**MEMORANDUM** May 29, 2015

**Subject:** **Potential Market Effects of Removing Crude Oil Export Restrictions: Eastern Europe**

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This memo provides background and information regarding potential market effects in Eastern Europe that might result if U.S. crude oil export restrictions were to be removed. Specific questions addressed in this memo include: (1) What is the refining configuration of Eastern European countries? (2) What are the potential economic effects of U.S. crude oil replacing Russian crude oil in these countries?, and (3) What are the potential economic and foreign trade effects on other countries that currently produce and export light/sweet crude oil?

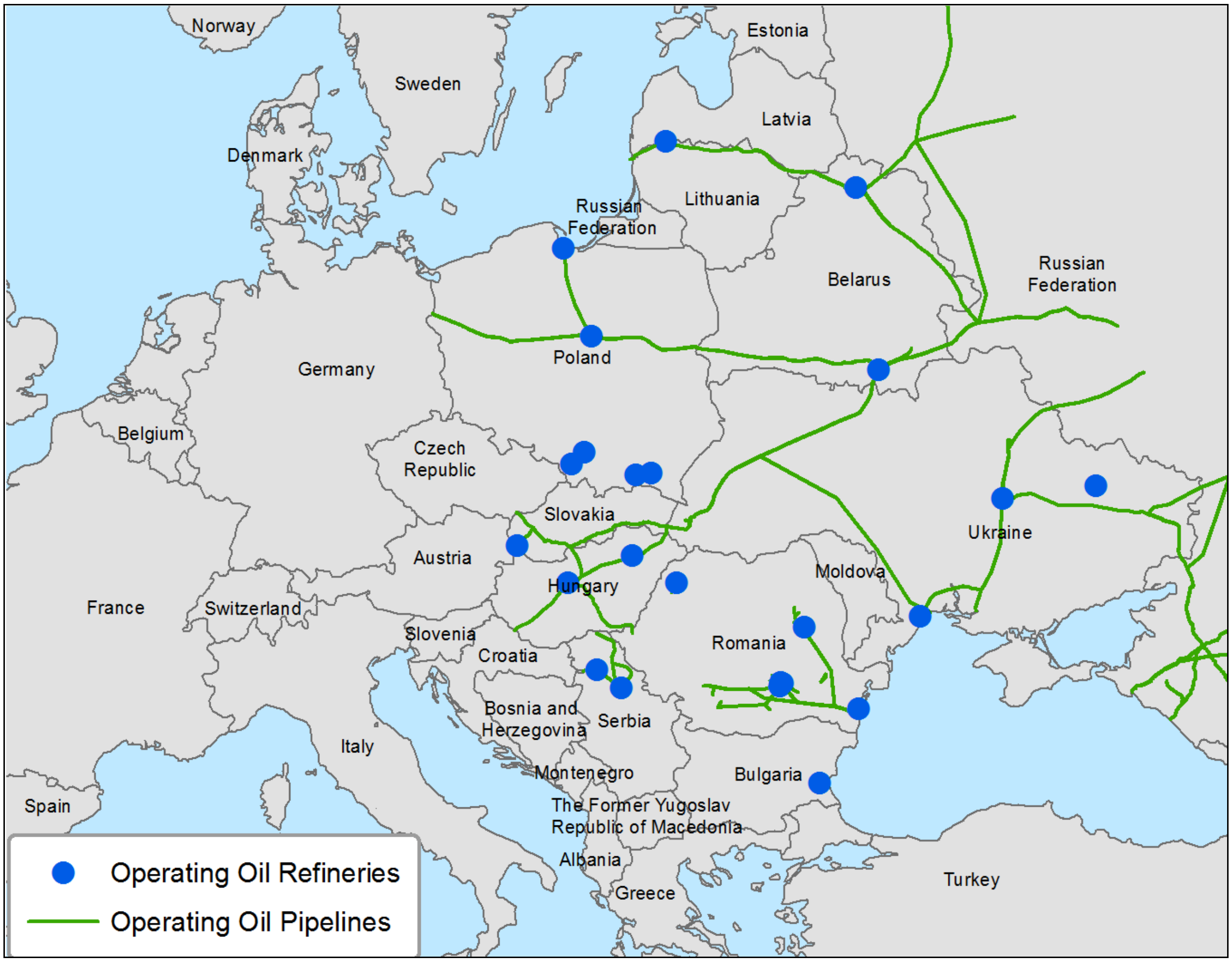
For the purpose of this memo, the following 12 countries were included in the analysis of Eastern European refining: Estonia, Latvia, Lithuania, Belarus, Ukraine, Moldova, Poland, Slovakia, Hungary, Romania, Serbia, and Bulgaria. Estonia, Latvia, and Moldova do not have operating crude oil refining capacity, and therefore are not included in the text, tables, and figures contained in this memo.

