[*WILL CHINA'S SHALE GAS INDUSTRY ACHIEVE ITS PRODUCTION GOALS WITH SUBSIDY REMOVAL?*]

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Overview

With the expectation of growing gas demand, a desire to improve environmental impact, the high resource potential of shale gas in China, and the success of the shale gas revolution in the U.S., the Chinese government has implemented incentive policies for shale gas development. But now the government has intention to phase out these subsidies. This paper aims to analyze the influence of the policy removal on shale gas industry by identifying and measuring the potential impact of key variables on shale gas development through quantitative modeling.

Considering both technical and economic factors, a shale gas development simulation model, using System Dynamics Analysis ("SD"), has been built. Current published incentive policies are as follows: a quantitative subsidy which is 0.3 CNY/ m^3 from 2017 to 2018, 0.2 CNY/ m^3 from 2019 to 2020, and resource tax reduction, from 6% to 4.2% between April 2018 and March 2021. We assume both the subsidy and resource tax reduction will end in 2021. As a result, China's shale gas production will peak in 2020 and 2021 at $175*10^8$ m^3 at before gradually decline.

Based on the SD approach, sensitivity analysis is introduced to more than ten variables involved in the system. From our tests, wellhead price, tax relief and direct fiscal subsidies show significant influence on shale gas production. Additionally, our analysis has indicated that wellhead prices are the most sensitive factor in shale gas production: doubling the wellhead price can increase shale gas production to $185*10^8 m^3$ in 2020 and $340*10^8 m^3$ in 2030.

From the simulation results, it's obvious that the investment solely funded by enterprise profit is insufficient in meeting the medium-term objective of China's shale gas production. The persistently phasing out fiscal subsidies will lose their general economic appeal to shale gas development investors and negatively impact future production.

Many articles and forecasts about shale gas development trends in China rely on either reviewing policies qualitatively or simulating industrial expansion planning with analysis based on a limited number of factors. In comparison, the SD model uses more relevant factors and has stronger competence to illustrate the behavior over time of China's shale gas development in the long-term.

Methods

We use System Dynamics Analysis to simulate how current incentive policies affect China's shale gas's demonstrated capacity, production, investment and enterprise profit.

In this paper, the period of simulation realized in Vensim is from 2017 to 2030. There are three aspects of China's incentive policies that may influence the dynamic system: (1) Liberalize shale gas wellhead price, making it fluctuate with market equilibrium; (2) Quantity subsidy and tax relief; (3) Lower development and operating cost by additional investment in technical research.

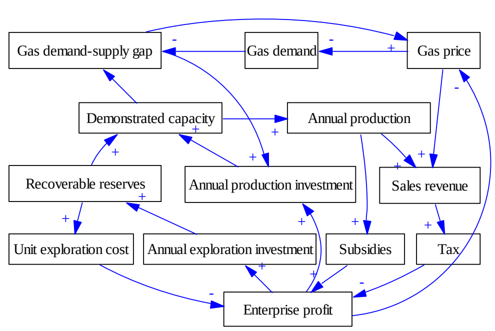

Fig. 1 SD Model

The hypothesis of this SD model is represented by a major causal loop as shown in Fig.1, which involves four principal blocks: ‘gas supply and demand’, ‘shale gas exploration and development’, ‘fiscal subsidy and tax relief’, and ‘enterprise profit’. We set 49 variables and model parameters. An abbreviated list is provided in Table 1.

Table 1 Variable Setting

Variable	Unit	Initial value	Data source
GDP	CNY	8.27E+13	Open Data
GDP gas consumption intensity	m³/CNY	0.0026	National Bureau of Statistics
Population changing rate	Dmnl	0.005	Open Data
Population	Person	1.39E+09	Open Data
Gas supply growth rate	Dmnl	0.01	C ZOU, 2018
Gas supply	m³	1.49E+11	Open Data
Annual demand-supply gap	m³	8.86E+10	National Bureau of Statistics
Shale gas in place	m³	1.34E+14	EIA,2015
Unproved recoverable reserves	m³	1.03E+14	EIA,2015
Technically recoverable reserves	m³	9.17E+11	National Energy Administration
Proportion factor of exploration investment	Dmnl	0.25	CNPC
Operation cost change rate	Dmnl	0.02	Experts Grading Method
Unit capacity construction cost	CNY/m³	0.67	Open Data
Demonstrated capacity	m³	1.00E+10	Open Data
Shale gas wellhead price	CNY/m³	1.261	Open Data
Investment fund	CNY	9.25E+09	Open Data

Results

1) Under the current incentive policy environment, China’s domestic shale gas production will peak at $175*10^8$ m³ in 2020 and 2021, declining thereafter. Enterprise revenue will peak at 22 billion CNY in 2021 and then gradually decline. The medium-term objective, set by China’s government, is to reach shale gas production volumes of $300*10^8$ m³ annually by 2020 and $800\text{-}1000*10^8$ m³ in 2030. However, this objective is unlikely to be achieved without a surge of additional investments or significant technological breakthroughs. 2) We analyzed the sensitivity of shale gas production, enterprise profit and investment in single-factor changes of fiscal subsidy (0.2, 0.1 and 0 CNY/ m³), wellhead price (raised by 20%, 50% and 100%) and tax relief (VAT, resource tax and income tax respectively). From our findings, prolonging current level of direct subsidy can only retard but not reverse production falling tendency after 2021. In comparison, resource and income taxes relief has a stronger influence on shale gas capacity and enterprise after-tax profit. Additionally, wellhead price adjustment has a noticeable impact on shale gas production; a 50% increase in price can maintain production at $200*10^8$ m³ till 2030 while a 100% increase can boost production up to $185*10^8$ m³ by 2020 and $340*10^8$ m³ by 2030. 3) Demonstrated capacity is directly impacted by annual investment. The capacity will experience decelerated growth between 2017 and 2021, due to incremental investment, and decrease due to annual investment being outpaced by high-rate declining capacity. Annual investment will peak at 4.244 billion CNY in 2021. 4) In order to achieve the production target of $300*10^8$ m³ in 2020 and $900*10^8$ m³ in 2030, additional investment of 29.5 billion CNY is imperative to encourage technical research in the next two years, based on a series of trial and error analyses.

Conclusions

The simulation results of this paper indicate that: 1) Currently, China's shale gas development enterprises earn meager profits, continuing current subsidy policy has limited help to increase capacity, but subsidy removal will result in scaling investment back and further undermine the growth of shale gas industry. As such, there is a lack of incentive to attract private capital into this high-investment and high-risk industry. We recommend the government prolong policy incentives because a supportive regulatory context in China is a key enabler of shale gas development. 2) A surge of additional investment for exploration and development is imperative in the next two years to increase capacity. Additionally, continuous regulatory incentives have the potential to reduce shale gas production costs in the future.

Further research will be conducted to break through limitations of this SD model, the primary limitation is that our SD model set generations of other energies as exogenous variables and omits consideration of their interactions with shale gas. This is an area of additional research we are interested in addressing in subsequent research.

As a final note, it should be emphasized that, despite a potentially large resource base, production and costs may vary when further assessment is conducted in different stages of unconventional gas industry in China.