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EUROPEAID/120569/C/SV/MULTI

Regulation on the Transport of Dangerous Goods along the TRACECA Corridor

Azerbaijan, Georgia, Kazakhstan, Turkmenistan and Ukraine

Working Paper 3 Transport Facilities Appraisal Report

May 2007

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Abbreviations

BAP	Burgas- Alexandroupolis pipeline
BLEVE	Boiling Liquid Expanding Vapour Explosion
CIS	Commonwealth of Independent States
CSC	Caspian Shipping Company
EC	European Commission
EU	European Union
Ft	Feet
kT	Thousand Tonnes
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
mT	Million Tonnes
MTCE	Maintenance
RTC	Rail Tank Car
TAP	Trans-Anatolian Pipeline
TCO	Tengizchevroil

1 Introduction

1.1 Background

This Working Paper 3 is part of a series of Working Papers that are prepared as part of the project *Regulation on the Transport of Dangerous Goods along the TRACECA Corridor*. The specific objective of the project is to provide a pre-feasibility study[1], which includes the technical, economic, financial, environmental and legal/institutional appraisal for the transport of Liquefied Petroleum Gas (LPG) through the TRACECA corridor.

This report focuses on the feasibility of transporting between 1.0 and 2.3 million tonnes per year of LPG on the TRACECA corridor, as established in Working Paper 2, considering the current and near future transport infrastructure, largely from a technical point of view. Together with working paper 4, which focuses on the safety requirements of LPG transport, it seeks to provide a major input for the overall (pre-)feasibility assessment of LPG transportation on the TRACECA corridor.

1.2 Objective of Working Paper 3

The objective of the report is to get proper insight in the technical feasibility and current prevailing situation of LPG transport on the TRACECA corridor, as well as the needed capacity improvements to cope with higher tonnage of LPG transported on the TRACECA corridor. In this report some initial and preliminary estimates are made of the possible cost level of LPG transport on the TRACECA corridor. All cost figures given at this stage in WP 3 are estimates and are still subject to possibly substantial fluctuations because :

- Published tariffs do not (always) contain all costs
- More comprehensive facts and figures will be obtained in the course of WP 6
- Significant price differences may occur depending on volumes shipped
- Long term loans at favourable interest rates provided for by EU bodies may change the finance cost calculation basis – e.g. longer pay back periods and lower interest rates allow for lower (and competitive) transport costs

The consultant is compiling the cost data base at this stage. This working paper and its initial cost assessment will provide the link with the financial-economic appraisal for the transport of LPG along the TRACECA corridor, to be dealt with in Working Paper 6. This working paper will also screen some important contextual aspects affecting the feasibility.

The LPG-supply side, in Kazakhstan and Turkmenistan, is potentially abundant as has been shown in Working Paper 1; the supply side is not likely to pose a constraint for project feasibility as long as LPG quality will conform to EU-standards.

The main challenge is to find the consumer markets at the western ends of the TRACECA corridor, as scanned in Working Paper 2, and this is largely dictated by the 'door-to-door' transport costs, from the site of the LPG producer in the East to the final consumers in the West. Estimation of realistic door-to-door or 'total chain' transport cost is therefore considered the project's most critical activity.

The TRACECA corridor's potential for LPG transports will be evaluated by comparing the project' cases with 'Base' cases as summarized in Table 1.1, which was presented earlier in the Inception Report (page 13) but has been slightly adapted as concerns both Kazakhstan and Turkmenistan.

[1] The Inception Report defines the pre-feasibility status.

Table 1.1 *Definition of base and project cases*

Production	Corridor	Consumption
Kazakhstan	**Base case:** From LPG loading stations in Kazakhstan by rail Kazakhstan- Russian rail-Black Sea via Odessa (today) or via Temruk/Safinat (near future)[2] **Project case:** From LPG loading stations in Kazakhstan to Aktau Caspian-TRACECA rail-Black Sea	Turkey Eastern Balkans, and optionally Central Europe via Ukraine
Turkmenistan	**Base case = Project case[3]:** Turkmenbashi Caspian-TRACECA rail-Black Sea Modernisation of existing corridor	Turkey Eastern Balkans, and optionally Central Europe via Ukraine
Azerbaijan	**Base case = Project case:** Baku-TRACECA rail-Black Sea Modernisation of existing corridor	Turkey Eastern Balkans, and optionally Central Europe via Ukraine

1.3 Contents of the paper

The second chapter of this report concentrates on general remarks on the transport, storage and handling of LPG, including a description of LPG transport equipment and operational cost elements of this equipment.

In chapter 3 the existing situation of LPG transport on the TRACECA corridor is described, with a focus on transport originating from Turkmenistan and Kazakhstan, as well as the needed increase in transport capacity to cope with future flows of LPG, as outlined in Working Paper 2. Chapter 4 then presents initial LPG TRACECA transport chain cost estimates Kazakhstan/Turkmenistan-Black Sea as an input for the later economic analysis. In Chapter 5 some specific aspects are discussed that might affect the feasibility of LPG transport in the TRACECA corridor, e.g. further restrictions on the transport of dangerous goods on the Bosporus. Chapter 6 presents conclusions.

[2] Alternatively: from LPG loading stations in Kazachstan to Aktau - Caspian (Makhachkala)-Russian rail-Black Sea via Taman/Oteko and/or Temruk/safinat (future)
[3] LPG exported South from Turkmenistan to Iran may substitute for Iran exports to Turkey (LPG 'swap') but this is not considered to be part of the base case

2 LPG Logistics

2.1 General remarks on transport, storage and handling

2.1.1 Transport of LPG

LPG is a dangerous, very light product and can only be transported under high pressure and/or low temperatures. All means of transport, either Rail Tank Cars (RTC's), LPG Trucks, LPG containers or LPG vessels must incorporate :

- Closed systems
- Specially designated tanks and safe surroundings throughout

LPG is carried by sea in large quantities. An LPG vessel carries the gas as a liquid. This liquid may be under pressure, semi-pressurised or fully refrigerated. Large gas carriers, engaged on international trade and which transport the vast majority of LPG, may carry on average 80,000 cubic metres of LPG. Generally this will be in a fully refrigerated state where the cargo is cooled to boiling or bubble point, and the cargo is kept cool by the re-liquefaction of the vapours produced once the LPG is in the cargo tanks. Carriage temperatures are around minus 44 degrees Celsius for propane and minus 5 degrees Celsius for butane.

More on LPG transport equipment is presented in Section 2.2.

2.1.2 Storage of LPG

The storage and transportation of LPG imposes stringent technical requirements. The tank's material must be carefully selected, systematic quality checks must be performed during manufacturing and comprehensive tests must be performed on completed tanks. LPG Tank Specifications are presented in Table 2.1.

Table 2.1 *LPG Tank Specifications*

Category	**Specifications**
Pressure vessel standard	ASME Section VIII - Division 1 and DOT MC-331 (*for LPG Transport Tank only*)
Materials of shell and tank head	SPV-490 Q, JIS 3115, ASTM-517 B or equivalent
Interior finishing	sandblasted + LPG resistance coated
Exterior finishing	sandblasted + epoxy primary coated + polyurethane coated

Figure 2.1 *LPG storage tanks up to. 3,000 mT - common type in the West ('sphere')*

Figure 2.2 *LPG storage tanks of approximately 1,000 mT - common type in the CIS ('cigar')*

2.1.3 Handling of LPG

LPG containers – i.e. any type of steel LPG tank/RTC/Tank container which can handle LPG - when subjected to fire of sufficient duration and intensity can undergo a boiling liquid expanding vapour explosion (BLEVE). This is typically a concern for large refineries and petrochemical plants that maintain very large containers. The remedy is to equip such containers with a measure to provide a fire-resistance rating. If the containers are cylindrical and horizontal, they are referred to as "cigars", whereas circular ones are "spheres". Large, spherical LPG containers may have up to a 15 cm steel wall thickness. Ordinarily, they are equipped with an approved pressure relief valve on the top, in the centre. One of the main dangers is that accidental spills of hydrocarbons may ignite and heat an LPG container, which increases its temperature and pressure, following fundamental gas laws. The relief valve on the top is designed to vent off excess pressure in order to prevent the rupture of the tank itself. Given a fire of sufficient duration and intensity, the pressure being generated by the boiling and expanding gas can exceed the ability of the valve to vent the excess. When that occurs, an overexposed tank may rupture violently, launching pieces at high velocity, while the released products can ignite as well, potentially causing catastrophic damage to anything nearby, including other tanks.

In the case of "cigars", a midway rupture may send two "rockets" going off each way, with plenty of fuel in each to propel each segment at high speed until the fuel is spent.

Mitigation measures include separating LPG tanks from potential sources of fire. In the case of rail transport, for instance, LPG tanks can be staggered, so that other goods are put in between them. This is not always done, but it does represent a low-cost remedy to the problem[4]. LPG railcars are easy to spot from the relief valves on top, typically with railings all around.

In the case of new LPG containers, one may simply bury them, only leaving valves and armatures exposed, for easy maintenance. Great care must be taken there though, as mechanical damage has been known to occur to the primers, which has resulted in hazardous corrosion of the containers. For the buried container, only the exposed parts need to be treated with approved fireproofing materials, such as intumescent and or endothermic coatings, or even fireproofing plasters. The rest are amply protected by soil. Speciality removable covers exist for easy access to the dials and components that must be accessed for proper maintenance and operation of the equipment.

LPG containers are subject to significant motion due to expansion, contraction, filling and emptying – even with very thick steel walls. This operational motion makes the burial option less attractive in the long run because one cannot tell mechanical damage to the outer waterproofing through soil. A simple pebble scraping back and forth across the epoxy-painted hull can remove the waterproofing and be the cause for corrosion.

Whilst one may calculate and justify on paper the use of inorganic plasters to cover entire spheres, it can be difficult to keep plasters operable for extended periods of time. Major errors have also been made in the past in this field, as the presumption was that the steel substrate would be adequately protected from rusting through the use of alkaline plasters. The alkalinity in such plasters is due to the presence of cement stone. This alakalinity, however, does not typically have a permanent character, which means that waterproofing with high quality epoxy primers is very important. Also, exterior waterproofing of the plaster is required by some fireproofing plaster vendors, as reduced alkalinity in exposed plasters can have a deleterious effect on the cement stone, which binds the plaster in the first place. By contrast, the intumescent and endothermic coatings are usually epoxy based to begin with, meaning that corrosion of the substrate is no problem whatsoever.

Fireproofing, not unlike all passive fire protection products, is subject to stringent bounding. The problem with this is though, that exterior structures of this nature are not subject to the building code or the fire code, meaning that one still sees the majority of LPG containers without any fireproofing at all, as there are often no local regulations, let alone any Authority-with-Jurisdiction, apart from an insurance inspector, to force owners to use the proper mitigation methods. Insurance companies are also in a competitive quandary, where such items are concerned, as they compete not only on the basis of rates, but also on the strictness of the demands by their inspectors. LPG vessel fireproofing tests are varied. The only realistic exposure offered is done at e.g. the Braunschweig test facility of "BAM" Berlin [2]. BAM's procedure is to expose a small LPG container to the hydrocarbon test curve and to quantify the results. North American methods are based on UL1709. While UL1709 uses the correct time/temperature curve for testing, it is limited to testing steel columns, whereas BAM actually exposes a real LPG container that has been fireproofed. No matter the fireproofing method one uses, it is very important to pay close attention to bounding and to be sure that the product one chooses has undergone product certification, whereby the original test included the environmental exposures that the product will be exposed to during operations. Particularly with organic products, such as the endothermic and intumescent ones, one must closely review the ageing criteria and be able to quantify how long the product is expected to be operable for. This is where UL1709 "shines". Anything that can withstand the full battery of environmental exposures prior to the actual fire test, is a very tough product indeed. The idea is to rule out conditions that may render the product inoperable before it is ever exposed to a fire. By using products that have received the appropriate environmental tests

[4] However, it will raise unit transport costs in comparison with those of LPG shuttle block trains.

FIRST, and the fire expose afterwards, using the very same test sample with all the applicable exposures, one can then demonstrate due diligence, but not otherwise. Likewise, the DIBt ageing qualifications for intumescents have proven to be very reliable. With close attention to the bounding and coverage of ageing and environmental exposures, it is absolutely possible to buy a lot of time for firefighting measures to relieve the LPG containers of the energy exposure from accidental fires and thus reduce the likelihood of a BLEVE to the maximum possible extent.

All this goes to show the complexity and thus the costly side of LPG handling along the door-to-door transport chain.

2.2 LPG transport equipment for East-West transport

This section describes equipment that is considered to be suitable for safe Butane and Propane transports from the CIS states to western European countries, including price indications. More details, including regulations on dangerous goods transport 'governing' equipment design and requirements, are contained in a separate report[5].

2.2.1 Rail tank wagon

The construction and operation of Rail Tank Cars (RTCs) is subject to the "Règlement concernant le transport International ferroviaire des marchandises Dangereuses" (RID) for rail transports. They are available in Europe with capacities ranging from 85 – 120 cub.m (carrying 40 – 60 tonne LPG mix, Propane or Butane). A new, largest capacity RTC (120 cub.m) is currently costing about € 140,000 in Europe. The consultant will further investigate if there may be a second-hand market in Europe of RTCs useful in CIS/RF when adapted to wide gauge rail infrastructure. Indications though are that this may be difficult due to different technical load and discharge systems.

Ukrainian-made RTCs for LPG with carrying capacity in the range 31-40 tonnes seem to be significantly cheaper, in the price range of US$ 65-75,000.

2.2.2 Container on flat-bed rail car

Another possible way to transport LPG (mix), Butane or Propane in an adequate way is by using tank containers. The construction and operation of this type of equipment in general is subject to the ADR and RID regulations as well as to the "International Maritime Dangerous Goods Code" (IMDG) for combined transports involving all kinds of shipments.

One type is a 40ft tank container which is described as a *cylinder pressure tank built in a 40' ISO-beam frame*, and additionally equipped with 20' contact angle according to UIC special steel E STE 420, with sun blind fitting and 6 baffles screwed. It has a maximum payload weight approx. 23.4 tonne LPG (up to 50 m³). Its tare weight is 9.8 tonnes and the tank container has an overall weight limitation is 34 T. Its acquisition value in West Europe is about € 85,000.

The alternative is a 20ft tank container described as a *cylinder pressure tank built in a 20' ISO-beam frame*, with fitting for sun blind and 2 baffles screwed. Maximum payload weight is approximately 11.7 tonne LPG (25 m³). Its tare weight varies between 6.4 and 7.7 tonnes and the overall weight limitation is 20 Ton. Its acquisition value in West-Europe is approximately € 40,000. A cheaper alternative of a 20ft tank container is offered from Estonia, at a cost of about € 25,000.

Two or even three 20ft tank container could be carried on a flat-bed rail car. A new Russian flat-bed rail car would cost about US$ 40,000.

[5] See dedicated report on Modern LPG equipment, as prepared for this project.

The investment needed for a flat-bed rail car and three 20ft tank containers with a carrying capacity of 35 tonne (3 x 11.7 T) would thus be at least € 110-120,000. What makes the flat-bed rail car with (three 20ft) tank containers[6] relatively very expensive, in terms of capital costs, is the long turn-around (door-to-door) time of tank containers delivered at the door of the client and then to be returned to the place of production.

