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Study on the Technical Aspects of Variable Use of Oil Pipelines - Coming into the EU from Third Countries

OVERALL REPORT

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LIST OF ABBREVIATIONS

Abbreviation	Description
AWP	Adria-Wien pipeline
BSP	Bratislava-Schwechat pipeline
CAPEX	Capital expenditures
CPC	Caspian Pipeline Consortium blend (type of crude oil originating from Kazakhstan)
d	day
DG ENER	Directorate-General for Energy of the European Commission
DRA	Drag reducing agent
EPCM	Engineering, procurement, construction management
EU	European Union
EUR	Euro
IGA	Inter governmental agreements
IKL	Ingolstadt-Kralupy-Litvinov pipeline
ILF	ILF Consulting Engineers
km	kilometre
MERO	Mezinarodni Ropovody CR. (pipeline operator in the Czech Republic)
mn	Million
MT	Million tonnes
MTA	Million metric tonnes per annum (year)
OBP	Odessa-Brody pipeline
PCK	PCK Rafinerie GmbH (operator of the Schwedt refinery in Germany)
REB	Russian export blend (or Urals blend)
SCADA	Supervisory Control and Data Acquisition
SPSE	South European pipeline
t	metric tonne
TAL	Trans Alpine pipeline
SCADA	Supervisory control and data acquisition
WP	Work package

1 INTRODUCTION

In August 2009, the Directorate-General for Energy of the European Commission (DG ENER, previously DG TREN) issued an Invitation to Tender TREN/485-1/C3/2009 for a study on the "Technical aspects of variable use of oil pipelines coming into the EU from third countries". In December 2009, ILF Consulting Engineers was awarded the study, which was kicked-off at a meeting in Brussels held in January 2010. ILF retained Purvin & Gertz as a subcontractor.

The scope of the study envisaged three phases, each with a defined scope of work and list of deliverables. The three phases were referred to as Work Package (WP) 1, 2 and 3. Purvin & Gertz took leadership for the execution of the WP1, whereas ILF took leadership for the subsequent WP2 and WP3. A draft report was issued at the end of each phase. The three draft reports were later finalized incorporating comments made by DG ENER. This report summarizes the entire study and conveys the relevant conclusions.

The study's objective was to analyse how the security of oil supply to the European Union member states could be enhanced in case of a lasting supply disruption.

Ultimately, this depends on the ability to feed a sufficient amount of refining capacity, which would in turn supply refined products to the market.

There are several refineries in the EU that take delivery of crude oil via pipelines that enter the EU from third countries. These refineries are located in Poland, Germany (i.e. Leuna and Schwedt), Hungary, the Czech Republic and the Slovak Republic. The majority of these refineries are normally supplied via the Druzhba pipeline system from Russia via Belarus or Belarus/Ukraine. These five countries represent the "core" study region. All of the other EU refineries are located on the coast or are served by pipelines that are within the territory of the EU. The Mazeikiiai refinery in Lithuania (also included in the study region) is a special case, as it used to take delivery of crude oil from Druzhba, prior to an interruption of supply in July 2006. Since then, the refinery has been taking delivery of crude oil via the Butinge sea terminal.

Three of the primary objectives of WP1 were:

- to gather a certain amount of information about the crude oil pipelines that enter the EU (and hence the study region) from third countries
- to use this information in order to ascertain whether the refineries in the study region have access to alternative crude oil supply routes

- to analyze whether the alternative routes are adequate to prevent supply disruptions in the territory of the EU, in case of unavailability of crude oil from the primary supply route

During WP1, the focus of the study was primarily on the pipelines that are located within the study region and only to a limited extent on the pipelines that carry crude oil to the EU borders. The purpose of the study was to determine whether the EU crude oil supply system has the necessary redundancies to prevent a supply disruption. The main exception to this was the Janaf system in Republic of Croatia, which provides an alternative supply route into the study region that is completely independent from Druzhba.

At the end of WP1, DG ENER selected three pipelines to be analysed in WP2. The following three projects were selected:

- reverse flow in the Bratislava-Schwechat pipeline¹ (BSP)
- expansion of Sisak-Szazhalombatta-Sahy pipeline
- use of the Odessa-Brody pipeline (OBP)

The objective of WP2 was to provide a high level review of the feasibility of each of these three projects and how they could contribute to supply on a mid-term perspective, i.e. for a disruption of Druzhba flow between 90 and 180 days.

At the end of WP2, DG ENER selected one project to be studied in further detail in WP3. The selected project was the Odessa-Brody pipeline. The selection of the Odessa-Brody pipeline was dictated by the fact that this pipeline has the potential to provide backup supplies to a large proportion of the refining capacity located along Druzhba on a long-term base, i.e. for more than 180 days or even forever.

¹ This pipeline does not exist yet, but the project is being developed by OMV to provide an additional crude oil supply route for the Schwechat refinery (Austria). For the purpose of WP2 we assumed that the pipeline would be built and we studied its possible use in the reverse direction.

2 EXECUTIVE SUMMARY

Sufficient and reliable availability of crude oil is one of the most important preconditions for economic stability of industrialized economies. Primary energy needs of European Union (EU) member states are covered up to 50 % by oil, i.e. oil represents the most important element of Europe's energy mix. Declining reserves in the North Sea will lead to higher dependency on imports within the near future. According to the PRIMES model, the EU's import dependency for oil will increase to over 90% in the year 2020.

The investigation of possible pipelines which could contribute best to secure a sustainable and reliable transport of oil to a large area of EU members in Central and Eastern Europe was the major objective of the present study. The review of the existing infrastructure is the initial entry to the "Study on the Technical Aspects of the Variable Use of Oil Pipelines Coming into the EU from Third Countries". The idea is to utilise spare capacities in Europe's oil pipeline network that may be adapted at low cost and little time where required and necessary.

2.1 Review of Existing Infrastructure

The review of the existing infrastructure mainly focuses on:

- gathering information about the crude oil pipelines that enter the EU (and hence the study region) from third countries;
- making use of this information in order to ascertain how the refineries in the study region are primarily supplied and in which way they have access to mid- and long-term alternative crude oil supply routes;
- analyzing whether the alternative routes are adequate to prevent different levels of supply disruptions in the territory of the EU in case of unavailability of crude oil from the primary supply route.

A large proportion of the pipelines included in the scope of this study are part of the Druzhba ("Friendship") pipeline system, which is the largest pipeline system in the world. Under normal circumstances, almost all crude oil processed in Poland, the Slovak Republic, Hungary and eastern parts of Germany as well as a substantial proportion of the crude oil processed in the Czech Republic originates from Russia and is delivered to refineries in these countries via the Druzhba. Historically, the Druzhba system also delivered crude oil to the Mazeikiai refinery in Lithuania. Crude deliveries along this section of the Druzhba line were suspended in 2006, and the Mazeikiai refinery activated (and continues to use) its own crude oil supply route from the Butinge tanker terminal.

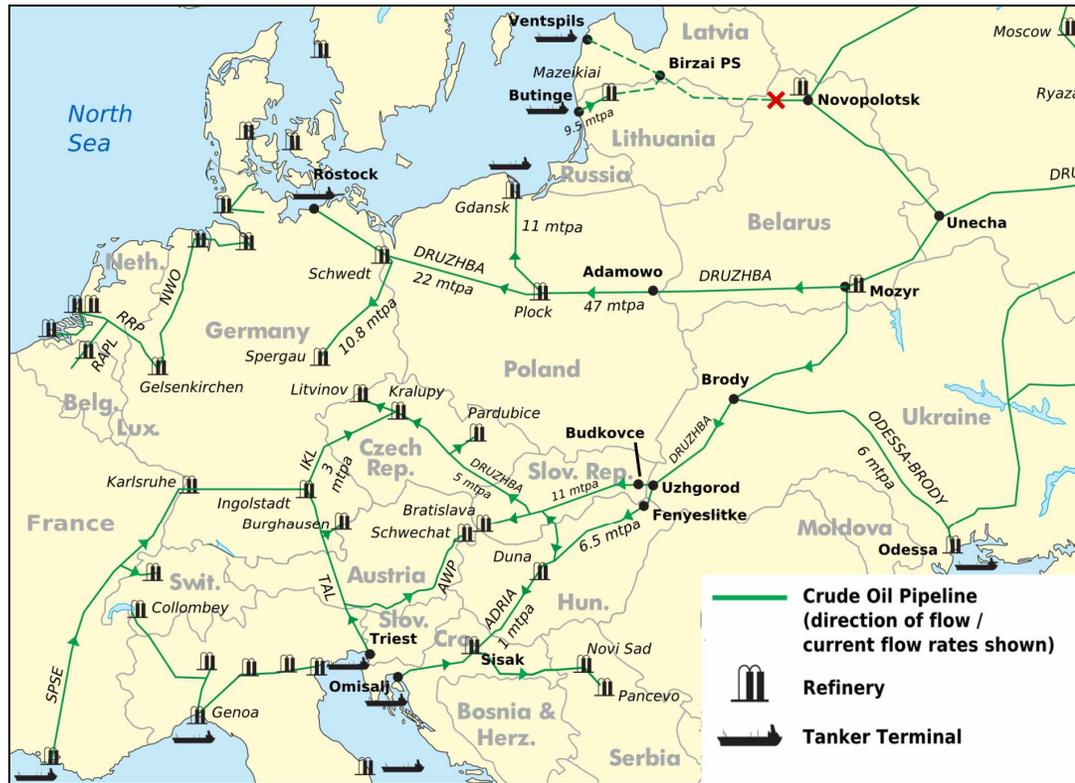


Figure 2-1: Current Flows in Central and Eastern Europe’s Oil Pipeline Network

The Druzhba line begins in South Eastern Russia, where it collects oil from Western Siberia, the Urals and, to a smaller extent, the Caspian Sea. Most of the crude oil is blended to a common export blend referred to as Russian Export Blend (REB), or Urals Blend. The line runs to Mozyr in Belarus where it splits into two branches, the Northern and Southern Druzhba lines. The current flow through Belarus amounts to 64 million tons per year (MTA) of REB in addition to some crude exported to non-EU countries (mainly via Odessa).

