Energy 35 (2010) 3097–3102

Contents lists available at ScienceDirect

Energy

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

Review

Forecast of oil reserves and production in Daqing oilfield of China

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ARTICLE INFO

Article history:
Received 14 August 2009
Received in revised form
17 February 2010
Accepted 23 March 2010
Available online 1 May 2010

Keywords:
Daqing oilfield
System dynamics
Forecasting model

ABSTRACT

As China' largest oilfield, Daqing is of great importance to China, this paper analyzes the status of the Daqing oilfield and forecasts its ultimate recoverable reserves by use of the *URR* model. The forecast results are presented for three scenarios which show that the ultimate recoverable reserves in Daqing oilfield are 3574.0 million tons in the optimistic scenario, 3169.3 million in the base case scenario and 3033.3 million in the pessimistic scenario, respectively. A system dynamics model is established and the quantitative relationships between variables in the model are determined. Total oil production, remaining recoverable reserves, annual newly discovered reserves, and the degree of reserves recovery before 2060 are simulated under the three scenarios by use of the system dynamics model. The forecast results show that the future oil production in Daqing oilfield will continue declining, under the base case scenario, from 41.6 million tons in 2007 to 8.0 million tons in 2060. For Chinese policy-makers, it is worth paying attention to the problem of whether oil production in new oilfields can effectively make up for the decline in production of the large, old oilfields.

1. Introduction

Robelius [1] found that giant oil fields are very important to the world oil production and for many countries' domestic oil production. The Cantarell field in Mexico accounted for over 50% of the total Mexican production in 2005. Campbell [2], Hirsch [3], Meng, and Bentley [4] also have pointed out the importance of giant oil fields.

Daqing oilfield is among of the largest oilfields in the world and is China's largest. Fig. 1 shows the location of Daqing within China. The field had already produced a total of 1.95 million tons of oil by 2007. It has maintained a high and stable yield of more than 50 million tons continuously per annum over the 27 years since oil production exceeded 50 million tons in 1976. After decades of high speed and high efficiency development, production in the Daqing oilfield has been decreasing since 1997. The annual production declined from the peak production of 56.0 million tons in 1997 to 41.6 million tons in 2007 – an average decline rate of 2.9% per year. Even though the Daqing oilfield is experiencing decreased production, it still accounts for nearly 25% of China's oil production.

The objective of this paper is to forecast the ultimate recoverable resources (*URR*) and future oil production in Daqing.

2. Analysis of the status of the Daqing oilfield

Fig. 2 shows the annual oil production of the Daqing oilfield and all of China. As can be seen, the Daqing oilfield has obviously made a tremendous contribution to China's oil industry, accounting for an average of 75% of China's yearly oil production throughout the 1960s and 1970s.

After that period, the contribution of Daqing to all of China's oil production gradually declined from a peak of 78.7% in 1964 to 22.4% in 2007. To maintain its important position and realize sustainable development, CNPC (China National Petroleum Corporation) put forward an objective of "establishing a centurial oilfield" (or, in other words, an oilfield that will last a century) in 2004 as pointed out by Yupu Wang [5–7]. The aim of this proclamation was to make the field an important oil and gas production base for China through to 2060, by which year the field will have been exploited for 100 years. As pointed out by Jinguo Chen and Yuqiang Chen [8], establishing a long-term plan is essential to ensuring the Daqing oilfield remains a productive asset to mid-century and beyond.

Fig. 3 shows annual newly discovered reserves and oil production in the Daqing oilfield. Newly discovered reserves in the field peaked in 1973, 24 years before peak oil production in 1997.

Based on a comparison between annual newly discovered reserves and oil production, the development of the Daqing oilfield can be divided into three phases. In the first phase (1961–1975), both annual newly discovered reserves and oil production kept increasing continuously. Furthermore, annual newly discovered

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doi:10.1016/j.energy.2010.03.043

