFOB is aimed at identifying fuel efficient technologies and sustainable electrical power alternatives to fossil fuels with the objective of making FOBs as 'fuel-sufficient' as possible whilst maintaining operational capability, therefore reducing the logistic burden imposed on the supply chain through the transportation of fuel. This is to be achieved through the use of 'open' systems, thus enabling a wide variety of different fuel efficient and renewable energy technologies to be integrated into a FOBs power supply.

Approach

The 1st Phase of PowerFOB was successfully undertaken in July 2011, at Episkopi Training Area, Cyprus. Cyprus was chosen as its heat and humidity make it a similar climate to Afghanistan, ensuring the technologies would be tested in an operationally relevant environment.

Utilising a FOB in Cyprus, Programmes and Technology Group (PTG) co-ordinated a group of industry technology providers, Subject Matter Experts (civilian, military and International), to assess fuel efficient technologies in the following areas of Energy Management:

- Diesel Generator Management
- FOB Demand Management
- Energy Storage.
- Renewables

Each technology was integrated into the FOBs power supply to measure fuel savings against the baseline, and expert assessments were made to gain an understanding of implications such as military utility, ease of deployment, maintenance burden etc.

This activity proved the concept that significant savings (22-46%) can be made with respect to FOB fuel use through integrating battery storage, demand management and renewable[1] energy sources with the in-service diesel generators that are currently used in FOBs.

Intelligent Power Management				Overlaying all power delivery
Power Architecture				
Generator Management	Demand Management	Energy Storage	Renewables Integration	Fuel Saving
X		X		22%
X	X			15%
X	X	X		37%
X	X	X	X	46%

Impact

If full implementation of all tested technology is undertaken at Camp Bastion fuel savings of up to 16.7M litres could be realised in the following 2 year period.

By reducing the amount of FOB fuel consumption the size and frequency of fuel convoys, which are often a high profile target for attack, can be minimised. This reduces the risk to troops on the ground, and also makes more troops available for operational missions.

Implementation of energy storage means generators can be turned off, often for hours overnight, with no impact on FOB core infrastructure or services. The reduced burden on the generators also means that maintenance periods can be extended, and the chance of generator breakdown is reduced.

This reduction in fuel use would contribute towards the UK MOD's target to reduce carbon emissions by 25% by 2020.

[1] Based on PowerFOB assessments and technology maturity, Solar PV is the preferred choice of renewable energy

Naval Economy and Flexibility

John BUCKINGHAM (BMT Defence Services Ltd)

Abstract – Coastguard vessels, offshore patrol vessels and corvettes typically have a two-shaft propulsion system comprising two medium-speed engines. This paper presents the findings of a study which compared the conventional propulsion arrangements with a four-engine solution and a hybrid design to assess the scope for energy savings through better fuel economy and propulsion and power generation redundancy. Suitably used, the alternative designs allow for a better loading of each engine and/or the use of a more efficient engine for power generation. The incidental issues of continuous slow speed manoeuvring and the size and number of DG-sets are also addressed.

Context

Conventional government vessels which patrol inshore and sea areas, with a displacement of 1500 to 3000 tonnes typically have a twin-shaft propulsion arrangement with each propeller driven by a medium-speed engine through a reduction gearbox. Just one engine can drive the vessel at cruising speed, with the other trailing, either with a stationary shaft and feathered propeller or with a non-driven rotating propeller: there will always be a drag effect exercised by the non-driven propeller. If the single engine is to be run up to full revolutions when at cruise, then a reduction ratio is needed that is different to that required for full revolutions at full speed. This calls for a double-path gearbox. Such vessels typically employ high-speed DG sets to provide electrical power to the ship.

If a single gearbox reduction ratio is adopted, the propeller blade is at full pitch and the engine is running at a point on the torque-speed curve which is away from the full-power point. If the engine is not sequentially turbocharged this will usually lead to a worse specific fuel consumption and thus worse economy. If the engine blade angle is fined off to move the engine speed to better economy point, this leads to worse propeller efficiency. In either case, there is a worse outcome for either engine or propeller efficiency at cruise speed.

A four-engine concept seeks to avoid the shortcomings of the standard approach. Each propeller shaft is driven by two high-speed engines through a single- or double-reduction gear. For this application, each propeller shaft is driven by two high-speed engines through a single- or double-reduction gear. An example power-pack is the RENK ASL 2 x 104 gearbox along with four MTU engines. This performance of this arrangement was considered against that of the typical medium-speed engine design.

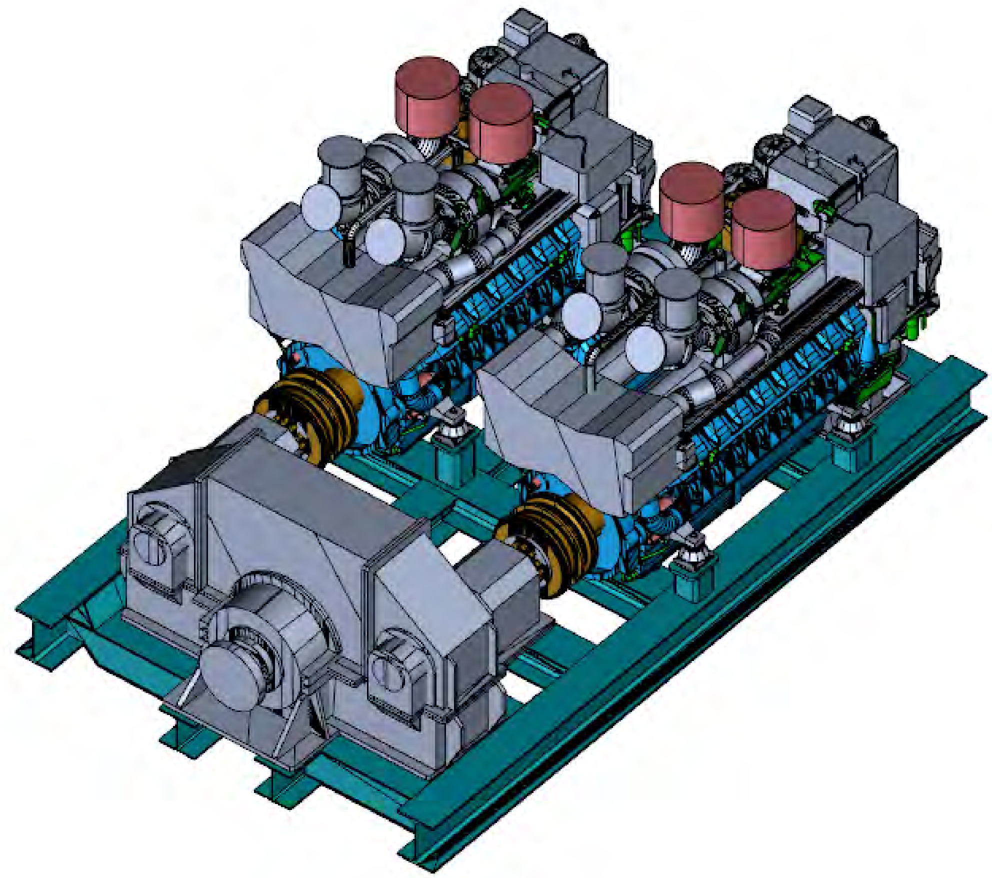

Figure 1: Power-Pack

The most important advantages of the Power-Pack arrangement

The Power-Pack concept attempts to offset the trailing-shaft drawback of the conventional arrangement. The higher gearbox reduction ratio may involve slightly higher losses but at cruise speed, one engine would run on each shaft thus avoiding the need to trail a shaft.

The high-speed engines are Sequentially Turbo-Charged (STC) and allow for good economy and better maximum torque capability across the whole engine speed range. Thus at cruise speed the engine can be located away from the smaller optimum load range as per the conventional design and can run at a good part-load efficiency. This allows the propeller pitch to be optimal for this speed.

Although they have good part-load efficiency (i.e. specific fuel consumption) relative to its full load performance, the high-speed engines' efficiency at full load is not always as good as that of a slower-speed engine, so the overall benefit is affected by the balance between propeller and engine efficiency.

Comparison: two- and four-engine options

A theoretical comparison of the different arrangements reveals how each of different options can be most suitable depending on fuel costs, engine support costs and the ship's operating profile.

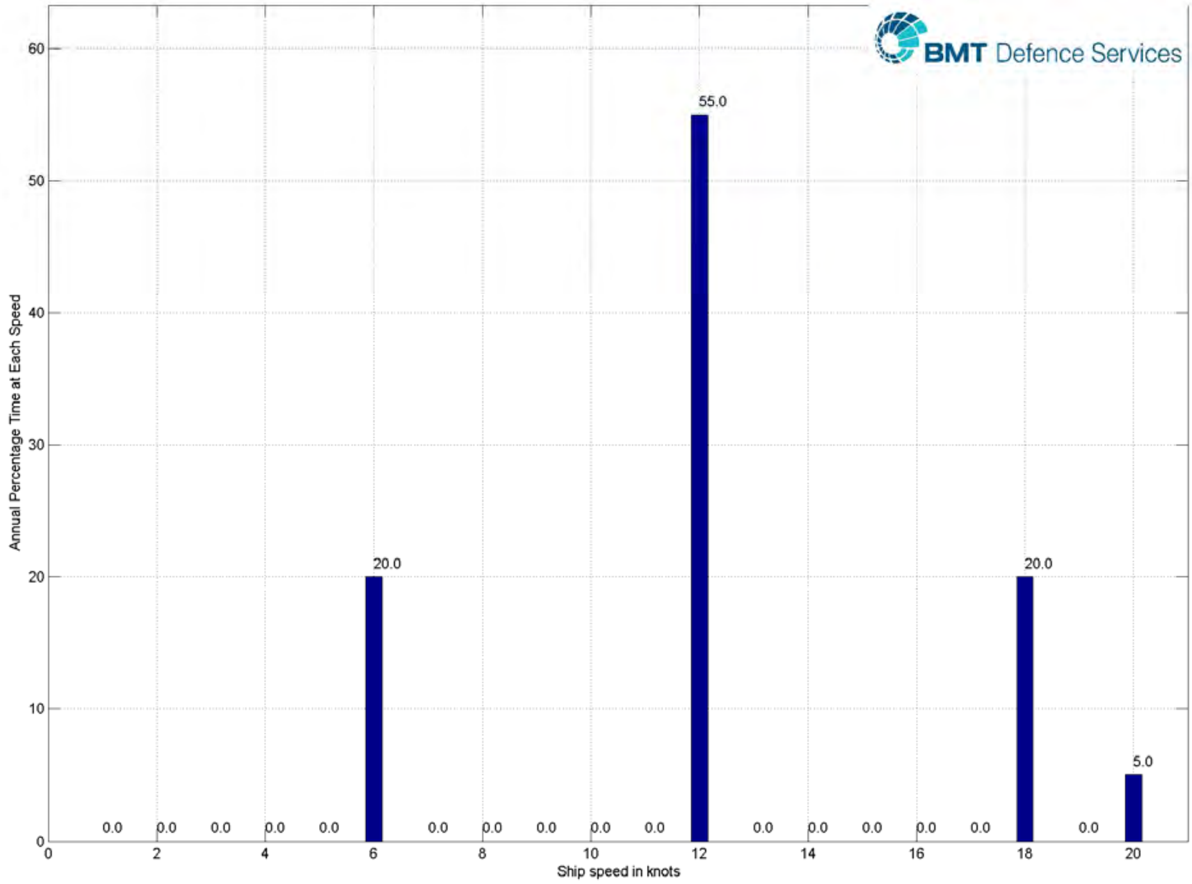

Figure 2: Ship Speed-Time Operating Profile

Figure 2 shows the assumed ship's operating profile. About half the time is spent at 12 knot cruise with periods at boost speed of 18 and 20 knots. There is also a significant time spent at the loiter speed of 6 knots. However it is also recognised that the ship's profile often reflects the optimised speeds for the machinery installed.

Space and Weight Savings

It is estimated that the four-engine design is about 30 tonnes lighter than the two-engine design. This is principally due to the 44 tonnes for the smaller high-speed engines versus the 73 tonnes for the larger engine. The four-engine design is estimated to have a smaller volume as the engines are both lower and shorter than the twin-engine design although the raft as a whole will be wider. Since almost all the auxiliary components are onboard the raft, upkeep on the smaller engines can be carried out by engine exchange. Components such as cooler, filters, hydraulic valves, sensors, controls, and pumps are mounted on the gearbox. The larger torque envelope of the STC engine allows for more engine operating flexibility and fewer restrictions on low-speed operations. The bespoke gearbox provides scope for engine input forward or aft.

Engine Costs

For the assumed ship speed profile, the four-engine design consumes 3.8% more fuel per year or 165 tonnes. This is £83k or €94,000 at £500/tonne. For this study, engine support costs are related to the engine rating through the factor £10/MWh. Thus an 8,000 kW engine costs £80/hour to run and a 4,000 kW engine costs £40 per hour. Whilst this figure is much higher than quoted by engine suppliers it does go some way to reflect the factored cost of infrastructure for the ship owner in terms of spares, ILS and the staffing required ashore. The figure is clearly representative yet would need to be subjected to sensitivity analysis. It does not consider the impact of higher running speeds on the Time Between Overhauls (TBO) or the relative ease of maintaining smaller engines in-situ or through upkeep by exchange. The two engine design has annual engine support costs of £0.711m compared to £0.504m for the four engine design. This does not include a factor for the markedly different number of engine cylinders.

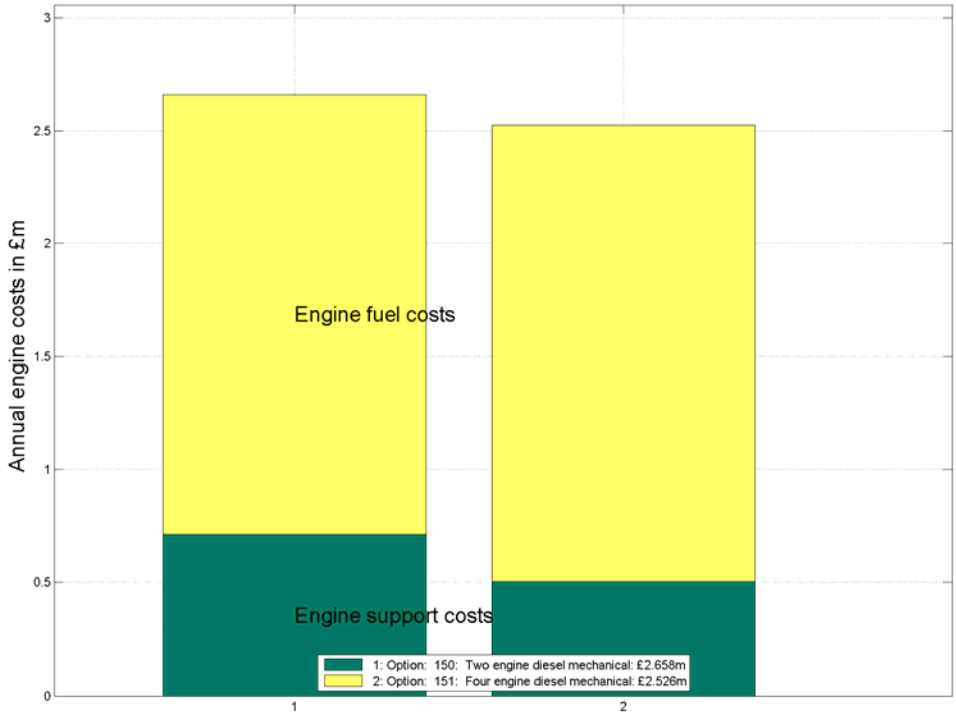

***Figure 2:** Annual Engine Costs for each Option*

Figure 3 shows the total annual engine costs for both options showing how the adoption of four engines can lead to a lower overall cost with a comparable fuel consumption.

Hybrid Designs

The Hybrid Design comprises an arrangement whereby two of the high-speed DG sets are removed from the basic design and replaced with two Hybrid Machines (HM) driven by the main engines through the gearbox PTO shaft.

Each HM can operate as a 200kWb motor drive with its speed controlled by a four-quadrant power converter. The same converter can treat the power generated when the HM is acting as a PTO-driven alternator to supply 600kWe 60Hz, 690V to the ship's bus.

The main engines are usually more efficient than the DG sets can be used to provide both propulsive and electrical power thus saving fuel and saving engine running hours and engine procurement costs.

The two 740kW DGs sets allow for HM motor drive to 7 knots and provides a useful continuous loiter capability. This avoids single main engine operations and the issue of a trailing shaft.

Between 8 and 19 knots, each main engine drives the propeller shaft and the HM generator to supply ship's power. This covers the major element of the operating profile and employs the full torque-speed capability of the main engines. At 20 knots, the main engines simply drive the vessel and the two DG sets supply ships power.

A hybrid design leads to fewer engine running hours with a 2% lower fuel consumption. The actual difference will vary greatly with the operating profile and the extent to which the trailing shaft in the conventional design provides propulsion drag.

There is also a greater reliability of propulsion power supply as there are four prime movers which can provide propulsive drive and not two.

The two motors provide the capability of a continuous slow speed for loitering but the nature of the design also allows one main engine to provide power to its own shaft and some power to the other to allow a zero-drag trailing shaft. This is a half-way house between full electrci loiter drive and main engine drive. The benefit of using this mode is closely associated with the trailing shaft drag, and the balance between propulsive and electrical loads. It is also usual to have a DG set running in such a case to ensure there are two independent sources of electrical power.

The Hybrid Design offers a more diverse and resilient source of electrical power as the HM machines are less vulnerable system faults and they can absorb energy from regenerative devices on the bus or from the HM motors when they act to brake the ship. (CPP is retained for a full speed crash stop capability).

A key aspect is the flexibility offered by the ability to load the main engines with a combination of propulsive and electrical to suit their best efficiency point. In this way the design can accommodate changes to the electrical load chart through life and yet maintain an economic means of operating.

Conclusions

The four-engine Power-Pack has footprint benefit in terms of length and on the basis of the assumptions in this study, an overall engine support cost benefit. There are no discernable differences in the endurance fuel requirement though the four-engine design has a worse range above the endurance speed.

The provision of four engines will make for a more available propulsion arrangement even if there is a high chance of any one engine failing. The choice of the four-engine design needs to reflect the ships operating profile as this can have a major bearing on the match of main machinery to ship usage and the fuel economy achieved. Where necessary a father-son arrangement may be more suitable than four of the same engines.

Hybrid designs are a relatively new phenomenon in the military world, being advanced through the benefits of cheaper and robust power electronics modules. They typically allow the removal of two DG sets from the ship and offer more flexibility at the cost of a more complex operating control strategy. They offer fuel savings through the use of the main engine's better inherent efficiency but they also future-proof a design as there is greater flexibility to achieve main engine running nearer its optimal efficiency point.

Acknowledgements

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Military Engine and Propulsion Systems Going Green

Thomas von RETH (FEV)

Abstract – *The awareness to use green technologies in military applications is continuously growing. The propulsion systems of military vehicles have a special role concerning "green" behaviour of technologies. Green, respectively environmental friendly, behaviour with respect to propulsion systems can be focused on two aspects:*

- CO2 Reduction
- Reduction of emissions like NOX, particulate matter (PM), CO and Hydrocarbons (HC).

Reduction of CO2 on one hand will reduce the impact of military engine operation on the climate, on the other hand will also significantly help to reduce operation cost in theatre, reduce the number of fuel convoys and increase operation radius, flexibility and independence. In addition the increase of fuel efficiency can support the re-design of protected vehicles in order to increase the protection level, albeit keeping the fuel consumption on the same level as before.

CO2 reduction of military propulsion systems can be achieved by a consequent lay out of engines towards military needs, at the same time using fuel saving technologies adapted from the civilian engine technology. Here a 10 to 15% fuel economy increase in comparison to today's military engine technology can be achieved.

One very promising fuel saving technology which can be adapted for the military area is the HEV, Hybrid Electrical Vehicle technology. In comparison to the civilian world, concept adaptations to the military needs have to be considered. For instance, the operational performance has to be guaranteed independent from the charge status of the battery. The Hybrid technology will bring further advantages in the field of stealth operation (pure electric drive), silent watch and limp home capabilities.

The necessity to reduce NOX, PM, CO and HC emissions is becoming a more and more important discussion. Modern diesel engines are using complex exhaust gas after-treatment systems in order to reduce above mentioned emissions down to Euro 6 emission level. For military vehicles with their special operation requirements, a Euro 3 emission level could be achieved by engine internal measures without significant deterioration of fuel economy. Euro 3 emission level can therefore be achieved under home land operating conditions and in theatre. Further emission standards require exhaust gas after-treatment systems, which will be under battle conditions too much of a burden for military vehicles. Here bolt-on solutions for home land operation have to be considered.

Environmentally Responsible Munitions – An EDA programme for the future

Adam CUMMING (Defence Science and Technology Laboratory, UK Ministry of Defence)

Abstract – *Part of the programme on the GEM 2 CapTech includes the study of how to produce and manage greener or environmentally responsible munitions. This Type B programme is aimed at providing validated methods for reducing the environmental impact of munitions throughout their life cycle and responds to the requirements of the participants. Led by the UK it includes France, Netherlands, Romania, and Norway with active interest from Portugal and Germany.*

The programme includes assessing and coordinating existing work; examining Life Cycle Analysis and modelling including assessing the prediction of reaction products by comparison with experiment; assessing results on toxicity and land contamination; formulating and assessing greener materials and the examination of options for recycling. The impact of REACH is also being examined. It is a programme where the participants are working together and sharing experience and understanding which adds to the value for the education of future scientists.

Safe and ecological destruction of ammunition

Bogdan JAKUSZ (JAKUSZ Security Systems), Olga DOBROWOLSKA (JAKUSZ Security Systems)

Abstract – *The utilization of munition, which had been withdrawn from use, in a safe and ecological way, constitutes a worldwide problem. Traditional methods of munitions disposal, such as detonation or burning in the open area, can no longer be used, because of prohibitions arising from international law, regulations and agreements ratified by most countries in the world.*

Restrictions on this matter are motivated by the concern for the environment. Ammunition destruction operations led to the emission into the atmosphere huge amounts of heavy metals, toxic gases and causes groundwater pollution.

For that reason the JAKUSZ company produced mobile installation "Jowisz" equipped with pollution abatement system, which has been designed for destruction of small-arms ammunition and ensures recycling of metal wastes emerged from ammunition.

"Jowisz", which has a NATO Stock Number (1385430012683), enables carrying out serial demilitarization of ammunition directly next to the ammunition storage. Due to no transportation necessity of dangerous or obsolete ammunition out of storage place, the risk of accidental detonation, potential lost, robbery or terrorist attack has been minimized. As a result of this, costs of utilization process have also been reduced.

The JAKUSZ company assure that the installation meets the highest quality standards and that our method of utilization implements all requirements and emission standards presented in regulations and legislatives, what has been approved by the appropriate environment protection institution in Poland. Additionally, our installation got admittance to work in an Army ammunition base in Poland with the possibility of doing research and development works.

The aim of planned improvement and modernization is to achieve possibility of energy recovery, which will be an additional and significant advantage of the existing installation. Next to ecological approach to ammunition utilization, it could give an opportunity to supply with energy e.g. nearly located buildings.

Introduction

Detonation process always introduce to atmosphere, as well as to the ground and later to the groundwater, a great number of pollution, like heavy metals or toxic gases. Researchers defined maximum quantities of emitting substances during detonation of ammunition – eqv 20 kg TNT/h (Table 1).

Name	TOC*	dust	HCN	HCl	SO_2	H2S	Hg	Pb	Sb	NO_x	CO
Emission kg/h	8	12	1	0,896	0,168	0,136	0,195	1,494	0,213	6	10

Table.1. Maximum substance emission produced during ammunition utilization: 20 kg TNT/h or 100 kg mass

* TOC – Total Organic Carbon

Due to increasing problem of necessity of disposal obsolete or withdrawn from use ammunition, an environmentally friendly disposal system is certainly needed.

Increment of ecological consciousness influences almost every field of our life. It causes development of many branches and the positive effect of which is reduction of pollution emission. This progress also led to creation of installations assigned for utilization of obsolete or withdrawn from use ammunition, such as mobile ammunition incinerator "JOWISZ".

Except significant advantage, which is environmentally friendly process of munition disposal, installation enables working in field conditions, with necessary access only to sources of electricity and indispensable periodical replacement of heating oil and chemicals in the pollution abatement system. "Jowisz" provides carrying out serial demilitarization for industrial scale within ammunition depots. Due to this, more benefits could have been achieved. Firstly, the costs of packing, loading, transportation and unloading of ammunition have been reduced. Secondly, risk of accidental detonation, potential loss, robbery or terrorist attack during transportation has been minimized.

Next advantage of ammunition incinerator is its mobility. Because the installation is based on standard shipping container, it enables easier transportation on trucks, ships or trains. Therefore, it is also much easier to rent or sell it. The only crucial requirement is positioning the system on a site with respect for safety distances from buildings defined in specific regulations in every country.

Installation description

Disposal of ammunition such as:

- small-calibre ammunition (5.45 – 12.7 mm)
- pyrotechnic ammunition (26.5 mm flares)
- ammunition elements (fuzes without boosters, primers, tracers)
- desensitized explosive wastes (high explosives, propellants, pyrotechnics)
- is carried out at an installation which is integrated in three shipping containers.

The installation (fig. 1) consists of the following equipment:

CONTAINER 1 with rotary chamber (fig.2):

- a rotary chamber

- a buffer chamber
- an afterburner
- a quench
- a demister

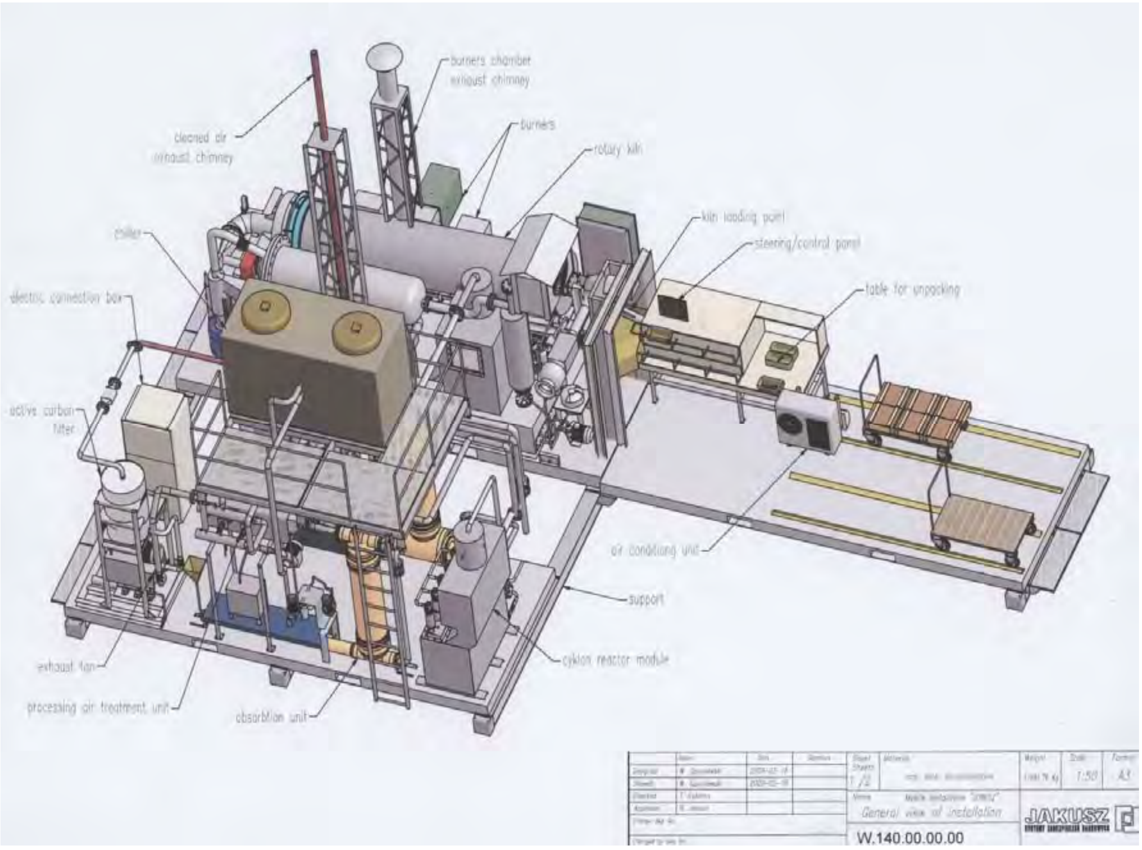

Figure 1: *Scheme of mobile ammunition incinerator "Jowisz"*

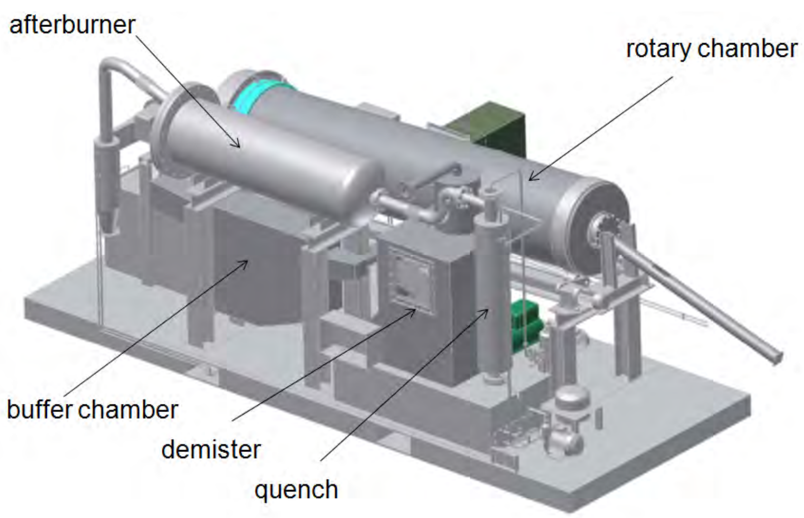

Figure 2: Container 1 – specific description

CONTAINER 2 – chemical (fig. 3):

- a cyclone
- a demister
- an acid scrubber
- an alkaline scrubber
- a particle filter
- a ventilating fan
- the active carbon filter

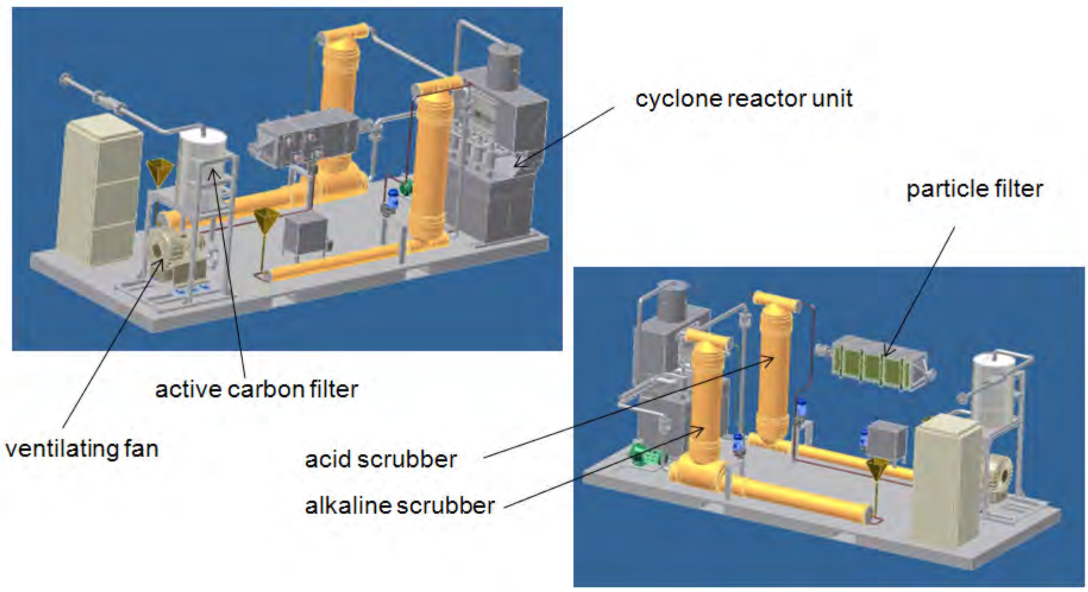

Figure 3: Container 2 – specific description

CONTAINER 3 - preparation and control (fig. 4)

- a control panel
- a loading conveyor
- a working table
- a transport trolleys
- an air conditioner

- other accessories

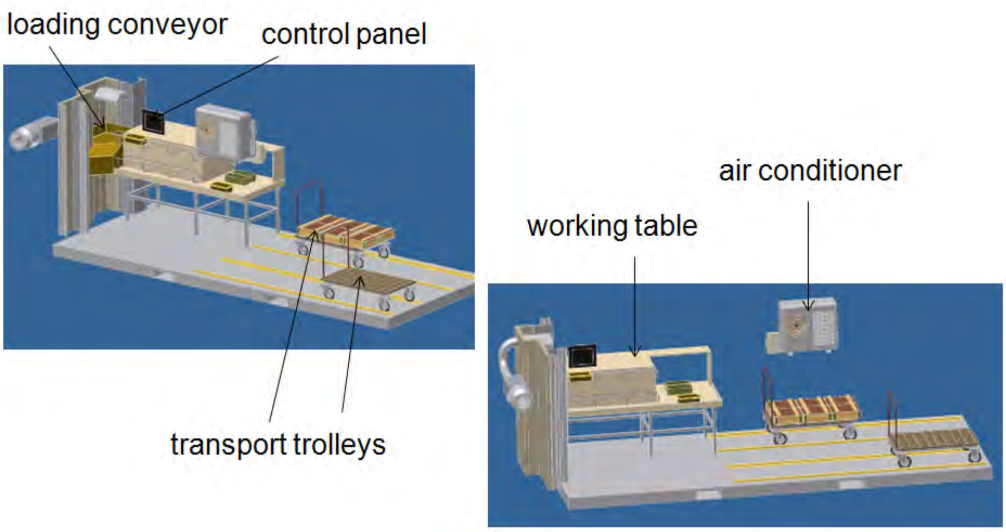

Figure 4: Container 3 – specific description

First stage of ammunition disposal

The disposal of ammunition always starts in container No. 3, which has a role of a preparation and control container. First and the most important is the choice of the appropriate working program, depending on the utilized assortment. Each of the programs is designed with high standard levels and after its selection all parameters, such as: chamber temperature, rotation or loading cycles etc., are set automatically. Independently, there is also a possibility of manual regulation of working parameters of rotary chamber, as well as pollution abatement system if needed.

Clarity of control panel prevents from making any mistake. Control system fully monitors the process and prevents from accidents. All situations which exceed normal working conditions are immediately perceived by the system, and oblige the operator to take action.

Assortments intended for disposal, which are delivered usually in boxes, are unpacked. Wooden boxes, papers, plastic inserts are recycled or burned in normal commercial incinerators, while cartridges, fuzzes, primers etc. are loaded into loading conveyor in batches prescribed by the control panel (Figure 5).

The batch is inserted into the chamber by action of a pneumatic piston and immediately returned back. To prevent from overheating a loading conveyor is cooled by the glycol chiller.

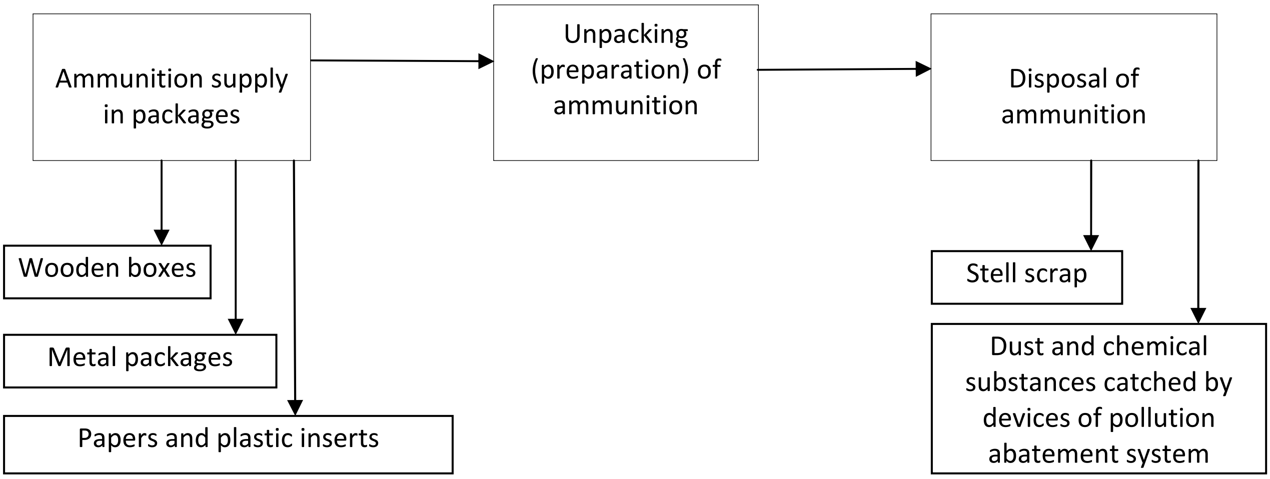

Figure 5: Material balance of ammunition disposal process

Exact ammunition disposal process

Ammunition disposal process is carried out in the rotary chamber, which is heated by 3 external burners running on heating oil. The chamber working temperature is about 450 – 600°C depending on the type of the burning assortment. The typical process comprises the rotary chamber preheating to achieve its established temperature, in which process could be conducted. Generally, the explosion heat of the first burned ammunition is sufficient to sustain a temperature during work with no necessity of additional heating. The ammunition batches loaded inside the chamber are separated by internal helix assuring transport of the ammunition along its length. Thanks to them and regular burning of the batches, collection of larger chunks of the ammunition in one spot is prevented.

Moreover, "Jowisz" was designed with taking into consideration protection from suction of the outside air inside the chamber. That improves the cleaning effectiveness, capacity and reduces costs, because only limited amount of high concentrated gases are able to enter the pollution abatement system.

Furthermore, the installation facilitates scarp segregation even with dividing for coloured metals and steel scrap. All scrap received from ammunition disposal are stored in the scrap collector, located at the rear end of the rotary chamber, which should be empty after about 4 hours of working. Fortunately, stoppage of the system is not necessary for removing the metal scrap. It is done by a fork lift. Separation of dust by the meshed double bottom is also achievable.

Next phase of disposal process is damping, by a buffer chamber, pressure pulses from incinerator, which could negatively influence pollution abatement system working conditions. Additionally, heavier dust particles from the gases are gravitationally separated in this stage.

After the first separation in a buffer chamber, gases goes to the cyclone, which serves elimination of main portion of dust from the gases entering the pollution abatement system. Dust automatically falls into a drum, whereas gases goes to the afterburner. With usage of direct flame from oil burner some substrates, such as carbon oxide, soot or organic compounds are oxidized as reaction shown below:

$$2\,C + O_2 \rightarrow 2\,CO$$
$$C + O_2 \rightarrow CO_2$$
$$2CO + O_2 \rightarrow 2CO_2$$

This stage is very important with regards for difficulty of removing (with usage of scrubbers) compounds like soot, caused by highly hydrophobic substance character.

Hot gases, which leaves the afterburner are directed towards a quench, where are cooled by means of water mist (or other absorption liquid depending on the cleaning process requirement) injected into column in counterflow. The water entering the column is cooled itself by an electrical chiller filled with the glycol. Final temperature of the gases is about 200°C, because it is maximum acceptable temperature for the following wet treatment in the scrubbers. Additional function of the quench is ability of catching dust, which precipitated in the filtration section.

Cooled gases goes to an acidic scrubber. Ceramic rings fulfillment are sprayed steadily by absorbing liquid (sulphuric acid with presence of 1,5% KMnO4, which is promoter of Hg oxidation), which enable removal of heavy metals, especially Hg during counterflow of gases.

Then, an alkaline scrubber, which has similar design as acidic one, neutralized acid gases, such as HCl and SO2 with usage of 20 % water solution Na2CO3.

At the end of the "Jowisz" installation we could specify two filters: particle and with the active carbon. The first one serves as final elimination of the dust particles eventually passing the scrubbers. The active carbon filter catches remaining volatile and semi-volatile organic compounds. The active carbon filler can be easily replaced or regenerated.

Modernization and improvement plan

Company Jakusz is equipped with incinerator "Jowisz", which enable environmentally friendly process of ammunition disposal. The only, but significant problem is energy recovery, which now is irretrievably lost.

Elements of the "Jowisz" installation like the rotary chamber or the afterburner needs a lot of energy to achieve appropriate temperature to enables the process. Later, a great number of energy is used for cooling the gases in a quench to temperatures acceptable for the next stages. Usually, reduction of several hundreds °C is carried out.

The aim of modification and improvement is to achieve a possibility of energy recovery, what will be additional and significant advantage of existing installation.

Conclusion

Experience of our constructors and chemists enabled designing of the installation “Jowisz”, which meets the highest standards approved by the environmental institution in Poland. Our ultimate goal is to produce system even more ecological and economical.

The installation for ammunition disposal needs a lot of heating oil. It makes the cost of the installation usage quite high, what can cause a big problem for indigent countries, which also should dispose obsolete ammunition. Globally thinking, it is important to give an opportunity to environmentally friendly disposal of ammunition even to poor countries. In our opinion such possibility could be met only with systems which assure an energy recovery system.

Whereas, disposal or destruction of wide range of ammunition do not constitute a problem, the Jakusz company still want to develop the system with recovery energy, to become more competitive.

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Hazardous Substance Management in military operations – how integrated software can enhance safety for people and the environment

Martin HILL (Centre of Excellence Sustainability EMEA, SAP)

Abstract – *Each army is deploying own manufacturing facilities, and therefore is faced with similar environmental and safety issues as a manufacturing company - plus some additional risk factors like the transport and handling of ammunition. Dangerous goods need to be processed and shipped in compliance with national and international regulations. People safety and occupational health is a key issue in a staff-intensive military environment. Employees get exposed to hazardous substances, explosives and other safety threats. Incidents, affecting both people and assets, need to be tracked and analyzed with the objective to avoid severe accidents. Safety risks need to be managed systematically and proactively in this very complex environment. Emissions to air, water and soil need to be measured, monitored and reported. High energy costs and the decommissioning of nuclear energy force organizations to analyze and reduce their energy consumption.*

Technology can play a major role in streamlining and managing sustainable operations. A holistic Environmental, Health and Safety (EHS) solution with integration to HR, Manufacturing, Asset Management and Financial data is a powerful tool to manage complex tasks and processes, to analyze potential risks, to gain resource and consumption visibility over multiple subsidiaries to detect work related hazards and track control measures.

Army installations are procuring and processing significant quantities of hazardous material and generating large amounts of hazardous waste. The use of hazardous substances compels organizations to protect employees and the environment from the hazards that these substances cause. Also, it obliges to observe numerous rules and regulations worldwide.

Employees that are exposed to hazardous materials, for example detergents or explosives, need to have all relevant information for safe processing, logistics and storage of the substance at the work place and to be trained on protective and emergency measures. Material Safety Data Sheets (MSDS) carry all relevant substance information and need to accompany the reportable chemicals throughout the supply chain.

New and emerging legislations constantly increase installation reporting requirements. Identification and documentation of approved hazardous material facilitates necessary tracking and regulatory reporting.

The complexity of processes across organizations affected by hazardous material requires centralization, integration and automation of the hazardous substance management system. Centralized control and management of hazardous material across the installation will reduce the cost for acquiring and disposing of hazardous material; enhance mission accomplishment by reducing the logistics footprint and streamlining operations; promote the safe storage, handling, and use of hazardous material; and reduce risk to employees and the environment. Operational

concepts, business practices, and data conventions vary widely in large organizations. Centralization is achieved through integration of selected logistic, environmental, safety, and occupational health practices into day-to-day operations. Integration is supported by a holistic software system that can exchange data with the ERP, Human Resource, Financial, Environmental Management and Supply Chain Management systems. Information that is once entered into the system is available to all employees and data silos, inaccurate data and dual data entry can be avoided with an integrated software solution.

