NATO ENERGY SECURITY CENTRE OF EXCELLENCE

Energy Security: Operational Highlights

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Contents

3 **National Research Council of Canada (NRC) backs up historic civil 100 percent biofuel flight with years of experience**

SHEILA NOBLE, WAJID CHISHTY, BRIGITA KUPSTAITYTE (ED.)

In late 2012, the National Research Council of Canada crossed a major hurdle in the move toward the economically effective use of biofuels in aviation industry with the world's first civil 100 percent biofuel flight, which may be part of rising trend towards biofuels use in aviation worldwide.

8 **Energy Security in South Caucasus: effective cooperation in the protection of critical energy infrastructure**

IOHAN DESSARD

Series of events symbolize the on-going cooperation between Azerbaijan and NATO. Could CEIP be the common point of interest that will allow Azerbaijan and Georgia to endeavour further strategic relations with the Alliance?

14 **Setting databases – another way to prevent attacks against the energy infrastructure?**

BRIGITA KUPSTAITYTĖ

A number of reports and analyses examining terrorist threats to energy infrastructures have been produced during the last decade. Can such examinations improve efficiency of operational planning process and mitigating threats?

National Research Council of Canada (NRC) backs up historic civil 100 percent biofuel flight with years of experience

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October 29, 2012. That is the date the National Research Council of Canada (NRC) flew the first civil jet powered by 100 percent unblended biofuel called ReadiJet™. The "drop-in" renewable fuel was processed by Applied Research Associated and Chevron Lummus Global and derived from Agrisoma Biosciences' Resonance™ feedstock crops. Dubbed by Popular Science as one of the top 25 science events of 2012, this 90-minute historic flight by NRC's Dassault Falcon 20 twin engine jet was a significant milestone for the aviation industry, as well as a major step toward advancing sustainable sources of renewable energy.

Introduction

The flight of the first civil jet powered by 100 percent unblended biofuel showed that an aircraft can operate on it. As it became evident, this biofuel was cleaner than and as efficient as conventional Jet A1 fuel. These results are promising, but the debate on the viability of biofuels for the aviation industry is still ongoing. At the same time, the industry is under enormous pressure to find more sustainable approaches to aviation. As it was later stated by Jerzy Komorowski, General Manager of the NRC Aerospace Portfolio, "the production of biofuels generates less greenhouse gas emissions than what is required to produce the same amount of petroleum-based aviation fuel. While the debate is still ongoing on the assessment of overall life cycle impact of biofuels production versus conventional fuels, the latest results of NRC's in-flight and ground tests continue to support biofuels as a viable option for the aviation industry, which faces increasingly stringent regulation of fuel emissions."

After months of testing in the air and on the ground, results show promise

While the world's first 100 percent biofuel flight garnered international attention last October, there was a great deal of work leading up to the big day. For months during the spring and summer of 2012, observers in Canada's capital city, Ottawa, witnessed two planes from the National Research Council of Canada (NRC) flying in tandem from time to time. These flights were, in fact part of the world's first comprehensive test flight program to measure real-time, in-flight emissions generated by a biofuel.

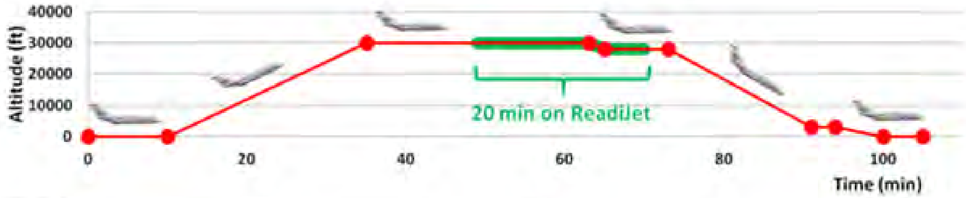
The leading aircraft that carried and burned the test biofuel was the NRC Falcon 20, a twin-engine business jet with a segregated fuel system. This fuel system modification carried out in-house renders NRC's Falcon 20 highly suitable for flight operations using experimental fuels because it allows NRC pilots to switch between different fuels for different flight segments. This ability to switch between fuels allows a portion of a flight to take place with an experimental fuel that may only be available in limited quantities.

The second aircraft, NRC's SilverStar Canadair TC-133, chased the Falcon to collect in-flight emissions data using pressurized, temperature-controlled pods under each wing. Each pod has an integrated emissions measurement system that allows NRC researchers to sample air quality at different altitudes, or during different segments of the flight profile, to determine the effect of altitude on emissions.

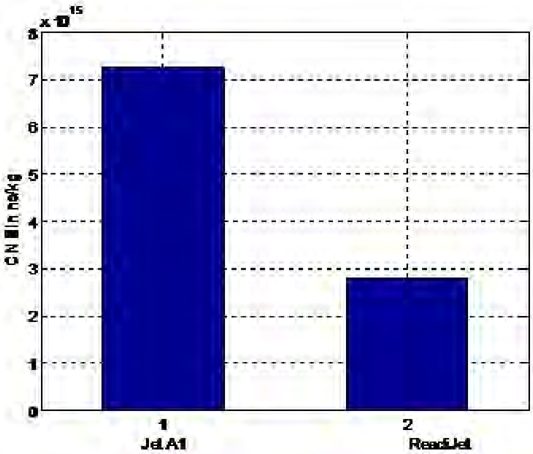
Prior to the 100 percent biofuel flight, NRC performed its due diligence by making sure that ReadiJet™ met all the requirements of NRC's rigorous airworthiness process, including laboratory analysis of the physical and chemical properties of the biofuel, which were then compared against known standards for Jet A1 fuel and found to be similar. NRC also tested ReadiJet™ on a static engine in a controlled environment to ensure that the biofuel functioned satisfactorily at all engine conditions anticipated during the actual flight.

The total duration of the flight was approximately 110 minutes, including the take-off and landing rolls. During this flight, the aircraft was operated on the "unblended" biofuel for about 20 minutes at the cruising altitude of 30,000 ft (9,250 m). Initially, the right engine, and then both engines, were operated on the biofuel.