The Northern Druzhba line runs from Mozyr to Adamowo in Poland, and from Adamowo onwards to Plock refinery, in Poland. Here the line connects with the Pomeranian pipeline, which runs from Plock to Gdansk refinery. The Druzhba pipeline continues across Poland to Heinersdorf in Germany where it splits into branches running to the Schwedt and Leuna refineries, respectively. At Heinersdorf, the Druzhba pipeline ties in with the Rostock-Schwedt pipeline.

The Southern Druzhba line runs from Mozyr to Brody in Ukraine, and then on to Uzhgorod close to the border of Ukraine with both the Slovak Republic and Hungary. At Uzhgorod the Southern Druzhba splits into two lines, Druzhba-1, which feeds the Slovak Republic and the Czech Republic, and Druzhba-2 which feeds Hungary. Druzhba-1 passes into The Slovak Republic and runs from Budkovce to Sahy, and then on to Bratislava refinery. Close to Bratislava, at Bucany, the line splits again with one branch con-

tinuing to Bratislava and the other running to the Czech Republic where it connects to the Czech refineries Pardubice, Kralupy and Litvinov. The Druzhba-2 section passes from Uzhgorod into Hungary and runs from Fenyestitke to Szazhalombatta refinery. There is also a connection between Szazhalombatta and Sahy, connecting Druzhba-1 and Druzhba-2.

There are other crude oil pipelines that supply or may supply crude oil into the study region:

- the Trans Alpine pipeline (TAL) links the port of Trieste (Italy) with Ingolstadt (Germany) and a total of five refineries in Austria and the south of Germany
- Trans Alpine pipeline connects into the Ingolstadt-Kralupy-Litvinov (IKL) pipeline, so as to allow supply to the Czech Republic from Trieste
- the Janaf pipeline system runs from the port of Omisalj (Republic of Croatia) to serve the refineries in Republic of Croatia, Republic of Serbia and Bosnia and Herzegovina. At Sisak, the pipeline connects with the Adria pipeline that reaches the Szazhalombatta refinery in Hungary
- the Rostock-Schwedt pipeline can provide crude oil to the Schwedt refinery in Germany, but currently there is no incentive to use it

These pipelines currently make a very low contribution to the crude oil supplies into the EU. They are either idle, underutilized or used in the opposite direction. The only exception is the Ingolstadt-Kralupy-Litvinov pipeline pipeline which is used regularly to supply up to 3 MTA of light sweet crude oil to the Kralupy refinery (Czech Republic). However, the presence of these pipelines becomes substantially more important if the crude supply via the Druzhba system is disrupted.

By analyzing the demand for refined products, it is possible to estimate the demand of crude oil, and, consequently, the need for security of supply. The product demand in Poland, the Czech Republic, the Slovak Republic and Hungary is expected to grow quite significantly from 41 million tons (MT) in the year 2008 to 49 MT in the year 2020, driven by a significant increase in demand for road diesel. Adding Germany to the total would have hidden the fact that a contrary declining trend in Western Europe can be observed. The Baltic States are well served by the Mazeikiiai refinery which responded to the cut of Druzhba supplies in 2006 by activating its own crude oil supply route. Therefore, the above mentioned four countries are those which might place additional strain on the pipeline infrastructure reviewed in this study because of a future growth in the demand of refined products.

This study considers the possibility that an interruption of supply on the Druzhba system could result in one of the following events:

- no flow of crude oil in the Northern Druzhba at Adamowo (Poland)

- no flow of crude oil in the Southern Druzhba at Uzhgorod (Ukraine)
- no flow of crude oil in the Southern Druzhba at Budkovce (Slovak Republic)
- no flow of crude oil in the Southern Druzhba at Fenyestitke (Hungary)

In case of an interruption of supply to Adamowo, the alternative would be to import crude at Gdansk directly to the refinery and also to feed into the Pomeranian pipeline. The Pomeranian pipeline has an import capacity of 34 MTA and can be reversed rapidly to supply the Plock refinery. Any short-term interruption of supply (less than 90 days) could be cushioned with strategic crude oil stocks. Allowing for future utilization of the full nameplate capacity of the Plock refinery, there would still be sufficient crude oil available for transportation to Germany. The current system is therefore capable of supplying the relevant refineries at their current capacities.

An interruption of supply to Uzhgorod is the worst case scenario for refineries in the Slovak Republic, Czech Republic and Hungary as it would cut off supplies to Southern Druzhba completely and it would impact crude oil supply to all of these countries:

- The Czech refineries would be able to receive supply via IKL. The capacity of the pipeline is adequate, providing that there is enough capacity in TAL to feed crude oil at the inlet of IKL pipeline. Its capacity exceeds the normal requirements of the Czech refineries. It would be technically simple to make modifications to the Druzhba pipeline to implement bidirectional flow.
- The Adria pipeline system may contribute to the security of supply with limited capacity only.
- Apart from a possible capacity increase of the Adria pipeline and an expansion of the Hungary-Slovak Republic connector, the situation could be improved by the construction of a pipeline between Schwechat and Bratislava. This project has been considered for some time. The line would be bidirectional; in normal operations would supply Russian crude oil to Schwechat. In case of emergency, its flow could be reversed.

An interruption of the supply to Budkovce or Fenyestitke essentially represents a less severe sub-set of an interruption at Uzhgorod elaborated above.

The proposed alternative supply routes to the refineries in the Czech Republic, the Slovak Republic and Hungary have in common that they are supplied by tanker imports to terminals on the Adriatic Sea, namely in Trieste and in Omisalj. If it is about the delivery of conventional crude oil, the tankers are most likely to come from the Black Sea passing the Bosphorus. Due to the longer and more congested supply routes from the Black Sea to Trieste and Omisalj in comparison to the direct Druzhba route, the transportation costs are higher.

In such a situation, the utilization of the Odessa-Brody pipeline in the direction of Brody injecting crude oil into the Southern Druzhba could be viable subject to the condition that the interruption of the Southern Druzhba occurs not at Uzhgorod or downstream of it, but upstream of Brody.

Based on the review of the various cases, there is sufficient reason to state that not all of refineries have equal access to alternative supply routes. When operating at lower utilisation, the refineries would most likely withdraw from refined product distribution and therefore affect the wealth of the surrounding economies.

2.2 Analysis of Selected Supply Routes

The realisation of alternative supply routes creates a redundant backup system for a mid-term interruption (from 90 to approximately 180 days) of the conventional supply route. It makes the realisation of a second or third backup system of questionable value. The selection of the most appropriate solution depends on the technical, economic and legal aspects of the variable use of the particular pipeline. Summarizing, the following pipelines have been analysed:

- Odessa-Brody pipeline
- Bratislava-Schwechat pipeline
- Sisak-Szazhalombatta-Sahy pipeline

The analyzed pipelines reflect the largest expected need for mainly technical changes in order to physically enable the variable use as well as meet the desired flow rates and direction. It must also be taken into account that the pipelines usually start at tanker terminals; furthermore, pipelines have different branches and takeoffs, and usually (at least in the vicinity of populated and condensed areas in Europe) supply more than just one refinery.

The Odessa-Brody pipeline was originally built as the initial section of a Euro-Asian Oil Transportation Corridor; however, it has not been extended to Poland nor used in that direction, yet. In its final stage, it has been designed to transport 33 MTA of Caspian crude using two intermediate pumping stations. The two pumping stations have not been built yet, leaving the pipeline at a capacity of 13.6 MTA of REB.

This capacity would be sufficient to supply the Southern Druzhba requiring only a small investment and minor technical changes. On this basis, no opposition from the permitting authorities is to be expected. The Odessa-Brody pipeline is operated by the state-owned Ukrtransnafta which would promote the project in case of a positive political decision.

Downstream of Brody, the Russian crude can follow the original route without any further changes. The case in which non-Russian crudes would replace the original supply is elaborated below. The transport from Odessa to Bratislava can be realised at a tariff of EUR 14.70 per tonne. The total transportation costs from e.g. Novorossiysk to Bratislava would amount to EUR 18.60 EUR per tonne.

The Bratislava-Schwechat Pipeline does not exist yet, but the project is being developed by OMV to provide an additional crude oil supply route for the Schwechat refinery (Austria). It was assumed that the pipeline would be built and would be able to be used also in reverse direction. The investment would be amortized by the normal use of the pipeline, i.e. pumping oil from Bratislava to Schwechat. It is planned to build the pipeline in a way that the flow could be reversed in case of emergency. If this possibility is taken into account for the design and the legal/contractual framework under which the pipeline is built and operated, the route via Trieste/Schwechat would constitute an attractive alternative route for emergency supply at very little or no extra cost.

