New Horizons for China Petrochemical Industry

Report series of China energy and petrochemical industry

Xiaodong Lyu
March 25th 2019
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Increasing Petrochemicals Capacity of China
Petrochemicals Giants Cooking Up Major Expansion for China

Capacity of ethylene and PX of China has reached 25MTA and 13.8MTA in 2018, which is expected to reach 53MTA and 40MTA by 2025, both ranking the 1st in the world.

Bohai Gulf
- 2025
  - C2: 15.3/27%
  - PX: 20.2/45%

Yangtze River Delta
- 2025
  - C2: 13.5/24%
  - PX: 13.3/30%

Pearl River Delta
- 2025
  - C2: 6.4/11%
  - PX: 2.0/4.5%

Announced Integrated Projects 2019-2025
- 2020: Hengli PC
- 2021: North Huajin PC
- 2021: RISUN
- 2019: Zhejiang PC Phase I/II
- 2021: Shenghong PC
- 2020-2025: ZRCC
- 2020: Gulei PC
- 2020: Quanzhou PC
- TBD: FHC & SABIC JV
- 2018: CNOOC & Shell JV
- 2020: ZRPC
- 2021: CNPC
- 2023: ExxonMobil OTC Project
- 2020-2025: Hainan Refining & Chemical
China Empowering the World Capacity Growth

China alone contributes 50-70% of the new capacity during another two round of expansion in 2019 and 2023.

Average Annual New Capacity of Basic Petrochemicals

Note: Basic chemicals including ethylene, propylene, butadiene, benzene, toluene, PX and methanol

- **China**: Dark Red
- **Middle East**: Light Green
- **US**: Yellow
- **Others**: Gray

<table>
<thead>
<tr>
<th>Year</th>
<th>MTA</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996-2000</td>
<td>14</td>
<td>11%</td>
</tr>
<tr>
<td>2007-2009</td>
<td>21</td>
<td>45%</td>
</tr>
<tr>
<td>2012-2013</td>
<td>15</td>
<td>44%</td>
</tr>
<tr>
<td>2018-2019</td>
<td>30</td>
<td>55%</td>
</tr>
<tr>
<td>2021-2025</td>
<td>25</td>
<td>69%</td>
</tr>
</tbody>
</table>
2 Booming Petrochemicals Market of China
China Still holds the largest share of world petrochemicals demand, which is expected to maintain a high growth after the recent booming period. Demand of synthetic resin, fiber and rubber is expected reach 135MTA, 60MTA and 3.2MTA respectively by 2025.
World petrochemicals demand are recovering from years before, growth of which outruns the world GDP. China, as a key driver, is expected to hold 1% higher than the world average demand growth by 2025.
Consumption Still Shows Great Potential

China per capita consumption of petrochemicals is catching up with Japan and Europe in the coming years. But 43kg (in equivalent ethylene) still has a long way to go compared with South Korea (89-90kg) and U.S. (70-80kg).

Consumption per capita of Equivalent Ethylene vs GDP per capita from 1990-2025
Aging Population VS Massive Urbanization

Massive urbanization is the best answer to the aging problem. Besides the second baby boom, we will see 170 million new citizens moving to cities by 2030, which means at least 250 billion $ new consumption and 2750 billion $ new investment.

2018

60%

18%*

*estimated

2030

70%

170 Million New Citizens

25%

110 Million New Elders

(aged over 60)

3-4 Million Second babies

250+ Billion $ New Consumption

2750+ Billion $ New Investment
Explosive Growth of E-commerce Boosting the Polymers Demand

Billions of online orders and catering services are creating a whole new area for polymers consumption, which is growing by 20-30% each year and increasing the demand of polyolefins by 1-2%.

Fast Delivery and Catering Services Boosting the Polymers Demand
New Demand from Environmental Protection Business

Recycling rate of China has been much higher than the average of the world, which makes it harder to get significantly improved in years, together with waste plastics import ban, increased the virgin PE demand by 0.7-1.0 million ton. While air-pollution control regulation has driven the natural gas pipeline demand by 10%.

Sources: Roland Geyer, Jenna R. Jambeck, Kara Lavender Law

Recycling Rates of Non-Fiber Plastics

Waste Polymers Import and Domestic Production

Natural Gas Pipeline Demand for Polyolefins
A Prosperous Outlook for High Performance Materials

Consumption upgrading promotes the high performance materials demand. A more than 10% growth will be expected in the coming years, and the revenue of this area will reach 145 billion \$ by 2030, accounting for 40-50% of the world.
C1/C2: Large Import Still There

Methanol effective supply cannot fully meet the fast growing MTO and fuel demand, net export approaching 10 MT. Self-sufficiency of ethylene is rocketing, while more than 10 MT of equivalent ethylene still has to be imported.

Note: Self-Sufficiency Rate = Production / Demand

Methanol Supply and Demand of China

Ethylene Supply and Demand of China

Note: Ethylene Demand including derivatives demand (in ethylene)
C3/C4: Balance is on the Horizon

Expanding propylene capacity and demand are getting near the balance point, while PP still needs import; Not only the large integrated projects but also the BDH has changed the whole landscape for butadiene.
Aromatics: Nearing the Overcapacity

Extensive investment on PX has dramatically change the outlook for it, balanced or even overcapacity is expected by 2025. For benzene, import won’t be absent, but potential increase of the capacity utilization clouded the market.
Balance across the Spectrum

Polymers supply still cannot meet the demand by 2025, while some, especially the aromatics, will be facing the overcapacity pressure.

Balance of China Major Petrochemicals in 2025
In 2018, China polymers gap reach up to 23 MTA, which will be increased by at least 5 MT by 2025. Far more incremental imports will be expected than other areas.
3 Trends and Challenges
A Further Opening-up Market

A series of measures are implemented to reduce the market access barrier, which has attracted not only the domestic private investors but also the foreign investors, like Saudi Aramco, SABIC to join the game.

