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Trajectories

Review of fossil fuels and future energy technologies

N. Abas, A. Kalair, N. Khan *

Department of Electrical Engineering, Comsats Institute of Information Technology, H/Q Campus, Park Road, Islamabad, Pakistan

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ABSTRACT

Fossil fuels production peaks, declines and depletions depend on their proved reserves, exploration and consumption rates. Worldwide proven oil, gas and coal reserves are 1688 billion barrels (Bb), 6558 trillion cubic feet (TCF) and 891 billion tons (Bt) being consumed at rates of 0.092 Bb, 0.329 TCF and 7.89 BT per day, respectively. The oil, gas and coal reserves are increasing at the rate of 600 million barrels (Mb), 400 billion cubic feet (BCF) and 19.2 Giga tons of oil equivalents (GTOE) per year. While the rate of annual increase in consumption of oil, gas and coal is 1.4 Mb, 4.5 BCF and 3.1 million tons (Mt). Global annual energy demand of over 12 billion tons of oil equivalent (BTOE) results in the emission of 39.5 Giga tons of carbon dioxide (Gt-CO_2), and the annual CO_2 emission would increase up to 75 Gt-CO_2 when future energy demand will rise to 24–25 BTOE. Oil, gas and coal may continue to exist for next several decades, yet the energy transition to low carbon intensity fuels is necessary to cope with rampant climate change. Renewable and alternative energy sources hold key to the solution of twin problems, energy and climate change, with a high initial investment. Transition from fossil fuels to sustainable and renewable energy resources of 150 Petawatt hours (PWh) requires major investment and innovatory technologies. Perhaps CO_2 and H_2O based fuel systems would facilitate climate change and grand energy transition. An energy mix consisting of fossil fuels, hydrogen, bio-fuels, and renewable energy sources seems to be a good initiative. This paper reviews evidence of hydrocarbons decline scenarios and timelines of future energy technologies.

1. Introduction

Oil peaking is the point in time when the rate of petroleum extraction reaches its highest plateau (Laherrère, 2000). Based on local oil and gas production peaking experience, prediction of King Hubbert in 1956 about the production of US oil fields hitting the highest point in the 1960s, proved correct (Hubbert, 1956). Based on the successful prediction of indigenous oil production peak (Hubbert, 1949), King Hubbert predicted global oil production to reach a peak plateau in 1995 (Hubbert, 1971), however, this timeline was extended due to subsequent oil discoveries (Hirsch, 2007). Global oil reserves were only 500 Bb in 1970 which were predicted to end by 1995 (Hubbert, 1971); yet due to new explorations, after two decades the world had 900 Bb despite consumption of 600 Bb. Oil and gas reserves increase rates were 0.11 Mb and 7.4 trillion cubic meter (TCM) per year in 2010 as shown in Figs. 1 and 2, respectively (BP, 2014).

So far global oil, gas and coal reserves are steadily increasing without any immediate depletion threat in sight, yet fossil fuels are finite resources. Despite climate change, population increase and inflation the living standards are rising over time.

* Corresponding author. Tel.: +92 3006490048; fax: +92 03006490048.
E-mail address: nasrullahk@yahoo.com (N. Khan).

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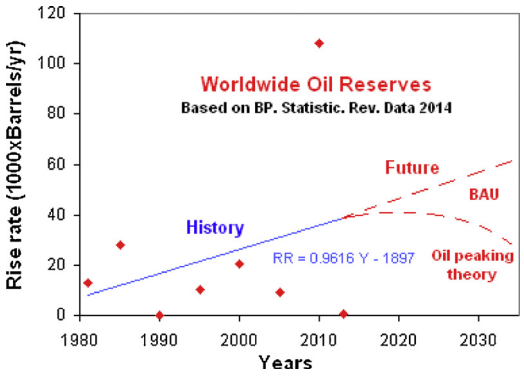

Fig. 1. Annual oil reserves increase rates from 1980 to 2013.