With a tariff of EUR 5.90 per tonne, the transportation of crude from Trieste to Bratislava has the lowest shipping cost within the investigated routes. The combined tanker-pipeline transportation from Novorossiysk would cost EUR 12.70 per tonne.

The critical factor of the Bratislava-Schwechat pipeline appears to be the permitting procedure. The pipeline route crosses a water protection area on Slovak territory that can not be bypassed. The environmental laws were revised and changed making the permitting of the originally planned route corridor virtually impossible. An inter-governmental Memorandum of Understanding was signed in 2009 between the governments of Austria and the Slovak Republic, discussing cooperation in the oil and gas sector, and also declaring the intention to build the Bratislava-Schwechat pipeline. It also made reference to further revisions to the environmental laws to allow a permit on the originally planned pipeline corridor.

Upstream of Schwechat the existing branch lines Trans Alpine pipeline and Adria-Wien pipeline constitute a bottleneck for incremental volumes of transported oil. Particularly the Adria-Wien pipeline is at the maximum possible capacity. Pumping stations are already situated at high frequency along the pipeline route.

The Sisak-Szazhalombatta-Sahy pipeline seems to be the most attractive and realistic option for security of supply in the short term. Its capacity could be expanded according to the actual requirements with very limited investment. Three technical measures have been considered along the Szazhalombatta-Sahy section in order to pump oil to the Druzhba-1 supplying the Slovak Republic and Czech Republic, if necessary:

- constructing a second parallel linepipe
- modifying the existing Szazhalombatta pumping station and using a drag reducing agent (DRA)

- adding a new intermediate pumping station and modifying the Szazhalombatta pumping station

The first option requires the highest investment with EUR 63.4 mn. It has the advantage of making it possible to achieve a higher capacity should that be needed. However, without normal use the second pipeline would be idle and would have no commercial justification.

The option of using a drag reducing agent provides negligible investment of EUR 1.1 mn and gives rise to the operating costs that are mainly variable in nature. These costs would not have to be incurred until the pipeline is needed. This option would be a very cost-effective solution. Another advantage of the drag reducing agent option is the minimal requirements for the permitting process.

The transportation from Omisalj to Bratislava would cost EUR 11.80 per tonne. It contributes to costs of EUR 18.30 per tonne if transportation from Novorossiysk is considered.

2.3 Contribution of Odessa-Brody Pipeline to Security of Supply

The Odessa-Brody pipeline has the ability to transport oil to a large area of EU members in Central and Eastern Europe in a sustainable and reliable way. It not only has the potential of long-term supply but it also offers opportunities to diversify the sources of crude oil with the positive effect of becoming a reasonable bypass of the Bosphorus; it also reduces the volumes of crude leaving the Black Sea region along other routes.

Nine possible scenarios for the Odessa-Brody pipeline used as backup system have been developed, investigated and evaluated in the present report. These scenarios shall reflect different extents of shortfalls in deliveries via Druzhba. They focus on:

- variations in the extent of disruption, starting with a cut down of 15 % (comparable to recent examples in the gas industry) and stepping up to minus 50 %, 85 % and finally total disruption (100 %) assuming the Odessa-Brody pipeline replaces the capped supplies
- providing capacities to regions with urgent need (e.g. Slovak Republic), with respect to the utilization of alternative supply routes, initially neglecting those regions in the beginning, which are in the position to cover their demand by other means

The required technical measures for returning to the normal flow direction (i.e. the reversion of the already reversed pipeline) and even a capacity increase have been developed in order to fit the above mentioned scenarios. These measures are based on a detailed analysis of the actual status and use of the existing Odessa-Brody pipeline sys-

tem, with regard to linepipes, pumping stations, terminals, buffer tank farms and in particular the flow direction and operation methodology.

As measures for this necessary capacity increase, the installation of intermediate pumping stations and the injection of drag reducing agents or a combination of both were considered. The possibilities of realizing the expansion in either one step or in several consecutive steps, where the system capacity is gradually upgraded by additional intermediate pumping stations, were analysed. The locations of the intermediate pumping stations are optimized in accordance with these requirements.

A detailed implementation schedule was designed for the realization of the maximum capacity of 64 MTA by installing eight intermediate pumping stations, expanding the existing main pumping station and carrying out various secondary activities.

The implementation is scheduled to take place in two steps. The first step is scheduled to take 37 months (enabling the system to deliver 45 MTA of REB) mainly due to the construction of up to four intermediate pumping stations. In a second step, up to four additional pumping stations with a capacity of 64 MTA are to be built - representing a full backup system for Northern and Southern Druzhba. The total time for completion would thus amount to 49 months.

The Capital Expenditures (CAPEX) are estimated to range between EUR 15 mn for a throughput of 14.5 MTA and EUR 670 mn enabling a throughput sufficient for all of the Central and Eastern European refineries. The outlined CAPEX consider the major installations, i.e. construction of new pumping stations, the upgrade of the main pumping station and expansion of the existing tank farms at Odessa and Brody.

Up to a supply of 13.6 MTA of REB, there is no need for an additional investment. Taking into account additionally accrued personnel costs, electrical power consumption and maintenance costs, the total annual expenditures for operation range between EUR 1.7 mn per year for 2.6 MTA and EUR 13.3 mn per year for 64 MTA.

The scenario that is closest to the original design of the Odessa-Brody pipeline allows a throughput of 33 MTA of REB. The investment for the construction of two intermediate pumping stations and for the expansion of tank farms amounts to approximately EUR 113 mn. Operating costs amount to EUR 28 mn per year.

A diversification of supply was also investigated. Consequently, the supply of REB could be augmented or substituted by supplies of other types of crude. Any additional type of crude would have a direct impact on the number of tanks installed at Odessa and Brody. The batch operation would not differ much from the blend operation. Some additional measures might be necessary downstream of Brody to enable the batch operation.

The permitting process is deemed to be smooth as long as the new pumping stations are placed at the designed and already prepared locations. Oil pipelines in Ukraine are

state property, and the privatization or alienation of individual pipelines as well as the change of ownership of state enterprises in charge of major pipeline transport systems are prohibited by local laws. Therefore, a state-supported decision for the construction of e.g. intermediate pumping stations or tank farms will generally not be obstructed by any subordinate authorities during the approval process.

Due to the positive signals which the Ukrainian authorities, have been sending constantly with regard to the assurance of reliable supply of hydrocarbon energy resources to the EU, no opposition or obstacles are to be expected. Consequently, the successful negotiation of relevant contracts to secure variable use of the Odessa-Brody pipeline, above all the reaching of an intergovernmental agreement, as well as smooth approval and permitting processes can be expected.

Finally the following conclusion can be drawn:

- In case of a breakdown of the Druzhba system, the supply of Eastern Europe's refineries will be no problem upstream of Brody; downstream of Brody the supply may either be guaranteed by a capacity increase at the Adria pipeline, the realisation of the Bratislava-Schwechat pipeline or by a combination of several (existing) routes of supply.
- Using the Odessa-Brody pipeline represents a technically viable possibility to secure crude oil supplies to the European Union avoiding further dependency on the deliveries via the Druzhba system.
- The above backup system utilizing the existing Odessa-Brody pipeline in its original design would require up to 49 months for total completion and consume CAPEX of around EUR 113 mn.

nected to the Druzhba system and receive a large percentage of their crude oil supplies from Russia via the Druzhba.

Country	Location	Capacity [MTA]
Lithuania	Mazeikiai	9.4
Poland	Gdansk	10.5 ²
	Plock	17.8
Germany	Leuna	11.2
	Schwedt	12.0
Czech Republic	Litvinov	5.1
	Kralupy	3.1 ³
	Pardubice	1.0
Slovakia	Bratislava	5.7
Hungary	Szazhalombatta	7.9
TOTAL		83.7

Table 3-1: EU Refining Capacities Linked to Druzhba

There is a total of 83.7 MTA of refining capacity in the study region. In order to provide an assessment of the volume of crude oil that is needed in the study region, we must make deductions for the Mazeikiai refinery, which has been cut off from Druzhba, and the Gdansk refinery, which is located on the coast. Therefore, a total of approximately 63.8 MTA of crude oil is needed to supply the nameplate capacity of the inland refineries.

3.1 Northern Druzhba and Adjoining Pipelines

The Northern Druzhba line runs from Mozyr to Adamowo in Poland, and from Adamowo on to Plock, still in Poland. Here the line connects with the bidirectional Pomeranian pipeline, which runs from Plock to Gdansk. The Druzhba pipeline continues across Poland to Heinersdorf in Germany, from where a short spur pipeline feeds the Schwedt refinery and another 338-km long pipeline reaches the Leuna refinery. At Heinersdorf, the Druzhba pipeline is connected with the Rostock-Schwedt pipeline, which is bidirectional but little utilized in either direction. The table below shows capacities and normal flows (in rounded numbers) along the Northern Druzhba pipeline.

² After completion of ongoing expansion project

³ Mainly supplied via TAL/IKL

From	To	Maximum Capacity [MTA]	Throughput [MTA]
Mozyr	Adamowo	43.0 / 50.0 ⁴	47.0
Adamowo	Plock	43.0 / 50.0 ⁴	47.0
Plock	Gdansk	22.0 ⁵	11.0
Gdansk	Plock	34.0 ⁵	-
Plock	Heinersdorf	27.0	22.0
Heinersdorf	Leuna	10.8	10.8
Rostock	Schwedt	6.9	-

Table 3-2: Northern Druzhba and Adjoining Pipelines Capacities and Utilisation

The section of Druzhba from Adamowo to Plock is normally used above its nameplate capacity of 43 MTA. This is accomplished by using drag reducing agents. The normal use of the Pomeranian pipeline is in the direction towards Gdansk to supply the Gdansk refinery and export Russian crude oil via Poland. The Rostock-Schwedt pipeline is used only sporadically, because there is no incentive for the Schwedt refinery to take delivery of crude oil by sea.