Box 2.1 *Costs of tank container transport Kazakhstan-Balkans*

For example, tank containers between Tengizchevroil (Kazakhstan) and a client in the Balkans, carried on (different, local) flat-bed cars on stretches in (i) Kazakhstan, (ii) Baku-Black Sea, and (iii) the Balkans and handled via (4) container terminals at say Aktau, Baku, a Georgian Black Sea port and a Bulgarian or Romanian Black Sea port while being carried across the Caspian and Black Sea in (the cheapest possible) containers ships[7], are likely to take 40 -55 days (4 days in Kazakhstan, 1,5 days cross-Caspian Sea; 4 days Georgia; 3 days cross-Black Sea, 3 days at the customers, plus backhaul and reserve time) for the round-trip, supposing that the total transport chain will be controlled by one and the same operator. This implies that already expensive containers will have a very low utilization rate of 6-7 times per year, and therefore very high annual capital costs.

2.2.3 LPG transhipment terminal

A typical LPG transhipment terminal, i.e. rail-to-terminal and terminal-to-tanker ship, has the following main 'operational performance' characteristics (with specific focus on operational steps and establishing a rough indication of costs involved):

- Annual design throughput: 200-300,000 tonne (first stage)
- Storage: one large tank (7,000-11,000 cubic metre, say 3,300-5,000 T) and/or flexible number smaller tanks (2,000 cubic metre, say 950 T each) - various smaller tanks is the most usual concept.
- Relation between Annual design throughput and Storage capacity: turnover of storage capacity 30-40 – i.e. an average 3 turnarounds of LPG capacity per month
- Train reception facility: 2x20 RTCs maximum (18 m length)
- Train unloading time: about 8-16 hours per block train of 35-45 RTCs.
- About 250 trains and 10.000 RTCs handled per year (average)
- Tanker vessel reception facility: desired draught 12 (m) (minimum 6-9) and carrying capacity 20 KT (minimum 5-10)
- Tanker vessel loading time: 1 day
- Number of LPG-tanker vessels handled: 50-100 per year (average)
- All in investment costs: US$ 25-45 Mio.
- All in annual operating cost: US$ 900.000-2 Mio. p.a.
- Estimated handling costs/prices per tonne LPG: US$ 18-30 MT

[6] A main advantage of containers, i.e. pressure tanks in a (20 or 40 ft) ISO-beam frame, is the certainty about the product's quality for the client, because the LPG is carried door-to-door in the same container without intermediate handling.

[7] LPG containers are normally allowed on 'liner' ships, albeit on-deck and 'on-top'.

Figure 2.3 *LPG vessel loading – special loading arm device*

2.2.4 Road tractor with semi-trailer—tankers or carrying LPG-container

This type of transport concerns normally[8] the stage of final delivery to client.
The construction and operation of specialised semi-trailers for Propane and Butane gases in general is subject to the European regulation "Accord européen relatif au transport international des marchandises Dangereuses par Route" (ADR) for road transports.

A Semi-Trailer tanker with 50-60 m^3 nominal contents (23.5-28 T load capacity) will cost about € 127,000 in West Europe. A 40 ft chassis to carry one 40ft or two 20 ft LPG containers will cost approximately €30,000 while the cheaper 20 ft LPG containers will cost € 25,000 each, i.e. € 80,000 capital costs for the semi-trailer with two 20 ft containers, less expensive than the semi-trailer tanker. In both cases, a new truck-tractor pulling the semi-trailer would cost approximately € 90,000 in West Europe.

The complete (LPG road transport 'delivery') combination's new value will thus be in the range of € 170,000 (Semi-trailer plus two 20 ft containers) - € 217,000 (Semi-trailer Tanker).

[8] They could also be deployed at the producer's end to deliver the LPG to a railway head or a Caspian Sea port, albeit at a very high costs if the distance is significant.

3 LPG Transport facilities on the TRACECA corridor

3.1 General

Today (early 2007) all LPG transports to 'the West'[9] from Kazakhstan, a flow of some 60-80,000 ton/month[10], are carried via Russian rail. There are today no significant LPG transports across the Caspian seas. Chevron, as a key producer of LPG in the region, has so far refrained from LPG transport by rail ferry across the Caspian sea. Aktau port authorities have not actively pursued LPG transport, whereby it appears that Aktau port may now become more interested in this respect. In principle LPG rail ferry operations Aktau-Baku could be arranged under well-defined safety precautions and perhaps with 'minimal' ferry terminal (bridge) upgrading works. Reportedly however, any LPG Caspian port operations would be shifted to (yet to-be-build facilities at) Kurik, but this would need to be confirmed by high level Kazakhstan authorities.

Relevant for the TRACECA corridor is that Caspian Shipping Company (CSC) and Azerbaijan/Georgian Railways have agreed to haul some 18,000 T of LPG from Turkmenbashi to Georgia (Batumi). Two shipments of around 1,000 T—to be precise 980 T in 28 wagons carrying 35 T) each were completed by November 2006 when a 3rd one seemed to be ready but the operations were halted (by Azeri authorities) until clarification of the safety risks. Reportedly, the operations are to be resumed in 2007. Interestingly, LPG was transported earlier from Kazakhstan to Batumi in 2001/2002 and 2003. It seems that the currently better organized and economically equal or more attractive routes via Russia have drawn the transport flows away from the TRACECA corridor.

This chapter concentrates on the LPG transport facilities along the TRACECA corridor. An assessment is made of the current capacity, as well as the improvement that would be needed to cope with envisaged capacity requirements, as estimated in Working Paper 2, i.e. up to 1.0 (minimum) to 2.3 (maximum) million tonnes of LPG. The structure of this chapter follows the logistic chain from origin (production) to destination (consumer market).

3.2 LPG logistics in country of origin

3.2.1 Kazakhstan LPG Logistics

This section concentrates on the transport in Kazakhstan from the fields, e.g. TCO/Kulsary rail loading station, to the port, notably Aktau, in order for LPG to be transported across the Caspian Sea. Currently, LPG is exported via Russia. An overview of current LPG export routes is presented in Table 3.1.

[9] LPG transports to 'the East' (notably China) are not considered here.
[10] Typically in February 2007 (all from Tengizchevroil): more than 25,000 T to Poland and 4,000 T to Finland, 24,000 T to Odessa, and 23,700 T to Central Europe (Slovakia, Hungary and Romania); this represents about 40% of total LPG tonnage carried by RF rail.

Table 3.1 *Actual LPG Export routes ex Kazakhstan*

Name of GPP, station	Transportation route	Country of destination	Station of destination
Tengiz GPP (Kulsary station)	Russia, Byelorussia	Poland	St. Brest, st. Bruzgi, st. Izov, st. Svisloch, st. Yagodin.
Tengiz GPP (Kulsary station)	Russia, Ukraine Port of Odessa	Turkey	
Тенгизкий ГПЗ (станция Кульсары)	Russia, Ukraine	Romania	St. Djakovo
Tengiz GPP (Kulsary station)	Russia, Ukraine	Slovakia	St. Chop
Tengiz GPP (Kulsary station)	Russia	Finland	St. Buslovskaya
Pavlodar PCP, st. Pavlodar-Port	Russia, Byelorussia	Poland	St. Brest, st. Bruzgi, st. Izov, st. Svisloch, st. Yagodin.

The TRACECA route would take LPG by rail to Aktau (or alternatively to Kurik if in the future a LPG terminal would be constructed there, as discussed in Section 3.3). A block train system would need to be designed that meets the capacity of the rail ferries, as indicated also in Section 3.3. Whether a 'Block train fast shuttle service' between say Kulsary and Aktau for 28-40 RTC units – always meeting the schedule of the 28-52 RTCs loading ferry boats – could be made competitive, remains to be assessed[11].

3.2.2 Turkmenistan LPG Logistics

Today more than 90% of LPG produced in Turkmenistan is exported to Afghanistan, Iran, Turkey and Pakistan. In January 2007, 11,068 mT of LPG was exported. In 2007, Turkmenistan plans to export 140,500 mT of LPG.

Ongoing LPG related developments in Turkmenistan are highlighted as follows:

- The Turkish company "ALP SAN" is building a LPG terminal in the East of Turkmenistan (station Pelvert, Halach etrap, Lebap region). It is estimated to store 3,000 mT of LPG. It will be the part of the complex of LPG production, processing, storage and loading. LPG will be piped to the left coast of Amudarya. A pipeline will be build by "Caspro pipeline service AG" (Liechtenstein). Cost of these two constructions – approx. $ 16 mln.
- A new Complex for gas production and processing is intended to produce 50,000 mT of LPG, 200,000 tonnes gas condensate and 1 billion m3 of gas. Canadian company "Thermo Design Engineering LTD" is realizing this project, which will cost $ 42 mln.
- In 2006 the production of the gas-transferring complex in Bagaja, intending to produce 12,000 mT of LPG started. It was build by Canadian company "Thermo Design Engineering LTD" and Turkmen experts.
- In Spring 2006 the LPG storage and loading terminal of Serhetabad (Mary region), intended to store 1,200 tonnes of LPG also started operations. Terminal consists of platforms for load and out RTCs, pouring in auto cisterns, storage tanks. In Serakhs (Akhal region) a similar terminal was build. These two terminals were built by Iranian company "Pars Energy"
- In the Caspian Sea Port Kiyanly the company "Pars Energy" is constructing a Tank Farm with the capacity of 3,000 mT of LPG and a pier for loading in two vessels at the same time. Capacity of this terminal intended to reload 1,2 mln mT of LPG, directed to Europe. Setting in operation (starting) of this terminal is planned in 2008. In 2020 Turkmenistan intends to increase their production and/or export figures up to 2 million mT. The intention is to build up to 20 plants in the East of Turkmenistan. Turkmenistan provides its own RTCs for the transport of LPG.

[11] This will be subject in Working Paper6.

Latest sales for LPG out of Turkmenistan were effected on terms and conditions as presented in Annex 5. It appears that for the time being the 'offered' transport costs and conditions via the TRACECA corridor are nowhere near the competition from Iran and other neighbouring countries – thus there is no LPG transit cargo flow these days via Azerbaijan and Georgia other than the few 980 mT shipments in 2006/7 mentioned earlier.

3.3 The Caspian Sea crossing

3.3.1 Assessment of current LPG transport capacity

The current shipping situation in the Caspian Sea can be characterised as follows :

- Russian flag vessels cannot enter Baku/Azeri Ports.
- Azeri Flag vessels cannot pass the Volga Don channel (with cargo) and do basically not enter Russian Ports.
- Iran Flag vessels would have significantly lower port costs in Iran (than any foreign flag vessels).
- No LPG Tankers are operating in the Caspian Sea – because no LPG loading/discharging terminals are available.

Specialized rail ferries
Presently, the following specialized rail ferries are available in the Caspian Sea which can carry LPG between the rail/ferry ports of Aktau and Turkmenbashi on the east and loading side of the Caspian Sea to Mahachkala and Baku being west of the Caspian Sea and unloading site:

Caspian Shipping Company
Caspian Shipping Company (CSC) owns seven, relatively old and small ferries ('Dagestan' type). Two of them have been rebuild (ventilation systems) to carry LPG (though it is unlikely that the more severe western safety standards can be met). The ferries operate between Aktau/Turkmenbashi and Baku.

These are the seven ferries:
1. "Dagistan" – 8212544
2. "Mercury-1" – 8212568
3. "Akademik Topchubashov" – 8212570
4. "Azerbaijan" – 8212582
5. "Akademik Hesen Aliyev" – 8212594
6. "Professor Gul" – 8225371
7. "Nakhchyvan" – 8225383

Figure 3.1 *Rail ferry Caspian Shipping Company*

The ferries intended for wagons , trailers , cars and passengers shipment. Specifics of the rail ferry, type Dagestan are presented in Table 3.2.

Table 3.2 *Characteristics railroad sea cargo-passenger ferries, type "Dagestan"*

КМ * П4 I СПА (oil tanker) Class of the USSR Register of shipping						
LENGTH OVERALL	M	154,47	REGISTER TONNAGE	GROSS TONNAGE	GRT	11,200
				NET TONNAGE	NRT	
BREADTH MOULDED	M	18,30	OUTPUT		EHP	2x7,395
DEPTH MOULDED	M	13,45	BUNKERS		T	190
MEAN LIGHT DRAUGHT	M	2,86		CARGO CAPACITY		
MEAN LOAD DRAUGHT	M	4,25/4,50	CARS OF "LADA" TYPE		q.ty	70
LIGHT DISPLACEMENT	T	5400		PASSENGERS CAPACITY		
FULL DISPLACEMENT	T	8800	BERTHS		pers.	84
DEADWEIGHT	T	3367/3950	SEATS		pers.	118
TONA PER 1 CM OF DRAUGHT	T	23	TOTAL		pers.	202
SAILING RANGE	ml	1000				
SPEED	KN	17,15				

Safinat Group

Four ferries (new and larger) owned by the Russian private group Safinat are operating between Turkmenbashi/Aktau and Makhachkala (RF). These Russian Ferries can carry up to 52 RTCs as compared to the type “Sovetski Dagestan” that Caspian Shipping owns with a capacity for ferrying 28 RTCs.

