PART 1 – PLANNING & LOGISTICS

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A) PLANNING OUTLINE

- Organisation of the event:
  - Sponsored by Chinese National Committee for WPC
  - Hosted by China National Petroleum Corporation
  - 3 Committee groups, which are Steering Committee, Technical Committee and Organizing Committee (see attached TECHNICAL PROGRAM in detail)

- Registration fee: Free

- Details of other National Committees involved and their role:
  - Iranian National Committee helps link the workshop information to WPCYP circle.
  - Canadian National Committee sent delegate to attend the workshop.

- Length of the workshop: 1 day

- Format of sessions:
  - Opening Session: hosted by LIU Zhenwu, CPC member, WPC. Jozsef TOTH, president of WPC, LI Luguang, Assistant President of CNPC and Pierce RIEMER, Secretary General of WPC addressed opening remarks.
  - Technical sessions:
    - Session 1, moderated by LIU Yuzhang, Director, Office of Senior Consultants, RIPED, CNPC. Four technical experts from PetroChina, Exxonmobil, Sinopec and HIS Energy gave the speeches.
    - Session 2, moderated by LI Qun, Director, S&T Cooperation, R&D Department, CNPC. Four technical experts from Shell, CNPC and Schlumberger gave the speeches.
    - Session 3, moderated by Liu He, Deputy Chief Engineer, RIPED, CNPC. Four technical experts from PetroChina, University of Petroleum gave the speeches.

- Sponsorship:
  - Chinese National Committee for WPC pay all for the workshop

- Registration fee:
  - Free registration. All logistics are served by CNPC and paid by Chinese National Committee.

- Communication strategy
  - Promoting the workshop by distribution of leaflets and oral report during EC & CPC meetings in Budapest 2015
  - Promoting the workshop at WPC website, Chinese National Committee website, and Iranian National Committee website.
  - Presenting written invitation letters and emails to WPC officers and National Committees, as well as the experts recommended by WPC colleagues.
  - Organizing the member companies of Chinese National Committee to send
EXPERT WORKSHOP REPORT

experts and professionals to attend the meeting.
- Inviting the experts from local companies or branches of foreign IOCs and NOCs to attend the meeting.
- Promoting the workshop through WPCYP links under the help of Iranian National Committee.
- Inviting the Chinese Youth Committee memebers to attend the meeting.

B) LESSONS LEARNED FROM THE PROCESS OF ORGANISING THE WORKSHOP
- High-efficiency organization
- Pre-workshop discussion
- High-quality simultaneous interpretation
- Hot and efficient Q & A

PART 2 – CONTENT & OUTCOMES

C) WORKSHOP OVERVIEW
- Introduction:
  Unconventionals have played a considerable part in oil and gas output with even more important future contributions. During 1-day workshop on ‘low-cost development of unconventionals’, held on September 6, 2016 at Research Institute of Petroleum Exploration and Development (RIPED), PetroChina (No.20 Xueyuan Road, Haidian District, Beijing, China), there are 13 experts and scholars who address the speeches, focusing on the past, present and future of the unconventionals in the world.
- The first part focuses on the unconventionals in China, its challenges, major breakthroughs, technical development and its prospect. The second part focuses on the worldwide unconventionals development. On the background of the decline of oil price, the extensively focused E&P of unconventionals has to encounter new challenges under a new situation and shall be carried out in some new ways against the changing background. Therefore, a path of cost reduction through technical innovations has become an imperative choice

- Objective of the event: (please state your main aims)
- From the aspect of technological and managerial innovation, the Workshop aims to explore the solutions and best practices of cost reduction and efficiency improvement for E&P of unconventionals with in-depth interaction and sharing of insightful views and successful experience.

- Key Topics: (please state the 5 most relevant topics)
  o Progress, Challenges and Opportunities of Unconventional Oil & Gas Development
  o Technical Challenges , Solutions and Practices for China’s Tight Oil
  o Progress in Coalbed Methane Exploration & Development Techniques and Geological Research in China
  o Current State of Unconventional Oil & Gas from International and Cost Perspectives
  o Practice and Development of Innovation to Drive Cost-saving and Profit-Increasing
D) KEY DISCUSSIONS AND OUTCOMES

China has achieved initially industrialized development in unconventional oil & gas.