## Eastern Europe Refining Assets

There are 22 operating refineries in the 12 countries of Eastern European as defined above.[1] **Figure 1** includes a location map of operating refineries as well as an illustration of operating oil pipelines in the region. Some refineries in south Poland and Eastern Romania appear to be disconnected from the crude oil pipeline infrastructure. CRS was not able to reconcile this apparent discrepancy in the data set, although there are several possible explanations (i.e., incomplete data set, categorization, etc.).

[1] Information available to CRS regarding Eastern European refineries is limited to an IHS database of global refining assets.

**Figure 1. Eastern Europe Operating Refineries and Oil Pipelines**




**Source:** By CRS using data from IHS (2014), Esri, HERE, DeLorme OpenStreetMap contributors.

**Notes:** This map reflects data for "operating" oil refineries and oil pipelines only. The data set used for this map includes several other categories such as "idled" and "shutdown" refineries as well as oil product pipelines, which are not represented in this figure.

Many of these Eastern European countries import the majority of crude oil for their refineries from Russia. Poland, Slovakia, and Hungary import 96%, 100%, and 100%, respectively, of their crude oil from Russia.[2] Ukraine and Lithuania also import crude oil primarily from Russia.[3] As indicated in **Figure 1**, oil pipeline infrastructure in Eastern Europe appears to be generally designed to deliver crude oil from Russia to refineries in the region.

## Refinery Configurations in Eastern Europe

The configuration of operating refineries in Eastern Europe may be an important consideration for those refineries when selecting which types of crude oil to process in order to produce the liquid fuel products

[2] Energy Intelligence, *World Crude Oil Data*, accessed May 27, 2015.

[3] Energy Information Administration.

needed within each country and the product markets served by each refinery. Generally, refineries are designed to optimally process a certain type and blend of crude oils. However, it should be noted that the configuration of a specific refinery does not limit that refinery to processing a specific crude oil. Rather, a refinery can generally process a range of crude oil types but may not run at its optimal capacity and/or efficiency should the crude oil type/blend deviate from that for which it was optimally designed to process. The types of crude oils purchased by a refinery will depend on crude acquisition costs as well as the value of products that are yielded from the purchased crude.

With regard to the refining configurations in Eastern European countries, **Table 1** provides information about crude oil import volumes and throughput capacity for primary and selected secondary refining processes. This information does not suggest that refineries in a particular country can only process a certain type of crude, although the table may provide insight regarding the types of crude oil that the refineries may be optimally designed to utilize.

**Table 1. Crude Oil Imports and Refinery Process Capacity for Selected European Countries**

Barrels per day

| Country (# of refineries) | Crude Imports | Crude Distillation (Primary) | Vacuum Distillation (Secondary) | Reformer (Secondary) | Catalytic Cracking (Secondary) | Hydro-Cracking (Secondary) | Coking (Secondary) |
|---|---|---|---|---|---|---|---|
| Lithuania (1) | 182,000 | 190,000 | 89,300 | 45,900 | 43,500 | - | - |
| Belarus (2) | 430,000 | 461,000 | 153,100 | 91,000 | 38,500 | 66,000 | - |
| Ukraine (3) | 238,600 | 313,200 | 145,500 | 75,900 | 29,600 | 7,200 | - |
| Poland (5) | 468,800 | 599,300 | 266,703 | 68,490 | 32,992 | 189,249 | - |
| Slovakia (1) | 117,700 | 115,000 | 55,000 | 21,000 | 18,000 | 42,600 | - |
| Hungary (2) | 108,100 | 161,000 | 77,500 | 29,600 | 24,000 | - | 17,000 |
| Romania (5) | N/A | 302,525 | 143,275 | 45,200 | 82,500 | 31,000 | 89,500 |
| Serbia (2) | N/A | 150,000 | 55,350 | 19,700 | 19,004 | 60,000 | - |
| Bulgaria (1) | N/A | 195,000 | 76,900 | 14,400 | 37,100 | - | - |
| **Total** | | **2,487,025** | **1,062,628** | **411,190** | **325,196** | **396,049** | **106,500** |

**Source:** Crude imports from the Energy Information Administration and Energy Intelligence. Crude distillation and refinery process capacity numbers from IHS.