Figure 3.2 *Rail ferry*

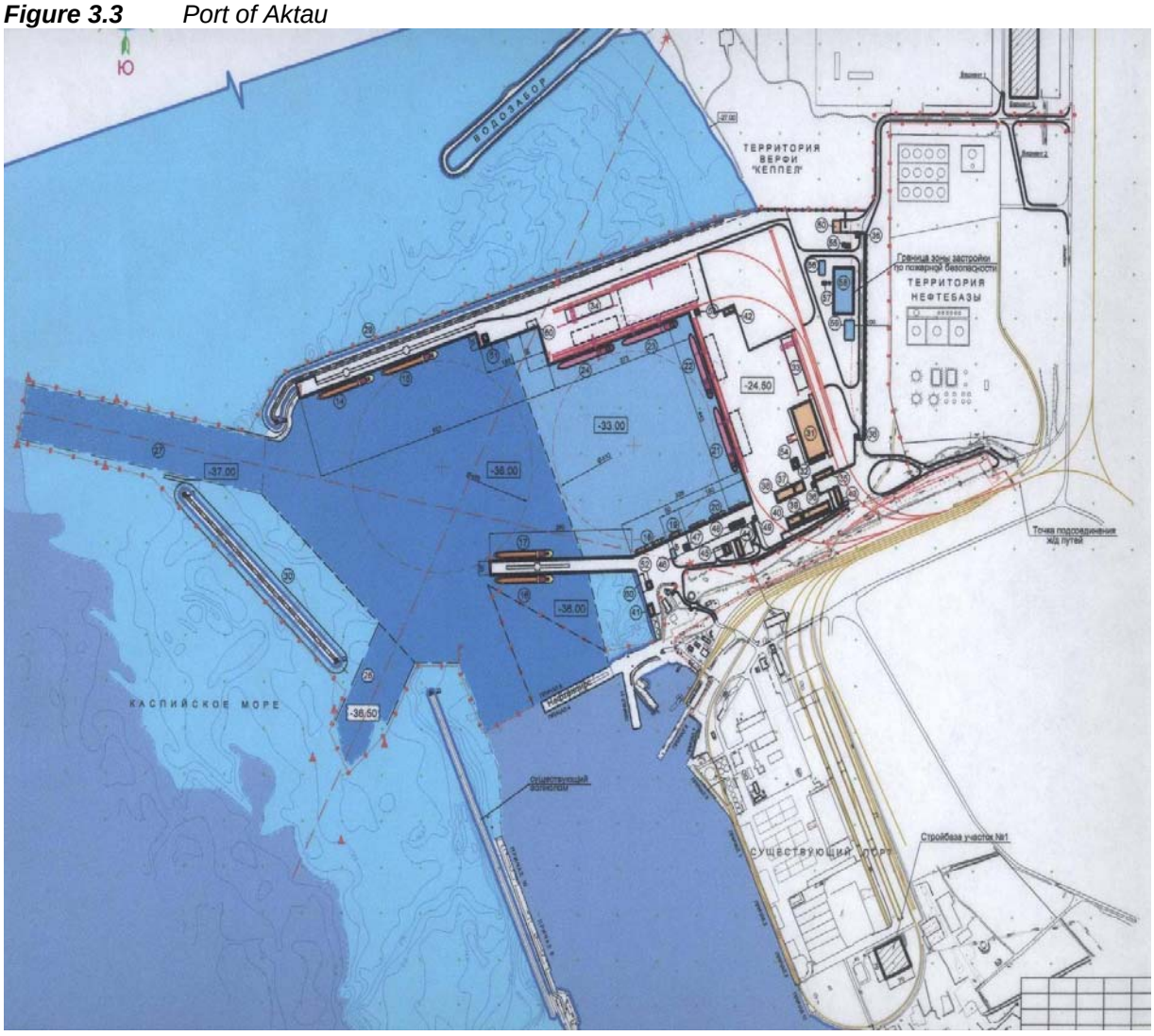
Aktau ferry pier

The ferry pier M 8 in the port of Aktau is a universal one. In the case of gas being shipped only, the capacity of the ferry terminal will be about 420 RTCs per month, considering the use of a ferry "Sovetski Dagestan" and a capacity of 28 RTCs per trip. In 2006 the ferry pier of the port in Aktau carried out a test case to put 56 RTCs onto 2 Caspian ferries respectively 1 Russian ferry. The LPG throughput volume ex Aktau might be increased to about 780 RTCs (approximately 24 KT) per month – as per information received from Kazakh Experts. This implies the (technical) possibility to reach annual throughput volumes in the range of 130,000 – 210,000 mT (see Box 3.1). The project team will verify and investigate these figures further.

At this point in time, the port of Aktau has no storage tanks for LPG. Loading various cargos at the multi modal Aktau Ferry jetty located next to a crude oil loading jetty shall be subject to separate carriage (in different holds or compartments, cargo space). The plan of Aktau Port on the next page presents the port facilities, including the Ferry boat Jetty next to Crude Oil Tanker loading facilities.

The travel time from the port of Aktau to Baku port is 18 hours. The loading time of the ferry is about three to four hours on average.

Figure 3.3 *Port of Aktau*



Box 3.1 *Estimate of potential LPG export capacity at Aktau*

The current capacities of Aktau Port for LPG Export (via TRACECA corridor) could be calculated as follows :

- Annual non operational days (fog/wind above 6 beaufort/other) 45
- Annual non operational days for LPG transport due to other ferry transports: 45
- Loading time 0,5 days;
- Total loading times available 275 days x 0,5 days = 137 voyages x 52 RTCs x 30 tonnes = about 210,000 tons. Considering the smaller capacities of the Azeri ferries at 28 RTCs intake the annual port throughput would be just 130,000 tonnes for LPG loadings
- Ferry availability : 4 'Dagestan' type (Azeri) ferries (assuming another 2 will be converted) x 28 RTCs or 4 'Makhachkala' type (Russian) ferries x 52 RTCs
- Such capacities could be increased through faster turnaround in the ports and usage of larger ferries which are available in the Caspian sea, to reach a technical capacity of about 250,000 mT/year.

Caspian sea transport

As concerns the Caspian sea transport, responsibilities in Azerbaijan have been split between Caspian Shipping Company (CSC), responsible for the physical shipping operations and a new State company called 'Meridian' responsible for 'sales', including the forwarding business operations.

Likewise in Azeri Railways there is a split between the physical railway operations (running the trains) by the Railways and the commercial operations by a State company called 'Transkavkaz' acting as rail forwarding agency.

In principle this organizational set up does not sideline the private sector but private sector operators would have to work with and under the supervision of these 'state actors'.

Box 3.2 *Indicative costs assessment of (minimum) LPG transport costs by ferry*

Rates of goods carried in rail wagons across then Caspian Sea in the second half of 2006—by CSC—are determined as follows: Price for putting one rail wagon on or off the ferry is US$ 36.
Price for ferrying a loaded/ empty rail wagon across the Caspian Sea is

- For TMB-Baku: US$ 35/30 per m' length of RTC, i.e. US$ 65/m' for the return trip
- For Aktau-Baku: US$ 40/35 per m' length of RTC, i.e. US$ 75/m' for the return trip
- Penalties/Premiums and additional costs (e.g. concerning waiting times, etc.) might lead to some adjustment of these prices.

Without any (safety/risk) surcharge for LPG transport, the price for ferrying an LPG train of 28 wagons of 15 m length, carrying 980 T, including 'empty return' may come to the following whereby the consultant considers this as best case scenario which still need to be checked :

- For Turkmenbashi-Baku: 65x28x15 + 36x28x2 = US$ 29,316—i.e. US$ 29.90/T and
- For Aktau-Baku: 75x28x15 + 36x28x2 = US$ 33,516—i.e. US$ 34.20/T12.

Considering that ferry boats can for safety reasons not transport any other cargo and/or passengers whilst carrying LPG the above figures may still have to be adjusted[13].

[12] Other information (see Annex-1) indicates a similar price (US$ 990 for a 33 tonne wagon, i.e. US$ 33/ton). N.B. Costs of loading the RTCs (at the place of LPG production?) could be included in the LPG-selling price 'at the gate' or, if not, would have to be added to the transport 'chain' cost.

[13] The consultant did receive during his investigations also other transport quotes – considerably higher than the above, i.e. US$ 80 MT for the 'leg' from Turkmenbashi to Gardabani (Azeri/Georgian border and US$ 55-65 MT for the trip from Aktau to Baku.

Other transport cost such as RTC rental must be added to the a.m. figures – as advised WP 6 will deal with these subjects more in detail.

3.3.2 Future perspective - towards increased capacity

The current situation indicates very little cross-Caspian LPG transport. Increasing LPG transport at this part of the logistic chain rests, from a technical point of view, on the improvement of the LPG (ferry) terminals at ports of departure and improved capacity of the ferry boats or tankers. On the short run the combination of LPG rail ferry terminals with ferry boats seems to prevail. In the medium to long run, the combination of dedicated LPG tankers in combination with LPG terminals at each side of the Caspian could be considered, particularly in the perspective of the total export volumes (not just the TRACECA corridor-oriented flows) of both countries.

LPG rail ferry terminal

- Building of LPG ferry terminal from rail to vessel in Kazakhstan is being debated, as mentioned in the introduction of this chapter. Possible locations are either in Kurik south of Aktau, or alternatively, a designated LPG terminal in Aktau. Similar initiatives are debated in Turkmenistan. Such terminals shall most probably have capacities to terminal initially 0.5 Mio. mT p.a. with possibilities to increase their capacities up to 2 Mio. mT p.a. Terminals shall be designed that the base capacity of say 0.5 Mio. mT p.a. can be increased by 'adding' some new storage tanks possible with an additional/extended facility for discharge of RTCs and new loading devices for the vessels to cope with the required rising market volumes.
- In the case of the newly designed port of Kurik we understand planning in this way is still possible. The consultant will also undertake to investigate the viability of new loading jetties for ferry boats whereby one such rail loading jetty can load maximum three ferry boats per day with an operational time weather permitting of say 320 days p.a. – thus maximum 1,5 Mio. tonnes p.a.

LPG terminal

- The combination of dedicated LPG terminals at each side of the Caspian and tankers operating between the terminals could be considered in the case of large quantities. From a technical point of view there are no restrictions, other than on the size of the tankers as a result draft restirctions . From an economic point of view conclusions may be different. In Working Paper 6 this issue will be looked at in more detail.

Ferry boats

- Current physical transport available capacities via ferry boats owned by Caspian Shipping are in best case approx. 1,600 tonnes per week for maximum 48 weeks p.a. per Ferry boat. The consultant sees maximum 3 Ferries – more likely only 2 Ferries. Therefore the overall available transport capacity via the two rail ferry jetties in Aktau and Turkmenbashi to the one railway Ferry jetty at Baku is about 130,000 – 160,000 tonnes p.a. considering all prevailing factors, such as weather, organisation, congestions, other cargo transport, etc.
- The above figure could possibly be increased by another maximum 100 KT to around 250-300,000 tonnes in case larger ferry boats can be used. The consultant does consider this as the maximum capacities for LPG transport via rail ferries through one receiving jetty at Baku and two loading jetties at Aktau and Turkmenbashi – unless other cargoes transported by rail ferry decreases significantly which seems not to be the case.
- It must though be understood that the 'Mercury type' CSC ferry boats are technically designed for combined transport of passengers, road trucks and rail trucks with a 'closed' compartment for the cargo unit (some ventilation devices have recently been build into it though). A rail ferry designated for LPG transport though would require a technical construction whereby the – for rail trucks only – cargo compartment is (at least partly) open – see Ukrferry and Safinat ferries. This may prove to be a major obstacle to make the 'Mercury type' ferry boats competitive at all because of (i). technical and safety reasons and (ii) economics are based on combined

transport for passengers/rail trucks and road trucks; thus carrying 'only' the light and therefore low quantity LPG cargo may make economics unfeasible

Tankers

- The purchase of LPG tankers for may be US$ 20-30 Mio. or more per tanker whereby each tanker should be able to carry about 170-200 KT of LPG p.a. In case of using the probably maximum limits for LPG cargo intakes for the Caspian sea of say 5-6 KT the annual capacities per tanker will go up to 250-300 KT p.a..

In conclusion it can be said that from a technical point of view the Caspian Sea crossing should not provide a major obstacle. With relatively small quantities creating capacity at LPG rail ferry terminals and additional capacity through more and higher capacity LPG rail ferries will do. In the case of higher capacities the option of LPG terminals and operating LPG tankers could become feasible.

3.4 Rail transport on the land corridor

3.4.1 Assessment of current LPG transport capacity

The railway infrastructure Baku-Black Sea

Between Baku (Azerbaijan) and Samtredia in Georgia, where the line from Tbilisi branches off to Poti and Batumi respectively, the line is double track and electrified, mainly operated by semi-automatic block systems. The average overall speed, whilst moving not counting waiting/standing times is 35-40 km/h (minimum approx. 10 km/h with a top speed of about 60 km/h) due to the overall bad conditions of the bridges, except in the Baku and Tbilisi metropolitan regions. The section between Samtredia and Batumi respectively Poti, 50-60-km single-track was the most serious infrastructural weakness of the corridor, but has been rehabilitated and today allows speeds up to 60 km/h. Reportedly this section can now handle at least 25 train pairs per day.

The distance between Baku and the Azeri-Georgian border should normally be covered in 16-18 hours, and the distance from there to Batumi in about the same time—adding up to 1.5 day travel time one way. Interference from passenger trains is not a problem (now) with just one long-distance passenger in each direction during night time. Passenger travel may increase but is for the time being not considered as a major restraint. Actual turnaround times for cargo trains between Baku and Batumi do however take about 2.5-4 days one way which leaves room for improvement especially for the cost sensitive LPG transport.

Figure 3.4 *LPG rail transport on the TRACECA land corridor*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Indicative costs assessment of rail transport
Reportedly, Azerbaijan Railways is charging for the LPG transport—in 35 Ton 'GOST SNG standard' tank wagons which are below EU standards—US$ 25 – 30 [14]/ton for the 500 km distance Baku-Border with Georgia, i.e. US$ cents 5/ton-km[15].

The railway stretch in Georgia Border with Azerbaijan-Batumi, is about 70% of the Azeri distance distance but Georgian Railway charges reportedly half the (Azeri) price—US $ 12.50[16]/ton, US$ cents 3.6/ton-km, probably a 'promotional' fare to attract LPG traffic to the dedicated LPG terminal in Batumi.

Box 3.3 *Rough calculations of unit rates*

To put these calculated unit transport rates by rail in a wider regional perspective, LPG transport cost data of two long distance routes from Ashgabat (Turkmenistan) to Kiev (Ukraine) in tank wagons of (reportedly) 33 Ton capacity. From these data the following unit rates (including empty return) can be indicated to show at this stage an order of magnitude :

- Turkmenistan (560-610 km): US$ cents 6.4-6.5/ton-km
- Uzbekistan (431 km): US$ cents 6.8/ton-km
- Kazakhstan (832 km): US$ cents 5.2/ton-km
- Russian Federation (1,032 km): US$ cents 5.5/ton-km
- Ukraine (705-864 km): US$ cents 4.1-4.3/ton-km
- Azerbaijan (503 km): US$ cents 5.5/ton-km
- Georgia (348 km) US$ cents 4,5/ton-km

The rates mentioned in Box 3.3 are probably at the lower of the cost range.

Bottlenecks in the railway system
As concerns the overall railway situation between Baku and Batumi there are currently the following constraints:

- In Azerbaijan four 'stopping' points (change of Locomotives/check of documents) are 'system-inherent'.
- Single track bridges reduce the speed and increase waiting times.
- Poor rail sections limit the speed to 10 km/h.
- Azeri rail is lacking locomotives – Georgian rail sublet allegedly 12 locomotives
- Georgia faces the world-wide most steep railway sections near Tbilisi which limit the speed down to 10 km/h.
- A limited number of trains can currently be handled at the Azeri/Georgian border (change of Locomotives/border formalities/exchange of documents/controls etc.).
- In the past – up to 2006 – the railway system became locally very seriously congested resulting in overall travel times of up to 12 days one way between Baku and Batumi. The consultant however considers this as a major problem of the past which should not occur again for the next years to come since the Crude Oil pipeline Baku-Ceyhan can take significant tonnages away from the rail system.
- The local managers consider the overall railway system as 'aging' and the consultant was confronted with remarks that around US$ 500 Mio. would be required for infrastructural investments – about US$ 1 Mio. per km of rail.

[14] The precise quotation received recently from TRACECA/Baku is US$ 24.10/ton as per published transport rates excluding costs such as forwarders, wagon disposal etc..
[15] This rate is supposed to include the cost of the empty return of the train.
[16] The precise quotation received recently is US$ 12.26/ton

3.4.2 Future perspective - towards increased capacity

Block trains
In order to significantly increase LPG transport capacity via rail on the TRACECA land corridor, i.e. the section Azerbaijan-Georgia, a block train operation is to be considered.

The state of the infrastructure, the bridges in particular, and the signalling system and progress in the rehabilitation and upgrading program of these main components, will have an important bearing on the realistically achievable turn-around time for LPG block trains in the medium to long term run.