3.2 Southern Druzhba and Adjoining Pipelines

The Southern Druzhba line runs from Mozyr to Brody in the Ukraine, and then on to Uzhgorod close to the border of the Ukraine with both the Slovak Republic and Hungary. At Uzhgorod, the Southern Druzhba splits into two lines, Druzhba-1, which feeds the Slovak Republic and the Czech Republic, and Druzhba-2, which feeds Hungary.

Druzhba-1 passes into the Slovak Republic and runs from Budkovce to Sahy, and then on to Bratislava. Close to Bratislava (at Bucany), the line splits again with one branch feeding the Bratislava refinery and the other running to the Czech Republic, where it connects to all three Czech refineries. The Druzhba-2 section passes into Hungary and runs from Fenyestitke to Szazhalombatta. There is also a connection between Szazhalombatta and Sahy, connecting Druzhba-1 and Druzhba-2, which is fully reversible. The table below shows capacities and normal flows (in rounded numbers) along the Southern Druzhba pipeline.

⁴ 50 MTA with Drag Reducing Agent

⁵ Same pipeline can be used with reverse flow

From	To	Maximum Capacity [MTA]	Throughput [MTA]
Mozyr	Uzhgorod	27.0	17.0
Uzhgorod	Sahy/Bucany	15.0	10.5
Bucany	Bratislava	9.8	5.5
Bucany	Kralupy	9.0	5.0
Kralupy	Litvinov	5.1	4.5
Uzhgorod	Szazhalombatta	7.9	6.5
Szazhalombatta	Sahy	3.5	-
Ingolstadt	Kralupy	11.0	3.0
Sisak	Szazhalombatta	9.8	-

Table 3-3: Southern Druzhba and Adjoining Pipelines Capacities and Utilisation

The Slovak section of Druzhba used to have a capacity of 20 MTA. However, the pipeline has been underutilized for some time to the extent that the design pressure has been reduced and the effective pipeline capacity is now considered to be 15 MTA. This is still more than adequate for its current utilization.

The Trans Alpine pipeline links the port of Trieste (Italy) with Ingolstadt. Trans Alpine pipeline serves a total of five refineries in Austria and the south of Germany. At Vohburg, near Ingolstadt, Trans Alpine pipeline ties in with the Ingolstadt-Kralupy-Litvinov pipeline. The combination of Trans Alpine pipeline and Ingolstadt-Kralupy-Litvinov pipeline can supply the Czech Republic from Trieste. This route is currently used to supply most of the crude oil processed by the Kralupy refinery, the main reason being that the Kralupy refinery has a configuration that is better suited to process light sweet crude oil (e.g. North African or Caspian) than Russian crude oil.

The Janaf pipeline system runs from the port of Omisalj on the island of Krk (Republic of Croatia) to serve the refineries in Republic of Croatia, Republic of Serbia and Bosnia and Herzegovina. At Sisak, the bidirectional pipeline connects with the Adria pipeline that reaches the Szazhalombatta refinery in Hungary. This line is little utilized, as there is only a small volume of crude oil that flows in the direction of Sisak.

3.3 Product Demand in the Study Region

Figure 3-2 below shows the past and forecasted total refined products demand by product in the countries: Poland, Czech Republic, Slovak Republic and Hungary. The Baltic States are well served by the Mazeikiai refinery which responded to the cut of Druzhba supplies in 2006 by activating its own crude oil supply route. Adding Germany's demand figures to the total would have hidden the fact that, contrary to the established trends in Western Europe, demand for refined products in most of the countries of the study region is still growing quite significantly. Therefore, the four countries included in the sub-

sequent diagrams are those which might place additional strain on the pipeline infrastructure reviewed in this study due to future refined product demand growth.

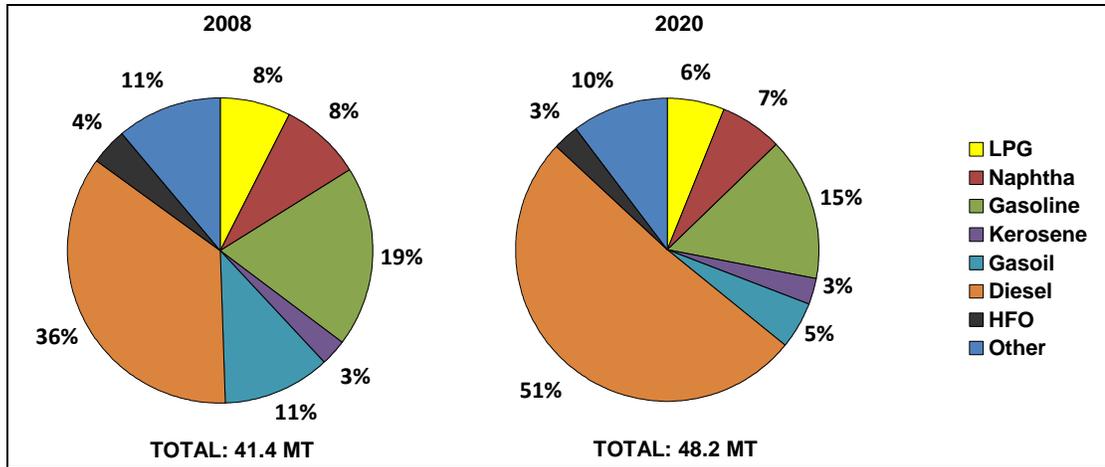


Figure 3-2: Refined Product Demand: Poland, Czech Republic, Slovak Republic and Hungary in the years 2008 and 2020

The figure shows that refined product demand is expected to grow by 16.5% in the four countries, mainly caused by a significant increase in the demand for road diesel. This is likely to put pressure on refiners in the region to increase crude oil processing and fuel oil conversion capabilities (e.g. hydrocracking or coking). Increasing the imports of diesel from surrounding areas via coastal ports (Poland) or the Danube River (Czech Republic and Hungary) is also likely.

Given the combination of existing rail infrastructure, the possible use of the Danube River as a trading corridor and the existence of a product pipeline system that links the Czech Republic to the Slovak Republic, there is a certain flexibility to move products from one country to another. The inland refineries of Poland, Hungary and the Czech Republic have a combined spare capacity in the region of 5 MTA. The coastal Gdansk refinery is increasing its distillation capacity by 4.5 MTA. Thus, the total refining capacity in the region seems to be adequate until 2020. This consideration made it possible to execute this study under the simplifying assumption that if the current refining nameplate capacity can be supplied, the EU is likely to have a system that will be adequate for a number of years to come. As the Gdansk refinery is located on the coast, its capacity increase does not have any impact on the ability of crude oil pipelines to guarantee security of supply. If there was a shortage of crude oil from Druzhba, the Gdansk refinery could switch to seaborne supplies.

3.4 Crude Oil Supply in the Event of Disruption of Druzhba

This study considered the possibility that an interruption of supply in the Druzhba system could result in one of the following events:

- no flow of crude oil in the Northern Druzhba at Adamowo (Poland)
- no flow of crude oil in the Southern Druzhba at Uzhgorod (Ukraine)
- no flow of crude oil in the Southern Druzhba at Budkovce (Slovak Republic)
- no flow of crude oil in the Southern Druzhba at Fenyestitke (Hungary)

Figure 3-3 shows how oil supply routes could be rearranged in case of any or all of the events defined above. In the following, a discussion about each case is provided.



Figure 3-3: Possible Utilisation in Case of Supply Disruption

3.4.1 Interruption of Supply to Adamowo

The alternative would be to import seaborne carried crude at Gdansk for supplying the local refinery and for feeding into the Pomeranian pipeline. This line would then feed the

Plock, Schwedt and Leuna refineries. Additional seaborne carried crude oil would be imported at Rostock and supplied to the Schwedt refinery.

The Pomeranian pipeline has an import capacity of 34 MTA and can be reversed rapidly to supply the Plock refinery. Any temporary interruption of supply could be cushioned with crude oil stocks held at Plebanka. Even after making a deduction for possible future utilization of the full nameplate capacity of the Plock refinery as reported by Orlen (i.e. 17.8 MTA), 16.2 MTA would still be available to be transported to Germany. This volume could be increased with 6.9 MTA delivered via Rostock, resulting in a total supply available to the Schwedt and Leuna refineries of 23.1 MTA. This is just above the combined capacity of the two refineries (i.e. 22.1 MTA). Therefore, the current system is barely capable of supplying the relevant refineries at their current capacities. The balance is quite tight. Any significant expansion of capacity at the Plock, Schwedt or Leuna refineries would not be supported by this system. However, the Plock refinery has never been operated at more than 14.2 MTA since 2000 (and not at its full nameplate capacity of 17.8 MTA), which means that there is currently an excess capacity of the pipeline system(s) towards the actual refined volumes of more than 4.0 MTA.

Table 3-4 determines system spare capacity assuming operation of accordant refineries at their nameplate capacities.