- Remove restrictions on wholly foreign funded petrochemical companies
- Remove restrictions on crude oil import of private companies
- Implement negative list for market access
- Introduce mixed ownership to SOEs
- Cut items requiring government review by 30%
- Cut taxes and administrative fees
  - Lower the VAT from 17% to 13%

Ethylene Capacity Share 2018 (inner circle) and 2025

PX Capacity Share 2018 (inner circle) and 2025
A More Diversified Market

In 2019, Zhejiang and Hengli PC will bring the aromatics version of OTC on board, and ExxonMobil will bring the olefins version to Huizhou, China years later. Meanwhile the first ethane VLEC will arrive in China and the first ACO unit gets into production.
Overcapacity of some products will bring downward pressure to the overall profitability. As the rebalance goes on, the self-sufficiency will decline again and the profitability will get rebound sometime after 2025.
Consolidation on the Way

Stricter environment regulations and fierce competition are forcing the disadvantages out of the games. Rapid decreasing small companies/units and climbing concentration ratio indicate the on-going consolidation.

- 2015: 25,200
- 2016: 24,500 (-18%)
- 2017: 23,300
- 2018: 21,300

Concentration ratio +27%
Takeaways

• As the largest producer and consumer, China petrochemical market to maintain a steady annual demand growth of 6-7% and a capacity growth of 9-10% before 2025.

• Opportunities are emerging from massive urbanization, consumption upgrading, infrastructure construction, e-commerce, environmental protection business and further opening up.

• China will take more imports from the Middle East and U.S., as the polymers gap of China will be widening up by 5 million tons by 2025.

• Steady economy and huge demand will help the market to get rebalanced quickly. And a rebound is expected sometime after 2025.
1. The refining industry in China ranking among the top in the world

2. In the future: oil demand growth shifting from fuel-driven to petrochemical feedstock-driven

3. Transformation and upgrading of refining industry in China under a new round of investment
The refining industry in China ranking among the top in the world
The refinery capacity in China ranks among the top in the world, and is still in expansion.

- State-owned refineries increased capacity to meet the growing rigid demand.
- Independent refineries began to accelerate their expansion.
- Structural adjustment is coming.

In 2018, China’s refinery capacity came to 16.8 Mb/d. New capacity mainly came from independent refiners.

In response to the upgrading of oil quality, refineries in China are becoming increasingly complex.

- In 2018, China’s refinery capacity came to 16.8 Mb/d. New capacity mainly came from independent refiners.
- In response to the upgrading of oil quality, refineries in China are becoming increasingly complex.
The increasing crude oil processing meets domestic demand

- By 2018, China’s refining throughput was 12.1 Mb/d, and the dependency on imported crude oil came to 70.8%.
- Since the release of imported oil quotas in 2015, the growth rate of refining throughput has risen from 4.1% to 5.4%.
- The utilization rate of independent refineries increased from 30% in 2014 to 60% in 2018, and the share of imported crude oil in processing feedstock increased from 21% to 71%.
Urgent issue: large numbers of refineries with small average capacity

- By 2018, the average refinery capacity in China was only 87 Kb/d, which is only half of the global average level.
- Excluding the outdated capacity of less than 40kb/d, the average utilization rate could be around 82% in 2018.
In the future:
Oil demand growth shifting from fuel-driven to petrochemical feedstock-driven
Outlook for demand-The key driver for China oil demand is shifting from fuel to petrochemical feedstock

The rough picture:
- The future oil consumption will peak due to factors such as economy, population, fuel economy and EV deployment.
- Compared with the relative rigid demand of jet fuel and petrochemical feedstock, gasoline and diesel are more likely to be replaced.
- There is still uncertainty about vehicle fuel economy improvement and the development of electric vehicles.
Driver shifting—Fuel-oriented oil consumption in China is decreasing

China's oil demand reached 12.4 million b/d in 2018. What's more, the oil consumption structure has changed or is about to change.

Instead of transportation fuel, petrochemical feedstock will become the major refining product by 2050.

**Industry:**
Oil consumption declines while NG and electricity use increase in the advanced stage of industrialization.

**Petrochemical industry**
In order to meet the growing demand for "clothing and daily use," oil consumption is increasing.

**Transportation**
2000-2014: The growth in car ownership drove the growth of oil consumption.
2014-2030: Commercial vehicle ownership trends to be saturated and fuel economy is being improved.
2030-2050: Travel modes will change and the development of EV will accelerate.
Compared with other countries, the energy consumption per capita GDP of China is still rising.

In the future, China's GDP growth will slow down, but the quality of economic growth will be improved.

The fertility rate is declining in China and the population will peak before 2030.
Industrial driver—Broad prospects for China auto industry in the take-off period

- Currently, the vehicle ownership in China was 130 vehicles per 1000 people, which is still in the take-off period of auto industry compared with developed countries.
- Considering the high density of population and the lack of oil and gas resources in China, the saturation level of vehicle ownership will not be too high. Even so, the vehicle ownership will still double that of now by 2050.
Industrial driver-Improved fuel economy offsets the growth in transportation fuel demand

- Compared with Japan and Europe, China still has great potential to improve the fuel economy. Downsizing and hybrid technologies are feasible.
- If the fuel economy target of China is on schedule, it will save about 100 million tons of oil by 2050.
Currently, natural gas and coal-to-liquid, coal-to-olefin are the main oil substitutes.