- Two giant tight gas area with $2 \times 10^{12} \text{m}^3$ scale discovered in Sulige Formation, Ordos Basin and Xujiahe Formation, Sichuan basin.
- The proven shale gas reserves reported reach $544.1 \times 10^9 \text{m}^3$ and three large marine phase shale gas fields with $100 \times 10^8 \text{m}^3$ scale named Fuling, Changning and Weiyuan have been discovered.
- Three large tight oilfields of $100 \times 10^9 \text{t}$ scale have been identified, namely Xinanbian in Erods basin, Fuyu in Songliao basin and Jimusaar in Junggar basin.
- Commercial CBM development has achieved initial success, forming Qinshui and Ordos production bases.
- The unconventional gas production was $138 \times 10^9 \text{m}^3$ in 2015, 32.5% of gas production in total in China, in which tight gas production was $36 \times 10^9 \text{m}^3$, shale gas production was $4.5 \times 10^9 \text{m}^3$ and CBM was $4.4 \times 10^9 \text{m}^3$.
- China becomes the third shale gas output country after America and Canada.

Tight oil & gas in China have achieved a “strategic breakthrough”.

- Tight gas production in 2015 was $36 \times 10^9 \text{m}^3$ and two giant tight gas area with $2 \times 10^9 \text{m}^3$ scale have been discovered in Sulige Formation, Ordos Basin and Xujiahe Formation, Sichuan basin respectively; Tight oil has been included into the reserve sequence and three large tight oilfields of 100 million ton scale have been identified, namely Xinanbian in Erods basin, Fuyu in Songliao basin and Jimusaar in Junggar basin. The annual production of tight oil in 2015 is $1.50 \times 10^4 \text{t}$.
- Sulige Gas Field, a typical tight sandstone gas reservoir in Ordos Basin has developed twelve main technologies which has improved the annual gas production from $1.8 \times 10^9 \text{m}^3$ in 2007 to $23.7 \times 10^9 \text{m}^3$ in 2015. Chang-6 reservoir in Huaqing oilfield in Ordos Basin has improved tight oil production from $10 \times 10^3 \text{t}$ in 2005 to $780 \times 10^3 \text{t}$ tons in 2015 with the developed matching technologies as following.
  - Hydra-jetting multi-stage fracturing in horizontal well has increased the single-well production;
  - Advanced water injection technique and well pattern optimization technique have enhanced tight oil and gas recovery;
  - Digital management platform and well factory approach have cut down the development cost.
  - “Factory-like” operation has achieved great success in Jilin Oil Field. A series of technologies, such as the mode of production well clusters, integrated optimization of geology and engineering, volume reconstruction of reservoirs, unconventional energy supplement, factory operations, etc. have been developed which "raise production and recovery rate, reduce investment and costs".

Shale gas has achieved great progress both in CNPC and SINOPEC

- CNPC: Two shale gas pilot projects in Channing-Weiyuan and Zhaotong of Sichuan Basin have finished construction and gone on stream. As a state-level pilot project, Changning-Weiyuan project has 145 wells drilled, 91 wells fractured and supporting facilities for an annual production of $2 \times 10^9 \text{m}^3$. Series of technologies...
have been developed.
- Shale gas seismic-logging geology assessment technology
- Shale gas development optimization
- Horizontal well drilling and completion
- Volume fracturing with slick water and ceramic
- Factory drilling with “Dual Drilling, Batch Drilling and Standardization” by installing skid and optimizing operation procedure to improved efficiency and drive cost-saving
- Skidded surface gathering & processing System

