## Where Have We Been? Where Are We Going? Will We Get There?

<table>
<thead>
<tr>
<th>Phase 1 2000 – 2011 Chinese Coal Growth</th>
<th>Phase 2 2012 – 2017 Coal to Gas Transition Begins</th>
<th>Phase 3 2018 Onwards Peak Coal and Beyond</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Driving Factors</strong></td>
<td></td>
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</tr>
<tr>
<td>- China experiences rapid:</td>
<td>- Shale gas boom</td>
<td>- Growth in population, economic development and energy demand in India, SE Asia and Africa</td>
</tr>
<tr>
<td>- Economic growth</td>
<td>- Climate change concerns</td>
<td>- Global gas access via LNG</td>
</tr>
<tr>
<td>- Energy demand growth</td>
<td>- Health concerns in China</td>
<td>- Renewable energy sources</td>
</tr>
<tr>
<td>- Low cost domestic coal</td>
<td>- ESG importance</td>
<td>- Increased effects of Phase 2 factors</td>
</tr>
<tr>
<td><strong>Outcome</strong></td>
<td></td>
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</tr>
<tr>
<td>- Global coal consumption grows by 60%</td>
<td>- Slowly, global coal consumption falls while gas consumption grows</td>
<td>- Energy demand growth is robust, coal retirement accelerates and renewables are unable to fill the void quickly</td>
</tr>
<tr>
<td>- China represents 84% of this growth</td>
<td></td>
<td>- This leaves natural gas as the rational high-growth energy source, but all molecules will be needed</td>
</tr>
</tbody>
</table>

### Phase 3 Factor Considerations

- **Transitions Are Tough**
- **Policy Does Not Equal Action**
- **Headlines (Maybe) Tell Part of The Story**
- **Economics and Capital Will Decide**
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I. Phase 1: 2000 – 2011, Chinese Coal Growth
## Energy Transition Periods of Focus

<table>
<thead>
<tr>
<th>Phase</th>
<th>Chinese Coal CAGR</th>
<th>Global Coal CAGR</th>
<th>Global Gas CAGR</th>
<th>Total Energy CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1: 2000 – 2011</td>
<td>8.6%</td>
<td>4.0%</td>
<td>2.5%</td>
<td>2.4%</td>
</tr>
<tr>
<td>Phase 2: 2012 – 2017</td>
<td>0.3%</td>
<td>0.3%</td>
<td>1.5%</td>
<td>1.1%</td>
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The diagram illustrates the change in total primary energy consumption (TWh) and the percentage of total energy consumed from various sources over time. The phases are labeled as Phase 1 (2000 – 2011), Phase 2 (2012 – 2017), and Phase 3.

- **Phase 1**: Chinese Coal CAGR 8.6%, Global Coal CAGR 4.0%, Global Gas CAGR 2.5%, Total Energy CAGR 2.4%.
- **Phase 2**: Chinese Coal CAGR 0.3%, Global Coal CAGR 0.3%, Global Gas CAGR 1.5%, Total Energy CAGR 1.1%.

Phase 1: China Drives Global Coal Consumption

- In 2000, the IEA forecasted that China would consume ~22,600 TWh of energy in 2020\(^{(1)}\), a level they reached in 2006.
- This energy growth was met predominantly by coal given domestic supply (Chinese coal represented 40% of global production in 2006\(^{(2)}\)) and relative economics.
- The factors that drove Chinese energy demand growth from 2000 – 2011 can be paralleled to India today (expected growth of: economic prosperity, population, industrialization and urbanization).