After 2025, electric vehicles will replace natural gas as the first alternative.
Electric vehicles-The leading role of China in the global market

In 2018, China EV sales accounted for about half of global EV sales.
- EV Sales: 1.26 million, market penetration rate: 4%
- EV ownership: 3.1 million, accounting for 1.6% of the total domestic vehicle stock

With clear government targets, EV may become the direction for the future auto industry in China.

### Targets for EV development in major countries

<table>
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<th>Country</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>Technology roadmap</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
<td>5 million Penetration rate: 7%</td>
<td>20 million Penetration rate: 15%</td>
<td>80 million Penetration rate: 40%</td>
<td><strong>Mainly BEV</strong></td>
</tr>
<tr>
<td>US</td>
<td>1.2 million</td>
<td>/</td>
<td>/</td>
<td>BEV &amp; PHEV</td>
</tr>
<tr>
<td>Japan</td>
<td>/</td>
<td>/</td>
<td>Penetration rate: 50%-70%</td>
<td>BEV, HEV &amp; PHEV</td>
</tr>
<tr>
<td>Germany</td>
<td>1 million</td>
<td>/</td>
<td>5 million</td>
<td>BEV &amp; PHEV</td>
</tr>
<tr>
<td>France</td>
<td>2 million</td>
<td>/</td>
<td>/</td>
<td>Clean energy vehicles</td>
</tr>
<tr>
<td>UK</td>
<td>1.6 million</td>
<td>/</td>
<td>/</td>
<td>Ultra-low emission vehicles</td>
</tr>
<tr>
<td>Norway</td>
<td>400,000</td>
<td>100% zero emission</td>
<td>/</td>
<td>BEV/HEV/PHEV/FCV</td>
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Electric vehicles-The decisive period: 2025-2030

- **After 2030:** Level 5 autonomous driving will be ready to be commercialized.
- **2025:** EV will reach cost parity with conventional vehicles, which makes large-scale promotion possible.
- **There is still uncertainty in the development of EV.**

**Battery material**
- Scarcity of lithium and cobalt resources
- Technology progress

**Technologies for car sharing**
- Sensing techniques
- Infrastructure such as high-precision maps
- Revisions of policies and regulations

**Tax reform issues**
- Fuel tax
- Purchase tax reduction for EV

**Infrastructure**
- Charging facilities
- Charging service economy
- Impact of peak charging load on the grid

- 1G lithium battery
- 2G lithium battery
- Next generation Lithium metal
- Fuel cell battery

Battery materials:
- Lithium iron phosphate
- Nickel-rich NCM
- Li-rich manganese based cathode
- Solid state lithium metal battery
- Lithium sulfur battery
- Lithium oxygen battery

- 2025: EV will reach cost parity with conventional vehicles, which makes large-scale promotion possible.
- After 2030: Level 5 autonomous driving will be ready to be commercialized.
- There is still uncertainty in the development of EV.
In the future, with the improvement of living standards, auto, home appliances, textiles and real estate industries in China will continue to develop. Significant growth is expected in ethylene and PX consumption.

Despite the diversification trend, Ethylene feedstock will still be dominated by petroleum-based feedstock.
Transformation and upgrading of refining industry in China under a new round of investment
Advanced capacity will replace outdated capacity in the future

- China will have 4.32 million b/d new capacity and phase out 2.1 million b/d backward capacity before 2025.
- The total capacity will reach 18.8 million b/d by 2025.
New capacity will be more concentrated, larger and more integrated

The new capacity is mainly located in bases in the eastern coastal areas.

- Under competition and the pressure of environmental protection, new capacity will be larger, more concentrated and integrated, and be more involved in the export market.
- Crude oil will be fully used in the processing.
Refineries are seeking a way out according to their own characteristics

**Transformation path**

**State-owned existing enterprise**
- Expansion: 15 Mtons/year refining capacity and 1.2 Mtons/year Ethylene capacity
- ... ...
- Overall optimization to produce petrochemical feedstock

**Integrated independent enterprise**
- Expansion: 20 Mtons/year refining capacity, 1.4 Mtons/year Ethylene capacity and 5.2 Mtons/year PX capacity
- ... ...
- The adoption of Diesel HC process

**State-owned new enterprise**
- Expansion: 16 Mtons/year refining capacity, 2Mtons/year Ethylene capacity and 1.6 Mtons/year PX capacity
- ... ...
- The adoption of H-oil process and cancel FCC units

**Local independent refineries**
- Phasing-out: outdated capacity less than 2 Mtons/year
- ... ...
- Expansion: 30 Mtons/year integrated units

**Environmentally friendly & Digital**
- Emission reduction from the source
- Process control enhancement
- End treatment
- IOT in refineries
- Process optimization
- Monitoring of operation
Increasing influence of China in the Asia-Pacific refined oil export market

In 2018, China's refined oil exports increased by 1.9 times compared with 2010 and became the fourth largest exporter in the Asia-Pacific region. (Top 3: Korea, Japan and India)

Due to the low yield of refined oil in new capacity, the net export of refined oil will not increase much by 2020-2025.

In the future, large refineries in coastal areas will target both domestic and international markets.
A more opening-up refining market in China welcomes cooperation in various fields

**Crude oil import**
- Oil import quotas for independent refineries

**Refined oil export**
- Refined oil exports will become ordinary

**Investments overseas**
- Yanbu Aramco Sinopec refinery put into operation in Saudi Arabia
- The “Belt and Road Initiative” boosts oil and gas cooperation among countries along the route

**Domestic refining**
- PDVSA-CNPC Jieyang refinery is under construction.
- Saudi Aramco joins Huajin Petrochemical and Zhejiang Petrochemical.
- BASF plans to build an integrated petrochemical base in Guangdong

**Refined oil sales**
- Relax market access and scrap limits on foreign holdings

**Retail market**
- BP will build 1,000 gas stations in China
- Saudi Aramco plans to enter the retail market in Zhejiang

**Charging service**
- Tesla has built supercharging stations in 27 provinces and cities.
- Shell’s first charging station was put into operation in Tianjin in September, 2018.
- In January 2019, BP’s first supercharging station was put into operation in Shanghai

**Refined oil pricing mechanism reform**
- Coming soon......
China’s Energy Transition and Development Path

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Zuoxian Luo
March 20th 2019
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<td>5. Non-fossil Energy Demand and Development Trend</td>
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<td>6. Future Energy Demand and International Cooperation</td>
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Evolution on China's Energy Supply and Demand
Energy production and consumption have maintained growth and energy self-sufficiency has declined.