The flight profile:
© The National Research Council of Canada (NRC)



Condensation Nuclei emission measurements:
© The National Research Council of Canada (NRC)



These important insights came from information collected in-flight and analyzed by a team of experts at NRC. Various emission measurements were made in-flight using NRC's CT-133 aircraft, which tailed the NRC's Falcon 20 aircraft burning the biofuel. These measurements include Oxides of Nitrogen, Black Carbon and Condensation Nuclei (Aerosol). The figure is presented as an example of the relative reduction in Condensation Nuclei (Aerosol) when the aircraft was operated on the biofuel. As may be noted, as much as 50% reduction in Aerosol was measured when using biofuel compared to conventional fuel.

ASTM D1655 is the document that specifies conventional aviation turbine fuel(s) certified for use i.e., Jet A and Jet A-1. JP-8 is the military equivalent of Jet A-1, with the addition of corrosion inhibitor and anti-icing additives. JP-8 meets the requirements of the U.S.

Conventional fuel brands

Additional tests performed on a static engine as a precursor to the actual flight showed a significant reduction in particulate matter emissions by up to 25 percent and a reduction in black carbon emissions by up to 49 percent, when compared with conventional fuel. These tests also show a comparable engine performance, in addition to an improvement of 1.5 percent in fuel consumption during the steady state operations. Furthermore, the aircraft and the engines required no modification as the biofuel tested in-flight met the specifications of petroleum-based fuels.

The National Research Council of Canada (NRC)

The National Research Council is the Government of Canada's premier research and technology organization (RTO). Working with clients and partners it provides innovation support, strategic research, scientific and technical services to develop and deploy solutions to meet Canada's current and future industrial and societal needs.

NRC is home to five gas turbine engine test cells with varying capabilities including high altitude, icing and performance testing. Each year, NRC works with the world's leading engine original equipment manufacturers in its facilities used for engine certification, engine performance, operability and durability, as well as high impact research in the areas of icing and alternative fuels.

NRC also maintains and operates a small fleet of dedicated research aircraft, including a Falcon 20, a Convair 580, a Harvard Mark IV, a T-33, a Twin Otter, a Bell 412, a Bell 205A, a Bell 206 and an Extra 300. Researchers use these aircraft to support projects in the laboratory's main program areas: flight mechanics, avionics and airborne research experimentation.

NRC, for its part, is laying the groundwork to assist industry in finding new approaches to sustainable aviation, including alternative fuels. A few years ago, NRC collaborated on an industry-led environmental technology "road map" exercise, which identified the critical pre-competitive enabling technologies and infrastructure the Canadian aerospace industry requires to meet environmental and sustainability requirements over the next 10 to 15 years.

NRC gives targeted support for the Canadian aerospace industry

As aircraft manufacturers from around the world strive to develop innovative technologies to overcome important challenges, the NRC has launched six new programs to support the Canadian aerospace industry.

"NRC has a long history of conducting research, performing technical services, and developing technology solutions to support the Canadian aerospace industry," says Jerzy Komorowski, General Manager of the Aerospace portfolio at the National Research Council of Canada. "These new programs target challenges faced by the global aerospace sector."

Two of the programs focus on improving travellers' safety and comfort. One aims to create a more comfortable and safe journey for air travel passengers and crew members by using new technologies to improve the flight experience. The other will help airlines detect, classify, and prevent icing threats with the development of processes and facilities for the demonstration and certification of innovative technologies.

Two more programs focus on the market delivery and effective regulation of innovative technologies. One looks to reduce the costs and environmental impact of operating air defence fleets by developing, testing and implementing new technology in Canada. The other will reduce the cost and risks associated with the development and testing of innovative aeronautical products and speed-up the delivery to market.

The last two programs tackle the challenges associated with emerging and transformative technology in the aerospace industry. One addresses the technological, regulatory and demonstration challenges associated with adopting unmanned aircraft systems for civilian use. The other focuses on developing and advancing critical technologies that are at the pre-competitive stage for new aircraft configurations.

Military Specification MIL-T-83188D and is the dominant military jet fuel grade for NATO air forces (fuel NATO code is F-34). The UK also has a specification for this grade, namely DEF STAN 91-87 AVTUR/FSII.

- **The specification for petroleum based jet fuel are given in ASTM D1655, MIL-T-83188D and DEF STAN 91-87. The specifications of the certified alternative fuels, including biofuel, are given in ASTM D7566.**

- **Physical and chemical properties that biofuels are required to meet in order to qualify for a certified aviation turbine fuel are given in ASTM D7566.**

Next on the horizon for NRC fuels research

NRC is continuing its work in the biofuels sector, combining efforts from its three research and technology development portfolios: Aquatic & Crop Resource Development; Energy, Mining and Environment; and of course Aerospace. From feedstock development to conversion processing to biofuel-powered flights, NRC is uniquely positioned in Canada to support the growing aviation fuels sector with its suite of multidisciplinary expertise and research infrastructure that crosses between life sciences and engineering.

A high priority will be the critical certification process, a key step in moving experimental fuels to a commercially ready stage. Fuel certification is a highly complex process that ensures the fuel will perform safely during all aspects of a flight.

"We have been working in our engine test cells to support the industrial qualification of certain biofuels, including ReadiJet™," said Komorowski. This involves running the fuel through static engines in controlled test cell environments to evaluate performance against a standard baseline, such as the traditional fossil-based Jet A1 fuel. Data is captured to measure how an engine performs in various conditions, including full power, cruise and idle conditions, and during transient operations like fast acceleration and deceleration to understand how quickly the fuel can respond to abrupt power requirements.

"We use a number of parameters to measure performance, including thrust, fuel consumption, and exhaust gas temperature," says Komorowski. "And NRC's high altitude chamber is always appealing to our partners as we can bring in an engine and test performance at test cell simulated high altitudes of up to 52,000 feet."

The majority of piston engine aircraft used in aviation operate on aviation gasoline that contains some amount of anti-knock additive called tetraethyl lead (TEL) - a highly toxic compound known to pose health risks even at low exposure levels.

More information about NRC's Aerospace portfolio is available at: www.nrc-cnrc.gc.ca/eng/rd/aerospace/index.html.

In addition, NRC has launched a new project to assist in the development and testing of alternative fuels for low lead (100LL) aviation gasoline, used primarily in general aviation. The project, which is in response to concerns from the aviation industry over the replacement of 100LL with a no-lead alternative, will support qualification and validation of new fuels leading towards their certification and commercialization.

