Ecological Economics 98 (2014) 62–71

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

World oil production trend: Comparing Hubbert multi-cycle curves

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ARTICLE INFO

Article history:
Received 15 August 2013
Received in revised form 14 December 2013
Accepted 27 December 2013
Available online 23 January 2014

Keywords:
Forecasting oil production
Multi-cycle Hubbert curves
Peak oil

ABSTRACT

Worldwide shale oil resources in the U.S., China, Russia, Poland and France could mean that potential world oil production could double or triple in the next few decades. However, not all of these new reserves may be as large or as productive as North Dakota's Bakken shale oil. In addition reserves of shale oil look to be a lot less in relative terms than the reserves of shale gas as evidenced by the price of natural gas in the U.S. compared to the price of oil. This suggests that the U.S. and world supplies of shale oil may be limited. In this article, we will look to attempt a different type of forecast for oil using a modified Hubbert curve oil production forecast. We look at possible world oil production trends rather than just U.S. oil production trends. Two interesting comparisons of the world oil production trend to other regional trends are the former Soviet Union's oil production trend and the U.S. oil production trend. If we compare the current world oil production trend to those previous trends using indexation, then we can get an idea of what may happen to world oil production in the future.

1. Introduction

We are on the precipice of an oil crisis. It doesn't appear as such since oil production from tar-sands[1] and shale oil[2] has been rising quickly causing the price of oil to stabilize around $100 per barrel and because U.S. natural gas supplies look to be vast. However, natural gas is difficult to substitute for oil, and had not those alternative oil supplies been developed in a timely manner, we would have had an oil price shock that could have caused hyper-inflation and economic decline. Even at $100 per barrel, oil prices still are having a detrimental effect on the world's tenuous post-recession performance (see for example Hamilton, 1983, 2009). So far, world oil supplies have kept rising due to shale oil and tar sands production, but that will not last forever. Therefore it is important to try to guess what the future supplies of oil will be.

When we consider energy in general, there are numerous supply sources and substitution strategies. However, if these other sources and substitution strategies are so numerous and powerful, then the price of oil should not have gotten as high as it has. The fact that oil prices are high, and a substitute like natural gas has low prices ever since the plateau of oil production first started in 2005, suggests that there is a problem with finding substitutes for oil. See Bardi (2012), Hall (2008), Hall et al. (1986), Cleveland et al. (2000), and Cleveland (1991) to understand the difference of energy. In fact if we look more closely at energy in general, and oil in particular, there are three basic economic needs that energy is used for: 1) electric power and electric power technologies; 2) space heating for consumers and process heating for industry, and 3) personal private transportation, cargo transport and Large Autonomous Mobile Machinery (LAMMs). As long as there is plenty of coal and natural gas, or even solar and wind power, the heating and electric power issues can be solved. It is only in the transportation, cargo transport and movement sectors where a dense, light, liquid fuel is necessary, mostly for LAMMs such as automobiles, trucks and large movable equipment. Such LAMMs induce much economic growth and consumer value. Therefore it should be clear that we do not have an overriding energy problem or crisis, but rather we have a specific problem with oil and that there are not a lot of good substitutes for oil. Although as Aleklett (2012) and Bardi and Pagani (2007) point out, we may indeed have peak oil, peak natural gas and peak uranium within a generation.

As far as LAMMs are concerned, it is very difficult to substitute electricity, natural gas and coal for dense liquid fuels. So far such substitutions as coal-to-liquids, gas-to-liquids and electric batteries for automobiles have been shown to be fairly expansive, and therefore we consider only conventional oil, tar-sands and shale oil supplies. This means that the world's considerable economic output is very dependent on relatively cheap, liquid fuels for its survival and so we need to emphasize the supply and demand of liquid fuels, and especially oil, as a worldwide strategic necessity.

In order to understand the supply of oil, Hubbert (1956, 1962) suggested the need to understand the logistics curve concept often called the Hubbert curve. The Hubbert curve is explained in economic terms

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[1] Tar sands production in Alberta, Canada is equal to about 2 mbd or 1/5th of the oil production of Saudi Arabia. Tar sands production is an unconventional oil production, but it is economic with oil prices at about $70 per barrel or higher.

[2] Shale oil includes natural gas liquids like propane, pentene and octane. Shale oil is considered unconventional oil production by some geologists due to its very quick rate of decline in production for each well. Shale gas includes methane and ethane. Shale oil production from the Bakken regions is close to 1 million barrels per day (mbd) while shale gas is roughly 0.5 billion cubic feet (bcf) per day or about 100,000 barrels per day of oil equivalent from North Dakota's Bakken region.

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http://dx.doi.org/10.1016/j.ecolecon.2013.12.016

in Reynolds' (1999) mineral economy model which is explained further below. To not include the Hubbert curve in resource studies, is to not actually understand non-renewable natural resource economics. Therefore in this article, we give a brief history of the Hubbert curve. Furthermore, since statistical analysis, such as Simmons (2005) and Sorrell et al. (2010), show evidence that the world production of conventional oil has reached a peak, then the supply of energy for LAMMs is limited baring a breakthrough in battery or compressed natural gas technology. Also Hall and Hall (1984) suggest that limits are based on flow rates and not just stocks alone. What we don't know is what will happen to shale-oil and tar-sands production going forward and how much of a supply boost they can give. One way to try to forecast the supply of conventional and non-conventional oil is to simply look at the geological regions and make informed estimates, another is to analyze previous Hubbert curve cycles of very large regions, and use those to forecast potential new supplies of oil.

