



Saudi Arabia's Reserve "Depletion Rates" provide Strong Evidence to Support Total Reserves of 175 Gb with only 65 Gb Remaining

Posted by [Sam Foucher](#) on April 20, 2007 - 11:05am

Topic: [Supply/Production](#)

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Summary

In Dr. Saleri's Saudi Aramco presentation on Feb 24, 2004 to the CSIS in Washington, D.C., he stated that ***Our typical depletion rate is about two percent.*** However, Aramco's definition of annual depletion rate is consistently calculated as annual production as a percentage of total reserves. Aramco's calculation method will be confirmed by the examples below.

Data from the presentation is used to convert Aramco's depletion rates into conventional depletion rates which show that conventional maximum depletion rates for Ain Dar/Shedgum, Abaiq and Berri are well above 5%/yr. In addition, Aramco's stated depletion rate for Shaybah shows that Aramco believes that Shaybah has up to 20 Gb total reserves.

In 2003, assume that Aramco could have produced at an average capacity of 9.5 Mb/day for the entire year. Production reached this level during the Iraq invasion in March 2003. The annual production is 3.5Gb ($9.5\text{Mb}/\text{d} * 365\text{d} * (1\text{Gb}/1000\text{Mb})$).

Aramco's proved reserves are equal to the annual production divided by Aramco's definition of annual depletion rate. Thus, total reserves are equal to 175Gb ($3.5\text{Gb}/2\%$), which is about half of their stated number of an extremely optimistic 359 Gb.

Finally, assuming that total reserves are 175 Gb and that these reserves are produced at a conventional depletion rate of below 5.5%/year, the oil production rate of Saudi Arabia is forecast to Dec 2020. This forecast shows that production follows an exponential decline curve down to 4.5 million barrels/day in Dec 2020 and that it is highly likely that the world's crude oil and lease condensate production has passed a peak of 74.2 million barrels/day on May 2005.

Definitions

Depletion rate (rem) = Common or conventional definition of depletion rate which is annual production as a percentage of remaining reserves (assumed to be the same as total reserves less cumulative oil reserves produced)

Depletion rate (tot) = Aramco's definition of depletion rate which is annual production as a percentage of total reserves (assumed to be the same as initial proved reserves)

Reserves depletion = Cumulative reserves produced as a percentage of total reserves

URR = Ultimate Recoverable Reserves or total reserves

Gb = billion barrels

Mb = million barrels

Saudi Aramco's Depletion Rate Calculation Method

Dr. Saleri's [presentation](#) shows Aramco's calculation method for depletion rates. Figs 1, 3, 5 and 6 are sourced from this presentation.

Fig 1 below states in the title that depletion rates are a "% of Initial Proved Reserves" which are the same as depletion rates (tot).