- Energy consumption grew; Supply stable;
- Self-sufficiency rate: 111.8% (1985) to 98.2% (1992), 93.7% (2000) and 79% (2018).
- Domestic oil and gas production is stable.
- Growth of oil and gas consumption replaces coal.
- 2018, coal consumption dropped to 59%, 10% lower than in 2000.

Coal
- Reserve: 136.8 billion tons
- R/P: 39

Oil
- Reserve: 3.5 billion tons
- R/P: 18.3

Gas
- Reserve: 5.5 trillion cubic m³
- R/P: 36.7
China Key economic development indexes estimated

**Industrialization**
- 2018: proportion of tertiary industry 51.6%
- 2030: 60.3%

**Population**
- 2018: 1.40 billion
- 2029: 1.44 billion, peak

**Urbanization**
- 2018: 60%
- 2030: 70%

**Economic Growth**
- 2018: GDP growth 6.9%
- 2030: GDP growth 5%
Targets for 2030 within the framework of China's energy revolution

Total Energy Demand: 4.2 billion toe
Greenhouse gas per unit of GDP: reduces 60%-65% than 2005
Terminal energy consumption: electricity increases to 30%

Energy consumption revolution
2020/2030, energy demand: below 5/6 billion toe (3.5/4.2 billion toe).

Energy supply revolution
Added energy is mainly from clean energy

International cooperation
Overseas cooperation: one belt one road energy corridor

Technology revolution
Energy-saving technologies; smart energy technologies

Energy system revolution
• Effective and competitive energy market system;
• Market-oriented pricing mechanism;
• Energy legal system.

- Oil: 17.8%  2.2% VS 2018
- Gas: 13%  7% VS 2018
- Coal: 47%  9% VS 2018
- Non-fossil: 24% 11% VS 2018
Coal Demand and Development Trend
Coal consumption reached its peak on 2013.

Consumption increased from 1990 to 2005.\(^1\)

- Production exceeded consumption.
- Self-sufficiency.
- Energy conservation.
- Emission reduction.
- Energy structure transition.
- Cutting the backward capacity.
- Encourage the import of high-quality coal.

Three stages of China's coal consumption since 1990:
- Steady development.
- Production exceeded consumption.
- Self-sufficiency.

Since 2005, China's dependence ratio on foreign coal remained between 6% and 7.5%. The external dependence ratio of 2018 is 7.3%.

Coal consumption, production and imports (100 million tons):
- Consumption: 4.2 billion tons
- Production: 2.3 billion tons
- Imports: 0.3 billion tons

2005, difference between consumption and production expand, coal imports accelerated.

2013, coal consumption and imports peaking at the same time.
Coal demand will decline in the future.

**Power generation**
- ✓ progress in RE power storage technology and support system for grid
- ✓ 57% of total coal used for power in 2035 and 45% in 2050.

**Steel**
- ✓ entering stable stage
- ✓ 10% of coal demand in steel in 2030, 7% in 2050.

**Building materials:**
- ✓ Slower development step.
- ✓ 13% of coal used in 2017, and 6% in 2050.

**Chemicals**
- ✓ Modern coal chemical industry develop
- ✓ Increase from 7% in 2017 to 30% in 2050.

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**Forecast of China’s Coal Consumption Structure**

(100 million tons)

**Coal demand target**
- 4.0-4.1 billion tons
  2016-2020
- 3.5-4.0 billion tons
  2021-2030
- 3.0-3.5 billion tons
  2031-2050
Optimization of coal industry is to mainly promote construction of integrated base

Base construction:
coal production, chemical conversion, electricity, building materials integrated

International cooperation in science and technology promote base construction

Around 2020, the output of **14 large coal bases** will be **3.7 billion** tons, accounting for more than **95%** of the total coal production.
Oil Demand and Development Trend
Domestic production decrease and refining capacity increase led to external dependence ratio rise

China oil demand, supply and foreign dependence ratio
(10 thousand tons)

Oil price down

199 million tons
192 million tons
190 million tons

Refining capacity growth

Net increase of 18 million tons
Refining capacity reached 770 million tons

Net increase of 22 million tons
Refining capacity reached 830 million tons
China has more oil trade partners in the world

- **2000**: 30 importing countries, covering the Middle East, Africa, Europe/former Soviet Union, the Americas and the Asia-Pacific region. The import volume was led by the Middle East, nearly **38 million tons**, far exceeding other regions.

- **2017**: 43 importing countries, **13** of which were added and mainly from Africa, America and Europe. Most of the new imports came from the Middle East and Europe, with Saudi Arabia increase more than **45 million tons**.
The oil demand will reach its peak with over 700 million tons around 2027.

- **Gasoline**: replaced by electrification; a decade of growth
- **Diesel**: replaced by gas in urban buses, and truck transportation.
- **Aviation kerosene**: Driven by annual growth rate of passenger turnover.

By 2030:
- China's population: 1.44 billion
- Energy efficiency: the world's advanced level
- Urbanization level: 70%
- Number of electric: 50-80 million; 1/4 of the total.