	MTA
Crude Supply via Pomeranian Pipeline	34.0
Plock Capacity	-17.8
Schwedt Capacity	-10.9
Crude Supply via Rostock-Schwedt Pipeline	6.9
Leuna Capacity	-11.2
SYSTEM SPARE CAPACITY	1.0

Table 3-4: Alternative Supply Crude Balance to Poland and Germany

A review of crude oil storage facilities along the Druzhba pipeline highlighted that there is limited amount of crude oil storage in the German Druzhba section. This may make it difficult to rearrange deliveries via Gdansk in a timely manner. By contrast, there are adequate crude oil inventories on the Polish side, where all of the strategic stocks of crude oil are held at locations connected to Druzhba.

PCK, operator of the Schwedt refinery and the Rostock-Schwedt pipeline, has made a study on the possibility to expand the Rostock-Schwedt pipeline and they believe the line can be de-bottlenecked to around 9 MTA without adding a second line.

3.4.2 Interruption of Supply to Uzhgorod

This is the worst case scenario for refineries in the Slovak Republic, Czech Republic and Hungary as it would cut off supplies to Southern Druzhba completely and it would impact crude oil supply to all of these countries.

The Czech refineries would be able to receive crude oil via the Ingolstadt-Kralupy-Litvinov pipeline pipeline, which has adequate capacities, provided that there is enough capacity in Trans Alpine pipeline to transport crude oil to Vohburg.

The Szazhalombatta refinery in Hungary would be able to receive full supply via the Janaf and Adria pipeline systems. From Szazhalombatta, there is also a 3.5 MTA connection into the Slovak Republic. However, this would leave some refineries with a shortfall due to limited capacity. Moreover, depending on the assumed level of future capacity and utilization of the Szazhalombatta refinery, the Adria pipeline may not be able to transport enough crude oil to Hungary and to the Slovak Republic to supply both refineries (13.6 MTA at full refinery capacity utilization). The import requirements of Hungary are reduced by its domestic crude oil production which amounts to about 0.7 MTA. However, production has peaked and is now falling by about 10% a year. The worst case scenario is represented by full utilization of the Szazhalombatta refinery (7.9 MTA) and zero domestic crude oil production in Hungary. In this scenario, the current capacity of the Adria pipeline (9.8 MTA) would leave only a mere 1.9 MTA of supply at the Hungary/Slovak Republic border.

The situation could be improved with the following projects:

- expansion of capacity of the Adria pipeline
- construction of a new pipeline between Schwechat and Bratislava
- reverse flow from Kralupy to Bratislava

The possibility to build a pipeline from Bratislava to Schwechat has been considered for some time. The line would be bidirectional. In normal operations, it would supply Russian crude oil to Schwechat via Bratislava; in case of emergency, the flow could be reversed and the Adria-Wien pipeline pipeline to Schwechat could be used to supply an incremental volume of crude oil beyond Schwechat. As noted later, the capacity of Adria-Wien pipeline would limit the volume of crude available for onward delivery to Bratislava.

According to MERO, a pipeline operator in the Czech Republic, another solution would be to implement bidirectional flow on the section of Druzhba beyond the Czech Republic. According to MERO, this is a fairly simple project from the technical standpoint. The capacity of the Ingolstadt-Kralupy-Litvinov pipeline exceeds the normal requirements of the Czech refineries by 2-3 MTA. This incremental capacity could be used to supply crude oil to Bucany via Trans Alpine pipeline. However, as noted later, Trans Alpine pipeline may be a bottleneck.

3.4.3 Interruption of supply to Budkovce or Fenyestitke

These cases are essentially less severe sub-sets of the above case.

An interruption at Budkovce, would not affect Hungary, and the entire capacity of the Adria pipeline would be available to supply the Szazhalombatta-Sahy pipeline. The capacity of the Szazhalombatta-Sahy pipeline could be expanded. Any of the other options discussed above could be implemented to provide full backup for the refinery.

An interruption at Fenyestitke, would not affect the Slovak Republic and the Czech Republic. The Omisalj-Sisak-Szazhalombatta system has enough capacity to supply 100 % of the requirements of the Szazhalombatta refinery.

3.5 Trans Alpine pipeline and Adria-Wien pipeline as possible bottlenecks

A simple comparison of the Trans Alpine pipeline capacity with the capacity (or the level of utilization) of the refineries served by Trans Alpine pipeline revealed that Trans Alpine pipeline may not have sufficient capacity to support the full utilization of Ingolstadt-Kralupy-Litvinov pipeline.

The Schwechat, Burghausen, Bayernoil and Petroplus-Ingolstadt refineries need a combined 27 MTA (approximately) of crude oil. The Karlsruhe refinery is currently supplied partly by Trans Alpine pipeline and partly by the South European pipeline (from Marseilles). Based on past statistics available for South European pipeline, it is possible to infer that about two thirds of the supply for Karlsruhe is typically provided by Trans Alpine pipeline. Currently, the volume received via South European pipeline has always been 7.5 MTA or more, leaving the maximum possible call on Trans Alpine pipeline capacity at 7.4 MTA. Trans Alpine pipeline has a capacity of 42 MTA, which leaves only 7.5 MTA of spare capacity.

Refinery	Capacity [MTA]	Owner(s)
Schwechat ⁶	8.0	OMV
Burghausen	3.6	OMV
Bayernoil	10.3	OMV, Agip, RuhrOil, BP
Ingolstadt	5.2	Petroplus
Karlsruhe ⁷	7.4	Shell, Esso, RuhrOil, ConocoPhillips
SUBTOTAL DEMAND	34.5	
Total capacity	42.0	
SPARE CAPACITY	7.5	

Table 3-5: TAL pipeline Capacity in Relation to Refining Capacity (all figures in MTA)

⁶ The capacity is 9.6 MTA, but crude oil imports are typically less than 8 MTA

⁷ The capacity is 14.9 MTA, but 7.5 MTA or more are typically supplied via SPSE

MERO is not a shareholder of Trans Alpine pipeline and we understand that it can only use the capacity that is available after the shipping requirements of the various shareholders of Trans Alpine pipeline have been met. Thus, if MERO wants to use enough Trans Alpine pipeline capacities to supply 9-11 MTA into Ingolstadt-Kralupy-Litvinov pipeline, as needed to supply the entire capacity of the Czech refineries, it may encounter difficulties with Trans Alpine pipeline. As a result, Trans Alpine pipeline may make Ingolstadt-Kralupy-Litvinov pipeline ineffective as a system devised to provide full backup to Druzhba and to serve the entire refining capacity of the Czech Republic.

South European pipeline has spare capacities typically in the range of 5 MTA. One way to increase the Trans Alpine pipeline capacity available to MERO could be to maximize the use of South European pipeline by the Karlsruhe refinery. In order to do so, the commercial interests of the shareholders of the Karlsruhe refinery would have to be considered.

Similar considerations can be made for the Adria-Wien pipeline. Assuming that the pipeline from Bratislava to Schwechat is built, Adria-Wien pipeline would be required in case of emergency. However, Adria-Wien pipeline primarily serves the Schwechat refinery and has only a limited amount of spare capacity (1-2 MTA) for onward deliveries to Bratislava.

4 ANALYSIS OF SELECTED OPTIONS TO SUPPLY SOUTHERN DRUZHBA

This section describes the work undertaken for WP2, and provides the respective conclusions. The basis for work undertaken in context with WP2 was provided by the results reached during WP1. Thus, DG ENER decided to perform an advanced analysis of the following pipelines:

- Odessa-Brody Pipeline
- Bratislava-Schwechat Pipeline
- Sisak-Szazhalombatta-Sahy Pipeline

The main reason for the selection of these pipelines was to provide all crude oil consumers in the study region with similar, indiscriminate access to an alternative supply route. These pipelines can be variably used at least on a mid-term perspective, i.e. in an approximate interruption period between 90 and 180 days on the primary supply route.

During the WP2, the following assumptions were made:

- the refineries operate at their full capacity
- the interruption is at full extent
- the refineries are supplied with their original type of crude

The investigated pipelines are sections within potential supply routes. They are currently either variably used, non-existent, or unused. The analysed pipeline sections are expected to be most challenging regarding the option of variable use. The precedent and adjacent pipeline sections of the potential backup supply systems are assumed to be operated in their original purpose.

The Bratislava-Schwechat pipeline is being developed for commercial reasons as a way to balance crude supply costs of both Bratislava and Schwechat refinery. The investment would be amortized by the normal use of the pipeline, i.e. pumping oil from Bratislava to Schwechat. The Bratislava-Schwechat pipeline was analyzed in this study as if the pipeline had been built already. This report analyzes what it would take to reverse the flow of the pipeline.

A comparison of the capital expenditures (CAPEX) needed to build the Bratislava-Schwechat pipeline and the CAPEX needed to just adapt the other, already existing pipelines to a new situation would be misleading. The Bratislava-Schwechat pipeline project is being promoted for commercial reasons, as mentioned. The only cost related to security of supply is the incremental cost needed to implement bidirectional flow.

Based on the present situation and existing facilities, the variable use (reversion of flow and capacity increase) of these pipeline systems was analyzed. This section deals with the following question: What technical measures at what incremental capital and operating expenditures in which legislative environment and subject to which economic consequence need to be applied to enable the pipelines to meet the ambitious requirements?

For all pipelines the operating costs are incrementally provided as the additional cost to either operate the pipeline in reversed direction or for realisation of additional flow. Therefore, the energy costs dominate since cost for operation and maintenance including personnel cost would be charged to the normal use of the pipeline. The energy costs for the normal operation are deducted from the energy costs for the emergency operation.