In the short term run a 'fast block train' LPG concept should be strongly considered whereby all current obstacles like stopping points/change of locomotives and personal, border crossing formalities etc. could be 'streamlined'. Specially marked, connected and organized block trains consisting of 25-35 RTCs, fitting through all 'bottlenecks' and one special designated locomotive – most probably specially hired/bought shall consist of a liner type/ferry boat or vessel like shuttle service for loaded and ballast voyages between Baku and Batumi.

The block train concept is to be carefully managed, linking the Caspian Sea crossing, i.e. rail ferries with the Batumi terminal at the Black Sea coast. A typical train of 28 LPG-RTC wagons could be pulled by (the equivalent of) a VL-11 electro-locomotive[17]. For LPG block train cost calculations (as included in section 4.2), it is perhaps best to consider the cost of an adequate locomotive type purchased in West Europe or North America.

With a block train system, it must be possible to achieve:
- Maximum 16 hours for Baku→Border with Georgia (almost 500 km),
- Maximum 4 hours for Azerbaijan-Georgia border crossing,
- Maximum 16 hours for Azeri-Georgian border→Black Sea terminal (~350km).
- Total 36 hours (1.5 day) rail trip Baku-Black Sea.

One day each for loading of Azeri export LPG at Baku and unloading at the Batumi terminal of 28 RTCs carrying 980 T, and 1.5 day travel time each way would result in a turn-around time of 5 days. Today the maximum achievable say per one block train might be a weekly (the target should be around 4-5 days) LPG-block train service Baku-Batumi, either loading from the Azeri LPG export point in Baku or arriving by (weekly) rail ferry from Turkmenbashi (Turkmenistan).

In order to carry some 150 kT LPG an estimates 150 trains per annum are needed, equivalent to some three block trains per week. This seems to be feasible on relatively short notice (within 1-2 years). In order to increase the tonnage to the anticipated levels, as indicated in Working Paper 2, i.e. 1,0-2,3 million tonnes, a massive increase in rail capacity is needed. Based on the rough calculations above, some 30 block trains per week are needed to carry 1,5 million tonnes of LPG. Railways would have to undertake serious efforts to undertake the required changes in respect to speed of transport considering that the charges per day for LPG RTC's are more than double per ton than for other light oil products.

Less optimistic projections though estimate the rail capacity for LPG limited at 600 kT p.a. between Baku and Georgia, which would be carried by approximately 12 block trains per week. Obviously, this falls short of the projected LPG volumes to be transported along the TRACECA corridor, making the rail link a critical bottleneck in the logistic chain and should be an incentive to railways to improve in the fields discussed in this Working Paper 3.

In section 4.2. the above is used as a basis to make initial cost estimates.

[17] Locomotive production in RF is practically monopolized by 'Transmashholding' (www.tmholding.ru); they also control the Novocherkassk plant in Rostov. The modernized VL-11 is sold by the 'Ural Factory of Rail equipment'—part of the Sinara Group.

Improvement of rail corridor
New rail corridor development could open up opportunities to transport LPG to markets directly by rail. The Kars-Tbilsi-Baku railway construction project is aimed at improving infrastructure and superstructure construction works would connect Baku directly to the Turkish market. Apparently the project received Ministerial Council approval for expropriation of land in Turkey and a tender is expected to be launched.

Additional measures that are envisaged :
- Purchase of RTCs
- Purchase of Locomotives
- Extension/new construction of LPG sea loading terminals in Georgia
- Well defined measures to increase the speed of railway transport for LPG, including repair investments into railway structures
- Instalment of a 'Ferry boat like' LPG train service whereby dedicated block trains are running back and forth with the same locomotives and without the prevailing stops in order to increase the turnaround speed to become competitive

3.5 LPG seaport terminal in Batumi

Besides the few LPG shipments from Turkmenbashi, the 'state of the art' LPG-terminal at Batumi port, which was opened in 2002/2003 has been operating for Azeri LPG export and Armenia LPG import.

The present annual (throughput) capacity is stated to be around 150-200 kT with a storage capacity of 1.200 cubic metre equivalent with about 700 tonnes. This implies a potential annual turnover of about 200 times the storage capacity whereby vessels would also be loaded directly from trains. The actual annual throughput, however, is (only) about 50.000 tonnes. This reflects the so far low standard of LPG transport possibilities across the Caspian Sea and the current low production volumes ex Azerbaijan. Figure 3.4 provides an overview of Batumi port and the LPG terminal.

Handling capacity
A 28 RTC train (980 T) can be unloaded in one day. LPG tankers of 1,500-3,000 tonnes carrying capacity can be loaded at a rate of 120 T/hour. Loading times would then be up to just over a day (25 hours) as concerns the larger tankers.

Figure 3.5 *Batumi port and LPG terminal*

3.6 Competition from Russian rail corridors

The project base case, as indicated in chapter 1, heavily concentrates on the Russian rail corridors. Figure 3.5 provides a graphical illustration of possible transport routes, from origin to destination.

A cost comparison of LPG transports Ashgabat-Kiev (see Annex 2) indicates that for Turkmenistan (Central/East LPG production sites) the TRACECA corridor (distance 890 km, transport costs around US$ 110-140 MT excluding RTCs) could be competitive with the Russian rail corridor (distance about 900 km from Mahachkala to Black Sea Ports through Chechnia and about 1,800 km via Volgograd , transport costs about US$ 135-165 MT excluding RTCs).

With respect to Kazakhstan and the Russian rail corridor to Odessa, the 2006 rate for LPG rail transport from Aksarayskiy (Kazazhstan-RF border)[18] to Odessa is reportedly US$ 97 per ton. With transhipment cost (rail-to-LPG terminal and LPG-terminal-to-tanker ship) in Odessa of approximately US$ 20 per ton, the transport costs Kazakhstan border-Odessa seem to be not more than US$ 120. Considering this and the upcoming competition from the newly build LPG terminals at the Russian Black Sea/Azov Sea coast a cost level of US$ 80-110 per tonne of LPG may be the 'benchmark' rate for LPG transports from Aktau and Turkmenbashi respectively. The consultant will undertake much more precise calculations in Working Paper 6 in this respect.

Considering the TRACECA transport rates (Turkmenbashi-Batumi) quoted in the previous paragraphs—say US$ 40-55 per tonne to cross the Caspian by rail ferry, plus a 'normal' (non-promotional) rate of US$ 45-55 per tonne (US$ cent 5 per ton-km) for the Baku-Batumi rail stretch, plus (an assumed) US$ 20 per tonne for the Batumi LPG transhipment cost plus estimated US$ 15-30 MT for RTC's — shows that the overall costs via the TRACECA corridor must be improved to get closer to being competitive.

[18] The LPG transport distance from the production site to the Aksarayskiy (RF) is shorter than the distance to Aktau—marginally shorter for the Tengiz production area, significantly shorter for the more northern Kazakh (future) production locations.

However, what remains to be confirmed is how financially sustainable each of these quoted rates are and how an overall cost comparison including the charges for the relatively expensive RTCs (the hire rate well above US$ 1-1,50 per tonne per day, whereby the actual and total turnaround times are very important) will look like.

It is most likely that additional investments in rolling stock (LPG rail tankers and/or locomotive power), rail ferries (adaptation of existing ferries or new one), and rehabilitation and/or possible improvements of the rail-jetties (Aktau, Baku, and Turkmenbashi) will be needed in order to establish a reliable weekly service (50,000 tonnes/year LPG flow) in a first stage—say in the year to come.

Before a notable improvement of the TRACECA transport corridor for LPG might be achieved, the competitive situation with regard to the Russian transport corridors will have undergone a change, because of the opening of at least one and possible two new LPG terminals at the Azov Sea Strait, i.e. at Temruk and Taman respectively.

The first one, at Temruk, is located on the North side of the Kavkaz peninsula, with draught limitations for tanker vessels up to 5 KT intake and a planned annual throughput of 300,000 T (storage 6,000 cub.m total consisting of 30 x 200 cubic metre, RTC unloading for 2x10 LPG-wagons, LPG-tanker loading at 130-200 T/hr). Like Odessa, it will be served by direct rail transport from Kazakhstan and off course Russian productions sites but it will not need the Ukrainian railways sections any more. Odessa may be likely to be the first to feel the competition of this new terminal; the transport distance from Aksarayskiy is (marginally) shorter and no border needs to be crossed, so the turnaround time of (block) trains can be notably shorter (and therefore the rate even lower than US$ 97 per tonne (the Russian rail rate only is quoted to be US$ 70 per tonne excluding charges for RTCs). Also the shipping distance—at least to Samsun (Turkey)—will be shorter than from Odessa, so that the (new) Temruk terminal might be in a position to charge higher transhipment cost (rail-to-LPG terminal and LPG-terminal-to-tanker ship) than Odessa[19].

[19] It is said that Temruk terminal might (try to) charge as much as US$ 35 per tonne transshipment. The Russian transport group Safinat will be the operator.

Figure 3.6 *Transport routes from origin to destination*

Source: consultants estimate

A significant larger terminal is under construction at Taman (see picture below), on the South side of the Kavkaz peninsula, owned and to be operated by the Oteko group[20], which is reportedly designed for an annual LPG throughput of 1 million tons.

Figure 3.7 *Taman port under construction*

The (Russian) rail route Makhachkala-Krasnodar-Taman/Temruk can be considered the Northern parallel route of the TRACECA route Baku-Batumi. This rail corridor offers direct rail transport, albeit over long distances, from Makhachkala or from other Russian/Kazakh border crossing points like Akzeraisk via Rostov-on-Don to Northeast Europe (Brest/Poland, Slovakia and Hungary) via Ukraine, or to Brest/Poland/Baltics even fully over Russian territory.

[20] Also owner of a large fleet of Russian, Estonian and Dutch RTCs, Russian river vessels, an Estonian Oil terminal and Russian and Estonian maintenance yards.

4 Initial TRACECA transport chain LPG cost estimates

4.1 RTCs for LPG and Caspian rail ferry

Caspian Sea crossing of RTCs in new ferries is roughly estimated to be in the range of US$ 30-45/ton LPG for Turkmenbashi-Baku and in the range of US$ 40-61/ton LPG for the Aktau-Baku trip.

Some estimation 'models' are shown in Annex 3. As concerns the capital investment cost, the ferry's economic lifetime is set at 30 years, with an assumed interest rate (including 'administrative charges') of 12% p.a. (which most probably will not be an achievable competitive interest rate) and expressed as an 'annuity' (average annual cost including pay back payments over lifetime). As shown in the following table, annual maintenance costs are supposed to vary between 1-1.5% of the ferry's replacement costs. Pure operating costs differentiate between time-at-sea and time-in-port (loading/discharging RTCs) within a range 'factor' 2. The costs of pulling the RTCs off and on the ferry are expressed as US$ 40 per RTC movement on or off the ferry. Annual LPG volumes carried across the Caspian Sea per ferry would be close to 200,000 tons/year for Turkmenbashi-Baku (200 trips/year), and close to 150,000 tons/year for Aktau-Baku (150 trips/year).

Table 4.1 *Cost estimated for Caspian rail ferry transport*

Cost of Ferry (28 RTC – 15 m)	Annual MTCE %	Operating cost Ferry at sea	Operating cost in port (un)load	Cost/Ton Turkmenbashi-Baku	Cost/Ton Aktau-Baku
US$ 25 million (min)	1% (min)	US$ 333/hour (min)	US$ 188/hour (min)	US$ 30 (min)	US$ 40 (min)
US$ 30 million (max	1.5% (max)	US$ 667/hour (max)	US$ 375/hour (max)	US$ 45 (max)	US$ 61 (max)

Note: Apparently the minimum estimate for Turkmenbashi-Baku seems to correspond almost with the actual charge mentioned in previous section

Please note that as advised earlier the consultant is currently building up the data base for Working Paper 6 and Table 4.1. is one of various calculations for the time being. Other calculations show for example a purchase price of about US$ 25 Mio. for a ferry boat carrying 52 RTC's – which would change the figures in Table 4.1 considerably.

A total of three ferries will be needed to guarantee a total of 350 trips/year and an annual quantity of close to 350,000 T LPG.

The rail-ferry crossing requires maximum 1.5 day between Turkmenbashi and Baku; the RTCs must be there when the ferry arrives, and time is needed to reassemble the train after leaving the ferry.

A typical train of 28 LPG-RTC wagons could be pulled by (the equivalent of) a VL-11 electro-locomotive[21], estimated to cost approximately US$ 1.6 million (minimum) but with long (uncertain) delivery time – we understand up to 5 years versus 2 years delivery time from western factories. Tare weight of this train is estimated at about 1,200 T and with a payload of close to 1,000 T (LPG) total loaded train weight is approximately 2,200 T.

[21] Locomotive production in RF is practically monopolized by 'Transmashholding' (www.tmholding.ru); they also control the Novocherkassk plant in Rostov. The modernized VL-11 is sold by the 'Ural Factory of Rail equipment'—part of the Sinara Group.

For LPG block train cost calculations (as included in section 4.2), it is perhaps best to consider the cost of an adequate locomotive type purchased in West Europe or North America at a cost level of 4 million Euro.

Although this may not yet be daily routine, it must be possible to achieve :

- Maximum 16 hours for Baku→Border with Georgia (almost 500 km),
- Maximum 4 hours for Azerbaijan-Georgia border crossing,
- Maximum 16 hours for Azeri-Georgian border→Black Sea terminal (~350km).
- Total 36 hours (1.5 day) rail trip Baku-Black Sea.

Currently, the freight train trip between TCO[22] (Kazakhstan) and Aktau (Caspian Sea) along some 500 km (the same distance as the stretches on Azerbaijan and Georgian territory) takes, reportedly, 5 days. Based on consultant's best estimate, it must be possible to reduce this trip time to 2.5 days or less.

Loading (of 28 wagons with 35 t LPG each, i.e. ~75 cubic metre tank contents) at TCO is estimated to take 36 hours including time losses (4 wagons loaded simultaneously at pumping capacity of 15-20 cub.m/hour, i.e. 7x4 hours 'net pumping time'), thus 1.5 day per block train.

RTC-unloading at a dedicated Black Sea LPG terminal might be faster if (say) 14 wagons could be discharged simultaneously, e.g. 2x4 hours 'net pumping time' and a total of 12 hours or 0.5 day per block train.

This 'TRACECA' LPG transport scenario (no. 1) would imply an LPG/RTC block train turnaround time of 15 days (i.e. 1.5+2.5+1.5+1.5+0.5+1.5+1.5+2.5= 13 days 'net travel + loading/ unloading' time plus a 2 days allowance for various disturbances; the single trip distance is: ~ 1,500 km on railways plus 253 Nm across the Caspian Sea; roundtrip distance/time altogether 3960 km in 15 days).

The block trains should be pulled by a single locomotive on the Baku-Batumi (or Batumi-Baku 'empty' return) stretch (no change of locomotive at the Azeri-Georgian border) by some 'sharing arrangement' between both countries' Railways, and by similar 'local' locomotives in Kazakhstan and Turkmenistan respectively. Whereas the block train (basically the 28 RTCs) with their average turnaround time of 15 days can perform about 24 trips per year, and thus carry 23,500 T LPG per train per year, the locomotives on both sides of the Caspian Sea have shorter turnaround times and can perform significantly more trips per year.