Data sources: EDRI
Domestic supply: widen E&P fields and EOR technologies

Resource

- Rich in petroleum
- 35% proven, and has potential

Resource Conversion Rate

- Resource conversion rate is Low
- Improving recovery and conversion rate through technological progress

Unconventionals

- Shale oil and oil sands are rich.
- The State Key Laboratory of Shale Oil has been set up.

Output

- Diversified investors
- Oil production will have space for growth
4 Natural Gas Demand and Development Trend
Natural gas demand is growing rapidly, with the External dependence exceeding 40%.

Medium and long-term energy planning outline: Energetically develop natural gas

The west-east gas pipeline in operation

Begin of pipeline gas import

Begin of LNG import

10 measures for the prevention and control of air pollution.

Utilization accelerating

First stage (before 2000)
- Utilization around of field
- Industrial gas is dominant

Stable demand (2000-2010)
- Cross-regional utilization
- City gas demand growth

Period of Rapid demand
- Import accelerate
- Channels and domestic pipeline
- Optimization of demand

Source: Operation bureau of national development and reform commission, EDRI
Diversified imports, more gas trade partners, quick LNG import growth

- **2006-2007**, 85% came from long-term contracts in Australia
- The rest from spot contracts in Oman, Algeria and Nigeria.

- **2012**, mainly from Qatar, Australia, Indonesia, Malaysia, Yemen and Russia.

**Map of LNG and pipeline gas import of China**

**Exporters in 2012**
- Qatar: 34%
- Australia: 24%
- Indonesia: 16%
- Malaysia: 13%
- Russia: 3%
- Yemen: 4%
- Others: 6%

**Countries and regions of pipeline gas import**

- **2018**, China has imported LNG from more than **20 countries**.

**Volume of import**

- Pipeline: 51.6 bcm
- LNG: 72.6 bcm
Medium and long-term gas demand structure will be stable

China's natural gas consumption forecast (bcm)

- City gas
- Power
- Industrial fuel
- Chemical materials

Source: EDRI

**POWER:** If gas turbine technology can be mastered, fixed cost of gas power plant will be reduced from 90% to 30%.

**INDUSTRIAL FUEL**
- Emission reduction
- Efficiency improvement
- Promoted to nationwide

**CITY GAS:** Rate of gasification: 80%
- Gas in public transportation and freight logistics will be promoted.

**CHEMICAL MATERIALS:** Growth will be slower.

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<th>Power</th>
<th>Industrial fuel</th>
<th>Chemical materials</th>
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<td>2018</td>
<td>1048</td>
<td>2040</td>
<td>1608</td>
<td>480</td>
</tr>
<tr>
<td>2050</td>
<td>210 bcm</td>
<td>70 bcm</td>
<td>231 bcm</td>
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**CHEMICAL MATERIALS:** Growth will be slower.

<table>
<thead>
<tr>
<th>Year</th>
<th>City gas</th>
<th>Power</th>
<th>Industrial fuel</th>
<th>Chemical materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>1048</td>
<td>2040</td>
<td>1608</td>
<td>480</td>
</tr>
<tr>
<td>2050</td>
<td>210 bcm</td>
<td>70 bcm</td>
<td>231 bcm</td>
<td>70 bcm</td>
</tr>
</tbody>
</table>
Upstream E&P
Increase investment to discover more reserves and output.

Pipeline network interconnection
Key natural gas infrastructure connectivity projects for 2019 have been launched.

Gas storage
Increase working gas storage capacity underground

LNG Terminals
Keep quick pace on construction of LNG terminals.
5 Non-fossil Energy Demand and Development Trend
Technological advancements enhance Non-fossil energy’s competitiveness

✓ From 2017 to 2025, China’s large solar photovoltaic and onshore wind power investment costs will be reduced by about 50% and 30%

✓ LCOE cost of electricity will be reduced by about 35% and 25% respectively.

Note: National average, LCOE: Levelized Cost of Electricity. Data sources: Chinese State Grid Energy Research Institute, IRENA
Non-fossil energy: China’s electricity generation capacity will keep fast growing

China’s Non-fossil energy cumulative installed power capacity

China’s Non-fossil energy electricity generation

- 2018, China’s non-Fossil energy cumulative installed power capacity is **780 GW**, 40% of the total installed power capacity, generating **2200 TWh** of electricity, 30% of total electricity generation.

- 2050, China’s non-Fossil energy cumulative installed power capacity will be over **2800 GW**, generating **7300 TWh** of electricity.
Energy Demand & International Cooperation Outlook
China's energy transition:
- Coal demand reduction; clean use of coal
- Natural gas demand increase
- Stable oil demand;
- Non-fossil energy keep growth

Total energy peaking around 2045
- 4.2 billion toe

Coal continues to decline
- 34% of total by 2050

Oil peaking around 2030
- 720 million tons

Natural gas peaking around 2050
- 700 billion m³

Non-fossil
- 1.4 billion toe by 2050,
- 35% of total
- Main energy source
Chinese companies' overseas business will maintain steady development

**Upstream**
- More than **30** oil and gas companies have overseas business
- More than **200** oil and gas projects in **50 countries**

**Refining**
- **12** overseas refining projects
- Total refining capacity of **73.6 million tons/year**.

**Chemical**
- **2010-2016**, Keep growth in overseas investment
- Total overseas investment: **200 billion yuan**

**Engineering service**
- Market service in Russia, Central Asia, the Middle East and South Asia

**Trading**
- More oil and gas trade partners
- Trading has become an important link
China’s booming oil and gas industry is providing opportunities for global enterprises

- International cooperation will enhance energy and chemical industries.
- More foreign enterprises are entering Chinese market.