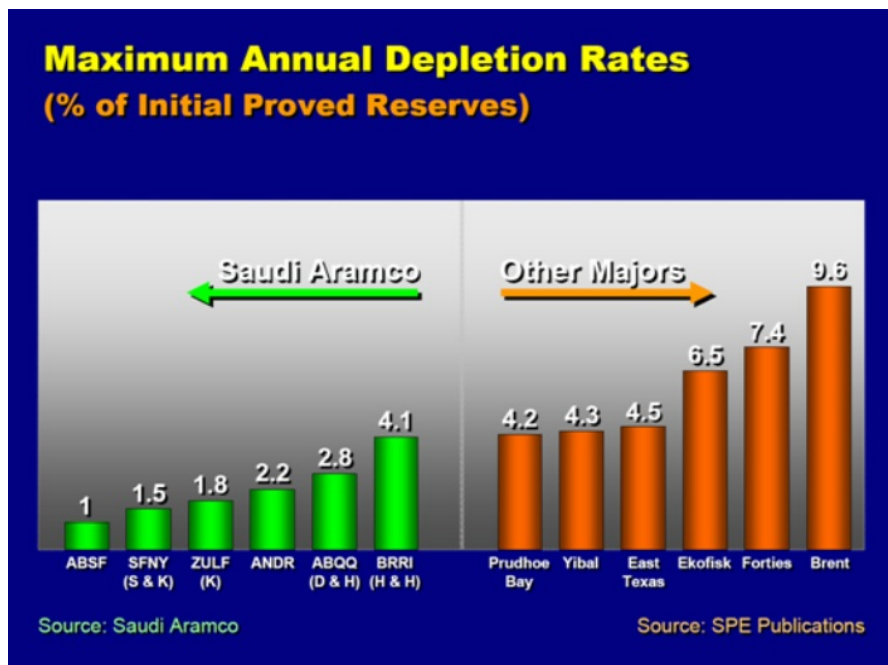


Fig 1 – Maximum Annual Depletion Rates (tot) – click to enlarge

To check this calculation, Prudhoe Bay's maximum depletion rate (tot) of 4.2%/yr is verified. Here is a chart of Prudhoe Bay's production profile. A total reserves (or Aramco's term of initial reserves) figure of 13 Gb is used from this [source](#) as it is dated 2002 rather than the chart's estimated reserves from 2001.

The maximum depletion rate (tot) is equal to the maximum annual production as a percentage of total reserves. Depletion rate (tot) = $0.55\text{Gb}(\text{years } 1980\text{-}87) / 13\text{ Gb} = 4.2\%$ which agrees with the depletion rate (tot) of 4.2% shown in Fig 1.

For comparison, in 1993, the depletion rate (rem) was much higher indicating that the Prudhoe Bay field was being produced aggressively. Annual production was less at 0.4 Gb and cumulative production was 8 Gb. Remaining reserves is total reserves of 13 Gb less cumulative of 8 Gb to give 5 Gb. Depletion rate (rem) = $0.4\text{ Gb} / 5\text{Gb} = 8\%/yr$.

Prudhoe Bay, Fifteenth Largest Field in the World

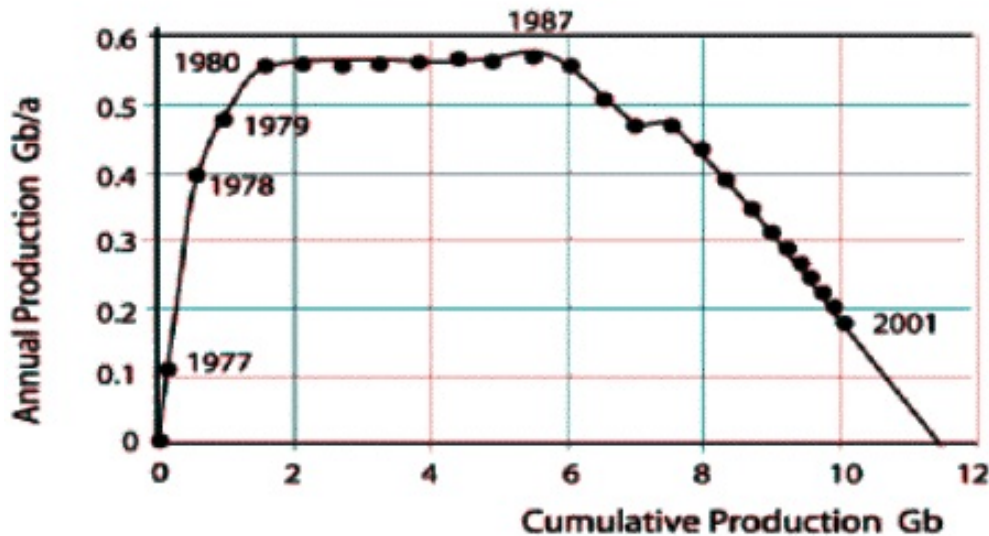


Fig 2 – Prudhoe Bay

Saudi Aramco’s Depletion Rates (rem) for Selected Fields

Fig 3 shows the reserves depletion of selected fields.

Abu Sa’fah has a reserves depletion of 21%. Fig 1 shows Abu Sa’fah (assumed to be ABSF) to have a maximum annual depletion rate (tot) of 1%. From the definitions above, reserves depletion is cumulative reserves produced as a percentage of total reserves. Depletion rate (tot) is annual production as a percentage of total reserves.

$$\text{Depletion rate (rem)} = \frac{\text{annual production}}{(\text{total reserves} - \text{cumulative reserves produced})} = \frac{1\%(\text{total reserves})}{(\text{total reserves} - 21\%(\text{total reserves}))}$$

Abu Sa’fah maximum depletion rate (rem)

The total reserves variable cancels in the above equation resulting in the depletion rate (rem) = 1%/(100%-21%)=1.3%/yr for Abu Sa’fah, which is a low depletion rate (rem).

Applying the same formula to the other fields:

Safaniya maximum depletion rate (rem)

Depletion rate (rem) = 1.5%/(100%-26%)= 2.0%, still low.