In communities without scheduled airline service, primarily in rural and northern Canada, general aviation is the primary method of air transportation for passengers and cargo. The majority of these aircraft utilize high compression piston engines burning leaded fuel, which is harmful to humans. NRC is seeking partners and collaborators to join this research and development effort to ensure the long-term viability of the general aviation industry. By collaborating with industry, NRC can help bring forward a healthier solution.

"In an industry where product development from concept to implementation can acceptably take up to 20 years, change isn't going to happen overnight," says Komorowski. "NRC will continue to support the aviation industry's efforts to meet increasingly rigorous emissions regulations with practical solutions."

Insight from other countries and organizations

Alongside these initiatives in Canada there are several others. One is the Advanced Biofuels Flight path Initiative by the European Commission Services. It is a project undertaken in cooperation with Airbus, Lufthansa, Air France and British Airways airlines companies and the key European biofuels producers like Choren Industries and Nestle Oil. The aim is to speed the commercialization of aviation biofuels in Europe. By the 2020, their goal is to produce two million tonnes of sustainable biofuels. Enthusiastic voluntary commitment is key to promote production, storage, distribution of biofuels and construction of the required plants[1].

In addition, there is the Brazilian Alliance for Aviation Biofuels, created in 2010 to promote initiatives for development of sustainable aviation biofuels. Positive carbon lifecycle and certification according to local and international fuel standards is needed for improvement. Founders of the Alliance are institutions from aviation, fuel technology and agriculture spheres. The goal is to support the use of sustainable biofuels for aviation as one of the key components. This goal goes along with the contribution to environmental protection and a low carbon economy[2]. In Brazil, as in Canada, the first flight with biofuel took place this year. The plane flew from Sao Paulo to the capital Brasilia. The cut of CO2 emission was up to 80 per cent. In the future, the plan is to use biofuel for 200 routes during the 2014 World Cup. According to the Brazilian Airline Association, fuel accounts for 43% of the cost of air fares in Brazil[3].

These examples from different countries show the rising interest and need to use biofuels in the aviation industry. Planes` engines are among the engines that use the highest amounts of fuel, which in turn produces a high amount of pollution. Pollution and the high cost of fuel are forcing the industry to search for improvements. The use of biofuels strengthens the potential for a sustainable economy and these examples from Canada, EU and Brazil may be the part of rising trend.

1. Renewable energy. European Advanced Biofuels Flight path Initiative. Found: http://ec.europa.eu/energy/renewables/biofuels/flight_path_en.htm
2. Brazilian Alliance for Aviation Biofuels. Rasta: http://aviationbenefitsbeyondborders.org/environmental-efficiency/case-studies/brazilian-alliance-aviation-biofuels
3. First commercial airline flight using biofuel takes place in Brazil. Industry News, 2013. Found: http://www.biofuels-news.com/industry_news.php?item_id=6953

Energy Security in South Caucasus: effective cooperation in the protection of critical energy infrastructure

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On November 19-20, a NATO staff team was in Baku to discuss the modalities of setting up Azerbaijan's first Partnership Training and Education Centre (PTEC). Moreover, on November 21, the conference "Cooperative Approach to Energy Security: View from NATO and Beyond" co-organised by NATO Energy Security Centre of Excellence (ENSEC COE) and the Centre for Strategic Studies under the President of Azerbaijan was held in Baku. This series of events symbolize the on-going cooperation between Azerbaijan and NATO but it also shows the Alliance's willingness to project stability as it develops its capacity to contribute to energy security, including protection of critical energy infrastructure as it was stated in NATO's strategic concept. Indeed, it could be argued that NATO could learn from the great developments in terms of Critical Energy Infrastructure Protection (CEIP) in South Caucasus[1]. Nevertheless, what could be the rationale behind this openness to NATO? Could CEIP be the common point of interest that will allow Azerbaijan and Georgia to endeavour further strategic relations with the Alliance?

NATO's Strategic Concept affirms the Alliance's commitment to contribute to Energy Security, including the protection of Critical Energy Infrastructure.

NATO and the challenge of energy security

From the consumer's point of view, energy security represents an uninterrupted access to affordable energy supplies. However, in NATO's case, energy security entails the constant and reliable supply of fuel to Allied Forces but also the protection of critical energy infrastructure as well as diversifying energy transit routes[2]. Moreover, the demand for energy among NATO allies keeps increasing. NATO countries account for 6% of the world oil reserves and 7% of gas reserves but account respectively for almost 40% of the oil consumption and 35% of the gas consumption worldwide[3]. Therefore, it is understandable that the Alliance has identified energy security as an area where NATO could add value in order to ensure the security interests of the allies. Critical energy infrastructures play a great role in energy security as they enable energy flows (tables 1&2) from one country to another but also ensure the supply of energy to the energy sector . Therefore, CEIP is a matter that goes way beyond borders as the infrastructure network is usually extensively interconnected from a country to another.

What is "critical" about energy infrastructure?

Critical Energy Infrastructure can be defined as systems and assets so vital to the basic operations of a state that its incapacity or its destruction would have a negative impact on national security, national economy security, national safety, or any of those combined[4]. However, precise criteria on how to define CEI have not been set yet[5] even though researchers have touched upon the subject for ten years already[6] proving that defining CEI is an on-going process. In any case, CEIP strive to limit the vulnerability of energy infrastructure

1. For the sake of comprehensiveness, South Caucasus will be used throughout this article to mention Georgia and Azerbaijan specifically.
2. Yetiv, S., & Cunningham, J. NATO and the Caspian. In Journal of energy Security (2012)
3. Ibid.
4. NATO Parliamentary Assembly. 157 CDS 08 E rev 1- Energy Security: Co-operating to Enhance the Protection of Critical Energy Infrastructures (2008)
5. Information provided by M. Masera from the European Commission JRC in Energy and Transport.
6. Copeland, c et al. Critical Infrastructures: What Makes an Infrastructure Critical? (2003)

to external threats. The latter can be defined as disruptions of the supply chain by physical attacks such as terrorism or other acts of violence[7]. It should be noted that the supply chain encompasses different parts of the infrastructure. Usually, it is composed of an energy extraction infrastructure (onshore/offshore) and an energy export infrastructure (pipeline). Moreover, any storage facilities also require security. Therefore, it appears that any networks of oil and gas pipelines fall into this definition of critical energy infrastructure. Indeed, any pipeline infrastructure is important to the state economy as it represent a source of revenues for transit countries and producing countries. Nevertheless, it should be noted that energy infrastructures that are considered critical for the Alliance do not only include infrastructures located on the territory of its members[8]. Some of its partner countries such as Azerbaijan and Georgia from the South Caucasus Region are hosting quite a few of these infrastructures (BTC oil pipeline, BTE gas pipeline, Baku-Supsa oil and gas pipeline, map 1).

