How Much Crude Oil Should an Oil Exporting Country Produce Annually for Export?

Abstract

We discuss the important issues faced by a crude oil exporting country in determining how much oil they should produce annually for export.

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1 The Decision Making Problem

1.1 Historical Background

At the beginning of the year 2015 international press had many headlines with news about the resurgence of the US Oil & Natural Gas industry using the newly developed horizontal drilling and hydraulic fracturing (fracking) techniques. These techniques of course require huge investments. News reports indicated that with these investments US natural gas production will go up so much that the country won't have to import natural gas; and even the US crude oil production will go up to such an extent that pretty soon the country will move from an oil importing country to an oil exporting country. Crude oil produced using these new techniques is usually referred to as *shale oil*. For a background, we remind the reader that for many years, the US has been a net importer of crude oil with 2014 imports of 7 million barrels/day.

Saudi Arabia (SA), the leader of OPEC (Oil Producing and Exporting Countries), is the world's largest exporter of crude oil with exports of 7.4 million barrels/day at the beginning of 2015. Russia which is not a member of OPEC, is the 2nd largest crude oil exporter. Both SA

and Russia mainly depend on the revenue from crude oil exports for their sustenance. So, these countries, as well as all other oil exporting countries were mainly interested in raising the crude oil price to maximize their revenue from its sale at that time.

At that time crude oil price was ranging between $100-110/barrel (in this paper the symbol " $ " denotes "US dollar"). Due to huge public expenditures in the country, SA's budget break-even crude oil price was estimated to be $88/barrel.

1.2 The Two Players Involved in the Decision Making Problem

One of the players with great interest in the outcome of the decision making problem that we will discuss is the US Government. For several years before 2015, the value of the US total annual imports was running higher than that of its total annual exports, resulting in a net annual trade deficit of around $500 billion. This has a negative effect on the growth of the US economy. US is the world's largest importer of crude oil until 2014, also crude oil imports were a large part of US imports. So, the US is very much interested in keeping the crude oil price as low as possible.

Also, there was another major event that happened in Europe around this time. There was a civil war in the Crimean Peninsula (or Crimea) that was part of Ukraine at that time. The vast majority of inhabitants of Crimea are Russian people speking the Russian language, and they never liked being a part of Ukraine. At that time the Russian Army marched into Crimea, and annexed it as a part of Russia. Supporting the Ukraine Government, the US Government imposed some sanctions on Russia. When these sanctions had no effect on Russia, the US Government was looking for some other actions they could take for punishing Russia. Since Russia depends heavily on their revenues from the sale of crude oil, reducing crude oil price will result in a severe punishment to Russia.

The 2nd player is the SA Government represented by their Oil Minister. The income from their exports of crude oil is the major source of revenue for the country, another source for them is the revenue from the Haj pilgrimage. SA imports most of their groceries and several other commodities using this income, also SA's population is growing at the annual rate of about 2%. Given these facts, clearly SA is interested in keeping the crude oil price at the then prevailing rate of between $100-110/barrel, and perhaps growing it on par with the growth rate in the prices of other commodities. In fact for a very long time, SA has been very modest in their

2

desire for higher crude oil prices.

Other crude oil exporting countries have been trying vigorously to push up crude oil prices; as the World's largest producer of crude oil, SA has been playing the role of a moderator of these ambitions by increasing their crude oil production rate to keep price raises in check. The world really appreciates this moderating role that SA has been playing regarding crude oil prices.

1.3   History of Saudi Oil Industry

The Kingdom of Saudi Arabia was formed in 1932 with Abdulaziz Al-Saud as its King. A major source of income for the country at that time was the taxes paid by Haj Pilgrims to visit the holy sites of Islam. But the great depression of the 1930's resulted in the number of pilgrims/year decreasing from 100,000 to below 40,000. This hurt the Saudi economy greatly, so they started looking for an alternate source of income. Oil seepages have been observed at Quatif on the eastern seaboard, so the King invited mining engineers to explore the eastern regions of the country for oil. They identified a promising site near Dammam and over the following 3 years they started drilling for oil in that region. They stuck oil on 3 March 1938. This discovery turned out to be the first of many, eventually revealing the largest source of crude oil in the world. For the kingdom, oil revenues became a crucial source of wealth, and these discoveries altered Middle Eastern political relations forever. Soon the name of the company dealing with these oil producing operations was changed to Arabian American Oil Company (ARAMCO). By 1988, ARAMCO was officially bought by the SA Government and became known as the Saudi ARAMCO.