In section 3.3.2 the concept of the block train is introduced. Based on that description the following calculations are made.

To carry 147,000 T in 150 trains—per year—from Kazakhstan via Baku to the Black Sea requires 7 block trains (196 RTCs for 35 tonne LPG each). To run this number of 150 trains according to schedule between Baku and Batumi and back requires minimally two (2) 'just-in-time' locomotives (90 round-trips per year at turnaround time 4 days) and to run them between e.g. TCO and Aktau and back in Kazakhstan, there is a need of at least two (2) similar locomotives. The suitable RTCs (196 for 7 block trains) and locomotives (4 in total) for the LPG flow of 147,000 T/year are to be rented. The consultant understands this is currently possible in the Ukraine and simultaneously bought – RTC's also most probably from the Ukarine (Azovmash. Suitable RTCs can be rented at around US$ 40 per day reportedly from Ukrainian railways – respectively about US$ 1,5 per tonne per day (about 3 times more expensive than Diesel RTCs). Locomotive rental will be investigated in Working Paper 6 by the consultant. If not, the level of investment to procure this rolling stock package could be as much as €16 million for the (4) locomotives and perhaps up to €14 million for the (196) RTCs, altogether € 25-

[22] A possible future alternative LPG origin will be Uzen, situated about 100 km from Aktau (close to the rail network, while for this distance a feeder pipeline to Aktau might be considered given adequate throughput quantities). This provides a much more interesting (transport) scenario than the (500 km) distant TCO origin of Kazakh LPG.

30 million[23]—per each 150 KT p.a. for the assumed Kazakhstan LPG flow – though excluding any (urgent required) investments into the aging railway systems.

Assuming that the (block) train operating costs and the charges for using the Azeri, Georgian and Kazakh railway-infrastructure would be around a level of € 0.05 per ton-kilometre (including empty return), the (block) train operating costs for the 1,500 km long trip of LPG from Kazakhstan to the Black Sea (Batumi), would come to € 75 per ton.

Summing up the *total LPG transport cost from TCO (ex gas plant Kazakhstan) FOB at the Black Sea*, the following first, very rough estimate—Euro/ton—would come to:

1.	Loading RTCs at TCO:	€ 10 (optimistic estimate)
2.	Rent of rolling stock:	€ 25 (see footnote 17)
3.	Railway operating costs:	€ 75
4.	Caspian Sea crossing:	€ 40 (minimum—up to € 61)
5.	Batumi Terminal rail → sea:	€ 25 (minimum estimate)
6.	**TOTAL:**	**€ 175** per tonne (minimum/optimistic estimate)

A similar estimate can be made for 200 block trains per year carrying a flow of 196,000 tonne of LPG from Turkmenistan via rail-ferry Turkmenbashi-Baku to the Black Sea. The rail ferry cost will be somewhat lower (minimum € 30—up to € 45 per ton—see table on page 11) and the railway operating costs in Turkmenistan from the source of LPG production to Turkmenbashi-port could be lower due a shorter distance. The consultant considers though that the currently offered rates and conditions are nowhere near to b e competitive to attract LPG traffic flow via TRACECA corridor away from current export routes via Russia for example.

4.2 LPG containers and Caspian rail ferry

Dedicated LPG tank containers would be carried on standard flat bed (4-axle platform) rail cars of 13-14m length, carrying two 20ft or one 40ft container, i.e. about 23 tonne LPG per wagon (significantly less than a 35 T RTC).
For the purpose of this first, preliminary exercise, the assumption is two 20 ft containers (2 TEU) costing € 50,000 (a quoted ex-Latvia price), carried on a (Russian) 4-axle platform rail car costing € 40,000

The annual 'capital and maintenance' cost of such a 20 ft LPG container depends on its lifetime (assume 10 years) and the (all-in) interest rate (assume 12%/year); under such assumptions, the 'annuity' is 0.177. With annual maintenance cost at 2% of replacement cost, the annual capital and maintenance costs would come to € 4,925 per year. Such a container might be used just 8 times per year, i.e. its turnaround time is 1.5 months, the cost of using just the container for transporting 8 times 11.7 tonne LPG per year comes to more than *€ 52/ton LPG* carried (and this might be an optimistic/minimum estimate).
This is more than twice the cost of renting the railway rolling stock for LPG transport in RTCs, whereas the cost of the flat bed railcars and locomotive power still need to be added to the €52/ton container cost.

Because of (i) the very high 'capital' cost of the LPG-container combined with (ii) the very long time such a container is underway until its next income-earning trip, this transport alternative may not be competitive—regardless of two alternative ways of transporting the containers, i.e.:

- On flat bed rail cars using rail-ferries to cross the Caspian Sea and the Black Sea (to either the Turkish, Bulgarian or Romanian railway network), or

[23] At 30 years economic lifetime (for both Locomotives and RTCs) and an assumed interest rate (including 'administrative charges') of 12% p.a. this works out as an 'annuity' (average annual cost over lifetime) of €3.72 million per year. This rolling stock, rented at this cost level, would imply a cost of € 25 per tonne LPG carried (just for rent of rolling stock).

- Through container terminals on both sides of the Caspian sea (Aktau/Kurik and Turkmenbashi—Baku), the Georgian Black Sea coast (Batumi/Poti/Kulevi after completion), and the Turkish/Balkan Black Sea coast (Bulgaria, Romania, Danube) served by 'liner container across both seas and flatbed railcars overland.

5 Special considerations

There are several special factors beyond the transport-technical considerations, as described in Chapter 3, and transport-economic scoping, as described in Chapter 4, that are likely to affect the feasibility of the TRACECA LPG transport concept under consideration, notably:

- LPG quality aspects
- Continuing, again increasing demand for TRACECA corridor oil transport by rail
- Restrictions on trans-Bosporus transport of dangerous goods
- Pipeline transports
- Producers' marketing behaviour focused on LPG 'net back' prices

These items are briefly described below. More detailed information is included in the Annexes.

5.1 LPG quality aspects

The recent more stringent quality parameters in the consuming European LPG countries may force LPG producers into further investments for unit installations to improve their qualities. Until such time LPG transport flows may change as countries with lesser quality restrictions will absorb more volumes from producers of 'lower quality' LPG.

Poland, the main CIS LPG export market, as of January 1, 2007 applies European standards EN-589 instead of CIS standards or GOST 20448-90. Poland started to develop quality controls at terminals (allowing blending of off specs LPG from CIS and better quality products to meet specs). Turkey, also is applying more stringent LPG qualities and is controlling quality for incoming vessels, thus not allowing for blending in Turkey sea terminals. Iran is satisfied with LPG qualities from Turkmenistan (the largest exporter to Iran) and Uzbekistan.

The above development may impact in the following way:

- To export newly produced LPG mix, LPG quality shall best adhere to European 'autogas' specifications to ensure acceptance in major import markets.
- New LPG plants, producing separately propane and butane, shall further diversify export markets and meet petrochemical requirements at export, with imports-countries adjusting the butane ratio to their climate environment (30% propane in Turkey).
- With new petrochemical plants planned in Orenbourg (Russia), Atyrau in Kazakhstan, and existing ones, including Tabriz in Iran, LPG demand as petrochemical feedstock is expected to grow. Also domestic consumption of autogas is growing particularly in Russia, Ukraine and Kazakhstan.
- Major plants like Orenbourg (70 kT/month), Perm, Surgut, Severgazprom and most oil refineries will have to redirect their output flows between exports to Bulgaria-Romania-China-Afghanistan-Iran, domestic markets and domestic petrochemical industry.
- Plants able to produce EN-589 specs. will maintain access to all major export markets and be able to optimize netbacks.
- Significant investments into quality improvements will be needed.

More details on LPG quality aspects is provided in Annex 7.

5.2 Railway capacity

Increasing demand for oil transports between Baku and Batumi/Kulevi may continue to put great pressure on this central railway line. All relief provided by the new BTC oil pipeline (with a capacity of 50 mln Ton/year which can be extended in the near future to 70-80 mln T/yr) will be claimed immediately by the flows to Batumi (maximum capacity 15 mln T/yr) and Kulevi (2008-capacity 8 mln T/yr to be increased to a maximum of 15-20 mln T/yr after 2010) so that the potential oil transport flow

by rail could remain at a level of (maximum) 35 mln T/yr. In any case, there is likely to remain 'great competition' from oil transports for LPG transports on the TRACECA rail connection Baku-Black Sea.

In contrast, another scenario should be considered as well: The overall configuration of the pipeline systems for crude oil in the former Soviet Union like the Russian Transneft system, BTC, Kazakhstan-Novorossisk, Baku-Supsa will probably reduce the railways (oil) cargo. Recently the railway traffic in Azerbaijan and Georgia decreased significantly; therefore all Logistic Partners on the TRACECA corridor may be interested to attract new volumes

Railways shall also consider to re-organize themselves via partnerships, with needed improvements in the administrative systems to provide customers with the required speed, reliability and credit worthiness to effect larger LPG transport volumes at competitive terms and conditions.

Interconnecting the TRACECA corridor railway line with the Turkish railway network (via Rail tankcars) will offer a new option to supply (East-)Turkey directly by LPG block trains, although today there is no LPG transport by railways at all within Turkey and its regulations would have to be amended accordingly.

5.3 Trans-Bosporus transport of dangerous goods

Bosphorus crossing is already limited for Suezmax oil tankers and will become more difficult in the next 5 years (until 2012) when oil pipeline by passes Burgas-Alexandropoulis, Odesa-Brody Plock and Samsun-Ceyhan will be operating.

Tankers transporting LPG "dangerous goods" do not have priority on oil tankers and demurrage on LPG tankers is expected to increase, particularly on LPG tankers crossing the Bosporus with destinations other than Turkey (unwritten rule). However, LPG tankers serving the TRACECA corridor, with destination Turkey-Mediterranean are not expected to be (severely) restricted in Bosphorus. This is important in as far as a significant portion of future LPG transport via TRACECA corridor will probably cross the Bosporus to the extent that the Black Sea market can not absorb all quantities.

Although not now likely, a third possible 'outlet' could become an LPG-route via Ukraine (Ilyichevsk) to Brest/Poland. This will depend on the policy and possibilities of the Ukraine to attract transit cargo at competitive terms and conditions. It also remains to be seen if traffic on the Danube will develop as an attractive transit path for the Ukraine.

5.4 Pipeline transports

A range of pipeline initiatives may be to be considered that may affect LPG transport costs[24]. First, because transport capacity is freed up in sections that are capacity critical, e.g. in rail transport on the Baku-Batumi stretch or in the Bosporus strait. Second, if technology allows it and if sufficient volumes can be realised LPG can be transported by pipeline, either dedicated or making use of pipelines that are used for other commodities.

Below some relevant initiatives are listed[25]:

Discussion on **Trans-Caspian gas pipeline** have been deadlocked for some time. However, both Turkmenistan and Kazakhstan are encouraged to participate in the East-West energy corridor as the main gas suppliers to Western markets. Question in relation to this initiative is whether it is technically feasible to pump wet gas through the Trans-Caspian gas pipeline.

[24] LPG pipeline transport, although technically feasible, is not considered a short or medium term solution for the TRACECA corridor. This study concentrates on the pre-feasibility of LPG transport cross Caspian-TRACECA land corridor.

[25] Besides mentioned initiatives other options are discussed and obviously a range of pipelines are already in operation.

The **Trans-Anatolian Pipeline (TAP)**, i.e. the Samsun-Ceyhan oil pipeline in Ceyhan, located on Turkey's Mediterranean coast. The project will provide a route to bypass the Turkish straits, namely the Bosporus and the Dardanelles, and will provide transportation capacity for further increases in Caspian and Russian oil production. The project will be carried out by Italian energy giant ENI, which the Turks are already familiar with for its contributions to the Blue Stream natural gas pipeline across the Black Sea, along with one of Turkey's holding companies, Çalık Holding. Having a length of 555 kilometres, the pipeline will initially carry 1 million barrels of oil per day (bpd) and is expected to increase to 1.5 million bpd.

The **Burgas- Alexandroupolis pipeline (BAP)**. This pipeline will have the capacity to transport 35 million tons of Russian oil per year from Burgas, located on the Black Sea coast, to Alexandroupolis, on the Aegean coast. The pipeline will be constructed and owned by an international project company, of which 51 percent of shares would belong to the Burgas-Alexandroupolis Pipeline Consortium, a joint venture of Russian Transneft, Rosneft and Gazprom Neft. The remaining 49 percent of shares will be distributed between Bulgargaz and Transexportstroy from Bulgaria, and Greece's Bapline consortium.

The US-led **Nabucco pipeline**, which will transport natural gas from Turkey to Austria, via Bulgaria, Romania and Hungary, considering the pipeline as a diversion from the current methods of importing natural gas solely from Russia.

It must be understood that pipeline issues are very complex and therefore additional aspects (not restricted to) should be considered :

- LPG can be transported by pipelines as follows : (i) obviously in special designed ‘LPG only’ pipelines – see Working Paper 2; (ii) possibly in Crude Oil pipelines, though various technical measures must be undertaken and (iii) possibly in Natural Gas Pipelines.
- No LPG pipelines are currently operating and/or getting planned – to the best of our knowledge.
- Plans and studies for Crude Oil and/or Natural Gas Pipelines across the Caspian Sea have been undertaken since quite some time. Given the political/geographical and geological status of the Caspian Sea, e.g. dividing Crude Oil reserves between Russia, Azerbaijan, Kazakhstan, Turkmenistan and Iran, it appears that possibilities for any cross Caspian pipeline realisation in the near future will be difficult. Even in the case of a realisation the consultant considers the timing needed about 5-10 years.
- The South Caucasus pipeline transporting Natural Gas between Azerbaijan and Georgia cannot transport LPG due to technical reasons.
- The Nabucco pipeline project was stopped for the time being.
- The (very) old and already long time not operating oil product pipeline between Azerbaijan and Georgia cannot be considered

5.5 Current LPG “net-back” prices

LPG prices are mainly determined and settled by the daily published quotations of the Platts publications (www.platts.com). Platts does determine the daily market prices by a world wide panel of experts. Alternative price publications are issued also by companies like Reuters/Argus/Bloomberg, etc. (Annex 8). Such prices are influenced by the ‘usual’ factors of the energy market, such as (but not restricted to) supply and demand, weather, taxes, logistics. LPG is also sold at fixed prices which however get adjusted – on a monthly basis, more often on a weekly basis. Therefore the overall calculation for a LPG producer to determine his ‘net back’ prices ex-plant are basically as presented in Table 5.1.