**Notes:** Crude Distillation is considered a "primary" refinery process and is generally the first step in refining crude oil. The other refining processes in the table are labeled "secondary" as they either further refine outputs from crude distillation or upgrade heavy residual material to intermediate products that can be further refined. Note that Slovakia's crude imports exceed its operating crude distillation capacity. This apparent discrepancy may be a result of the numbers reflecting different years. For example, crude imports represent the years 2012 and 2013, depending on the source, and operating crude distillation is as of 2014.

In order to provide some context about the function of different refinery processes, following is a brief description of the refinery processes listed in **Table 1**.

- ***Crude Distillation:*** also referred to as atmospheric distillation, it is generally the first step in refining crude oil. Crude oil enters the crude distillation unit and is heated to different temperature gradients whereby various products are distilled from the crude oil feedstock.

- ***Vacuum Distillation:*** a secondary refining process that converts heavier oils left over from crude distillation to produce other petroleum products.[4]
- ***Reformer:*** a secondary refining process that produces reformate, a high-octane gasoline blending component.[5]
- ***Catalytic Cracking:*** a secondary refining process that uses a catalyst to create smaller hydrocarbon molecules from larger hydrocarbons in order to increase production of gasoline and distillate fuels. Generally, a more complex refining process than distillation.[6]
- ***Hydrocracking:*** a secondary refining process that upgrades low-quality heavy oils from crude or vacuum distillation, catalytic cracking, and coking units using hydrogen and a catalyst. Heavy oils are converted to lighter fuels such as gasoline, diesel, and jet fuel.[7]
- ***Coking:*** a secondary refining process that upgrades heavy materials, known as "bottoms," into higher value products.[8]

The data in **Table 1** provides a general indication of the crude oil quality that Eastern European refineries may be optimally configured to process. The amount of vacuum distillation capacity provides some insight into the type/quality of crude oil that is expected to be processed. Since the secondary vacuum distillation process generally processes heavier materials from crude distillation, the ratio of vacuum distillation to crude distillation can indicate expectations of heavier materials from the crude distillation unit that may require secondary processing.

Based on the information in **Table 1**, the ratio of vacuum distillation to crude distillation is approximately 0.43. This indicates the expectation of a relatively high volume of heavy material from the distillation unit that will be secondarily processed. Comparing the 0.43 vacuum distillation ratio to the residue product yield of 43.7% for Urals—the most commonly used Russian crude in Eastern Europe—in **Table 2** suggests that refineries may have been configured, to some degree, to process a Urals-like crude oil, which is generally classified as a medium/sour grade. **Table 2** provides a quality and product yield comparison of Russian Urals crude and West Texas Intermediate (WTI), a benchmark light/sweet crude oil in the United States. However, being optimally configured to process a certain crude oil type/blend does not prevent a refinery from processing other crude oils with different quality characteristics.

## Russian Crude Oil to Eastern Europe

Russia is the primary source of crude oil for Eastern European refineries. As mentioned above, the majority of crude oil exported from Russia to Eastern Europe is a type of crude oil known as "Urals". Urals is a blend of Russian, Kazakh, and Azeri crudes.[9] The quality of Urals fluctuates and generally has

[4] Energy Information Administration, *Today In Energy*, "Vacuum distillation is a key part of the petroleum refining process," December 10, 2012.

[5] Energy Information Administration, *Today In Energy*, "Catalytic reforming boosts octane for gasoline blending," April 9, 2013.

[6] Energy Information Administration, *Today In Energy*, "Fluid catalytic cracking is an important step in producing gasoline," December 11, 2012.

[7] Energy Information Administration, *Today In Energy*, "Hydrocracking is an important source of diesel and jet fuel," January 18, 2013.

[8] Energy Information Administration, *Today In Energy*, "Coking is a refinery process that produces 19% of finished petroleum product exports," January 28, 2013.

[9] Energy Intelligence, *World Crude Oil Data*, accessed May 20, 2015.

an API gravity[10] range of 31˚ to 33˚ and a sulfur content ranging from 0.8% to 1.8%. While there is no standard classification of crude oil types, Urals might generally be considered a medium/sour grade of crude oil. In addition to API gravity and sulfur content, product yield distribution is also an important market consideration for refiners when selecting crude oil grades to process.