Zuluf maximum depletion rate (rem)

Depletion rate (rem) = 1.8%/(100%-16%)= 2.1%.

Ain Dar/Shedgum maximum depletion rate (rem)

Depletion rate (rem) = 2.2%/(100%-60%)= 5.5%, this field is being pushed hard.

Abqaiq maximum depletion rate (rem)

Depletion rate (rem) = $2.8\% / (100\% - 73\%) = 10.4\%$, this is very high but this field has been producing since 1946.

Berri maximum depletion rate (rem)

Depletion rate (rem) = $4.1\% / (100\% - 28\%) = 5.7\%$, this field is being pushed hard.

As shown above, the maximum depletion rates (rem) range from 1.3% to 10.4% which is more realistic as supported by this statement for Middle East fields from this [source](#). "Adopting a depletion rate for Iraq of 4-5%, which is well within good management practice for large fields".

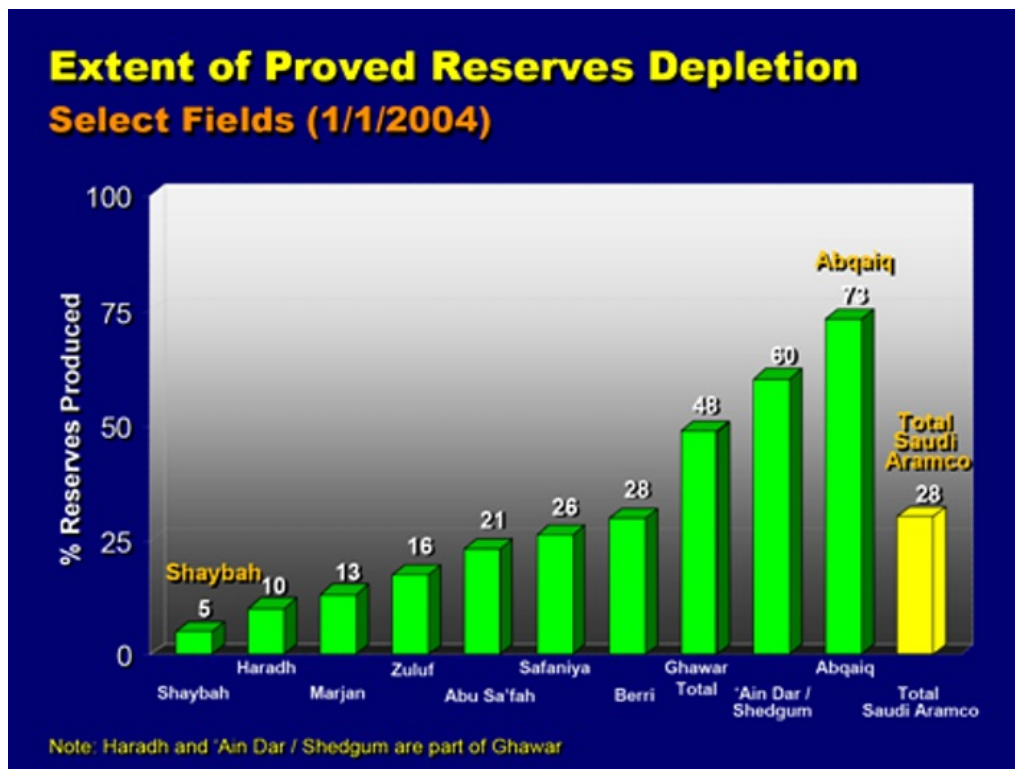


Fig 3 – Reserves Depletion – click to enlarge

Fig 4 below shows the actual depletion rate (rem) for Aramco, assuming total reserves of 175 Gb. The actual depletion rate (rem) is now between 4-5%. If the depletion rate (rem) is kept below a maximum of 5.5%, reflective of good reservoir management, then Aramco's production will stay below 9 Mb/d and will continue to decline in order to keep the depletion rate (rem) below 5.5%, shown in Fig 7.