Map 1: Main pipelines in South Caucasus

Source: South Caucasus Pipeline Routes. Retrieved from nealrauhauser.wordpress.com (2013)

These pipelines account for considerable amount of energy resources transported from Azerbaijan to Europe through Georgia and Turkey (tables 1 and 2). Moreover, the region is also witnessing new projects in the so-called Southern Gas Corridor. The official signing ceremony of the Azerbaijani-Turkish Trans-Anatolia gas pipeline project (TANAP) took place on June 26th 2012[9]. Once finished, it will be able to transport additional gas supplies (see table 2) from Azerbaijan to Europe in order to ensure the supply of energy to NATO and EU members[10]. Another project is the Trans Adriatic Pipeline (TAP) which will connect to TANAP in Kipoi, Greece's border with Turkey. The TAP has been chosen over Nabucco Pipeline project to ensure gas deliveries (see table 2) to Europe. It should be mentioned that the Trans Adriatic Pipeline (TAP) project is heavily dependent on the TANAP as the latter will be the former's main supply source[11]. Consequently, once the Trans-Anatolian Pipeline (TANAP) and TAP are constructed and brought online, Azerbaijan and the other transit countries hosting the different pipelines of the Southern Gas Corridor will become vital partners for the Alliance and major contributors to Europe's energy security as natural gas suppliers.

7. NATO Parliamentary Assembly. 157 CDS 08 E rev 1- Energy Security: Co-operating to Enhance the Protection of Critical Energy Infrastructures (2008)
8. ibid
9. ANAP. Tanap Project, the silk road of energy, has been signed.(2012)
10. Socor, V. Azerbaijan Drives the Planning on Trans-Anatolia Gas Pipeline Project in Eurasia Daily Monitor Volume: 9 Issue: 164 (2012)
11. Tunglan, K. time to act on Diversifying EU Gas Supplies. New Europe. (2013)

Table 1: Characteristics of the major oil pipelines.

OIL PIPELINES	LENGTH (KM)	TOTAL CAPACITY (MBarrels/Year)	AMOUNT TRANS-PORTED IN MTons (2012)
BTC	1768	365	27.9
Baku-Supsa	830	80	3.9

Table 2: Characteristics of the major gas pipelines.

Source: the tables (1 & 2) prepared by the author on the basis of data by OECD. Development in Eastern Europe and the South Caucasus Armenia, Azerbaijan, Georgia, Republic of Moldova and Ukraine, p.134 (2011) and Trans-Anatolian Natural gas Pipeline Project environmental impact assessment application file, p.8 (2013)

GAS PIPELINES	LENGTH (KM)	TOTAL CAPACITY (BCM/Year)	AMOUNT TRANS-PORTED IN BCM (2011)
BTE	692	8.8 (20 after expansion)	4.7
White Stream	1238	8 (projected by 2016)	N/A
TANAP	3825	16 (projected by 2018)	N/A
TAP	867	10 (projected by 2018)	N/A

What has to be protected and how?

The protection of energy infrastructures all along the supply chain is necessary to ensure secure energy supplies to Europe and other NATO members since these infrastructures, which are located at the beginning of the supply chain, are more attractive to terrorists. Indeed, as it was mentioned above, other services and sectors are heavily dependent on energy. Consequently, the negative economic impact of a disruption of the supply chain will engender a spill over effect as other energy infrastructures downstream will be affected. This will undermine the good functioning of the economy especially considering the reaction of stock markets. Hence, there is a great need for cooperation in order to protect those infrastructures. Moreover, the energy coming from the Caspian Sea Region flows through Azerbaijan and Georgia as it reaches the global market. Therefore it is important for NATO to build good relations with each of those countries through different partnerships to ensure their energy security. NATO could easily develop the capacity to contribute to energy security by cooperating with partners as well as private actors in order to ensure the protection of critical energy infrastructure and transit lines[12].

- **BP's case should be consider as a worldwide benchmark in terms of CEIP as it represents an efficient cooperation between governments and the private company which is operating the infrastructure**

- **BP, together with the national and local authorities, has done a tremendous work in protecting the BTC pipeline**

- **BP has implemented projects of development and mobilization within the communities where the BTC pipeline passes**

International cooperation can foster a more efficient CEIP but its success lies into information sharing. Some governments might not be willing to share information on their own nation's weaknesses. Nevertheless, Azerbaijan and Georgia have developed very efficient policies under the British Petroleum (BP) umbrella. Hence, NATO could analyse and learn from those developments in the process of contributing to Energy Security through cooperation with partners and consultation with allies in order to enhance global security. For example, the protection of critical energy infrastructure such as the Baku-Tbilisi-Ceyhan pipeline in the south Caucasus region is important for all the countries through which the pipeline passes. BP's strategy in protecting the pipeline has been based on introducing physical as well as technological monitoring. They hired locals to patrol along the way of the pipelines, which has considerably enhanced the preparedness against disruptions as the locals are more aware of any attacks that could be planned towards the pipeline. Moreover, BP strives to increase the sense of ownership and organization within communities where the pipeline passes in order to involve them in the protection of the pipeline[13].
This is one way to enhance CEIP. Nevertheless, there are various ways to enhance critical en-

12. Rühle, M. NATO and Energy security in NATO Review Magazine (N.D)

13. Cornell, S. The BTC pipeline: Implications for Azerbaijan. Silk Road Studies, p.64 (N.D)

ergy infrastructure security[14]. Conventional physical security encompasses the use of movement sensors, drones, satellites and radars as well as setting up fences and patrols at interconnections and compressor stations in order to minimize vandalism and labour related attacks. It is also required to have an effective coordination between authorities . Nowadays, some new trends in CEIP have been established. They are based on the rapid recovery of the infrastructure, which should be able to maintain its functions even if some of its critical parts have been damaged. Moreover, there shall be a coordinated crisis management characterized by an effective monitoring to ensure early detection of disaster and the availability of team that can rapidly define emergency protocols to restore functionality[15].