- SINOPEC: Fuling shale gas field is located in the Jiaoshiba, Fuling, Chongqing City, southwest of China, about 90km far from Chongqing City. This area belongs to mountainous and hilly areas, with a 300-1000m above sea level. In 2012, Jiaoye 1HF horizontal well achieved high gas flows after staged fracturing and the Fuling shale gas field was found. In 2015, the first productivity construction stage of 0.5×10^8 m³ of Fuling shale gas field was completed. Daily gas production of 169 producing wells is 16.30×10^6 m³/d. Several progresses have been achieved in Fuling shale gas development as following.
- Staged fracturing comprehensive techniques system of horizontal well shallower than 3500m
- “Well Factory” development model for shale gas which reduced time period of drilling and fracturing by 40% compared with the initial phase.
- “Four Modernizations” construction mode: “standardized design, standardized procurement, modularized construction, informationized improvement” ground construction mode to achieve factory prefabrication, modular skid, skid-setup and digital management of shale gas ground gathering and transportation system.

Commercial CBM development has achieved initial success.
- CBM in China has formed two industrial development zone in southern Qinshui Basin and eastern Ordos Basin. By 2015, the proven reserves of CBM are of 626.6×10^9 m³. The commercial yield is 4.4 ×10^8 m³ with 15000 wells (11131 as producers).
- Three major factors control high rank CBM accumulation in China. (1) Sedimentary system controls coal reservoir distribution and seal capacity; (2) Hydraulic sealing process controls water retention area of coalbed methane enrichment and high gas content; (3) Tectonism and evolution of CBM controls reservoir property.

- China has developed fit-for-purpose CBM development techniques such as: CBM well type optimization techniques, coal reservoir production stimulation techniques and stage pressure control techniques, horizontal /cluster well techniques (tree-like horizontal well, L-type horizontal well and fish-bone horizontal well)
- Low rank CBM, accounting for 70% of the 36.8 trillion CBM resources in China, has made important progress and will be the important substitution of high rank CBM in the future.

New Technologies and innovation to drive cost-saving and profit-increasing for Unconventional Oil & Gas Development in China
During the last decade, great technology progress has been made in China's unconventional oil & gas resources concerning the following areas. Key technologies such as tight gas horizontal well volumetric fracturing + large platform "factory-like" exploitation, large platform "factory-like" development for shale gas with burial depth shallower than 3500m, multiple well type development for CBM with burial depth shallower than 800m and industrial testing for reservoir volume fracturing in tight oil horizontal wells, have been mature and improved. In detail, they are:

- "sweet spots" geological and engineering comprehensive evaluation method
- High-resolution seismic to predict hydrocarbon reservoir
- Geo-engineering evaluation (integrating of geological reservoir and engineering, which is as a whole life cycle from seismic to drilling, reservoir engineering, production engineering and surface engineering)
- Horizontal drilling + SRV fracturing (Horizontal well SRV to make fracture system)
- Micro-seismic monitoring artificial fracture system
- Factory drilling and fracturing( “Factory-like” operation of multi-well platform )
- L-type, U-type and multilayer horizontal well
- Simplification and optimization of well structure
- ERP service model
- ‘Continual Integration’ innovative management

Challenges and opportunities of Unconventional Oil & Gas in China

Great challenges exist in developing unconventional oil & gas in China as following:
- small “sweet spot”, thin “sweet interval”, low single well production
- low oil & gas price and as a result, poor economic performance
- complex surface conditions, dense population and fragile water environment
- making the “factory-like” production hard to operate

Opportunities for developing unconventional oil & gas in China as following:
- China energy structure adjustment provides great potential for unconventional oil & gas development
- Abundant resources and low recovery percent make unconventional oil & gas an important domain of energy development in China.
- Technology for “artificial reservoir ” to reconstruct underground production system, such as seepage field (artificial permeability), temperature field (temperature decreasing and recovery), pressure field(rapid pressurization and slow conduction), stress field(stress variation and fracture propagation), surface property(changing rock water wetting and oil wetting performance), fluid property(changing fluid physical and mechanical properties(viscosity, density and micro-emulsification)).
- Encouraging policies in China promote unconventional oil & gas development.
- The rapid development of unconventional oil & gas in recent 10 years has nurtured many innovative teams.

