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Stage Resume of Underground Gas Storage Development in China, Perspectives and New Challenges

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Foreword

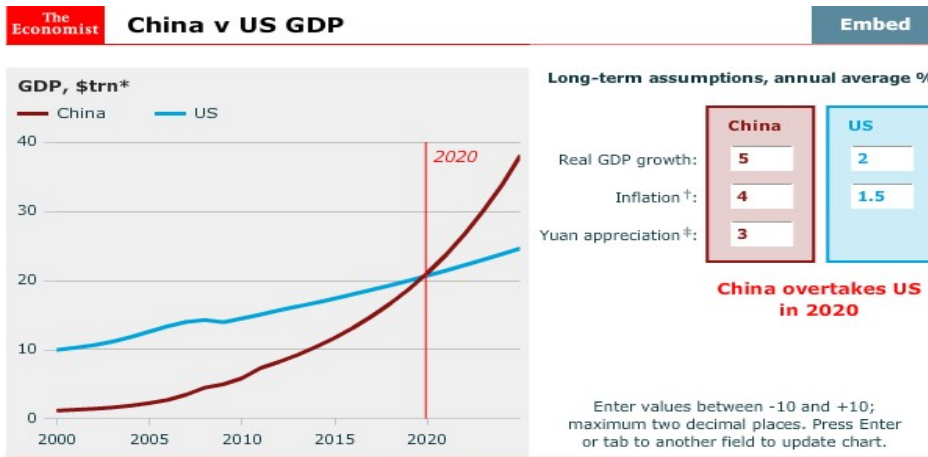
The development of underground gas storage (UGS) in China is still at preliminary stage; however, fast growing natural gas consumption will request significant modulation capacity. To better develop UGS, it is important to surpass the related market, technical and economical challenges.

Outline

- **Market situation and Need of UGS**
- Main technical challenges for a rapid UGS portfolio growth
- The economical challenges: Regulation and Pricing
- Conclusion

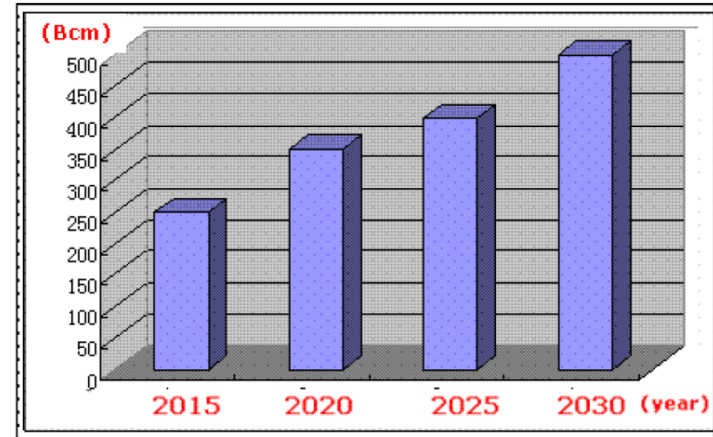
Natural gas and UGS Market

In order to use relatively clean resource to meet huge domestic energy demand, China is increasing fastly the consumption of natural gas in the long term: from 46 bcm in 2005 to 180 bcm in 2014; estimation of 350 bcm in 2020.



*At current prices and market exchange rates †GDP deflator ‡Against the dollar

Source: [Standard & Poor's](#)