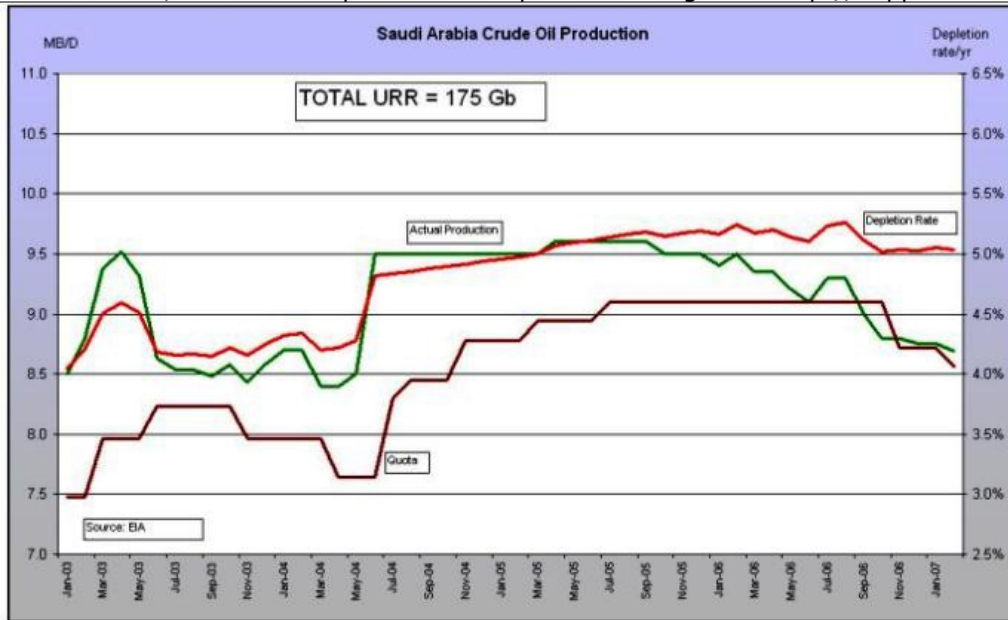


Fig 4 – Actual Depletion Rate (rem) – click to enlarge.

Shaybah Field Total Reserves

The figure below is also from Dr Saleri’s presentation. The depletion rate (tot) is given as 1%/yr with an optimistic production plateau of more than 50 years.

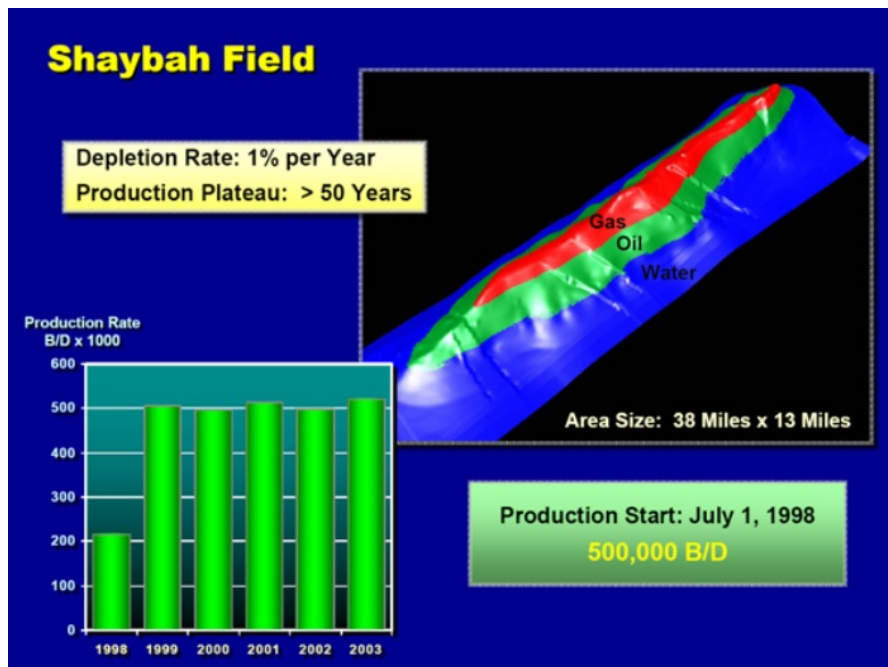


Fig 5 – Shaybah – click to enlarge

The annual production is $0.5 \text{ Mb/d} \times 365 \text{ d} = 182.5 \text{ Mb/yr}$ or about 0.18 Gb/yr . Applying Aramco's depletion rate (tot) of 1%/yr gives total reserves $= 0.18 \text{ Gb} / 1\% = 18 \text{ Gb}$ for Shaybah. This number appears very optimistic next to Colin Campbell's figure of 6 Gb reserves for Shaybah, discovered in 1968, from his book "The Golden Century of Oil 1950-2050".