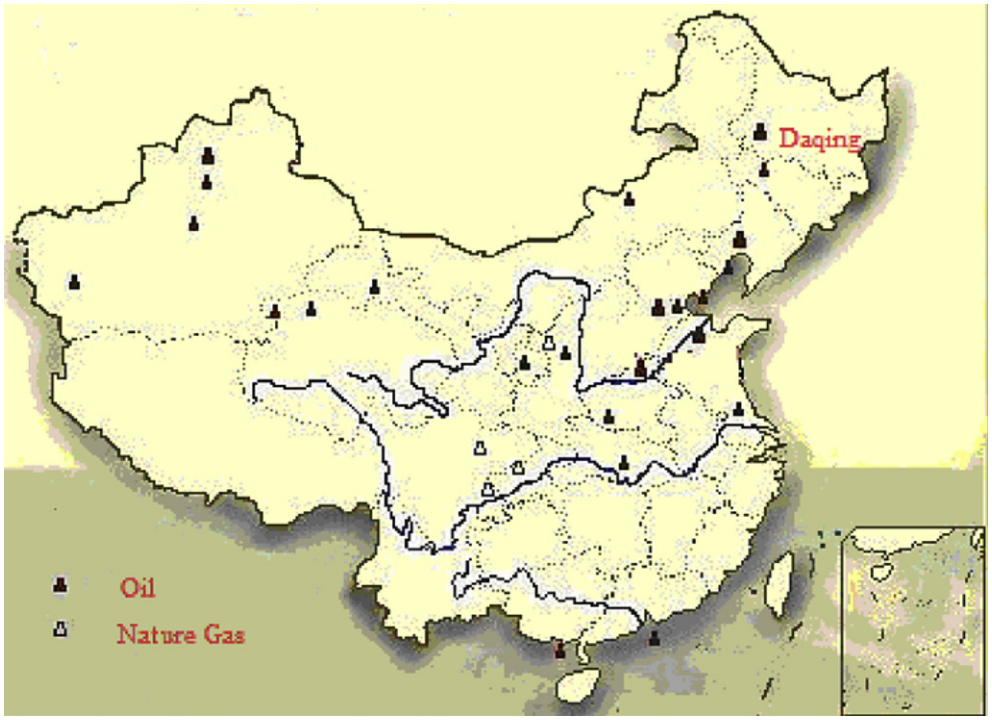

Fig. 1. Location of Daqing oilfield in North East China.

reserves increased faster than oil production, which meant it exceeded oil production every year and the remaining recoverable reserves increased very rapidly.

In the second phase (1976–1991), annual newly discovered reserves were lower than oil produced per year over the period of 1976–1983. Newly discovered reserves then exceeded oil production per year in the period from 1984 to 1991. However, cumulative newly discovered reserves were almost equal to cumulative oil production over the whole phase. Thus, remaining recoverable reserves remained stable.

In the third phase (1992-present), annual newly discovered reserves declined and were less than oil production in each year. Remaining recoverable reserves consequently declined rapidly.

3. Forecast of oil reserves in the Daqing oilfield

3.1. Introduction of the URR model

There are many different ways to model the reserves of an oil field. Decline curves, probabilistic methods, stochastic approaches, and much more have been utilized for reserve estimations. These are described in various studies, such as Li & Horne [9], Chang & Lin [10] and Ayeni & Pilat [11]. This article utilizes a different reserve estimation model. The following equations and formulas provide the basis for the *URR* estimation technique used here.

Wenbo Weng [12], Xudong Zhao [13], Fusheng Huang et al. [14] showed that the degree of *URR* recovery (R_D) in an oilfield will change as more historic data becomes available and the development time (t) increases. The relationship between R_D and t is reflected in the following formula (1).

$$\lg\frac{R_D}{1-R_D} = A + B\lg t \tag{1}$$

both A and B are constants which can be determined by linear regression.

Formula (1) has been successfully testified by Chinese oilfield data, and it is mainly used to estimate R_D in the future to know the development phase of the oilfield. In fact, it can be further used to estimate the *URR* as follows:

Formula (1) can also be described as Formula (2),

$$R_D = \frac{1}{1+10^{-A}t^{-B}} \tag{2}$$

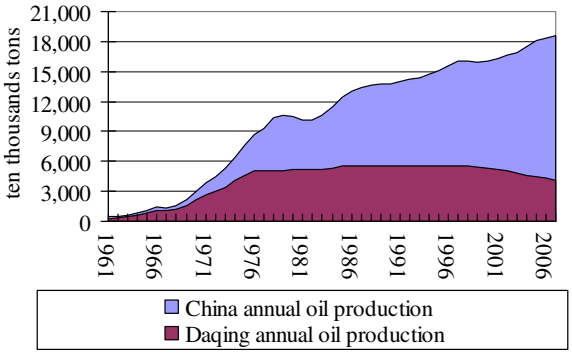

Fig. 2. Annual oil production in Daqing and China.

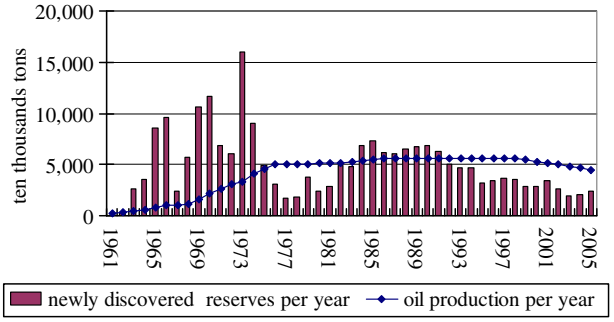

Fig. 3. Annual newly discovered reserves and the oil production in Daqing oilfield.