Bratislava has been chosen as the common point of delivery for the three routes studied in WP2. We estimated the transportation costs (freight rates and tariffs and miscellaneous costs) that would arise when delivering crude oil from a representative common point of origin in the Black Sea to Bratislava along each of these three different alternative routes. The representative point of origin was chosen to be Novorossiysk and the crude oil was chosen to be REB.

4.1 Odessa-Brody Pipeline

The Odessa-Brody pipeline system starts at the port of Pivdenny near Odessa; it was designed to pump crude oil from the Caspian oil reserves (CPC) to Brody where it feeds into the Southern Druzhba. The pipeline is currently used in the opposite direction, i.e. to export Russian Export Blend via Odessa. Throughput has been about 9 MTA, but is expected to fall to 6 MTA in the year 2010. The pipeline could be restored to its original design purpose and used to supply oil to Europe.

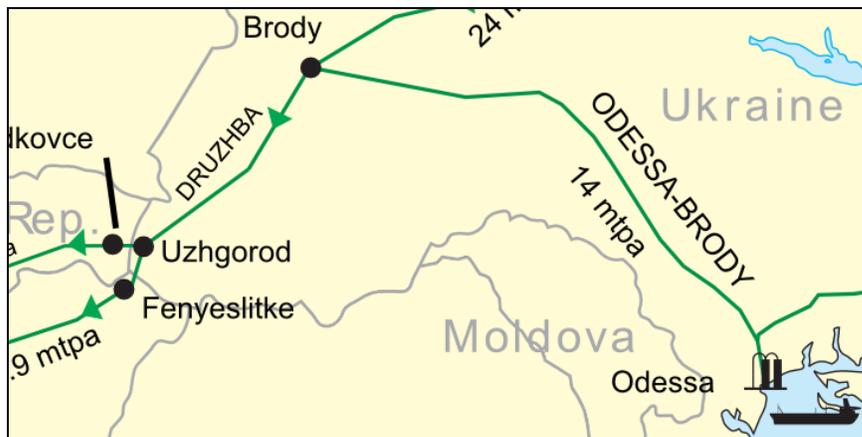


Figure 4-1: Odessa-Brody pipeline overview

The current capacity of the Odessa-Brody pipeline is 14.5 MTA of CPC. It is well known that the Odessa-Brody pipeline can be expanded well beyond the current capacity; potentially, it has the capability to supply the entire capacity of the Southern Druzhba (refer to section 5).

The Odessa-Brody pipeline could achieve a capacity of 14.5 MTA of Russian Export Blend with the addition of a small intermediate pumping station, the investment of which is estimated at EUR 4.1 million (mn).

The tariff between Odessa and Bratislava would range around EUR 14.70 per tonne. The total transportation costs from Novorossiysk would amount to EUR 18.60 per tonne.

Due to the short maturity, it might be relatively easy to change the contracts. Also, apart from a few technical changes, the permit procedure should proceed without much resistance.

The Odessa-Brody pipeline can only be considered as a secure backup to Druzhba if the EU accepts to rely on Ukraine as a transit country and if the pipelines from Brody to the EU borders can be guaranteed to be in sound conditions.

4.2 Bratislava-Schwechat Pipeline

The Bratislava-Schwechat pipeline has been designed to link the Western oil pipeline network with the Southern Druzhba to transport crude oil to the Schwechat refinery, referred to in the WP1 report. Currently, there is no pipeline connection between Schwechat and Bratislava. Once built, this pipeline could also be used in case of emergency to supply the Bratislava refinery from Schwechat by reversing the flow.



Figure 4-2: Bratislava-Schwechat pipeline overview

Oil destined for Bratislava would reach Schwechat via the Adria-Wien pipeline (AWP), which branches off Trans Alpine pipeline (TAL) and has sufficient capacity to feed the

Schwechat refinery. However, the limited capacity of AWP would hold down the amount of crude oil that could be delivered beyond Schwechat. If the objective was to supply more than a few MTA beyond Schwechat, the capacity of the AWP would need to be expanded. TAL could be a bottleneck if the need to transport crude beyond Schwechat occurs at the same time as Mezinardni Ropovdy (MERO) is seeking to maximize use of TAL/Ingolstadt-Kralupy-Litvinov (IKL) pipeline to supply the Czech refineries. This might happen in case of a total interruption of supply from Druzhba.

A minor investment of EUR 5.1 mn has to be made to reverse the Bratislava-Schwechat pipeline if the pipeline is designed and built to allow a bidirectional flow. No particular permit is required for the reverse operation and contracts should be concluded to allow the mid-term emergency supply right from the start. The possible tariff between Trieste and Bratislava for this solution would amount to EUR 5.90 per tonne. The total delivery costs from Novorossiysk would be EUR 12.70 per tonne.

If the possibility of bidirectional operation is included in the design and in the legal/contractual framework under which the Bratislava-Schwechat pipeline is built and operated, the route via Trieste/Schwechat would provide an additional route of emergency supply at very little or no extra cost.

4.3 Sisak-Szazhalombatta-Sahy Pipeline

The Adria pipeline connects Omisalj (Republic of Croatia) with Szazhalombatta (Hungary) via Sisak (Croatia). A further section of the pipeline transports oil from Szazhalombatta to Sahy, which is the connecting point between the Adria and Druzhba pipelines. This pipeline section is currently idle and has no commercial justification. From Sahy, oil can be pumped via Druzhba to diverse destinations.

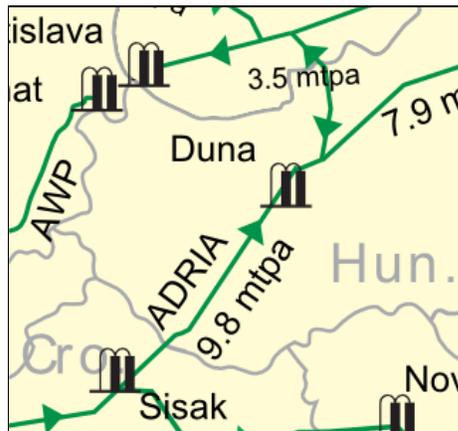


Figure 4-3: Sisak-Szazhalombatta(Duna)-Sahy pipeline overview

In order to align the security of supply in the countries of EU, the Adria pipeline should be able to transport at least 13.6 MTA of Russian Export Blend (REB) from Sisak to Szazhalombatta. Of these, approximately 60% could destine in Szazhalombatta, whereas approximately 40% could be pumped on to Sahy and beyond.

The capacity required in the Sisak-Szazhalombatta section can be achieved by reactivating the intermediate pumping station at Csurgo that used to be part of the pipeline system but was mothballed because the pipeline has never been utilized at its design capacity.

The Szazhalombatta-Sahy pipeline was designed for a capacity of 3.5 MTA. This study has identified the following three options to expand its capacity to 5.7 MTA:

- construction of a second parallel pipeline which would require an investment of EUR 63.4 mn. This investment makes this option uncompetitive in comparison with other options detailed below. The permit procedure and right-of-way acquisition are expected to be exhaustive. That is usual for entirely new pipelines; however, this option bears the highest potential for further expansion if needed
- modification to the Szazhalombatta pumping station and use of drag reducing agents (DRA) needing a minor investment of EUR 1.1 mn and few additional permit requirements: however, this would lead to considerable operating costs
- modification to the Szazhalombatta pumping station and adding of a new intermediate pumping station resulting in an investment need of EUR 7.2 mn and significantly higher operating costs than for the previous options; the permit procedure would be moderate depending on the selection of the pumping station's location

The tariff between Omisalj and Bratislava is EUR 11.80 per tonne. In total, the crude could be delivered for EUR 18.30 per tonne from Novorossiysk.

Even though existing contracts —transportation agreements in particular— need to be reviewed for changes in requirements, any changes will probably be moderate as MOL controls the majority of the facilities concerned by this supply alternative and is therefore the single party to negotiate with.

The DRA-based option would be very cost-effective. However, regular use of DRA may not be economically reasonable if the Szazhalombatta-Sahy pipeline is operated for a longer term.

4.4 Comparison of the Different Pipelines

In the remainder of this section, the quantitative and qualitative characteristics of the three investigated alternatives are compared. There is no definite favourite. Different perspectives suggest different rankings of the alternatives.

The analyses of the variable use of the Odessa-Brody, Schwechat-Bratislava and Sisak-Szazhalombatta pipelines reveal minor technical changes. The permit situation is strongly linked to the scope of technical measures and no opposition is expected.

	Odessa-Brody	Schwechat-Bratislava	Sisak-Szazhalombatta-Sahy
Capital expenditures (CAPEX) [EUR mn]	4.1	5.1	1.1
Marginal operating expenditures (OPEX) [EUR/d]	5,024	4,400	21,400
Pipeline tariff from respective port [EUR/t]	14.70 (Odessa)	5.90 (Trieste)	11.80 (Omisalj)
Total transportation cost from Novorossiysk [EUR/t]	18.60	12.70	18.30

Table 4-1: Quantitative comparison of all pipelines

With investments ranging from EUR 1.1 to 5.1 mn, the capital expenditures do not inhibit the implementation of any of the modifications of the investigated pipelines. The Odessa-Brody and Schwechat-Bratislava pipelines require similar investments and operating costs. The operating costs for both amount to approximately EUR 5,000 per day. In contrast to that the Sisak-Szazhalombatta-Sahy pipeline has four times higher operating expenditures. This fact should not abstract away from the fact that transport to the pipelines and from the pipelines to the final destination also may cause additional costs. Those costs are not included in the figures provided above.