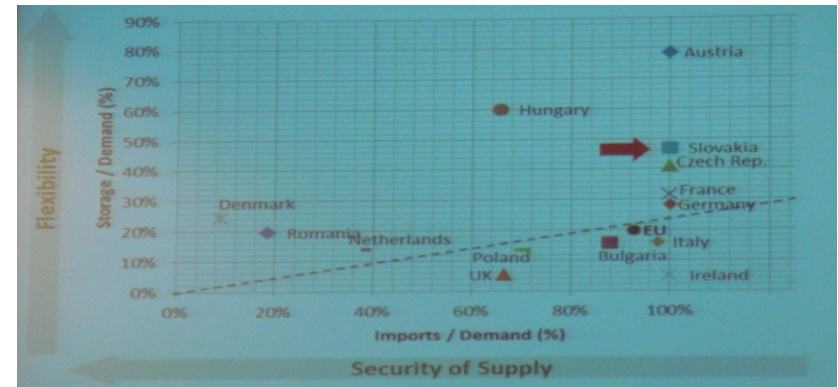
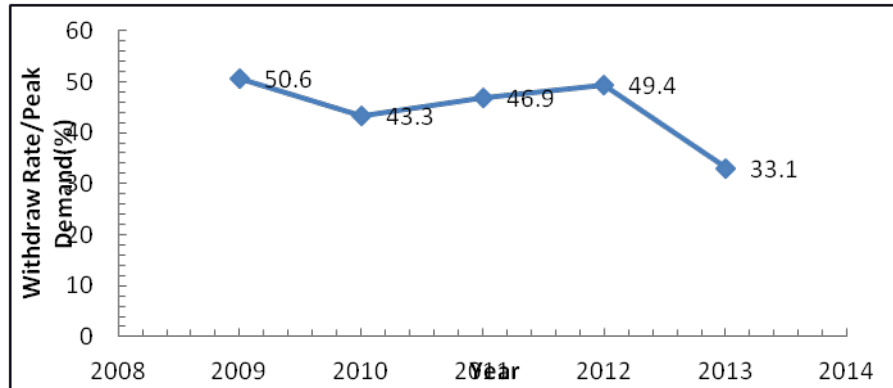


Gas consumption prediction

Source: [Chinese Academy of Social Sciences](#)

Natural gas and UGS Market

- ◆ In the mature gas markets, stable gas supply is often modulated by UGS so as to match variable demand of end-users. UGS has been developed in China since early 90's and now it plays an important role.
- ◆ However, UGS lags behind pipeline construction and is not sufficient to reply current modulation need: the share of stored gas on total consumption in China (around 4.7 bcm in 2014, 3% of consumption) is still far less than the ratio known in North America or Europe (around 20%).



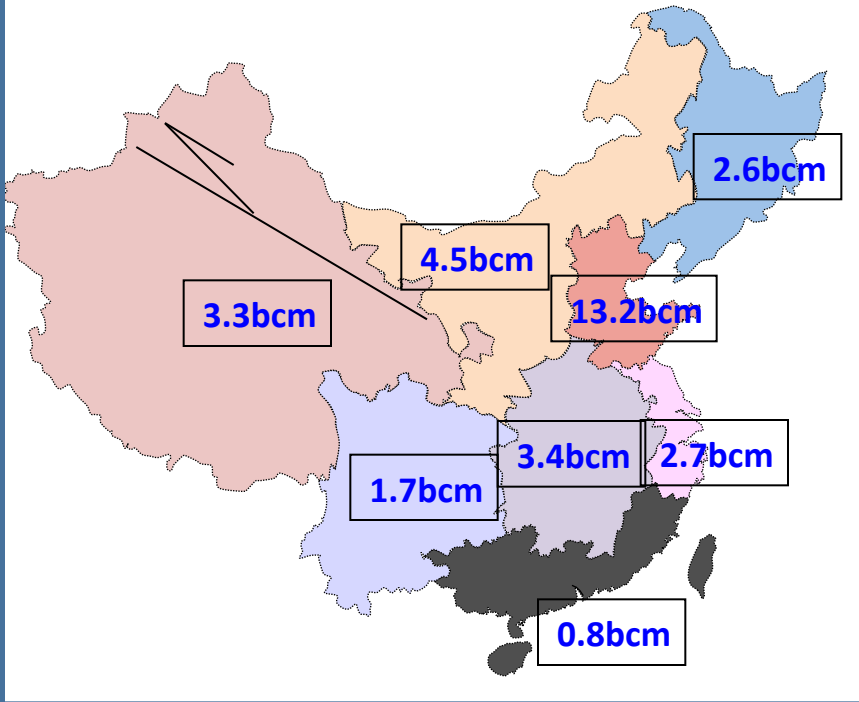
Current situation of UGS



- ◆ Currently, more than 20 depleted UGS of 4.7 bcm capacity have been constructed, with part of working gas under commissioning.
- ◆ There has been already a salt cavern site operated by Petrochina in Jiangsu Province, South-East China, while several caverns are still under leaching by other players in the same region. Jiangnan Region in central China, another area rich of salt resources, a new salt cavern storage pilot leaching program is ongoing now..
- ◆ Several aquifer prospects are under exploration by Petrochina in Huabei Region, North China, which is one of the key gas consumption areas.