Table 5.1 *LPG net back prices*

	Variable sales price e.g. as per Platts quotations delivered on CIF Basis
plus/minus	quality differentials (can be significant up to US$ 50-100 MT)
plus/minus	market differentials
plus/minus	actual time differentials e.g. premiums if the market is in 'contango' (futures are above actual quotations) or a discount if the market is in 'backwardation' (futures are below actual quotations)
minus	sea transport costs e.g. FOB Georgia/Ukraine-CIF Bulgaria/Turkey/Greece
minus	Black Sea terminal costs
minus	rail* costs Georgia/Azerbaijan/Ukraine/Russia
minus	terminal costs Azerbaijan Caspian Sea
minus	Cross Caspian costs
minus	terminal costs Kazakhstan/Turkmenistan
minus	rail* costs Kazakhstan/Turkmenistan
minus	other costs like forwarding/inspection/finance/demurrage/insurance etc.
minus	customs fees on cargo and/or for transit

A typical break of costs for rail transport looks usually as follows :

- published tariffs
- discounts/premium to the tariff
- RTC rental charges
- possible charges for special rail sections in ports e.g. Mangischlag-Aktau; FCA Turkmenbashi tank farm – FOB Ferry boat
- RTC movements and placements
- Return of empty RTCs
- Border crossing costs
- documentation

Current (Spring 2007) actual LPG prices:

FCA Kysil Orda/Kazakhstan	US$ 350 MT
FOB Batumi asking price	US$ 465 MT
FOB Batumi bidding price	US$ 400 MT
CIF Black Sea	US$ 525-550 MT
DAF Polish border	US$ 540 MT and above
FOB Turkmenbashi	US$ 350-400 MT

6 Conclusions

Most promising option

Whereas LPG transport demand within the likely 'servicing' area of the TRACECA corridor is expected to follow a gradual growth pattern, the only promising concept for TRACECA for the short-to-medium term, from a technical point of view, is block train transport in dedicated LPG RTCs, while using rail ferries across the Caspian Sea and deliverable ex-Batumi at the LPG terminal.

The technical possibilities of this short-to-medium term TRACECA corridor LPG transport concept are dictated primarily by the following 'transport chain' characteristics:

1. Operations of LPG block trains in Kazakhstan and Turkmenistan respectively from the LPG production sites to the Caspian Sea ports (in as far as the LPG is not produced close to those ports or carried there by pipeline).
2. Operations of RTC rail ferries across the Caspian Sea between Aktau (Kazakhstan) and Turkmenbashi (Turkmenistan) respectively and Baku (Azerbaijan), ferrying the block train RTCs.
3. Operations of LPG block trains (of the same RTCs) between Baku (Azerbaijan) and Batumi (Georgia/Black Sea).
4. Throughput of the Batumi LPG Terminal receiving LPG from the shuttle block train-RTCs and loading it onto LPG-tankers.

A phased approach in time

For practical reasons, a distinction should be made between what is technically possible on the:

1. Short term, i.e. within the next three years,
2. Medium term, i.e. 3-5 years from now, and
3. Long term, i.e. more than five years from now.

Current situation

The current LPG flow along the TRACECA corridor (Baku-Batumi) is less than 20,000 mT/year (whereas the operation of two block train per week, representing an annual flow of 100,000 mT might be considered the 'current (lowest) capacity potential') while the potential near future demand has been estimated (see Working Paper 2) at 1.0 – 2.3 million mT/year.

Low volumes are explained by high asking transport prices of the parties in TRACECA compared to alternative routes. Kazakhstan is exporting via Russia, as well as East bound, and Turkmenistan to Iran and other countries. Besides, there is currently a lack of a well structured overall competitive organisational set up for LPG transport on the TRACECA corridor.

Short term (now-2010)

In the short term (now-2010), the Batumi LPG terminal with an estimated annual throughput of approximately 150,000 mT/year is considered a most determining technical component in the LPG transport chain capacity. This annual throughput supplied from the Baku end calls for three block trains per week, i.e. slightly more than 150 LPG transports per year (28 RTCs carrying altogether 980 mT). From a technical point of view, this performance level should be attainable in the short term. Likewise, the trans-Caspian RTC rail ferries operating the Aktau-Baku and Turkmenbashi-Baku, should be able to guarantee the supply of the (average of) three block trains (84 RTCs) per week from the two exporting countries—the concerned train ferry terminals would need some technical improvements and more 'Dagestan' type ferries would need to be made suitable for LPG transport but this may not be a great obstacle in a technical sense.

Medium term (2010-2012)

In the medium term (2010-2012), the throughput capacity of the Batumi LPG terminal would need to be quadrupled, perhaps in two steps (300,000 mT/year in 2010, and 600,000 mT in 2012—not necessarily all at the present location) to meet the capacity of eventually 12 block trains per week (2 per day) on the Baku-Batumi railway line, and of the Caspian Sea ferries that could supply up to a

combined 600,000 mT/year from Aktau/Kazakhstan and Turkmenbashi—using larger ferries of the 'Makhachkala' type (52 RTCs).

From a technical point of view, this level of 600,000 mT/year is believed to be the upper limit of what could be achieved with the block train LPG-RTC transport concept-cum-rail ferries across the Caspian Sea. Bottlenecks are the current two multimodal loading jetties at Aktau and Turkmenbashi and the one discharging jetty at Baku and provided other cargo flows do not increase and/or interfere significantly. In addition, rail capacity for LPG transport may prove to be a serious bottleneck. This represents about 60% of the estimated (1.0 million mT/year) minimum potential demand and just 25% of the estimated (2.3 million mT/year) maximum potential demand. The future construction of additional ferry jetties and the creation of sufficient rail capacity may add to available transport volumes.

Clearly, there are alternative East-West routes to satisfy growing LPG demand in the West. These circumvent the TRACECA corridor, either as a northern (Russian) parallel route Kazakhstan-Azov/Black Sea (Temruk, Taman) or a southern (Iranian) parallel route Turkmenistan-Iran-Turkey. From a technical (planning and implementation) point of view both parallel routes seem to be ahead of the present TRACECA 'project'. It is also likely that both non-TRACECA routes will be very competitive in transport pricing, each within its most probable market area outreach. Whether the TRACECA LPG rail transport concept can effectively compete on financial-economic terms remains to be assessed in Working Paper 6.

The three mentioned corridors (Russian, TRACECA, Iranian) will most probably together be able to accommodate the earlier estimated (2.3 million mT/year) maximum potential demand, although little can be said at this moment about the likely share of each of the three routes.

A possible victim of this competition might be the Ukranian port complex of Odessa/Ilyichevsk/Reni which presently is exporting practically all Black Sea-LPG from Kazakhstan, etc. In case of continued rapid growth of demand in North-east Europe (Poland, Czech Republic) there might be a possibility for a (limited) transit function of LPG transport from the Caspian Sea via Batumi to North-east Europe.

Long term solution (after 2012)
The longer term solution (after 2012), given the potentially LPG supply quantities, might be transport by pipeline. When using, i.e. sharing an LNG pipeline, this will be economically feasible at a significantly lower annual throughput volume then in the case of a dedicated LPG-only pipeline Baku-Black Sea.

A dedicated LPG-only pipeline is believed to require an annual 'contract' throughput volume that might be in the range of the estimated maximum potential demand (more than 2 million mT/year). The decision to implement such a pipeline would require great confidence in the capability of the pipeline to attract the LPG flows away from both the Russian and Iranian parallel corridors; this could be a risky assumption.

Greater perspective would be offered by a transport-sharing arrangement with a Trans-Caspian LNG pipeline connecting with the envisaged Nabucco pipeline for LNG. Further efforts should focused on the technical feasibility of this concept[26].

At the same time, the technical feasibility of a transport-sharing arrangement with a Trans-Caspian LNG pipeline connecting with the envisaged Nabucco pipeline for LNG should be elaborated, unless this would seem inappropriate at this moment, e.g. due to non-technical considerations.

The challenges on the short, medium and long run, based on the above, may seem high. However, an interesting parallel can be drawn with the transport of crude oil and oil products in the beginning of the

[26] The consultant refers in this respect to the apparently difficult and already long ongoing discussions and investigations about any cross Caspian pipelines.

nineties. At this point existing infrastructure was poor and there was basically no transit transport via Azerbaijan and Georgia. Ever since crude oil and oil product flows have gradually risen up to 11 million tonnes per annum. Despite considerable efforts and investments since the nineties into the crude oil logistics on the Traceca corridor it must be understood that the prevailing and existing infrastructure from the 'Soviet times' could still cope with such crude oil and oil product volumes. This is clearly not the case for LPG transport as the existing infrastructure does not have the required capacities, structures and competitiveness. The crude oil case illustrates, however, that under the 'right' circumstances there is substantial transport potential for the Traceca corridor. The required new infrastructure requires sizeable investments[27]. Furthermore, considerable efforts should be put in the organisation of the transport flows to improve the speed and competitiveness of LPG transport on the TRACECA corridor[28].

[27] As will be detailed in Working Paper 6
[28] Which will be subject of study in Working Paper 5.

ANNEX-1: Main LPG characteristics as a dangerous good

LPG is manufactured during the refining of crude oil, or extracted from oil or gas streams. At normal temperatures and pressures, LPG will evaporate. Because of this, LPG is supplied in pressurised steel containers (tanks, RTCs etc.). In order to allow for thermal expansion of the contained liquid, these containers are not filled completely; typically, they are filled to between 80% and 85% of their capacity. The ratio between the volumes of the vaporised gas and the liquefied gas varies depending on composition, pressure and temperature, but is typically around 250:1. The pressure at which LPG becomes liquid, is approximately 220 kilopascals (2.2 bar) for pure butane at 20 °C (68 °F), and approximately 2.2 megapascals (22 bar) for pure propane at 55 °C (131 °F). LPG is heavier than air, and thus will flow along floors and tend to settle in low spots, such as basements. This can cause ignition or suffocation hazards if not dealt with.

LPG has a higher calorific value (94 MJ/m³ equivalent to 26.1kWh) than natural gas (methane) (38 MJ/m³ equivalent to 10.6kWh), which means that LPG can not simply be substituted for natural gas.

Anyone concerned with handling and storage of LPG should be familiar with the following characteristics and potential hazards:

(a) LPG is stored as a liquid under pressure. It is almost colourless and its weight is approximately half that of an equivalent volume of water.

(b) LPG vapour is denser than air: butane is about twice as heavy as air and propane about one and a half time as heavy as air. Consequently, the vapour may flow along the ground and into drains, sinking to the lowest level of the surroundings and be ignited at a considerable distance from the source of leakage. In still air vapour will disperse slowly.

(c) LPG can form a flammable mixture when mixed with air. The flammable range at ambient temperature and pressure extends between approximately 2 % of the vapour in air at its lower limit and approximately 10 % of the vapour in air at its upper limit. Within this range there is a risk of ignition. Outside this range any mixture is either too weak or too rich to propagate flame. However, over-rich mixtures can become hazardous when diluted with air and will also burn at the interface with air.

At pressures greater than atmospheric, the upper limit of flammability is increased but this increase with pressure is not linear.

(d) Escape of even small quantities of the liquefied gas can give rise to large volumes of vapour / air mixture and thus cause considerable hazard. A suitably calibrated explosimeter may be used for testing the concentration of LPG in air.

(e) At very high concentrations in air, LPG vapour is anaesthetic and subsequently an asphyxiant by diluting or decreasing the available oxygen.

(f) Commercial LPG is normally odorised before distribution by the addition of an odorant, such as ethyl mercaptan or dimethyl sulphide, to enable detection by smell of the gas at concentrations down to one-fifth of the lower limit of flammability (i.e. approximately 0, 4 % of the gas in air). However, in certain cases where the odorant may be detrimental to a process (for example in aerosol applications) the LPG is not odorised.

(g) Escape of LPG may be noticeable other than by smell. When the liquid evaporates, the cooling effect on the surrounding air causes condensation and even freezing of water vapour in the air. This effect may show itself as frost at the point of escape and thus make it easier to detect an escape of LPG. Because the refractive index of LPG differs from air, leaks can sometimes be seen as a 'shimmering'.

(h) Owing to its rapid vaporisation and consequent lowering of temperature, LPG, particularly liquid, can cause severe frost burns if brought into contact with the skin. Personal protective equipment (e.g. hand and eye protection) should be worn if this hazard is likely to occur.

A container which has held LPG and is 'empty' may still contain LPG in vapour form and is thus potentially dangerous. In this state the internal pressure is approximately atmospheric. If a valve is leaking or is left open, air can diffuse into the container forming a flammable mixture and creating a risk of explosion: alternatively, LPG can diffuse to the atmosphere.

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ANNEX-2: LPG transport cost data of two long distance routes from Ashgabat (Turkmenistan) to Kiev (Ukraine) in tank wagons

Information concerning the cost of LPG transport in own tank wagons by capacity of 33 tons
(including an empty run) on the route Ashgabad- Kiev

Direction of transport		Distance km	Tariff, $ per 1 ton	Railways of countries																				
				TRK			UTI			KZKH			RZHD			UZ			AZ			GR		
				Distan km	Tariff	Rate for 10 th km	Distan. km	Tariff	Rate for 10 th km	Distan. km	Tariff	Rate for 10 th km	Distan. km	Tariff	Rate for 10 th km	Distan km	Tariff	Rate for 10 th km	Distan km	Tariff	Rate for 10 th km	Dista km	Tariff	Rate for 10 th km
I option	Ashgabad-Kvashine-Kiev	3831	207,64	610	39,09	0,64	431	29,10	0,68	832	43,25	0,52	1094	60,51	0,55	864	35,67	0,41						
II option	Ashgabad-Turkmenbashi-Baku-Poti-Ilyichevsk-Kiev	2128 *	226,53**	560	36,24	0,65										705	30,31	0,43	503	27,82	0,55	360	24,88	0,69

Notes:
* - without including a distance of ferry crossings Turkmenbashi-Baku and Poti-Ilyichevsk
** - including the freight price on ferries Turkmenbashi-Baku ($990 per wagon) and Poti-Ilychevsk ($2550 per wagon)

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ANNEX-3: Details of rail-ferry cost estimation – LPG in RTCs (possible upper limit variant)

Maximum cost case	Max. draught: at TMB 5.1m; at Baku (7-9) 8m; at Aktau 7m									
Rail-Ferry	Caspian Shipping Cy		plying across Caspian sea at 4.5 m draught							
	carrying 28 rail tank cars (15 m')			35	loading/unloading:	3	hrs	trips/year (incl. 'lost time')	Quantitiy T/year	
TMB-Baku - hrs/Nm	12	165	speed:	13.5	knots	turn around	36 hours	200	196,000	
Aktau-Baku - hrs/Nm	19	253	speed:	13.5	knots	turn around	48 hours	150	147,000	
US$ million	25-30	Annuity at 30 yrs lifetime and 12% interest rate:				0.1241	Total (2 ferries)	350	343,000	
Cap costs+Mtce/yr	$4,173,000	Annual maintenance costs (% of replacem value):				***0.015***				
	TMB-Baku	Akt-Baku		US$/hour	Operational cost/year	**TMB-Baku**	**Aktau-Baku**			
Hours/year at sea:	4,889	5,622		***667***		$3,260,889	$3,750,022			
Hours/year in port:	2,400	1,800		***375***		$900,000	$675,000			
Total	7,289	7,422				$4,160,889	$4,425,022			
					Operat. Cost/ton:	$21	$30			
					Cap cost+Mtce/ton:	$21	$28			
					Load+unload RTCs/ton	$2	$2			
					Full cost/ton:	**$45**	**$61**	maximum		

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ANNEX-4 Kazakhstan LPG logistics

Liquefied gas deliveries from Kazakhstan to Batumi

Cargo	2000	2001	2002	2003
Scheffelu	36	-	-	-
Butane	-	329,45	3390,089	663,80
Propane	-	166,25	1666,91	165,65
Propane and butane mixture	-	1427,4	-	-