Introduction

For many product manufacturers, the move toward safer and environmentally friendlier products involves mixed emotions. The benefit to the planet is a given. However, if not approached strategically, this direction can come at a high cost; and in margin-sensitive industries, profitability still has a dominant position in the triple bottom line of “people, planet, and profit.” The European Union Restriction of Hazardous Substances (RoHS) Directive is just one example of a recent European mandate that intends to make products safer and “greener” by restricting the use of four heavy metals and two classes of flame retardants in most electrical and electronic products. A recent survey by Technology Forecasters Inc. (TFI) for the Consumer. Electronics Association indicated that implementation of a RoHS compliance program costs about 1.1% of annual revenue, with ongoing maintenance estimated at 11% of the start-up cost. Most executives would like to see such a compliance program as a one-time initiative. However, this will not be the case. Environmental compliance is not about one directive from one specific market. The pressure to become “green” is mounting from all directions. Regulators, customers (both business and consumer), competitors, consumer activists, and shareholders are all driving manufacturers to reduce the environmental impact of their products.

This paper provides a perspective on product-related environmental regulations, their business impact, their trajectory, and how companies can move from tactical and reactive risk mitigation to seizing competitive advantage. You can use this perspective to facilitate internal discussions about what a robust strategy could include and what an associated solution architecture could look like.

Demand for a Greener World, Pressure from Governments and Consumers, as Well as Investors

A number of key trends are driving increased pressure on product manufacturers to take a more strategic approach to improving product environmental performance, starting with being compliant with the applicable regulations. Consumer groups, governments, environmental NGO s, investors, and customers are all taking actions:

- Several recent reports, including a survey conducted by UK research firm Canalys, all indicate that consumers are increasingly concerned about environmental, health, and safety (EHS) aspects of products. Results show that consumers are even willing to pay a premium for products manufactured in a more environmentally conscious way.

- The number, scope, and complexity of environmental regulations applicable to manufactured products are expanding rapidly around the world. RoHS and similar substance restriction or disclosure regulations are being adopted around the world. The European Union is also implementing Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH), with a disclosure requirement for products that began in the fall of 2008.

- A long with the increasing number of regulations, enforcement agencies are stepping up surveillance. As agencies in the European Union have become more knowledgeable about how to enforce regulations like RoHS, and about the use of equipment required to enforce it, they have been more active and successful in finding violations. In the United Kingdom in 2007, the National Weights and Measures Laboratory (NWML), the enforcement agency for sustainability-related legislation, "detected some 300 cases of noncompliance that were resolved in a positive way by engaging with the company and remedying the situation. Additionally, authorities sent out 25 to 30 compliance notices, 10 enforcement notices, and brought two cases to justice."1 Whistle blowing as a competitive tactic may well increase the visibility of poorly managed compliance programs. For example, the NWML reported receiving about one competitor complaint a week.

- In the United States, the Consumer Product Safety Improvement Act of 2008 (H.R. 4040) funds the Consumer Product Safety Commission (CPSC) for more effective enforcement. CPSC will begin to place fulltime staff at some of the nation's busiest ports, such as Seattle. CPSC is being given access to real-time information and data from customs officials about shipments bound for the United States to enable CPSC staff to help pinpoint high-risk products.

- In the public sector, purchasing policies are being updated to include environmental performance. An example is the Ecolabel Regulation – a voluntary scheme designed to encourage businesses to market products and services that have a reduced environmental impact and to easily identify them. It is actually perceived more as a potential market differentiator than as an environmental objective. According to the Ecolabel Evaluation Report, "The public sector is a key target for many companies, and therefore public purchasing can be an effective driver." Stakeholders are asking for "the inclusion of the EU Ecolabel as a facilitating condition for public procurement." In the United States, the voluntary Electronic Product Environmental Assessment Tool (EPEAT) standard was made mandatory for federal government purchases. The Federal Acquisition Regulations now require federal agencies to purchase at least 95% EPEAT-registered products (currently limited to desktop PCs, notebook computers, and monitors).

- Business customers are requiring more information on environmental performance and sustainability from product manufacturers. For example, the Hewlett-Packard Company recently stated it has seen a 150% increase in the number of customers asking about green initiatives on their requests for proposals. Large institutional and government purchasers are also asking electronic manufacturers for more information on and to reduce their products' carbon footprint.

- Consumer and environmental advocates and NGO s are very concerned and are actively driving awareness and change. Groups like Greenpeace, with its “Guide to Greener Electronics,” are having a marked effect on the actions of industry to “green” their products. A coalition of European NGO s, including Friends of the Earth Europe, World Wide Fund for Nature, and others have put together a guide to help activists understand and use the EU’s REACH regulation.

- Shareholders are also asking for more transparency on sustainability via activities like the Carbon Disclosure Project. This independent not for- profit organization is working on behalf of institutional shareholders with publicly held companies to acquire and publish greenhouse gas emission and other climate change– related information, as well as assess the risks and opportunities related to it and to shareholder value. The Investor Network on Climate Risk works with institutional investors and financial institutions to understand the risks and opportunities climate change presents to their investments in public companies. The Investor Environmental Health Network, a collaborative partnership of investment managers advised by environmental NGO s, has actively been bringing health and toxic chemical–related shareholder resolution filings to publicly held corporations over the past few years. Also, the Dow Jones Sustainability Indexes, launched in 1999, are the first global indexes tracking the financial performance of the leading sustainability-driven companies worldwide. While economic sustainability is a major part of the indexes, so are environmental and social sustainability.

Environmental compliance is not about one directive from one specific market. The pressure to become “green” is mounting from all directions. Regulators, customers (both business and consumer), competitors, consumer activists, and shareholders are all driving manufacturers to reduce the environmental impact of their products.

The Four Vectors of Product-Targeted Environmental Regulations

For a majority of companies, being green starts with being compliant with regulatory requirements. Environmental regulations and customer requirements are intended to improve your products’ environmental performance, which is the impact of your product on the environment. It helps to think of these requirements along four axes, as follows.

1. Substance Restriction and Disclosure Requirements

Substance restriction and disclosure requirements can range from narrow to very broad. These include, for example, the End of Life Vehicles (ELV) Directive, Restriction of Hazardous Substances (RoHS) Directive, and more recently, the Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) regulation from the European Union. Laws similar to RoHS, but with some different requirements, are being enacted in China, South Korea, Japan, Norway, Turkey, and California in the United States. Phthalates were banned in products for toddlers in the European Union in 2000, while the United States recently passed the Consumer Product Safety Improvement Act of 2008 (H.R. 4040), which restricts lead and three phthalates in toys for children under seven years old.

Data to be managed includes:

- Substance information (such as name or Chemical Abstract Service number)
- Where used
- Concentration
- Absolute weight
- Supplier (where applicable)

2. Reuse and Recycling

Countries and locales are seeing the volumes of products manufactured from refined materials, such as electronics, rising dramatically in municipal waste streams. At the same time, landfills are reaching capacity. An increasing number of regulations around the world include the Waste Electrical and Electronic Equipment (WEEE) Directive in the European Union, similar regulations in China and South Korea, a wide variety of state-specific regulations in the United States (and even a city specific regulation in New York City), and others around the world. The intent is to divert these items away from the municipal waste stream as well as encourage manufacturers to design products to:

- Be easier to recycle
- Be manufactured with more recycled materials (to ensure a market for the recycled materials)
- Last longer via modular design and a defined, supported upgrade path
- In addition to products, specific items like batteries or packaging are also targeted.
- Data to be managed includes:
- Product mass
- Where sold

- Percent recyclable
- Mass by recyclable substance per item

3. Energy Use

Energy use is being regulated to a greater degree than ever before. Not only is absolute energy use being driven down by continuous redefinitions of acceptable performance by such standards as ENERG Y STAR, but energy use during nonuse conditions (such as standby power dissipation of electronics) and during the manufacturing process is being targeted by regulations such as the directive on the ecodesign of energy-using products in the European Union.

Data to be managed includes:

- Product energy consumption in use and standby modes
- Energy consumption during manufacturing, perhaps even by individual part (based on standard energy models yet to be created)

4. Carbon Footprint and Greenhouse Gases

Another concern is an area related to energy use and the source of the energy. Increasingly, manufacturers are being asked by customers to describe their products' carbon footprint, defined as how much carbon dioxide or other greenhouse gas is released by a product directly or indirectly over its entire life cycle. With no available and usable standards to help companies define and measure these emissions or emission equivalents, this area is nascent.

There are many efforts underway in this area where product manufacturers should get involved with, or at least keep track of, these initiatives.

> Many large manufacturers are taking extensive approaches to environmental responsibility and sustainability at both the corporate and product levels. This requires suppliers upstream of manufacturers to push requirements for environmental information further back up the supply chain. So environmental compliance regulations and requirements march up the entire supply chain, regardless of where that supply chain extends. Basically, every manufacturing company will be impacted.

Data to be managed includes:

- Greenhouse gas type and other substance information (such as name or Chemical Abstract Service number)
- Mass per item, roll-up per part or component used Common Traits Among the Four Areas What common traits do all four areas share?
- They are being implemented at a rapid pace all over the world.
- They all have significant data tracking, management, and reporting requirements.
- Nearly all have unique characteristics that are not shared by similar regulations elsewhere; this complicates the above-mentioned data requirements.
- Once implemented, they are not static but evolving. Changes may come suddenly, like the recent revocation of the decabromodiphenyl ether exemption to EU RoHS, or be planned well in advance, like the 11-year rollout of REACH.
- Your customers are already, or soon will be, asking about your compliance with these regulations.
- Your customers may, in fact, be requiring stricter requirements than regulations in most, if not all, of these environmental performance segments.

Compliance Today - Impact on Every Manufacturing Company

As a result, business executives are starting to pay attention to "green." According to a March 2008 McKinsey global survey, "Executives and consumers are now equally concerned about environmental issues, including climate change. Fifty-one percent of the executives – up 20 percentage points from 2006 – pick it as one of three sociopolitical issues that will attract the most attention during the next five years."

Many large manufacturers are taking extensive approaches to environmental responsibility and sustainability at both the corporate and product levels. This requires suppliers upstream of manufacturers to push requirements for environmental information further back up the supply chain. So environmental compliance regulations and requirements march up the entire supply chain, regardless of where that supply chain extends. Basically, every manufacturing company will be impacted.

Initially, many companies simply looked at a regulation like the European Union's ELV or RoHS Directive and put together a team to address it for their relevant product lines. According to the TFI survey mentioned earlier, many electronics companies, for instance, simply redirected existing resources in engineering and manufacturing to the task of ensuring RoHS compliance.

They collected data or certificates from their suppliers saying that the components and materials they were buying were compliant, noted it in a spreadsheet or flagged it in a database, and redesigned or retooled existing products and processes where necessary.

An Ongoing Effort

Corporate executives are missing the bigger picture if they believe that life will return to business as usual once they are "done" with a RoHS or REACH project. The complexity of environmental requirements for individual products, their evolving nature, increasing demands for publication of product environmental information, and regulatory reporting will put continuous pressure on the company to respond.

Additionally, the lack of harmonization across worldwide regulations will only further complicate compliance and reporting across markets. Yet these requirements are increasingly becoming part of purchasing decisions by large institutional purchasers as well as consumers. Executives at manufacturing companies must understand the environmental sustainability landscape and trajectory in order to address it efficiently, effectively, and profitably.

Those companies that do see the bigger picture have now started to implement actual formal, executive sponsored compliance programs. This begins with assigning responsibility for more general environmental compliance to a single person or group. The companies then develop a corporate compliance policy, often accompanied by statements on the company's Web site. The challenge, however, is how to get such a policy "operationalized" in the organization.

Managing Compliance Data

A first challenge is building up the required knowledge about environmental performance of materials and manufacturing processes, which is typically rather specialized. In order to make this knowledge scalable to the rest of the organization, it needs to be documented in product specifications, built into automated compliance-analysis tools, embedded in purchase- and sales-order management checks, and so forth.

Many processes, however, are not yet assessed for compliance risk; and even if there is some sort of compliance check, these checks – often manual – lack the desired consistency to reduce risk.

Obtaining the necessary environmental material information is a time-consuming project, as illustrated by the cost involved in RoHS compliance, mentioned previously. And when, for example, a new substance becomes restricted or reportable due to new regulation, amendments to existing regulations, expiration of exemptions, or specific customer requirements, its impact needs to be assessed against the entire product portfolio. This requires identifying which types of parts could be at risk and contacting the relevant suppliers to ascertain whether or not the sourced materials contain the newly regulated substance. Without efficient supply chain collaboration and compliance analysis tools, the company runs the risk of either an incomplete assessment, missing an implementation deadline, or redirecting existing resources to determine this information after the fact, which increases the compliance cost.

New requirements also require changes to the supporting data management systems. Clearly, managing this sort of data in spreadsheets – a common approach – is a dead-end solution for companies with products of any consequence.

The information derived from a basic substance analysis also needs to be combined with other enterprise data in order to perform subsequent analysis and reporting. For example, data from a sales-order management system will be required to determine how many units were actually shipped to California in the past year, and it must be combined with mass per-unit information to determine the reportable mass of restricted substances, as required by California legislation. Similarly, the number and mass of products shipped to the European Union must be assessed in order to determine WEEE payments. For REACH, substance volumes need to be calculated by legal entity in order to determine registration requirements. This requires managing substance data as part of the overall enterprise data so it can be easily combined to support the required analysis and reporting. Managing substance data in an engineering-data management tool is helpful for engineers to deal with substance restrictions during design, but it does not enable the rest of the organization to manage their side of the compliance requirements. Product compliance is not solely an engineering responsibility.

A Proactive Approach - Key to a Sustainable Approach

The challenges that come with the implementation of a formal compliance program indicate that some fundamental changes are needed. The transformation from a reactive, risky compliance approach to a sustainable approach for product safety and stewardship requires two capabilities that are likely new to most companies:

- Know your product's environmental characteristics in full detail. Without this information, it will be impossible to effectively deal with both regulations and market-driven initiatives.
- Have embedded product-compliance controls in all product-related processes. Compliance should not only be designed into the product but also ensured for the actual manufactured product, across your different customers and markets, all the way through the end-of-life phase. In short, a company needs to make environmental thinking part of the company's DNA rather than taking a "green shot" every time a new environmental requirement shows up.

Know Your Product

Most manufacturers know their product down to the material or item number, as that is what drives the transactional systems for forecasting, inventory management, purchasing, and so forth. It is clear that with the product-targeted environmental regulations, the material master needs to be extended with a vast amount of chemical and environmental information. But how much information needs to be collected?

The European Chemical Substances Information System (ESIS) describes over 1,000 substances from which the European Chemicals Agency is selecting REACH -related Substance of Very High Concern (SVHC) candidates. A coalition of European NGO s recently came out with its own list of 300 substances. On top of this, large OEM purchasers, "big-box retailers," and large institutional purchasers such as healthcare organizations often have their own set of substance and other environmental requirements that suppliers must meet. The implication is that without a predictable way to identify upcoming reportable or restrictable substances, product manufacturers need as much information as possible about the substances used in the products they define and build. They also need information about the energy used throughout the manufacturing process, as well as key environmental properties such as the recyclability and reusability of the substances used – and the supply chain used to provide it all.

What does it take to know your product to this degree? This is not a simple task today. The most basic level of information is the names of the substances that comprise your products and their concentrations and locations. This will give you a start, but in the era of sustainability, you can expect to be held responsible for every molecule in your product. Where did that molecule come from? Is it recycled? How did it get into your product? How much is used? Why is it used? Is there a better molecule to use? Is it recyclable? Is it toxic? Is it regulated?

Knowing this level of detail about your product should be considered the end goal, not the initial objective. Today, this vision is nearly impossible to achieve for most product-manufacturing industries. But architecting a strategy that will enable its eventual achievement is not only possible but critical to future success.

This new capability requires an enterprise- level EHS information repository linked to the material master, readily accessible to product marketing, engineering, supply chain management, manufacturing, quality, sales, distribution, service, and finance. This data will help them manage and execute their legal and business responsibilities in the areas of substance restriction and disclosure, reuse and recycling, energy use, and carbon footprint.

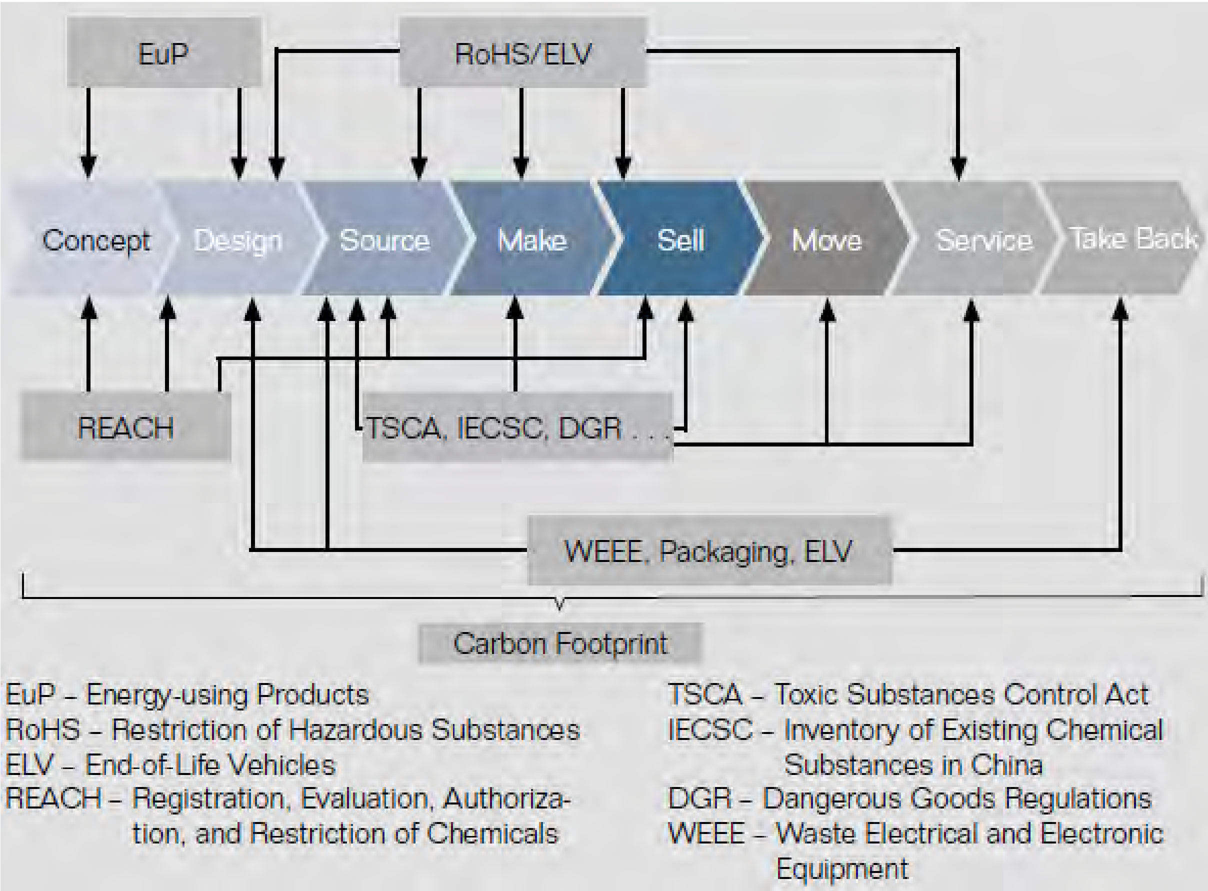
A key factor in the strategy is to consider how you will obtain, manage, and distribute all the information described above. Whether you request compliance data for a single material from a single manufacturer or leverage a third-party compliance-data service provider, minimizing the need for manual data entry of this complex information is critical. Standard tools and even computer readable formats for data transfer like IPC 175x are starting to see adoption. But they are not yet widely used, nor can they handle all of the information described above – and much of the data is not yet available. This means your data management system needs to be very flexible and readily able to incorporate new data transfer standards.

Control, Not Hope

Simply collecting massive amounts of chemical and environmental product data will do a company no good unless it knows what to do with it all. You can't have your developers define product specifications in a product life-cycle management tool to meet regulatory requirements and then simply hope that nothing will go wrong in the supply chain or in other downstream business processes. Product compliance throughout the life cycle is achieved by embedding compliance controls in all business processes that affect compliance as defined in applicable regulations.

At the highest level, the corporation should define goals and policies for product environmental performance. Reviewing your product life cycle and looking at where you can define, manage, measure, and report environmental performance attributes will inform how you implement it.

The Figure below shows the primary impact points of certain EU directives and regulations on the product life cycle. Clearly defining environmental product requirements will be increasingly important in order to ensure compliance with regulations, as well as to better position your products against your competitors.



The ability to effectively compare and trade off different materials, technologies, and parts during product design requires access to details about environmental properties and, longer term, even the supply chain that produces them. Usually the supply chain expertise does not sit with engineering but with manufacturing or operations.

Working together, both will define requirements and collaborate on selection to optimize environmental performance while at the same time optimizing function, cost, quality, and other business and technical performance properties.

Likewise, attention early in the product design phase must be focused on manufacturing requirements to ensure that energy use during manufacturing is minimized, along with considerations such as supply chain optimization for carbon footprint based on likely customer locations. This requires data not just on parts but also on the suppliers that provide them. Extending your current supplier selection and management process to include their environmental performance requires knowing their corporate approach to environment.

Do they have a policy? Do they manage it up their supply chain? Can they provide you the data you need (for example, can they provide full material disclosure, or do they just say, “It meets RoHS”)? You may find yourself having to go on-site to suppliers’ facilities and survey their business processes and facilities to help make the right sourcing decisions. Challenging Conventional Wisdom Minimizing carbon footprint in manufacturing will challenge many accepted principles: is “just in time” really environmentally preferable? Can assembly processes be changed or relocated, or can inventories be rearranged to save energy? Likewise, the factors affecting more detailed technical implementation of manufacturing will need to be tracked and managed. Improving and tracking temperature profiles, operator training, usable stock, and work-in process inventories and segregation must all be assessed and addressed. Managing configuration and sales to track product shipments and verify that they are delivered to the specific locales intended is ultimately one of the most challenging problems for global manufacturers. Identifying regulations, restrictions, and labeling requirements that impact a specific product may require different top-level configurations for different locales. Likewise, service and repair require control of service inventories. Making sure you can legally pull a specific part number to replace a failed item in the field requires knowing whether the replacement complies with local environmental regulations – not just whether the spare will function in the customer’s configuration. And if support services use substances like adhesives, lubricants, and so on, there may be more specific substance related regulations to focus on in addition to product-related regulations.

This level of control requires the enterprise business system for the abovementioned processes to be natively integrated to the EHS compliance data. And this integration goes beyond having a compliance flag on the material master. Decisions will depend on the regulatory requirements and compliance status of the material or product – a function of the customer or market and the material or product EHS attributes.

Compliance with Confidence - Support from SAP

SAP has a long-standing reputation when it comes to supporting its customers in dealing with EHS challenges, offering a more comprehensive solution than other best-of-breed vendors. AMR Research Inc. states, “SAP customers ready to adopt comprehensive compliance platforms are pleasantly surprised at the depth of functionality relative to some stand-alone EHS applications.”

SAP offers a comprehensive set of solutions based on a core capability to manage materials beyond the traditional engineering and supply chain data.

The SAP Environment, Health, and Safety Management (SAP EHS Management) application contains the specification database, which supports data management for material characteristics like weight, volume, substance composition, hazardous classification, postconsumer recyclability, and so forth. Since its introduction over a decade ago, this specification database has become the EHS foundation for some of the largest product manufacturers, from chemicals to consumer products, high tech, industrial manufacturing and components, and automotive.

Because the EHS solution is an enterprise resource planning (ERP) enterprise service, part of the SAP Business Suite applications, the EHS functionality is natively integrated via the material master to the product development processes, as well as other downstream business processes including procurement, quality inspection, inventory location management, material safety data sheet management, sales, distribution, and more.

For example:

- Any part, assembly, or complete product maintained in the SAP Product Lifecycle Management (SAP PLM) application can be assessed against regulatory, voluntary, and customer-driven substance requirements by cross-referencing compliance data in the EHS database to the bill of materials, enabling efficient compliance by design. For customers with non–SAP PLM software, the bill of materials can directly be imported, either during the design phase or as part of the design release process.

- Chemicals – whether substances, substances in preparations, or contained in a product (or "article") – can be identified and assessed in terms of percentage weight and sales volume, and associated registration and reporting can be efficiently managed.

- Integration with the SAP Supply Chain Management application enables purchase orders to be checked for material compliance before submission, avoiding scrapping no usable inventory.

- Integration with sales and distribution functionality in the SAP ERP application supports substance-volume tracking by legal entity as well as recycling administration for any national compliance scheme, avoiding laborious manual analysis and reporting.

SAP and its partner ecosystem have the right solutions and services to help customers with product environmental regulations.

Executive teams the world over are recognizing the trends related to product targeted environmental regulations and their relation to revenue. They are realizing that this is not about how to deal with one more regulation but about building a strategic business capability to be accountable for the company's products. When a company's chief executives come to grips with these realities, they are well underway to making a major transformation – from associating a compliance program with cost and risk mitigation to seeing it as a competitive advantage.

For more information about SAP solutions that will support your ongoing efforts in product environmental compliance, please call Frank Soudan, Account Director European Institutions (+32.486.136.401) or visit us online at www.sap.com/solutions/business-suite.

The Role of ICT in energy efficient military camps, civil cases studies and business model examples

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Abstract – The initiative proposed by EDA, of reducing energy consumption in CMOs is foreseen to have a positive impact not only on the environment but also on other important aspects, as increasing personnel safety, reducing operational costs, improving logistics and even increasing the efficacy of the operations. This article will present many relevant figures favouring the introduction of green military practices for CMOs.

Remote monitoring and management of energy resources will be a very important tool for a successful implementation of such ecological practices, as will be explained and documented. The importance of having aggregated information regarding energy, water and waste, available on data centers will be addressed. Many conclusive civilian case studies will be presented, showing the importance of remote monitoring and management of energy resources, in identifying sources of energy waste and improving efficiency of energy supply logistics.

Finally, it will be discussed how examples of business models from the civil society may contribute to achieve economic viability with green CMOs.

Outline

In the present time Europe is facing two major problems, the instabilities in the economy generated by the globalization of the markets together with a severe degradation of the world environment, both pointing to the necessity of introducing more energy efficient practices, for a more sustainable world. Such difficulties are also affecting the Defence sector.

According to the EDA National Defence Data document, member states are more aware about this situation and have spent, approximately, €7 billion dollars less in two years, €194 billion in 2010 against the €201 billion in 2008. This is an effort tendency not adopted by United States of America that spent €114 billion in the same period, €416 billion in 2008 against €520 billion in 2010, which was essentially caused by the Iraq and Afghanistan conflicts.

In Operations & Maintenance activities, Europe spent approximately €41 billion, while US €155 billion. This is, respectively, 23% and 30% of the total expenditure in defence, as can be seen in figure 1.1

(1 billion = 1 000 000 000 - US numeric system)

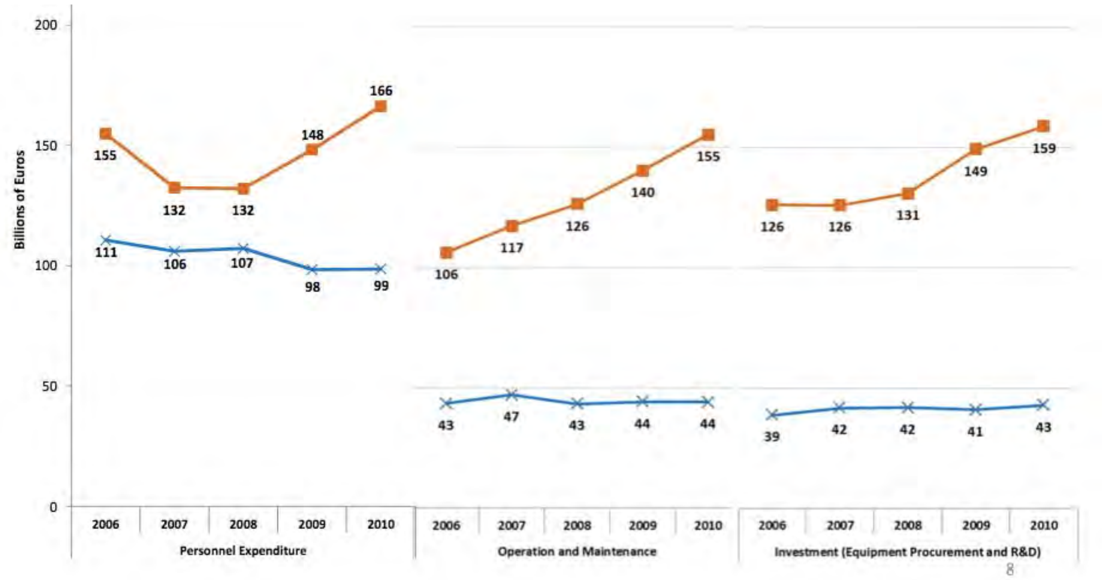

Figure 1: Defence expenditures European Union and United States of America1

Below it is presented a compilation of relevant information related to the energy logistics of military operations.

Table 1: Logistic data of military operations

Amount of fuel transported to Afghanistan every year[2]	1,2 billion litres
Amount of fuel managed every year in Kandahar Airfield[2]	35 million litres
Number of generators in Afghanistan in military applications[2]	300.000
Average price of one gallon of fuel inside camp in Afghanistan[2]	$400
Estimated price of kWh inside a camp in Afghanistan[3]	$10
Vehicles lost in Iraq during June 2008 in convoy attacks[4]	44 vehicles
Civil and military casualties in convoy attacks in Afghanistan from June to September 2010[5]	145
Vehicles lost in Afghanistan from June to September 2010[5]	123
Every $10 increase in the price of a barrel of oil costs the	$1,3 billion

Department of Defense[6]	
Amount of fuel lost in Iraq just during June 2008[4]	220.000 gallons
Reduction of soldiers involved in convoy mission for 1% increase in fuel efficiency[7]	6444
Energy Storage savings[8]	22%
Energy Storage plus monitoring and demand management fuel savings[8]	37%
Savings in fuel by mixing renewable sources, with remote monitoring and energy storage[8]	40 to 50%

The analysis of such information raises the main question of how much can be saved by introducing more ecological practices. The Military Green initiative is foreseen to have a positive impact in many different directions:

- **Environment:** Following the 20-20-20 agenda, launched by the European Commission, EDA is also taking its initiative on an Environmental Responsibility. As follows, there is also a great concern for CO2 emissions and a special focus on reducing the dependence of CMOs on fossil fuels. It is very important to bring together all stakeholders and establish a concrete roadmap, aligned with EU energy and environmental policies, which will lead to more sustainable CMOs.

- **Safety:** At present times, in accordance to the figures presented in Tab.1, CMOs deployments have severe logistics problems, particularly in the use of transport convoys that impose costs, burdens and risks to operational effectiveness and to the safety of military and civil personnel. The risks of transporting fuel over long distances and the price paid for it, in terms of loss of lives of personnel and loss of equipment have driven several countries around the world to take actions towards reducing the need for fossil fuels. From June to September 2010, more than 145 civilian truck drivers and guards were killed in attacks on convoys and 123 vehicles were destroyed in Afghanistan[9]. Regions with limited infrastructures present additional difficulties to operational safety. The environment presents its own set of challenges, like heavy rain, which can conceal mines in roads, or dust and heat, which cause mechanic problems to the convoys. Black markets of fuel represent large business in many regions posing an extra risk to safety.

- **Logistics:** Reducing the need for fossil fuels also increases the operational degrees of freedom and reduces non-European dependencies. In a single month of combat, (Iraq, June 2008), 44 vehicles and 220.000 gallons of fuel were lost in attacks or other events.

  In some countries with war or crises scenarios, borders are closed and do not have any digital control, which can cause significant delays in processing documentation. With a large supply chain, it is essential to ensure no delays at the borders, which can cause some serious supply issues. With fuel it is essential that the supply chain remains as constant as possible because storage is limited and any fluctuation in the supply can cause serious effects for the CMOs logistics. In some cases road accesses are limited, many roads are destroyed and the few left are not capable of handling the traffic moving at an adequate speed, so travel can be greatly extended. Convoys are also at the mercy of local political influence and often find procedures and policies changed without previous notice, this can hold up trucks for weeks while the new procedures are either negotiated or implemented.

- Economics: The ever increasing prices of oil in the world markets, together with the difficulties and risks of transporting fuel to the camps makes the cost of energy a heavy component to the overall Defence budget. Overall fuel expenditures of US defence department, to produce energy, were almost $18 billion in 2008. It is interesting to observe that since 2000 the actual increase of the fuel volume purchased was only about 30% but the price has raised 500%.The values give a clear hint of the necessity of more energy efficient practices and also show the importance of the economic impact of fuel in defence expenditures.[2]

  This impact is well illustrated by the fact that nowadays the price paid for a kilowatt in a military crises scenario can be from 10 to 100 times higher than the price paid by the civil industry.

  The current energy solution is neither economically bearable nor easy or secure. New technologies will change the way missions are planned, improve them, making this process more agile and flexible, allowing focusing in critical tasks. Local production of energy based on the technologies for producing the so-called alternative energies is certainly a way to explore. Further, there should be still some space for testing new concepts and develop new technologies.

  Other advantages of Military Green are the direct and indirect benefits that it brings to the civil society. Examples of direct impacts are the infrastructures left on the theatres that may be used after the missions being completed. An indirect impact is the know-how that is developed on implementing the green solutions. There is a possible symbiosis in the process, where the Defence, starting by exploring the present solutions offered by the civil society, may also contribute with new solutions useful to the civil society. Another form of impact is an improvement in the image of the Military among the European citizens.

Case Studies of Civil Applications

There are many successful case studies, involving civilian activities, where the integration of ICT (Information and Communication Technologies) in Remote Monitoring and Control is used to optimize processes and reduce sources of waste and operational costs. All the example cases that are presented here, which were applied to the management of electricity, water and fuel, have not only demonstrated to be beneficial from an economical point of view but also to have a very positive impact on the environment. These cases, although applied to civilian activities, show many similarities to situations occurring during military operations.

These examples presented here demonstrate the importance of implementing a structure for remote data collection, concerning many different operational parameters, e.g. volumes, temperatures, pressures, voltages, fluxes, among others, where the data is then available in a standardized format to allow fast and detailed analysis of the processes.

There is nowadays a clear conscience that a detailed evaluation of the actual state of energy consumption in CMOs requires an enormous effort. Through the implementation of a data platform, such detailed analysis will be possible almost in real time and it will also make it possible to follow the evolution of the many parameters being monitored, giving a much deeper knowledge of all the processes involved.

Energy Efficiency System Installed in Financial Buildings, Portugal

The system was installed in a total of 19 administrative buildings and 358 agencies of a major Portuguese Bank, scattered along the whole territory of the country. The project has started in January 2011, with a 2 months auditing phase, a deployment phase from March till end of May and the run phase started in June 2011, representing today a total of more than 1 year of continuous operation, with an annual consumption of 56GWh.

This energy management system allows the bank to analyse and monitor real time energy consumptions of all buildings and agencies, as a support to the implementation of the actions for reducing energy consumption and to quantify the results of this implementation. With this methodology the bank has achieved savings in energy of 12%, allowing for a payback of the entire solution in less than 2 years.

The project comprised the monitoring of:

- 1998 points;
- 5.000 collaborators;
- 200 cities.

It is vital to know where and how energy is spent to find abnormalities, inefficient processes and behaviours. With accurate time and consumption information it was possible to take specific actions in the field, in order to reduce this abnormalities and inefficient behaviours, implementing specific energy efficiency policies.

Figure 2: Hardware and Software diagram

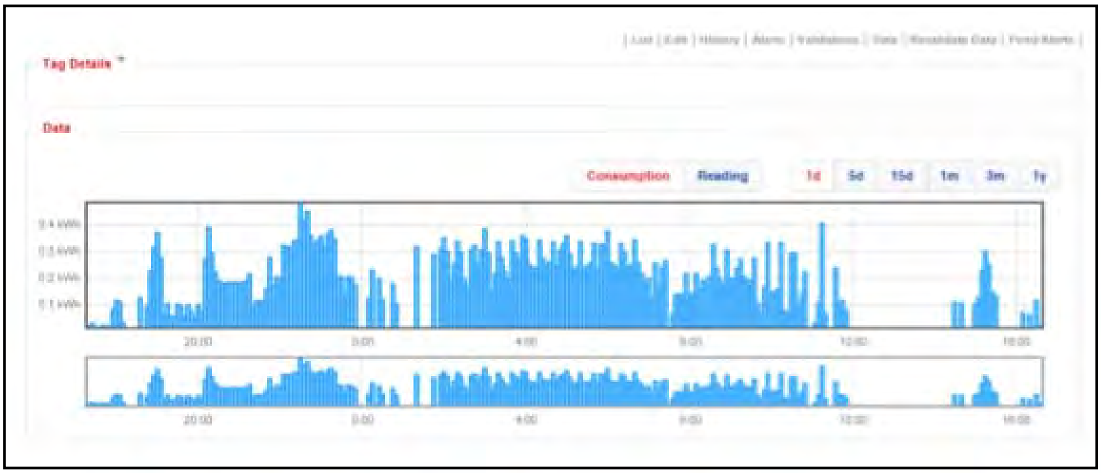

Figure 3: Monitoring Interface of installed solution

Table 2: Summary of the results of the project

Energy consumption reduction achieved in the financial buildings project[11]	12%
Number of agencies monitored[11]	358
Number of cities monitored in the Project[11]	200

Number of employees being monitored[11]	5.000
Number of buildings monitored[11]	19
Annual Savings with the implementation of monitoring system[11]	€700.000
Total Investment in the monitoring system[11]	€1.100.000
Payback time of the system installed[11]	2 years

Save Energy – EU Project Implemented in Public Buildings

In the past years, the European Union dependency in foreign energy has been increasing. Nowadays Europe imports around 50% of the energy consumed, representing a great vulnerability to the European Economy given the instability of the energy markets.

The SAVE ENERGY project has gathered several partners, from different areas of competence and different countries, in order to implement five energy efficiency pilots, in five different cities around Europe. The chosen cities were Helsinki, Leiden, Lisbon, Lulea and Manchester. In each one of the pilots were installed several real time energy data collection systems and displays in order to transform consumer behaviour of these public buildings. Another important aspect of this project was the user-driven open innovation approach. This methodology allows citizens to interact with the systems, making informed decisions that may lead to energy savings by a better understanding of the impact in energy consumption. The project led to new ICT-based services, new business models and recommendations for energy efficiency public policies.

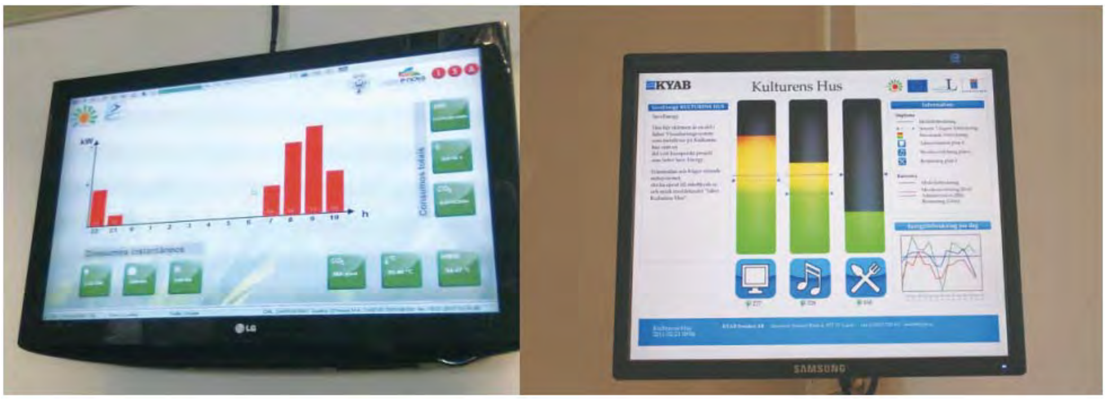

Figure 4: Displays installed in several pilots [12]

Some interesting results were achieved in this project, not only in energy savings but also in the user engagement that was very important to create suitable solutions in the different pilots and reach average savings around 24%. The fact that the project was developed in 5 different cities has contributed to experiment different challenges and to learn important lessons in terms of installation, implementation and acceptance of the ICT solutions. The diversity of environments and activities involved in the pilots was important to understand where the larger savings in energy could be achieved.

Pilot	Test Object	Annual savings [%]	Annual savings [kWh]
Lulea	Restaurant	8	17708
	Music Rooms	7	1470
	Office	30	15260
Manchester	Catering	8	17400
	Lighting	47	70000
Helsinki – **Ala-Malmi**	Pavilion 2	17	180
	Lighting	9	93
	Kitchen	17	5274
Helsinki – **Pihkapuisto**	Entrance hall	40	4683
	Kitchen	27	4261
	Gym Hall	74	15895
Leiden	Lighting	7	1476
	Heating	19	4560
Lisbon	Offices	27	8760

Figure 5: Save Energy pilot savings [12]

Table 3: Summary of the results of the project

Percentage of imported energy consumed in Europe [12]	52%
Percentage of total energy consumed by Public and Commercial Buildings [12]	25%
Average savings achieve on public buildings with the SAVENERGY project [12]	24%

Management and monitoring Systems in Airport fuel tanks

Managing stocks, and supervising logistics related to supply, assuring fuel quality, constitute a considerable load in the aviation market. Companies have been showing an increase interest in a real time monitoring of how their fuel is handled. Therefore the largest aviation companies worldwide have been investing on technology to automatically manage stocks and supplies, as well as to supervise safe oil transportation between tanks, distributor vehicles and aircrafts. This promotes logistics optimization, while at the same time increases energy efficiency.

This solution is already installed in five Spanish airports to monitor jet A-1 aviation fuel tanks, at fixed time intervals, allowing the distributor to remotely access the level of each tank.

This innovative solution avoids stock ruptures in the tanks required due to the high consumption of fuel, with frequent replenishments, which are now better controlled. It also allows a better management of stocks and supplies, as well as, increasing safety during the oil transportation between tanks, distributor vehicles and aircrafts.

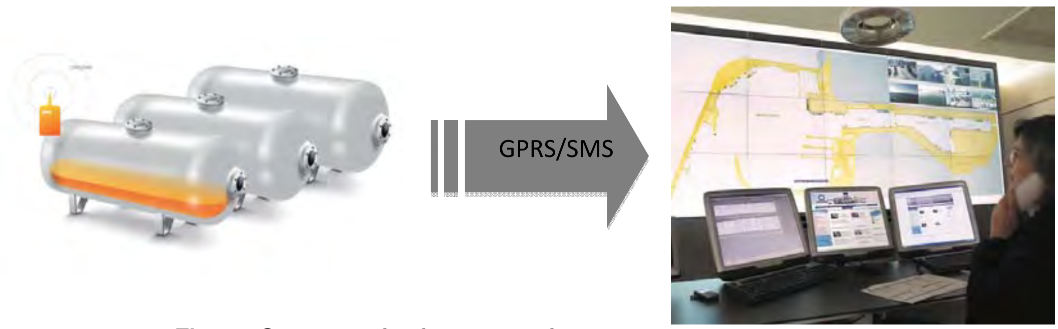

Figure 6: Flow of information from meters to the management system.

The tanks being monitored are more up to more than 10 meters high, having a capacity of 1 million litres. Each field device can simultaneously monitor up to 10 oil tanks.

The installation is an easy process, where the field devices can be quickly set in operation. The result is a low cost solution that allows companies to achieve significant reductions on logistic costs.

The results of the project were mainly in terms of increasing safety of operations, namely:

- Assisted monitoring during the process of filling the tanks, avoiding overfilling;
- Avoid the exposure of personnel while the periodic daily inspections of the tanks (6 times a day) in order to measure their levels;
- Guarantee a better quality of the fuel stored in the tanks.