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II. Phase 2: 2012 – 2017, Coal to Gas Transition Begins
## Energy Transition Periods of Focus

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<thead>
<tr>
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Phase 2: Key Factors

Coal consumption falls by 2% from 2012 to 2017, while global energy demand rises by 7%

- Shale gas boom
- Coal faces increasing political and capital access challenges
- Global climate change concerns
- Increasing ESG focus and ‘Millennial Effect’
- Health concerns in China
Phase 2 Factors – Shale Gas Boom

- The shale boom in North America improved relative natural gas economics vs. coal.
- In 2000, coal and gas both represented 25% of US energy demand. In 2016, coal represented 16% while gas represented 32%.
- Although political, public and international pressure have an influence on coal vs. gas decisions, relative economics remain the most influential deciding factor.

**US Shale Dry Natural Gas Production**

**US Primary Energy Demand and Emissions**

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2. BP Statistical Review of World Energy, 2018; “Gas – Coal Price Spread” reflects power equivalent price; negative numbers reflect gas prices being lower than coal.
Phase 2 Factors – Environmental Effects of Coal

- Coal consumption produces 2x the greenhouse gas emissions ("GHG") and 5x+ the air pollutants relative to natural gas.
- The short term effect of air pollutants and long term expected effect of greenhouse gas emissions has driven a public, political and international response against coal consumption.

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**GHG Emissions by Energy Source**

- **Coal** produces ~2x the GHG as natural gas.

**Air Pollution by Energy Source**

- Coal produces ~5x the NOx and ~90x the SOx as natural gas.

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(1) World Nuclear Association. Represents Lifecycle Emissions, which include the overall impact of an energy source including each stage of production/construction and use.
(2) US Government Accountability Office. Represents emissions associated with each MWh of electricity generated.
Phase 2 Factors – Environmental / Health Concerns in Asia

- In 2013, air quality in China was reaching unprecedented levels of risk:
  - Fine particulate levels in Beijing briefly reached 40 times the limit recommended by the World Health Organization\(^{(1)}\)
  - Beijing air quality was deemed unsafe for more than 60% of the days in the first half of 2013\(^{(1)}\)
- In response, China’s State Council issued an Action Plan to reduce pollution associated with coal consumption, industrial production, and transportation.

**Chinese CO\(_2\) Emissions\(^{(2)}\)**

- CO\(_2\) Emissions
- Chinese Coal Consumption
- Chinese Gas Consumption

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Phase 2 Factors – ESG Performance Becomes More Prevalent

- UN initiatives related to ESG investing and reporting have had steadily increasing membership(1).
- Studies have shown that millennial investors are more likely to incorporate ESG factors into their investment decisions(2).
- The importance of ESG factors in capital decisions is likely to continue to grow.
- Population demographics may play a role in medium term energy transition decisions.

Relative Likelihood to Invest(2)

Invest in Companies Targeting Social / Environmental Goals
- All Individual Investors: 12%
- Millennial Investors: 22%

Invest in Companies Using High-Quality ESG Measures
- All Individual Investors: 9%
- Millennial Investors: 17%

Exit an Investment Due to Objectionable Activity
- All Individual Investors: 7%
- Millennial Investors: 15%

Principles for Responsible Investing Signatories(1)

Signatories (such as Azimuth) commit to incorporating ESG factors into their investment and ownership decisions

Number of Signatories
- 2006: 0
- 2008: 500
- 2010: 1000
- 2012: 2000
- 2014: 1500
- 2016: 2000

Relative Likelihood to Invest(2)

- All Individual Investors: 12%
- Millennial Investors: 22%

Percentage of Population Under 25 Years Old(3)

- World: 42%
- India: 47%
- US: 33%
- China: 31%

(1) PRI, December, 2017.
(2) Morgan Stanley, June 2016.
(3) Population Pyramid, data represents 2015.
Phase 2 Factors – Policy Pressure and Capital Access Challenges

**Anti-Coal Political Pressure**
- China aims to cut coal consumption by as much as 10% in major industrial hubs such as the Beijing-Tianjin-Hebei and Yangtze delta regions\(^{(1)}\)
- Established the Coal Exit Commission to develop the path to reduction and exit of coal-powered energy\(^{(2)}\)
- Under Alberta’s Climate Leadership Plan, coal-fired electricity generation will be phased out by 2030\(^{(3)}\)

**Capital Access Challenges\(^{(7)}\)**
- 19 banks have stopped direct financing to new coal mines, while 17 banks have stopped direct financing to new coal plants.
- Investment and insurance companies such as Allianz, Lloyds Bank, AXA IM, and BMO have announced plans to divest from coal companies.
- Chinese banks provided 60% of the $600 billion of global financing deployed to the top 120 coal developers from 2014 to 2017.