**Oil and gas E&P**
- Domestic upstream market will be further **open**
- **Cooperation field** diversified

**Pipeline**
- **infrastructure construction** accelerating
- The new negative list of foreign investment **encourages multiple investment entities to enter**

**Refining & Chemical**
- China is committed to building high-end, low-energy consumption petrochemical integration base.
- By 2020, build 7 domestic bases.
Review and Prospect of China’s Energy and Petrochemical Industry

Report series of China energy and petrochemical industry

Jiao Yu
March 25th 2019

3 Modules
- Economy Forecast
- Market Analysis
- Insights on Hot Events

6 Industrial Chains
- Refinery, C2, C3
- C4, PX, C6

3 Parts
- Energy
- Refinery Industry
- Chemical Industry

Over 40 Products
- Crude oil, natural gas, refined oil, ethylene, propylene, ethylene glycol, butadiene rubber, acrylic ……
Main content of the 2019 report

Review 2018

Prospect 2019

How many? How much? How to change? How to impact?

Demand & Supply & Price

Pattern of Supply and Demand & Trend of Price

Impacts of Hot Events

International Market

China Market
CONTENTS

1  The Development of China Energy and Petrochemical Industry over the Past 40 Years

2  The New Pattern of Long-term Development of Energy and Petrochemical Industry in China

3  Market Prediction for 2019
The Development of China Energy and Petrochemical Industry in the Past 40 Years
1. Has been the vital component of China’s and even the world economy

An important role in global energy and petrochemical system

<table>
<thead>
<tr>
<th>Primary Energy Consumption</th>
<th>Crude Oil Import</th>
<th>Natural Gas Import</th>
<th>Processing Capacity of Crude Oil</th>
<th>Ethylene Production Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2017) 23 %</td>
<td>19%</td>
<td>8%</td>
<td>15%</td>
<td>14%</td>
</tr>
<tr>
<td>(2018) 3,248 Mtoe</td>
<td>Imported crude oil 462 Million tons</td>
<td>Imported natural gas 123 Billion cubic metres</td>
<td>16.8 Million barrels per day</td>
<td>25 MTA</td>
</tr>
</tbody>
</table>

A vital position in the development of national economy

1978-2017年

The main business income of the industry is 2.0 trillion US dollars, increased by 182 times. The number of large and medium-sized enterprises is 10 times more, and large ones is more than 30000.

2. Has Achieved “Leapfrog Development”

Industry development strongly fueled by the reform and opening-up in 1978

- Previous period: self-sufficiency, profitable export
- Dramatic increase of energy demand after 1990
- Refining capacity gradually exceeded crude oil production
- More joint venture and cooperation in refining and petrochemical business

Industry development accelerated after joining WTO in 2001

- The 10-year period of oil price rising started
- Active investment, consumption and trade

Source: BP Statistical Review of World Energy 2017, EDRI
3. Opening and cooperation helps be in line with the global industry system

Overview of overseas business of Chinese oil companies

- Preliminary Exploration Stage (1978-1991) Focused on “bringing in”
- Go Abroad Stage (1992-1998) Started to “going global”
- Mutual Integration Stage (1999-2012) Combined “bringing in” and “going global”
- Upgrading Stage (2013~Now) Upgrading international energy cooperation system

- Overseas investment enterprises: 34
- Overseas Oil and Gas Projects: 210
4. A number of petroleum and petrochemical international enterprises have emerged

<table>
<thead>
<tr>
<th>Year</th>
<th>CNPC</th>
<th>SINOPEC</th>
<th>Shell</th>
<th>BP</th>
<th>TOTAL</th>
<th>Chevron</th>
<th>ExxonMobil</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>4</td>
<td>3</td>
<td>87</td>
<td>5</td>
<td>8</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>2013</td>
<td>5</td>
<td>4</td>
<td>93</td>
<td>1</td>
<td>6</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>2003</td>
<td>69</td>
<td>70</td>
<td>&gt;500</td>
<td>4</td>
<td>5</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>
5. The level of some energy and petrochemical technologies has entered advanced ranks in the world

Oil & Gas exploration and development theory as well as technology highlights characteristics

- Conventional → Unconventional
- Marine Facies → Continental Facies
- Onshore → Offshore

Refining Technology
Overall advanced, some leading

- Technology with independent intellectual property
- Capacity to design and build ten-million-tons oil refinery
- Complete technology series of clean petroleum products production

Petrochemical Technology
Reaches or approaches the world's advanced level

- Complete technology series of megaton ethylene project
- Complete technology series of highly efficient and environmentally friendly aromatic hydrocarbons
- Complete technology series of modern coal chemical industry

(Exploration of Shale Gas at Fuling)

(Exploration of Shale Gas at Fuling)

(Offshore drilling)

(Yanbu Aramco Sinopec Refining Company Ltd.)

(Yanbu Aramco Sinopec Refining Company Ltd.)

(Sinopec technology series of highly efficient and environmentally friendly aromatic hydrocarbons)

(Sinopec technology series of highly efficient and environmentally friendly aromatic hydrocarbons)
The New Pattern of long-term Development of Energy and Petrochemical Industry in China
Past——Meet the Demand of Basic Necessities of Life
In the past 40 years, petroleum and petrochemical industry emphasized on satisfying **quantity and speed requirement**

Clothing  Food  Housing  Transportation

Future——Meet the Requirement of High-quality Development
In the future, petroleum and petrochemical industry emphasized on satisfying **quality and efficiency requirement**

Cleaner  Higher-end  More Intelligent  More Sustainable
1. Steadily growing economy in China will constantly provide a sustained impetus for industrial growth

- China will be able to maintain GDP growth rate at 6-6.5% by 2025. Also, the population will continue to grow and is expected to reach peak at 1.44 billion in 2029.