The most competitive route would be most probably realised first. The economics definitely favour the Schwechat-Bratislava pipeline. Compared to the alternative supply routes, the delivery via this route is cheap with a pipeline tariff of EUR 5.90 per tonne from Trieste to Bratislava and total transportation costs of EUR 12.70 per tonne from Novorossiysk. The Sisak-Szazhalombatta-Sahy pipeline would be the second choice in case the Bratislava-Schwechat pipeline will not be built. Odessa-Brody pipeline has its advantages that may be backed by qualitative strengths.

Odessa-Brody	Schwechat-Bratislava	Sisak-Szazhalombatta-Sahy
<p>No major technical measures are required due to the fact that the system was originally designed to transport oil from Odessa to Brody. There is a high potential for a rather long-term use and for a simple expansion to larger volumes. Permitting does not pose major problems as a state-owned company owns and operates the pipeline. Low investment and operating costs support this advantage. The transport via this route is relatively secure with regard to the Bosphorus bottleneck despite the relatively high pipeline tariff. Ukraine would remain a transit country.</p>	<p>If the Schwechat-Bratislava pipeline existed, few technical modifications requiring only minor investments would be needed. The operating expenditures are still moderate. However, the use of the pipeline would require a capacity increase of the Adria-Wien pipeline/Trans Alpine pipeline pipelines. Permitting is difficult for the section in the Slovak Republic, due to the fact that the route crosses a water protection area. That fact threatens the implementation. The Bratislava-Schwechat pipeline is designed to be able to reverse the flow easily, cost-efficiently and in accordance with the contracts. Despite the fact that this route offers competitive transportation costs, attractiveness is limited due to the fact that the Bosphorus bottleneck must be passed.</p>	<p>If a drag reducing agent is injected, this pipeline is easy from a technical point of view. The investment is low; however, operating costs are high. That makes the pipeline attractive for short emergency use only. Contractual burdens are expected to be overcome, due to the fact that MOL controls most of the pipeline system including JANAF, as well as the Bratislava and Szazhalombatta refineries. From the permitting point of view it is an unproblematic option.</p>

Table 4-2: Qualitative comparison of all pipelines

All of the three investigated pipelines solve the problem of a backup route:

- The Schwechat-Bratislava pipeline creates the least problems for an emergency supply, if it is built. The major obstacle is the permitting process in the Slovak Republic that needs to be concluded successfully. Without doubt, the capacities of Trans Alpine pipeline and the Adria-Wien pipeline need to be expanded if the supplied refineries are not to be underutilised.
- If the realisation of the Bratislava-Schwechat pipeline is delayed, the second feasible solution is the Sisak-Szazhalombatta-Sahy pipeline. Only few additional technical measures, a security of transport and no stranded capital expenditures render this alternative supply route attractive.
- The Odessa-Brody pipeline ranks as the last option. This pipeline has disadvantages with regard to a mid-term supply but successfully compensates this weakness with regard to a long-term supply of a wider area of Central and Eastern Europe. This is the reason why the Odessa-Brody pipeline was selected for in-depth investigations in WP3.

5 CONTRIBUTION OF ODESSA-BRODY PIPELINE TO SECURITY OF SUPPLY

This section considers how the Odessa-Brody pipeline contributes to the security of supply in a large area of the EU. Furthermore, it investigates what technical measures at what time in which legislative environment and at what cost need to be applied to enable the Odessa-Brody pipeline to meet the ambitious requirements, i.e. to contribute to secure reliable transport of crude oil to the EU.

The Ingolstadt-Kralupy pipeline, the Trans Alpine pipeline, the Adria system and other existing pipelines may contribute to supplying the nameplate capacity of many refineries. But not all of them are equally furnished with alternative supply routes what may advantage the one refinery over the other. Compared to the other alternatives investigated during earlier stages of this study, the Odessa-Brody pipeline offers the largest contribution potential, even though the pipeline is situated outside of the EU and never crosses its borders.

For this study, DG ENER chose the Odessa-Brody pipeline out of three alternative oil supply routes (Odessa-Brody, Bratislava-Schwechat and Sisak-Szazhalombatta-Sahy). The reason for this selection was that in DG ENER's opinion, the Odessa-Brody pipeline seemed to be able to transport oil in a sustainable and reliable way to a large number of EU members in Central and Eastern Europe.

The Odessa-Brody pipeline starts near Odessa (Ukraine) and runs 674 km north-westwards towards Brody, near the Ukrainian-Polish border. It was originally designed to transport 32 MTA of crude oil from the Caspian region to Brody where it meets the Southern Druzhba, coming from Belarus.

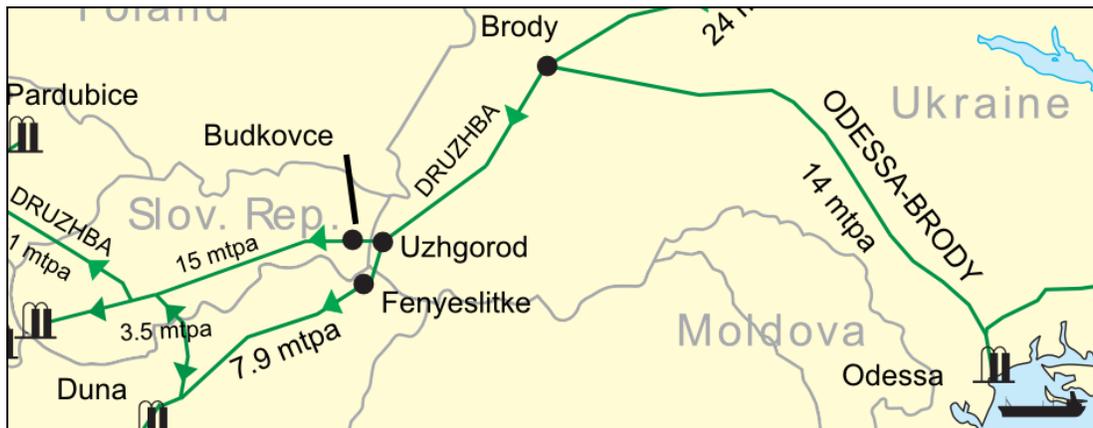


Figure 5-1: Contribution of Odessa-Brody pipeline to security of supply

However, the pipeline is now used to transport oil in the reverse direction for export via the Black Sea. The scenario in which the Odessa-Brody pipeline could make a signifi-

cant contribution to secure crude oil supplies in Europe is the permanent shortage or permanent interruption in the Druzhba system.

The Druzhba pipeline system currently delivers around 64 MTA of Russian Export Blend (REB) from Western Siberia, from the Urals and partly from the Caspian Sea to member states of the European Union. That crude mainly accommodates the demand of the member states themselves. Some parts are used for export purposes via Gdansk (Poland) and Odessa (Ukraine). This fact underlines the potential and the importance of the Odessa-Brody pipeline as a backup system of the Druzhba pipeline system.

The distribution of crude oil in the Druzhba system is carried out with the help of two lines: the Northern Druzhba serves Poland and the North-East of Germany and the Southern Druzhba serves the Slovak, Hungarian and Czech Refineries.

Nine possible scenarios for the Odessa-Brody pipeline utilisation as a backup system were developed, investigated and evaluated in the present report. These scenarios shall reflect different extents of shortfalls and deliveries via Druzhba. They focus on:

- Variations in the extent of disruption, starting with a cut down of 15 % (comparable to recent examples in the gas industry) and stepping up to minus 50 %, 85 % and finally total disruption (100 %) assuming the Odessa-Brody pipeline replaces the capped supplies;
- providing capacities to regions with particular need (Southern Druzhba in favour), with respect to the utilization of alternative supply routes, initially neglecting those regions in the beginning, which are in the position to cover their demand by other means;

The combination of disruption and the range of supply leads to the following set of scenarios:

Scenario	Extent of Disruption	Druzhba Branch	Odessa-Brody Pipeline Throughput [MTA]
Scenario 1	15%	Southern Druzhba	2.6
Scenario 2		Bratislava nameplate capacity	5.7
Scenario 3	50%	Southern Druzhba	8.5
Scenario 4	15%	Southern + Northern Druzhba	9.6
Scenario 5	85%	Southern Druzhba	14.5
Scenario 6	100%	Southern Druzhba	17
Scenario 7	50%	Southern + Northern Druzhba	32
Scenario 8	85%	Southern + Northern Druzhba	54.4
Scenario 9	100%	Southern + Northern Druzhba	64

Table 5-1: Considered Scenarios for the Odessa-Brody Pipeline

Required technical measures for returning to the normal flow direction (i.e. the reversion of the already reversed pipeline) and even a capacity increase were designed in order to fit the above-mentioned scenarios. These measures are based on a detailed analysis of

the actual status and use of the existing Odessa-Brody pipeline system, with regard to pipelines, pumping stations, terminals, buffer tank farms and in particular the flow direction and operation methodology; therefore, they involve the installation of additional intermediate pumping stations and / or the injection of drag reducing agents.

The possibilities of realizing the expansion in either one step or in several consecutive steps, where the system capacity is gradually upgraded by additional intermediate pumping stations, were analysed. The locations of the intermediate pumping stations are optimized in accordance with these requirements.