All the international, federal and local authorities should be coordinated with the crisis management team in order to deal successfully with a disruption in the system

Who has the responsibility to ensure CEIP in South Caucasus?

Besides private companies, numerous government agencies are responsible for the security of energy infrastructures in South Caucasus. In Azerbaijan, The Special State Protection Service (SSPS) is responsible for the physical protection of onshore infrastructures such as export pipelines[16] and the security of offshore facilities (picture 1) is under the responsibility of NAVY working under the Ministry of Defence (MOD) and of the Coast Guard under the State Border Service (SBS)[17].

Azerbaijan's energy system is composed of three interconnected components. There are

Picture 1: The Deep water Gunashli platform, offshore Azerbaijan.

Source: Media Library Preview. BP

energy extraction infrastructures (onshore and offshore), energy export infrastructures (BTC and BTE pipelines) and the Sangachal Terminal. BP is operating the offshore platforms which account for the main part of Azerbaijan's total energy production. Onshore, BTC and BTE are the most significant pipelines in terms of volume transported per day (see Tables 1&2) and they both originate from Sangachal Terminal, where offshore oil and gas is processed prior to export[18][19]. The combined control building in Sangachal Terminal is the centre of BP's operations from where the flow of oil and gas into the pipelines is controlled[20] . Consequently, any large scale attack on the terminal would have disastrous impacts. Indeed, the platforms,

14. Critical Infrastructure Protection: Strategies for securing gas pipeline infrastructure. In Global Gas transport. (2013)
15. Federal Emergency Management Agency. Organizational emergency response (N.D)
16. British Petroleum. BI in Azerbaijan Sustainability Report, p. 19 (2011)
17. Ibid.
18. British Petroleum. Annual Report and Form 20-F (2012).
19. B. Aslanbayli, Critical Infrastructure Aspects of Energy Security: Azerbaijan and Regional Market. (N.D)
20. British Petroleum. BTC pipeline Project Description, p.1 (2003)

the pipelines as well as the terminal represent a single and interconnected system. Therefore, if one part of that system was to be damaged, it would have an impact on the other parts as well.

Both British Petroleum and State Oil Company of Azerbaijan (SOCAR) operating the pipelines and terminals are responsible for the security of these facilities. The SSPS undertakes armed patrols along the BTC pipeline while pumping stations require stationary security[21] . As mentioned before, the personnel recruited to ensure the security along the pipelines are often locals as they are more inclined to acquire valuable information about possible attacks or threats. The SBS in cooperation with the Coast Guard and the NAVY usually undertake joint actions to protect the offshore infrastructure such as the platforms and the underwater pipelines. Nevertheless, the different areas of responsibility have to be clarified to avoid any redundancy of the patrols. Therefore, adequate training in cooperation with NATO allies could enhance the operability of the different teams responsible for CEIP in Azerbaijan. Consequently, NAVY and Coast Guards are expected to participate to exercise, which will test their capacities to response to different scenarios such as the attack of a platform or the discovery of a mine on one of the underwater section of the pipelines.

In Georgia, BP is also operating the main energy infrastructures such as BTC, BTE and Baku-Supsa pipelines. Considering the great amount of energy resources that they transport (see table 1&2), disruptions or any acts of violence undermining the good functioning of the infrastructure would have a dramatic impact on Georgia who benefits greatly from its position of transit country but also on the countries downstream. For example, during the unrest of the brief Russian-Georgian war in 2008, the PKK attacked a Turkish section of the pipeline, which resulted in its shutdown for more than ten days accounting for a loss of $ 300 000/day downstream[22].

The BTC and SCP pipelines run side by side for 248 kilometres within Georgia and are under the responsibility of the Strategic Pipeline Protection Department operating under the Ministry of Foreign Affairs of Georgia[23]. However, the security of the Baku-Supsa pipeline is ensured by the Special Task Force Police who is fully responsible for the pipeline's safety and security[24]. The role of the SPPD is quite similar to the role of the Azeri's SSPS. Indeed, SPPD undertake patrolling along the energy infrastructure on a 24 hour basis. They have a constant control over the ways of access to the pipeline. Moreover, they control any persons moving on the pipeline territory. The SPPD is trained to react effectively in case of emergency[25]. They have developed an efficient cooperation between different departments such as Special Task Department, Intelligence Department, Patrol Police Department, etc.

BP's role in Georgia should not be underestimated. As we already noticed with the Azerbaijani case, BP has been involved in the early development of trainings and courses in order to ensure the security of the infrastructure that they operate on Georgian and Azeri territories. Moreover, the Georgians have developed specific trainings to ensure the readiness of their troops. Trainings entail the use of fire-arms, the ability to read maps and give first aids. Moreover, ever since 2006, special courses focusing on CEIP have been developed under the framework of NATO program.

21. British Petroleum. BTC Pipeline – Routine Operational Impacts and Mitigation, p.8 (2002)
22. Tsereteli, M. The Impact of the Russia-Georgia War on the South Caucasus Transportation Corridor. The Jamestown Foundation. (2008)
23. OSCE. Pipelines on Georgian Territory as a Part of the Euro-Atlantic Energy Infrastructure and the Issue of their Security, p.8 (2010)
24. BP operated interests in Georgia and its protection. BP in Georgia Sustainability Report (2011)
25. OSCE. Pipelines on Georgian Territory as a Part of the Euro-Atlantic Energy Infrastructure and the Issue of their Security, p.9 (2010)
26. Visit of the North Atlantic Council on 26-27 June, 2013.
27. Reuters. BP to buy stake in Azeri gas pipeline pro-

What is the rationale behind NATO's presence in South Caucasus?