Technical and operational characteristics of railway lines (2006)

Indices	Extension, km	Signalling equipment type- 'modern Soviet type'	Traction type	Length of stock in conventional wagons		Number of main tracks at spans	Freight train weight, t				Problem zones
							Unified for transit trains		According to locomotive capacity		
				odd	Even		odd	even	odd	even	
Uzen-Mangystau (Aktau port)*	**175**	ПАБ	Diesel traction	57	57	1	3200	3800	3200	3800	
Beyneu-Mangystau including sections:	**403,2**										
Beyneu-Say-Utjes	178	ЦАБ	Diesel traction	57	57	1	3200	3800	3800	4500	
Say-Utjes-Shetpe	134,4	ЦАБ	Diesel traction	57	57	1	3200	3800	3200	3800	+
Shetpe-Mangystau	90,8	ЦАБ	Diesel traction	57	57	1	3200	3800	3200	3800	+
Makat- Beyneu	**300**	**АБ, ДЦ**	**Diesel traction**	**57/71**	**57/71**	**1**	**4500**	**4500**	**6000**	**6000**	
Kandyagash-Aksarayskaya including sections:	**838,8**										

Kandyagash - Shubarkuduk	85,1	ДЦ	Diesel traction	71	71	1	4000	4000	4400	4200	+
Shubarkuduk-Sagyz	169,4	ДЦ	Diesel traction	71	71	1	4000	4000	4400	4000	+
Sagyz-Makat	137,9	ДЦ, АБ	Diesel traction	57/71	57/71	1	4000	4000	4400	4500	+
Makat-Atyrau	124,1	ДЦ, АБ	Diesel traction	57/71	57/71	1	4500	4500	5400	5500	
Atyrau-Ganjushkino	242,5	ДЦ, АБ	Diesel traction	57/71	57/71	1	4500	4500	6000	6000	
Ganjushkino - Aksarayskaya	79,8	ДЦ, АБ	Diesel traction	57/71	57/71	1	4500	4500	6000	6000	
Kandyagash-Azinki including sections:	**683**										
Kandyagash-Aktobe	94	ДЦ	Diesel traction	57/71	57/71	2	3200	3500	5000	4500	
Aktobe-Zhaysan	99	ДЦ	Diesel traction	57	57	1	3200	5500	3500	5000	
Zhaysan-Iletsk	96	ДЦ	Diesel traction	57	57	1	3200	3500	5500	5000	
Iletsk-Kazakhstan	146	ДЦ	Diesel traction	57	57	1	3700	3500	4500	4000	
Kazakhstan-Uralsk	118	ДЦ, АБ	Diesel traction	57	57	1	3700	3500	4500	4000	
Uralsk-Ozinki	130	ДЦ, АБ	Diesel traction	57	57	1	3700	3500	4500	4000	

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ANNEX-5 Turkmenistan LPG purchase prices

Date	Company	Product	Discount ($/mt)	Floor strike ($)	Amount (mt)	Advanced payment (%, $)	Period of lifting (days/months)	Direction	Terms of delivery
05.01.2007	**Petrochemical Commercial** (Iran)	**LPG** (Naip Terminal)	**-102**	**300**	**500 mt**	**50%**	**3 months**	Iran	FCA Наипский терминал
26.01.2007	**East Energy FZCO (UAE)**	**LPG** Turkmenbashi Refinery)	**-91**	**300**	**10 000 mt**	**100%**	**3 months**	Iraq, Armenia	FCA TKNPZ
07.02.2007	**Petrochemical Commercial (Iran)**	**LPG** Turkmenbashi Refinery)	**115**	**300**	**30 000 mt**	**100%**	**6 months**	Iran	FCA Turkmenbashi Refinery
14.02.2007	**Petrochemical Commercial (Iran)**	**LPG** (Naip Terminal)	**-102**	**300**	**5 000 mt**	**100%**	**3 months**	Iran	FCA Naip terminal
16.02.2007	**Petrochemical Commercial (Iran)**	**LPG** (Naip Terminal)	**-102**	**300**	**5 000 mt**	**100%**	**3 months**	Iran	FCA Naip terminal
21.02.2007	**Petrochemical Commercial (Iran)**	**LPG** (Naip Terminal)	**-80**	**300**	**5000 mt**	**100%**	**3 months**		DAF Serakhs
26.03.2007	**Bordoo Construction (Iran)**	**LPG** (Turkmenbashi Refinery)	**-103**	**300**	**10 000 mt**	**100%**	**4 months**	Iraq, Armenia	FCA Turkmenbashi Refinery
04.04.2007	**Meraban Zambro** (Afghanistan)	**LPG** (Naip) FOB AG Cargoes, Propane 40%, Butane 60%	**-74**	**300**	**5 000 mt**	**20%**	**4 months**		EXW Serhetabat Terminal
11.04.2007	**Azia Energy** (Iran)	**LPG** (Turkmenbashi Refinery) FOB AG Cargoes, Propane 20%, Butane 80%	**-175**	**300**	**10 000 mt**	**$ 1 000 000**	**4 months**	Russia	FCA Turkmenbashi Refinery

Date	Company	Product	Discount ($/mt)	Floor strike ($)	Amount (mt)	Advanced payment (%, $)	Period of lifting (days/months)	Direction	Terms of delivery
11.04.2007	**–**	**LPG** (Turkmenbashi Refinery) FOB AG Cargoes, Propane 20%, Butane 80%	**-119**	**300**	**10 000 mt**	**50%**	**4 months**	Afghanistan	FCA Turkmenbashi Refinery
11.04.2007	**Golden Crown** (UAE)	**LPG** (Turkmenbashi Refinery) FOB AG Cargoes, Propane 20%, Butane 80%	**-110**	**300**	**10 000 mt**	**70%**	**4 months**	Iran	FCA Turkmenbashi Refinery

ANNEX 6 Ukraine LPG logistics

The consultant considers the current situation for the Ukraine in respect to competitive LPG transports as follows :

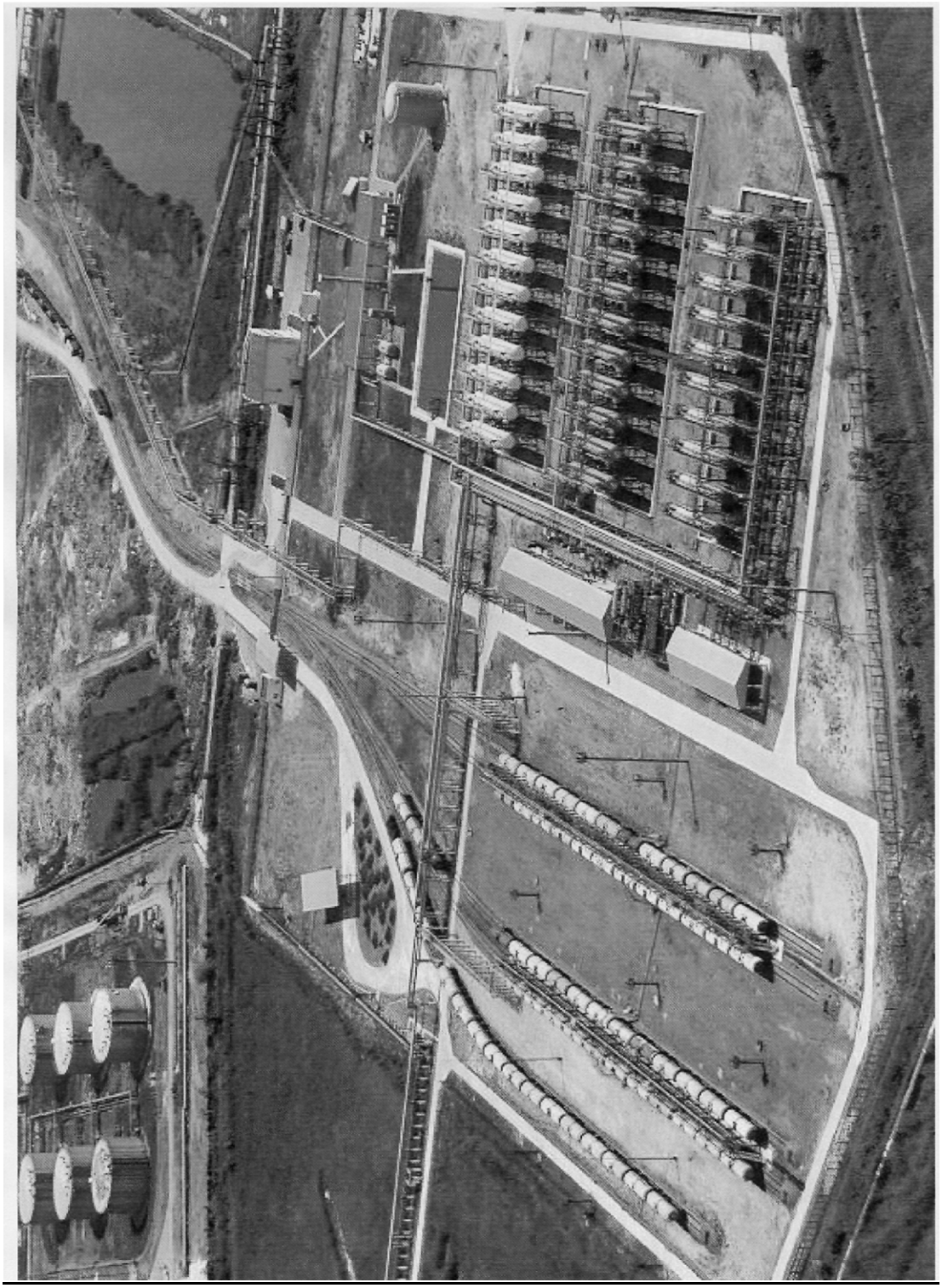
- Well organized and established LPG terminals at the Black Sea coast did secure considerable transit volumes from Russia and Kazakhstan;
- Competition for these terminals will arise from the newly constructed Russian terminals at the Black (Azov) Sea coast (Temruk, Taman);
- Rail way speed (for example waiting times between Odessa and the Polish border) must be subject to improvements;
- Transport schemes potential whereby the Ukraine functions as transit corridor between the Black Sea and Central Europe – being it by rail, on the Danube and/or by pipeline – bypassing the Bosporus strait.

Below Ukrainian transit LPG terminals in the Black Sea ports are described.

The Port of Odessa

Storage capacity:	Butane/Propane	6000 m^3
Train unloading capacity or time:	Train unloading capacity or time:	120 RTCs per day; 14 RTCs*4 = 8 hours
	No. tracks for (parallel) unloading	4 tracks, 2 railway overpasses
LPG-tanker loading capacity or time	Typical tanker load capacity	200 tons/hour
	No. of berth (length) for loading	3 (130 m)
	max. no. of tankers/day	0,5
	loading cost per tanker of specific tonnage	$ 1,5 per tonne of cargo
Typical annual throughput	Butane	500 000 tons
	Propane	350 000 tons

On the next page an overview of the port of Odessa is presented.



The Port of Kerch

The construction of a terminal on transshipment of Kazakh gas has been started in the Port.
Capacity of the first stage is 1 million tonnes per year.

The private terminal on gas handling is working in the port.
There are 2 rail tracks for parallel unloading with 10 tank wagons.
Ton load capacity: 1000 tonnes per day (8-9 thousand tonnes per month).
The terminal can handle tankers with gross tonnage up to 3000 tons.
LPG-tanker loading capacity or time: 1,5 – 2 days (2-3 tankers per month).

The Port of Ilyichevsk

LPG terminal first stage was put into operation in 2001.
The capacity is 220 thousand tons.
An additional births N 29 with length of 122 m and depth of 7,5 m was built by the Port.
LPG is transported to the terminal in tank wagons by capacity of 75 m^3. Double railway overpass is foreseen for 30 tank wagons by 15 from each side. LPG (propane and butane) is being transshipped directly without storage.

Gas-carriers with gross tonnage up to 10-12 thousand tonnes are handled in the terminal.
The owner is "Khimoil transit" company. Since 1999 a contract with the Port was made.
The Port receives only tonnage due for using the berth at $1,5 per 1 ton.

The Port of Reni

Storage capacity:	Butane/propane	3000 m^3
Train unloading capacity or time:	Block train	Two-way
	of no. RTCs with	10 tank wagons
	Ton load capacity	-
	tracks for (parallel) unloading	2
	max. no. of block trains/day	2,5
LPG-tanker loading capacity or time	Typical tanker load capacity	1000 tons/day
	berth (length) for loading	1
	max. no. of tankers/day	1

The owner is "Laguna-Reni" LTD

Information of "Ukrferry" Shipping Company, closed JSC
Ferry boats of "Heroes of Shipki" type (2 Ukrainian and 2 Bulgarian) working on the line Ilyichevsk-Poti, can carry up to 40 LPG tank wagons each trip. One of the ferry boat "Hero of Shipki" was upgraded to enable carrying of fire hazardous cargo on internal decks and now can accommodate for carriage up to 80 tank wagons with LPG each trip.

Taking into account that freight ferry boats make average two portcalls to Poti weekly, so monthly carrying capacity of a ferry terminal on the route Poti-Ilyichevsk is up to 500 tank wagons with LPG (10-11 thousand tons). Transit time of delivery from Poti to Ilyichevsk is 3 days including 2 days as a sea days, 1 days – for loading/unloading.

The carriage is implemented according to current tariff policy (it is published on web-site of both "Ukrferry" company and Bulgarian Maritime Fleet – BMF EAD) with increase by 1,2 times (increasing coefficient on fire hazardous cargo).

Additionally, when ferry line Kerch-Poti is put into operation (it is expected in June/July 2007), delivery time will be reduced to 2 days, and carrying capacity will be increased by 2 times.

ANNEX 7 LPG quality aspects

LPG-mix Specifications at export						
	Turkey		Europe(1)	Poland (1)	Iran	
	Commercial	Auto-Fuel	auto fuel	LPG mix	Propane	Butane
	TS 2178	TS-EN-589	EN-589	PL-EN589		
DENSITY						
at 15.5°C	0.547-0.573					
Specific Gravity at 60/60 c max					0.510	to report
LIGHT COMPONENTS						
C1+C2, Max	2,0 wt%					0.08 mol
C2, mol % Max					4.5	
VAP pressure,at 40°C, kpa, Max	1.430 Max (a)	1,550	1,550	1,550		70
Min.Vapor Pressure at temp. °C,		Winter grade	Winter grade	Winter grade		
150 kpa, Max		- 19 °C	- 19 °C	- 19 °C		
Vapor Pressure, Max 100°F(psi)						70
Vapor Pressure, (psi) Max					200	
PROPANE C3						
C3	30				95 mol % min	2 mol max
BUTANE C4	70					97.5 mol min
I-C4, mol % max					1.5	
N-C4, mol % max					0.4	
OLEFINS						
Dienes (1,3-Butadiene), vol.%, Max.		0.5	0.5	0.5		
HEAVY COMPONENTS						
C5+	2.0 vol. max%					0.82 mol max
Evaporation Residue, mg/kg or ppm, Max		100	100	100		
Volatile Residue at 95% evaporation	2.2 max°C	-				
Residual on evaporation of 100 ml. max.	0.05 ml.					
Residual on evaporation						0.05 ppm max

SULFUR COMPONENTS						
Total Sulfur, mg/kg or ppm, MAX	140	50	50	50	150 ppm, max	30 ppm max
Hydrogen Sulfide		Nil	Nil	Nil	(ppm) max, negative	
Free Water content	none	Nil at 0°C	Nil at 0°C	Nil at 0°C		10 ppm max
Copper corrosion, max.	No. 1	No. 1	No. 1		1A	No. 1
Odor		Distinctive	Distinctive	Distinctive		
MON		89 min	89 min	89 min		

(1) Valid in Poland since January 1 2007, waiver for Bulgaria and Roumania. By 2009 Sulfur content to be reduced to 10 ppm

The main LPG quality criteria are :

- Light material content (methane - ethane) or safety requirement
- Propane content is mainly linked to local weather conditions as reduced propane content for Turkey compared to West Europe
- Olefin contents to be limited as it can generate gum in autogas
- Pentane plus content, or non volatile components to be restricted
- Sulfur compounds and acidity for environmental and corrosion considerations

The European autogas specifications in force since 2001 has been developed by the “COMITE EUROPEEN DE NORMALIZATION”: **EN589**

Currently the total sulphur limit is 50 ppm max, but is due to be reduced to 10 ppm Max in 2009.