A detailed implementation schedule was designed for the realization of the maximum capacity of 64 MTA by installing eight intermediate pumping stations, expanding the existing head pumping station and carrying out various secondary activities. This agenda was based on an Engineering, Procurement, Construction Management (EPCM) approach as this strategy is the best one for the integration of existing and new facilities. Under this approach, the project owner appoints an engineering company as contractor for the engineering and design works, the procurement on behalf of the owner and construction management.

The implementation is scheduled to take place in two steps. The first step is scheduled to take 37 months (enabling the system to deliver 45 MTA of REB). In a second step, a capacity of 64 MTA is to be reached - representing a full backup system for Northern and Southern Druzhba. The total time for completion would thus amount to 49 months.

The Capital Expenditures (CAPEX) are estimated to range between EUR 15 mn for a throughput of 14.5 MTA and EUR 670 mn for a throughput of 64 MTA for the major installations (pumping stations incl. the upgrade of the head pumping station, and tank farms). No additional investment was ascertained for scenarios 1 to 4 with throughputs ranging between 2.6 MTA and 9.6 MTA. The total annual expenditures for operation range between EUR 13 mn for scenario 1 and EUR 105 mn for scenario 9.

Scenario	Throughput [MTA]	CAPEX [EUR mn]	OPEX [EUR mn p.a.]	OPEX [EUR/t/672 km]
Scenario 1	2.6	0	13.07	5.13
Scenario 2	5.7	0	13.36	2.34
Scenario 3	8.5	0	13.74	1.62
Scenario 4	9.6	0	13.90	1.45
Scenario 5	14.5	15.6	15.44	1.07
Scenario 6	17	18.1	16.41	0.95
Scenario 7	32	113.3	28.92	0.87
Scenario 8	54.4	452.4	73.09	1.31
Scenario 9	64	672.4	105.10	1.61

Table 5-2: CAPEX and OPEX results for different scenarios

From a mere economic point of view, those scenarios which cover more than 50% of Southern Druzhba and Northern Druzhba, i.e. scenario 8 (throughput 54.4 MTA) and

scenario 9 (throughput 64 MTA) lead to comparably high investment costs compared to the other scenarios as well as to projects of comparable extent.

The calculation of the operating costs reveals a similar outcome; scenario 7 (throughput 32 MTA) has the lowest unit costs (per-tonne OPEX) which positively affect the transportation costs and the minimum required tariffs.

Further investigations were conducted on batch operations i.e. the transport of different crude oils through the pipeline. Four possible scenarios in batch operation mode were considered with a total throughput of 13.6 MTA. In addition, hydraulic calculations were performed for each of the desired crude types, respectively. The Odessa-Brody pipeline can transport three different types of crude oils: CPC, REB and Azeri. The existing SCADA⁸ system of Odessa-Brody pipeline could be used for batch operations of different crude types. Thus, taking into account the hydraulic gradient for different operation modes as well as minimal batch sizes and the influence of mixing zones, it is technically possible to operate the Odessa-Brody pipeline with different crude types in batch operation mode.

The study also tries to superficially evaluate the legislative environment. The investigation of these legal matters within the present study was not as in-depth as originally planned due to DG ENER selecting the Odessa-Brody pipeline, a pipeline situated outside the original geographic scope of the study and involving several restrictions on access to information. The legislative situation as well as the permitting procedures in the Ukraine significantly differ from those in the member states of the European Union.

In general, it has to be stated that the transport of crude oil using a pipeline infrastructure requires an internationally binding contractual framework. Taking into account that the legislative situation in third countries is different, the commitments and cooperation agreements for the variable use of pipelines must be concluded on a secure and international legal basis which can be enforced best by Inter-Governmental Agreements (IGA).

Oil pipelines in the Ukraine are state property, and the privatization or alienation of individual pipelines as well as the change of ownership of state enterprises in charge of major pipeline transport systems are prohibited by local laws. These facts concern the permitting process. Therefore, a state-supported decision for the construction of e.g. intermediate pumping stations or tank farms will generally not to be obstructed by any subordinate authorities during the approval process; the permitting process should cause no problems.

Due to the positive signals which the Ukrainian President, Viktor Yanukovich, has been sending constantly with regard to the assurance of reliable supply of hydrocarbon en-

⁸ SCADA: Supervisory Control and Data Acquisition

ergy resources to the EU, no opposition or obstacles are to be expected. Consequently, the successful negotiation of relevant contracts to secure variable use of the Odessa-Brody pipeline, above all the reaching of an intergovernmental agreement, as well as smooth approval and permitting processes can be expected.

Summarizing, it can be stated that there is a technically viable possibility to secure crude oil supplies to the European Union in the case of a complete and lasting supply disruption in the Druzhba system. This backup system utilizing the existing Odessa-Brody pipeline would require up to 49 months for total completion and consume CAPEX of around EUR 672.4 mn for a flow of 64 MTA. This figure has to be seen in relation to the possible impact on the EU economy in case of a disruption on the Druzhba system.

6 CONCLUSIONS

The investigation of possible pipelines which could contribute best to secure a sustainable and reliable transport of oil to a large number of EU members in Central and Eastern Europe was the major goal of the present study. The result of the “Study on Technical Aspects of the Variable Use of Oil Pipelines Coming into the European Union from Third Countries” can be summarized as follows:

The conducted investigations and research offer several possibilities to secure sustainable energy supplies for the consumers in EU member states. A lasting supply disruption in the Druzhba system would threaten refining consumers. For such a situation, a backup system with alternative supply routes could offer remedy.

The consumers in the Slovak Republic cannot be fully supplied via alternative routes in the event of a disruption of the Druzhba pipeline system. All other refineries have access to alternative supply routes that can be activated quickly.

Initial assessments indicated that the pipeline systems which showed up to improve security of crude oil supply ascertained in the present study were:

- the connection between Szazhalombatta and Sahy connecting the Hungarian and Slovakian Druzhba system with a potential contribution of 4.5 MTA
- the Adria pipeline from Sisak to Szazhalombatta with a potential contribution of 14 MTA
- the MVL Rostock-Schwedt pipeline offering a contribution of 9 MTA or higher
- reversal of Druzhba line from Kralupy to Sahy (and hence to Bratislava)

The scope of this study concerned the existing pipelines. However, it is apparent that the construction of new bidirectional pipeline from Schwechat to Bratislava would also be worth considering. This project may have the merit of being financially viable for normal use in the direction of Schwechat as well as making a contribution to security of supply using the pipeline in reverse mode.

The Odessa-Brody pipeline offers the largest potential for contribution to the security of supply. Hence, the Odessa-Brody pipeline was finally selected by DG ENER for an in-depth investigation reflecting its high strategic importance.

Research showed that the Odessa-Brody pipeline is able to serve —without additional investments— all needs in case of a disruption of up to 50 % of the Southern Druzhba or a 15 % simultaneous disruption of the Southern and Northern Druzhba. This represents a flow of up to 13.6 million tons per year (MTA) of Russian Export Blend (REB) equivalent. Beyond security of supply, the Odessa-Brody pipeline enables diversity of supply

so that other types of crude may be transported to the consumers through the existing pipeline systems.

The compensation of further shortfalls in the transport of crude calls for several technical measures to be applied. These measures require investments of

- EUR 15 mn using one additional Intermediate pumping station (IPS) for partial compensation of the Druzhba capacities
- EUR 670 mn for total backup of Southern and Northern Druzhba invested in eight IPS, additional tank farm capacities and secondary measures to upgrade the existing facilities

Those scenarios which simultaneously cover more than 50 % of the Southern and Northern Druzhba, i.e. the scenarios with a throughput of 54.4 MTA and 64 MTA, lead to comparably high investment costs compared to the other scenarios as well as to projects of similar extent. The calculation of the operating costs reveals a somehow similar outcome; the scenario with a slightly lower throughput of 32 MTA provides the lowest unit costs (per-tonne OPEX) which positively affect the transportation costs and the minimum required tariffs. That is due to the fact that pipelines are most cost-effective at their optimal design. For Odessa-Brody, the pipeline was originally designed for a flow of 33 MTA. Underutilised or extended systems always lead to relatively higher transportation costs per tonne.

Scenarios offering between 13.6 and 33 MTA could be realized within the relative short period of approximately 37 months only. Reaching 100% of transport capacity through the Odessa-Brody pipeline would take an additional 12 months. The relatively long lead time for the engineering, procurement, construction and commissioning of one to two IPS can be shortened if the locations of the original design are re-used. However, if the need for higher throughputs increases, the Odessa-Brody pipeline system can only be expanded with relatively high capital and operating expenditures.

The study also superficially evaluated the legislative environment. Due to the fact that the contractual situation in so called third countries differs from those within the EU, the commitments for variable use of pipelines are to be concluded on a secure and internationally binding legal basis in Inter-Governmental Agreements (IGA).

Ukrainian state ownership of major transport facilities, local Ukrainian laws prohibiting privatization of pipelines and above all statements of Ukrainian authorities' showing commitment with regard to the assurance of reliable supply of hydrocarbon energy resources to the EU lead to the conclusion, that permitting procedures as well as contractual negotiations will run smoothly and reaching an intergovernmental agreement can be expected.

There is a technically viable possibility to secure crude oil supplies to the European Union without depending on the Druzhba system. This backup system utilizing the original design of the existing Odessa-Brody pipeline would require at least 37 months for completion and consume capital expenditures of around EUR 113 mn; a figure which is to be seen in relation to the possible impact on the EU economy in case of a disruption on the Druzhba system.