**Pro-Coal Political Support**
- Under the Draft National Energy Policy, coal is expected to remain at ~50% of total primary energy supply, with national capacity doubling by 2040\(^{(4)}\)
- The US intends to mandate the purchase of electricity from coal and nuclear plants on grounds of national security\(^{(5)}\)
- Japan revised their coal energy supply goals up from 10% to 26% of the total energy mix in 2030\(^{(6)}\)

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\(^{(2)}\) CNBC, August 2018.
\(^{(5)}\) White House Memo, May 2018.
\(^{(6)}\) Basic Energy Policy, May 2018.
\(^{(7)}\) Banktrack.org, The Guardian, Reuters, Company disclosure.
Phase 2 Factors – Alberta Case Study

Domestic Natural Gas Supply\(^{(1)}\)
- Alberta is currently producing \(\sim 12.4\) bcf/d.
- Alberta is the 6\(^{th}\) largest natural gas producer in the world.
- Only approximately half of the gas produced in Alberta is consumed in Alberta.

Environmental Considerations\(^{(2)}\)
- In 2016, almost 50\% of Alberta’s electricity generation was from coal.
  - Canada as a whole generated 9\% of its electricity from coal.
- In 2016, Alberta emitted the most greenhouse gases of any province.

Political Pressure\(^{(3)}\)
- In 2015, Alberta’s NDP government committed to phasing out coal power by 2030.
- Their plan included a $1.1bn payout to coal power companies, a new electricity market and C$45mm in transition expenses for coal communities.

Company Response\(^{(4)}\)
- “We’re actually looking at greening [our coal plants] by 2020, not 2030... Our belief is that it makes sense to move to gasification of those coal plants now” – Nancy Southern, President and CEO, ATCO, May 2017.

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\(^{(1)}\) Natural Resources Canada, 2018; XI Technologies; BP Statistical Review of World Energy, 2018.
\(^{(2)}\) Natural Resources Canada, 2018; Government of Canada, 2018.
\(^{(3)}\) International Institute for Sustainable Development (“IISD”), 2018.
\(^{(4)}\) Financial Post, 2017.
Phase 2 Outcomes – Coal Transition Begins

- Increasing coal retirements and declining coal builds demonstrates that the transition has begun.
- Coal’s percentage of total energy demand has fallen by 1% since 2008, while gas has risen by 1%\(^{(1)}\).
  - This level of impact demonstrates the scale and timeline of the transition

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Global Coal Capacity Builds vs. Retirements\(^{(1)}\)


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II. Phase 3: 2018 Onwards, Peak Coal and Beyond
## Phase 3 Key Factors

<table>
<thead>
<tr>
<th>Continuing Factors</th>
<th>Factor Importance Increasing</th>
<th>Critical Developing Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale gas boom</td>
<td>Increasing ESG focus and ‘Millennial Effect’</td>
<td>India, SE Asia and Africa Experience Massive Energy Demand Growth</td>
</tr>
<tr>
<td>Global climate change concerns</td>
<td>Coal faces increasing capital access challenges</td>
<td>LNG Development Alters International Gas Economics and Access</td>
</tr>
<tr>
<td>Health concerns in China</td>
<td></td>
<td>Advancements in Renewables Introduces Alternative Energy Source</td>
</tr>
</tbody>
</table>
Phase 3 Factors – India, SE Asia and Africa

- 300% more people are going through the “Tipping Point” today relative to the 40-year historical average. By 2025, approximately 60% of people on earth will be in the S-curve tipping point\(^{(1)}\).