Thus adhering to EEC autogas specs shall allow export of propane/butane mix to EEC countries, East European countries and Turkey. As regards to Iran, with the increasing utilization of LPG as autogas in major cities as Teheran, safety and environnement considerations are expected to be addressed in the future.

LPG norms and qualities in CIS export plants

We have compared . in TABLE 2 CIS LPG norms with actual LPG mix qualities (quality passports) from various CIS plants from Russia (Orenbourg), Ukraine (Kremenchug, Lisichansk), Kazkhstan (Uzen, Pavlodar, Tchikent), Uzbekistan (Shurtan) and Turkmenbashi the main LPG producer in Turkmenistan.

LPG norms GOST 20448-90 are used in all above CIS Countries for LPG mix (or propane butane mix) used for local requirements for residential, autogas, petrochemicals,…demand), and is the main grade produced in all CIS Countries. Some exceptions: Tengizchevroil in Kazkhstan which built the processing plants to make propane and butane separately and at the most stringent specs at the time.Also several gas plants in Russia (Tchaikovky, Tobolsk, Kuybishev) are also producing propane, butane separately and some normal butane iso butane, isopentane, normal pentane.

With the EN-589 specs, almost all Oil refineries in CIS are producing off specs LPG mix, except possibly Kirichi refinery in Russia and Lisichansk in Ukraine producing butane as petrochemical feedstock and Turkmenbashi refinery LPG mix and technical butane.

Among the gas processing plants, several gas plants in Russia (Tchaikovsky,Tobolsk, Kuybishev), Tengiz in Kazakhstan, New Shurtan in Uzbekistan can meet E-589 specs.
(Turkmen and Ukraine gas plant detailed specs are not available).

As of April 20 at Moscow international LPG conference, no new investments for improving LPG qualities in the CIS have been announced as yet.

Iran has accepted C1+C2 content up to 4 wt % from Tchimkent and is accepting Uzbek and Turkmen LPG qualities in larger quantities.

Exports to China, Afghanistan and Countries surrounding Kazakhstan are not expected to be affected by quality considerations.

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LPG CIS Specifications and Qualities

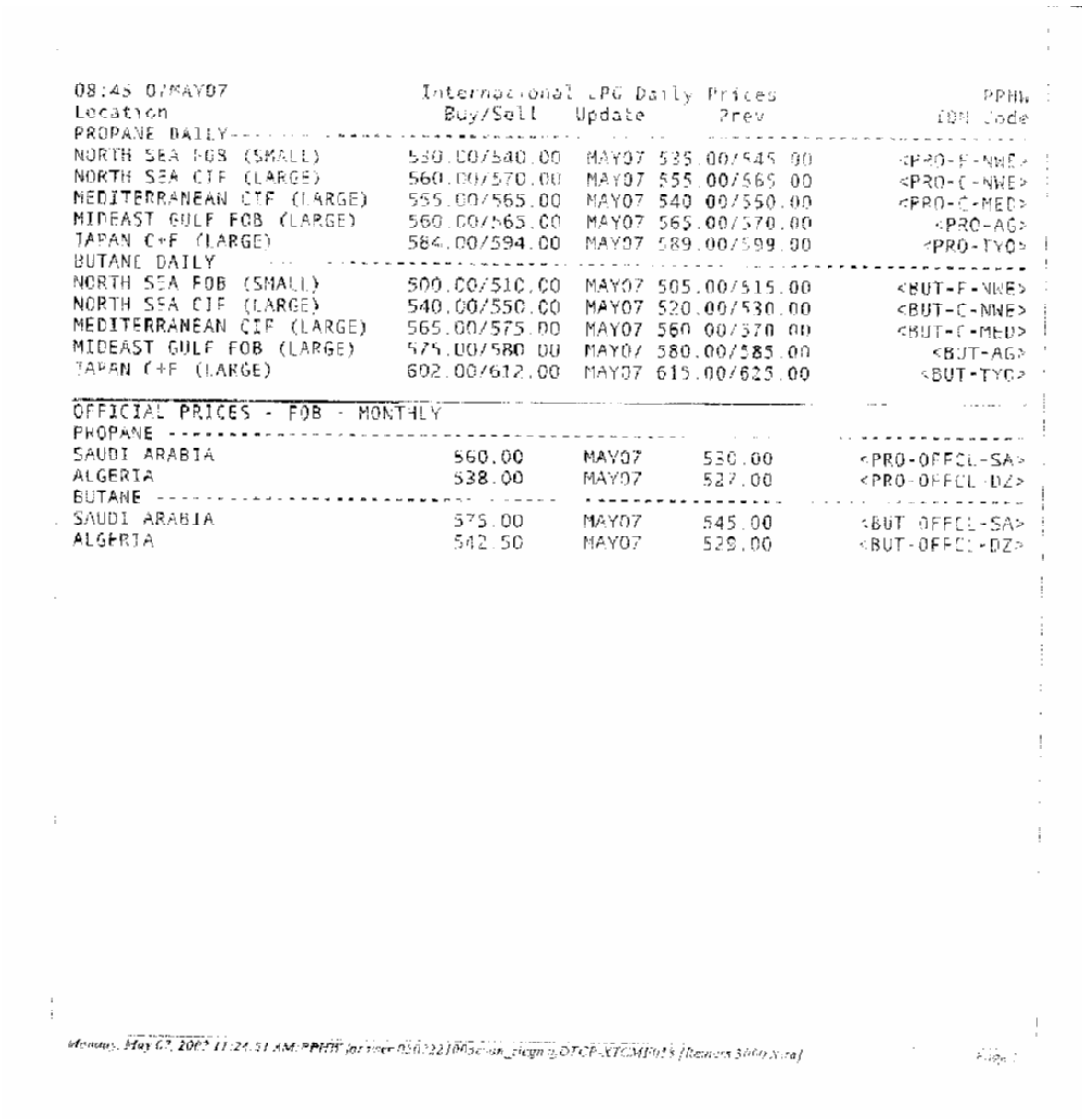
components, %, weight	***CIS Specifications GOST 20448-90***	***CHEVRON SPECIFICATIONS***		***Actual lpg (Propane:Butane maix) quality***							
		Tengiz C3	Tengiz C4	Orenburg (1)	Kremenchug	Lisichansk	Uzen	Tchimkent (2)	Pavlodar (3)	**Turkmenbashi**	Shurtan new
Sum of C_1, C_2,	no standard	2.0 Vol% Max		3.3	0.34	0.50	0.26	0.03	1.41	0.39	0.17
sum of propane , propylene, %	no standard	95.0 Vol% min	Report	64.6	34.55	39.70	52.38	48.84	54.00	16.08	47.13
sum of butanes, butylenes, % Max	60	-	95.0 Vol% min	32.9	64.69	59.80	44.86	48.02	44.56	**83.36**	48.74
C5+, max		2.0 Vol% Max	2.0 Vol% Max	0.1	0.42				0.00		
Liquid balance at +20°C, %, max	1.6			0.2		Nil	0.3				0.5
Vapour pressure, excessive, Mpa, at 45 °C, max	1.6			1.33		1	1	1.03	1.17	0.65	1.035
at 37.8 °C		1.434	0.483								
Mass content of hydrogen sulphur and mercaptan sulphur,%, max	0.013 (130 ppm)			0.007-0.013	0.0063	0.0087	0.002	0.0023	0.0024	0.002	0.0023
Mass content of hydrogen sulphur and mercaptan sulphur, ppm equivalent	130	15 ppm Wt	15 ppm Wt	85	63	87	20	23	24	20	23
including hydrogen sulphur, max	0.003	0.5 ppm Vol	0.5 ppm Vol	Nil	Nil	Nil	Nil	Nil	Nil	0.0001	Nil
Water and alkalis content	Nil	Nil	Nil	Nil		Nil	Nil	Nil	Nil	Nil	Nil
Corrosion		1	1	1					> 1 (3)		
Density at +20°C, Kg/m3						547		524			

Methanol - none
Ammonia - none
dienes < 0.1% by weight
N/Iso butane split:
appoximately 2:1
Unsaturated Hydrocarbons:
None.

(1) Orenbourg Sulfur vary between 70 and 130 ppm
(2) Tchimkent C1+C2 was advised to fluctuate between 3 and 13%wt
(3) Pavlodar is reported by Primagaz to be offspces for corrosion.

ANNEX 8 LPG price quotation

Below an example of a LPG price quotation is presented



08:45 07MAY07 International LPG Daily Prices PPHM

Location	Buy/Sell	Update	Prev	PPHM Code
PROPANE DAILY				
NORTH SEA FOB (SMALL)	530.00/540.00	MAY07	535.00/545.00	<PRO-F-NWE>
NORTH SEA CIF (LARGE)	560.00/570.00	MAY07	555.00/565.00	<PRO-C-NWE>
MEDITERRANEAN CIF (LARGE)	555.00/565.00	MAY07	540.00/550.00	<PRO-C-MED>
MIDEAST GULF FOB (LARGE)	560.00/565.00	MAY07	565.00/570.00	<PRO-AG>
JAPAN C+F (LARGE)	584.00/594.00	MAY07	589.00/599.00	<PRO-TYO>
BUTANE DAILY				
NORTH SEA FOB (SMALL)	500.00/510.00	MAY07	505.00/515.00	<BUT-F-NWE>
NORTH SEA CIF (LARGE)	540.00/550.00	MAY07	520.00/530.00	<BUT-C-NWE>
MEDITERRANEAN CIF (LARGE)	565.00/575.00	MAY07	560.00/570.00	<BUT-C-MED>
MIDEAST GULF FOB (LARGE)	575.00/580.00	MAY07	580.00/585.00	<BUT-AG>
JAPAN C+F (LARGE)	602.00/612.00	MAY07	615.00/625.00	<BUT-TYO>
OFFICIAL PRICES - FOB - MONTHLY				
PROPANE				
SAUDI ARABIA	560.00	MAY07	530.00	<PRO-OFFCL-SA>
ALGERIA	538.00	MAY07	527.00	<PRO-OFFCL-DZ>
BUTANE				
SAUDI ARABIA	575.00	MAY07	545.00	<BUT-OFFCL-SA>
ALGERIA	542.50	MAY07	529.00	<BUT-OFFCL-DZ>

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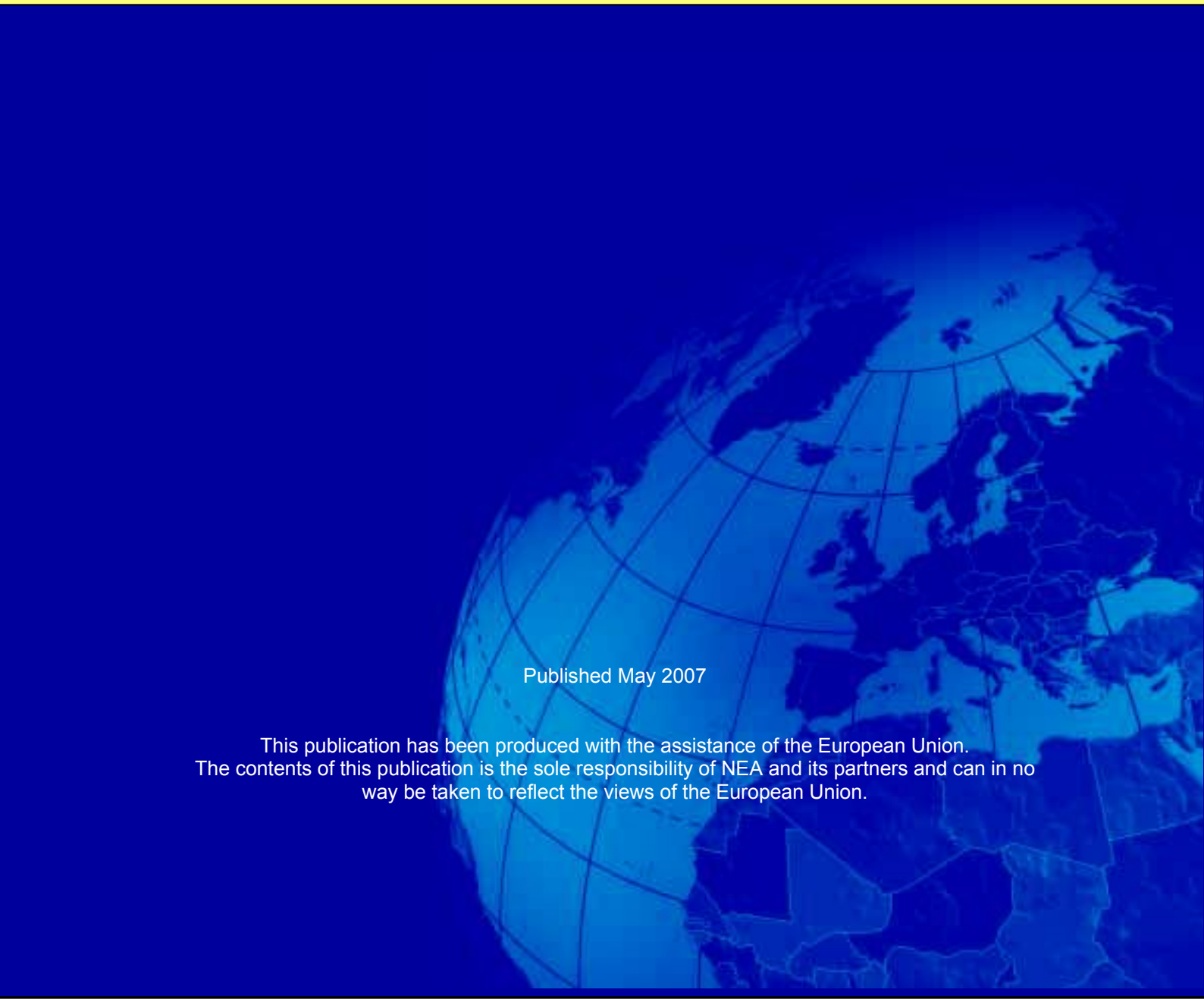

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