However, this [source](#) agrees that Shaybah might have 18 Gb:

UAE: Saudi Border Oilfield

The UAE and Saudi Arabia are debating the ownership of the border oilfield at Shaybah, which contains nearly 1.5 per cent of the world's total crude resources. Discovered in 1968, the field straddles the UAE-Saudi border and is believed to be one of the world's largest onshore oilfields, with current estimated proven reserves of 15.7 billion barrels. Up until 25 December 2003, the field had yielded one billion barrels, however oil industry sources believe its recoverable oil potential could rise to 18 billion barrels in a few years with the deployment of new technology (such as horizontal drilling).

Fig 3 shows Shaybah's reserves depletion to be only 5% to 1/1/2004. Given that Shaybah has produced (0.5 Mb/d*365d*5yr plus 0.2 Mb/d*365d, or 985 Mb) about 1 Gb to 1/1/2004, Shaybah's total reserves using this calculation is the about 1Gb/5% or 20 Gb. At least, Aramco's data shows consistent optimism within their presentation. I do not share their optimism and believe that Shaybah's reserves are much lower than 18 Gb.

Saudi Aramco's Real Reserves

Fig 6 shows a pie chart for Aramco's resources. Based on this chart, the total reserves are 260Gb+99Gb=359Gb. The reserve depletion is cumulative reserves produced divided by total reserves or 99/359 =28%, which is equal to the reserve depletion number of 28% in Fig 3. This shows that Aramco's presentation data is consistent.

However, what is not consistent on Fig 3 is showing Ghawar's depletion at 48% while Total Saudi Aramco is only 28%. Since Ghawar production has been a majority of Aramco's total production, the depletion for Total Saudi Aramco should be at least 48%. If it is assumed that Aramco's total reserves are 175Gb then the more realistic figure for reserves depletion for Total Saudi Aramco in Fig 3 should be 99/175=56%.

In 2007, the cumulative amount produced would be 99 Gb plus 11 Gb from Jan 2004 to Feb 2007 to give 110 Gb produced. The current reserves depletion is 110/175=63% which implies that future Aramco field production decline rates will accelerate to ensure that depletion rate (rem) are kept below 5%.

As the 260Gb reserves number is reported in BP's annual statistics, and the BP reserves number is supposed to be remaining reserves, Aramco had no choice but to exaggerate their reserves upward to an enormous 359Gb! Note that in 1983 when Saudi Arabia nationalised its oil assets, BP stated reserves of 169 Gb for Saudi Arabia. This implies that a total reserves of 175 Gb is consistent with the 169 Gb number as no giant fields have been discovered in Saudi Arabia since Lawnah (only 1.2 Gb) in 1975.

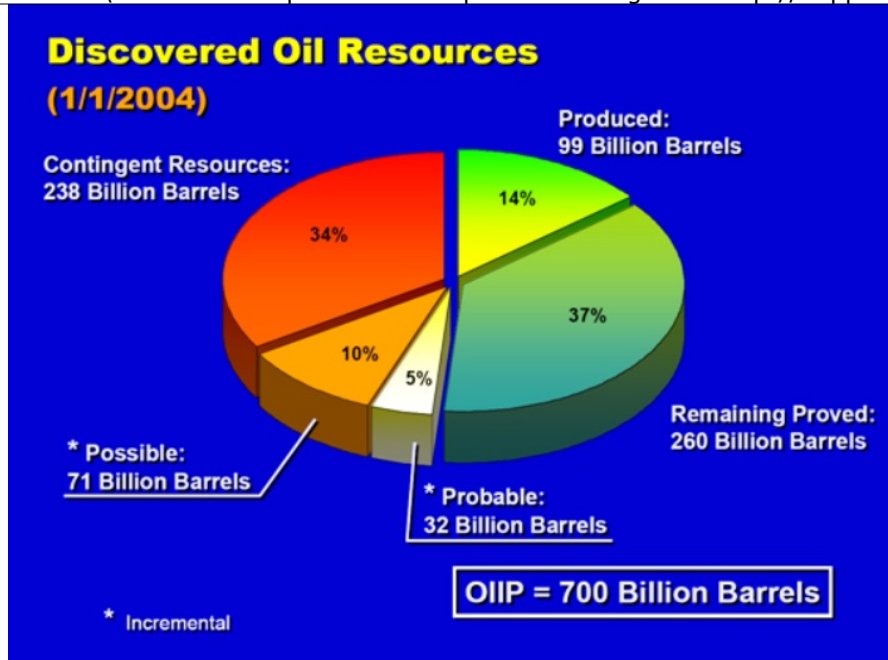


Fig 6 – Saudi Aramco Discovered Oil Resources – click to enlarge

A comment from Dr Saleri from his accompanying [speech](#) to the presentation was ***Our typical depletion rate is about two percent.***