Demand of UGS

2025 Demand for WGV 32.3bcm



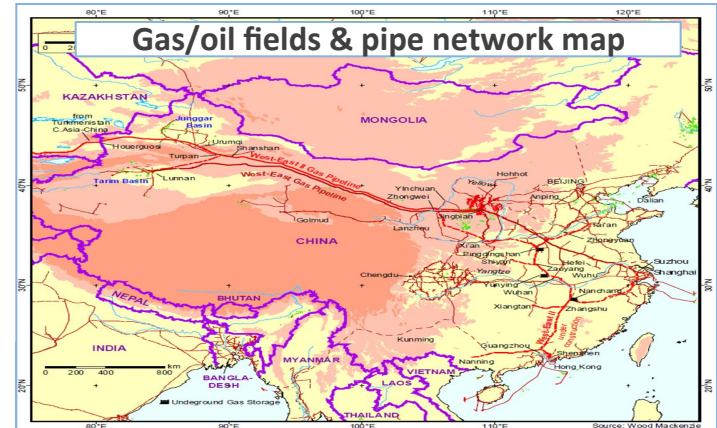
- ◆ It is estimated the gas storage demand (seasonal modulation and emergency reserve) in 2025 could be around 32 bcm. Current storages only can meet 10–13 bcm.
- ◆ Thus, UGS in China, the major tool of gas modulation, cannot meet the current and future demand; it is important to develop rapidly more UGS capacity with good quality.

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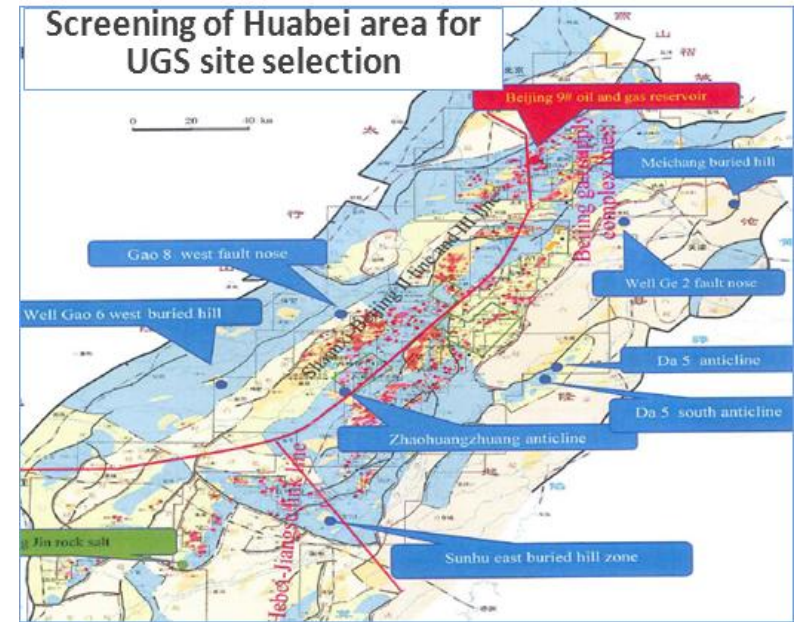
Gas supply difficulties and transportation issues

- ◆ China Gas markets are located in the eastern border far from the gas supplying areas
- ◆ China continues to invest in natural gas pipeline to link production areas in the Western and Northern areas with the demand centers along the eastern coast and to accommodate greater imports from Central and Southeast Asia
- ◆ New (unconventional) gas resources are also in areas far from domestic markets
- ◆ LNG exports impose UGS flexibility