In this paper, we consider a Hubbert curve forecast rather than a normal geologic forecast, to try to determine how long and how much the current worldwide rise in oil production will last. We will do this by comparing the current world oil production pattern to that of other regions. This will help in understanding how long oil prices may remain relatively low, near \$100, and stable as the world's economy proceeds forward. While a current Hubbert analysis suggest shale oil supplies could peak in 2050, alternative forecasts could see world oil production peaks as early as this year.

2. A Potential Play

Consider a specific shale play and its drilling trend in Fig. 1. That figure shows the Haynesville shale basin rig count over the last few years and shows the drilling declining by roughly 90%. Why would there be such a huge decline in drilling since it is often stated that shale plays have potentially huge supplies of energy?

There are three possible reasons for this collapse in Haynesville exploration and development:

1) Haynesville shale mostly includes dry natural gas, mostly methane, but little natural gas liquids (NGL), propane, ethane and butane, which can in many ways be used for crude oil. Therefore there are no NGLs and NGL value to pay for the dry natural gas drilling. Then because natural gas prices have been low there is less incentive to drill.
2) Even though Haynesville is made up mostly of dry natural gas and even though natural gas prices are low, nevertheless it is often touted that shale technology is becoming better by leaps and bounds. However in this case, it is possible that the increases in technology have been small compared to the decline in price, and so there is a lack of enough technological improvement to reduce costs low enough to make the basin profitable in the face of low prices. In that case there is not enough cost reduction technology to keep costs lower than prices in order to keep the drilling continuing.
3) It is possible that all the “sweet” spots for the Haynesville natural gas sites have been taken and that the play is running out of natural gas to find. If this is the case, then even though there are many shale plays around the world, they may become quickly exploited and emptied. Remember, the economics of Hubbert are such that you discover along a process, this process causes the increase, then the peak and then the decrease.

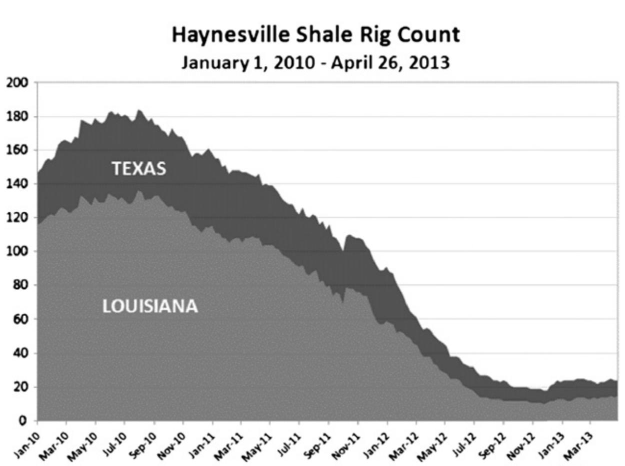

Fig. 1. Haynesville shale rig count collapse. The Haynesville shale play had a 90% reduction in the number of rigs from July 2010 to November 2012.
Source Haynesvilleplay.com and Examiner (2012).

If the first reason for the decline looks reasonable, then the second reason is also reasonable which is to say that technology is not powerful enough to keep shale drilling costs low while prices are low so that drilling cannot be made profitable. That suggests there is a limit to how cost effective technology will ever become rather like how wind, solar and renewable technologies have not always been cost effective. The shale gas drilling technology costs have therefore not been able to match the hype surrounding the shale gas potential and so instead of massive new supplies of energy, many shale basins will have low potential (see Berman, 2012).

If the third reason is true, then this suggests that many of these shale gas and shale oil plays will be flash in the pan developments. They will experience massive increases in drilling creating a quick shoot up in supplies, but then be followed by a quick peak and collapse. In that case, as Berman and Pittinger (2011) shows, the Hubbert curve is exactly the analysis we need to use with regard to these supplies. Nevertheless, no matter the reason, this dramatic decline in drilling suggests that it is possible for shale plays to expand as well as contract and to do so rapidly, in which case the massive supplies of shale energy around the world could be a lot less than we are lead to believe. Either way it is important to understand the Hubbert curve in order to analyze shale oil supplies.

3. The Hubbert Curve

M. King Hubbert (1956), in a highly controversial treatise (Adelman and Lynch, 1997; Maugeri, 2004; Ryan, 2003; Sorrell et al., 2010; Wiorkowski, 1981), used a simple logistics function to describe the trend in oil production in the U.S. and suggested that oil production would peak. The logistics curve (Richards, 1959) is shown in Eq. (1):

$$QP = URR * a * \exp(-a(t-t_0))/[1+\exp(a(t-t_0))]^2. \qquad (1)$$

where QP = the current rate of production; URR = ultimately recoverable reserves; t = time; t_0 = the year of peak production; and a = a parameter that determines the initial rate of increase in production. Although, Ryan (2003) says such a logistics curve is “ad hoc,” nevertheless, Cleveland (1991), Cleveland and Kaufmann (1991) and Kaufmann et al. (2001) explain one reason behind the trend which is diminishing returns to drilling, which over the long run create a U shaped cost curve as Slade (1982) explains. Campbell (2004), Campbell and Laherrere (1998), Smith and Paddock (1984), Ramsey (1980), Pindyck (1978a, b), Pesaran (1990), Pesaran and Samiei (1995), and Brandt (2007) show that oil regions around the world do indeed follow roughly the Hubbert trend even if there are some variations. Another reason behind the trend is Uhler's (1976) information and depletion effect explained in Norgaard (1990) and Reynolds (2002). The information effect has to do with Peterson (1978), Uhler (1979) and Adelman (1993) information externalities whereby when oil drillers explore for oil, they give other explorers information of where to drill and show where not to drill. Eventually, Depletion sets in, where a finite resource is more difficult to find as it runs out. Reynolds (1999) explains the neo-classical