**Table 2. Crude Oil Assay Comparison: Urals and WTI**

| | Unit | Urals | WTI |
|---|---|---|---|
| Assay date | Year | 2011 | 2000 |
| Gravity | API degrees | 31.31 | 40.8 |
| Sulfur content | Wt. % | 1.25 | 0.42 |
| **Product Yields** | | | |
| LPG | Vol. % | 2 | 2.5 |
| Light Naphtha | Vol. % | 9 | 5.9 |
| Heavy Naphtha | Vol. % | 8.4 | 18.3 |
| Kerosene | Vol. % | 15.3 | 22.7 |
| Gasoil | Vol. % | 21.6 | 17.4 |
| Residue | Vol. % | 43.7 | 33.2 |

**Source:** Energy Intelligence, *World Crude Oil Data*, May 27, 2015.

**Notes:** WTI = West Texas Intermediate. Petroleum products are listed in order of lightest (LPG) to heaviest (Residue).

**Table 2** shows that Urals and WTI differ in API gravity, sulfur content, and product yield with Urals being the heavier and more sour (more sulfur) of the two crude oil types. Quality and product yield differences do not necessarily prevent a refinery from substituting medium/sour Urals crude with a lighter crude oil. The refinery could make such a substitution but may have to adjust its operating parameters and/or sacrifice in other areas such as efficiency or throughput capacity. However, price discounts could justify crude oil substitution even when taking into account efficiency and operating considerations.

## Potential for U.S. Oil to Displace Russian Crude

In the context of U.S. crude oil export policy, analysts of the international market have focused on the potential opportunity for light/sweet U.S. crude oil to be absorbed by global refiners. The potential to displace Russian crude oil within Eastern Europe is a topic of interest associated with foreign policy aspects of U.S. crude oil export policy. Since the decision to export U.S. crude oil will be based on commercial and economic considerations, not directed and controlled by the federal government, predicting and quantifying physical crude oil flows to a particular region in the world under a non-restricted export scenario is difficult and is subject to several assumptions that may or may not be realized. However, multiple considerations regarding the potential for U.S. crude oil to displace Russian crude oil in Eastern Europe can be discussed qualitatively.

[10] EIA defines API gravity as follows: "American Petroleum Institute measure of specific gravity of crude oil or condensate in degrees. An arbitrary scale expressing the gravity or density of liquid petroleum products. The measuring scale is calibrated in terms of degrees API; it is calculated as follows: Degrees API = (141.5 / sp.gr.60 deg.F/60 deg.F) - 131.5.

First, as discussed above, refinery configurations can be used to determine if U.S. crude oil is well suited for not only for a specific refinery but also for its product yield to satisfy local and regional market demands. Refineries do have some degree of operational flexibility and can also invest in new processing equipment to handle increasing volumes of a specific crude oil type. However, making such changes and investments may result in the refinery requiring a price discount to compensate for the additional costs or reductions in efficiency. This, in turn, may result in reducing the attractiveness to U.S. producers to export crude oil to the region.

Second, infrastructure is an important consideration when discussing the potential for physical deliveries. Port infrastructure, pipelines, and other modes of moving crude oil from a seaborne delivery point to the refinery assets must be in place in order for physical delivery to take place. Much of Russian crude oil supplies to Eastern Europe arrive by pipeline. Infrastructure can be built out over time, assuming there is justification (e.g., economic or national security) and resources (e.g., capital) to do so. An assessment of the suitability of existing infrastructure in the Eastern European region is beyond the scope of this memo.

Third, the negotiated price of U.S. crude oil that might be purchased by Eastern European refiners is another important consideration. From the perspective of the refiners, they may not be willing to pay more per barrel of delivered crude than the price of Russian crude and may even require a price discount if the crude type purchased results in less-than-optimal operations. From the perspective of the U.S. producer, crude will need to be priced to compete with Russia's Urals blend (which typically sells at a $2 discount to dated Brent, an international crude oil price benchmark), minus discounts, if any, required by the refiner and less transportation costs (waterborne transportation, depending on vessel size, from the Gulf Coast to Europe may range between $2 and $4 per barrel). Basically, for physical delivery to take place, the price which the refiner is willing to pay for a barrel of crude must be greater than the value of crude oil a producer can receive in its domestic market or from another international destination. Crude oil prices, transportation costs, price differentials, and arbitrage windows change constantly. As a result, the financial justification for delivering U.S. crude oil to Eastern Europe may or may not exist over time. One important unknown factor in this discussion is the potential price response of Russia. It is unlikely that Russia would keep prices static, should competitive crudes threaten Russia's existing markets, and it may decide to reduce prices to maintain market share. Russian oil companies are government controlled and they may make price and marketing decisions that are influenced by non-commercial considerations. One potential outcome for the Eastern Europe region as a result of removing U.S. crude oil export restrictions is that very little physical crude oil is delivered to the region, but that crude oil prices for Eastern European refiners are reduced to some degree as a result of increased competition with Russia and/or downward price pressure on international crude oil benchmarks (i.e. Brent, the benchmark for Russian crude sales). Should this price effect be realized, Russian oil revenues may be reduced.