Subsurface issues

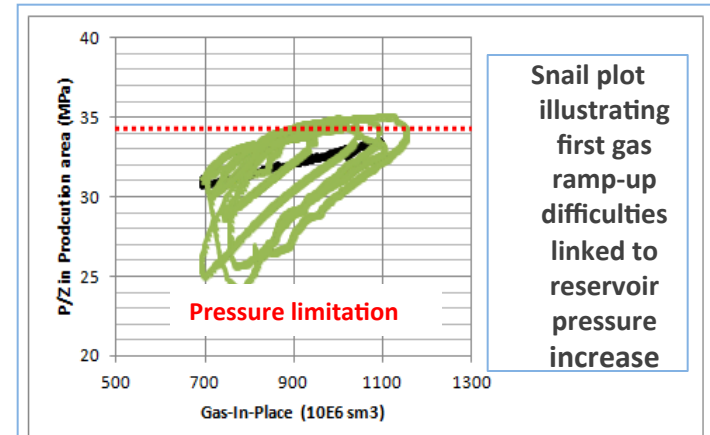
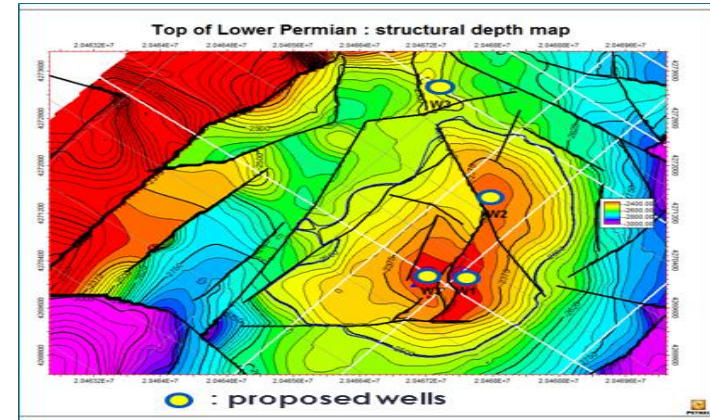
- ◆ Underground gas storages require high quality geological sites with good reservoirs at moderate depths in order to insure high gas peak-rates and to attract investors with moderate investments
- ◆ Despite exhaustive site screening studies including oil/gas depleted fields & aquifer exploration in some basins, the identified sites lead to technical challenges and make UGS development more complex than expected, especially in the eastern geological basin



**Typical reservoir target characteristics
(Ordovician deep target up to 3000-4500m,
low rock properties, high pressure system**

UGS need time to be operational

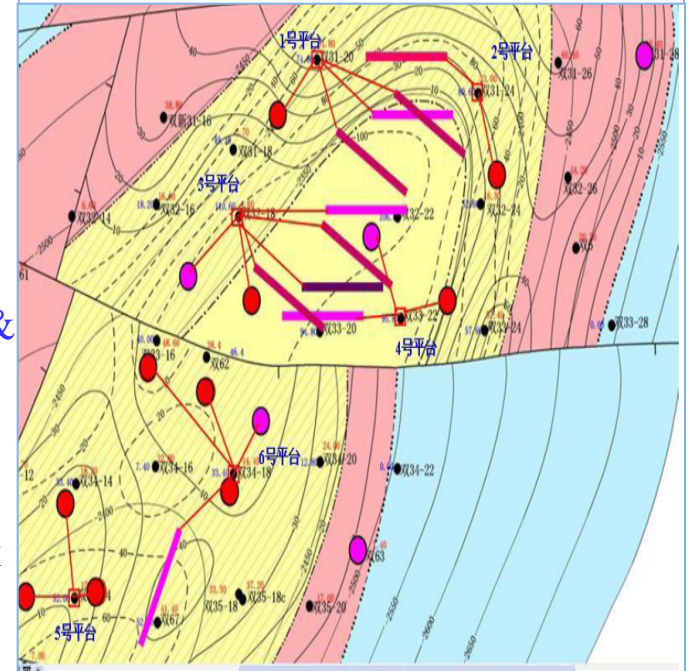
- ◆ Chinese authorities have to face with “incompressible” time constraint to build its ambitious UGS portfolio
 - Moderate reservoir properties lead to long gas ramp-up to avoid any gas spill-over or excessive reservoir pressures
- ◆ Exploration of aquifer requires time for exploration & appraisal site candidates by running 3D surveys & drilling of several wells & performing many long duration well testings
- ◆ De-risking of project leads to phased development decision with initial limited capacity
- ◆ Keeping in mind from international feedback that UGS development is time and capital consuming (the most quicker facilities to develop are salt caverns & gentle depleted reservoirs : request 5 to 10 years to build)