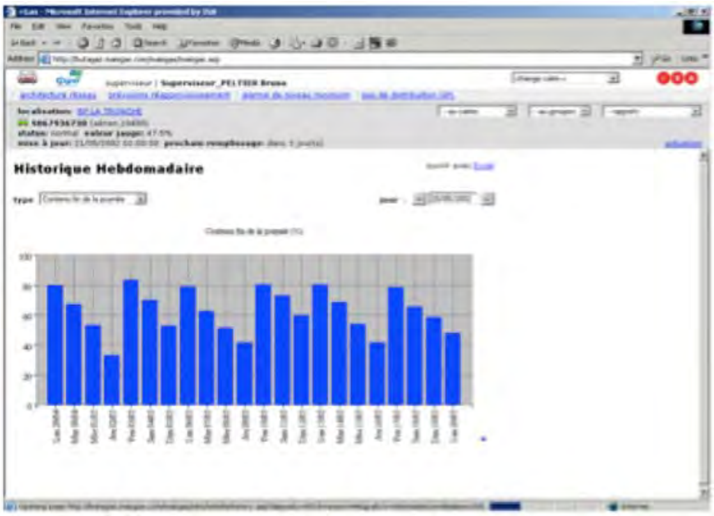

Figure 7: Management and monitoring software for fuel tanks

Water management system, Portugal

As well as energy, water demand has increased in the past years mainly due to cities growth. Therefore this scarce resource has become more valuable and it has increased pressure on water utilities to provide a quality and sustainable service to their clients. Management infrastructures were very inefficient, with high levels of leaks, accountable for around 25% to 45% of water losses. The lack of information about the network, and particularly on stress points, was an important contribution to the inefficiency of the entire water network supply. This situation can be very prejudicial and unsustainable to the water utility company and undesirable to their clients. Without any monitoring system of the network supply, water networks may become very hard to control.

Figure 8: Control and Management System for water utilities

To solve this problem a Water Management System was implemented in a major Portuguese water utility, responsible for supplying 3 million clients, in order to improve meter reading methodologies, communications, billing and overall network management.

This telemetry system, composed by data loggers, flow and pressure sensors together with water meters, allow a precise study of network behaviour in real time, through the iWater software. iWater is a dynamic management platform that allows prompt problem identification and corrective actions, from the technical personnel, in case of anomalous situations.

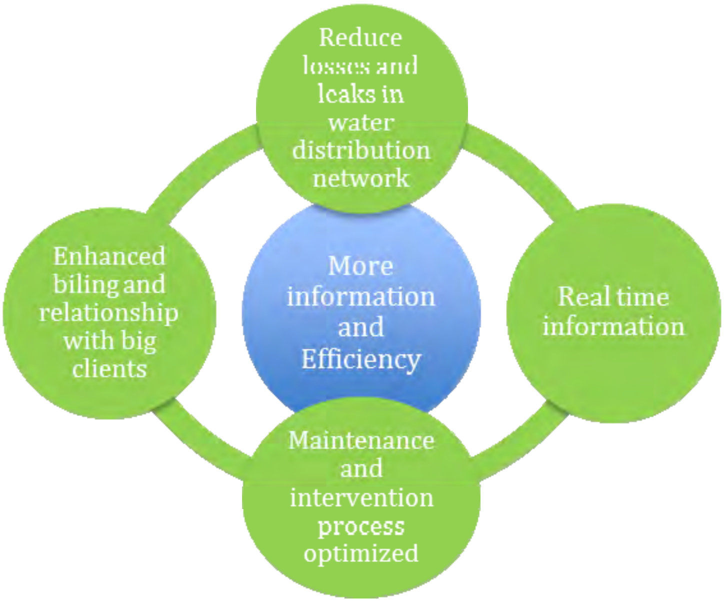

Figure 9: Water management and control System capabilities

This project was implemented in the whole Portuguese territory, covering 6.950 km2, with a total of 700 points of remote monitoring and a cost of €250.000.

Table 4: Summary of the results of the project

Water utilities level of leaks[14]	25% to 45%
Area covered by water management project[14]	6.950 km^2
Points monitored water management project[14]	700
Water management platform cost[14]	€250.000

Remote Monitoring of Gas Supply, France:

After being introduced in the market by ISA, in 1997, a remote telemetric system for LPG tanks, Gas Distributors have been investing in remote monitoring and management systems to analyse the amount of gas in each tank, as well the consumption of each customer. These systems allow them to improve the service provided to their clients and optimise their logistic chain.

The solution was built to monitor tank levels and meter readings, of either LPG or natural gas. This solution increases the efficiency of operations by avoiding manual readings, providing consumption profiles of the customers, estimating the autonomy of each tank for a better control of stocks, which associated with optimized delivery routes, reduces the number of vehicles to be allocated for the distribution. With these advantages, it is possible for the distributor to increase his gains by improving the efficiency of the logistics and to recover the investment made in telemetry in a very short time.

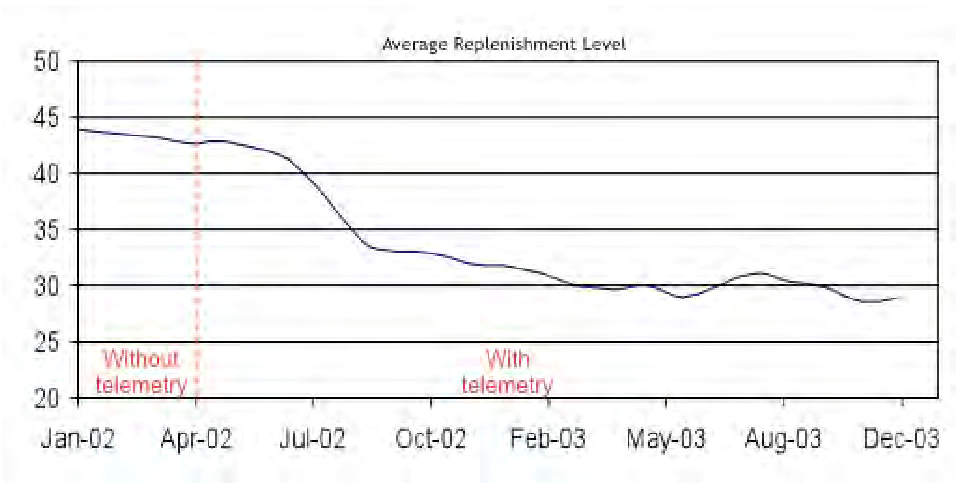

Figure 10: Average Replenishment level without and with telemetry

The project started in 2006 with a testing phase, which involved the installation of the system in 90 gas tanks. After examining its benefits, the gas distributor decided to expand the telemetry onto a total of 13.000 meters and 4.000 tanks.

Currently the distributer has remote access to tank levels and gas consumption.

Fig.10 shows the decrease of the tank level before replenishment, during the pilot phase of this project contributing to a reduction in the frequency of gas deliveries. According to the estimated gains, it is foreseen that the investment made by the company was recovered in two years, which perfectly justifies the use of telemetry.

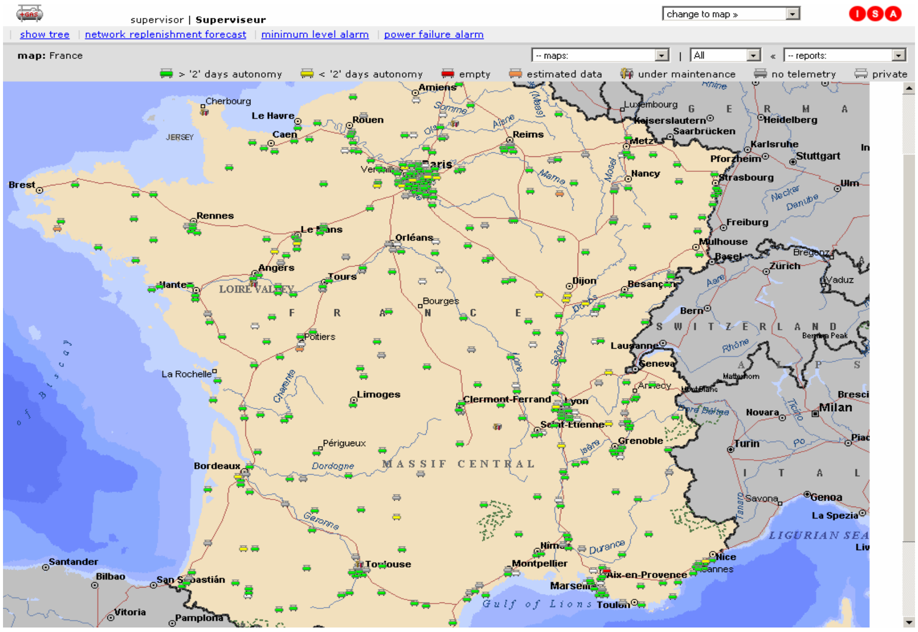

Figure 11: Management system installed to monitor LPG tanks in France.

Table 5: Summary of the results of the project

Total meters deployed to gas tanks monitoring [15]	13.000
Number of tanks monitored in gas management system implemented [15]	4.000

3- Telemetry for energy efficient CMOs

The importance of a more efficient management of energy resources was well emphasized in the first two sections. In case of CMOs, the operating conditions are somehow different from civil applications, although many of the main goals are common. The constraints for achieving energy efficient CMOs, may be summarized in the following way: strong dependence on external energy supply having high risks and costs; large consumption of energy; uninterruptible supply absolutely critical; diversity of environments and camp structures.

Implementing a logistics data platform that gathers information about energy and water is very important for achieving an efficient management of those resources. The implementation of such a data platform is important for a proper evaluation of the reality as it is now; to assist on planning the necessary actions to be implemented; to allow a quantitative evaluation of the results; to assist on the management of the resources, either locally or remotely.

Through the observation of a time evolution plot like the one of Fig. 10, it becomes clear the importance of starting monitoring the processes from the very beginning. This allows not only a direct final evaluation of the total savings obtained but also during the implementation of the actions, it gives an important guidance, by quantifying the impact of each action taken.

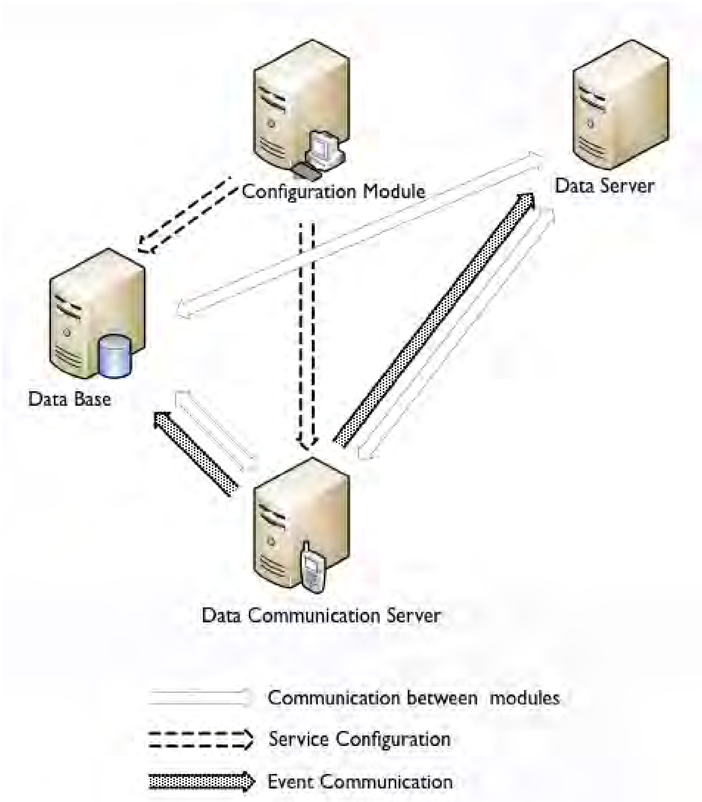

Figure 12: iCenter physical architecture

A data platform such as the iCenter16; Fig. 12, that was used in all five case studies described in the last section and also in many other EC funded projects, from which are examples: EnerEscolas, ENERsip, E3SoHo and Apollon, is an important guiding reference for a future energy data platform dedicated to energy management in CMOs.

The iCenter comprises a middleware that integrates different inputs, from a diversity of equipment and sensors, into a standard data format. It allows the combination of data from very different origins, providing a logistic management in a holistic approach, by co-relating many different processes.

In a typical layout configuration, the data is obtained through the different inputs scattered throughout the remote site, which, in a typical configuration, are either directly cabled or connected through a radio mesh network configuration that transfers all readout information to the remote control unit (Hub). Protocols such as ZigBee, 6LoWPAN, Wi-Fi, PLC, along with proprietary radio protocols have been used for this short-range communication. This remote unit will then transfer the data to the database, through standard long-range communication formats that can be TCP/IP, SMS, GSM, and GPRS GSM/UMTS, as examples of protocols that already have been implemented. Other formats may also be implemented, as the case of satellite, when required for communications with remote regions. This could be the case for CMOs, if such logistic data cannot be integrated in a communication infrastructure already existent.

The major specifications of such Energy Logistics Data Management Platform are:

- Remote monitoring of: electrical production, transportation and consumption; fuel and gas stock levels and consumption in camps; consumption of fuel in vehicles; water storage and distribution facilities; levels of toxicity in waste incinerator equipment and the overall pollution in the environment of the CMO.
- Guaranteeing effectiveness, security, reliability and continuity of operation. Define levels of priority in order to assure continuous operation of strategic equipment.
- Open Protocol: allowing the integration with other software – guaranteeing interoperability.
- Standardization of the input information: such that many different physical parameters can be integrated.
- Modular architecture: there is no generic infrastructure therefore modular and scalable solutions are needed. Adaptable to each CMO scenario
- Logistics support: monitor energy storage capacity and prevision of necessities by an efficient evaluation of consumptions.
- Data collection: information about energy stocks in real time and historical modes;
- Data validation: guarantee data reliability of the input values.
- Safe communications: using appropriate encryption algorithms.

The infrastructure used for the data collection of energy, water and waste can also be compatible with monitoring healthcare parameters from the personnel in the camps. The new concept of Ambient Assisted Living applied to the civil society has been growing in correlation with Energy Efficiency solutions due to a great share of technology.

We believe that also CMOs may take advantage from such potential. Although, despite the possibility of sharing some of technical infrastructures, these two different natures of data, healthcare and energy, should be handled in different databases.

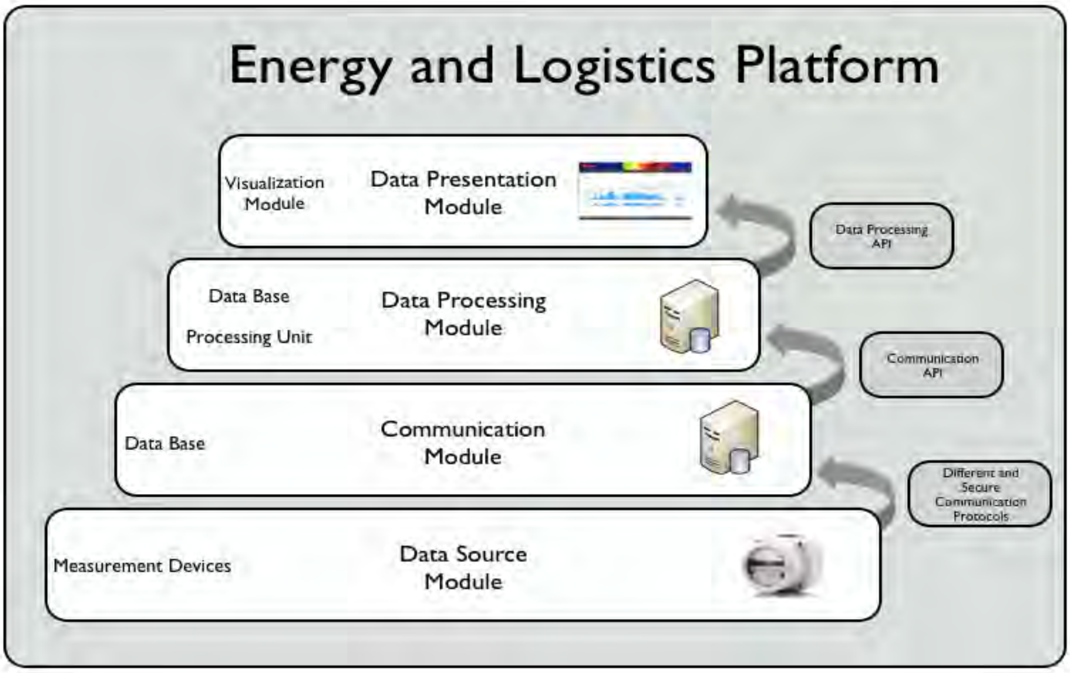

Figure 13: Functional description of the platform showing the flow of information

Associated to this list of features, such platform should also be able to predict the consumptions and the production of energy inside the CMOs. Such predictions are very important for an efficient management of the energy resources inside camps, allowing an optimisation of the use of energy.

Algorithms for forecasting consumptions, based on historical data combined with weather predictions and other environmental or operational factors, are already being implemented in Energy Efficiency projects.

On the other side, it is currently possible to implement regional weather forecast computational models in order to forecast the production of energy. This tool allows a focused short period forecast, normally between 24 to 72 hours but extendable up to 120 hours, for the desired meteorological parameters. This information can be used for a calculation of expected power generation by renewable based sources, as the case of solar and wind, within the same time period.

Both spatial and time resolution could be adjusted. The Example below shows a regional domain, with an area of about 50.000km2, 15km spatial resolution and 1h time resolution.

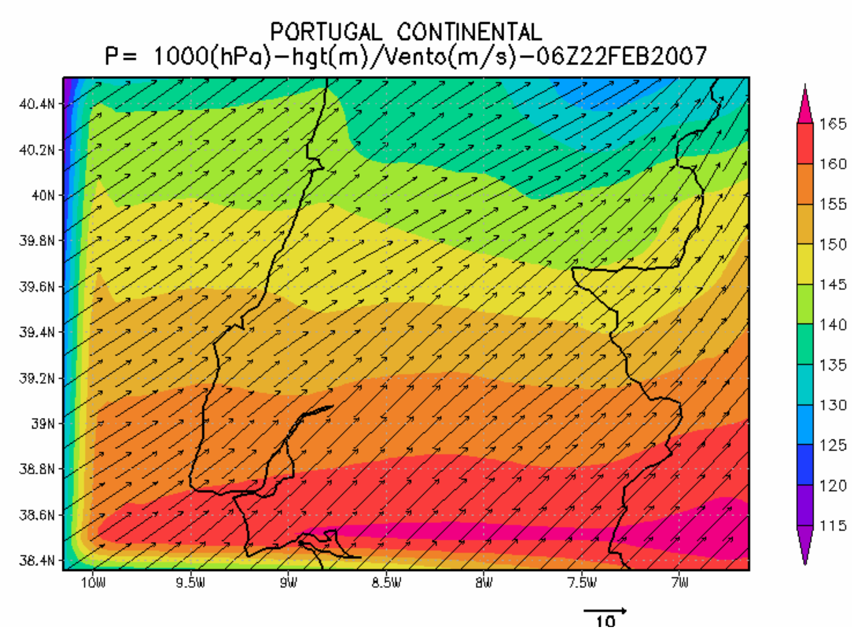

Figure 14: Forecasting Weather prediction scheme

Major Advantages of the Energy Logistics Data Platform are:

- Real-time and historical detailed information of vital resources – energy, water;
- More efficient supply processes
- Savings, by cutting unnecessary costs and supressing waste of resources
- Decision-making support tools with possibility of defining priority levels, focusing on critical resources;
- Capability of predicting consumptions and local production of energy;
- Assistance on planning necessary logistic actions;
- Monitor and improve the overall environment of the Operations.

Energy efficiency in CMOs does not mean less effectiveness. The Energy and Logistics Centre will allow a better control of resources in line with established priorities. It will be focused on reducing sources of waste, allowing a re-allocation of resources into the strategic areas, and to optimise the whole logistic chain. More than just maintaining operational capability it allows definition of levels of priority focusing on critical tasks.

Business Models

As mentioned in the first section, the cost of energy inside CMOs, and particularly in war theatres, may reach extremely high values. With a cost of a gallon of fuel inside a camp reaching up to $400, this translates into a cost per kilowatt of about $10 euros. Considering these high values, finding alternative options that are economically viable seems likely to be achievable. It is also important to have in mind that there are other very important advantages in using alternative forms of energy besides the economic aspect, as already referred.

Such cost for producing 1 kWh of energy has to be compared with the cost of local production based on alternative sources of energy, e.g. solar and wind. For a proper evaluation, it is necessary to consider the cost of the equipment, transportation to the camps, installation and maintenance and this has still to be weighted with either (whichever is shorter) the time of duration of the operation, or the expected lifetime of the equipment considering its working conditions. The estimation of the time duration of the operation is possibly the most difficult parameter to evaluate and therefore it should be done, in our opinion, based on elaborated risk assessment methodologies, more than just taking into account the political horizon defined for the operations. This approach should not be interpreted as a way to influence decisions, rather to have more effective management procedures, based on a rational analysis of probabilities. As an illustrative example, consider the case of a person who receives a contract for a new job with duration of one year. If the person needs to rent a house because of the new job, he might consider making a rental contract for a three year period instead of only one year, taking into consideration: the better rental conditions that he might get, the probability of getting an extension of the working contract and the extra cost for an early termination of the three years rental contract. Note that in the whole process does not have to be taken into account any kind of pressure placed on the company that offered the job in order to obtain an extension of the contract.

Many advantages have already been pointed out for justifying the introduction of more Energy Efficient practices in CMOs. On the other side, two major points that have been raised against this initiative are: first that it represents a diversion from the main objectives of the missions and second that it demands a considerable financial effort to be invested in new technologies and methodologies.

The first argument is a well-known difficulty of most human activities. When a new methodology / procedure / tool has to be introduced in a process that is already working, this action is normally seen as a diversion from its main objectives, though that investment of time and resources leads to an improvement of the process. This can certainly also be the case for the Military Green initiative, where the final gains will appear in the many different formats that were described in Section 1.

Concerning the aspect of financing such an initiative, particularly in a time where most budgets are shrinking, it may require creative solutions. Hence, since the same financing problems are also being faced by the civil society, either by domestic energy consumers, industry or services, it is wise to search for civilian business models that may be also useful to the Military Green initiative.

One case worth to be analysed is the business concepts adopted by Energy Service Companies – ESCOs. These are companies that provide a diverse role of services to consumers, with the aim of reaching savings through energy efficiency. These services are: Energy Management and analysis; Audits and Consulting; Maintenance and operation; Evaluation of savings; Supply of Energy or equipment; Direct delivery of services like space heating, cooling, lightning.

In ESCO models, the savings are used to cover the investments made and in this way avoid the need for an initial payment from the side of the consumer. Savings are then divided by both parts according to the rules defined in a contract established between the ESCO and the consumer.

Inspired on such model, we propose a challenge to the Military Green initiative, where instead of buying equipment to produce renewable energy, CMOs would buy directly renewable energy that is produced locally from an external energy company in charge of supplying the camp. This means that CMOs will pay for the kW.h of energy locally produced, instead of paying the investments in new equipment. In this case, the complex business analysis, necessary to verify the viability of introducing renewable energies in CMOs, would be transferred to the private companies. Besides, it will not be necessary to deal with the extra technical complexity that the production of renewable energy will bring.

In order to ensure redundancy, such solutions can still be combined with standard fuel generators inside camps. The alternative energies supplied by the renewable energy companies will reduce the amount of fuel consumption and storage in the camps.

This model raises administrative, technical and security issues that need to be carefully analysed. Just to give a further insight on these issues, some examples will be discussed here. Although, a deeper discussion of such issues would go beyond the scope of this article.

The model requires the establishment of contracts with the Renewable Energy Suppliers that would be interesting enough for both parts. From a conceptual point of view CMOs will simply buy energy, either in form of fuel or in the form of renewables produces locally. It is important to guarantee that the Supplier has the opportunity to cover the investments that they have to do. For this, it is necessary that, from one point, CMOs guarantee that will buy the energy produced and, most critical, as already referred before, is to determine the time duration of these contracts.

The accounting necessary for this solution, concerning the trade between the CMO and the Supplier, could be based on the telemetry solution proposed in Section 3.

A major concern in terms of security could the location of the Renewable Energy Equipment, since by being operated / maintained by civilians it may not be possible to be located inside the camps. A solution could be to build a small compound next to the camps. From a point of view of the vulnerability of such compound to possible attacks, it has to be considered that apart from the cost of the equipment, such damages would cause no major disturbance in overall performance of the CMO, if redundancy would be observed, as mentioned above.

The business model here proposed is a solution to transfer the responsibility, of implementing and operating the renewable energy solutions, to the private companies. All the benefits linked to the Green Military initiative that were discussed would also be kept for this model.

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Renewable Energies in combination with energy storage systems for military field camps

Dr. Karsten PINKWART (Fraunhofer ICT), Dr. Carsten CREMERS (Fraunhofer ICT) and Dr. Peter FISCHER (Fraunhofer ICT)

Abstract – The increasing lack of fossil fuels puts the use of batteries more and more into focus. The effective and efficient integration of renewable energy under the precondition of powerful and reliable batteries in military field camps is one important goal. Currently, the energy demand is mainly met electrically with the help of fuel operated generators. Besides the logistical complexity for the tracking of the required fuel and related costs, this approach has other drawbacks. In future it is reasonable to use locally available renewable energy sources to feed-in the camp in conjunction with batteries, in order to achieve savings in primary energy demand and thus to increase the autonomy of the camp. An important step to be able to operate a constant uniform electrical infrastructure with renewable energies is the use of large-sized energy storage systems. For this case, redox flow batteries are a promising technology because power supply and energy content can be constructed separately.

Introduction

Electrical energy is currently used in several military applications, from mW to MW. Both mobile and stationary applications are involved (see figure 01). The rising complexity of the applications and technologies has led to a steady increase in the demand for electrical energy. The main way to provide this is through fossil fuels such as diesel which are transferred into generators. Most national procurement plans are based on this concept of energy supply. However, it is uncertain whether technologies based on diesel fuel can supply all military needs in the near future. The application of batteries is becoming increasingly relevant to military users due to the decreasing availability of diesel fuel in the foreseeable future. Even the integration of renewable energies with efficient and reliable energy storage and conversion systems is under investigation. However, the efficient utilization of existing technology for electrical energy supply must be the first priority.

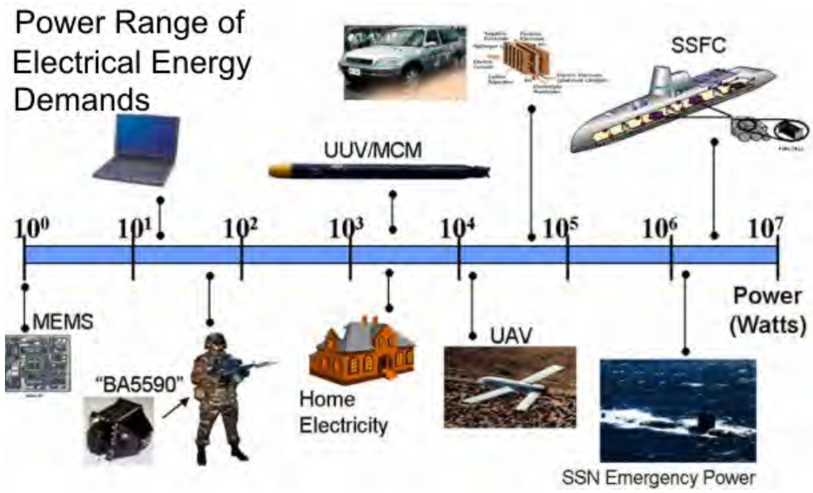

Figure 1: Defence applications make increasing demands to electrical power supply over a broad power range

Most non-portable applications such as stationary power supplies for military bases, in the form of power generation or backup power, or mobile power supplies for military land, sea, or air vehicles are not very different from corresponding civil applications. However, specific military conditions make it necessary to develop specialized solutions.

Batteries

Batteries are still the most important source of electric power in military applications, and are expected to continue to play an important role in future power supply scenarios. A broad range of batteries are currently used in the military sector (see table 01). One important trend is an increasing use of lithium-based technology for both primary and secondary batteries. Another important trend is a greater use of secondary lithium batteries. This will become necessary as the increasing demand for electrical energy causes severe logistic difficulties where only primary batteries are used to fulfill the demand. In addition, rechargeable batteries offer a higher flexibility as part of hybrid systems or energy networks. As with all military equipment, batteries for military applications need to be able to operate under relatively harsh conditions. As a result, temperature endurance from -40 to +70°C, high humidity resistance and resistance against shock and vibrations are usually required. A further constraint is the required ability to operate at high altitudes of at least 2500m.

Table 1: Different battery systems in contrast to here energy density

Energy density		**Lead**	**NiCd**	**NiMH**	**High temp.**	**Li-Ion**	**Supercap**
volumetric	Wh/L	90	150	200	190	250	5
gravimetric	Wh/kg	35	50	70	120	120	4
Power density							
volumetric	W/L	910	2000	3000	270	4200	25.000
gravimetric	W/kg	430	700	1200	180	2000	20.000

Battery type	**Lead**	**NiCd**	**NiMH**	**High temp.**	**Li-Ion**	**Supercap**
Cycle number (80 %DOD)	700	3000	3000	1000	3000	>500 k
Cycle efficiency (80 %DOD)	75	65	70	85	96	98
Life time in years	5	5	15	10	15	15

The main focus of research and material development in the field of lithium batteries is therefore an improved tolerance to external influences such as temperature or electrical parameters, improved storage properties and the improved intrinsic safety of storage systems through the use of new materials.

So far the specific energy of lithium batteries has been increased mainly by manufacturing improvements without the need for significant changes in cell chemistry. Manufacturing improvements are made by using progressively lighter cases (e.g. replacing stainless steel by aluminum) or by optimizing the cell design, for example by increasing the loading of active materials. A limit has now been reached beyond which further increases in specific energy require modification of the cell chemistry.

On the application side the requirements of future energy storage systems are especially long operating times at low weight and volume. For this reason, current research activities are mainly focused on improving energy density.

So-called 5V systems (the combination of an anode and a cathode with a cell voltage > 4 V), which are not yet available commercially, can increase the energy density by about 25% compared to standard systems with comparable capacity. Examples of such systems are based on manganese spinel cathode materials (e.g. LiFe0.5Mn1.5O4, LiNi0.5Mn1.5O4, etc.) and phosphates with an olivine structure (e.g. LiNiPO4, LiCoPO4). The biggest barrier for the commercialization of those systems lies in the decomposition of organic electrolytes at a voltage of 4 V.

Alloy anodes of tin or silicon can reach a significantly higher specific capacity than graphite. However, the lithium intercalation into the material can lead to an increased volume expansion, which in turn places significant stress on the electrode during charging and discharging. One solution could be the use of nano-crystalline materials, a uniform particle allocation, the coating of carbon structures or thin film technology. Despite this it is currently difficult to foresee when these new anode materials will be commercially available. It is likely that mass production will not be possible in the next five years as the production of nano-wires is complicated and expensive and also includes a large number of process steps.

For safety reasons, metallic lithium is not currently used in lithium-ion batteries. Due to its high specific capacity, however, lithium metal has some potential as an anode material for rechargeable batteries in the future. For both lithium-sulfur and lithium-air batteries, intensive research is currently being carried out into electrolytes that are stable with a lithium metal anode and can therefore increase the safety of the battery.

With cathodes made of sulfur (in a conductive matrix) combined with lithium metal anodes, the energy density can potentially be increased by a factor of 2-3. In addition, sulfur is non-toxic, very cheap and available in large quantities (see figure 02). One reason why lithium-sulfur batteries have not yet achieved sufficient marketability is a parasitic shuttle mechanism which runs parallel to the normal electro-chemical reaction. It leads to high self-discharge of the cell and results in poor efficiency. Lithium-sulfur and lithium-air batteries are the most promising technologies in the field of high-energy batteries. Extremely high energy densities and low material costs are the main features of these new cell technologies.

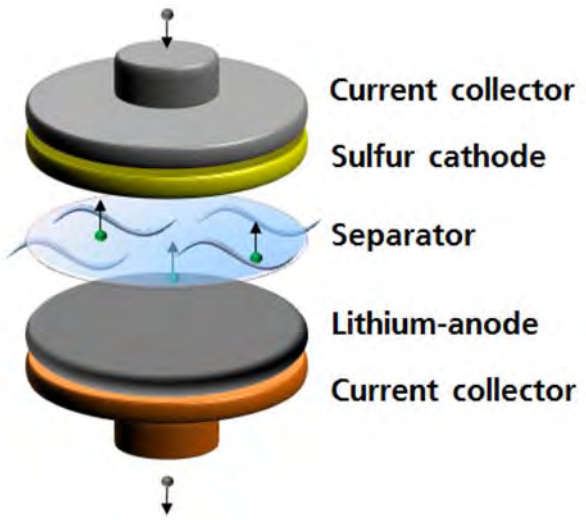

Figure 2: Lithium sulfur battery

Redox-Flow Batteries

Due to the increasing use of fluctuating renewable energy sources such as photovoltaics and wind energy the storage of electrical energy is becoming a key technology. Different techniques are available to store the energy. Beside pump storage, compressed air energy storage, high-temperature batteries and water electrolysis combined with fuel cells, there is also a possibility to store energy in redox-flow batteries.

Redox-flow batteries also have potential for application in the energy grid as readily-available energy stores, and for uninterrupted power supply. Redox-flow batteries allow energy and performance to be scaled independently of each other (see figure 03).

Through their modular construction and relative simplicity they can achieve a high service life combined with high availability. Due to their intermediate position between fuel cells and classic secondary batteries, redox-flow technologies have a high innovation potential in terms of performance and energy density

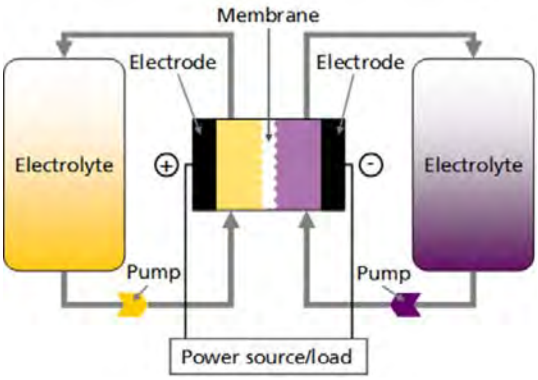

Figure 3: Schematic view of redox-flow technology

Vanadium redox-flow batteries could be a promising candidate for decentralized storage in the range of kW up to some MW. Redox-flow batteries also have potential as energy storage systems for military camps or other military applications where a system with an overall efficiency of more than 75% is required (see figure 04).

Figure 4: Development of Military Battery Systems at Fraunhofer ICT under contract of WTD 51 - Wehrtechnische Dienststelle für Pionier- und Truppengerät (17 kW VRFB, 24 Stacks (600 cm², 22 cells), current max. 360 A; potential 175 V, power 34 kW, powerdenisty 30 kWh)

Conclusions

In connection with renewable energy, energy strorage systems will only be mandatory if the coverage from renewable primary energies, is above a threshold of approximately 10% of the total capacity. The use of energy storage systems can even be useful, for example to smooth the load profile and thus to utilize the power generators more evenly. However, it is also possible to use energy storage systems to specific times, e.g. to avoid the operation of the generators and the associated noise during night or in certain situations.

The development of containerized storage modules is therefore recommended. The redox flow battery technology offers the greatest flexibility with regard through its scalability. For smaller installations the development of a module with lithium ion batteries could be useful. In addition to scalability and efficiency of the corresponding energy storage systems also their low noise and IR signature militate in favour for them. Perhaps here, the integration into a power distribution is possible similar to the current SVC container.

Demonstration of Hydrogen Fuel Cell Technology for German Land Forces

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Abstract – Due to their low noise, IR and exhaust emissions, fuel cells are an interesting option for the future energy supply for military applications. This was demonstrated in two specific applications, i.e. the use of 2 kW hydrogen PEM fuel cell systems in a tactical generator and in an unmanned ground vehicle. In each case the advantages of the replacement of internal combustion engines by the respective fuel cell systems was evaluated. It was found that the fuel cell systems showed reduced emissions and were more lightweight than the respective conventional systems. In addition, the safety of suitable pressurized hydrogen storage tanks was evaluated with respect to the military application. Here, it was shown that fire up to a certain caliber causes only very localized damage without ignition of the effusing hydrogen.

Introduction

The reliable supply of electrical energy is an important issue for the success of armed forces missions. The logistics of the fuel needed today to secure the required power supply is, however, an important factor of the operational costs for troops abroad. Furthermore, and not less important, the logistic chain itself is vulnerable against attacks and thus increases the vulnerability of the mission. The use of locally available renewable energy sources would reduce the dependency on the fuel supply logistics. Thus, it could help to enhance the safety of the missions and reduces costs at the same time. In such a scenario hydrogen could be used as energy storage medium in combination with fuel cells to achieve the required efficiency. The Bundeswehr Technical Center for Engineer and General Field Equipment WTD 51 in Koblenz is investigating such future scenarios supported by the Fraunhofer ICT.

An important non-technical obstacle encountered in this endeavor is the still existing reservations in the troops against hydrogen and hydrogen fuel cells in spite of the successful introduction of direct methanol fuel cells by another Bundeswehr Technical Center. In order to dispel these reservations it was decided to realize two hydrogen fuel cell demonstrators which shall demonstrate the advantages of the use of fuel cells and hydrogen technology and the reliability of the technology. In addition, the behavior of pressurized hydrogen tanks under fire with different calibers was assessed together with the Bundeswehr Technical Center for Weapons and Ammunition WTD 91 in Meppen.

Fuel Cell Technology for Military Applications

The benefits of fuel cells compared to diesel generators as existing technology are low noise emission, low IR signature, low vibration and potential weigh reductions. In order to exemplify these benefits, two fuel cell demonstrators were planned. Both had a projected fuel cell power of 2 kW_{el} and used similar stack technology. The applications which were chosen are a tactical generator with 2 kW electrical power output as AC and / or DC current and a 2 kW_{el} range extender for an autonomous unmanned ground vehicle (UGV). In both cases low noise emissions are of high importance in order to reduce the detectability of the appliances. Also in both cases weight reduction is important in case of the generator to make the handling easier for the soldiers and in case of the autonomous vehicle to leave more room for payload. In order to achieve the desired goals it was decided to use air cooled systems with an open cathode structure. The general advantages expected from this choice are more efficient and lighter systems. Also it can be expected that these systems which have fewer parts than water cooled systems will be more robust in harsh environments.

FutureE was selected by the Bundeswehr as partner for the realization of the fuel cell systems. With its Jupiter series FutureE has realized a lightweight and highly efficient air cooled system for back-up power based on the Ballard 1020ACS stack technology. The mounting technique using polymer foams should also give the systems a high robustness during transport or in mobile applications.

Tactical Fuel Cell Power Generator

Increasing electrical power demands even of single squads and the single fuel policy have led to the development of a 2 kW diesel based portable power generator (SEA 2kW) which is used today by the Bundeswehr. This system consists of two required modules, the motor generator module including a control panel and the battery module for electrical starting of the generator and battery charging. A strong drawback of the system is its heavy weight: the motor generator module alone weighs about 70 kg with an additional 21 kg for the control panel. This module contains a diesel tank with 2.8 l tank volume which allows for 3.7 hrs of operation at an average load of 75% of the rated power. The battery module which incorporates also the direct current interface weighs another 58.5 kg. Accordingly, the overall weight of the system amounts to 149.5 kg.

The goal of the demonstration was to provide the same functions as the existing system, i.e. 2 kW electrical power output via 230 VAC and / or 24VDC, respectively, with a substantially reduced weight of not more than 40 kg excluding hydrogen tanks so that the net weight of the generator module is more than halved. Taking into account the efficiency of the fuel cell system of 50% which has been demonstrated by FutureE in their Jupiter system, about 3.7 Nm3 of hydrogen (0.33 kg) will be required to provide the same run time as currently achieved with 2.7 l of diesel. Adding a portable 300 bar composite tank with 20 l of hydrogen will add about 30 kg of weight but almost double the run time. And still the total weight of the fuel cell system will only be about 70 kg, which is 20 kg less than the existing generator module. The design of the control panel followed the panel of the existing diesel generator as far as possible to make the use of the fuel cell system as easy as possible. The hydrogen tank shall be connected via a quick connector which can also be handled wearing gloves.

With respect to operating conditions the system shall comply with new British-German Dual Standard Def-Stan 61-23 / VG 97010-1. However, due to technical limitations the temperature regime for starting the fuel cell system is restricted to +3 °C to +45 °C. Once the system is operating steadily, the lower limit of the temperature regime can be reduced to -20 °C. For the transport of the system a temperature between -30 °C and +60 °C is specified. As a minimal requirement for mechanical stress an exposure to vibrational stress in the frequency range of 10 – 80 Hz with forces of 39.2 m s-2 (4 g) along all axes was requested without an adverse effect on the device.

Regarding signatures a noise level of 40 dB in 1 m distance around the generator should not be exceeded. Furthermore, with respect to IR signature but also regarding safety in operation a maximum temperature of 60 °C for all tangible surfaces was specified.

Another important requirement of the system is hydrogen safety. Here, an emission of 0.4 vol.-% (4,000 ppm) in average and 1 vol.-% (10,000 ppm) in peak should not be exceeded in order to stay away from the lower explosion limit of hydrogen (4 vol.-%, 40,000 ppm).

Figure 1 shows a front and a side view of the finalized tactical fuel cell generator.

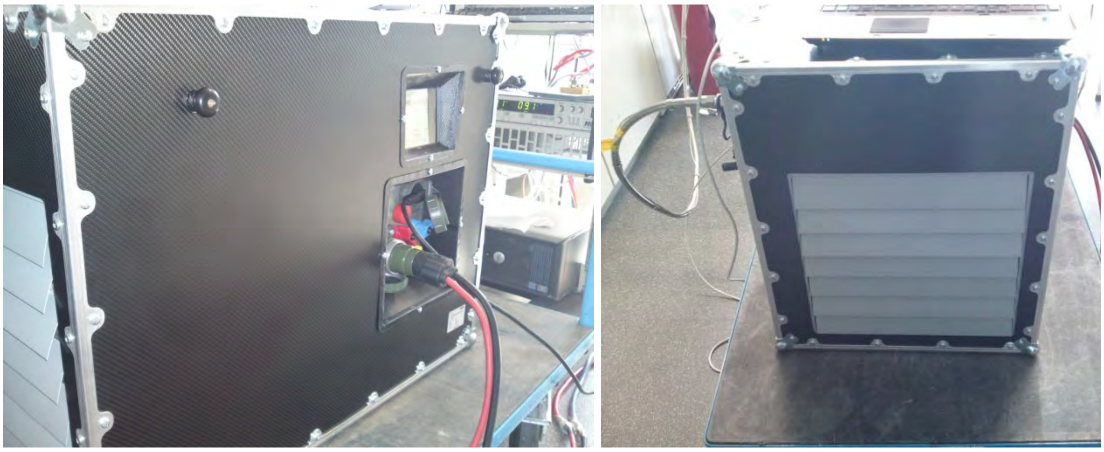

Figure 1: *Front view (left) and view of the exhaust shutters (right) of the fuel cell generator.*

The finalized generator system had a weight of approximately 50 kg which exceeds the set limit of 40 kg. However, the fuel cell generator already includes a battery and the direct current interface which were not included in the main module of the conventional generator. This makes a direct comparison difficult. Furthermore, there is anyway a potential for weight reduction in the system design and the used commercial components of the fuel cell generator which were originally designed for stationary application.

During commissioning of the generator the required specifications were tested. It was found that the noise level of 40 dB was exceeded in certain situations, e.g. during full load or shut-down. In these situations a high rotational speed of the blower is required. As the blower was identified as main emission source of the noise, the replacement by a more silent blower or the more efficient management of the waste heat in the system could help.

As shown in Figure 2, the maximum surface temperature of 60 °C during operation was only reached at the exhaust shutters.

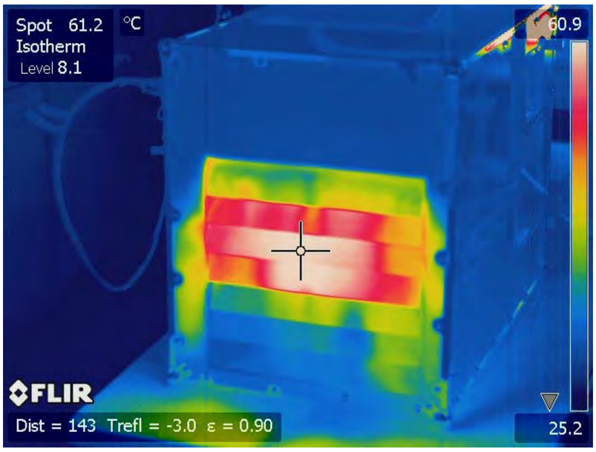

Figure 2: Thermal image of the exhaust shutters of the fuel cell generator during operation.