Technology of Unconventional Oil & Gas Development in the world

- ExxonMobil: improving well productivity through an agile organization with the ability to act quickly and responsibly while maintaining the focus on results
  - ExxonMobil is active in the major unconventional resource plays in United States through its 100% owned affiliate, XTO Energy Inc. This large scale
activity, covering all unconventional resource types, has made ExxonMobil the largest unconventional producer in the USA.

- A major contributing factor to this success is the relentless pursuit of both cost reduction and Well productivity improvements has generally been a >50% reduction in drilling days, a 50% increase in oil well productivity, and > 50% reduction in oil development cost per OEB and also yielded a tripling of the onshore liquids production from the Bakken, Permian, and Ardmore plays in the last 5 years

- Key drivers of success are:
  - Flat organization, few formal meetings, working managers
  - Ability to move / act quickly...bias for action
  - Streamlined processes, focus on results
  - Continuity of people in key positions
  - Business risk-tolerance

- Schlumberger: Lowering total cost through geo-engineering and integrated project, application of fit-for-purpose technology and collaborative business model

  - Geo-engineering begins with the understanding of rock & fluid properties such as matrix permeability, natural fractures, pore pressure, Total Organic Content (TOC), and geomechanics attributes. The knowledge is used to engineer the well by selecting the best well location, developing optimize well path and staying within the sweet spots. During drilling execution, most efficient drilling system is selected to reduce total drilling time hence drilling cost. In addition, data acquired in real-time is compared with the pre-drill knowledge and used to adjust well path for best reservoir contact. Post-drilling logging information is used to further optimize the completion system, which has the attributes of effective design and simple stimulation operation. Effective stimulation design followed by an optimized flowback process will ensure best production is achieved. The key technologies are:

    - Geo-engineering(an integrated workflow that link rock & fluid characterization at the centre with drilling engineering, completion and production engineering)
    - Fit-for-Purpose Technology(Value driven rather than unit cost driven, Technology chosen to deliver the best outcome for each Geo-engineering building block)
    - Collaborative Business Model (Commercial and objectives alignment between service provider and operator, Collaborative project planning & execution)

- North American operators are attempting to succeed in the low oil price environment.

  - In history, operators used optimizing location, increasing lateral length, proppant loading to get succeed.
  - Now, operators are playing with a different set of levers in the “new” price environment, considering high-grading, DUC (drilled but not completed), shut ins and nothing matters without funding.
  - Growth will come back if prices recover, but not like it was because of fewer operators, less “greenfield exploration”, slower and more deliberate activity. Permian Basin has the most upside, now and when
Outside North America, IOCs (large integrated companies) are largely leaving operatorship to the independents and national oil companies (NOCs), where there is still interest.

- No meaningful production from shale is expected in any country outside of Russia, Argentina, and China this decade.
- Tight gas on the other hand continues to generate more interest, and further investment and results are anticipated from this activity.

Other technologies for unconventional oil & gas are emerging.

- IUP technology, which is in situ upgrading progress by thermal cracking of bitumen in place by slow heating to T>300°C, has matured and entered the stage of commercial pilots for heavy oil in Canada.
- ICP technology, which is in situ conversion process by enhancement of natural maturation of kerogen by slow heating to T~330°C, can revitalize depleted Liquids-Rich Shale fields where the source rock is adjacent to the hydraulically-fractured tight sand. Pilots are on-going in Colorado, USA and Jordan.
- Opportunities being sought that can leverage this technology and enhance the value of applicable assets around the world – heavy and waxy oil

E) CONTACTS
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(please insert contact details of the speakers)
For contact of speakers, please see the Annex I

(please insert contact details of the attendees)
For contact of attendees, please see the Annex II

F) SUPPORTING DOCUMENTS AND PRESENTATIONS
Please see the annex III or visit official website of Chinese National Committee at www.wpcchina.org for documents including Agenda, Programme, Presentation Abstracts, Speaker Profiles and Photographs.