Energy in 2018: An Unsustainable Path

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Chief US Economist & Head of Oil Analysis

#BPstats
2018: Primary energy, CO₂ emissions grew in tandem and at strongest rate in many years
Three countries account for 2/3 of 2018 growth.

Contribution to primary energy growth in 2018:

- China: 34%
- US: 20%
- India: 15%
- Other developing Asia: 10%
- Russia: 7%
- Middle East: 5%
- Africa: 3%
- Rest of world: 5%
Gas and renewables grew strongest vs trend

Annual change

2007-2017

2018
Price, GDP growth fail to explain increase

Annual change

-2% -1% 0% 1% 2% 3% 4% 5% 6%


Primary energy consumption
Predicted energy
But 2018’s weather effects help explain...
Model can account for some of the variation

Annual change

-2%  -1%  0%  1%  2%  3%  4%  5%  6%


Primary energy consumption
Predicted energy
Predicted energy (with weather effects)
China’s energy intensive sectors slowed in ‘14-16

Outputs of iron, steel and cement

Annual change

- Iron
- Crude steel
- Cement

2004-2014
2014-2016
2016-2018

-8%
-4%
0%
4%
8%
12%
16%
Chinese cyclical decline, rebound explains the rest

Annual change


Primary energy consumption
Predicted energy (with weather effects)
Predicted energy (with weather and Chinese industry effects)
Emissions grew because energy demand grew

Annual change

- Primary energy
- Fuel mix
- CO₂ emissions

2012-2017 2018
US growth offsets slowdown in rest of world

Demand growth by region

Demand growth by product

-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0

Mb/d

Average 2005-15
2016
2017
2018

China
India
US
Rest of world
Total

Average 2005-15
2016
2017
2018

LPG, naphtha, ethane
Jet Fuel
Other
Gas oil/Diesel
Gasoline
Total
Gasoline demand growth has sharply contracted since 2015

The US had always played a significant role ...

...but prices did not help.

The Brent price and gasoline demand relationship

Gasoline demand growth by region (1987-2018)

% Chg in Global demand (ex-US)
% Chg in US Demand
% Chg in Brent, $2018 (RHS)
US tight oil dominates global supply growth

Annual growth, Mb/d

<table>
<thead>
<tr>
<th></th>
<th>Average 2005-15</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>-0.1</td>
<td>1.0</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>OPEC</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Other</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>World</td>
<td>0.4</td>
<td>1.0</td>
<td>1.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>
The US set a record for the largest annual increase in oil production ...
... and is now a major component of global oil trade

US now accounts for 10% of exports

Yet it still imports 10 mb/d
OPEC+ “overcomplies” with its cuts

Oil production

Deviation from baseline*, Mb/d

0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0

Cut
Target cut

1st OPEC+ Agreement

2nd OPEC+

OECD stocks: deviation from 5-year moving average

Mbbls


*Baseline in the 1st OPEC+ Agreement was October 2016.
For the 2nd OPEC+ Agreement it was October 2018
US tight oil drives refinery utilization higher and offsets decline in Latin America
Natural gas
5% growth in gas production and consumption
The US double first: largest growth in oil and gas supply by any country and in same year

Annual growth, bcm

- US 2018
- Russia 2010
- US 2014
- USSR 1984
- Russia 2017
US gas demand grew at same rate as last six combined

<table>
<thead>
<tr>
<th></th>
<th>Power</th>
<th>Buildings</th>
<th>Industry</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average 2011-16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2018</td>
<td></td>
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</tbody>
</table>
Local air quality regs raise Chinese gas consumption

Annual change

- Industry
- Buildings
- Power
- Other

Average 2011-16
- 8%

2017
- 12%

2018
- 16%
10% increase in LNG exports last year
LNG prices fall to US exporters’ operating costs

Operating costs = 1.15* Henry Hub + $2/mmBtu (transport) ; Full costs also include liquefaction fee ($3/mmBtu)
Coal
World coal consumption