The average hydrogen emission was with 0.3 vol.-% within specifications. In close proximity to the exhaust, peak hydrogen emissions slightly exceeding 1 vol.-% were detected during purging of the system. However, it can be stated that no ignitable atmosphere was created outside the generator.

Autonomous Unmanned Ground Vehicle with Fuel Cell Range Extender

In future, unmanned or autonomous vehicles including unmanned ground vehicles can be used for a number of tasks that today pose large risks for soldiers, e.g. the detection and identification of improvised explosive devices or mines and possibly their clearing, but also for reconnaissance missions. The department for robotics and sensors at the WTD 51 is therefore working on an experimental platform of such an autonomous ground vehicle. The platform is based on the Mustang MK 1 vehicle by Diehl Defence, which itself is based on a motorized wheel chair by Otto Bock. The drive train of the vehicle consists of four hub motors with 0.55 kW peak power each. Additional sensors and payload increase the peak power demand of the vehicle to roughly 3 kW. In its original state the system was equipped with two 12 V lead acid starter batteries and a 2 kW diesel engine by Honda as range extender. For reasons of secured supply the original batteries have been replaced by two military lead acid starter batteries. Instead of the engine two additional batteries of the same type have been added to increase the duration of emissionless operation. However, these batteries have created a huge weight burden, as each battery weighs 40 kg. The target of the demonstration is to replace the additional batteries by a 2 kW fuel cell system as range extender, giving the same endurance as achieved with the motor but without its noise and exhaust emissions. A major benefit will also be the weight reduction as the fuel cell system which is expected to have a weight of 30 to 35 kg. Allowing for a hydrogen tank of about 30 kg, the total weight of the fuel cell system will be about 60 kg, which is 20 kg less than the batteries it will be replacing. A further benefit is expected from reduced vibrations compared to the motor which should enhance the quality of the pictures obtained by the 3D laser scanner which is mounted on the vehicle (Figure 3).

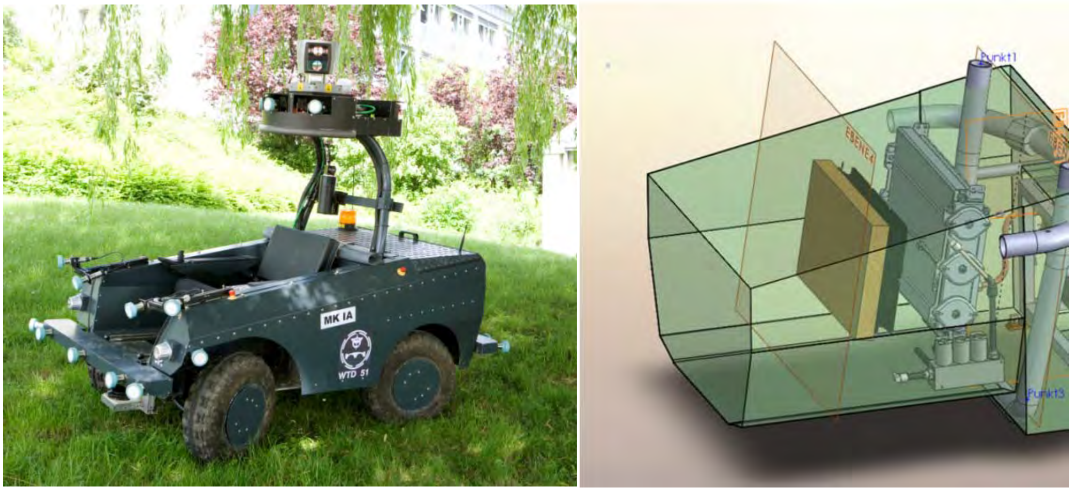

Figure 3: *Mustang MK 1 vehicle (left, source Bundeswehr WTD 51) and cartoon of the fuel cell position in the vehicle (right, source FutureE).*

As the same type of fuel cell system as in the tactical generator was built into the UGV, basically the same standards and regulations (Def-Stan 61-23 / VG 97010-1) apply. Accordingly, apart from the total weight of the fuel cell system (30 to 35 kg), a noise emission below 40 dB in 1 m distance, a hydrogen emission below 0.4 vol.-% in average and 1 vol.-% in peak and a surface temperature of less than 60 °C were specified, respectively.

With a weight of 41 kg the finalized fuel cell system including air duct and baffles for ventilation exceeded the threshold of 35 kg. However, during mounting of the fuel cell system some parts of the original UGV needed to be removed so that the overall weight gain for the installation of the fuel cell system was about 35.3 kg which roughly is in accordance with the specified weight of 35 kg.

Concerning temperature it was found that the temperatures of tangible surfaces around the fuel cell stack are around 44 °C and thus well below the specified value. However, at the exhaust shutters the detected temperature rises to 55 °C which is still within the specifications (Figure 4).

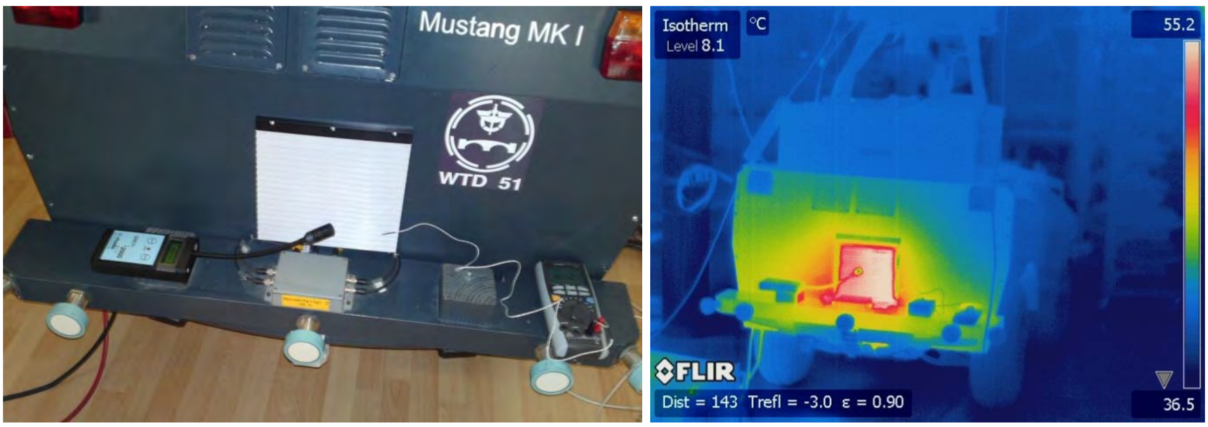

Figure 4: *Rear view of the unmanned ground vehicle with exhaust shutters during commissioning (left) and as thermal image during operation (right).*

With 100 ppm hydrogen emission in average during operation this value is clearly below the specified value of 0.4 vol.-% (4,000 ppm). However, as for the fuel cell tactical generator, the peak hydrogen emission slightly exceeds the specified value of 1 vol.-% (10,000 ppm) but only for short periods of time (< 2 sec.).

The noise emissions were not quantified during commissioning, however, it is assumed that the specification of 40 dB in 1 m distance may also be exceeded due to the noise generation of the blower at high rotational speeds.

Hydrogen as Fuel in Military Environment

The use of PEM-type fuel cells for military applications requires the handling of hydrogen in military environment. Therefore, tests exceeding the civilian standards need to be done. In order to assess the impact of fire with different calibers on the pressurized hydrogen tanks, ballistic tests were performed at the test site of the Bundeswehr Technical Center for Weapons and Ammunition WTD 91 in Meppen. Here, pressurized composite hydrogen tanks were taken under fire with the calibers 7.62 mm, 12.7 mm and 40 mm from different distances and angles.

It was shown that the smallest caliber 7.62 mm always penetrates the front side of the hydrogen cylinder and, depending on the distance, may penetrate the rear wall as well (Figure 5). In all cases hydrogen effuses without ignition.

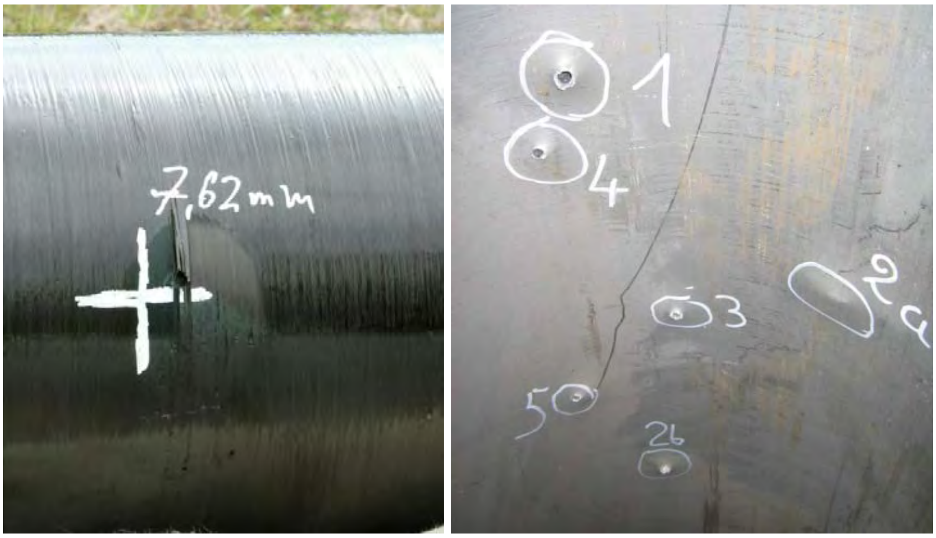

Figure 5: Views of the front wall (left) and the rear wall (right) of a hydrogen container after having been taken under fire with caliber 7.62 mm.

Increasing the caliber always causes the penetration of the front and the rear wall of the container. In all cases the effusing hydrogen is ignited which causes large flames. However, the damage is localized to the bullet holes, and the structure of the containers stayed in one peace.

This changes when the pressurized hydrogen tanks were subjected to explosion or cutter-charges. In these cases the hydrogen is set free at once and explodes upon impact. The structure of the hydrogen tank collapses and falls apart into two pieces. However, there was no further fragmentation or shrapnel formation observed.

Conclusions

The demonstration projects described above could principally show the usefulness of fuel cell systems for military applications. Although not all set goals were completely achieved, the main advantages of the technology, i.e. low noise, IR and exhaust emissions and a possible weight reduction compared to conventional systems or secondary batteries could be demonstrated.

In addition, although the demonstration systems are intended to gain operation experience and not to enter service in theatre, they are already designed according to the relevant standards and regulations (Def-Stan 61-23 / VG 97010-1). This emphasizes the readiness of the technology.

Furthermore, by performing ballistic tests on commercial pressurized composite hydrogen tanks, a first insight into hydrogen safety and handling in military environment is given. It was shown that when being hit with a small caliber, hydrogen effuses without ignition. Increasing the caliber or subjecting the container to explosion causes large flames and explosion-like scenarios. However, although the structure on the composite tank may collapse under these conditions, there is still no fragmentation into pieces observed.

Acknowledgements

The authors would like to thank WTD 91 for the ballistic tests of the hydrogen containers. Financial support of this work by the German Federal Ministry of Defence under contract no. E/E510/AZ001/8F124 and E/E510/AZ002/8F124 is gratefully acknowledged.

TSS Habitat Systems: Supporting and Sustaining Life in Remote Locations

Kris VANCOMPERNOLLE, Alan SPERO, Stephen WYLE (Thermal Storage Systems, Inc.)

Abstract – *The desirability of minimizing the use of fossil fuels in crisis management operations, particularly at forward operating bases, has motivated an interest in the use of energy from renewable sources. Combining multiple types of renewable sources (e.g. wind and solar) with energy storage is generally considered important as a means of compensating for the intermittent nature of these sources. However, the resulting complexity can have a negative impact on the logistic supply chain and thus be self defeating. An alternate approach that integrates solar energy collection and thermal energy storage, and which emphasizes interoperability, modularity, and component commonality, is discussed herein.*

Introduction

The European Defense Agency's (EDA) Crisis Management Operations (CMOs) currently depend almost exclusively on fossil fuels to supply their energy needs. While this approach is appropriate for the most immediate response needs, as the CMO's deployment lengthens, reliance on fossil fuels burdens the logistics supply chain and makes the operations susceptible to fuel price fluctuations and supply chain disruptions by insurgent actions. Accordingly, one of the EDA's top ten capability priorities is to reduce fossil fuel dependence by CMOs[1]. This goal will increase the safety of the supply chain, which in turn leads to better survival rates for CMO personal and more stabilized budgets that are less dependent on market fluctuations. In addition, this goal promotes the added benefit of being an environmentally responsible strategy.

The EDA Fuel and Energy Work Strand states that a key part of the solution will be "novel technologies such as renewable energy conversion, high density energy and power storage systems and alternative fuels, alongside conventional systems.[2]" While increased energy consumption awareness among personnel certainly plays an important role, the adoption of renewable energy systems is critical in reaching this goal. As will be discussed, compact and efficient energy storage will be critical to ensure the reliable availability of energy whenever it is needed.

Logistical Efficiency

A key component of a CMO is the Forward Operating Base (FOB) where troops eat, sleep, rest and plan. To meet the EDA's priority of fossil fuel reduction, FOBs must increasingly rely on energy supply systems incorporating renewable sources. While this is the right approach, it must be addressed in the context of the overall energy efficiency of the CMO, which includes the FOB and the logistics system that supplies it. Utilizing multiple renewable energy sources at the FOB, which is frequently proposed to mitigate the cyclic and intermittent nature of renewable sources, imposes its own logistic burden on the CMO. Multiple systems increase the FOB's maintenance load with the need for a larger and more diverse spare parts inventory, greater storage needs, and more complex maintenance tasks. Additional skill sets, training requirements and supply requirements can further burden the logistical chain.

A successful strategy will maximize the energy efficiency of a CMO, by balancing the FOB's energy supply and maintenance requirements with those of the logistic supply chain that supports it. Both energy efficiency and logistical flow must be considered and maximized for this strategy. An efficient CMO will employ technology that is modular, interoperable and builds on each module for additional capability by using similar constructs and parts to minimize logistical needs, training time and parts storage. In this way, the CMO can implement an effective method to provide alternative sources for the FOB’s energy needs.

The Need for Energy Storage

Solar and wind power sources are both cyclic and intermittent, which makes energy storage critical if they are to be used as base load power. Combining both solar and wind sources at an FOB can mitigate their cyclic nature somewhat, since wind typically peaks in the afternoon while solar peaks at noon; but without storage the combination still suffers from intermittency, lack of output at night, early morning, and evening. Furthermore peak demand can often occur at times when neither solar or wind are producing power. This forces a greater dependence on fossil fuel powered backup generators than might otherwise be unnecessary.

To address this shortcoming, an energy storage device is usually included as part of a power system intended for remote operations. The storage device serves as a buffer that stores excess production and meets demand when the instantaneous demand exceeds the instantaneous production. For renewable power technologies such as photovoltaic solar cells and wind turbines that directly produce electricity, the only practical storage technology is the battery. However batteries have their own shortcomings that should not be overlooked.

Batteries are consumable items that require replacement. Consider the simple example of a photovoltaic panel and battery pack combination that is designed to produce an average electrical output of 1 kW over 24 hours when exposed to 12 hours of sunlight. To meet this requirement, the photovoltaic panel must produce 24 kW hrs of electricity in 12 hours, and the battery pack must store the 12 kW-hr of energy that will be needed during the 12 hours of darkness. Assuming that the battery discharges 80% of its stored energy by the end of the night, it's capacity must be 15 kW-hr, and it can be expected to last approximately 250 nights (if it was a lead-acid battery) before it must be replaced. The lifetime of the battery pack could be extended to 500 nights by doubling its capacity to 30 kW-hr, but this trade off does not affect the logistical reality that replacement of 15 kW-hr of capacity is needed for every 250 days of operation.

Given an average specific energy density of 38 W-hr/kg for a lead acid battery[3], this implies that approximately 400 kg of batteries must be replaced every 250 days just to support this simple 1 kW photovoltaic power system. Furthermore, the expended batteries must be transported out of the operational theatre for environmental reasons. Therefore, even this modest 1 kW system will require 800 kg of transportation capacity per 250 days of operation. The logistical implications are significant.[4]

These estimates assume that the battery pack's specific power requirements are small (~1 to 10 W/kg). The situation worsens if the battery pack is required to meet a high power demand, since the effective capacity of a battery decreases as the power requirements increase (see Figure 1). This means that if high power outputs are required from the system, even more excess storage capacity must be included in the design and the transportation weights increase.

Of course the specific energy density and cycle life of the battery pack will depend on the type of battery used. For example lithium-ion batteries can have four times the specific energy of lead acid batteries, and lifetimes between 400 and 1200 cycles, depending on factors such as operation temperature and discharge rates. However, these batteries impose other burdens on the system including a substantially higher cost of acquisition, the need to operate them in a temperature controlled environment and their greater potential for environmental damage if not disposed of properly. Thus improvements in battery technology can reduce the logistics load, but it will still remain significant.

Thermal Energy Storage

Thermal storage is a promising alternative means of storing energy. In this approach, the energy from a power source (e.g. the sun) is used to heat a material in an insulated container. When energy is needed to meet demand, the stored heat is extracted and used to drive an engine, generator, or some other device. This technology offers some very significant advantages over batteries.

If the material being heated undergoes a phase change (such as converting a solid to a liquid) during the storage process, thermal energy storage is capable of very high specific energy densities. For example, Thermal Storage Systems Inc (TSS) has developed a proprietary high temperature material whose specific energy density significantly exceeds that of even lithium ion batteries and is comparable to that of fuel cells (see Figure 1). Furthermore, its specific energy density is independent of the energy extraction rate, which is can also be very high. This implies that the 12 kW-hr energy storage requirement, discussed in the example above, could be met with a 51 kg TSS thermal storage device, as opposed to 400 kg of lead acid batteries or 107 kg of lithium ion batteries. The volume-specific energy storage density for the TSS device, including the insulation surrounding it, is approximately 225 kW-hr/m^3 for capacities on the order of 50 kW-hr.

The TSS storage device uses no moving parts nor does it exhibit any of the life cycle issues such as those found in batteries. The useful life is instead determined by normal material degradation effects and is expected to be at least ten years.

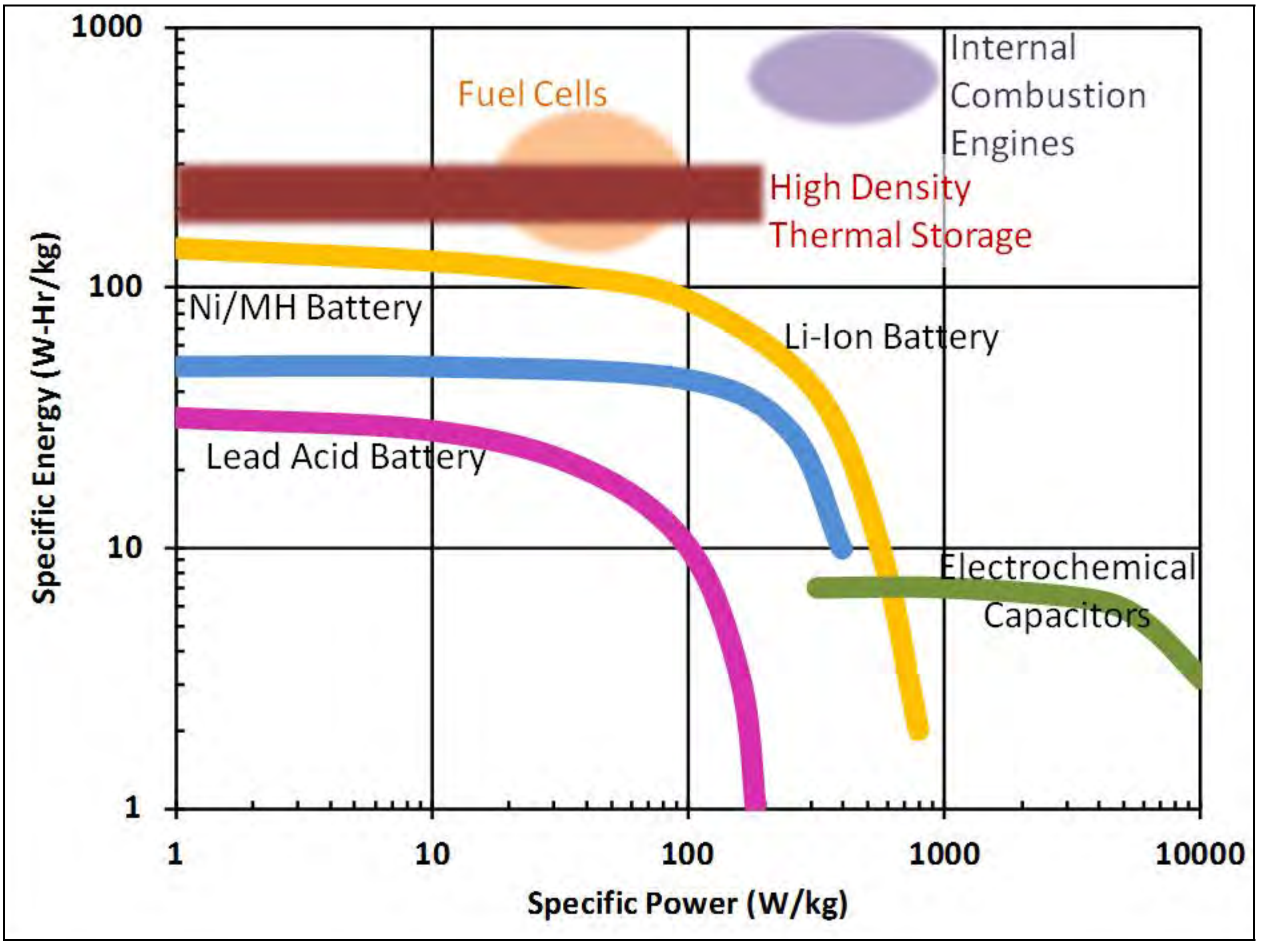

Figure 1: Ragone plot showing the interplay between specific energy and specific power for a number of energy storage and conversion devices. Note that the TSS High Energy Density Thermal Storage performance significantly exceeds that of battery technologies.[5]

A second significant advantage of thermal storage over electrical storage is that many FOB energy needs can be met by a thermal source without the need to convert the thermal energy to electricity. For example, space heating and cooling, water heating, and water distillation, can be done with thermal energy without the need to produce electricity. This is a significant advantage if the power source is solar energy. Collecting solar energy and converting it to electricity with photovoltaic cells is typically only 15% efficient, whereas the collection of solar energy and conversion to heat is 70 to 80% efficient. This means that five times as much solar collector area is required to collect 1 kW-hr of electricity than to collect 1 kW-hr of thermal energy. This can have significant logistical implications when employed at a FOB. If the energy is needed to heat water or run an HVAC unit, the thermal collection approach will vastly outperform the photovoltaic approach. Should electrical power be required, the thermal energy can be converted to electrical energy with efficiencies of approximately 30%, making it more efficient than current photovoltaic technology.

TSS has tested this storage concept using U.S. Army funding as part of a program to develop deployable hot water systems for FOBs. Results of the tests showed that thermal energy could be stored and extracted with very high efficiency. Overall the results of the tests demonstrated the efficacy of its storage technology.

Habitat Systems™

TSS is developing a deployable solar power system, based on the thermal storage device described above, for use at FOBs and other remote off-grid locations., The key concept behind the TSS Habitat System is the use of modular standard energy collection and storage units that can produce hot water as well as power heaters, absorption chillers, water distillation units, and electrical generators.

The power supply unit consists of a two-axis sun-tracking solar collector and an integrated thermal energy storage device. The collector is a 12.5 m^2 rectangular aperture, off-axis parabola with field-replaceable polycarbonate mirror panels. The design emphasizes easy field maintenance and portability. The units function independently, which increases deployment flexibility.

Each power supply unit is capable of collecting a net 73 kW hr of solar energy and storing 43 kW-hr per day given 10 hours of sunshine. This configuration can supply an average of 3 kW of thermal power throughout a 24 hr period and can accommodate higher power demands as needed. The units themselves are self-powered, so an external electrical power supply to run the tracking motors, pumps, and controls is not needed.

By incorporating energy storage directly into the unit, a continuous supply of energy is assured day and night, so long as the sun can replenish the energy consumed. The units deliver energy in the form of steam, which can then be used to heat water, provide HVAC power, or serve other uses. The thermal energy can also be converted to electrical power,

The hot water needs alone of an FOB can be significant. Based on US Army requirements, a 60 person FOB requires almost 8400 liters of hot water (60 ^{o}C) per day just to service the showers, kitchen, laundry, and latrines. Should a medical facility be included the hot water requirements of course increase as well as introduce a need for steam to power sterilization equipment. Meeting this requirement with photovoltaic or wind power is impractical. The TSS unit stores thermal energy in a high-temperature phase change material and produces hot water on demand, thus eliminating the need for large insulated hot water storage tanks.

The modularity of the system reduces the logistical supply burden of an FOB by emphasizing commonality among the power supply units. Furthermore, the system is designed to ship in standard sized shipping containers (six units fit in a 2 m long TRICON shipping container) and can be set up by four people in a few hours without special lifting devices.

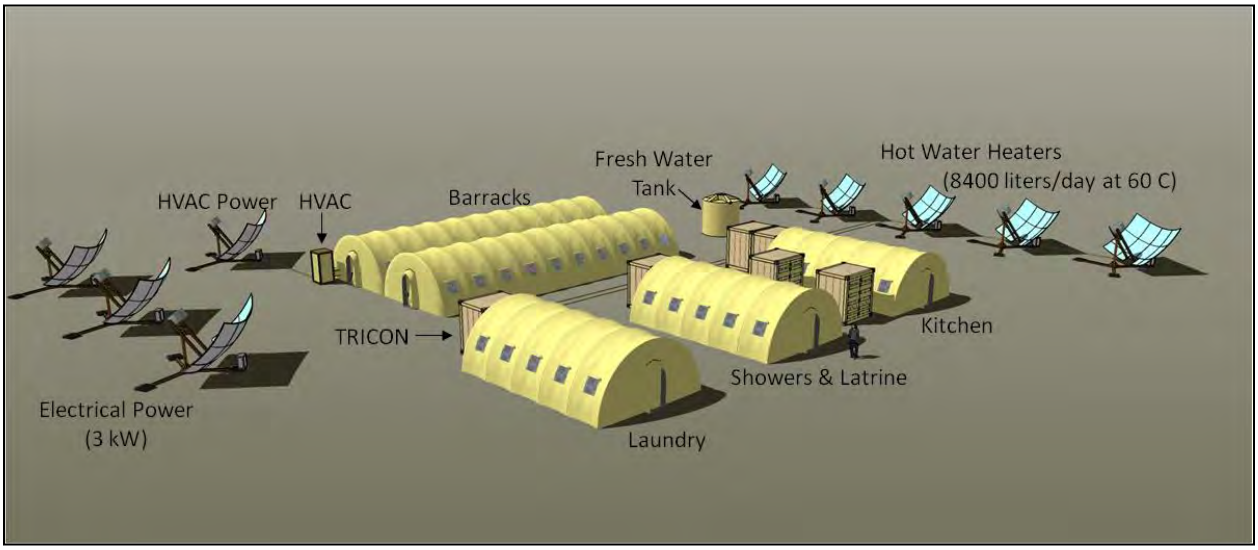

Figure 2: Notional Habitat System for a 60 person encampment.

Conclusions

Employing renewable energy sources at forward operating bases offers the potential of significantly reducing the logistics burden on Crisis Management Operations as well as reducing the cost of fossil fuels employed for non-combat applications. However, the use of multi-modal systems such as photovoltaic panels, wind generators and storage batteries can offset these benefits by imposing additional burdens that include increased spare parts, maintenance, training and the need to transport consumables such as batteries.

To a great extent, this logistics burden can be reduced through the use of an innovative, modular solar thermal energy source capable of providing power on demand for multiple base requirements that include hot water, steam, water desalination and purification, and electrical power. As most of the power source components employed are common across these applications, training and spares inventories are minimized. Transport cost can be minimized by avoiding the need to periodically replace bulky items such as storage batteries. Man-portability of system components allows for deployment without special handling equipment, and shipment is simplified by the ability of the systems to pack efficiently in containers for transport.

References

[1] EDU Capability Development Plan, Top 10 Priorities: Fuel and Energy, described in http://www.eda.europa.eu/Capabilitiespriorities/Top10priorities/FuelandEnergy

[2] Ibid

[3] The specific energy of a battery is the storage capacity divided by the weight of the battery. See The EDA Expert Group 4 Final Report on Batteries, from the CEN Workshop 10, Brussels, June 30, 2011 for a summary of performance characteristics for different types of batteries. According to this report, lead acid batteries have specific energy

densities between 25 and 50 W hr/kg and lifetimes between 200 and 300 deep-discharge cycles. We have used average values for this example.

[4] According to the EDA Expert Group 4 Final Report, "The cost of ownership of batteries may represent an important part of the total cost of certain systems, in particular for portable equipment. Indeed, the batteries life is quite limited, and is generally much less than the service life of the systems or platform."

[5] Based on material from Venkat Srinivasan and John Newman, Lawrence Berkeley Laboratory, California, as presented in "Batteries and Electrochemical Capacitors", Daniel A. Scherson and Attila Palencsar, The Electrochemical Society Interface • Spring 2006.

Methanol Steam Reformer – High Temperature PEM Fuel Cell System Analysis

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Abstract – The implementation of a high-temperature PEMFC stack into a combined system with a steam methanol reformer (SMR) has been studied. Comparison of efficiency between systems with a high temperature (HT) PEMFC stack and a classical, low-temperature (LT) PEMFC stack has been made. In both systems the methanol reformer operates at 250 °C and steam-to-methanol ratio of 1.5. Classical PEMFC stack operates at 90 °C while high-temperature PEMFC stack operates at 250 °C. Additionally, the system with a classical PEMFC stack uses a catalytic burner to supply the endothermal reforming process with sufficient heat. Partial heat regeneration has been also used in this system because hot exhaust gases from the reformer need to be cooled down before entering the fuel cell stack. Modelling of both systems and sensitivity analysis was performed in Aspen Plus. The results show that efficiency of approximately 54% (based on higher heating value) can be reached with the HT PEMFC system, which is more than 40% higher efficiency compared to the LT PEMFC system.

Introduction

One of the major constraints for the PEMFC is that they use hydrogen as a fuel which has a very low energy density per volume at conditions of standard ambient pressure and temperature (SAPT). Therefore hydrogen is stored either as gas at very high pressures (up to 800 bar) or as liquid at very low temperatures below -253 °C. As an alternative the reforming of liquid fuels (fossil or renewable) is showing promise because they have much higher energy density per volume. For small portable applications methanol shows good potential because it is sulphur free, has a high hydrogen-to-carbon ratio in its composition and is in liquid form at SAPT, which greatly facilitates its storage and transportation. It can be seen from Table 1 that at SAPT methanol has more than thousand times greater energy density per volume compared to hydrogen.

Table 1: Higher heating value (HHV) of hydrogen at different conditions and methanol at SAPT

Hydrogen		Methanol	Ratio
141.9 kJ/g		20.0 kJ/g	7.1 : 1
SAPT	11.5 kJ/L	15.7 MJ/L	1 : 1,365
800 bar	6.0 MJ/L		1 : 2.6
-253 °C	10.1 MJ/L		1 : 1.6

Another shortcoming of PEMFC is that the heat released during the electrochemical reaction is on relatively low temperature level and it is mostly discarded as waste heat. This is one of the main reasons that the research is also starting to focus on the so called high-temperature PEMFC, which could operate at temperatures higher than 200 °C. This would allow the reaction kinetics to proceed faster and consequently raise the efficiency of PEMFC and at the same time allow the use of waste heat in cogeneration for different applications.

As it turns out, raising the temperature above 200 °C would have another advantage. The reformate gas exiting the steam reformer always contains some carbon monoxide (CO) which is the main inhibitor of electrochemical reaction in PEMFC. The reason for that is the preferential adsorption of CO onto the active sites of the platinum (Pt) catalyst. At higher temperatures this occurs at a much lesser extent and the HT PEMFC operating above 200 °C could work normally at concentrations higher than 2% of CO in the inlet gas (based on [1]). With good design of the steam reformer such composition of the reformate gas is not too difficult to achieve. This would also remove the need for downstream hydrogen purification processes (WGSR, PrOX or methanation) and reduce the costs substantially.

Increasing the temperature of PEMFC operation above 250 °C would have an additional benefit because the heat released during the electrochemical reaction would be on a sufficiently high level to support steam reforming of methanol. The steam reforming process can achieve practically 100% conversion of methanol at temperatures between 250 °C – 300 °C. This depends on the design of reformer. The integrated system with such HT PEMFC stack would have higher efficiency compared to the LT PEMFC because it would not need a catalytic burner to supply continuously the SMR with additional heat for the reforming of methanol.

System modelling

Modelling of the SMR was based on the kinetic model proposed by Peppley et al [2]. The kinetics was included directly into Aspen plus using the R-Plug model unit with Langmuir-Hinshelwood kinetic model.

The model of a PEMFC was based on calculations from an in-house developed model in SIMULINK. The results from SIMULINK model were integrated into Aspen Plus User-2 model of PEMFC downloaded from Aspen support site.

Methanol reformer

To describe properly the methanol conversion as a function of temperature we have used the kinetic model proposed by Peppley et al [2]. The same kinetic model was also used in a study made by Pattekar and Kothare [3] and in a study made by Telotte et al [4]. Comparing all the articles there were some minor mistakes found in equations and some discrepancies in parameters. The values used in our model of the SMR are presented on **Figure 1**.

The kinetic model presumes that in the SMR three reactions proceed simultaneously: steam methanol reforming (Eq. (1)), direct decomposition of methanol (Eq. (2)), and water gas shift reaction (Eq. (3)):

$$CH_3OH + H_2O \leftrightarrow CO_2 + 3H_2 , \quad (1)$$

$$CH_3OH \leftrightarrow CO + 2H_2 , \quad (2)$$

$$CO + H_2O \leftrightarrow CO_2 + H_2\,. \tag{3}$$

The rate of reaction r_i depends on the rate limiting step in its set of elementary reaction steps. The process of steam reforming is a combination of all three reaction sets therefore it is given in the form of the following equations:

$$r_R = \frac{k_R \cdot K^{*}_{CH_3O(1)} \cdot \left(\frac{p_{CH_3OH}}{p_{H_2}^{1/2}}\right) \cdot \left(1 - \frac{p_{H_2}^{3} \cdot p_{CO_2}}{K_R \cdot p_{CH_3OH} \cdot p_{H_2O}}\right) \cdot C_{S_1}^{T} \cdot C_{S_{1a}}^{T} \cdot S_C \cdot A_b}{\left(1 + K^{*}_{CH_3O(1)} \cdot \left(\frac{p_{CH_3OH}}{p_{H_2}^{1/2}}\right) + K^{*}_{HCOO(1)} \cdot p_{CO_2} \cdot p_{H_2}^{1/2} + K^{*}_{OH(1)} \cdot \left(\frac{p_{H_2O}}{p_{H_2}^{1/2}}\right)\right) + \left(1 + K_{H(1a)}^{1/2} \cdot p_{H_2}^{1/2}\right)}, \tag{4}$$

$$r_D = \frac{k_D \cdot K^{*}_{CH_3O(2)} \cdot \left(\frac{p_{CH_3OH}}{p_{H_2}^{1/2}}\right) \cdot \left(1 - \frac{p_{H_2}^{2} \cdot p_{CO}}{K_D \cdot p_{CH_3OH}}\right) \cdot C_{S_2}^{T} \cdot C_{S_{2a}}^{T} \cdot S_C \cdot A_b}{\left(1 + K^{*}_{CH_3O(2)} \cdot \left(\frac{p_{CH_3OH}}{p_{H_2}^{1/2}}\right) + K^{*}_{OH(2)} \cdot \left(\frac{p_{H_2O}}{p_{H_2}^{1/2}}\right)\right) + \left(1 + K_{H(2a)}^{1/2} \cdot p_{H_2}^{1/2}\right)}, \tag{5}$$

$$r_W = \frac{k_W \cdot K^{*}_{OH(1)} \cdot \left(\frac{p_{CO} \cdot p_{H_2O}}{p_{H_2}^{1/2}}\right) \cdot \left(1 - \frac{p_{H_2} \cdot p_{CO_2}}{K_W \cdot p_{CO} \cdot p_{H_2O}}\right) \cdot C_{S_1}^{T\,2} \cdot S_C \cdot A_b}{\left(1 + K^{*}_{CH_3O(1)} \cdot \left(\frac{p_{CH_3OH}}{p_{H_2}^{1/2}}\right) + K^{*}_{HCOO(1)} \cdot p_{CO_2} \cdot p_{H_2}^{1/2} + K^{*}_{OH(1)} \cdot \left(\frac{p_{H_2O}}{p_{H_2}^{1/2}}\right)\right)^2}, \tag{6}$$

Eqs. (4)-(6) where used in Aspen Plus process modelling software where R-Plug model unit was used as a SMR. The reactions where integrated into the unit in the form of Langmuir-Hinshelwood kinetics. The reactor is modelled as a plug flow tubular reactor which means that there is no change of thermodynamic properties in radial direction (no concentration, temperature and pressure gradients) but the changes exist in the axial direction. The reactor is designed as a tube of 150 mm length and 10 mm diameter.

Fuel Cell Stack

The efficiency of PEMFC η depends on the generated current density *j,* which is directly proportional to the molar flow of used reactants $\dot{n}$ via the Faraday's law of electrolysis:

$$\dot{n} = \frac{I}{z \cdot F} = \frac{j \cdot A}{z \cdot F}, \tag{7}$$

where *I* represents electrical current, *A* active surface area of PEMFC, *z* number of charge carriers and *F* Faraday's constant. In general, the efficiency of an energy system is defined as a ratio between energy supplied to the system and energy produced by the system. In terms of PEMFC the efficiency can be deduced as:

$$\eta = \frac{P_{out}}{P_{in}} = \frac{I \cdot U}{\dot{n} \cdot \Delta H_{HHV}} = \frac{z \cdot F \cdot U(I)}{\Delta H_{HHV}}, \tag{8}$$

where ΔH_{HHV} is higher heating value of hydrogen and *U(I)* fuel cell voltage. From Eq. (7) one can conclude that *U(I)* can also be seen as a function of hydrogen molar flow and the efficiency can also be expressed as a function of hydrogen molar flow.

Parameter	Value
k_R	$7.4 \times 10^{14} exp(-102800/(RT))\ m^2/mol.s$
k_D	$3.8 \times 10^{20} exp(-170000/(RT))\ m^2/mol.s$
k_W	$5.9 \times 10^{13} exp(-87600/(RT))\ m^2/mol.s$
K_R	$10^{(1.4142\times10^{-13}T^5-4.2864\times10^{-10}T^4+5.3993\times10^{-7}T^3-3.6385\times10^{-4}T^2+1.4096\times10^{-1}T-2.0258\times10^1)}\ bar^2$
K_D	$10^{(2.9463\times10^{-13}T^5-8.8919\times10^{-10}T^4+11.1130\times10^{-6}T^3-7.4160\times10^{-4}T^2+2.7969\times10^{-1}T-4.4944\times10^1)}\ bar$
K_W	$10^{(-1.4936\times10^{-13}T^5+4.5026\times10^{-10}T^4-5.6216\times10^{-7}T^3+3.7206\times10^{-4}T^2-1.3726\times10^{-1}T+2.4537\times10^1)}$
$K^*_{CH_3O(1)}$	$exp(-41.8/R-(-20000/(RT)))\ bar^{-0.5}$
$K^*_{CH_3O(2)}$	$exp(30/R-(-20000/(RT)))\ bar^{-0.5}$
$K^*_{HCOO(1)}$	$exp(179200/R-(100000/(RT))\ bar^{-1.5}$
$K^*_{OH(1)}$	$exp(-44.5/R-(-20000/(RT)))\ bar^{-0.5}$
$K^*_{OH(2)}$	$exp(30/R-(-20000/(RT)))\ bar^{-0.5}$
$K_{H(1a)}$	$exp(-100.8/R-(-50000/(RT)))\ bar^{-1}$
$K_{H(2a)}$	$exp(-46.2/R-(-50000/(RT)))\ bar^{-1}$
$C^T_{S_1}$	$7.5 \times 10^{-6}\ mol/m^2$
$C^T_{S_{1a}}$	$1.5 \times 10^{-5}\ mol/m^2$
$C^T_{S_2}$	$7.5 \times 10^{-6}\ mol/m^2$
$C^T_{S_{2a}}$	$1.5 \times 10^{-5}\ mol/m^2$

Reactor Parameter	Value
Catalyst density, ρ_b	$1300\ kg/m^3$
Specific surface area, S_C	$102000\ m^2/kg$

Figure 1: *Parameters used in the model of SMR*

A model of PEMFC stack was downloaded From Aspen Plus support site. It is based on User-2 model unit where a user subroutine is written in Fortran programing language. The programing code was modified in such a way that the efficiency of the PEMFC stack changes in accordance with incoming hydrogen molar flow in a form of a 6th degree polynomial (**Graph 1**). The polynomial was fitted to the results of 1D model calculated in SIMULINK.

The model of PEMFC in SIMULINK calculates the reversible voltage *E* according to the Nernst equation:

$$E = E_0 + \frac{\Delta s}{z \cdot F}(T - T_0) + \frac{R \cdot T}{z \cdot F} \cdot ln\left(\frac{p_{H_2} \cdot p_{O_2}^{1/2}}{p_{H_2O}}\right), \tag{9}$$

where E_0 is the reversible voltage at SAPT, Δs is the change in reaction enthalpy (for PEMFC it is negative), *z* is the number of charge carriers, *F* Faraday's constant, *T* temperature, T_0 temperature at SAPT, *R* universal gas constant and p_i partial pressure of component i.

There are several factors that affect the reversible voltage in form of losses. Three major types of losses occur in PEMFC as a result of slow kinetics on electrodes (activation losses), depletion of reactant concentrations due to mass transport (concentration losses) and poor conductivity of protons through the polymer membrane (ohmic losses). These losses are subtracted from the reversible cell potential to obtain the characteristic polarisation curve of the PEMFC.