Now SA is the world's largest producer and exporter of crude oil and has 25% of world's known oil reserves (over 264 billion barrels). As the world's largest producer and exporter of crude oil, SA plays the leading role in the global energy industry, its policies have a major impact on the energy market and the global economy. Mindful of this responsibility, the country is committed to ensuring stability of supplies and prices; so far they have been covering any drop in oil supplies by increasing their output.

With domestic demand and population raising rapidly, a very important objective for the SA Oil Minister to consider in reaching important decisions about oil production levels, is to make sure that his country's domestic oil needs, and needs for revenues from oil exports, will be

covered for *as long a planning horizon in future as possible*. This important objective function is measured by:

Objective 1: Lifetime of the country's crude oil reserves resource = (country's estimated crude oil reserves)/(country's annual crude oil production rate) in years.

For Saudi Arabia the estimated oil reserves in 2015 are 264 biliion barrels, and the country was producing 9.6 million barrels of crude oil daily at that time, so Objective 1 at that time was (264 billion)/(9.6 × 365 million) ≈ 75 years. After all, the oil reserves are a fixed finite resource that is being depleted by oil production. The SA Oil Minister is aware that about 40 years ago, the countries in Northern Europe were plush with oil from the reserves in the North sea; now these reserves are nearing depletion, and many of these countries are importing crude oil from Russia. One of his prime responsibilities is to make sure that this does not happen to his country SA, for the largest possible time interval in future, i.e. maximize Objective 1.

At that time they were exporting 7.4 million barrels/day of crude oil. At $100/barrel this was providing oil revenues of $100 ×7.4× 365 million ≈ 270 billion/year. This revenue of $270 billion was meeting their needs for oil revenues at the beginning of 2015. This is the 2nd important objective function to consider in our decision making problem to decide how much crude oil the country should export annually, it is:

Objective 2: Amount in US $ the country's exports of crude oil generate annually.

For Saudi Arabia at the beginning of 2015 it was $270 billion.

The 3rd important objective function to consider in our decision making problem to decide how much crude oil the country should export annually is:

Objective 3: Market share of the country in the oil export market = (the country's annual export of crude oil in barrels)/(Worldwide annual crude oil exports in barrels).

Saudi Arabia at the beginning of 2015 was exporting 7.4 million barrels/day, and the World-wide crude oil exports was 44 million barrels/day. So this Objective 3 had a value of 7.4/44 = 17% of market share in the crude oil exports market for Saudi Arabia at that time.

1.4   The Decision Making Problem, Recent Background

In early 2015, when International News headlines were predicting that with shale oil production US may change from an oil importing country into an oil exporting country, US Secretary of State had discussions with the Saudi Oil Minister and other top level persons in the **Saudi Arabian (SA)** Government. He briefed them about these developments.

One of the countries in the Middle East with which SA does not have good relations is another OPEC member, Iran. At this time, the permanent members of the UN Security Council have imposed sanctions on Iran under the suspicion that the country is engaged in secret research to produce nuclear weapons, even though Iran has always denied these allegations. For many years now, negotiations have been going on between Iran and these big 6 powers on conditions that Iran has to meet, to lift the sanctions placed on it. In discussions with Saudi authorities, US Secretary of State has pointed out that these Iran nuclear negotiations may at last be successful, and if so the sanctions on Iran will be lifted at that time. If this happens, Iran will begin oil production and enter the oil export market. He pointed out that these recent developments may affect SA's *market share in the crude oil export market*; and that they have to do something to protect their market share.

News reports in Western Media at that time indicated that the SA Oil Minister considered the emerging US Shale oil industry a big threat to the Saudi market share in the crude oil export market. So, in order to discourage additional investment in the US Shale oil industry, he decided to do everything in his power to make these investments unattractive. Knowing that this can be achieved by reducing the price of crude oil in the oil market, which can be achieved by flooding the market with crude oil; he took the decision of increasing the value of the Country's crude oil production to the maximum extent that the Saudi oil industry can pump.

This recent Saudi action is contrary to the actions of all the OPEC members including SA until recently. Previously all the OPEC countries had the United policy of maintaining capacity limits for oil production by each country, to either increase the crude oil price or at least keep

it from falling. That was to make sure that they are rewarded adequately for making their precious natural resource available to the World.

This action by SA was not popular with other OPEC members, they kept their crude oil production levels more or less stable. These actions raised the Saudi crude oil production to 10.6 million barrels/day, a record high. They resulted in the overall OPEC production increasing from 32 million barrels/day in 2014 to 33.1 million barrels/day in early 2015. The net result is that within a few days crude oil price dropped to 52$/barrel, and kept falling still further, a 50% drop due to the this action.