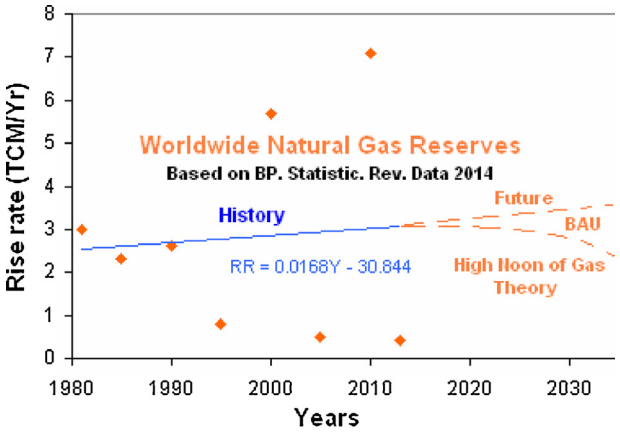

Fig. 2. Annual gas reserves increase rates from 1980 to 2013.

Human prosperity may substantially be attributed to the discovery and utilization of fossil fuels, the reserves of which, though limited in nature, are increasing to date. Oil peaking has, no doubt, become an academic debate with no concurrence to date (Cheney & Hawkes, 2007). The optimists believe that the planet earth has an abundant quantity of oil and its production rate will rise to peak in 2100 at the rate of about 105 million barrels per day (Mbpd) and decline to 40 Mbpd by 2400 (Trendlines, 2012). However, the pessimists trust in the oil era is over (Heinberg, 2005); gas shall be peaking soon (Darley, 2004) marking the end of the hydrocarbon age (Goodstein, 2005). According to pessimistic reports, the peak oil occurred in 2009 at a production rate of 86 Mbpd and global oil production will decline to 40 Mbpd by 2050. A moderate view holds that the oil production will peak in 2025 at the rate of 120 Mbpd but will decline to 40 Mbpd by 2115. The majority of scientists argues that the world oil production has either peaked already or will be peaking in coming few years (Cohen, 2009; Deffeyes, 2002; Simmons, 2007) while oil and gas professionals consider the oil peaking as no more a relevant topic now, because it was conceived long ago (Chapman, 2014). The oil depletion scenario may be attributed to supply chain disconnection due to the oil embargo in 1970s and decline in oil demand due to paradigm shift toward energy efficient cars, electricity and gas heating in the late 1970s and early 1980s (Toth & Rogner, 2006). Energy experts have various opinions on the decline rate after the occurrence of peak oil production between 2000 and 2030 with peak production rates varying from 75 to 120 Mbpd. The decline of oil production rate determines the actual decline profile. Several terms like ultimate, ultimate resources (UR) and ultimate recoverable resources (URR) are used to describe total oil and gas reserves in the earth. Normally, fossil fuel reserves are expressed by proved (1P), probable (2P) and possible (3P) reserves. Oil and gas resources are called reserves, contingent resources and prospective resources. According to BP statistical review of world energy, proved world oil reserves at the end of 2013 were 1687.9 Bb (BP, 2014). There will be peak oil in the near future, but experts are not aware of the exact date (Andrews & Udall, 2003; EIA, 2013; Gail, 2012; Höök, 2010; Pedro & Pedro, 2009; Tea, 2008; Towler, 2014). Environmentalists advise to minimize the use of fossil fuels due to their adverse effects on nature irrespective of repletion or depletion. Environmentalists relate the peak production of oil and gas with peak emission of CO_2, which is so far constantly rising (402 ppm in 2014) (Aleklett, 2007). There is no chemical process which can clean ballooning volumes of CO_2 volumes from the atmosphere. Energy experts have started thinking of sustainable hydrocarbon fuels by recycling H_2O and CO_2 with renewable energy resources (Christopher, Sune, Mogens, & Klaus, 2011). CO_2 capture and sequestration (CCS) process may help in converting CO_2 back into hydrocarbon fuels in the presence of H_2O as it converted vegetation and dead animals into fossil fuels over tens of millions of years in the past (Hu, Guild, & Suib, 2013). Meanwhile, using CO_2 as refrigerant may help