- China’s Per Capita GDP will increase significantly. Compared to 2018, it will double in 2025, triple in 2035, and seven times in 2050.

Source: The State Information Center · Development Research Center of the State Council · EDRI
The 1st New Driver: New urbanization and the rural vitalization strategy will inspire the potential of China's economic and industrial development

- The rural vitalization strategy will break the urban-rural dual structure and drive economic growth strongly.

- By the free flow of factors, the integration of urban and rural industries could be promoted, level of urbanization could be raised, the synergy of urban development and rural revitalization could be achieved.

The gap between China's urbanization rate and that of developed countries has narrowed rapidly (%)

Source: UN, National Bureau of Statistics of China, EDRI
The 2\textsuperscript{nd} New Driver: The rising middle class has become a strong driver of consumption growth and industrial upgrading

- Urban residents' consumption is upgrading along the path from necessary consumption to \textit{improved consumption} to high-end consumption.

### Consumption Expenditure Structure of Urban Residents (%)

<table>
<thead>
<tr>
<th>Category</th>
<th>2013 %</th>
<th>2017 %</th>
<th>Growth Rate 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food, Cigarette and Liquor</td>
<td>30.1</td>
<td>28.6</td>
<td></td>
</tr>
<tr>
<td>Clothing</td>
<td>8.4</td>
<td>7.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Daily necessities and Service</td>
<td>6.1</td>
<td>6.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Residential</td>
<td>23.3</td>
<td>22.8</td>
<td>-</td>
</tr>
<tr>
<td>Transportation, Communication</td>
<td>12.5</td>
<td>13.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Education, Culture and</td>
<td>10.8</td>
<td>11.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Entertainment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health Care</td>
<td>6.1</td>
<td>7.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Other Supplies and Services</td>
<td>2.7</td>
<td>2.7</td>
<td></td>
</tr>
</tbody>
</table>

Source: National Bureau of Statistics of China
The 3rd New Driver: The coordinated regional development strategy will provide a broader space for industrial further expansion.

GDP ( % ) : Northeast China-Eastern Inner Mongolia Economic Zone
- 2017: 35%
- 2050: 40%

GDP ( % ) : East + South
- 2017: 51%
- 2050: 46%
The 4th New Driver: Technological revolution will foster new growth and promote the upgrading of traditional petroleum and petrochemical industries.

Emerging Industry Developing and Growing

- **New Business Model**
  - “Internet Plus”, Block chain, Sharing Economy, Modern Supply Chain, etc.

- **A New Generation of Information and Technology Industry**
  - Big Data, Cloud Computing, High-end Software, etc

- **New Energy, New Materials**
  - Clean Energy, Advanced Polymer Materials, High Performance Materials, etc

- **New Energy Vehicle**
  - Electric Vehicles, Fuel Cell Vehicle, etc

Boosted GDP by more than $7.5 trillion

Traditional Industry Transforming and Upgrading

- **Traditional Manufacturing**
  - Promoting the In-depth Integration of the Internet, Big Data, Artificial Intelligence with the Real Economy

- **Energy Industry**
  - Building a clean, low-carbon, safe and efficient modern energy system

- **Chemical Industry**
  - Product Upgrading, Resource Conservation and Clean Production
China will substantially ease market access, strengthen intellectual property rights protection, and take the initiative to expand imports.

China will never close but open its door even wider.

---

**The 5th New Driver:** More comprehensive opening-up in China will create a more favorable industrial investment environment

- China will substantially ease market access, strengthen intellectual property rights protection, and take the initiative to expand imports.

**Going Global**
- Opening-up of Services
- Open to developing countries
- Opening-up of inland areas
- Regional opening-up (free trade zone)

**Bringing In**
- Opening-up of Manufacturing
- Open to developed countries
- Opening-up of coastal areas
- Multilateral opening-up (WTO)
The 6th New Driver: The requirement of green development will lead traditional industries to explore new development paths.

- Environmental protection costs have accelerated the industry reshuffle, further enhanced the industry concentration.
- Outdated production capacity will be largely eliminated to make room for the development of advanced clean production capacity and green production.
- Environmental costs of companies will be increased significantly.
- The development space of urban enterprises will be limited.
2. **China’s energy transition will move faster than the world, and energy efficiency will be greatly improved**

---

**China's energy intensity descends most quickly**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total World</th>
<th>China</th>
<th>Europe</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>24</td>
<td>28.5</td>
<td>31.5</td>
<td>34.5</td>
</tr>
<tr>
<td>2010</td>
<td>22.2</td>
<td>28.5</td>
<td>31.5</td>
<td>34.5</td>
</tr>
<tr>
<td>2020</td>
<td>21.6</td>
<td>28.5</td>
<td>31.5</td>
<td>34.5</td>
</tr>
<tr>
<td>2030</td>
<td>20.0</td>
<td>28.5</td>
<td>31.5</td>
<td>34.5</td>
</tr>
<tr>
<td>2040</td>
<td>19.3</td>
<td>28.5</td>
<td>31.5</td>
<td>34.5</td>
</tr>
<tr>
<td>2050</td>
<td>18.6</td>
<td>28.5</td>
<td>31.5</td>
<td>34.5</td>
</tr>
</tbody>
</table>

**Will reach the peak of carbon emissions before the world does**

- Carbon dioxide emissions (Billion Tonnes)
  - The world will reach the peak during 2035 to 2040
  - China will reach the peak before 2030

---

**China's energy consumption has been decoupled from GDP growth**

- 2000-2017: 10%
- 2017-2025: 8%
- 2026-2035: 6.5%
- 2035-2050: 5%

---

**GDP growth rate**

**Energy consumption growth rate**
3. The market for petroleum and petrochemicals remains huge, especially in natural gas, chemicals and new materials.