The kinetics of electrochemical reaction in PEMFC is described by the Butler-Volmer equation:

$$j = j_0 \cdot \left(e^{\frac{\alpha \cdot z \cdot F \cdot \eta_{act}}{R \cdot T}} - e^{\frac{-(1-\alpha) \cdot z \cdot F \cdot \eta_{act}}{R \cdot T}} \right), \tag{10}$$

where α is the transfer coefficient and η_{act} are the activation losses. If it is assumed that $\alpha = \frac{1}{2}$ the Euler equation can be used and activation losses can be deduced as:

$$\eta_{act} = \frac{2 \cdot R \cdot T}{z \cdot F} \cdot arcsh\left(\frac{j}{j_0}\right), \tag{11}$$

where j is the current density of PEMFC and j_0 the exchange current density. The contribution to activation losses is only calculated on the cathode side because the kinetics on the cathode side is much slower than that on the anode side. The same situation stands for the concentration losses, which are far greater on the cathode side than on the anode side, especially when air is used as an oxidant. Concentration losses η_{conc} are calculated as:

$$\eta_{conc} = \frac{R \cdot T}{z \cdot F} \cdot \left(1 + \frac{1}{\alpha}\right) \cdot ln\left(\frac{j_L}{j_L - j}\right), \tag{12}$$

where j_L is the limiting current of the PEMFC. Ohmic losses η_{ohm} are defined according to Ohm's law and can be written as:

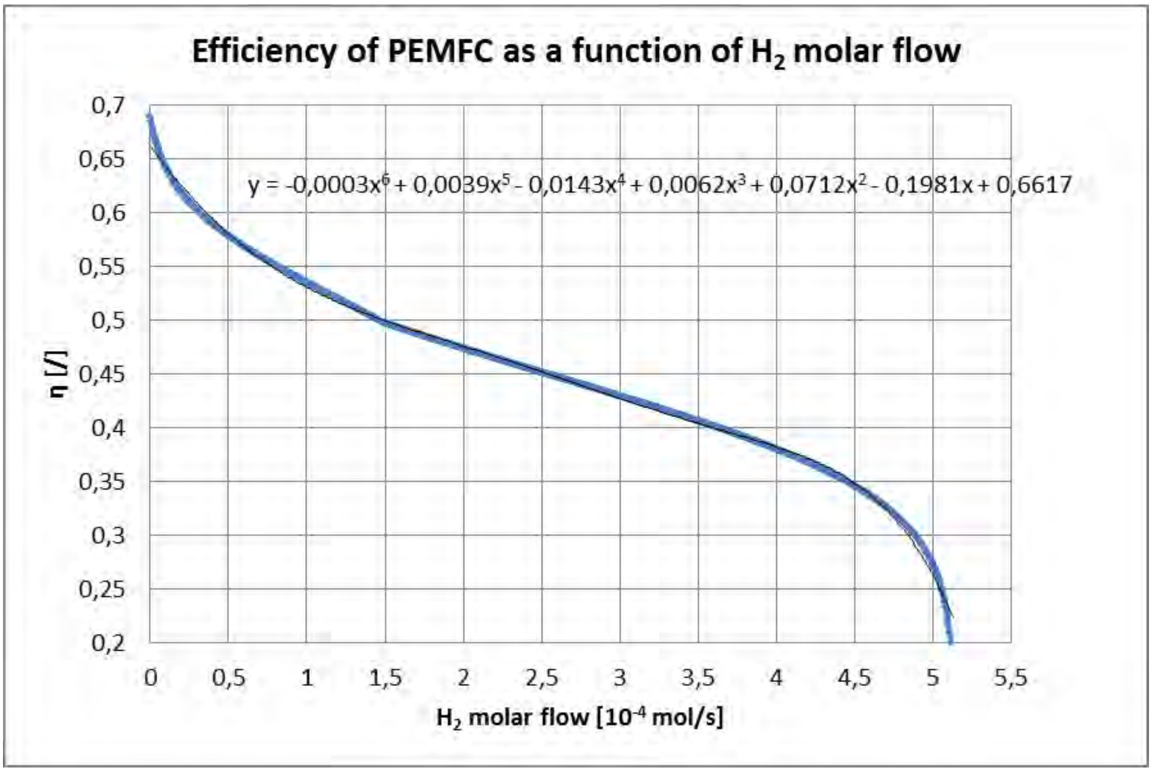
$$\eta_{ohm} = j \cdot \frac{d}{A \cdot \sigma}, \tag{13}$$

where d stands for thickness, A for active surface area and σ for proton conductivity of the membrane. It is assumed that all the other ohmic losses originating from stack components contact resistances are negligible.

At this point it needs to be mentioned that LT and HT PEMFC use the same characteristic curve for the stack efficiency even though it is clear that they will be different. Despite the fact that at higher temperature the equilibrium potential of PEMFC is lower the efficiency will be higher due to faster kinetics on the electrodes.

Combined system

Aspen Plus software was used to model a simplified system with the SMR and the PEMFC stack (low temperature – **Figure 2**, high temperature – Figure 3). In both cases the SMR operates at 250 °C and steam-to-methanol ratio = 1.5. The LT PEMFC stack operates at 90 °C, whilst the HT PEMFC stack operates at 250 °C. Because the temperature level of the system with the LT PEMFC stack is too low to be used for the endothermic reforming reaction an additional catalytic burner is needed to provide the sufficient heat to the SMR. In the system with LT PEMFC partial heat regeneration is also used from hot exhaust gases exiting the reformer to the vaporiser of water methanol mixture.



Graph 1: Efficiency curve of PEMFC obtained from SIMULINK model

In presented SMR and PEMFC stack systems there are some assumptions and idealisations that need to be mentioned:

- adiabatic insulation of PEMFC stack and SMR
- ideal heat transfer between PEMFC stack and SMR (no losses)
- 100% methanol conversion in SMR
- 100% utilisation of hydrogen on anode side of PEMFC stack
- no scrubbing of gases exiting the reformer is considered (this is important particularly in the case of LT PEMFC CO poisoning)
- PEMFC stack operates at the same efficiency and nominal electric power of 25 W in both cases, the difference is only in the temperature level of generated heat

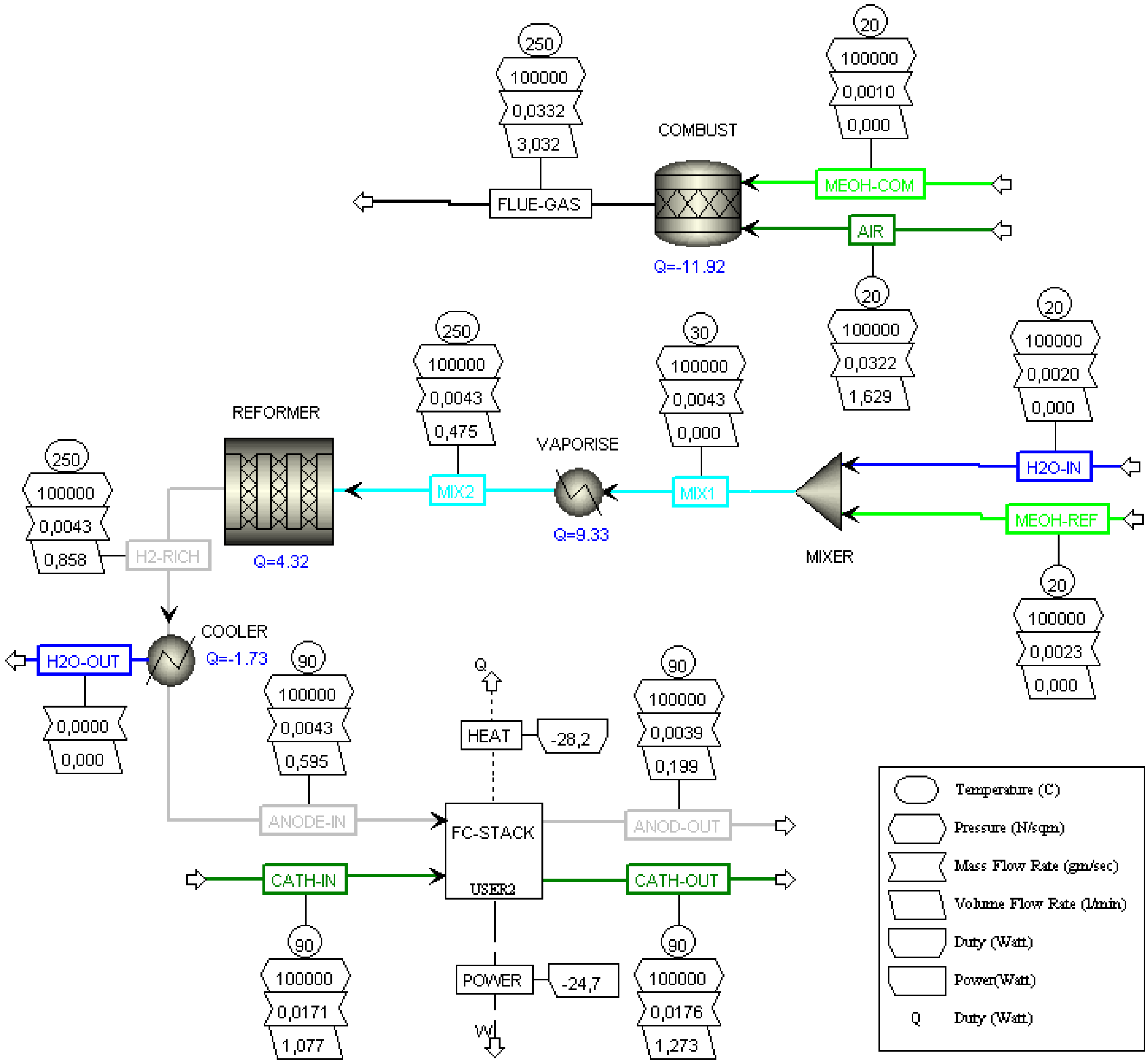


Figure 2: Mass and energy balance analysis of the system with SMR and LT PEMFC stack

Results

Methanol reformer

Based on the assumption that the system produces 25 W of electricity and that 100% methanol conversion is achieved it was calculated that $7.3 \cdot 10^{-5}$ mol/s of methanol would be needed to supply sufficient hydrogen flow to the PEMFC stack. At the specified molar flow and based on reforming kinetics and dimensions of the reactor (see chapter 0) the sensitivity analysis of methanol conversion as a function of temperature was performed (Table 2). Also the heat flow needed for the reforming reaction and for the vaporisation of water-methanol mixture was evaluated.

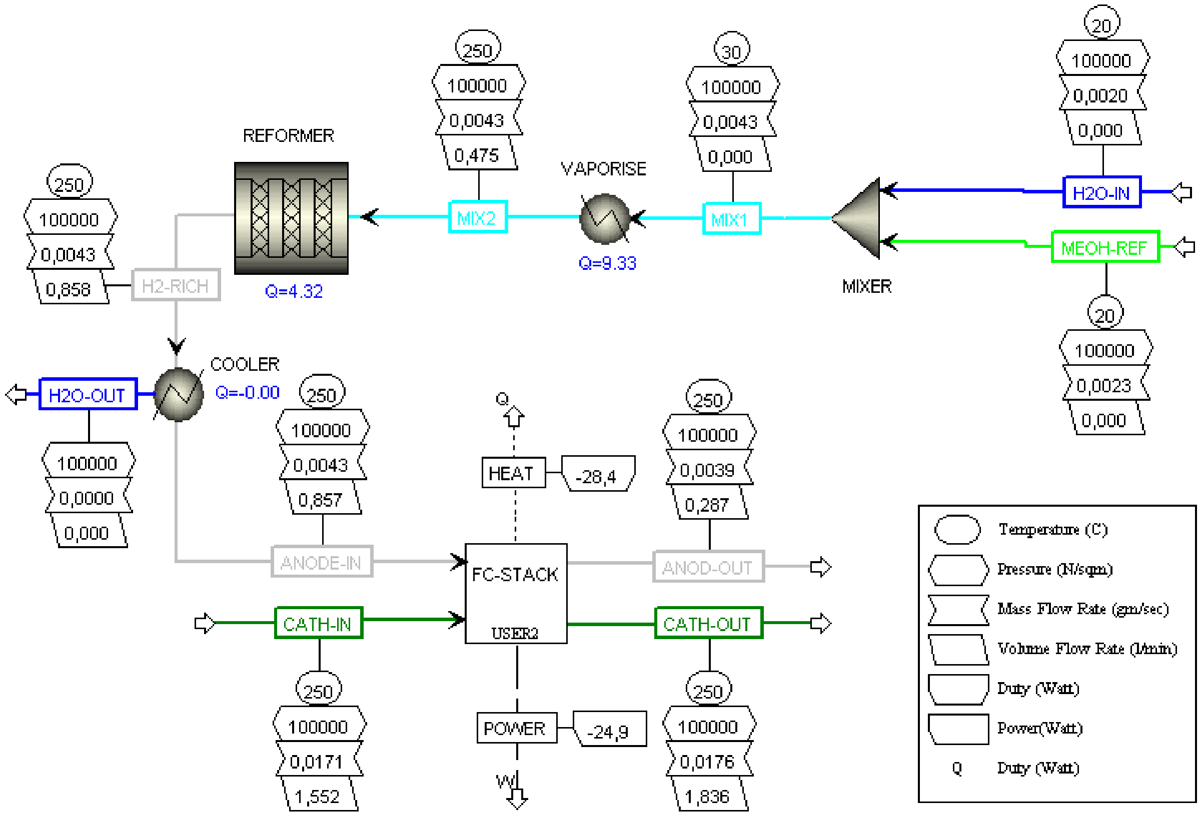
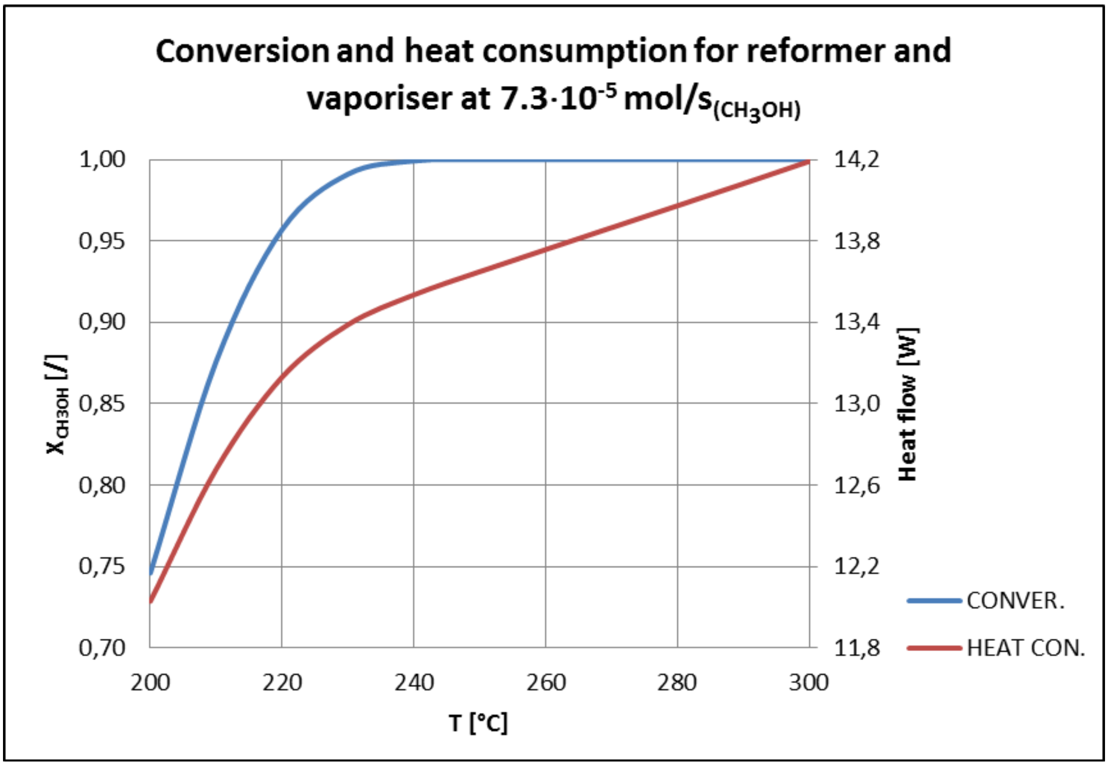


Figure 3: Mass and energy balance analysis of the system with SMR and HT PEMFC stack

Table 2: Conversion of methanol and heat flow needed in SMR and vaporizer as a function of temperature

T	X_{CH3OH}	$\dot{Q}_{VAPORISER}$	$\dot{Q}_{REFORMER}$	$\dot{Q}$
°C	/	W	W	W
200	0.7461	8.92	3.11	12.03
210	0.8761	9.00	3.68	12.68
220	0.9569	9.08	4.05	13.13
230	0.9910	9.17	4.22	13.39
240	0.9991	9.25	4.29	13.53
250	0.9999	9.33	4.32	13.65
260	1.0000	9.42	4.34	13.76
270	1.0000	9.50	4.36	13.87
280	1.0000	9.59	4.38	13.97
290	1.0000	9.67	4.41	14.08
300	1.0000	9.76	4.43	14.19



Graph 2: Methanol conversion and heat consumption as a function of operating temperature of the reformer

The blue line on **Graph 2** shows the methanol conversion as a function of temperature at constant molar flow of $7.3 \cdot 10^{-5}$ mol/s. The model predicts that 100% conversion is achieved at temperatures above 240 °C. The red line shows the combined heat flow needed for the reforming reaction and vaporisation of methanol-water mixture at different operating temperatures of the reformer.

Comparison of LT and HT PEMFC Stack Systems

The comparison of both systems is quite straightforward because it is based on the assumptions stated in chapter 0. Nonetheless, it still allows a sufficiently accurate evaluation of the difference between both systems. The efficiency of an energy system is defined as stated in chapter 0 and with the use of Eq. (8) the following results are obtained:

$$\eta_{LT} = \frac{P}{\dot{m}_{LT} \cdot \Delta H_{HHV}} = \frac{25\,W}{0{,}033\ g/s \cdot 20\,kJ/g} = 37.9\ \%, \qquad (14)$$

$$\eta_{HT} = \frac{P}{\dot{m}_{HT} \cdot \Delta H_{HHV}} = \frac{25\,W}{0{,}023\,g/s \cdot 20\ kJ/g} = 54.3\ \%, \qquad (15)$$

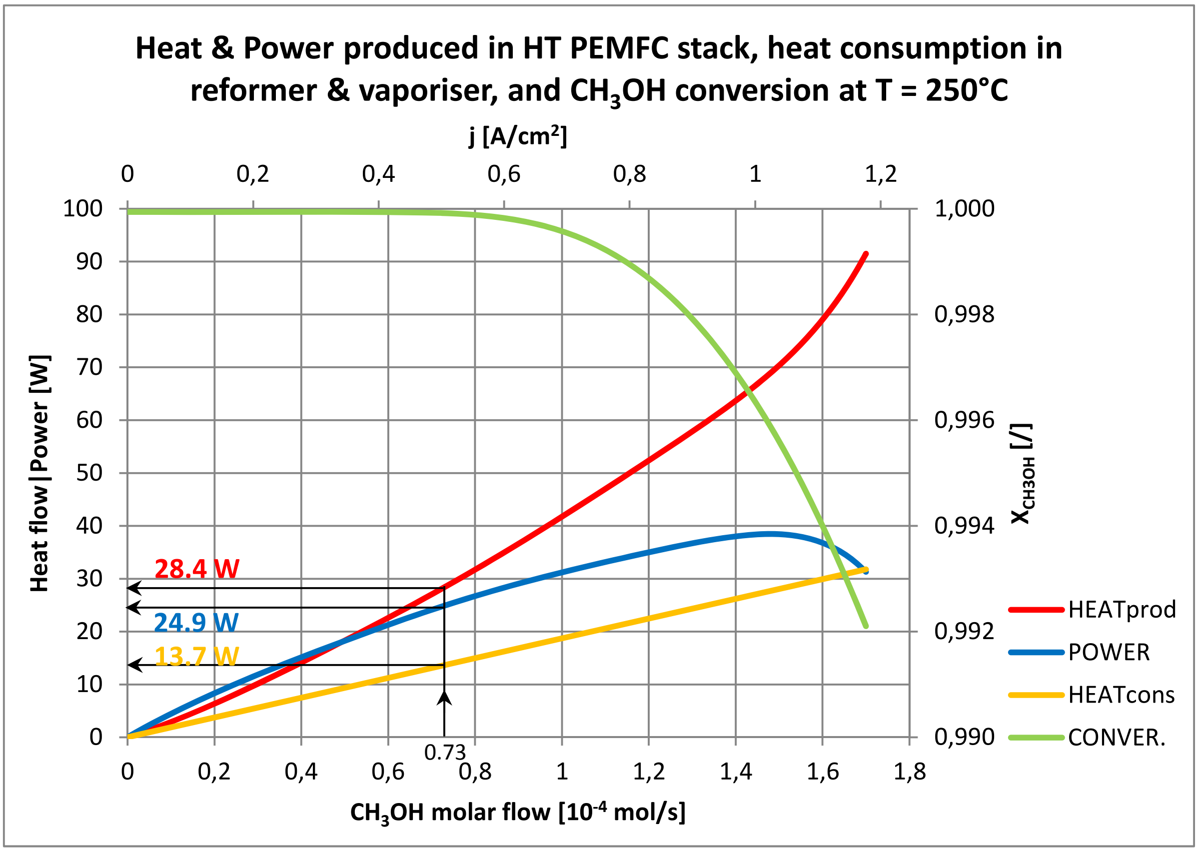
where $\dot{m}$ is the molar flow of methanol and ΔH_{HHV} the higher heating value of methanol. The calculations show that with the use of waste heat produced in electrochemical reaction the HT PEMFC system would have around 40% higher efficiency compared to the classical LT PEMFC system, where low level waste heat is in most cases useless.

The main characteristics of the two systems working at nominal operating point are given in Table 3. The cause of small difference in heat and power produced is in difference of the temperature of the reformate gas. Reformate gas entering the LT PEMFC stack at 90 °C has lower enthalpy and hence less energy is available to produce power and/or heat. The difference in consumed heat flow is only due to the heat regeneration of reformate gas; otherwise the same amount of heat is consumed in the SMR and vaporiser.

Table 3: Main characteristics of LT and HT PEMFC systems

Stack	Operating temperature	Power	Produced heat flow	Consumed heat flow	Additional heat flow	Efficiency
LT	90 °C	24.7 W	28.2 W	11.9 W	11.9 W	37.9%
HT	250 °C	24.9 W	28.4 W	13.6 W	0 W	54.3%

Sensitivity analysis of the HT PEMFC system as a function of methanol molar flow was performed. In that case the temperature of SMR and HT PEMFC was held constant at 250 °C.



Graph 3: Heat & Power produced in HT PEMFC, Heat consumption in reformer & vaporiser, and CH_3OH conversion at T = 250 °C

On Graph 3 the red line represents the heat flow produced by the HT PEMFC, the blue line represents the power produced by the HT PEMFC and the orange line represents the heat flow needed to supply the SMR and the vaporiser. The green line represents the conversion of methanol where it can be seen that at molar flow $7.3 \cdot 10^{-5}$ mol/s of methanol the reformer still achieves practically 100% conversion. Increasing the molar flow above this value reduces the conversion; however it is still well above 99% even at peak power of the HT PEMFC.

If nominal operating point is selected at conditions of methanol molar flow $7.3 \cdot 10^{-5}$ mol/s and temperature 250 °C, the system produces 24.9 W of electricity, 28.4 W of heat flow and consumes 13.7 W of heat flow. Under the assumptions stated in chapter 0 this would mean that the system has the potential to produce more than twice as much heat as needed for the SMR and the vaporiser.

Conclusions

This study shows the feasibility of the HT PEMFC stack integration into a combined system with the SMR. The presented model of the system is based on certain idealised assumptions which will have to be changed when designing a real system. In this context a good isolation of such a system has to be provided and some temperature gradient will always be needed when heat is transferred. The SMR must be carefully designed to achieve high methanol conversion and also a proper design of the HT PEMFC stack is needed to achieve maximum utilisation of hydrogen. Nevertheless, the potential of the HT PEMFC stack stands in the use of a reformate fuel containing 2-3% of CO without downstream cleaning of hydrogen fuel.

Despite the idealised assumptions, the model demonstrates that such a system would achieve greater efficiency compared to a classical system with LT PEMFC stack. The use of high-level heat released during the electrochemical reaction would raise the efficiency of the system to 54.3% which is more than 40% higher compared to the LT PEMFC system.

It further demonstrates that the amount of heat released is twice as high as needed in the system. This means that there is still a lot of heat available to be used in other cogeneration processes that would increase the efficiency of the system even further. For example, this heat can be used in combination with thermoelectric modules (reverse Peltier element) to produce additional electric power.

Acknowledgements

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Sustainable development, defence and the EU law making process

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Introduction

From its very beginning, European integration has relied on federal policy making and the so-called “spill over” method based on common standards.

Competences, including environment and single market, were progressively entrusted to the institutions of the European Union both in terms of policy making and legal supervision.
Among common policies also developed by the EU, some pertain to the field of state sovereignty. Alongside with common foreign policy, Defence is the topical example, so far the EU policy left aside to the largest extent by the so called “méthode communautaire”.

The EU had until the Lisbon treaty a pillar structure where the pillars were autonomous and had different procedures. This is still the case, even if Lisbon paves the way for an inclusive and comprehensive approach, encompassing the whole EU policymaking. For common security and defence policy (CSDP), unanimous decisions within the Council of the European Union remain the rule.

Nonetheless, as pointed out by last EDA steering boards, defence is increasingly impacted by EU federal policies: internal market, research, single sky, space, more recently trade, last but not least sustainable development (energy and environment).

This development is challenging. It entails both costs and benefits. More awareness needs to be brought within the EU on military matters while mainstreaming military matters into EU procedures. In other words, the EU defence community needs to be addressed not only within the classic EU military structure, but also within what we used to call “the first pillar”.

Security policy, defence, sustainable development topics like energy and environment and internal market are interrelated and the common area is the place to try new methods aimed at better promoting the interests of the defence community.

For a better European Union, we need to actively pursue the interrelationship. It is a two-way street and the EU should be made ready for it. The Defence community does environment, already for many years. It already implements environmental rules and management systems. The EU environmental and energy community within the Commission is willing to look into defence, but lacks the knowledge and is hindered by the special position defence has in the treaties. The world’s problems pertaining sustainable development, and thus security, are however, spinning out of control. It is time to prepare our policy structures for the future.

A paradigm shift: EU single market now includes defense goods

EU is historically a single market, based on the free movement of goods, capital and services. Relying on integrated, supranational, "federal" policies, the EU interior market is at the heart of the EU governance system. It is implemented under the supervision of the EU institutions (Commission and Court of justice).

If CSDP has for many years precluded defence goods from being considered as part of the internal market, things changed, following the adoption by the Commission of the "Defence Package" in December 2007.

Two directives were enacted in 2009 with a view to developing a European market for defence equipments:

1. The directive 2009/43/EC on intra-EU transfers of Defence products simplifying terms and conditions of transfers of defence products within the Community;
2. The defence and security directive on the coordination of procedures for the award of contracts.

The package also consists of the Communication entitled "EU strategy for a stronger and more competitive defence industry".

These instruments which need to be implemented under the supervision of EU institutions (Court of Justice and EU commission) are the first step towards an EU integrated market for defence goods.

"Green defence": how to conciliate Defence interest with sustainable development

According to the article 3 of the TFEU, environmental protection is part of the EU internal market. The European vision on sustainable development is a balance between economic, social and environmental interests.

Initially, environment protection limited the free circulation of goods but, progressively, environment became a policy on its own, giving rise to a fully fledged law and policy making process. The result is that more than 85% of Member States' environmental law stem from the EU.

Sustainable development has become a strategic challenge for the EU defence community and will increasingly be so in the future. Look how, for example, big business' attitude changed towards "green" issues in the last few years. As Defence is increasingly not an island in society anymore, this attitude will certainly be part of our jobs too. Defence as a whole (Industry and armed forces) is the economic sector most reliant on fuel energies, hence from third countries suppliers. Afghanistan has shown how critical security of supply was for armed forces. "Green defence" is therefore a prerequisite for EU strategic autonomy. This topic is also where security policies and sustainable development meet.

As a result, EU Member States MoD's activities are more and more concerned with EU environmental law in all sectors (defence industry, materials, planning, training, operations, dismantling…). The EU decision making process must thus conciliate defence interests and environmental concerns. In fact, there is no choice.

As the impact of EU policy making steadily increased, the first temptation for defence was to seek systematic waivers from EU regulations. In the long run, this is not a solution, because it continues, in a rather contorted way, the strict separation between Defence and the rest of society. Furthermore, it remains to be seen if such exemptions do not harm the interests of defence in the future. It may well be that companies cannot comply with them or that defence will slowly lag further and further behind on technological improvements. But, as said before, it is a two way street. If environmental policy makers and legislators in the EU do not have defence interests in view, the defence community cannot do otherwise than go for damage limitation in the form of exemptions through Council interventions.

Hopefully, we are now moving towards environmental conformity in many ways and activities. Defence environmental awareness has become a reality. Yet maintaining check and balance between environmental protection and operational capability will always be necessary.

Methodology for policy making: influencing the EU legislative process to fine tune defence needs with environmental standards

What is at stake for the defence community? We want to build up a European industrial and technological base while saving scarce resources and ensuring sustainability. How can we achieve this? By better understanding the EU legislative process and making defence interest prevail whenever possible. No doubt, lobbying is a field where military stakeholders need to catch up with civilian experts.

Defence Network (Defnet), which is an informal think tank made up of environmental experts from EU ministries of defence, has on these matters a good track record which, in EU terms, might qualify as a "good practice".

The first step is to build confidence with the EU Commission at the early first stage of the Commission's work on a specific topic. This means close working contacts with the EU policy officer in charge to trigger a "defence reflex" wherever European environmental regulations and directives are being prepared, discussed and applied. This requires that the defence community knows in detail what the Commission is doing and is planning to do. Doing this comprehensively is a huge task, which requires a long term dedicated effort with specialised knowledge. It also requires that somebody is coordinating this effort and intervenes at the right moment. At the moment, only DEFNET seems to be capable of doing this. However, the future of DEFNET is uncertain, as it is an informal and relying on voluntary effort.

The second step would be to ask for making a military paragraph obligatory in all impact assessments that accompany any environmental or sustainable development related legislative proposal coming from the Commission.

The ship dismantling dossier is a good example of this “comprehensive approach”.
The aim was to ensure that the defence waiver provided for by a legally binding international instrument (e.g. the Hong Kong convention on ship dismantling) would also reflect in the EU instrument.

Early contacts between the EU commission (DG ENV) and EU MoDs, through the DEFNET, proved fruitful. As a result defence interest was taken into account in the March 2012 EU regulation proposal.

This approach is helpful in case of “comitology” procedures to explain what are the defence constraints and required actions in terms of environmental protection. Contacts on halon gas ban or on the protection of the marine biodiversity were also useful. In this case, the defence community (DEFNET) was even taken on board by the Commission as a stakeholder.

Last but not least, a dossier where even EDA had to deal with the ramifications, namely REACH. Here the defence exemption was not well formulated and gave rise to blockades and uncertainties. Up to now, the effort to amend the defence exemption by EDA were not yet successful, but it is a matter of time, before it will succeed.To be successful, these initiatives need to be in tune with the EU legislative agenda. The example of the reshaping of the REACH regulation is topical and shows how tiny the window of opportunity can be.

There is clearly an issue for defence stakeholders with REACH whose waiver is not consistent with the aims of the EU regulation on arms transfers. This provision needs to be changed and it must be done before the Commission will submit its new proposal (probably by no later than Fall/Winter 2012). If this opportunity is missed, it will be hard to promote further defence interest on this dossier in a way which is legally safe.

Beyond environment, DEFNET also worked on the energy efficiency directive which, to begin with, was not well tailored to the defence needs. Some additional work has to be carried out on a set of indicators which would more accurately measure the performance of defence equipments/facilities. In the end, DEFNET information towards the EU Commission resulted in a belated partial defence exemption that makes implementation of the Regulation doable. However, as said, exemptions should be sought only with caution.

Conclusions

All in all, DEFNET has proven very successful over the past ten years, yet it lacks the institutional backbone to act on a more operational and systematic way. That’s where EDA fits in. EDA and EU ministries of defence should talk more one to each other in the field of sustainable development. The Commission and the EU Military Staff are other institutions that should be involved. It is time to sit down and talk business.

Closer cooperation is all the more required that this is a win/win game. At least for the time being, EDA needs DEFNET for its technical expertise and network, whereas DEFNET needs EDA (and others) for its increasing bargaining "soft power" within the EU institutional framework.

Why not see the decreasing defence budgets as an incentive to start this process? It would indeed make the process of integrating sustainable development and security much more efficient at a European scale.

Reduction of Energy Costs and Enhancement of military energy supply cooperation-Present and Future Policies and Measures

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Abstract – *The expected increase in oil prices is a systemic risk for many developed countries. It also affects the operational capacity of military forces and therefore has a security dimension.*

The possible effects make it necessary to examine technical implications for affected nations. The United States' Forces have set quite ambitious targets in terms of cost reduction and less (fossil) fuel consumption in recent years. Most European Nations are still in the stage of concept development or are hoping that oil prices will be stable in the near and far future. This delay in technical and strategic preparation poses a high economic risk.

Looking at defence technology improvement there is a short-term need to upgrade military camps for future operations. In addition, rising transport costs for fuels in remote areas have to be addressed. Therefore all potentials for energy savings and efficiency enhancement need to be considered.

An overview of the current state of the discussion in selected nations including the United States will be presented. In addition, the motivation to shift to a post-fossil future and possible milestones will be discussed.

Introduction

The expected price increases of fuels and electricity as well as the problems related to climate protection concern many indutrialized nations. A global lack of oil could represent a systemic risk because its versatility as a source of energy and as a raw material for chemical industry. Nearly every social subsystem would be affected by rising costs.

The "World Energy Outlook" , which is updated every year by the International Energy Agency (IEA) poses several key trends in worrying directions [1], e.g. the increase of global energy demand by one-third from 2010 to 2035 with China and India accounting for 50% of the growth. EU oil imports will overtake those of the US around 2015, and the largest natural gas suppliers in 2035 will be Russia (mostly conventional), followed by United States (more unconventional production). International coal markets & prices become increasingly sensitive to developments in Asia; the value of subsidies to fossil fuels will rise from $66 billion in 2010 (compared with $409 billion for fossil fuels), to $250 billion in 2035. An increasing share of Russian oil and gas exports will shift from EU to Asia. Despite steps in the right direction, the door to reach the 2°C-limit is closing.

It is therefore worth for several reasons to analyze national energy strategies. The so-called "Hirsch Report" [2] urged a crash program of new technologies and changes in manners and attitudes in the US. The report cites a peaking crude oil supply as the main reason for immediate action. So far a part of the changes ultimately requested by Hirsch for the US have been already implemented in Europe. Europe adapted its economy after the various oil shocks and enhanced the changes by introducing much higher taxes on gasoline. Taking this into account, peak oil shock as outlined by Hirsch will have a much more severe outcome in the US compared to other parts of the world, especially Europe. As energy is an essential component of military operations, the United States have a vested interest in ensuring that it “possesses the energy resources needed to deter all would-be aggressors in present and future”. There is a huge program for “preparing the US Department of Defense for a Post-Petroleum Era” . By 2040 DoD should ensure that it can operate all of its systems on non-petroleum fuels.

It was already recognized that the issue of "military energy supply" is quite suitable for international military cooperation within the framework of the EDA or NATO. The Conference “Military Green 2012” is one result out of this finding. The subject of "fuel and energy" is one of 10 highly prioritized capability fields at the EDA.

As a critical resource, energy must be readily available to support armed forces missions operating tactical and non-tactical vehicles and equipment, powering soldier-carried equipment, and providing electricity and other utilities to fixed installations and military camps. The central role of energy security was highlighted in 2006 when the commanding general of the multinational forces in western Iraq submitted a priority request to reduce the number of fuel logistics convoys. Although necessary, these convoys and the associated logistical fuel tail were increasingly vulnerable to attack. This vulnerability points to a potential asymmetric advantage for an adversary. Reducing such risks will be therefore a priority for future operations.

Policies and Measures in selected Countries

United States of America

The US Armed Forces have set ambitious goals, and there are some doubtful voices about the strict course to reach the goals set for 2020. On the other hand, the armed forces are seeking a new modern and innovative image with those activities.

Until a few years ago, energy efficiency was not a major issue for the US Armed Forces. On the one hand, the United States could rely on its own oil production, on the other hand, oil could be imported in large quantities and at low prices (2008: 40% domestic, 60% import). Accordingly fuel consumption has strongly increased since World War II, and the Forces’ energy supply has become a considerable cost factor at least over the last 10 years. The U.S. DoD spent $ 16 billion in 2008 to purchase 19 billion liters of petroleum derivatives.

For strategic reasons, the Assured Fuels Initiative (AFI) of the U.S. DoD was launched in 2001. In the framework of this initiative, the ability to produce liquid fuels from coal and natural gas resources should be increased. The Fischer Tropsch (FT) process is used, which has already been applied in World War II by Germany. Efforts in such "alternative fuels" received new impetus in 2007 through the "Energy Independence and Security Act" (EISA) [3]. The idea behind this law is that rising energy costs in connection with constant defense budget will lead to a reduction in military capabilities which might threaten national security.

Therefore, in the short term, efficiency potentials should be realized and in the longer term dependency on oil needs to be reduced. Primarily, the United States should find alternatives and solutions and be able to control the fuel production process. Environmental and climate protection issues played only a minor role in EISA, however, it was agreed that authorities may buy only synthetic fuel, whose CO_2-balance is better (or at least equal) than that of petroleum derivatives (EISA, Section 526). This significantly restricts the use of coal-based synthetic fuels. EISA sparked much activity in the Department of Defense and the services. The title of a report of the Defense Science Board set the course: "More Fight - Less Fuel". Within short time ambitious energy strategies were designed for all parts of the forces, and many projects were initiated.

In the short term, the requirements should be achieved mainly by two types of measures: in the transport sector drop-in fuels were examined, that means synthetic and/or bio fuels which can be mixed with conventional fuels without platform modifications. On the other hand investigations have been made in the field of military installations. Common civilian technologies (such as thermal insulation, solar panels and heat pumps) can be used, and there is no need for adaption to military use. In addition, US forces currently use the existing military camp infrastructure in Afghanistan to test new technologies and to reduce dependence on gasoline under real conditions before the withdrawal, planned in 2014.

US Army

The "Army Energy Security Implementation Strategy" (AESIS), approved in January 2009 by the Senior Energy Council, established five strategic energy security goals and outlines a broad approach for accomplishing them [4]. The strategy also focusses on creating a new culture of energy awareness throughout the Army.

The five strategic Energy Security Goals (ESGs) are:

- Reduced energy consumption
- Increased energy efficiency across platforms and facilities
- Increased use of renewable/alternative energy
- Assured access to sufficient energy supplies
- Reduced adverse impacts on the environment.

These goals implicitly incorporate the fundamental principle that the improvements achieved shall not lead to reductions in operational capability or the ability of the army to carry out its primary missions.

The goals should be achieved with the procurement of more efficient vehicles, the use of ethanol and FAME[1] additives, as well as the increased use of solar thermal energy for hot water production. Specifically, the strategy contains maps with estimations, where alternative energy could be used (solar energy, geothermal energy, wind power, biomass, also nuclear energy).

[1] Fatty Acid Methyl Esters

An example of the developments in the field of land vehicles is the “Fuel Efficient ground vehicle Demonstrator (FED) Bravo", developed by the U.S. Army’s Tank Automotive Research, Development and Engineering Center (TARDEC). The vehicle concept is an armored Humvee, however the parallel diesel-electric hybrid has a 50% to 70% lower fuel consumption. In connection with new concepts for the energy supply of military camps should be mentioned the "contingency basing integration & technology evaluation Center" (CBITEC) within the maneuver support center of excellence (MSCoE, Fort Leonard Wood, Missouri). The CBITEC corresponds to a "real" camp for long-term operations and is used initially by 150 soldiers for training purposes. It is used for the testing of new systems to improve energy efficiency and to increase the use of alternative energies, as well as for the training of soldiers. A later expansion to a capacity of 600 soldiers is planned.

While the CBITEC is still under construction, a smaller, provisional camp is operational since September 2011 and is used extensively for testing new technologies. It consists of two camps for 150 soldiers. In one camp new systems and technologies are tested, while the second serves as a "Control experiment". First results show that with the use of decentralized power generation ("micro-grid power distribution") about 35% fuel consumption can be saved. In addition to energy supply systems, methods for the treatment of industrial water were tested.

US Air Force

The operation of military aircraft required vast amounts of fuel. In the US DoD, 58% of total energy consumption are aircraft fuels (another 13% are marine diesel, 11% electricity, only 5% fuel is needed for land vehicles). The US Air Force as the operator of most aircraft has difficulties to realize significant fuel savings in the short term, since flying platforms are in use for several decades and therefore cannot be replaced in short time. In addition to a "culture change" the air force has a focus on the increased use and addition of alternative fuels ("increase supply"). With regard to the use of alternative fuels, jet-powered aircraft have the inherent advantage that their engines easily tolerate the addition of alternative fuels to conventional kerosene. As an alternative, Fischer-Tropsch (FT) fuels are offered from different raw materials such as coal or natural gas, and hydrogenated fats. Occasionally the addition of ethanol or alcohol oligomers is discussed.

At the beginning of 2012 all flying platforms have been certified for 50/50-mixtures from FT products and kerosene. For 50/50 mixtures with HEFA[2] the certification is expected to be completed in the near future. The certification of a mix with alcohol oligomers ("alcohol-to jet", ATJ), should be started as soon as sufficient amounts of this fuel are available . By the year 2016, the US Air Force should be able to substitute up to 50% of kerosene. This only should happen, if it is cheaper and less harmful to the environment than the use of pure kerosene.

The „Air Force Acquisition & Technology Energy Plan 2010“ is an appendix of the „Air Force Energy Plan 2010”[5]. It describes on the one hand, how available technologies should be used to increase the efficiency of current material. On the other hand it is shown how R&D should lead

[2] Hydroprocessed Esters and Fatty Acids

to increased efficiency for future material. Both methods are focussed on the issues of alternative fuels, more efficient propulsion technologies, aircraft design, and lightweight structural materials.

US Navy

The US Navy has declared to gain at least 50% of its energy from alternative sources by 2020. Nuclear power generation and drop-in fuels on the basis of camelina plants and algae are the prime options to reach this ambitious goal. Tests with the aim of certifying the use of 50/50 blends of biofuels and petroleum based fuels are currently being performed. By the end of 2011 seven air vehicles and six swimming platforms have been successfully tested with no operational differences found between conventional fuels and the new blends. In July 2012 a “Green Strike Group”, formed by the Nimitz aircraft carrier and four other major ships, will take part in the RIMPAC exercise. All ships and aircraft of this strike group are fueled by nuclear power or 50/50 blended fuels. By 2016 such a “Green Strike Group” is planned to be continuously operational.

Germany

There are various successful campaigns to reduce the energy consumption and expenses in military properties in Germany (Project “E-Mission”) and also in military camps in Afghanistan (demonstration projects).

The study "Peak Oil – Security policy implications of scarce resources" published by the Future Analysis Branch of the Bundeswehr Transformation Centre in 2011 excited for the first time a wide discussion in Germany about future energy and propulsion concepts in connection to armed forces [6]. The report covers the A to Z of peak oil. Core issues are, how to maintain operational capability in times of rising prices for oil and at the same time how to reach the ambitious goals concerning climate and environment protection. The study shows, similar to the Hirsch Report, the existence of a very serious risk that a global transformation of economic and social structures, triggered by a long-term shortage of important raw materials, will not take place without frictions regarding security policy. The disintegration of complex economic systems and their interdependent infrastructures has immediate and in some case profound effects on many areas of life, particularly in developed countries. Efforts must be made on a multi-level and cross-government base to understand dependencies. Not only efficiency but also resilience becomes an important criterion of sustainable policy.

The scenarios outlined by the Bundeswehr Transformation Center are drastic. Even more politically explosive, there are recommendations to the government that the energy experts have put forward based on these scenarios. They argue that "states dependent on oil imports" will be forced to "show more pragmatism toward oil-producing states in their foreign policy." Political priorities will have to be somewhat subordinated, they claim, to the overriding concern of securing energy supplies.

Oil will become one decisive factor in determining the new landscape of international relations: "The relative importance of oil-producing nations in the international system is growing. These nations are using the advantages resulting from this to expand the scope of their domestic and foreign policies and establish themselves as a new or resurgent regional, or in some cases even global leading powers."

For importers of oil more competition for resources will mean an increase in the number of nations competing for favor with oil-producing nations. For the latter this opens up a window of opportunity which can be used to implement political, economic or ideological aims. As this window of time will only be open for a limited period, "this could result in a more aggressive assertion of national interests on the part of the oil-producing nations."
The study may not have immediate political consequences, but it shows that parts of the German government fear that shortages could quickly arise.

What are actually the consequences for the German MOD? A short review of past results and pre-commercial developments within defence research has shown that they need not to start at zero and can pick up former technical results, which were developed in the past (for tactical advantages) but were still too expensive to bring into production.

Fraunhofer INT has co-chaired a project of the Federal Ministry of Defence over a period from 2011 to 2013 ("Technological implications for a post-fossil Bundeswehr"). A (civilian) technological advantage can be clearly seen in many technology fields.

Other European Countries

According to the Guardian, the DECC, the Bank of England and the British Ministry of Defence are working alongside industry representatives to develop a crisis plan to deal with possible shortfalls in energy supply. Inquiries made by Britain's so-called peak oil workshops to energy experts have been seen by several journals. A DECC spokeswoman sought to play down the process, telling the Guardian the enquiries had no political implications.

France has a clear priority to electric vehicles, battery development and hydrogen-fuel cell-technology. In the coming years the civilian technologies will be promoted with more than 2 Bn.€. The Defence Ministry seems to hesitate. But there are strong interests in more efficient energy camp supply, maybe in cooperation with other countries or EDA.