We will analyze this action taken by the Saudi Government in the next section.

1.5   Analysis of the Decision Taken

First let us examine the consequences of the decisions implemented. In a few days after the decisions mentioned were implemented, the price of crude oil dropped by about 50%. So as a result of this action by SA, all the oil exporting countries are experiencing a similar decline in their returns/barrel exported these days. Prices of all other goods and commodities remained stable, so the net result is that SA is now having to export twice the amount of their precious natural resource to import the same quantity of other goods and commodities for their national needs, or use up some of their dollar reserves.

It is quite possible that maintaining market share is a matter of national pride, but is it worth having to pay twice the amount of the country's fixed natural resource for importing the same quantity of other goods and commodities? Also at the current production rate of 10.6 million barrels/day, the estimated lifetime of the current known reserves of SA will be (264 billion)/(10.6 × 365 million) ≈ 68.2 years, which is a significant drop of the other objective function Objective 1 from its previous value of 75 years, as a result of the decision implemented.

1.6   The Procedure That OPEC IS Using Currently to Decide The Oil Production Quota Of Each Of Its Members

Each OPEC country wants to maximize the amount of money in US $ that they receive by exporting their crude oil, while making sure that their crude oil export volume is the same or higher than that in the recent past.

2 Lessons to be Learnt from the Events Over the Last Two Years (2015 - 2017)

Crude oil prices have remained below US $50/barrel all this time, and even now with OPEC and other major crude oil producers like Russia limiting their crude oil production, they are struggling to reach 50 US $ /barrel. Here briefly are the lessons we can learn from the events over this period.

1. To maintain the desired price level, unity of OPEC countries in abiding by agreed upon production limits is essential. Even if one country produces above their limit, the results may slip.

2. Keeping Objective 3, Country's Market Share at a high level may be a matter of National pride for the time being; but Ojective 1, Lifetime of the country's crude oil resource is very important for the well being of the next generation in the country. So, Objective 1 is very important and should not be ingnored in decision making.

3. Just increasing country's crude oil production is not enough to make more money in US $, it is also necesssary to make sure that the increased production does not result in lowering crude oil prices.

4. For every country, the country's crude oil reserves is a fixed finite resource, and crude oil production by any technique including fracking, depletes that resource.

5. When OPEC countries and others like Russia stick to their agreed upon crude oil production limits; if the US tries to keep crude oil price artificially low , by flooding the market with crude oil produced through fracking, they will soon realize that this effort is depleting their crude oil reserves resource faster than necessary.

6. To keep crude prices at desired levels, once this level is reached, it is necesssary to make sure that the agreed upon production limits leads to available crude oil in the market equal to

the demand for that oil.

3   Simple Approach to Calculate Crude Oil Export Quota for Each OPEC Country

Under these conditions, we get the following simple approach for calculating the crude oil export quota for each OPEC country:

1. Each Country Selects its Desired Value for the Lifetime of its Crude Oil Resource: For each country, calculate (its crude oil reserves in barrels)/(its current annual crude oil production level in barrels) = its current value for "Lifetime of its crude oil crude oil resource". Then let the country modify that value to their "desired lifetime for its crude oil resources".

This implies that the country's "desired annual crude oil production rate" = (its crude oil reserves in barrels)/(its desired lifetime of its crude oil resource). Denote this quantity by the symbol y_i for OPEC Country i.

2. Determine x = the Amount of Crude Oil in Barrels that OPEC as a Group Should Export for Coming Year: = (total estimated world crude oil demand in barrels) - (expected amount that non-OPEC countries are likely to export next year).

3. Distribute the Quantity x Among OPEC Countries in Proportion to Their Desired Annual Crude Oil production Rate y_i: There are two cases to consider here:

Case 1: If $x \geq (\sum_p (y_p : \text{over all OPEC countries } p))$, make the crude oil export quota for the year as y_i for OPEC country i ; and leave $x - \sum_p (y_p : \text{over all OPEC countries } p)$ as portion of the crude oil demand for the year, x , for other non-OPEC countries to fill.

Case 2: $x < (\sum_p (y_p : \text{over all OPEC countries } p))$: In this case, for OPEC country i, make its crude oil export quota = $x \times (y_i / (\sum_p y_p : \text{over all OPEC countrys } p))$.

We hope that the OPEC Countries at their meeting remember these facts in reaching their Unified decisions as a group.

4 References

1. *Challenging Aspects of MCDM*, Katta G. Murty, 2015, see:
   http://www-personal.umich.edu/~ murty/MCDM3.pdf