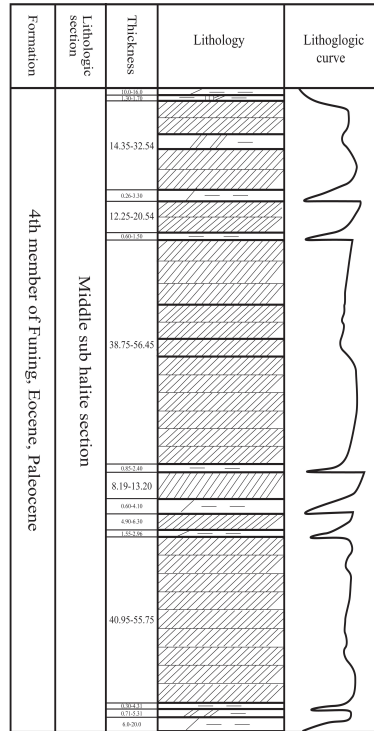
Additional difficulties linked to technology challenges

- ◆ High injection pressure is required due to active aquifers & deep reservoirs. This leads to:
 - High investment
 - Excessive OPEX for fuel gas
 - High temperature variations in well
 - Reservoir damage by drilling fluids
 - Tubular cementation more complex
- ◆ Limited well productivities encountered lead the horizontal (& deep) wells to avoid to duplicate well number
- ◆ Oil, condensate or sour gas presence to integrate to gas process plant
- ◆ Important number of former wells with seal integrity to check and possibly perform heavy Work Overs

UGS development combining vertical and horizontal wells

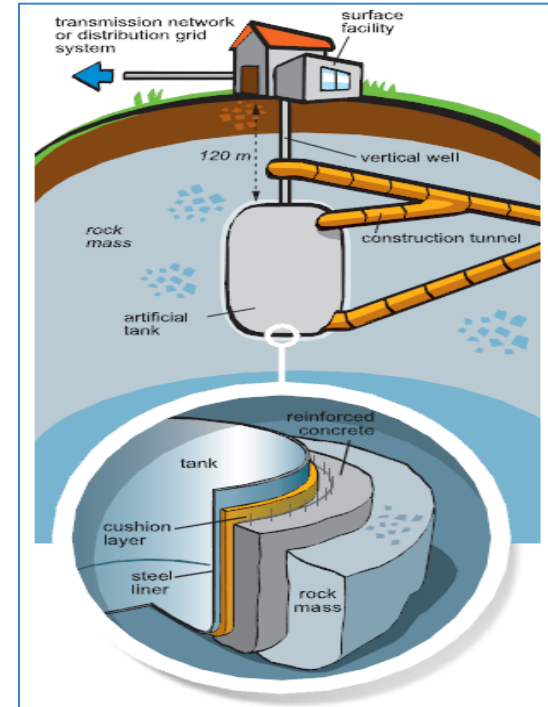


Alternative solutions are not less challenging



Jintan Lithology

- ◆ LRC (lined rock cavern) of large volume is an innovative technology but is costly and need well suited geological conditions
- ◆ Building salt caverns is limited only to few areas in China
- ◆ Both alternatives are complementary to depleted/ aquifer underground gas storages because they present a limited stored volume, but can give a quick response to the market need.



LRC concept

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The economical challenges: Regulation and Pricing

Existing UGS policies

- ◆ Measurement for the implementation of fair and open supervision for oil and gas pipeline
- ◆ The guidance of speeding up construction gas storage facilities
- ◆ The guidance of innovation investment and financing mechanism to attract social capital in key area