However, to be consistent with the presentation, that means that the Aramco depletion rate (tot) = 2%/yr. Assume that Aramco could have produced a “typical” 9.5 Mb/d in 2003. Fig 4 shows that a production level of 9.5 Mb/d was reached during the March 2003 Iraq invasion.

Annual production for 2003 equals 9.5 Mb/d*365d*(1 Gb/1000 Mb)=3.5Gb. Therefore, using this method, Aramco total reserves equals 3.5Gb/2%=175 Gb, which is about half of their stated number of 359 Gb.

Saudi Arabia Production Forecast

The actual production and depletion rates (rem) are shown in Fig 4 above. Fig 7 shows a forecast of production to Dec 2020. It is assumed that Aramco will continue to practice good reservoir management and consequently the depletion rate (rem) will not exceed 5.5%/year. If the depletion rate (rem) is kept lower than 5.5%, say at 4.5%/yr, then production rates would probably drop below 8 Mb/d in early 2008 and continue to decline.

The forecast shows clearly that Saudi Arabia having its reserves already 63% depleted must increase production decline rates to ensure that reservoirs are not damaged. Themegaprojects shown in the chart are too small to stop the exponential production decline. The reserves of the megaprojects' underlying fields are included in the total reserves of 175 Gb.

Furthermore, if the total reserves of Saudi Arabia are truly 175 Gb and Aramco's production is constrained by keeping the depletion rate (rem) under 5.5%, then the world's crude oil and lease condensate production is highly likely to already have passed a peak of 74.2 million barrels/day on May 2005.

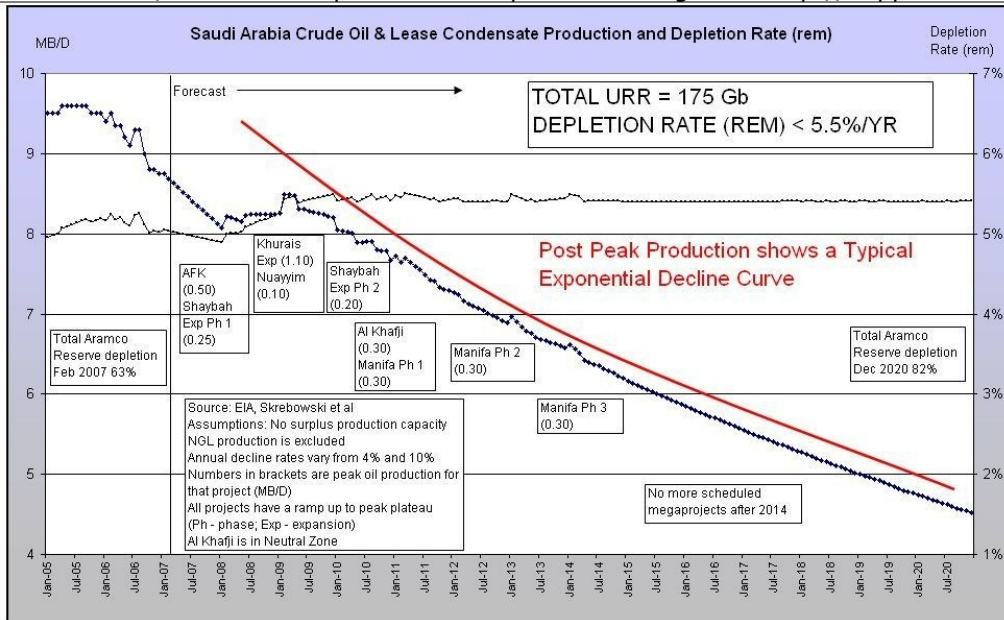


Fig 7 – Saudi Arabia Forecast Production Rates and Depletion Rates (rem) (EIA actual lease condensate for Saudi Arabia is zero and forecast lease condensate assumed to be zero. Actual and forecast production is crude oil only.) – click to enlarge



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