NATO

All NATO Member States are oil dependent in the transportation sector. All NATO military land, sea and air based tactical weapon systems run on oil. By making NATO forces more energy efficient,“Smart Energy” represents a timely contribution to “Smart Defense”.

In 2011 the NAMSA-Conference in Vilnius brought together a lot of information and insights from different viewpoints. During a seminar in March 2012, five speakers from Canada, Germany, Italy, the UK and the US highlighted innovative ways to deliver low-cost, effective solutions to reduce the dependence on fossil fuel [7]. There is a remarkable overlap to EDA-activities.

The economic and also environmental benefits of using alternative fuel and energy options can be clearly seen, as well as energy savings in short term, enhanced insulation, and electric power alternatives to fossil fuels.

Conclusions

So far in Germany, as well as in many other EDA Member States, there is no military energy strategy nor specific targets for armed forces' procurement, as it is already done in the United States, where the process due to concerns for the long-term energy security and energy supply is very obvious. However, savings, that can be realized in the United States in the short term, are mostly long established in EU armed forces, such as the diesel generators' regulation or efficiency potentials in military installations. As in other cases, a technological gap compared to other nations is caught up very quickly in the US, so an overtaking seems possible, if the leading EU nations act carelessly.

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The end of Heavy Armour? Energy security will change warfare

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Abstract – Armed Forces and agencies are working hard to improve energy-efficiency of expeditionary forces. Important because energy security is under pressure. The supply lines are long, expensive and dangerous. Introducing sustainable energy will save fuel but its potential is limited. It will only partially help the military to prepare for a future where fossil fuels are scarce and expensive. Armed Forces must accept that energy security is a "game changer" that will have a major impact on warfare. If state-of-the-art Armed Forces do not improve their energy security, the low-tech, low energy warrior on his mule and with his Kalashnikov might win the war. In this article sustainable energy, alternative fuels and technologies are evaluated for future use on compounds. However, even when new concepts for on-site generation are implemented, more fuel is needed as armoured vehicles tend to become bigger and heavier to protect against more effective rocket propelled grenades (RPG's) and improvised explosive devices (IED's). In search for comprehensive solutions the author has looked into the fuel - technology - weapon systems chain and has studied new commercial concepts for energy and mobility. Combining them will provide solutions where new weapon systems substantially differ from the ones we are used to.

Introduction

For the military energy is a "conditio sine qua non". Modern Armies use a lot of fuel and consumption tends to increase rather than to lessen[1]. Especially during expeditionary operations supply lines are expensive and dangerous. In due course energy security is under pressure due to depleting oil reserves. On top of that Armed Forces have to face the security implications of climate change[2, 3] and comply with regulations on abating climate change. Nations and agencies develop policies to prepare the Armed Forces for the challenge of a changing energy market.

Efforts are particularly directed at improving the energy security of compounds: the temporary camps from which expeditionary forces operate. Well justified because it is there where energy security is already under threat. Undoubtedly a lot of energy can be saved by new investments, energy saving measures and the introduction of sustainable energy. In most Western countries efforts are undertaken to improve the energy household on compounds.

In 2011 the UK Ministry of Defence with partners carried out the "Forward Operating Base (FOB) Concept Demonstrator" project. On a small compound in Cyprus military and civil engineers installed a large number of systems to reduce the energy used, to make existing systems more energy-efficient and to introduce sustainable energy. A video recording shows the camp bustling with activities. Generators are fitted with intelligent start-stop systems, solar panels are installed and hot water boilers placed. Surfaces are covered with Photo-Voltaic (PV) solar cells. All hands raise an awesome looking windmill constructed by wires, telescopic tubes, cross bars and rotors that seem to be covered with canvas. Everywhere there are data loggers and people with laptops and thermal image camera's. Results show that with effort and focus up to 45% of fuel for generators can be saved[4].

A good effort because every litre of diesel saved is a litre not transported and payed for. The results of the Forward Operating Base Concept Demonstrator are impressive but perhaps a little bit too optimistic. Some scepticism remains whether these results hold in normal practice. Results might even suggest that once the scientists and engineers have mastered the technology, it is again business as usual, the Army can carry on as before. Are efforts paying off or are we chasing a green delusion? Will it win the war? Does not the low-tech, low-energy warrior on his mule and with his Kalashnikov draw the longest straw because - energy wise - time is on his side? Will the military be the only sector that with some effort and good intent will master the quickly changing energy market? In that case pick-up the phone and inform the Secretary General of the United Nations and the President of the European Commission. It is doubtful and more fundamental changes are needed.

Energy as a game changer

Historians and military know that changes in warfare have often been initiated by new technology and new weaponry. Examples are the change from sail to steam, the invention of the machine gun, the arrival of the tank on the battlefield, the airplane, the nuclear bomb and more recently C4I and cyber warfare. The idea that energy security will be the next game changer is still not widespread. However, the United States is an exemption. The Department of Defense (DOD) has since 2011 an "Operational Energy Strategy". The "Assistant Secretary for Operational Energy Plans and Programmes" is politically responsible and overseeing efforts to realize targets.

In a speech commemorating the 2011 Diës Natalis of the Royal Netherlands Naval Academy, professor Douwe Stapersma, lecturer at the Academy and at Delft Technical University put forward two thesis.

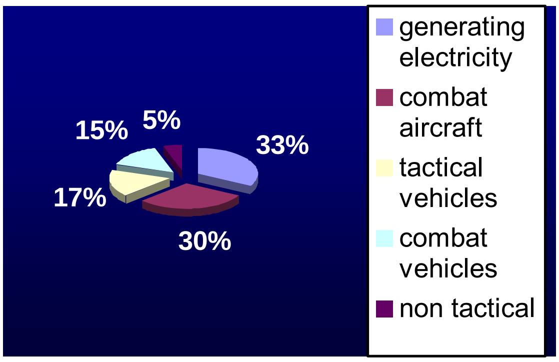
- In due course energy security is the biggest threat to current weapon systems.
- If no solutions are found to replace fossil fuels, current weapon systems will disappear changing the character of conflict.

Many colleges suppose things won't be as bad as that. Not only because they don't like to give up their familiar rolling stock, ships and jetfighters but they struggle to see what kind of new weapon systems will replace them. Changes will indeed not happen overnight but the quest for alternatives and innovation must start without delay. Weapon systems will be operational for 40 years or more and by that time the energy market will dramatically differ from now. Weapon systems that halfway their operational life have to be shelved because fuel has become too scarce and too expensive are a poor investment. Indeed, it is difficult to foresee what will replace them. Little studies and publications to guide and direct are available.

Expeditionary forces operate out-of area, far from home in areas without an adequate or reliable energy-infrastructure. Supply lines are long and often under threat. When there are doubts whether a combination of savings and sustainable energy will sufficiently improve energy security, alternatives are required. In order to find them it is necessary to study the chain fuels - technology - weapon systems. From a military point of view it would be preferable to start with the weapon systems. However, the military can not change the energy market but has to adopt to it.

Fuels - Technology - Weapon systems

Compounds build in recent years in Iraq and Afghanistan vary from accommodation for a hundred to thousands of soldiers. A lot of diesel is needed to house them, to feed them, to take a shower and to let them work. About as much is used by the vehicles that operate from the compound. The supply of fuel, counting for around 70% of the total volume of transport[5], is transported by truck in convoy. It is expensive because of the distance of travel and the need for Force Protection. Military involved in Force Protection are not available for offensive operations or winning hearts and minds. In 2008 the DOD report "More fight- Less fuel" already proved that the Fully Burdened Costs of Fuel (FBCF) were manifold of the purchasing costs[6]. Transporting fuel to a Forward Operating Base (FOB) costs hundreds of dollars per gallon, especially when airlift is used. Despite Force Protection many life's have been lost to get the fuel to the consumers.



Graph 1: *fuel use Army in wartime DOD FY 05*

According to a US study[7] in wartime the US-Army's fuel is used for 33% to generate electricity, 30% for combat aircraft, 17% for tactical vehicles, 15% for combat vehicles and 5% for non-tactical vehicles. Fuel for transport is less clearly administered as Air force and Navy as well local contractors substantially contribute to supplying the Army.

What alternatives for diesel, now used as fuel, are available? Lets go through the options.

Sustainable energy

On a large scale local governments, companies, and private investors invest in sustainable energy. Compounds can also produce sustainable energy. With systems operational, sustainable energy is cheap and secure. The downside is that the generated energy fluctuates. It also requires large surfaces to raise capacity. In his very instructive book "Sustainable Energy - without hot air" David JC Mackay[8] calculates the limits of raising sustainable energy. That there are limits, is also demonstrated by the struggle of European governments to comply with the EU goal to have 14% of energy from sustainable origin by 2020. For instance, The Netherlands despite a lot of effort, has yet only reached 4%. In the World Energy Outlook 2011[9] it is predicted that the share of sustainable energy will rise between 2010 and 2035 from 13% to only 18%.

As the FBCF are much higher than the market price, investments in sustainable energy for compounds are financially more viable than at home. But what sources of sustainable energy are there? Solar power is generally abundantly available in areas where expeditionary forces operate but it requires large vulnerable surfaces. Wind power is difficult to capture as large wind turbines have big superstructures and need elaborate foundation. They are difficult to transport and built out-of-area. Small wind turbines are generally not very energy-efficient. New air-borne wind power offers better prospects but is still immature. The use of local biomass has potential but requires further study. Hydro-power, tidal power and geothermal power are not available.

Alternative fuels

Apart from coal and nuclear power that have serious drawbacks for use on a compound, there are liquid alternatives: bio fuels, synthetic fuels, Liquid Natural Gas (LNG) and liquid hydrogen. But all have their negative sides. What do they offer?

Bio fuels have almost the same characteristics as liquid fossil fuels. That makes them ideal for blending with remaining fossil fuels, to transport them and for using them in existing systems as a "drop-in-fuel". Producing large amount of bio fuels will however conflict with the production of food. If not closely controlled it might cause widespread famine. This limitation will only be overcome with better technology to produce 2nd and 3d generation bio fuels. Another set back is the low Energy Return on Investment (EROI). Where crude oil produces fuel at a 11:1 ratio, bio-ethanol for instance only has a 4:1 ratio[10]. Consequently bio fuels require much more energy from well-to-wheel. Predicting to what extent bio fuels can replace liquid fossil fuel is difficult and depending on technology breakthroughs, market mechanisms and energy scenario's. The World Energy Outlook 2008 from the International Energy Agency forecasted for the reference scenario a 6% share in road transport in 2030 provided all liquid bio fuels were applied in that sector. The Energy Outlook 2009 from the Energy Information Administration of the United States projects higher productions of bio fuels reaching in the reference scenario almost 10% share in 2030 for road transport[11]. However, most of the bio-fuels (80%) will be ethanol for petrol engines where armies use almost only diesel engines.

Synthetic fuels are produced by various industrial processes from gas, coal and biomass. They can be tailored to match liquid fossil fuels. They share with bio fuels all the advantages of a drop-in-fuels. Leading oil companies like Shell already produce Gas-to-Liquid (GTL) synthetic fuels in upstream plants (Qatar, Malaysia) and sell it on the consumer market: Shell V-power is regular petrol blended with small percentages of synthetic fuel. Draw back is that producing synthetic fuels requires a lot of energy and hence produces extra CO_2. Changing on a large scale from oil to synthetic fuels would increase CO_2 -levels and accelerate climate change. As the US "Security and Independence Act of 2007" orders the government to only purchase alternative fuels that are less polluting than conventional fuels, synthetic fuels have lost importance as an alternative fuel for the DOD.

The world reserves of natural gas are much bigger than that of crude oil. Recent discoveries of shale gas and new technologies to extract it, have made gas an attractive long term alternative for oil. Conventional and unconventional gas reserves could last another 250 year at current production levels[12]. Natural gas can also be supplemented by methanised bio gas. Prices of gas are lower than that of oil and it is forecasted that the difference will increase[13]. However, gas is difficult to transport as transport by pipelines is expensive and geo-political vulnerable. Long distance transport can be done by cooling (-173°) the gas "upstream" to liquid and ship it by tanker to the markets. Initially natural gas was used for power plants and local heating. Nowadays LNG has entered the transport sector as a fuel for ships, trucks, busses and cars. It produces 25% less CO_2 than diesel. There are set backs. LNG has a poorer volume - to - weight ratio than diesel. As a rule LNG requires about 40% more space for transport and storage. The cryogen infrastructure to keep the LNG from well to wheel at low temperature is yet only available on a limited scale.

Hydrogen is a highly flammable element that is not available as a natural resource. It has to be produced by electrolyse, gasification or steam reforming of hydrocarbons. By making hydrogen, a fuel for the transport sector is produced from sources not suited for mobile applications. In essence it is a carrier of energy, like electricity, rather than energy itself. Hydrogen has a high energy - to - weight ratio but a very low energy - to - volume ratio. Like LNG it has to be transported and stored either by pressurizing or by cooling, or by using a metal hydride. Studies reveal that hydrogen can be used for urban transport and light hauling (busses, distribution trucks)[14]. Hydrogen can replace diesel but when produced by fossil fuels, little has been gained to improve overall energy security or the environment. Only densely populated area's benefit from the environmental "dividend" as hydrogen only emits water as exhaust. There are critics[15] that claim that the hydrogen economy is due to fail as producing, transporting and storing hydrogen is to expensive to become a real alternative for fossil fuels.

What is the best alternative to replace diesel for expeditionary operations? The four alternatives are tried by the criteria availability, risk, affordability and climate impact. Availability is measured by the long term reserves of the fuel. The risk is measured by the volume of transport to get the fuel to the compound. The affordability is important as Defence budgets are tight. Money spent on fuel is not available for other essential investments and activities. Climate change is a global concern. International agreements and market mechanisms (Emission Trading Scheme) must stop global temperature to raise more that 2°Celsius. Armed Forces can not claim immunity from these developments.

Sub conclusion Fuels.

In the transition period (2030-2050) where alternatives have to take over from liquid fossil fuels, bio fuels will still struggle to compensate for the loss of oil. Synthetic fuels, LNG and hydrogen are produced from sources that last much longer than oil.

As bio fuels and synthetic fuels have almost the same characteristics as diesel, transport risks will not differ from current supplies. LNG and hydrogen have lower energy-to-volume ratio's and especially hydrogen is extremely flammable. Consequently transport risk will increase.

Bio fuels and synthetic fuels are drop-in -fuels and therefore will follow the market price of diesel. As no additional logistic requirements are needed the FBCF will not differ from costs of getting diesel to the troops. Transports of LNG and hydrogen require a new, complex and expensive logistic chain, causing the FCBF to raise dramatically.

Bio fuels can when produced from suitable feedstock, reduce CO_2 -emissions and help to stop climate change. Using LNG too will reduce CO_2- emissions. Hydrogen will only reduce CO_2 -emissions when produced from non-fossil sources. Synthetic fuels will produce significantly more CO_2 than diesel and other alternatives.

From the four alternatives bio fuels, although scarce and expensive, are the best choice as alternative for diesel for expeditionary operations.

Table 1: relative scores of alternative fuels to diesel as a fuel for expeditionary operations

	Availability of resources	Risks of transport	FBCF affordability	Climate impact
Bio fuels	–	0	0	+
Synthetic fuels	+	0	0	– –
Natural Gas	+	–	– –	+
Hydrogen	+	– –	– –	0

As in the foreseeable future bio fuels can not compensate for the loss of liquid fossil fuels and sustainable energy can not bridge the gap, it is imperative to use less energy. In what way can technology and weapon systems help to reduce the need for fuel?

Fuels - Technology - Weapon systems

Power conversion

The conversion of fuel into energy goes through a number of steps. The total energy-efficiency is the sum of the individual steps added with energy recovered from exhaust gases and/or cooling water. In order to improve total energy-efficiency the first step must be more efficient and the number of steps, including waste-heat recovery, must be as low as possible.

The first conversion is done by what is generally called a "prime mover". Other prime movers than the diesel engine are a steam generator, petrol engine, gas turbine, Stirling engine, fuel cell and nuclear reactor. Disregarding nuclear power as too complex and too risky, all other prime movers but the fuel cell are less energy-efficient or less suitable. The fuel cell is relatively new and still maturing. Markets will offer in due course sets up to 1 MW offering the range of power to be used on compounds. Fuel cells offer better efficiency than traditional prime movers as the chemical energy of the fuel is directly converted into electrical energy. The Solid Oxide Full Cell Gas turbine combination (SOFC GT) claims 60% energy-efficiency[16]. Especially in de USA a strong market is emerging for fuel cells for essential back-up power. Low temperature fuel cells are fuelled by hydrogen (supplied or produced on-site). High temperature fuel cells are fuelled by liquid and gaseous hydrocarbons.

Figure 1: 10 units of 120 kw fuel cells are installed on the top floor of Adobe headquarters in San Jose, photo Edelman

Solar power can be used to produce heat and electricity. Producing hot water for domestic use must come first as it requires less conversions than generating electricity by PV solar cell for that same purpose. Hot water can also be more effectively stored in insulated vessels than electricity can be stored in batteries. Another way to directly use solar power is by heating an absorption cooling installation. The chemical attraction between salts and liquids can be used to cool with less electrical energy than conventional chiller plants. A proposal to further investigate the use of absorption cooling for military use has won the NL MOD innovation award 2010. Important because on a compound 47% of the generated electric power is used for air-conditioning[17].

Power generation

Big power plants and the national grid are more energy-efficient than small scale local production of power. Large producers can more easily change the energy mix (gas, coal, oil, bio-mass, nuclear) and adopt to the markets. To follow demand they can switch from "base load" to "peak load" plant. Big power plants can use coal that when in future combined with Carbon Capture an Storage (CCS) technology and when co-firing biomass, can produce electricity with low CO_2 -emissions. Exhaust heat can be used for district heating or sold to local industry. The national grid allows also a large number of small size sustainable energy producers to transport and distribute their energy.

Due to these developments the costs of electrical power have dropped considerable below the costs of power from a combustion engine. This promotes electric mobility and the use of heat pumps for heating and cooling. As a consequence the need for electricity will grow faster than the use of liquid fuels. A development called "electrification".

Small generation on a compound differs from the national grid and does not have the advantages of scale. Nevertheless the Army can make use of the innovation pushed forward by electrification like e-mobility, fast rechargeable batteries, smart grids, high tension distribution, energy storage, heat pumps, etc.

Advanced Electric Power

For large mechanical power demand, combustion engines have up to recently prevailed over electric motors. The one-step conversion of the combustion engine was more efficient than the two-step conversion to generate electricity and to use it to drive an electro motor. However, the potential to further improve the energy-efficiency of combustion engines is limited[18],[19] Its energy-efficiency might be even under threat due to stricter emission regulations. On the other hand the energy-efficiency of electric power improves due to smarter power electronics, Advanced Induction Motor, Permanent Magnet Electric (PME) motor, and High Temperature Superconductivity (HTS) systems. Not only energy-efficiency has improved but also the power-to-weight and power-to-volume ratio's are better, making them more suitable for mobile applications.

Even in the maritime sector where the diesel engine is still unchallenged as prime mover, electric motors drive nowadays the propellers of new war- and cruise ships[20] because of a better over-all energy-efficiency. The new RNLNavy Holland-Class has a hybrid propulsion using e-power for speeds up to 10 knots and propulsions diesels for more speed. Electrification and advanced E-power team-up and will find their way in more and more forms of e-mobility.

Sub conclusion Technology

Rather than sticking to a single fuel policy, the army should pursue for expeditionary operations a single carrier of energy: electricity. It is the best way to funnel available sources of energy, converse them efficiently to electricity by a fuel cell, preferably a high temperature fuel cell, and distribute it to a myriad of low and high power users. In this way maximum use can be made of new technology driven by electrification and advanced electric power.

Sustainable energy that can be directly converted into hot- or chilled water must have priority over raising electric power.

Technology can help to generate electricity more efficiently but vehicles counting for half of the needed energy, still need liquid fuels. Can they use less energy without losing operational effectiveness?

Fuels - Technology - Weapon systems

Thanks to saving energy, new technologies and the introduction of sustainable energy, less fuel is needed to generate electricity. However the amount of fuel that is needed for armoured vehicles tends to increase. As RPG's and IED's become more effective, armoured vehicles will despite using (re)active armour and artificial fibres, become bigger and heavier[21]. As a rule a 10% increase of weight demands 7% more fuel to drive. Getting the armoured vehicles in theatre also requires a lot of jetfuel and marine diesel in the logistic chain. Soldiers transported in armoured personnel carriers are passive and invisible. In no way they can survey and control the area they are crossing. They do not contribute to securing the hinterland.

In a US study[22] a survey was done to reduce energy consumption of ground vehicles. The survey included: alternative power, alternative fuels, waste energy recovery, alternative propulsion and grid integration with timelines 2014, 2024 and 2030+. Innovations that will undoubtedly reduce fuel consumption but fail to convince as breakthroughs (Technology Levels of Readiness are not given and potential savings are unclear). With armoured vehicles still gaining weight these innovations might probably only slow down the need for more fuel but not reduce it. Although the study mentioned the requirement to limit overall vehicle weight no new technologies to reduce weight were forwarded.

That it is difficult to improve energy-efficiency of armoured vehicles is demonstrated by the DODs Operational Energy Strategy Implementation Plan[23]. Where the US-Navy endeavours to use less operational energy and the US-Air force tries to improve energy-efficiency of aviation fuel, the US-Army only focuses only on introducing zero energy, waste and/or water systems in camps .

An Army without armour?

Coalition forces in Iraq and Afghanistan initially suffered many losses due to inadequately protected armoured vehicles. Add-on armour was introduced or vehicles were replaced by other, generally heavier types, giving more protection. An armoured vehicle protects soldiers but it inevitably becomes a high-value target itself. Especially in asymmetric warfare where danger lurks around every corner and where low-tech and cheap weapons used at close range, are a lethal threat. Eventually more effective weapons will reach opposing forces, requiring again more armour for protection and more fuel for mobility. Armies better stop this dead-end rally and pursue more promising innovation.

Figure 2: Bushmaster Armoured Personnel Carrier; photo NL MOD

Combat airplanes never used any armour but some light shielding to protect pilot and fuel tank. Warships had heavy armour in the 19th and 20th century. Navies gave up armour realising that in the end of the day ships would become too heavy to sail and to operate. Can armies too find ways to rely less on armour for protection?

Generation of electricity can be done much more efficiently by using fuel cells. Electrification and advanced E-power are dominant trends in technology. E-mobility for the Armed Forces would be a logic step ahead but is it an option for armoured vehicles? Unfortunately even the lightest armoured vehicles can't store enough electric energy in batteries to give it effective range. Can weight be saved by using other means of mobility?

In the NL MOD "Defensiekrant" some time ago an article was published about RNLN Marines operating in Afghanistan. When on foot patrol they used mules to carry their equipment. According to the PO in charge this was, apart from not using any fuel, "effective and safe against IED's as with the animals they could chose different and unpredictable routes". Unpredictability obviously provides protection as good as moving around in a big, heavy, noisy, exhaust and heat emitting armoured vehicle that has little alternative routes to go.

E-motorbikes

Despite all efforts, e-mobility is slow to get started as the obstacles to get electric cars on the roads are difficult to overcome. However the introduction of the e-bike gains impressive momentum especially in the Far East[24]. In the USA there are a number of companies building e-motorbikes. US Company Brammo for instance produces the Zero S with a 22 kW electromotor and weighs 135 kg. It has a top speed of 142 km/hr and a maximum range of 183 km. Performance of e-motorbikes can in due course even improve due to better energy density of batteries and tailor made battery configurations. When weight is used as a measure for the energy used, 8 soldiers on e-motorbikes use 13 times less energy than when transported in a Bushmaster (15 tons); an armoured personnel carrier as used by the RNL Army. Calculating energy savings by weight is only a rough guess but it clearly demonstrates the saving potential when soldiers drive an e-motorbike rather than being transported in a armoured vehicle.

Figure 3: Brammo Zero S, photo zeromotorcycles

When driving an e-motorbike a soldier does not have the protection that an armoured vehicle offers. But he moves silently and without hot exhaust, he is fast and manoeuvrable and can pick dozens of routes. By use of modern communication and navigation he can move on his own without losing touch with his team. By his visual and physical appearance he can be effective while moving and contribute to safety and security. When under way he can use his power pack to charge the batteries of his personal kit; taking away the logistic burden to provide soldiers with sufficient batteries. During longer hold-ups and when in camp e-motorbikes can charge, at least partially, their power pack with solar blankets that are stored, when driving, in an inbuilt compartment. E-motorbikes can with their power packs plugged-in to the base network, store excess energy and provide emergency power when needed.

Most countries have extensive programmes to modernise the soldiers personal kit. To improve his effectiveness his traditional gear is augmented by navigation systems, voice communication, night vision goggles, PDA and associated batteries. Although special attention is given to light weight materials it will add further weight. An average soldier that weighs 80 kg has to carry 24 kg when in battle order and extra 36 kg when in marching order[25]. In order to handle this back-breaking load an e-motorbike as part of his personal equipment comes in very useful.

This new form of light cavalry doesn't only suit transport of soldiers but can by its flexibility also be effective in operations. Especially when soldiers on e-motorbikes are supported by other means of light transport like electric trikes and quads that can carry light reconnaissance (mini UAV's to survey routes) and weapon systems. Light e-mobility also seems to be the natural stepping stone to introduce military robots in warfare. Systems that are generally small, light, and often use battery power for traction, communication, sensors and weapons[26]. It would certainly change the character of warfare.

Combat vehicles

For heavy armour vehicles like a tank, it will be more difficult to change to e-power. However, when combat vehicles are out of reach for e-mobility, they could disappear. Its role in expeditionary operations will be taken over by weapon systems with similar capabilities that offer more energy security: intelligence and close-air-support by manned and unmanned aerial vehicles or from naval ships firing long-range guns or launching missiles and aerial vehicles. Heavy vehicles only survive in roles where "mass" itself is essential like for construction, breakthrough and recovery. Vehicles were mass comes first and protection and mobility are less important, will look different and use less fuel than the ones used now for these tasks.

In 2011 the NL government decided to make the NL-Army's Leopard tanks redundant. The decision to do so was formally not motivated by worries about energy security but if so, it would be in line with a US study "DOD's energy Dilemma: Fuel consumption vs Platform Performance" which stated that the 70 ton Abrams is too big and cumbersome for conditions in most parts of Iraq and Afghanistan[27].

Sub conclusion Weapon systems

In order to reduce operational energy armoured vehicles must lose weight. When impossible with existing technology they will loose relevance in out-of-area conflicts. For transport of soldiers e-mobility comes into range when soldiers move on e-motorbikes rather than being transported in light armoured vehicles. The capabilities of combat vehicles will be taken over by air- and sea systems that offer more energy security.

Fuels - Technology -Weapon systems

In the transient from fossil fuels to alternatives bio-fuels are advantageous over other liquid alternatives. However, the competition for food and a low EROI will make it impossible for bio fuels to compensate for the loss of liquid fossil fuels. As sustainable energy will be unable to close the gap, the army must adopt new technologies and introduce new weapon systems to ensure energy security of expeditionary forces. New technologies must focus on electricity as a single carrier of energy and adopt electrification as a leading technology trend. Mobility must come into range for e-power and heavy armour must be abandoned leaving their capabilities to other systems .

Recommendations

Will future expeditionary forces only operate on bio-fuels that feed fuel cells? Will the e-motorbike become part of the soldiers personal kit? It would be over pretentious to claim a blue-print for future expeditionary forces. A wide array of future conflicts and scenario's could demand other and even more complex solutions. Nevertheless a holistic approach is required to ensure that future Armed Forces are capable to ensure vital interest in a changing energy market. The following recommendations are given.

- Go through the fuels - technology - weapon systems chain to develop comprehensive solutions.
- Pursue introduction of sustainable energy on compounds but accept that it only partially contributes to energy security.
- Concentrate on sustainable energy that directly converts solar power into energy for heating and cooling.
- For expeditionary (land) operations bio fuels are the best option to step-by-step replace diesel as fuel for prime movers.
- Closely monitor commercial and technology trends. Where possible introduce fuels cells, starting on FOB's.
- In order to substantially reduce energy the Army must introduce new forms of mobility to replace armoured vehicles. The introduction of e-motorbikes and other forms of light electric transport requires further study.

The transformation of an Army that "runs" on diesel to an Army that uses less energy, introduces sustainable energy and makes maximum use of new technology, is a challenge for scientist, engineers, military planners and decision makers. Will it turn everything upside down? To put things in perspective: on the video recording covering the efforts on the FOB Operational Concept Demonstrator the chief cook is happy. His sausages and scrambled eggs are as good on sustainable energy as on the old-fashioned fossil fuels.

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Cooling people, not places. Recycling 20th century defence science to meet 21st century challenges.

Andy BUXTON (Sleepbreeze ltd), Jill BUXTON (Sleepbreeze ltd)

Abstract – *As the ISAF operation in Afghanistan draws down,attention will, quite naturally, turn to the lessons learned. Undoubtedly public opinion will focus on the human and financial cost of the operation. Certainly NATO members supporting the ISAF operation in Afghanistan have paid a high price for their involvement. And rightly this will influence the appetite for future operations.*

A persistent feature of the campaign has been the ease with which relatively crude tactics and weapons have had such a significant impact on casualties and operations conducted by the most advanced military nations on the planet. Road side bombs are one such example which could, and no doubt will, be easily replicated in other theatres in the future, making the movement of supplies hazardous and tying up resources for convoy protection. If the gravity of this issue needs illustrating then UK MoD figures suggest that more than a quarter of British deaths - in excess of 100 men - have been a direct result of fuel convoy movements and protection.

Of the 100,000 litres of fuel delivered to Camp Bastion each day, fully half (50,000 litres per day) is used to power air conditioning, 25,000 litres being used each day to cool sleeping accommodation.

The difficulties moving fuel further forward to the frontline with which to cool hardened shelters used for sleeping is a luxury that cannot be entertained. Anecdotal evidence is of frontline troops achieving as little as 2-hours sleep each night over a typical 3-week patrol due to excess heat. The effect of lack of sleep on operational effectiveness is well documented.

There are, therefore, powerful commercial and operational reasons to find ways to cool troops at the front line and to reduce the fuel used to do so in main camps.

This paper will illustrate how the Sleepbreeze - a low-energy alternative to traditional air conditioning - could be used in two scenarios. In the first we report how comfort levels in a FOB can be improved sufficiently to facilitate improved sleep and rest. In the second scenario we report how the same technology could be used in conjunction with existing air conditioning at main bases to reduce the fuel consumed. A variety of strategies are offered.

The paper concludes by suggesting that it is not the availability of affordable and proven green technologies that needs addressing so much as the challenges getting them into everyday use with the military.

Introduction

Scientific knowledge often comes at a high price. This is especially true when applied to military science. Passing ideas and lessons from one generation to the next, to be reapplied and, even, used in imaginative new ways ensures that we get the best "value" from the original research. This paper explains how a problem faced by the British military in the 1940s – and its eventual solution – has been rekindled, applied to a new problem, namely cooling people sufficiently to help them sleep, could help military personnel in the years to come.

In the 1940s & 50s the Royal Air Force was operating from desert airfields in the Middle East. Jet aircraft were, then, a new innovation, capable of far higher speeds, greater acceleration and higher altitutdes than had ever been experienced by pilots before. Protective clothing was being developed to counter each of these new physical challenges. Self-inflating anti-g clothing and insulative clothing to counter extreme cold at altitude had a downside; namely in combination with the searing desert heat on the ground whilst on standby caused excessive heat strain, fatigue and reduction in g–tolerance. The initial solution was to provide cockpit air conditioning – effective, but in turn with such an impact on fuel consumption that payloads and range were compromised! The solution was both simple and innovative. Instead of cooling the whole aircraft cabin, cooling would be concentrated on the aircrew using a newly developed item of flying clothing – the Air Ventilated Suit (1). We will leave the story of aircrew clothing at this point, save to note that the system was further refined over the years, adopted by NASA for their Apollo missions, is used widely in industry, and most recently has come full circle and been integrated into the flying clothing worn by Eurofighter (Typhoon) pilots.

So, how does the fuel-range-payload problem faced and solved by the RAF over 60 years ago translate to those faced by ground-based units in Afghanistan and in conflicts yet to come? Energy supply and how it is used are essentially the same as they ever were. RAF aircraft had a finite fuel capacity. How it was used impacted on their mission effectiveness. Today fuel supply to ground units can easily be restricted by either insurgent or geo-political factors. Cooling was a priority then as it is today. The RAF found a way to use the cooling available cooling as effectively as possible. We suggest the solutions worked out previously can be applied today to help military personnel sleep in hot climates and, thereby improve their mission effectiveness.

In a nutshell, *"Cooling people, not places"* has tangible benefits for reducing energy consumption whilst providing sufficient cooling to maintain or improve mission effectiveness. In the first example we outline how it can provide cooling at Forward Operating Bases, where currently this is beyond current capability. In a second example we examine how the concept of localized cooling might be used to help reduce fuel consumption at main bases. Before doing so, however, it is worthwhile having some understanding of *why* people need to be cool down before they can sleep.

Too hot to sleep!

In brief, evolutionary processes have equipped man with a number of traits which include:

- an underlying cycle in daily body temperature which rises from the hours of the morning through to mid / late afternoon and then falling through the early evening and into the night.
- a sleep pattern which has us awake during the day and asleep at night.
- a strong link between the fall in body temperature and the onset of sleep.

Sleep studies have shown that the time taken for sleep to occurs is significantly increased as environmental temperature increases. If heat cannot be shed from the body because of high ambient air temperature then sleep is delayed, or denied. It is not just sleep onset that is affected but also the duration and quality of sleep that are affected.

Cooling for the frontline

Anecdotal evidence from Afghanistan tells of troops trying to sleep in hardened shelters getting as little as 2-hours sleep, each night of a 3-week patrol. Why would this be? Simply, hardened shelters get heat soaked and the air inside remains excessively hot even at night, made worse by there being little or no air movement to improve habitability. The natural solution would be to sleep outdoors where it is cooler. Sadly this pragmatic approach leaves troops vulnerable to insurgents throwing hand grenades over the perimeter wall and has cost soldiers their lives. The combination of a cooled, hardened shelter would, therefore, offer the best option for improving sleep onset, quality and duration whilst offering the protection needed against insurgent activity.

Forward Operating Bases (FOBs) and Patrol Bases (PBs) come in all shapes and sizes. It is safe to say, however, that the provision of air conditioning is not a feature of any of them. Air conditioning is a particularly fuel-intense capability and moving sufficient fuel from main bases further towards the frontline to power air conditioning is neither affordable nor practical.

The problem can be solved, however, by remembering that it is not the *shelter* that needs to be cool, but the *people* within it. In other words “Cooling people, not places”. Sleepbreeze ltd has developed a compact, lightweight, low-energy cooling system that does just this. Comprising of a small fan unit and self inflating duct from which a cooling breeze emanates through holes along the length of the duct. Specifically intended for sleeping accommodation it is ideal for FOBs and PBs and is an easy retro-fit to a standard NATO cot or mosquito net (NSN: 4120-99-151-7421). Instead of attempting to cool or ventilate an entire tent / hardened shelter, our approach is to provide sufficient ventilation to cool a person resting in their cot space (Figure 1). Cooling is provided, not by chilling the air, but by facilitating the evaporation of sweat on the skin surface. Typically to properly air condition a shelter would require some 600 watts of cooling for each bed space. The Sleepbreeze, however, uses just 6 watts – 1/100th of the energy. This is a major benefit as it moves cooling from being “needed, but unachievable” squarely into the realm of “needed and achievable”.

In 2011 UK MoD undertook trials of the Sleepbreeze at FOB Spartan as part of the PowerFOB programme. The Sleepbreeze was found to work well in temperatures of 50°C, turning the "unacceptable" into "acceptable" in terms of thermal "comfort". UK MoD has made it clear that the environmental conditions in which the Sleepbreeze was tested were significantly harsher than they envisage accommodating troops. The Sleepbreeze was also found to be unaffected by dust – endemic in such environments.

PowerFOB was a significant achievement for MoD and its partners in industry – small and large. From the perspective of cooling provision we can now offer a validated cooling product for use by frontline troops that delivers an improvement to the quality of infrastructure at FOBs and PBs, helps troops rest and sleep in austere environments and by increasing their ability to sleep we can make a significant contribution to their operational effectiveness.

Cooling, therefore, moves from the "just not possible" list to the "CAN DO!" list.

Figure 1: The Sleepbreeze is an affordable, available, easy and versatile retro-fit to a standard NATO cot. Left – fitted to a mosquito net, Centre – stows compactly, Right – intuitive controls.

Cooling for main bases

Air conditioning at main bases, such as Camp Bastion, is a significant burden both financially and from a logistics point of view. History also teaches us that geo-political events, such as the diplomatic tension between NATO and Pakistan can result in convoys being stalled. Of the 100,000 litres of fuel that moves into Camp Bastion each day, half of this is used to air condition accommodation areas. Half of this (25% of the total) is used to air condition sleeping accommodation.

Over the 10 years of the current campaign some 365M litres of fuel will have been used at Camp Bastion at a rough cost of £365M (451M EUR, $565M). Or, if you prefer, something approaching 1BN tonnes of CO2.

Technologies that can assist in reducing the fuel used by air conditioning systems would make a significant impact on the financial cost of operations of this scale. More importantly, perhaps, is that reducing the size, or number, of fuel convoys would have a positive impact on the resources tied up in convoy protection; resources that would otherwise be used in prosecuting the war. Over-riding both these considerations, of course, is the loss of personnel who over the years have died protecting fuel convoys. MoD figures for UK deaths suggest that over 100 men were lost in fuel convoy protection.

Part of our role as a technology company is to think of new and, possibly, unconventional ways, harnessing our knowledge and expertise to solve pressing problems. At Sleepbreeze ltd we considered how we could utilize our technology and knowledge to reduce the amount of fuel used at major bases such as Camp Bastion.

We began by analyzing the daily meteorological data for weather station EQBH, situated at Camp Bastion, over a period from March to October. The data set, consisting of many thousands of data points, gave a detailed picture of the hourly / daily temperature variation over those months when air conditioning would be used. Based on these data we were able to propose 3 simple strategies for fuel savings. Each involves a reduction in the cooling provided by air conditioning and a greater emphasis on loclised cooling to return people to thermal comfort.

- “Top and Tail” the cooling season – essentially delay the switch on of air conditioning for 2 weeks in Spring and bring forward its switch off by 2 weeks in Autumn. Figure 2.
- “Night time switch off” – switch air conditioning off for 4 – 6 hours at night during all but the most intense of summer months. (Figure 3).
- “Turn thermostat up” - every degree that the load on the air conditioning is reduced saves fuel.

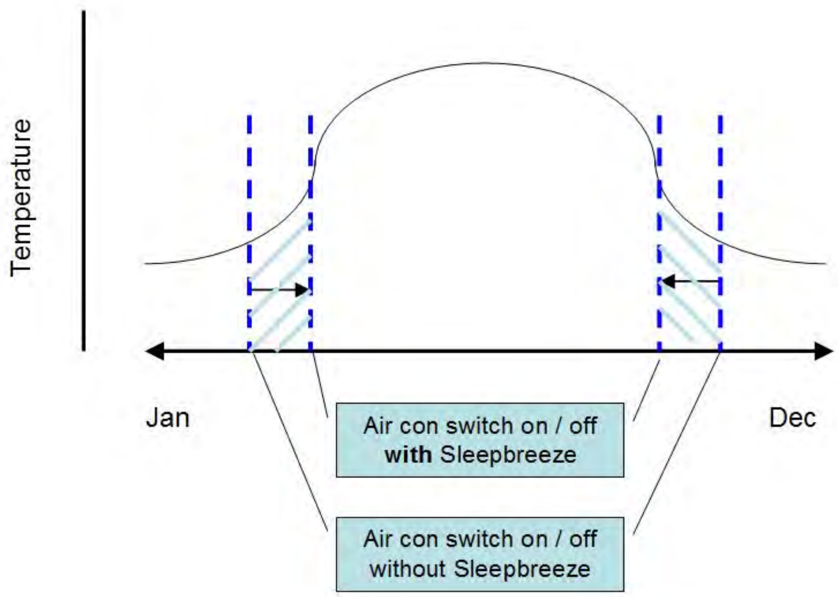

Figure 2: *« Top and Tail the cooling season. « Switch on » air conditioning later in season, « Switch off » air conditioning earlier in the season. Support thermal comfort with Sleepbreeze low energy cooler.*

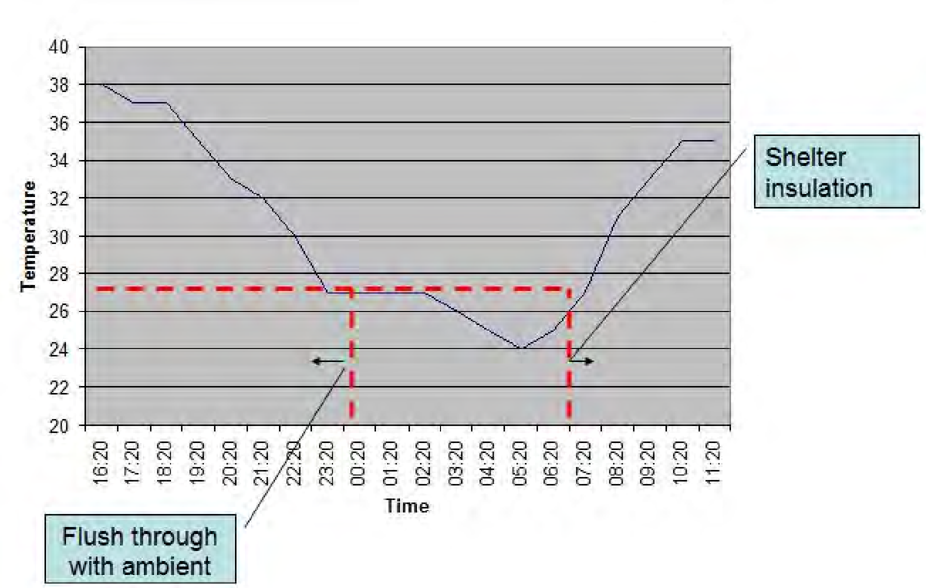

Figure 3: Turn off air conditioning at night.Graph shows meteorolgical data for June 12th 2009. Strategy suggests switching off active cooling between 00:00 – 07:00. Flush shelter through with ambient air only. Support thermal comfort with Sleepbreeze low-energy cooler.

A business case was prepared for each based on a broad brush analysis of the fuel consumption data available, and the fully-burdened cost of fuel. Each method showed a ROI within weeks based on 2009 fuel prices of £0.35 GBP spot and £1 GBP fully burdened cost to Camp Bastion.

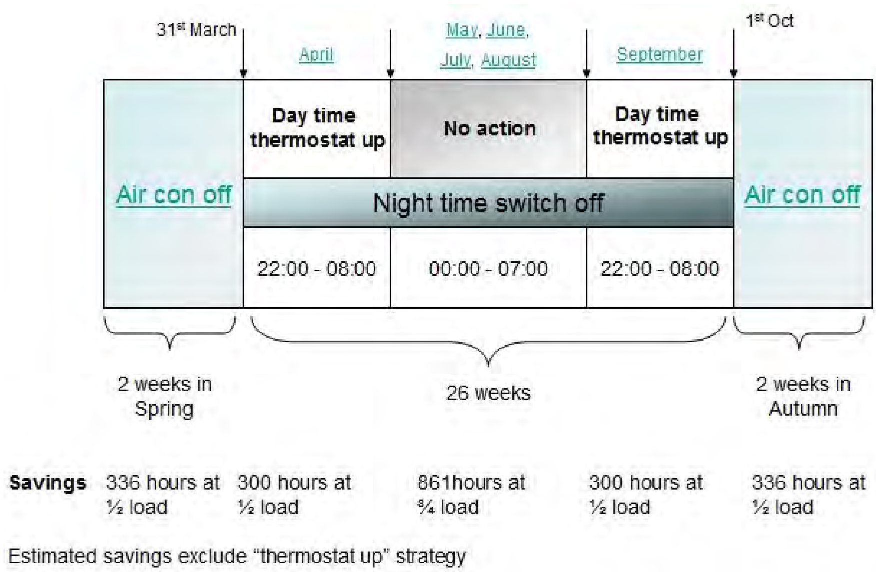

Figure 4: Overview of cooling strategies and potential number of « coolinng hours » saved.