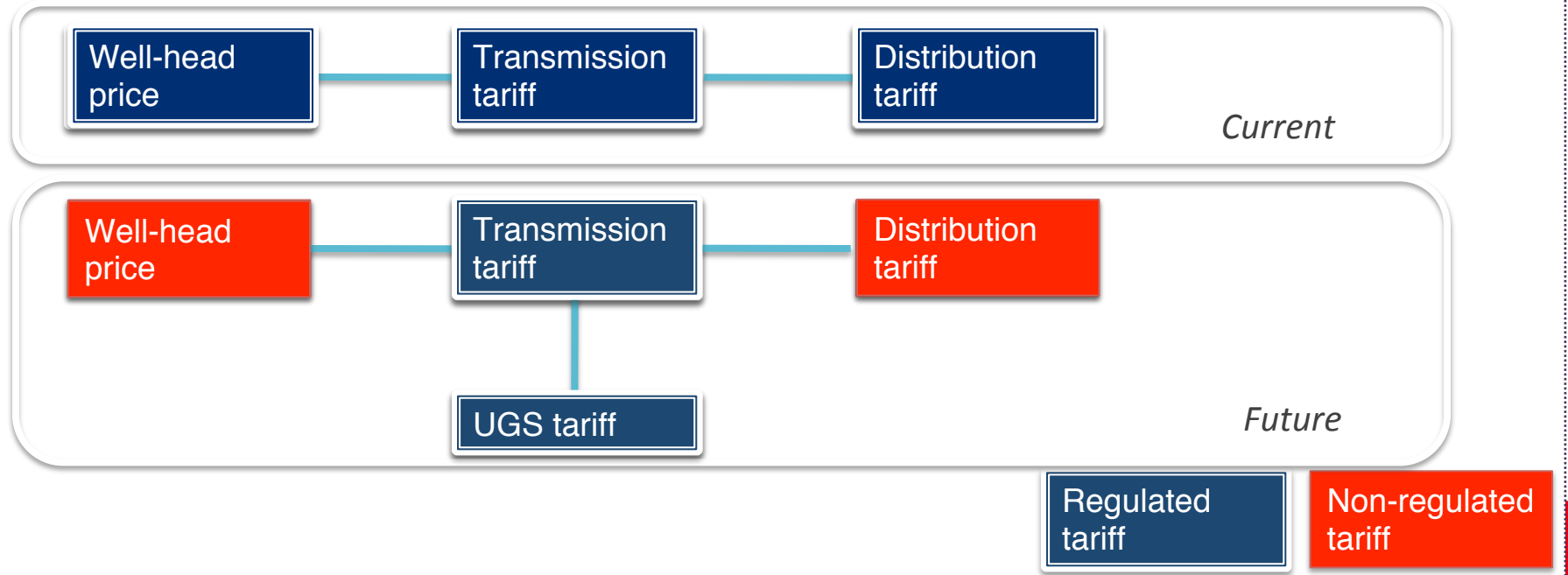
The economical challenges: Regulation and Pricing

Necessity of regulation and pricing reform

- ◆ As the market needs rapid UGS development , it is important to involve private and international players to accelerate related projects. Thus, the main challenge is to build a stable system giving confidence to the investors in order to:
 - mitigate the perception of economical risks => a fair pricing system (based on cost and regulated margin) with storage obligation;
 - mitigate the technical risks => introduction of international capital associated with experiences could help certain aspects such as operating performance of low permeability reservoir, well integrity in deep reservoir and construction in multi-laminated layers.
- ◆ As China is a big and heterogeneous country, it is necessary to take a pragmatic and step-by-step approach.

The economical challenges: Regulation and Pricing

Possible scenario of natural gas policy (regulation & pricing) evolution



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Conclusion

- ◆ The development of UGS is still in its first steps in China, who will need more and more UGS as modulation capacity and should optimize their geological distribution.
- ◆ By nature and international experience, UGS developing requests lot of time (several years).
- ◆ UGS and E&P share some technical similarities but fundamentally they are strongly different. If the gas fields are producing over 20 years, the UGS are depleted over only 90 days with very huge intake rates.

Conclusion

- ◆ Consequently, Chinese UGS developers have to face with:
 - the lack of experience and the absence of learning curves due to the lack of injection/withdrawal histories;
 - the geological complex frameworks making the UG design complex;
 - the imposed tight UGS deployment schedule where projects are developed simultaneously penalizing the feedback experience.
- ◆ Also, in order to reach and to optimize the performance of the UGS on the long run for guarantying the profitability, specifics UGS support and operation teams would have to be created.
- ◆ Cooperation with International UGS experienced companies is one of the key success factor allowing better efficiency and saving of time.
- ◆ It is also necessary for the government to deepen the regulation and pricing reform regarding natural gas and/or UGS in order that foreign and private capital is attracted to involve into this sector and then accelerate UGS development.

Acknowledgements



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Thank you for your attention !

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