- Crude Oil
  - Peak Time: around 2030
  - Peak Value: 720 million tons

- Natural Gas
  - Peak Time: before 2050
  - Demand in 2050: about 700 Bcm

- Refined Oil
  - Peak Time: 2027
  - Peak Value: 370 million tons

- Ethylene
  - Peak Time: 2035-2040
  - Peak Value: 72 million tons

- PX
  - Peak Time: 2040-2045
  - Peak Value: 41 million tons
4. China's market will be more competitive, with the gradual formation of a pluralistic supply system

Supply of Oil and Gas
- Private LNG terminals operating
- Foreign and private-owned refining projects perform actively
- International chemical giants have entered China
- Fine Chemicals
- Foreign and private-owned companies have invested in gas stations

Sale Terminals
- Foreign and private-owned companies have invested in gas stations
Market Prediction for 2019

1. What Are the Roads Ahead for World and China Economy?
2. How Do We Evaluate Forces that Influence the Sustainable Development of Energy?
3. Will Gas Supply be very tight in 2019?
4. How Will the New Expansion of Refinery and Petrochemical Capacity Influence the Market?
5. How Will the Market Demand Be in 2019?
1. What Are the Roads Ahead of World and China’s Economy?

Higher Risks

- 2018: 3.2%
- 2019: 3.1%

Stability First

- 2018: 6.6%
- 2019: 6.0-6.5%

I. Shrinking Trade
- Trade friction
- Unilateral sanctions

II. Contracting Real Economy
- The manufacturing PMI has decreased by 3.8% since the beginning of 2018

Employment: Stable
Finance: Stable
Foreign Trade: Stable
Foreign Investment: Stable
Investment: Stable
Expectation: Stable
2. Whether the Energy Industry Can Achieve Sustainable Development?

**Production:** A clean, efficient and diversified energy supply system is forming

- **Coal**
  - Capacity clearance has been basically completed

- **Oil & Gas**
  - Upstream investment continues to recover

- **New Energy**
  - Subsidized development → connotative development

**Reform:** The process of marketization has been accelerated

- Crude oil futures trading launched: 2018.3
- Subsidies for PV reduced: 2018.5
- Liberalization of petroleum retail market: 2018.6
- Upstream investment continues to recover: 2018.6
- Electricity spot market operating: 2018.8
- Establishment of China Pipelines Corp.: 2019

**Consumption:** The goal of optimizing energy structure was achieved ahead of schedule

- **Total amount of energy consumption**
  - Billion tonnes oil equivalent
  - The 13th five-year plan: 2018

- **Energy consumption per unit of GDP**
  - Tonnes of oil equivalent / RMB ten thousand yuan
  - 2019E: 0.43
  - 2018: 0.45
  - ’three five’ target: 0.42

**Technology Development:** The cost of non-fossil energy continues to fall

- Cost of PV power generation
  - Before 531 Policy: 6 yuan/W
  - After 531 Policy: 4.14 yuan/W
  - Parity level: 4 yuan/W

- Offshore wind power generation has been developed rapidly
  - 2018: 2.10GW
  - 2019: 2.6GW
3. Will Gas Supply be very tight in 2019?

More rational demand
Fuel conversion from coal-to-gas will be more rational.

Urban Gas

Industry

Electricity Generation

Chemistry

Year-to-year growth: 10.1% (2018: 17%)

305 Bcm

+28 Bcm

More sufficient supply
The establishment of production, distribution, storage and sales systems has been stepped up.

Production: Domestic gas production will be increased by over 7%

313 Bcm

+33 Bcm

Year-to-year growth: 11.7%

(2018: 15.9%)

Supply:
Global LNG production +76%
LNG terminal: +6.40Mt/Y

Storage: Gas storage +3 Bcm

Pipeline network interconnection has been accelerated
• “Gas supply from South to North”: 30 Mcm/d
• Supply increase in Beijing-Tianjin-Hebei surrounding areas: 60 Mcm/d

Sales:
4. How Will the Operation of Private-owned Refinery and Petrochemical Capacity Influence the Market?

“3 Reconstructions” and “1 Breakthrough”

- Production capacity increase of ethylene and PX are equivalent to the amount of new capacity added in the past 4-7 years combined.

Reconstruction of oil refining and petrochemical industrial layout
- Refinery +40%
- Ethylene +4.8%
- PX +9.5%
- EG +2.0%

Reconstruction of trade flow

Reconstruction of synthetic fiber raw materials industry value chain
- PX Self-sufficiency Ratio: 2018 = 40%, 2019 = 60%
- EG Self-sufficiency Ratio: 2018 = 41%, 2019 = 48%

Breakthrough: Exports of refined oil has exceeded 5 million tons.
5. How Will the Market Demand Be in 2019?

**Demand of refined oil will weaken**
- Downturn of Auto: -3% to 0%
- Growth rate of auto consumption: -5%
- Growth rate will decrease: 2%
- Total volume will increase: 366 (2017), 379 (2018), 386 (2019E)

**Demand of petrochemicals will slow down**
- The supporting factors of last year disappeared: 47.2 (9.2% growth), 49.8 (5.5% growth)
- Focus on export: 2.1%
- Environmental protection /overhaul: 0.6%
- Ban of plastics import: 1.5%
- Basic growth: 4.9%
- Infrastructure construction will stand out: 4.3%

*end-use consumption

Unit: Million tons

- **Refining**: The low-sulfur requirement of bunker fuel will extend the refinery margin, but China’s margin will be lower than world average level for the reason of significant new capacity.

- **Petrochemical**: Under strongly increasing supply but decreasing demand, China’s Petrochemical profit ability will decline from high level.

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Northeast Asia Chemical Industry Profit Index

Average Gross Profit of Three Regions in World

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2019E
Thank you