The series of event that have been recently organized in Baku highlight the interest that Azerbaijan has for fruitful cooperation with NATO. Likewise, NATO team recent visit in Baku for informal talks on the modalities of setting up Azerbaijan's first Partnership Training and Education Centre (PTEC) highlights the willingness of NATO ENSEC COE to play a greater role in cooperation with partner countries. The Azerbaijani side expressed its interest in developing a course on CEIP and proposed to share their experience in this field. This appears as a good opportunity for NATO ENSEC COE to share its experience in Education and Training while Azerbaijan's knowledge in terms of CEIP would make a substantial contribution to NATO's approach towards emerging energy security challenges.

The PTEC could add value as the first centre to offer courses on CEIP open to a wider NATO and partner audience.

In terms of CEIP, it can be argued that NATO has a lot to learn from the developments in Azerbaijan and Georgia. Indeed, NATO could assess the way a private company (BP) has been able to cooperate with the state institutions in order to ensure the security of its infrastructure: such an efficient cooperation could be analysed and reproduced within NATO's framework with other Allies or Partner Countries. Notwithstanding, it could be argued that NATO's recent presence in Azerbaijan and Georgia[26] is not only related to CEIP. The latter is rather a common point of interest that brings together different actors pursuing distinctive goals.

Firstly, NATO countries energy companies have become increasingly involved in the Southern Gas Corridor region as the different pipelines that Europe relies on originate from Azerbaijan and pass through Georgia and Turkey, which is the closest NATO member. Therefore, it comes with no surprise that NATO countries companies (BP, Chevron, Total, Statoil) have come to join SOCAR in the BTC pipeline project. More recently, the gigantic TANAP project, which was at first a project financed by SOCAR and Türkiye Petrolleri Anonim Ortaklığı, has witnessed the willingness of BP to become one of the main partner of the project[27]. Moreover, the TAP project, which is of high importance to the NATO members in Western Europe, has seen the Swiss Axpo, E-On and Statoil composing the shareholding structure[28].

Secondly, it could be considered that Azerbaijan is not only willing to enter into this framework of cooperation for the sole NATO's good. It has been acknowledged that Azerbaijan has developed efficient ways to protect its energy infrastructure but why would they open themselves to NATO so easily? Why would they share so openly details of homeland security while it was argued that CEIP tended to remain a national responsibility? In this context it could be noticed that Azerbaijan shares common borders with Russia, Iran and Armenia. Hence, Azerbaijan's call for security comes with no surprise considering the recent conflicts close to its territory. As the security guarantees expressed under the Article 5 of the North Atlantic Treaty[29] only applies to NATO members, it may be presumed that Azerbaijan endeavours to sign another partnership agreement with the Alliance in order to further ensure its security while NATO members will be interested in enhancing the protection of the infrastructures which are indispensable for their energy supply[30]. In other words, Azerbaijan's strive for more than a consultative relationship with NATO and focus on CEIP could be also perceived as an attempt to foster new relations with NATO. Time has come for NATO to respond.

ject TANAP. (2013)
28. Statoil. E-on becomes new shareholder in Trans Adriatic Pipeline. (2010)
29. The North Atlantic Treaty. Art. 5 "The Parties agree that an armed attack against one or more of them in Europe or North America shall be considered an attack against them all and consequently they agree that, if such an armed attack occurs, each of them, in exercise of the right of individual or collective self-defence recognised by Article 51 of the Charter of the United Nations, will assist the Party or Parties so attacked by taking forthwith, individually and in concert with the other Parties, such action as it deems necessary, including the use of armed force, to restore and maintain the security of the North Atlantic area" (1949)
30. B. Aslanbayli, Critical Infrastructure Aspects of Energy Security: Azerbaijan and Regional Market. (N.D)

Conclusion

Ever since the adoption of its strategic concept during Lisbon summit in 2010, NATO has acknowledged that it would enhance consultations and cooperation with partner and other international actors and integrate energy security considerations in NATO's policies and activities. Indeed, energy has become a mainstream NATO issue. This argument can be supported by the increased cooperation between NATO and partner countries reflected by the organization of a series of events in the South Caucasus Region. This region has become of great importance for Europe as it represents its main possibility to diversify its energy supplies. This argument has been underlined by the numerous projects that have seen the light of day in the Southern Gas Corridor. Consequently, the involvement of NATO countries energy companies in South Caucasus comes with no surprise as NATO members will be interested in enhancing the protection of the infrastructures which are indispensable for their energy supply. The developments that have been made in terms of protection of critical energy infrastructure in Azerbaijan and Georgia under BP's supervision should be of great interest to NATO as they represent an efficient cooperation between public and private actors in ensuring security. Nevertheless, it seems that Azerbaijan is not only sharing details of its homeland security for NATO's own good. Indeed, it could be argued that Azerbaijan aspires to revise its Partnership with NATO in order to acquire further guaranties, which are fundamental for its security considering its common borders with Russia, Armenia and Iran.

Setting databases – another way to prevent attacks against the energy infrastructure?

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On October 7 Colombia state-owned oil company Ecopetrol (the seventh most valuable producer in the world in 2012) announced the shutdown of some of its pipelines, including country's second largest crude oil pipeline, due to violent attacks carried out by left-wing guerrilla groups in Santander and Bolivar provinces (Northern Colombia)[1]. Aside from the damage, a serious question has to be answered - was it possible to predict and prevent such attacks avoiding the supply disruptions of significant amount of crude oil? If so, who is working on monitoring and analysis of such attacks worldwide or is it pure responsibility of the owners of such infrastructure?

"Expected unexpected" in Colombia?

As noted by Bloomberg, Ecopetrol is known as the oil company, which "turned decades-old fields in areas once overrun by guerrillas into drivers of double-digit output growth".[2] In this context there is no surprise that the rising profit of the „best-performing major oil company" made it a target for attacks, extortion and kidnapping. In particular, guerrillas seek for new revenue sources after a government crackdown on cocaine production and this resulted in increased threats to energy infrastructures. According to the president of Ecopetrol, there were 109 attacks aimed at the oil sector in Colombia in 2012,[3] thus impacting production and supply.

Lack of security can deter investments into infrastructure,[4] the presence of which is directly related to companies' oil production goals and global supply needs. President of Ecopetrol revealed a plan to invest $359 million in 2013 "to guarantee the integrity of the energy transport infrastructure" . Nevertheless, at the end of 2013 pipeline that carries 15,000 barrels-per-day was wrecked by two explosions and went out of order. In addition, several explosions damaged gas and crude oil pipelines in Cantagallo, forcing to close 30 wells with production capacity of 5,000 barrels per day. It seems that in addition to traditional measures (physical, cyber and other "concrete" measures of protection), the research sector also has something to offer in this regard.