Figure 4 shows an overview of how these strategies might work over the seasons where air conditioning would be used. It should be noted that the two strategies where cooling is “switched off” are incompatible witth the third strategy which proposed a modest rise in the thermostat “set point”. Fuel savings are expressed as the number of hours of cooling saved and the potential loading on the Environmental Control Unit. The latter is an approximation needing validation.

There are sound arguments that support these ideas and perfectly valid reasons why there should be no change.

In favour of these ideas each strategy would be expected to save fuel and is likely to have minimal impact on thermal comfort, particularly with the 3rd option which proposes a modest uplift in the thermostat setting.

From a physiological point of view the “Night time switch off” would have been acceptable, bearing in mind, from the small hours onwards, body temperature starts to rise as a direct result of physiological heat conservation mechanisms. Behavioural traits also come in to play to help.

Even in heat waves humans also exhibit certain behavioural traits to facilitate heat conservation and a consequent rise in body temperature in preparation for the coming day; for example, drawing bed clothes over themselves. Turning off the air conditioning during this period is entirely in tune with this.

People’s preference for air conditioning also varies. Some seek it out, whereas others shun it as it “only emphasizes the intense heat the next day”. Some younger soldiers are keen to explore “greener”, “better” ways of doing things and have an appetite for change.

Against these strategies is a feeling that “Main camps should be like hotels – a place to recover after a period at the frontline”. It has also been expressed that “saving money is not the issue”. We also sense resistance to change from the end users who lack trust in the motivation for change. To some there is an inherent, deep seated suspicion that the fuel saving agendum is about cost cutting and a further erosion of their working conditions.

On balance it is fair to say that, yes, there may well be alternative ways of using air conditioning that offer fuel savings. But these need much greater thought and assurance that they work and deliver meaningful benefits whilst not leading to a reduction in living conditions and morale. Following the PowerFOB trials in 2011 we would also suggest that they need putting in the context of the most recent data on the actual amount of fuel needed to cool a shelter.

Less the availability of a solution than the willingness to change?

Innovation is a double edged sword, offering both the *benefits* of change but also the *need* to change ingrained and trusted ways of doing things. In the military context this seems to create strange paradoxes. For example, the news reports frequently stories of selfless bravery with soldiers risking and losing their lives during combat for their comrades. Why is it, therefore, that a seeming luxury item – air conditioning - that has cost so many lives is not offered up as a sacrifice worth making. Indeed no-one is asking for this – just greater flexibility in the way it is used.

Conclusions

We live in a world where there is constant encouragement to "Reduce, Re-use and Recycle". There is no reason why this should not apply to knowledge as much to physical products. The Sleepbreeze is an example where knowledge has been re-used and recycled from previous generations in a new format to help improve both the living conditions and operational effectiveness of frontline soldiers in our own generation.

Thanks to the UK MoD PowerFOB trials the Sleepbreeze has now been tested and validated in an environment no different from those encountered at the frontline in theatres such as Afghanistan. Hence it is now no longer a case of the availability of technology but putting it into practice. The frist step need not be done on a grand scale but could be through local purchase to equip regiment-sized units.

We also believe that there is scope for the wider use of the Sleepbreeze to work in support of centralized air conditioning systems at main camps to help reduce reliance on fossil fuels. Whilst this needs further study the first step does not need to be a be a grand gesture but could be undertaken on a much smaller scale to gain further evidence to back up our concepts.

Every journey starts with a first step. We suggest that success is far more likely if this step is a small, manageable and affordable one.

Acknowledgements

We would like to acknowledge the help and support of MoD DE&S PTG during the PowerFOB series of trials in 2010 and 2011. Their work on the Generic Base Architecture has provided both a context and framework for our ideas. The Sleepbreeze makes up a piece of the jigsaw and we are proud to be part of this bigger and far reaching picture.

The Sleepbreeze product is built around a set of scientific principles discovered by scientists and engineers at the RAF Institute of Aviation Medicine and Royal Aircraft Establishment in the 1940s and patiently refined over many years. In re-applying their work to the well-being of soldiers of our own generation we hope, in some small way, to remember and honour their contribution.

SSgt Francesco Corrado – a soldier of 35 Engr Regt – who helped us understand the reality of life at the frontline, encouraged and inspired us. We are proud and humbled to offer our knowledge and expertise in return.

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Solar energy from space – challenges and opportunities

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Abstract – *The concept to obtain solar energy from space for the use on Earth has receive a lot of intention recently, in particular due to technological advances and reduction of the price of space travel. Innovative concepts to build the photovoltaic power plant and lift it in Earth orbit will be presented. Microwaves and lasers are the most common possibilities to transfer the energy from the orbit to the surface of Earth. We also explore possibilities to use the Tesla transformer for the resonant power transmission in order to reduce the losses. Solar energy from space could already be made economically viable using the current technology for the distribution of electric energy to areas without electric grid, such as for example remote areas in Afghanistan. Described innovative concepts offer good possibilities to further reduce the cost and make solar energy from space also economically viable for large scale production of energy in the relatively near future.*

MBDA is building a munitions demilitarization capability in France

Sébastien LUCAS (MBDA)

Abstract – By end of 2013, the MBDA company will have a demilitarization unit based in Bourges (Center of France) employing about twenty employees and allowing the dismantling 2.500 tons per year of ammunition of various types including missiles.

Presentation of MBDA

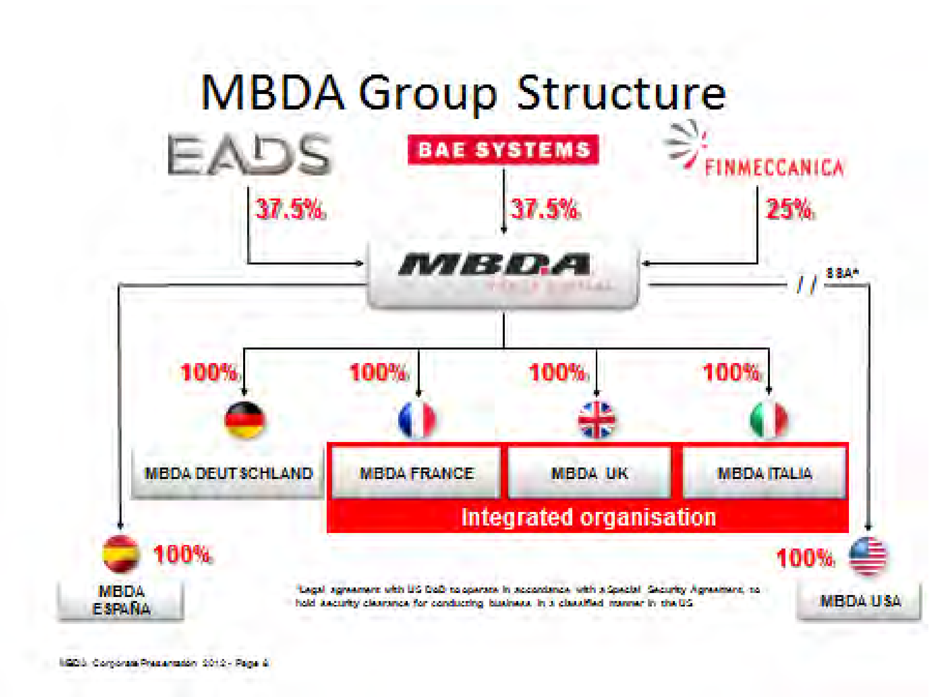
Created in 2001, MBDA is an industry leader and a global player in the missile and missile systems sector with an unrivalled product portfolio covering the whole range of requirements

Supported by three major shareholders: BAE Systems, EADS and Finmeccanica, MBDA is the first fully integrated European Defence group with a single management and operating structure.

MBDA sustains sovereign capabilities, security of supply and through life management

MBDA: a Global Player

- MBDA is Number 1 in Europe and one of the worldwide leaders, thanks to its wide market coverage and customer basis.
- MBDA delivers world class weapon systems to answer armed forces operational needs
- MBDA is prime contractor of some of the world's most advanced future missile systems
- MBDA masters key advanced technologies and has secured access to critical subsystems



Demilitarization, a new activity for MBDA

Calling on its wealth of experience in the missile systems domain, MBDA undertakes to establish a demilitarization unit in its Bourges facility (center of France) to process ammunition in accordance with the regulations that apply to safety, security and environment. **By end of 2013, the unit will be operational and employing about twenty employees and allowing the dismantling of 2.500 tons per year of ammunition of various types including missiles.**

The establishment of this new demilitarization unit, is the result of a **€ 12 millions investment** borne by MBDA to meet the requirements of an ammunition demilitarization contract awarded end of 2011 by NAMSA (Nato Maintenance and Supply Agency), center of excellence for demilitarization activities in Europe.

This contract has been established within the framework of the Oslo Convention, which was ratified by France in 2010 and requires all signatory countries to dispose of their cluster munitions before 2018.

The notion of a "cluster munition" is a generic term to designate any weapon comprising a container (a missile, bomb, shell or rocket) used to carry and disperse high quantities of explosive munitions or sub-munitions designed to operate upon impact.

In particular, MBDA will be responsible for disposing of more than 1,000 missiles, 22,000 M26 rockets (Multi Launch Rocket Systems or MLRSs), each containing 644 sub-munitions, and 13,000 155-mm grenade shells, each containing 63 sub-munitions, before the year 2018 – hence more than 15 millions sub-munitions.

MBDA's Chief Executive Officer Antoine Bouvier said: "The demilitarization of complex weapons has become a new strategic activity for MBDA. This fits in perfectly with our determination to establish close and sustainable partnerships with our domestic and export customers. These customers not only require guaranteed availability and sustained support for their equipment, but also that we ensure the safe end of life disposal of their complex weapons as well".

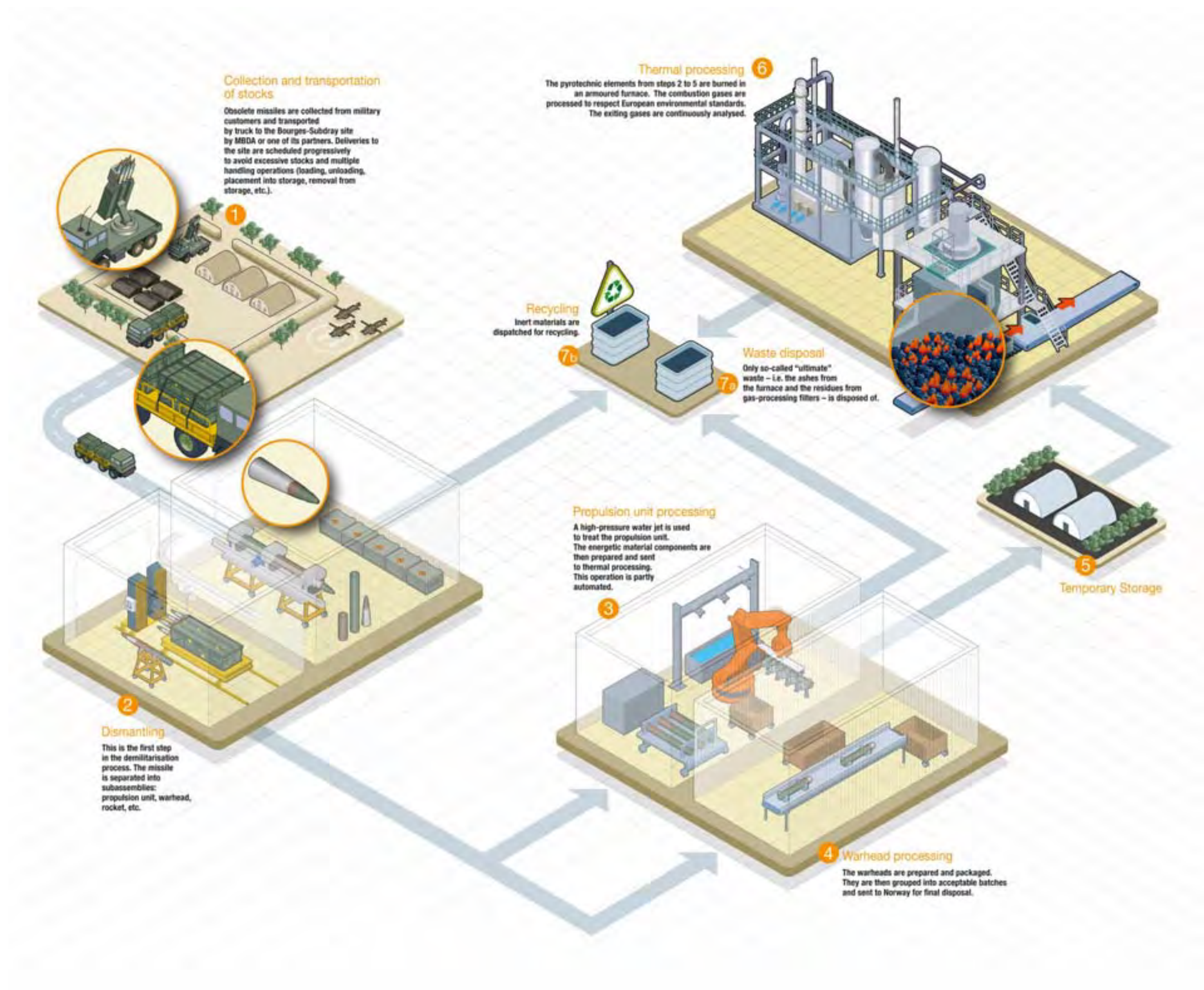
Also MBDA has been prone to **avoid duplication in Europe but rather to complement existing capabilities** with a solution meeting the requirements of NAMSA with a high added value demilitarization capability. In order to do so MBDA has brought together the best skills available on the market - with ESPLODENTI SABINO and AID in Italy, and NAMMO in Norway.

Capabilities to be installed in Bourges Subdray

The new capability will be componed by:

- 3 workshops for dismantling
- 1 workshop for rocket motors preparation
- Storage capacities
- Related equipments for handling, dismantling, cutting, crushing, etc.
- A team of 20 people
- An incineration capability (incl. off gas treatment)
- Overall a disposal capacity of 6 missiles per day (on 1 shift)

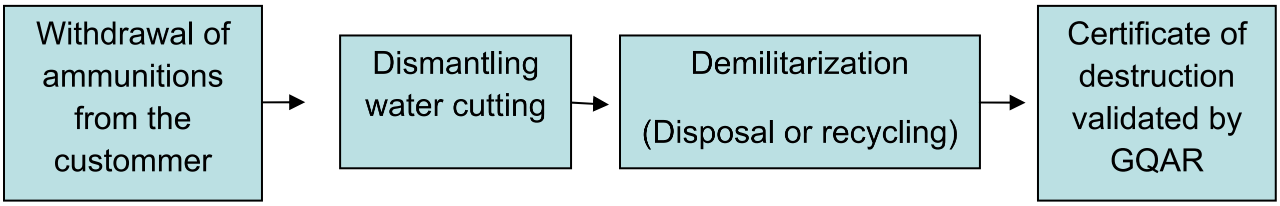
The following graphic displays the basic design of the ammunition disposal facility currently under construction by MBDA in Bourges (Center of France).



At each stage, safety and environmental protection are guaranteed in compliance with the EU and French environmental regulations including European Directive 2000/76/EC on the incineration of waste.

Dedicated customer interface

For the current contract, all processes are validated by the end customer and NAMSA, through GQAR (Government Quality Assurance Representative) services.



The ammunition demilitarization cycle

Stakeholders can monitor in real time the progress of transportation and demilitarization operations through a dedicated and secured IT tool accessible through a virtual private network (VPN).

Environmental friendly process

The specifications established by NAMSA for the demilitarization of missiles and cluster weapons are particularly strict in terms of environmental protection. MBDA is contractually obliged to comply with NATO, French and European regulations in this respect. Accordingly, a rigorous process and cutting-edge technologies are being used.

First, ammunition components are sorted. Inert components (metallic casings) are cut up and directed towards the traditional recycling process. More sensitive elements, whether confidential (eg. guidance system) and non-recyclable (eg. boosters) are treated separately. A thermal treatment unit (TTU) is capable of incinerating energetic materials and, at the same time, processing the gaseous emissions from the TTU to minimalize the release of hazardous substances into the atmosphere.

Environmental performances of the demilitarization unit

All potential impacts on the environment have been investigated and appropriate decisions were taken at all levels.

Infrastructure

The new demilitarization facilities will be located on an existing site operated by MBDA France in Bourges. This site is already classified "Seveso II high risk." The new infrastructure only requires an update of the existing facility.

Transport

Demilitarization operations require a very large number of convoys to transport ammunitions from military bases to the treatment site

The transport of ammunitions from the military ammunition depot is performed by dedicated freight forwarders and carried out according to the EU regulations related to dangerous material. (ADR regulation). The first convoys started in February 2012.

In addition, for safety reasons as well as in order to reduce the dioxide footprint, partial railway transport has been selected.

Emmissions from the thermal treatment unit

The thermal treatment unit, designed by DYNASAFE, is composed of a Static Detonation Chamber (SDC) and an Off Gas Treatment (OGT) system.

- Emmissions to atmosphere

The disposal of ammunitions in the SDC generate emissions of hazardous gazes.

The OGT processes the gaseous emissions resulting from the incineration of the munition and makes sure that the stringent thresholds set by the actual Directive 2000/76/EC (and the future 2010/75/UE applicable as off January 2014) are being met.

This system is based on a principle of consecutive filtering : gases pass throught various filters and scrubbers to eliminate the most hazardous particles before discharge through the stack.

In addition, a gas cleaning system with high-temperature afterburning (800 – 1000°c) is set up.

Systems will be installed to measure the stack emissions, and thus to verify compliance with the relevant Directive values.

- Emmissions to water

The OGT is configured as a closed circuit system, thus avoiding any liquid discharge into the environment.

- Incineration scraps

All waste from the incineration process are treated by the specialized channels.

Waste

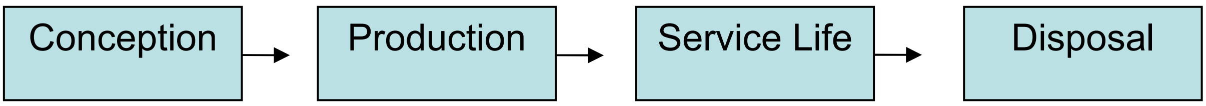
The different processes for demilitarization of ammunition are generating various type of waste. The demilitarization processes favor reuse and/or recycling, keeping the process by incineration or the landfill as a last resort.

The demilitarization facility set up by MBDA allows a maximum recovery of waste and their processing in compliance with European and French standards.

All waste expected to be recycled by external contractors is subject to special treatment to ensure compliance with the confidentiality requirements related to the nature of the products destroyed: metal parts and the WEEE are recycled after they have been rendered unidentifiable and non re-usable.

Conclusion: Demilitarization is a strategic activity for MBDA

This new service allows MBDA to complete its activity portfolio, closing the loop from conception to the management of end of life of complex weapons systems. The company is now capable of managing the full life cycle of its products, and of complex weapons in general, from design through to elimination. This new and innovative solution allows the demilitarization of end-of-life munitions to be properly managed.



In conclusion, MBDA will provide as early as end 2013 a clean alternative to uncontrolled emissions of the by-products deriving from the open burning or open detonation (OBOD) of energetic materials. Measures have also been taken inside the company to integrate the end of life management into the development of all new programs.

Demonstration Papers (click on the titles)

Ampair HeliPoD Hybrid Generation Systems

What Does it Do?	What Are the Energy and Environmental Benefits?
The Ampair HeliPod Hybrid generation systems are parter of the larger Ampair 'Hybrid Power' range that replace diesel generators with renewables only or hybrid diesel /renewable systems which vastly reduce diesel consumption, maintenance costs and associated fuel transportation costs in remote power applications.	Greatly reduced carbon emissions from all legs of the fuel supply chain. Greatly reduced local noxious emissions for personnel working next to equipment. No noise (PV only systems) - low noise (with turbine) No/minimal trucking in of fuel supplies or the requirement for local storage of large quantities of fuel with associated environmental spillage risks
How Does it Work?	**How Will This Enhance Defence and Crisis Management Capabilities and How Will it Be Implemented in an Operational Setting?**
The system consists of a large battery bank that is charged by Ampair's world renowned 600W wind turbine and solar panels with the option for the charging to be augmented by diesel, propane or fuel cell generation sources. As the equipment to be powered only draws the power that it needs from the battery bank there is no wasteage in the system (e.g., a 4kW generator running constantly to power a 100W load). If additional 'boost' generation is required in periods of poor weather or on high power systems, the generator runs at maximum power and efficiency to quickly charge the batteries in a short time and then shuts down until next required.	The power supplies could be heli-lifted to 'complex' sites where the risk to personnel and cost of providing continuous fuel transports is too high. The equipment can be Heli-lifted and is modular in design allowing for multiple units to be daisy-chained together to provide higher power outputs. The unit could also be used for advanced operations such as a remote unmanned inductance loop charging station for micro quadrotor surveillance UAV's. The system can provide uninterrupted power for upto 5 years on a set of batteries.

Contact

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UK

Conteno – The Most Important Weapon Runs On Water

What Does it Do?	What Are the Energy and Environmental Benefits?
The ContenO smart mobile water bottling plant is a 20-ft ISO container with a built-in bottle production, water filling, capping and labelling system delivering up to 36.000 litre of water a day. With only one operator the plant can be operational in less than one hour.	No more long distance transportation and distribution. One truck filled with small preforms corresponds to the equivalent of twenty trucks of bottled water. Light and durable PET performs are easy to transport, shred and recycle locally. This not only reduces the operations' ecological footprint, recuperated PET allows producing new bottles, shelters, building materials, water reservoirs, tools…
How Does it Work?	**How Will This Enhance Defence and Crisis Management Capabilities and How Will it Be Implemented in an Operational Setting?**
The Mobile water bottling Plant produce PET bottles and fill them starting from very simple and lightweight PET preforms. The machines are fully automated, simple of design allowing operations to start in less than 1 hour upon arrival on site. Large quantities of PET preforms are poured into the container on one end from where they are transported to a blowing machine in which the preforms are blown into the final bottle shape. After blowing, the bottles are filled with safe potable water, capped and sealed. Bottles are labelled prior to leave the fully automated machine. UV treatment is being applied, eliminating all germs, bacteria and fungi and assure the safety of the potable water. Depending on customer application and specifications an optional integrated water purification system can be installed.	A number of obstacles hinder the supply of safe reliable drinking water to mobile teams in the field. Imagine the logistic impact of twenty trucks carrying water bottles, in terms of storage space on ships, the availability of trucks and the support to keep them going. Think of the extreme expenditure in terms of fuel, trucks, and personnel involved. And what about safety during transport, both from a technical and a hostility point of view? Providing reliable drinking water to teams in action in theatre and in the field is to organize on site production and distribution rather than rely on vulnerable long distance transport.

Contact

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Fraunhofer Fuel Cell Generator

What Does it Do?	What Are the Energy and Environmental Benefits?
The fuel cell based tactical generator provides electrical power to smaller forward operating squads. Its power output is 2 kW via 230 VAC and/or 24 VDC.	With respect ot the environmental impact the energy generation in a hydrogen fuel cell is advantageous as just water and no carbon oxides are released. Furthermore, hydrogen as energy carrier can be created from renewable resources. In addition, compared to an internal combustion engine the conversion efficiency of the fuel cell is by far higher making the fuel cell system a very efficient energy conversion unit.
How Does it Work?	**How Will This Enhance Defence and Crisis Management Capabilities and How Will it Be Implemented in an Operational Setting?**
In the fuel cell hydrogen and oxygen from the ambience react in a controlled exergonic manner. The released electrical energy can directly be provided to electrical appliances.	Compared to the traditional generator with a diesel engine, the fuel cell generator shows reduced noise, IR and exhaust emission. Furthermore, the replacement of the internal combustion engine by a fuel cell has a high potential for weight reduction. The benefits of a fuel cell system, i.e. the reduction of emissions, can be a great advantage during missions in theatre. However, in order to operate the fuel cell generator, hydrogen needs to be provided which requires the setup of a hydrogen infrastructure.

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Fraunhofer Redox Flow Battery

What Does it Do?	What Are the Energy and Environmental Benefits?
The Redox-Flow Battery is suitable to store energy from Renewable Energies such as windpower or photovoltaic. This battery type uses liquid energy carriers (vanadium ions). With the help of a power modul, the chemical energy can be converted to electrical energy and vice versa. Relevant performance data: programmable logic controller, EtherCAT remote monitoring, 1kW, 230V power supply	To achieve a reasonable hourly reserve a redox flow battery offers some advantages. In a redox flow battery, the capacity can be set individually via the electrolyte volume in the tank. The degree of autarky from external power sources can be set by the design of power module.With respect to the environmental impact the energy generation has no carbon oxides released.
How Does it Work?	**How Will This Enhance Defence and Crisis Management Capabilities and How Will it Be Implemented in an Operational Setting?**
Vanadium redox flow batteries are based on the principle of chemical energy storage, in the form of dissolved redox couples in external tanks. Electricity is generated in a separate power module. During discharge the electrodes are continually supplied with the dissolved substances from the holding tanks, and once these are converted the resulting products are returned to the same holding tanks. As the storage capacity depends chiefly on the quantity of electrolyte solution, and the efficiency is over 75 %, this type of storage has potential for large scale application. Vanadium redox flow batteries have a similar energy density to lead batteries, however their service life is almost ten times longer.	An important step to be able to operate a constant uniform electrical infrastructure with renewable energies is the use of large-sized energy storage systems. For this case, redox flow batteries are a promising technology because power supply and energy content can be constructed separately. Furthermore, Redox Flow Batteries show no noise, IR and exhaust emission. Base stations for telecommunications exhibit typically performance requirements in the single-digit kW range. For use in the field, telecommunication base stations can be operated by renewable energies such as solar cells as well as conventional diesel power packs. For continuous operation or operation in silence mode/ silence watch a combination with an electrochemical storage is inevitable.

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Geoter – Geothermal Energy Supply

What Does it Do?	What Are the Energy and Environmental Benefits?
The container generates heating, cooling and DHW with high energy efficiency providing the required comfort standards with low energy consumption, saving a lot of fuel and lives as HVAC uses the biggest amount of energy among all the systems in the camp .	From the energy point of view, using this device we could save up to 60% of the energy. From the environmental point of view we will be decreasing up to 60% of the CO2 emissions, decreasing footprint and we'llavoid a part of the risks of manipulating large amounts of fuel like spillages, explosions...
How Does it Work?	**How Will This Enhance Defence and Crisis Management Capabilities and How Will it Be Implemented in an Operational Setting?**
The container, which dimension is the usual 20 feet, integrates a heat pump with all the auxiliary elements designed to operate either with water or air, switching from heating to cooling mode as required in the facilities. When it works in geothermal mode, heat transfer is made with the ground and when it'sworking in aerothermal mode, heat transfer is made with surrounded air.	It will provide HVAC and DHW for the camp being very quick to install and saving a lot of energy, which means saving fuel and avoiding all the costs and risks associated to fuel transportation. It'seasily transportable and it'squick to connect thanks to the "quickcoupling" system designed. In the aerothermal mode it can work instantaneously and when the camp is going to be longer periods on the same placement, the geothermal heat exchanger will be built and energy saving will be even higher. It´s being designed to perform to its highest in camp conditions.

Contact

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SkyBuilt Power – Rapidly Deployable Renewable Power

What Does it Do?	What Are the Energy and Environmental Benefits?
Power anywhere without logistics or fuel. SkyBuilt is the leader in rapidly deployable, solar/wind hybrid power systems for military, crisis management and other uses. Systems range from 500W man portable systems to MW scale microgrid compatible systems for mobile Air Force bases. Product line: Suitcase size, trailers, skids, solar blankets, containerized systems and microgrid compatible systems. On or off grid systems, with or without backup fuel-based generators. Full monitoring and communications systems available.	Power without logistics or fuel. Limited or no heat signature or radar signature. No emissions. Saves lives from IED attacks on fuel convoys. Cuts maintenance, fuel, and personnel costs. More rugged and more reliable than the grid or generators. Payback in months to a few years.
How Does it Work?	**How Will This Enhance Defence and Crisis Management Capabilities and How Will it Be Implemented in an Operational Setting?**
Solar, wind, batteries, inverters, communications packages and other components are pre packaged in rapidly deployable systems that range in size from man-portable suitcases to mobile systems (trailer, skids), and freight containers. Systems set up in minutes to hours and run for many years with minimal or no maintenance. Military spec. Used by CIA, US Army, Air Force, Navy, intelligence community, Homeland Security and others.	Get power fast anywhere. Cuts maintenance costs, fuel, and personnel costs from using diesel generators for power. Provides more reliable power on and off grid. Sets up in minutes to hours. Operates in any climate. Extremely rugged, proven systems used for years by US military and intelligence communities and communications companies in war zones and hostile climates from mountain tops to deserts. Systems can be available for field demonstration, etc. in various power ranges and configurations in 90-120 days.

Contact

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Sleepbreeze Personal Cooler – Individual Cooler for Rest and Sleep in Hot Climates, Shelters etc.

What Does it Do?

The Sleepbreeze personal cooler (NSN 4120-99-151-7421) helps personnel rest and sleep in hot climates, unventilated tents and hardened shelters etc.

Good quality sleep is essential to allow personnel to perform efficiently. Fatigue is known to cause errors in job performance which in the military setting can be disastrous. Over-hot environments are difficult to sleep in. The Sleepbreeze helps cool the user down, making getting to sleep quicker and the quality of sleep better. The Sleepbreeze is a practical means to improve sleep and to improve and extend mission effectiveness.

How Does it Work?

The Sleepbreeze retro-fits to the side of standard NATO-issue cots or to the side of mosquito nets. It requires little or no training to use. The Sleepbreeze consists of a power supply, fan unit and diffuser duct.

People resting and sleeping in hot environments sweat to cool down. HOWEVER, this is only effective if the sweat evaporates. Tentage and shelters tend to have little air movement. The Sleepbreeze produces the essential air movement across the user's body to evaporate sweat, cooling them down and helping them sleep – even in hot climates.

What Are the Energy and Environmental Benefits?

The Sleepbreeze is an environmentally sensitive alternative to air conditioning, using approximately 1/100th of the energy. Where air conditioning is not available, e.g. for logistics reasons, the Sleepbreeze is an effective means of cooling. Its low energy consumption allows a cooling option where otherwise there would be none.

The benefits of the Sleepbreeze are to deliver cooling capability where fuel is at a premium and air conditioning isn't a possibility. It may also be used to reduce fuel consumption in combination with air conditioning – when available.

How Will This Enhance Defence and Crisis Management Capabilities and How Will it Be Implemented in an Operational Setting?

The Sleepbreeze helps improve and extend the operational effectiveness of personnel by helping them sleep in hot climates. Well rested personnel perform more efficiently and with less errors creeping into their work.

The Sleepbreeze (NSN 4120-99-151-7421) would be implemented as personal issue to individual soldiers, travelling with them as they move from main camps to FOBS / PBs. Alternatively it could be provided as part of the equipment at camps for each bed space along with the cot and mosquito net.

The Sleepbreeze can also be used in a variery of situations, ranging from the early establishment of camps prior to major infrastructure being put into place through to the reduction of fuel consumption by air conditioning once such infrastructure is in theatre. Management of thermal stress and strain is a fundamental issue which effects health, well-being and mission performance. Hence the Sleepbreeze is of relevance to anyone deploying to hot climates, including military personnel and aid workers as well as for displaced populations in communal shelters where power outages remove air conditioning (Hurricane Katrina) and heat strain causes significant risk.

Sleepbreezes can be powered from either diesel generators, by battery or renewable sources such as solar panels.

Contact

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UnatSolar – Powersolution Which is Redusing Fuel in Remote Areas

What Does it Do?	What Are the Energy and Environmental Benefits?
The UnatSolar powersolution is providing electricity from the sun and wind. The electricity will be stored in battery bank of which you can invert to 24 or 220 volt	The system do make electricity from Wind and Sun, which is free resources and who is aviable anywhere in the world. No need of diesel, experiences from Afghanistan is that cost of 1 liter diesel do cost up to 10-15 liters in transport and other expenses.
How Does it Work?	**How Will This Enhance Defence and Crisis Management Capabilities and How Will it Be Implemented in an Operational Setting?**
The windturbine and the solar panels is connected to charge controller, and the power is stored in a battery bank, and from that you can invert up to 220 volt. Out standard solution gives you 1,8KW/h Of cause if its needed we can make the solution bigger or smaller	The solution reduse needs of fuel, its easy to deploy, easy to use, easy to setup, simple to assemble/build, simple to maintain, logistically frugal, adaptable, scaleable and flexible, able to integrate with other systems in a base, light and robust.

Contact

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Stavnsholt Gydevej 97
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Denmark

Windtronics Wind Turbine

What Does it Do?	What Are the Energy and Environmental Benefits?
The Windtronics small wind turbine provides electrical power for residential and commercial properties. It can provide power for communication towers. The uses are limitless. Currently a trial is taking place at US Army Fort Benning camp to use the turbine horizontally over air conditioning air outlets. The results so far are extremely impressive with 1000 watts being consistently generated. This equates to over 8000 kWh/year.	The system uses wind, either natural or exhaust from any source to generate electricity. It is silent, vibration free and has a small footprint. The turbine is only 1.8m in diameter. It is easily erected on a pole which could be telescopic.
How Does it Work?	**How Will This Enhance Defence and Crisis Management Capabilities and How Will it Be Implemented in an Operational Setting?**
Wind power drives a wheel with 6 magnets on the blade tips which pass through copper stators on the enclosed rim of the wheel to produce electricity	The turbine could be used to provide back up power to communications cells and to unit locations. For fixed NATO installations the turbine can be used to recature the power from exhaust outlets of air.

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Biographies

High Level Day

Opening Session

Ms Claude-France ARNOULD

Chief Executive, European Defence Agency

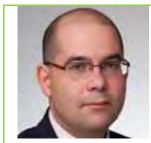
Claude-France Arnould is the Chief Executive of the European Defence since 17 January, 2011.

Previously, Ms. Arnould worked on defence matters in other EU positions. She led the Crisis Management and Planning Directorate (CMPD) at the General Secretariat of the Council of the European Union, between 2009 and 2010, and as Director for Defence Issues at the General Secretariat of the Council of the European Union from 2001 to 2009 (in charge of operations, military capabilities, partnerships and chair of the EU Satellite Centre Board).

Earlier in her career (1998-2001), Ms. Arnould worked as Director of International and Strategic Affairs at the French National Defence General Secretariat /Prime Minister (preparation of national "Council of Defence", CIEMG / interagency process for weapons exports control, armaments and space issues).

Claude-France Arnould started her career at the French Ministry of Foreign Affairs, as Desk Officer at the North America Directorate (1981-1983). Afterwards, she became Desk Officer at the Economic and Financial Affairs Directorate, at the French Ministry of Foreign Affairs (1983-1986), responsible for EC trade policy and external relations. After serving at the Private Office of the Minister for European Affairs (dealing with Community issues), in 1987, she became Secretary-General of the French National School for Public Administration (ENA), until 1989. In 1989, she was appointed Deputy Director of European Community Affairs, at the French Ministry of Foreign Affairs (in charge of external relations, trade, budget, institutions, CAP and development). She was then posted in Germany, as First Counsellor of the French Embassy (1994-1998). Ms. Arnould has been "Ministre plénipotentiaire" (French Ministry of Foreign Affairs) since June 2001. She is a former student of the Ecole normale supérieure, and holds an agrégation in Classics and a degree in art and archaeology. Ms. Arnould is a former student of the Ecole Nationale d'Administration (ENA).

Claude-France Arnould has been awarded the distinctions of Chevalier de la Légion d'honneur, Officier de l'Ordre National du Mérite and Bundesverdienstkreuz Erster Klasse.



H E Dr Tamas Ivan KOVACS

Ambassador to Kingdom of Beglium and Grand Ducy of Luxembourg

EXPERIENCE:

Ministry of Foreign Affairs Brussels, Belgium
- Ambassador, Embassy of Hungary (Kingdom of Belgium, Grand Duchy of Luxembourg) 2012-

Ministry of National Development Budapest, Hungary
- Deputy State Secretary for European Union and International Relations 2010-2012

European Commission, European Anti-fraud Office (OLAF) Brussels, Belgium
- International Relations Officer, Inter-institutional and External Relations Unit 2007-2010

Ministry of Foreign Affairs Budapest, Hungary
- Executive Civil Officer, Diplomat, International Law Department 2006-2007

Prime Minister's Office/Hungarian Consulate (USA/New England) Boston, MA, USA
- Executive Civil Officer, Head of Consular Office 2002-2006

Ministry of Youth and Sports Budapest, Hungary

- Head of Cabinet, Head of Department, Executive Civil Officer 2000-2002

ELTE Budapest Faculty of Law and Political Sciences, Constitutional Law Department Budapest, Hungary
- Associate Professor of Constitutional Law (part-time) 1998-2002

Hogan & Hartson L.L.P. Washington, D.C., USA

Nagy & Pintér Law Firm Budapest, Hungary
- Attorney-at-law, Member of the New York Bar and the Budapest Bar Associations 1996-2000

Other experience:
- Internships: Constitutional Court (intern, 1993-1995); New York State Senate (intern, Albany, NY, USA, summer of 1993); National Assembly (intern, 1991-1992)

EDUCATION:

The Fletcher School of Law & Diplomacy, Tufts University Medford, MA, USA
- Master of Arts in Law & Diplomacy (M.A.L.D.), JESSUP Moot Court Coach 2002-2004

- Fields of Study: International Security Studies, International Law and Organisations
- Scholarships: Fulbright Scholarship, Academy of Achievement, Sasakawa Young Leader, Bradley/ISSP

University of Michigan Law School Ann Arbor, MI, USA
- Master of Laws (LL.M.) (BEEP/NAFSA scholarship) 1995-1996

ELTE Budapest Faculty of Law and Political Sciences Budapest, Hungary
- Political Science (M.P.Sc.) – *„excellent"* qualifications 1992-1999
- Juris Doctor (J.D.) – *„summa cum laude"* qualifications 1991-1997

- Scholarship of the Republic, Bibó István College, Invisible College 1993-1996
- President of Student Government, Member of Faculty and University Councils 1991-1994

PERSONAL:

Born: 1972.02.29. Budapest, Hungary **Family:** married with two sons. **Honours**: Order of Merit of the Republic of Hungary, Officer's Cross (civilian), 2011. **Languages:** Hungarian; English; French; Russian. **Computer Literacy:** advanced user. **Professional memberships:** Budapest Bar Association, New York State Bar Association, American Bar Association, American Society of International Law. **Volunteer work and other experience:** Electoral Committee membership; "pro bono" legal work; organisation of Red Cross blood drives; student government elected positions; Emergency Medical Technician "pro bono" service (EMT-Tufts University Emergency Medical Services). **Drivers's licenses:** Category "B" (HU/BE/USA)

Mr Indrek TARAND

Member of European Parliament

Education

1972–1983 Tallinn 21st Secondary School
1983–1991 Tartu University, history and political science studies
1992–1993 Paul H. Nitze School of Advanced International Studies, The Johns Hopkins University, Bologna – European Studies

Additional Education

1983–1985 Compulsory Soviet military service
1997 Battle School of the Defence Forces – reserve officers' course

2005 Reserve officers' additional course *Cior Cia* in Budapest

Work experience

1991–1992 Tartu Maja – PR Manager
1993 Special representative of Government of the Republic of Estonia in Narva
1993–1994 Advisor to prime minister Mart Laar
1994–2002 Chancellor at the Ministry of Foreign Affairs, representative of Government of the Republic of Estonia at the Holy See, Vatican
2002–2003 Chief of Staff at the Bank of Estonia

2003–2009 Freelance journalist, television and radio host
2005–2009 Director at The Estonian War Museum - General Laidoner Museum
2007 Advisor to the Administration of the President of Georgia

2009- Member of the European Parliament

Television and Radio work

"Teletaip" – "Have I Got News For You"
"Targem kui 5B" – "Are You Smarter Than A 5th Grader?"
"Tantsud tähtedega" – "Dancing with the Stars"
Etc

Social activity

Member of Estonian Student Society
Founder of the Estonian Reserve Officers' Association
Member of the Museum Committee in Estonia
Donor

Published articles

Indrek Tarand has published numerous articles on a regular basis.

Awards

Commandeur de la Légion d`Honneur (France)
Companion of the National Order of Merit (Malta)
Magna cruce equitem ordinis s.gregorii magni (Vatican)
Order of the Merit of the Polish People's Republic (5th class)
The Royal Norwegian Order of Merit (Norway)
Order of the Aztec Eagle (Mexico)
Order of the White Star Third Class (Estonia)

Mr Tom SPENCER

Vice Chairman, Global Military Advisory Council

Tom Spencer is Visiting Professor of Public Affairs at the Universities of Brunel and Chester. He is a member of the Professional Practice Panel of the European Public Affairs Consultants' Association (EPACA). He was Associate Dean of Templeton College, Oxford from 1984-89 and founding Executive Director of the European Centre for Public Affairs from 1987-89. He served a second term as Executive Director from 1999-2011. He is currently Convenor of the Global Public Affairs Network.

He was MEP for Derbyshire from 1979-84 and for Surrey from 1989-99. He was Chairman of the Conservatives in the European Parliament 1994-97. From 1997-99 he was President of the European Parliament's Committee on Foreign Affairs, Human Rights and Defence Policy. He is a member of The Council of Federal Trust 2003- and of the Advisory Board of CRonEM (The Centre for

Research on the European Matrix) at the University of Surrey, 2012-.

He is Vice Chairman of the Institute for Environmental Security 2002-, and Vice Chairman of its Global Military Advisory Council 2012-. He was President of GLOBE International (Global Legislators Organisation for a Balanced Environment) 1995-99. He was Chairman of Counterpart Europe 2000-02, an NGO active in sixty countries; a Commissioner of the Commission on Globalisation 2000-03 and Visiting Professor of Global Governance at the University of Surrey 2000-04.

His books, "Public Affairs and Power: Essays in a Time of Fear", "Everything Flows: Essays on Public Affairs and Change" and "Challenge & Response: Essays on Public Affairs & Transparency", "The Future of Public Trust: Public Affairs in a Time of Crisis" are available from Amazon.com

Ms Marie DONNELLY

Director for New and Renewable Sources of Energy, Energy Efficiency and Innovation, DG Energy, European Commission

Marie Donnelly is currently working with the European Commission, in the Directorate General for Energy as Director, New and renewable sources of energy, energy efficiency and innovation, responsible for:

- The development of the policy and actions on energy efficiency supporting the achievement of the target of 20% energy savings by 2020, including the implementation of legislative requirements for buildings, ecodesign and labelling, as well as concrete actions supporting energy saving;
- The development of policies and actions leading to the achievement of the EU 20% target for renewable energy (20% share of energy from renewable sources by 2020 and a 10% share of renewable energy specifically in the transport sector);
- Coordination of the research actions in the field of energy including the development of technologies and innovative solutions for low carbon technologies leading to their widespread market take-up (European Strategic Energy Technology Plan (SET-Plan))
- Actions aiming at supporting the achievement of the 20-20-20 targets - 20 % greenhouse gases, 20 % better energy efficiency, and a 20 % share of renewables - through the Program "Intelligent Energy - Europe", in co-operation with "the executive Agency for Competitiveness and Innovation.

Previously she was working with the European Commission, in the Employment and Social Affairs Directorate General as Director, Resources and Communication, responsible for:

- Management of the strategic planning and work programming of the DG, budget preparation and execution (10% of Community budget); human resource management (recruitment, deployment ad training);
- Responsible for the design and implementation of communication policies for both the corporate DG as well as policy areas;
- Provision of informatic support for all activities of the DG.

Previously she was Head of units, ESF Policy, Coordination; EQUAL Community Initiative, including:

- Policy development and horizontal coordination of ESF activities within DG EMPL including the establishment of policy options for the reform of the ESF and the Structural Funds;
- Developing a coherent policy for employment development within the European Employment Strategy, building on existing Commission initiatives and experience;

Prior to that she was head of unit within the same DG, Equality for women and men, which included:

- Responsibility for the Community Framework Strategy, mainstreaming in all policy areas and institutions;

- Legislation on equal treatment and non discrimination (based on sex).