Finally, while much of the focus to date has been on the potential for U.S. light/sweet crudes finding new global markets, it is important to note that other U.S. crude oils may be more attractive for export than light/sweet oil. For example, industry consulting firm Wood Mackenzie reported in March 2015 that removing U.S. crude oil export restrictions would result in more medium sour crude oils being exported than light/sweet.[11] The firm emphasized that the most likely destination for U.S. medium sour crude is Asia. However, if crude oil export restrictions are removed there is a potential for refiners in Eastern Europe to access other grades of U.S. crude oil. Medium sour crude from the United States to potentially displace Russian Urals crude oil may be more suitable for Eastern European refiners.

[11] Energy Intelligence, *Oil Daily*, March 24, 2015.

## Foreign Trade Effects

Removing U.S. crude oil export restrictions would have effects on other nations exporting similar crude oils. The magnitude of these effects would likely depend on the actual volumes the United States exported, as well as the time frame; long or short-run. Changes in demand or supply in the world oil market are felt by every nation participating in the market, although the effects are not likely to be equally apportioned among the market participants. The primary mechanism that transmits these effects is the price of oil.

The International Energy Agency (IEA) estimates that world oil demand is likely to be over 93 million barrels per day in 2015. This level of demand is met through consumption of domestically produced oil, supplemented by a complex set of import and export transactions. The degree to which the introduction of additional supplies into the market is likely to disrupt the pattern of existing relationships depends, partly, on the magnitude of the change in oil supply on the market. A supply increment of some hundreds of thousands of barrels per day can be expected to be absorbed more easily than one measured in millions of barrels per day.

If U.S. crude oil export restrictions were removed, there is no way to accurately predict the actual level of exports that would occur. Decisions as to whether to export oil or to sell it in the domestic market are commercial decisions determined by the oil producer, likely based on the market price differential between world and domestic markets. As an oil producer takes advantage of, for example, a world price higher than the domestic price, the two prices will themselves begin to adjust to close the spread that created the profitable export opportunity. As potential U.S. oil exports enter the world market, they would likely cause the world price to decline and the domestic price to rise. If the level of U.S. exports is small relative to the market, it might be difficult to isolate these price effects amid the normal volatility of oil prices. Furthermore, any small price effect could be offset or enhanced by unforeseen global events.

In the short-run new competitors can affect nations in a variety of ways. For example, in 2010, Nigeria was exporting 983,000 barrels per day of crude oil to the United States. By 2014 that total had dropped to 59,000 barrels per day, and by February 2015 exports totaled 2,000 barrels per day to the United States, reflecting the substitution of domestic light oil for imported Nigerian crude oil.[12] Nigeria was forced to find new customers for its oil and suffered declining revenues, which reportedly left the country less able to fight Boko Haram and less a focus of U.S. foreign policy.[13] If the United States began to compete with Nigeria, Azerbaijan, Algeria, Kazakhstan, and other light crude oil exporters, they all could experience some disturbance to existing trade relationships and their fiscal positions in the short run. Currently, the Energy Information Administration reports that the United States does not import crude oil from Algeria, Azerbaijan, or Kazakhstan. There is no way to predict whether potential U.S. exports would directly compete in the same markets as these nations. If competition did occur, the effect on these nation's finances would depend on the magnitude of the change in the price of oil.

In the long term, the price of oil will likely adjust to reflect the availability of U.S. export quantities in the market. If the world price is lower as a result, and all else being equal, all exporting countries will suffer a loss in revenue and consuming nations will experience the benefit of lower oil prices. On the basis of the new demand and supply balance in the world market, new trading relationships would likely be established, while some older relationships might persist and others might not.

[12] Energy Information Administration data available at, http://www. eia.doe.gov.

[13] Robert Windrem, "Needle on Zero: Nigeria's Economy Tanking as U.S. Oil Exports Dry Up", NBC News, November, 2014.