1. Explosions knock out Colombia's Ecopetrol pipelines, some wells. For details see: http://www.globalpost.com/dispatch/news/thomson-reuters/131009/explosions-knock-out-colombias-ecopetrol-pipelines-some-wells
2. For details see: http://www.bloomberg.com/news/2012-07-09/ecopetrol-beats-top-global-oil-companies-as-rebels-loom.html
3. For details see: http://colombiareports.co/attacks-in-2012-cost-9559-barrels-of-oil-ecopetrol/
4. For details see: http://colombiareports.co/attacks-in-2012-cost-9559-barrels-of-oil-ecopetrol/

Importance of the focused attention

Armed aggression related vulnerabilities and threats to energy infrastructure are familiar to NATO as security Alliance: as it was recognized in the latest Chicago Summit (2012), "energy security with increasing aspect of critical infrastructure protection has the impact on total security level for NATO countries dependent on energy import". In other words, nobody doubts inside NATO that a chain of logistical supply for the operation could be overset because of attacks over energy supply infrastructure, management system or strategically important delivery routes, air and sea ports, etc. In this context it is recognized that diverse nature of attacks and lack of analysis determine the unpreparedness of NATO to react to these events.

On the one hand, risks are possible to identify, they do determine real damage and the most powerful military Alliance does see its role in tackling these issues. On the other hand, attacks on energy infrastructure are still lacking adequate and comprehensive worldwide cataloguer, analysis and clearly articulated proposals on how to deal with the challenges. The scarcity of data about periods of attack and absence of most useful methods to mitigate negative consequences remains an undisclosed area for the scientists and is great disadvantage for the Armed Forces. Development of such knowledge would increase understanding of energy infrastructure attack waves and positively influence on an efficiency of operational planning process and supply chain. In other words, everyone would benefit from the increasing attention to the issue, but someone should elevate the monitoring-analysis-research-proposals process to another level.

Major monitoring and analysis initiatives

It would be false to presume that attacks on energy infrastructure are lacking any adequate cataloguer or analysis. For example, the Global Terrorism Database (GTD) provides a comprehensive resource on reported terrorist threats, some of which include threats to energy infrastructures (often coded under 'utilities'). In addition, in the last decade there have been a number of reports and analyses examining terrorist threats to energy infrastructures. However, the Energy Infrastructure Attack Database (EIAD) offers a sector specific dataset. EIAD is a resource developed through the Targeting Energy Infrastructure (TEI) project at the Center for Security Studies (CSS), ETH Zurich in collaboration with the Technology Assessment (TA) Group of the Laboratory for Energy Systems Analysis (LEA) at the Paul Scherrer Institute (PSI). It is a compilation of data from 1980 through 2011 on reported (criminal and political) attacks/threats to energy infrastructures by non-state actors.[5] Analysis of EIADs data, conducted by CSS and PSI, reveals the broad distribution of attacks as well as the density of threats. To illustrate, image 1 (Giroux and Burgherr, 2012) maps some of the incidents contained in EIAD (excluding the incidents recorded in the US)[6], not only revealing patterns of targeting density but also highlighting some of the more sensitive or vulnerable energy transportation routes. Overall, this kind of knowledge about the type and target of attacks as well as their location is relevant for both scientific purposes and practices. It can enhance situational awareness and increase understanding of the threat and thus improve efficiency of operational planning process.

5. For information and access to EIAD, see: http://www.css.ethz.ch/research/research_projects/index/EIAD
6. Jennifer Giroux and Peter Burgherr (2012). Canvassing the Targeting of Energy Infrastructure: The Energy Infrastructure Attack Database. Journal of Energy Security, July. Found: http://www.ensec.org/index.php?option=com_content&view=article&id=379:canvassing-the-targeting-of-energy-infrastructure-the-energy-infrastructure-attack-database&catid=128:issue-content&Itemid=402
7. Ibid
8. See: http://www.css.ethz.ch/research/research_projects/index/EIAD
9. Ibid

Energy infrastructure attack rate and intensity

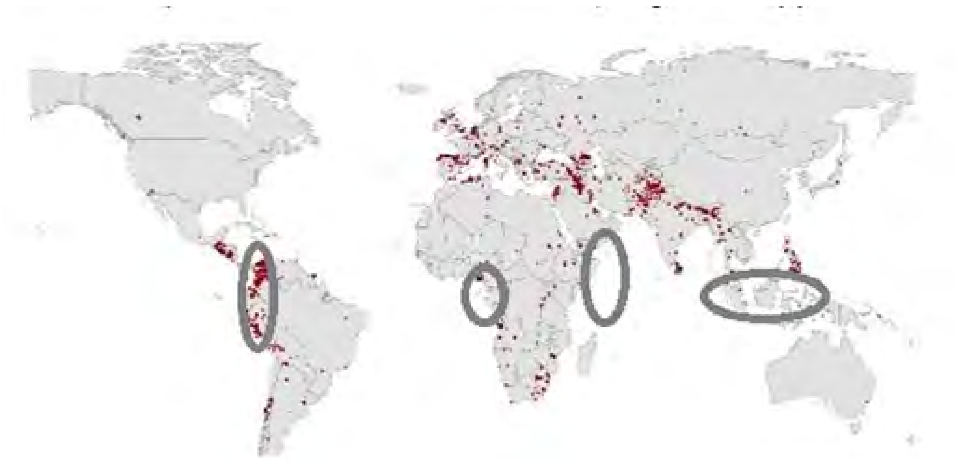


Image 1: Jennifer Giroux and Peter Burgherr (2012). Canvassing the Targeting of Energy Infrastructure: The Energy Infrastructure Attack Database. Journal of Energy Security, July