Before that she worked in the Directorate General for Enterprise in the area of Industrial policy in Pharmaceuticals - Human and veterinary medicinal products.

Immediately prior to joining the Commission, worked as Industry Group Director with the Federation of Irish Chemical Industries in Dublin, Ireland

Mr Andrew BARRETT

Senior Advisor, IHS CERA

Andy Barrett, IHS CERA Senior Advisor, has an extensive background at the highest levels of the international energy business, with broad senior careers in Shell and BG. As a founding Executive Vice President with the BG Group he was responsible for S Europe, Middle East, East Asia, and South America as well as the United Kingdom and Ireland (excluding N.Sea and Transco), along with functional responsibility for the Strategy, Business Development, Electric Power and Regulatory functions. He previously headed BG's International Downstream Business, and led BG's major entry into Brazil. With BG he led a number of successful international gas pipeline and gas distribution projects and acquisitions

Over the last ten years as a senior member of the IHS CERA team Andy has led or advised a wide range of consulting studies for major upstream and downstream gas companies and for independent power producers and utilities in Europe, Middle East, Russia and Asia. He has also headed part of the major energy masterplan studies which IHS CERA has undertaken for the governments of Dubai and Oman, and designed the midstream strategy and structured the new company for gas marketing and transportation for a North African country. Recently he has headed the European Commission and World Bank study to design the Caspian Development Corporation for delivery of Caspian gas to Europe, including commercial design for a trans-Caspian pipeline.

Mr. Barrett has a PhD. Natural Sciences from Oxford University, is a qualified with the Institute of Chemical Engineers and is an alumnus of Wharton Business School.

Mr Karl HALLDING

Senior Research Fellow, Head of China Cluster, Stockholm Environment Institute

Karl Hallding heads the China Programme of the Stockholm Environment Institute (SEI). He has had extensive experience in international cooperation with China on environment and sustainable development since the mid-1980s. In the late 1990s he spent two years with the Swedish Embassy in Beijing with responsibility for building Chinese – Swedish environmental co-operation on a political level. Karl is currently working on the broader geopolitical changes that are reflected by the growth of China and other emerging powers, with particular focus on the consequences of environmental degradation and sharpening competition for scarce resources. A selection of his latest publications includes: China's Carbon Emission Trading: an Experiment to Watch Closely (2012), Together Alone? BASIC countries and the climate change conundrum (2011), The Economics of Climate Change in China: Towards a Low- Carbon Economy (2011), Balancing climate concerns and energy security: China searching for a new development pathway (2010), China – U.S. relations and domestic politics on the road to Copenhagen (2009 - set of three policy briefs), China's Climate- and Energy-security Dilemma: Shaping a New Path of Economic Growth (2009), A Balancing Act: China's Role in Climate Change (2009). He was the main author of UNDP's China Human Development Report 2002, Making Green Development a Choice, and contributed to the 2007 OECD Environmental Performance Review of China.

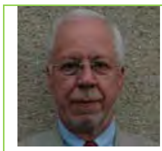
Dr Jason J BLACKSTOCK

Institute for Science, Innovation and Society, Oxford University and CIGI Strategic Advisor

With a unique background spanning physics, technology development and international affairs, Jason is emerging as a leading international scholar and policy adviser on the interface between science and global public policy. Since 2008, he has developed and led research and policy engagement programs from the International Institute for Applied Systems Analysis (Austria) and the Centre for International Governance Innovation (Canada) that have interactively examined the scientific, political and global governance dimensions of our planetary climate and energy challenges. These programs have included internationally recognized foci on the science and policy of emerging geoengineering technologies, short-lived climate forcers and sustainable energy transitions.

Over this time, Jason has co-authored more than two dozen scholarly and public articles (e.g. Science and Green Futures); given over 40 invited presentations to leading academic and policy institutions across five continents; contributed to or helped lead five international technology assessment processes and reports, most recently including the Solar Radiation Management Governance Initiative (www.srmgi.org) and the Equinox Summit: Energy 2030 (www.wgsi.org); and provided expert testimony and advice to legislative committees and policymakers around the world.

Jason obtained his Master (Edinburgh, 2001) and PhD (Alberta, 2005) in physics, followed by his Graduate Certificate in International Security (Stanford, 2006) and Master of Public Administration (Harvard, 2008), and worked from 2003 to 2007 as a Research Associate of Hewlett Packard Lab's Quantum Science Research Group. He is an Associate Professor (Adjunct) of the School of Environment, Enterprise and Development at the University of Waterloo, and in 2010 Jason was elected an Associate Fellow of the World Academy of Art and Science. Jason will be a Visiting Fellow in InSIS until the end of the year.



Dr Marcel LEROY

Senior Researcher, Africa Programme, UN-mandated University for Peace

Marcel Leroy was born in Belgium and studied at the University of Brussels and at Johns Hopkins University in Baltimore, where he obtained the degree of Doctor of Philosophy in International Studies in 1974. He undertook academic work at universities in Canada and Belgium, attaining the rank of full professor in 1984. His research dealt mainly with the relevance of population and environmental factors in international politics.

Since 1991 Dr Leroy held a number of international appointments. He was the head of Multilateral and Regional Affairs at the NATO Secretariat in Brussels till 1996 and then joined the Directorate General for Development of the European Commission. Since 1997 he completed a number of international assignments on behalf of European institutions, as Special Advisor for Multilateral Issues at the Delegation in Addis Ababa, and later in Djibouti, Moldova and Nigeria. He was coordinator of the Addis Ababa office of the EU Special Representative for Sudan from 2005 till 2008.

Dr Leroy joined the University for Peace Africa Programme in 2008 and has worked mainly on security implications of environmental factors and of climate change.

Mr Peter OLAJOS

Managing Director Green Player

Born 1968 in Budapest, Hungary, Peter Olajos holds a Bachelor of Science in Industrial Engineering and a Master of Chemical Engineering from the University of Chemical Industry Veszprém, Hungary. He further has a Master of Science in European Environmental Science and Engineering from the International Technological University in Paris.

Peter Olajos is currently Managing Director of Green Player Ltd. in Budapest. This consulting company inspires green improvements. Specialized for big scale green investments in Central and Eastern Europe. Covered areas and main responsibilities are: Clean Energy and Energy Efficiency, Building Retrofitting Programs (ESCO), Green Innovations and Climate Policy.

From 2011 to 2012 he served as Deputy State Secretary of Ministry of National Development in Hungary responsible for Green Economy and Climate Policy. Covered areas and main responsibilities: Climate Policy, Clean Energy and Energy Efficiency, Building Retrofitting Programs, Green Innovations and Sustainable Development.

Between 2010 and 2011 he served as Deputy-State Secretary of Ministry for National Economy in Hungary responsible for the Energy- and Climate Policy.

From 2004 to 2009 he was a member of the European Parliament (MEP). Mr. Olajos was a full member of the Environment (ENVI) and Budget Committees. He was shadow rapporteur of the Parliament's Report on energy efficiency, promoting environmental friendly social housing projects and the enlargement of the market of energy efficiency services. When the Commission proposed an integrated climate and energy policy, dealing with non-ETS sector, climate change policy and alternative energy facilities, Mr. OLAJOS was responsible for these affairs in the Hungarian and the EPP-ED delegation. Hungary, as a new member state of the European Union, has gained access to substantial amounts of EU funds, however, municipalities as well as SMEs are lacking own resources to run for EU funds. MEP Olajos used to promote and tried to implement a new entrepreneurial culture in field of green developments in Hungary to encourage PPP solutions.

He is since 2009 honorable President of the Association of Hungarian Small and Medium size companies (KKVE)

Between 1999 and 2004 he was a member of the Presidency Management Board of the Hungarian National Radio Public Foundation (two times was (re-)elected by Hungarian National Assembly). During the same period he also fulfilled various positions at centre-right Hungarian political party MDF (Hungarian Democratic Forum), working in the Hungarian National Assembly, he was Head of the European Integration Office and was Head of Chairman's Secretariat and Party director. He was finished his political carrier as vice-president of the party. Today he has no member of any political party.

Scholarship received are IFES (1992 USA, Washington DC., Florida State) and between 2002 and 2004 (three times intern in the European Parliament), working as an expert at Environmental Committee. He speaks Hungarian, English and French. He has authored several publications:

- "Green Conservativism" a book on the future politics and green economy, L'Harmattan Publishing House, Budapest, 2011 www.konzervativzoldseg.eu
- Renewable Energies: Best Practices 198 pages book on the best Hungarian practices of the renewable energy applications and solutions with theoretical and technological background. The Book contains maps and pictures about the real practice.
- Green Hungary – Development Model 26 pages booklet on the possible transformation to a modern sustainable Hungary. Detailed program about the Green New Deal, which includes job creation, infrastructural development, in focus energy efficiency, and renewable energy resources.
- Political Yearbook of Hungary: How Hungary acting as Member State from the European Parliament point of view. 15 pages publication on the personal experiences of the MEPs. Hungary as a new member state had a lot of challenges and this publication shows us the real experiences of the first 2 years. (2006)
- Scientific Articles: Since more than 10 years editor and writer of 'Today and Tomorrow' Environmental and Regional Development Magazine's European Union part (30-40 scientific articles

Session B

RAdm Bruce WILLIAMS

Deputy Director General, EU Military Staff

1980-1991: Bruce Williams' formative years were mostly spent in Frigates; during which time he graduated as Navigator and Principal Warfare Officer. As the 2nd Frigate Squadron Operations Officer he coordinated preparations for the first Gulf War and introduction of the first women to sea going billets in the RN.

1991-1996: Having graduated from Staff College and been promoted, whilst on the staff of Flag Officer Sea Training (FOST), to Commander (OF4), he was appointed as the British Assistant Defence Adviser and RN Liaison Officer in Singapore (in command of Naval Party 1022) - with specific responsibility UK maritime aspects of the Five Powers Defence Arrangement.

1996-2001: From the UK's Permanent Joint HQ (PJHQ) Chief of Staff's outer office (1996-98), a period that included operations ranging from the Western Balkans to West Africa and the 1998 Strategic Defence Review, he moved on to command HMS NORFOLK whose operational exploits included intervention in civil wars in Sierra Leone and Kosovo, as well a contribution to NATO's Standing Force Naval Atlantic (SNFL). HMS NORFOLK was awarded the Wilkinson Sword of Peace for its humanitarian and peacekeeping operations in Sierra Leone in 1999.

2001-2004: After a year in the Directorate of Policy Planning (UK Ministry of Defence), he was promoted to Captain (OF5) in 2001 just before '911'. As Assistant Director, Directorate of Naval Operations, he was concurrently appointed as the Joint MOD Current Commitments Team Leader for the UK response post '911'. By 2003, in command of HMS CAMPBELTOWN, the ship's operations focused on counter terrorism and maritime security in the eastern Mediterranean (as Flagship to Commander SNFL) and in the Persian Gulf, Horn of Africa and Indian Ocean (as part of CTF150 and 152). He was concurrently appointed as Captain Initial Sea Training responsible for ab initio Fleet training for RN junior officers

2005-2007: A shortened tour as Deputy FOST resulted from promotion to Commodore (1*) and appointment as the UK's first Commander Coalition Task Force (CTF) 58 (southern Iraq and the northern Gulf) in 2005. From 2006, as Commander UK Task Group and Deputy Commander UK Maritime Force, he deployed again as Commander CTF150 (Red Sea, Horn of Africa to Gulf of Oman). On return in 2007 he then stood-up, as Deputy Maritime Component Commander for NATO's High Readiness Force (Maritime) for NRF9.

2008-2012: From appointment in 2008 as Deputy Commandant of the UK's Joint Services Command & Staff College, and concurrently as an ADC to Her Majesty the Queen, he was promoted, in 2009, Rear Admiral (2*) and posted as Chief of Staff to HQ Allied (NATO) Maritime Command Naples and, concurrently, Senior UK Military Representative in Italy. By Sep 2011 he had moved again to his current appointment as Deputy Director General of the European Union Military Staff in Brussels.

Bruce Williams is married with three children. Hobbies (when time permits) are sailing, walking, gardening and an ex-rugby player's interest in the game.

H E Gábor IKLODY

Ambassador and Assistant Secretary General Emerging Security Challenges, NATO

Ambassador Gábor Iklódy is NATO's Assistant Secretary General for Emerging Security Challenges. He is the Secretary General's primary advisor on emerging security challenges and their potential implications for the security of the Alliance and a member of the Secretary General's senior management team.

The Division, which he directs and manages, aims to provide a coordinated approach by the Alliance to the challenges of the 21st Century. These include terrorism, Weapons of Mass Destruction proliferation, cyber threats, as well as energy security challenges, including those posed by environmental changes.

The Division will play an important role in the implementation of the new Strategic Concept, as well as in the development of a strategic analysis capability to enable the Alliance to better anticipate crisis situations and assess risks. The division also promotes security cooperation through a variety of programmes, in NATO, with Partner nations, and with other international organisations, as appropriate.

Ambassador Gábor Iklódy has a distinguished record of public service. He joined the Hungarian Foreign Service in 1983 and has since then built up a long record in security policy and multilateral diplomacy, a large part of which he devoted to Euro-Atlantic integration.

Before taking up his new position at NATO, he worked as Political Director and State Secretary in charge of multilateral issues, a position he was appointed to in 2009, with the main focus being on Hungary's upcoming EU Presidency in the first half of 2011.

In the period between 1999 and 2009 he served two four-year terms in Scandinavia as Ambassador, first in Norway (accredited also in Iceland) and later in Sweden. In between the two (2003-2005) i.e. at the time when Hungary joined the European Union and got integrated into its work, he filled the position of Director General for European Political Cooperation in Budapest.

In 1996 he headed the Foreign Ministry's Security Policy and Arms Control Department and later, from 1997 through 1999 its NATO and WEU Department. This latter coordinated work on Hungary's NATO accession talks and ran, on behalf of the Government, a large public diplomacy campaign that led to a successful referendum on NATO membership in 1997.

From 1990 until the end of 1995, he worked in Vienna at the Hungarian CSCE/OSCE Mission, from 1992 as deputy head. He was part of the team negotiating and implementing the CFE treaty (was also a CFE inspector) and was responsible during the 1995 Hungarian OSCE Chairmanship for all activities related to the organization's field missions.

In 1989-90, after having returned from his first posting abroad in Romania (between 1986-89), he worked as private secretary to State Secretary Ferenc Somogyi.

Ambassador Iklódy is married to Ilona Iklódy-Meiszter. They have two children.

Colonel Romuladas PETKEVIČIUS

Deputy Director, Energy Security Centre, Ministry of Foreign Affairs, Lithuania

He joined Lithuanian Air force in 1992. Col. Petkevičius held positions of chief engineer at First Airbase, Šiauliai, Lithuania.

After graduating from Air force Command and Staff College, Maxwell AFB, Montgomery, Alabama in 1998 Colonel Petkevičius was appointed to the position of chief logistics planning section in Air Force HQ and later chief of logistics of Lithuanian Air force.

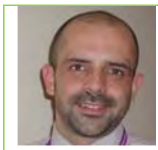
In 2000 Colonel Petkevičius was appointed as a Director of NATO department in the Ministry of Defense of Lithuania. His responsibilities included interaction with NATO in order to ensure Lithuania's preparation for NATO membership.

After graduating from Air Force War College Maxwell AFB, Montgomery, AL in 2004 col. Petkevičius was appointed to the position of Defense, Military, Air and Naval Attaché to the United States and Canada.

Next Colonel Petkevičius served as National Military Representative of Lithuania to Supreme Headquarters Allied Powers Europe (SHAPE).

At present col. R. Petkevičius holds position of deputy director of Lithuanian Energy Security Center under Ministry of Foreign Affairs.

Colonel Petkevičius was born on January 30, 1967 in Skuodas Lithuania. He is fluent in Lithuanian, English and Russian languages. Can communicate in French. Among his hobbies are ultra-distance running, computers and technology, and beer sampling. Col. R. Petkevičius is married to Larisa (Petkevičienė) and has son Artūras, who is 19.



Mr Paul JOHNSSON

Logistic Systems & Operational Energy Management – Section Head, Director Technical – Technology Delivery, DE&S, UK Ministry of Defence

Paul graduated from Sheffield University with a Masters Degree in Mechanical Engineering in 2002, subsequently joining the MoD's Defence Engineering and Science Group (DESG) as a Graduate in the same year.

Following the successful completion of his graduate programme, Paul undertook several project management roles in both the Land and Air domains before joining the Future Business Group, where he managed Portfolios of Research Projects relating to Weapons, Land and CBRN technologies. Paul subsequently took on the role of Science Innovation Technology (SIT) Demonstrator Programme (DP) Delivery Manager, leading his team of Portfolio Managers to work with Defence Equipment and Support (DE&S) Project Teams to deliver the SIT Demonstrator Programme, thus enabling the timely exploitation of Defence critical and battle-winning technologies.

Following a strategic re-alignment of SIT in April 10, Paul was been given the task of formulating, managing and delivering a Portfolio of Logistic Systems and Operational Energy Management Research Projects. This is a new area of focus for DE&S, and Paul has created (and is building) a team to effectively manage and deliver his portfolio which is focussed on improving the UK MoD Operational Base capability. This Portfolio is predominantly centred on the use of open systems to deliver improvement and efficiencies, and includes high-profile technology demonstrations such as FOBEX and PowerFOB.

Paul currently lives in Bristol, and his passions are football (watching and playing), scuba diving (Paul holds the PADI Advanced Open Water qualification) and travelling (usually in conjunction with one of his first two passions!).

Brig Jon MULLIN

Capabilities Director, European Defence Agency

Brigadier Jon Mullin is currently the Capabilities Director of the European Defence Agency. He was posted from the British Army to the European Defence Agency as a Temporary Agent in January 2008.

A career officer since 1975, and a Royal Engineer by origin, over the past 21 years he has served in the full range of staff posts focused on delivering military capability (Sponsor, User and Provider), interspersed with commanding operational units at squadron and regimental level.

Twice awarded a national level honour, he has significant operational experience ranging from serving in Northern Ireland (1979) in the infantry role, the Falklands War (1982) as a Parachute Engineer Troop Commander, and the Balkans (1999) as Commanding Officer 28 Engineer Regiment.

He has also provided UK based direct support to operations in Rwanda, Afghanistan and Iraq in a range of influential appointments. Prior to the European Defence Agency, he was the Assistant Director for Force Protection in the UK MOD Directorate of Joint Capability.

He holds a Natural Sciences degree from Cambridge University and he is a Fellow of the Institution of Civil Engineers.

Session C

Mr Jose Maria FIGUERES OLSEN

President of Carbon War Room (former President of Costa Rica)

After a successful business career and serving as Minister of State, José María Figueres was elected President of Costa Rica at the age of 39. As President he created a comprehensive national development strategy based on the tenets of sustainability: sound economics, investment in human development, and a strong alliance with nature. He pioneered the linkage between sustainable development and technology, work which he continued after leaving government by helping create and then leading the United Nations ICT Task Force as its first Chairperson. He was the first person to become CEO of the World Economic Forum, where he strengthened global corporate ties to social and governmental sectors. Later he was named CEO of Concordia 21, dedicated to supporting organizations that promote development and democratic values around the world.

Figueres is currently President of the Carbon War Room, which implements entrepreneurial market-driven solutions to reduce carbon emissions at the gigaton level and mitigate climate change. He holds an Engineering Degree from the U.S. Military Academy at West Point, and a Masters in Public Administration from the Kennedy School of Government at Harvard University.

Prof Jacqueline MCGLADE

Executive Director, European Environment Agency

Professor Jacqueline McGlade became Executive Director of the European Environment Agency in Copenhagen in 2003. The EEA is a vital source of information for the European Commission, the European Parliament EU Member States and other EEA member countries in developing and implementing environment and climate policies, and in providing the knowledge base to help Europe make informed decisions about improving the environment and integrating environmental considerations into economic policies so as to develop along a sustainable low-carbon and resource efficient path. Professor McGlade is currently on leave from her post as Professor in Environmental Informatics in the Department of Mathematics at University College London.

Prior to this, she was Director of the Centre for Coastal and Marine Sciences of the UK Natural Environment Research Council, Professor of Biological Sciences at the University of Warwick, Director of Theoretical Ecology at the Forschungszentrum Jülich and Senior Scientist at the Bedford Institute of Oceanography in the Federal Government of Canada.

Her research is focused on the governance of resources and environmental informatics with particular reference to ecosystems, marine resources and climate change. She has more than 100 peer-reviewed papers and more than 200 articles, books and legal submissions and has produced and presented a number of TV and radio series and programmes plus three feature films. She has been awarded international prizes and honours from Czech Republic, Germany, Italy, Monaco, Romania, Sweden, UK and the USA.

Professor McGlade has held a number of key advisory roles and chairs at national level, including Trustee of the Natural History Museum and Board Member of the Environment Agency, at European level, including the European Bank for Reconstruction and Development, and at international levels including for the United Nations and the Consultative Group on International Agriculture Research. She has also run her own company specialising in the area of software development and intelligence systems.

Session D

Mr Ivan BLAZEVIC

Programme Coordinator, Post-Conflict and Disaster Management Branch, UN Environment Programme

Ivan Blazevic is the Programme Coordinator at the Post-Conflict and Disaster Management Branch (PCDMB) of United Nation Environment Programme (UNEP). He leads UNEP's work in assisting the UN's Department of Peacekeeping Operations (DPKO) and Department of Field Support (DFS) improve their environmental management practices. He is a sustainable design and construction expert with a degree in Civil Engineering and an MSc in Architecture: Advanced Environmental and Energy Studies. Prior to joining UNEP, Ivan has worked on mainstreaming environmental engineering and green building principles within private, humanitarian and public sectors in the United Kingdom, the Balkans and Lebanon. He is an accredited LEED and BREEAM professional.

Col Georgios DROSOS

Director of Department on Infrastructure and Environmental Protection, Hellenic Ministry of Defence

Georgios DROSOS is Director of the Infrastructure and Environmental Protection Department of the Hellenic Ministry of National Defence, since Feb 2010. His main activities comprise the co-ordination of the MoD Environmental Policy implementation, the forwarding of the strategic co-operation with Hellenic Ministry of Environment, Energy & Climatic Change, as outlined within the MoU signed between the two Ministries, and the advancing of the Hellenic Armed Forces Infrastructure, by launching new regulations for the incorporation of Sustainability Criteria in the construction of military installations. He represents MoD in various NATO/ EU Environmental/ Infrastructure Committees (RPPB, IC etc) and Working Groups (DEFNET, NATO EPWG, EDA Go-Green etc), as Head of Delegation.

Previously, he served from 2007 to 2010 in Hellenic Air Force General Staff, as Head of National Infrastructure Dept, while being actively involved in environment, health & safety and quality issues (also as qualified auditor for ISO 9001, ISO 14001, OHSAS

18001), as well as in planning & exercising for disaster response operations in co-operation with other Nations (US, France, Israel, China, Turkey, etc).

He has also served in NATO, HQ SACT, Supreme Allied Command Transformation (Norfolk, USA), from 2004 to 2007, as NSIP staff officer, Capability Package Coordinator and Primary Action Officer for European airfields.

Overall, in his military career up to now, following his personal interests, he gained considerable experience in Infrastructure, Environment and Energy sectors, as well as in Disaster Response management, having served at all levels of command.

In the academic field, after graduating Air Force Academy, Department of Engineering, Infrastructure Section with an Honors Degree in 1986, he followed a postgraduate course in the Imperial College, University of London, Department of Civil & Environmental Engineering, Soil Mechanics Section, where he obtained DIC, MSc (with Distinction) in Engineering Geology in 2001. He also completed successfully postgraduate studies in The George Washington University, School of Business in Project Management in 2007, followed by postgraduate studies in Environmental Management in the Hellenic Management Association in 2010. Currently, he is conducting a PhD in the National Technical University of Athens. Finally, numerous scientific publications and conference papers have also been produced during his studies.

He attended all military schools up to his rank in the Armed Forces and he graduated Air War College in 1997. In parallel, he attended numerous military training courses worldwide (Germany, Israel, USA, etc) and participated in various scientific conferences, in the fields of Military/ Combat/ Civil Engineering, Project/ Quality/ Risk/ Crisis Management, PPP etc.

He has elaborated technical manuals/ specifications for use in Airfields and coordinated the revision of the National Technical Standard for Concrete Pavements Construction in 2009.

He is an active member of various National and International Scientific Bodies, such as the International Society for Soil Mechanics & Geotechnical Engineering (ISSMGE); and fellow of The Geological Society (London).

He has been honored with several military and academic medals, among which the “Gold Cross of the Order of Phoenix” & the “Gold Cross of the Order of Merit” by the President of Hellenic Republic, and “The Lapworth Medal”, as meritorious student, by the Imperial College. He was also awarded various Commendations, for distinguished service, by Hellenic Minister of Defense, Chief of HAF General Staff, NATO SACT Chief of Staff, etc

Georgios DROSOS was born, in 1965, in Ioannina, Hellas. He is married with two children. To relax, he enjoys reading and writing, and also likes music, art and sports.

Session E

Mr David MUCHOW

President and CEO Power Anywhere

David Muchow is founder and President and CEO of Power Anywhere, LLC, a developer of high renewable energy and other transformational technologies. He is an attorney, business executive, and consultant with over 35 years of experience in energy matters.

He is a founder and former President and CEO of SkyBuilt Power, Inc., a leading provider of rapidly deployable renewable energy systems. SkyBuilt Power provides hybrid solar/wind and other mobile power stations for Homeland Security, intelligence, military, humanitarian, and commercial use.

David Muchow has worked with natural gas, electric and other energy companies, the National Rural Utilities Cooperative Finance Corporation (CFC), Toyota, Aisin, ECO Technology Solutions and others interested in energy and business solutions, including mergers, acquisitions, and green field energy projects. From 1976 to 1998 he served as General Counsel and Secretary to the Board of Directors of the American Gas Association (AGA) that represents over 100 natural gas distribution and transmission companies and supervised its international operations.

He is General Counsel to the Business Council for Sustainable Energy (fostering energy efficiency, renewables, and natural gas) and Counsel to the Natural Gas Supply Association; has been General Counsel to ECO (distributed generation arm for rural electric cooperatives); the Natural Gas Council (an association of the chairs of the major natural gas associations); an officer in various technology companies, and former Vice Chairman of the Gas Committee of the American Bar Association.

He is the former Vice President, Secretary to the American Gas Index Fund (publically traded mutual fund); is co-editor of the seven volume treatise, Energy Law and Transactions, (Lexis/Nexis), and the Energy Handbook. Formerly he was Special Assistant to Assistant Attorney General Richard L. Thornburg, Chief of the Special Activities Unit and a trial attorney in the United States Department of Justice and received the Attorney General's Distinguished Service Award. He served with the National Security Council; Smathers and Herlong Attorneys; the Office of Management and Budget and as an assistant to Hon. James A. Haley, Chairman, House Interior Committee. He is an inventor of energy systems and an Edison Awards Judge; attended Georgetown University (BSFS, 1966), Cornell Law School, and Georgetown University Law Center (JD, 1971).

Mr Jean PERROT

Vice President in Charge of R&T Institutional Affairs, EADS France

2012 EADS FRANCE Headquarters

Vice President Head of R&T Institutional Affairs

2005 EADS TESTS & SERVICES

Vice President – CEO of TEST and SERVICES France

Chairman and CEO of IFR subsidiary of Test & Services France for Maintenance Information Systems

1998 EADS TESTS & SERVICES

Executive Vice President – Marketing and Sales

Responsible for civil and military sales of test benches, software and services, worldwide.

1996-1998 MATRA SYSTEMES & INFORMATIONS

Sales C3i and Simulation Systems Division Manager

This business Unit is responsible for sales and program management concerning Gc3I and simulation activity beside the French Army. I was responsible for both sales and turn over.

1993-1996 MATRA CAP SYSTEMS

Sales Manager for Joint Staff and Army programs.

At the head of a group of 4 salesmen, responsible for sales and negotiation of large information systems contracts, such as the "systemes d'information Régimentaire"

1985-1993 FRENCH MINISTRY OF DEFENCE

Project Manager for main Battle Tank weapon systems

Mr Alexis Christian HAMMER

Domain Leader Acquisition Policy, Dstl, Ministry of Defence UK

Graduated in 1990 in Industrial Design Engineering from Newcastle Polytechnic, Alexis spent his early career in Engineering

Consultancy where he specialised in the design of Aircrew Life Support and NBC (Nuclear, Biological & Chemical) Protection Systems. He led research in support of both the US F-22 Raptor, and the French "Rafael" fighter aircraft Man-Mounted Life Support systems.

In 1997, He moved into public service as Programme Manager – Respiratory Protection at CBD Porton Down, where he led the research and development of the UK's replacement General Service Respirator. During this time he was a Board Member of the International Society for Respiratory Protection (ISRP), and UK representative to TTCP TP11 (Physical Protection). In 1998 he progressed to Group Leader - Physical Protection, heading a group of 70 scientists, with responsibility for all research and development supporting Chemical & Biological defence.

Following the formation of Dstl, in 2002 he was appointed as Department Manager – Detection, sat on the Chemical & Biological Defence Board, and led 270 scientists supporting the £40 Million UK Detection and related research programmes, where he had responsibility for technical coherence and capability development, leading research in support of Chemical, Biological & Explosives Detection.

Between 2004 and 2009 Alexis held the post of Non-Executive Director of Enigma Diagnostics, a Joint Venture company established to exploit MoD Intelectual Property in Rapid PCR for medical diagnostics. His responsibility was to safeguard Government's interest in this start up company, build value & equity for MoD and enable Enigma to secure a partnership with a major Pharma.

In 2006 Alexis was appointed Senior Programme Leader – Acquisition Policy. He led the introduction of Capability Based Planning in the MoD S&T community, and re-positioned S&T support to Defence Acquisition; establishing a strategic presence in a key customer organisation, integrating senior Dstl staff into the key decision making structures of the acquisition community, resulting in significant growth in S&T support to defence programmes. In 2010, in recognition of these achievements he was awarded a MoD Chief Scientific Advisor's Commendation.

Alexis established the current UK MoD research programme in support of "Sustainability" (now termed "Resilience"). This programme has transformed UK MoD understanding of the implications of many factors (Energy, Emissions, Climate Change, Critical Resources and implications of our Decision Making) on MoD's ability to operate freely. Resilience is now a mainstream issue in MoD, reflected in Policy; Energy Efficiency targets are now mandatory.

Alexis was appointed to dual role of Domain Leader & Research Category Leader in 2011. Responsible both for research to improve defence acquisition, and for delivering coherence across a quarter of MoD's S&T investment (circa £100M), to drive down the cost of delivering defence. He has tutored at the Defence Academy Shrivenham for the past 3 years.

In 2012 Alexis was elected Fellow of the Institute of Directors.

He is married to Sarah and has 2 young children. Alexis is Chair of his local Scouting Association, a member of Hampshire County Cricket Club, maintains (and occasionally drives) a classic car.

Dr Christian BREANT

R&T Director, European Defence Agency

Christian BREANT has been first appointed by J. Solana in May 2008, EDA Director for Research & Technology, and for a second mandate by C. Ashton in November 2011.

From February 2005, he was deputy director for "technology strategy" at the Directorate for Force System and Strategies for Industry, Technology and Cooperation, and Research and Technology Director for Defence and Security of the "Délégation générale pour l'armement".

Aged 56, he is a graduate from Ecole Polytechnique (1976) and PhD scientist in Laser Physics from Paris University. He was post-doc at JILA, Boulder, University of COLORADO, USA.

In 1985, he was assigned to the Directorate for Research and Technology (DRET) of Délégation Générale pour l'Armement (DGA). Initially in charge of R&T studies in the field of laser sources and systems, he became manager of the optronics and laser department in 1989.

In 1993, he was appointed to the office of the National Armament Director (NAD), in charge of the development of the Defence

Scientific Campus in Palaiseau.

In 1994, he became Deputy Head of the Directorate for Research and Technology and Assistant to the NAD's Chief scientist Adviser.

In 1997, he joined the Directorate for Cooperation and Industrial affairs (DCI) in Paris as Deputy Director in charge of industrial and economic analyses.

In addition to his work, he was an auditor at the Centre for Advanced Studies in Armament (CHEAr, Paris, 1995-1996), the Centre for Advanced Military Studies (CHEM) and the Institute for Advanced Studies in National Defence (IHEDN, Paris, 1999-2000). In 2000, he was appointed Managing Director of the Defence Analysis Centre (CAD) in charge of operational analysis and simulation for the preparation of the future defence systems.

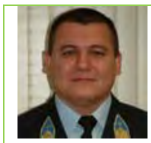
In 2004, he became Director of the common technologies department and in charge of technological prospective and preparation of the technical policies for DGA.

In March 2005 Christian Bréant was elected a member of the French Academy of Technologies. In 2006-2007, he was a member of the European Security Research Advisory Board (ESRAB) of the European Commission and presently member of ESRIF. He is also a member of the Conseil Economique de la Défense, France.

He has been awarded the distinctions of Officier de la Légion d'Honneur and Officier de l'Ordre National du Mérite.

Christian BREANT is married and has two children.

Technical Conference



Dr Laszlo CZÖVEK

Energy Project Officer, Capabilities Directorate, European Defence Agency

Laszlo CZÖVEK started his military career as a pilot student of the Military Flight School in Frunze Russia on MiG-21 in 1982. After the basic training he enrolled at the Military Aviation Engineering University in Kiev, Ukraine. He served with the Hungarian Air Force from 1983 to 2001 and has held several positions including Leading Specialist Engineer, Head Engineer of the Wing, Chief of Technical Engineering Service and Deputy Base Commander-Chief of Logistic. He has gained further international experience as Director of Support at NATO Combined Air Operational Center 5 in Poggio Renatico, Italy. Moreover, he was for over two years Chief of Logistics at the Head Quarters of the United Nation Observer Mission in Georgia as well as the Logistic Liaison Officer for IFOR-SFOR Mission in the Balkans.

He has in addition an impressive academic background having received a Bachelor of Science in Avionics Engineering from the University of Kiev (1988), a Master of Science in Flight Theory and Analysis (1994), Bachelor of Applied Economics – Specialised in Defence Economics – from CORVINUS University of Budapest (1997) and a PhD in Aviation Theory from Budapest University of Technology and Economics (2005). He has also been a correspondence student of law at the University of Pecs.

Since 2008 he has been employed by the European Defence Agency at the Capability Directorate and since autumn of 2011 he is focusing on Energy.

Mr Alisdair PETTIGREW

Senior Advisor Carbon War Room and Managing Director Blue Communications

Alisdair is a Senior Advisor to Carbon War Room and an expert contributor to media and analysts on maritime developments. He has over twelve years experience of working in the marine and allied fuel and commodities markets, including six as a journalist. Alisdair is a former Associate Publisher with Informa Group (owners of Lloyd's List) and a former director of Petromedia, where he founded the highly regarded environmental news and information site SustainableShipping.com.

He is co-founder of Blue Communications, an agency whose mission is to bring new strategic intelligence to reputation management and public affairs in industries that must alter perceptions of their economic and social value.

Alisdair has extensive contacts and networks within these industries spanning international media to government and regulatory bodies, and has lobbied at the highest level, where he has been responsible for driving positive change within the marine industry. He has pioneered the development of powerful and farsighted public relations platforms in the marine, energy and environmental sectors, achieving major breakthroughs in reputation for clients and influencing policy on key industry issues.

Dr Adam CUMMING

Principal Consultant Energetics Technology

Adam S Cumming is recognised as an international authority on energetic materials, representing the UK in several forums. He studied Chemistry at the University of Edinburgh where he gained his PhD, before joining the UK MOD to begin UK work on forensic research on traces of explosives. In 1988 he took over the running of the UK explosives formulation research to which in 1990 was added gun and rocket propellant work.

In 1994, as Technical Manager for Energetics, he was responsible for the content of the UK programme and for leading the UK in international forums. He is still employed by UK MOD as a lead advisor for Energetics research and continues work with other nations. He chairs several Research Groupings involving Europe and the USA, and has received both a Western European Armaments Group award and a NATO AVT Research Panel Scientific Award.

In 2007 he was made an Honorary Fellow of the High Energy Materials Society of India. He has served on the advisory boards of several international conferences including the Czech NTREM where he chairs the scientific committee. He is a member of the editorial board of the Wiley Propellants, Explosives and Pyrotechnics journal and is encouraging Indian scientists to publish and to take a more active role internationally.

His current interests include leading international studies on the environmental aspects of energetics and on the technology for insensitive munitions.

Mr Dinesh H C REMPLING

Technical Project Officer R&T, R&T Directorate, European Defence Agency

Dinesh H C Rempling has been with the European Defence Agency (EDA) since 2008. As Technical Project Officer at the Research and Technology Directorate (R&T), he has the R&T responsibility for three areas. As the moderator of the forum for Energetics, Missiles and Munitions he is responsible for launching multinational collaborative projects and establishing and maintaining the Strategic Research Agenda for the area. Within C-IED he has mainly focused on Detection – focusing on a systems engineering approach to deliver systems for IED detection – and Exploitation – where he was the co-project manager for the development and deployment of the first European C-IED forensics exploitation laboratory. He is also the driver of Military Green developing a comprehensive approach to mitigating adverse effects to the environment in the context of defence and crisis management.

Between 2001 and 2008 he worked for the Swedish Defence Materiel Administration (FMV) at the Naval Procurement Command in Stockholm, Sweden. Here he was co-responsible for the area Marine Electrical Systems for surface- and submersible crafts. This also included being the Swedish representative in NATO and Western European Armament Group forums and in 2006 he was appointed Government Expert for Energy and Propulsion within the EDA framework. He holds a Master of Science degree in Electrical Engineering from the Royal Institute of Technology (KTH) in Stockholm, Sweden.

Mr Antoine VINCENT

Technical Project Officer R&T, R&T Directorate, European Defence Agency

Antoine Vincent

Antoine Vincent joined the European Defence Agency in 2008. He established the technical forum “Ground Systems and their Environment”, and developed the first Strategic Research Agenda of the group. He is the manager of several multinational Defence R&T projects, focusing primarily on vehicle architecture and mobility, soldier systems, area surveillance, and energy for land installations. He currently co-chairs the Combat Equipment for the Dismounted Soldier program, and is a key contributor to the EDA’s Future Land Systems work strand.

From 2004 to 2008, he worked for the French defence procurement directorate DGA in Paris. In the aeronautical systems division, he was the technical chair of national project teams for different aircraft engines, involving engine manufacturers, users, government-owned test and evaluation facilities, maintenance, repair and overhaul centres. He worked as French technical manager for the engines of the Tiger and NH90 helicopters, and of the Mirage 2000 fighter aircraft. The scope of his duties encompassed airworthiness issues and management of both development projects and in-service contracts.

Antoine Vincent graduated from Ecole Polytechnique in Paris with an Engineer’s degree, and took a complementary Master of Science in Aeronautics from the Massachusetts Institute of Technology (MIT).

Cdr Henning FALTIN

Concepts Branch, EU Military Staff

Military Career

01 July 1985	Entry into the Bundeswehr (as conscript)
1987 - 1991	Bundeswehr University, Hamburg (Education Science)
1991 – 1995	Watch Officer on Fast Patrol Boats
1995 – 1996	Principle Warware Officer Course
1996 – 2000	Commanding Officer on Fast Patrol Boats (2 commands)
2000 – 2001	Deputy Squadron Commander 2nd Fast Patrol Boat Squadron
2001 – 2002	Student 28th Command and Staff Course, Canadian Forces College, Toronto/ Canada
2002 – 2004	Staff Officer/ Dep. Branch Head Naval Plans and Policy, German Ministry of Defense/ Navy Staff, Bonn
2004 – 2006	Staff Officer Polmil Policy and Bilateral Relations, German Ministry of Defence/ Armed Forces Staff, Berlin

2006 – 2008	Military Assistant to Parliamentary State Secretary Christian Schmidt, MP, German Ministry of Defence, Berlin
2008 – 2010	Squadron Commander, 1st Corvette Squadron
2009	Commander 8th German UNIFIL Contingent/ Commander UNIFIL Maritime Task Group 448.03
2009	Student NATO Regional Cooperation Course II, NATO Defence College, Rome/ Italy
2010 (Feb - Sep)	Temporary assignment as staff officer to the Commissioner of the German Government for the German Bundestag Committee of Inquiry on the Kunduz Air Attack, German Ministry of Defence, Berlin
2010	Action Officer, European External Action Service (EEAS)/ EU Military Staff (EUMS), Brussels/ Belgium

Prof Aleksander ZIDANSEK

Faculty of Natural Sciences and Mathematics and Researcher at »Jožef Stefan« Institute and Secretary General of Jožef Stefan International Postgraduate School

Dr. Aleksander Zidanšek, Prof. of Physics at the Faculty of Natural Sciences and Mathematics is also a researcher at »Jožef Stefan« Institute and Secretary General of Jožef Stefan International Postgraduate School.

Research fields:

- physics in security, including georadar and THz spectroscopy and imaging
- environmental physics and sustainable development including space applications
- condensed matter physics
- physics of liquid crystals
- education and training

Physics in security

In the field of security Prof. Zidanšek is active in several international European projects, such as the 7th Framework project UNCOSS and two EDA projects where he is the project leader at Jožef Stefan International Postgraduate School.

Condensed matter physics

Prof. Zidanšek studies various systems with magnetic resonance including application of magnetic resonance (NMR) and ground penetrating radar (GPR) for detection of explosives. He has also studied tablet composition of drugs composed of different polymorphs using double magnetic resonance. This research is important for determination of drug quality during tableting. In this field Prof. Zidanšek is the project leader at Jožef Stefan International Postgraduate School of the 7th Framework project CONPHIRMER.

Prof. Zidanšek also developed a mathematical model of fibrinolytic lysis of blood clots. The model explains the difference in the lysis velocity between clots in veines where the lysis is significantly slower due to a small pressure gradient and can take even a few days, and clots in arteries where a channel through the clot is formed due to a larger pressure gradient, while the remaining part of the clot is lysed significantly slower.

Physics of liquid crystals

Prof. Zidanšek with co-workers studies phase transitions of nematic and smectic confined liquid crystals with magnetic resonance and synchrotrone scattering. Studies of confined liquid crystals are important both for understanding of basic physics as well as for potential applications in electro-optical systems such as liquid crystal displays.

Environmental physics and sustainable development

In the field of environmental physics Prof. Zidanšek is active in research of renewable energy sources, in particular with applications in multifunctional devices and innovative energy systems on Earth and in space including solar power satellites in the orbit.

Awards and Prizes:

- Prešern Prize FNT, University of Ljubljana, 1989
- Fulbright Grant at Montana State University, 1995/1996 with Prof. V. H. Schmidt
- Secretary of the Slovenian Association for the Club of Rome since 2000
- Associate member of tt30 since 2001
- Associate member of the Club of Rome since 2005 (www.clubofrome.org)
- Junior Fellow of the World Academy of Art and Science since 2010

Mr John BUCKINGHAM

Chief Mechanical Engineer, BMT Defence Services

John Buckingham is the Chief Mechanical Engineer within BMT Defence Services, Bath, UK. He joined BMT in 1992 after 8 years with Vickers Shipbuilding and Engineering Limited, Bath. John has a BSc in Engineering with French and an MSc by research in hydraulics and simulation; both at the University of Bath.

John leads the marine power and propulsion studies within the company and has published several papers on this topic. He leads the in-house development of software to analyse this topic which includes features for hybrid propulsion, LNG fuels and the use of advanced waterjets. He has also published other papers on a range of subjects from biofuels to submarines and rail-gun cooling. He has recently been working on the assessment of technologies for energy efficient ships for the commercial and military marine.

Capt (N) (ret) Marcel HENDRIKS VETTEHEN

Consultant, Energie voor Inzet

Marcel Hendriks Vettehen has served the Royal Netherlands Navy as an engineering officer. He did seagoing jobs on board frigates, tankers and amphibious ships. Ashore he worked for the Netherlands Ministry of Defence, The Royal Navy and was Military Attaché in Berlin. From 2005 to 2009 he worked for the NL MOD Material Organisation where he was responsible for Marine Engineering. In that function he started the "Think-tank on energy for the military". In 2011 he left the Navy as a Captain. He works now as a consultant advising the military and the defence industry on preparing the military for the post-fossil fuel era