Annual change

-4% -3% -2% -1% 0% 1% 2% 3% 4%


Rest of world Other developing Asia*

India China USA Total

* Other developing Asia is defined as all Asia-pacific countries excluding four OECD countries, China, and India.
Power
Growth in power absorbed ½ of growth in primary energy

Contributions by region

<table>
<thead>
<tr>
<th>Region</th>
<th>2007-2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest of world</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>US</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>India</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>China</td>
<td>4%</td>
<td>4%</td>
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</table>

Contributions by fuel

<table>
<thead>
<tr>
<th>Fuel</th>
<th>2007-2017</th>
<th>2018</th>
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<tbody>
<tr>
<td>Other</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Gas</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Coal</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Renewables</td>
<td>1%</td>
<td>2%</td>
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</tbody>
</table>
Penetration of renewables now more widespread

1998

Number of countries

<table>
<thead>
<tr>
<th>Share of power generation</th>
<th>Number of countries</th>
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</thead>
<tbody>
<tr>
<td>1-5%</td>
<td>20</td>
</tr>
<tr>
<td>5-10%</td>
<td>0</td>
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<tr>
<td>10-15%</td>
<td>0</td>
</tr>
<tr>
<td>15-20%</td>
<td>0</td>
</tr>
<tr>
<td>+20%</td>
<td>0</td>
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2018

Number of countries

<table>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
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<td>10</td>
</tr>
<tr>
<td>15-20%</td>
<td>5</td>
</tr>
<tr>
<td>+20%</td>
<td>10</td>
</tr>
</tbody>
</table>
Although in the US renewables penetration has helped ...

2018: US Power Mix

- Natural Gas: 36%
- Coal: 28%
- Nuclear energy: 19%
- Hydroelectric: 6%
- Renewables: 10%
- Oil: 1%

Chart showing the share of different energy sources from 1998 to 2018.
... depressingly on a global basis, the fuel mix remains largely the same.
For most of last 20 years we’ve had electrification without decarbonization
Now that is changing, but it is not enough
What would it take to keep emissions levels flat?
Carbon emissions from power sector

Gt CO₂

2008 2010 2012 2014 2016 2018
Carbon emissions from power sector

Add renewable generation of China + US
Carbon emissions from power sector

- Add renewable generation of China + US
- 10% coal-to-gas switch
Conclusion
China: LPG, naphtha & ethane account for ~40% growth in 2018

China product demand growth

Kb/d

2006 - '15 avg.  2016  2017  2018

Gasoil/Diesel  Gasoline  Jet/Kero  LPG & Ethane  Naphtha  Other

Total

China passenger cars sales growth

% YoY

Jan  Mar  May  Jul  Sep  Nov

2017  2018  2019

Other: bitumen, biofuels, pet coke, refinery loss/own use.

Source: IHS Markit, China Association of Automobile Manufacturers
Cobalt and lithium prices

Cobalt price and supply

‘000 tonnes, US$/t

Lithium Price and Supply

‘000 tonnes, US$/t

Cobalt metal, Min 99.8% purity, Ex W Europe. Source: Benchmark minerals
European gas imports

Growth in European gas imports

European gas imports by source

- Russia
- Other pipeline
- Net LNG imports
- Total

Share

- Russia
- Africa
- Caspian
- Net LNG imports

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Wind and solar power

Net additions to installed capacity

<table>
<thead>
<tr>
<th>Year</th>
<th>Solar</th>
<th>Wind</th>
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<tbody>
<tr>
<td>2000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2006</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>2018</td>
<td>120</td>
<td>160</td>
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</tbody>
</table>

Net growth in generation

<table>
<thead>
<tr>
<th>Year</th>
<th>TWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>0</td>
</tr>
<tr>
<td>2006</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>0</td>
</tr>
<tr>
<td>2018</td>
<td>43</td>
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