Valuable findings empowered by EIAD

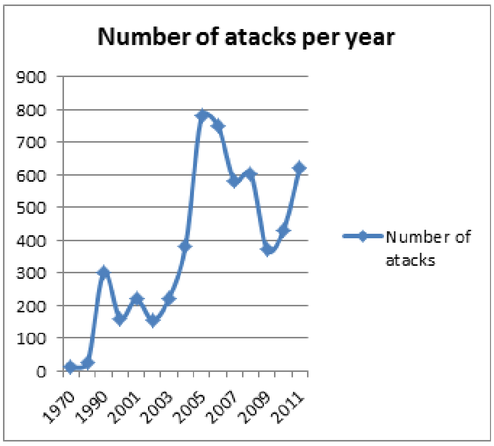
EIAD collects the information on attacks or attempted attacks (successful, unsuccessful and threats) aimed at energy infrastructures defined as "all human (energy sector personnel), physical (energy sector physical assets) and information (energy sector cyber systems supporting operations) infrastructures in the following core energy sectors: Biomass, Coal, Geothermal, Hydropower, Natural Gas, Nuclear, Petroleum, Solar, and Wind."[8] Information is coded into categories and sub-categories, such as incident date, incident location, also information on incident, attack, target, perpetrator, consequences (casualties & fatalities, hostage info), etc.[9] EIAD contains over 8000 incidents that span a 30 year period (1980-2011). Analysis carried out by Giroux and Burgherr (2012) notes that 3500 of these attacks took place between 2000 and 2011 (Image 2), which they attribute the increase in attacks to a number of factors, namely the growing instability of oil and gas producing/exporting regions as well as the contagion of violent activity in such regions. For instance, before 1999 the average annual occurrence of accidents was less than 200, but this average has increased to more than 350 per year. In particular, 2011 was significant in that it was marked with more than 600 attacks aimed at energy infrastructure, most of which occurred in Colombia, India and Afghan-Pakistan border. It's critical to note here that many of these attacks (40%) are part of a multiple attack. EIAD codes multiple attacks that involve related and coordinated attacks by a perpetrator. For example, if four bombs explode nearly simultaneously along different parts of an oil pipeline in one city it is recorded as four separate but related incidents. Consequently, not only does the aforementioned attack in Colombia fits into the larger pattern of EI targeting in this country but also the increasing threat to energy infrastructures has implications for recourse supplies for the countries of the Alliance and military theatre performance.

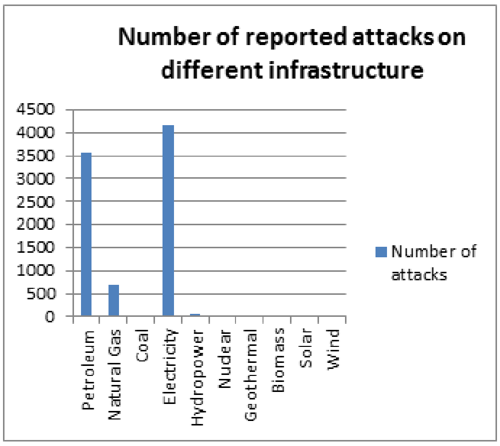
Another interesting finding from Giroux and Burgherr's analysis is that EIAD's data show that from 1990 to 2011 the most intensive waves of attacks were happening in the regions affected by internal or external conflicts: late 1990s to 2002 was the case in Colombia, early 2000s to 2005 - in Malacca Straits (Indonesian based), 2003-07 - in Iraq, 2006-09 - in Nigeria, 2007 – 2011 - in Gulf of Aden, Indian Ocean and Arabian Sea, 2008-2011 - in Afghan-Pakistan (with

10. Ibid
11. The full analysis of this study will be published in early 2014.
12. Raymond Gilpin, Jennifer Giroux, Fatima Kyari Mohammed and Shadé Brown (2012) Regional Security Lessons from the Attack on Algeria's In Amenas Gas Plant. USIP Olive Branch. Found: http://www.usip.org/olivebranch/regional-security-lessons-the-attack-algerias-in-amenas-gas-plant

smaller clusters of EI targeting in India and Colombia) and 2009-Present - in Gulf of Guinea. Analysis also demonstrates that majority of incidents occured at oil and gas infrastructure – primarily pipelines and mobile energy targets such as tankers and personnel, all of which are difficult to protect especially in a challenging environment. Electricity infrastructure is also frequently targeted and there have been some attacks aimed at hydropower facilities.

Image 2: Figures adapted from - Jennifer Giroux and Peter Burgherr (2012). Canvassing the Targeting of Energy Infrastructure: The Energy Infrastructure Attack Database. Journal of Energy Security, July[10]





Augmentation of the energy infrastructure attacks and most often targets

Other research initiatives

In collaboration with the efforts at CSS, ETH Zurich and PSI to examine the targeting of energy infrastructure, in 2012 the US Institute of Peace (USIP) Center of Sustainable Economies supported further analysis of EIAD's data as well as case studies on global patterns of energy infrastructure attacks.[11] According to Gilpin et al (2012), preliminary insights from the USIP project show that attacks on energy infrastructure tend to happen in waves and cluster in areas of instability.[12] Another interesting observation is made regarding the targets: transport infrastructures in the oil and gas sector are often attacked because they are usually away from administrative centers, easily accessible, and high-value. The authors note that continuity of support and engagement with local communities (in areas where energy infrastructures are vulnerable) as well as deeper understanding of the threat will help to mitigate attacks.

In terms of other database efforts, the Paul Scherrer Institute /PSI (also based in Switzerland) has created Energy-related Severe Accident Database (ENSAD), which demonstrates another interesting tendency in the area of critical energy infrastructure – increasing share of man-made accidents in comparison to natural disasters. Further, the aforementioned Global Terrorism Database is a useful resource for examining terrorist incidents and also exhibits a tendency for attacks to cluster in certain areas.[13] Alongside with databases the Supervisory control and data acquisition (SCADA) technology should be also mentioned. It has evolved over the past 30 years as a method of monitoring and controlling large processes: SCADA systems are generally used to control dispersed assets using centralized data acquisition and supervisory control. Recently an attack using Stuxnet virus for purpose of intellectual property theft and espionage has been recorded. This incident is one of the examples of cyber crimes on energy infrastructure. Categorizing of cyber-crimes is another issue. It faces the difficulty of source identification because of existing challenges related to labeling it as intention of state or non-state actors.

13. Global Terrorism Database. Found: http://www.start.umd.edu/gtd/search/Results.aspx?chart=attack&search=marathon

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