- India and Developing Asia are entering periods of expected massive population growth and economic development which historically has coincided with energy use acceleration\(^{(2)}\).
  - We believe that this relationship is currently being under forecasted

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\(^{(1)}\) World Bank; International Monetary Fund; and Goehring & Rozencwajg, March 2018. Real USD from 2000. Goehring & Rozencwajg defines the “Tipping Point” as when an economy reaches a certain level of per-capita GDP which results in each additional unit of GDP per capita driving an estimated 3x more energy demand relative to countries not in the “Tipping Point”.

\(^{(2)}\) Source: BP Statistical Review of World Energy 2018; World Bank; and EIA. “Developed Asia” includes Hong Kong, Japan, Singapore and South Korea. “Developing Asia” includes Indonesia, Malaysia, Philippines, Thailand and Vietnam.
Phase 3 Factors – Continued Development of Global LNG

- Global LNG export capacity will grow significantly from now to the early 2020’s, driven by the US(1).
- The combination of technological improvements, increased global competition and a well supplied market should result in falling LNG costs globally.
- Creative project development, such as small-scale floating LNG projects (ex. Steelhead LNG) will also provide downward cost pressure.

**US LNG Export Capacity To Triple in 3 Years**(1)

**Increasingly Competitive Pricing**(1)(2)

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(1) HSBC Research, 2018.
(2) Bloomberg, 2018.
Phase 3 Factors – Renewables

Electricity Transition Considerations

- In 2017 the world generated 23,400 TWh from non-renewable sources, 11x renewables generation.(1)
- Full transition to renewable power sources would require significant storage or capacity overbuild, especially in areas that are not naturally suited to generation.
- Envisioned timelines for a transition to predominantly renewables based electricity generation fail to grasp the capital scale, geographical challenges and climate considerations.

Solar Generation Ability Visualization(2)

- The seasonal effect of solar radiation creates a requirement for either massive battery capacity or electricity generation overbuild.

Global Wind Atlas(3)

- Red = highly amenable to wind power generation

Replacing All Non-Renewable Electricity(4)

- Assumes battery capacity capable of storing peak seasonal generation for use in low season. The capital cost of these batteries would be >US$650 trillion.
- Alternative – build enough capacity that generation in low season would match power demand. If Germany were to do this, the solar panels and wind turbines would cover ~1/10 of the country’s land mass.

<table>
<thead>
<tr>
<th>Renewable Power Source</th>
<th>Required Nameplate Generating Capacity (TWh/yr)</th>
<th>Multiple of Total 2017 Capacity (x)</th>
<th>Cost of Required Capacity ($USbn)</th>
<th>Multiple of 2017 Total Global Renewables Spend (x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% Solar Generation</td>
<td>159,289</td>
<td>126x</td>
<td>$22,502</td>
<td>86x</td>
</tr>
<tr>
<td>100% Wind Generation</td>
<td>98,045</td>
<td>78x</td>
<td>$16,229</td>
<td>62x</td>
</tr>
<tr>
<td>Current Solar / Wind Split</td>
<td>119,640</td>
<td>95x</td>
<td>$18,361</td>
<td>70x</td>
</tr>
</tbody>
</table>

(2) Per Energy Matters, reflects illustrative conditions at 40 degrees north latitude (New York City).
(3) Per World Bank Group, 2018.
(4) Electricity generation analyzed by country/region, applying assumed load factors and seasonal variation based on latitude / historical results for solar and historical results for wind. Capacity and battery capital costs per Lazard, 2018. "Current Solar / Wind Split" reflects the assumption that each country level proportion of wind vs. solar is maintained.
Power density per square meter shows the ‘orders of magnitude’ of the challenge in alternative power sources.

- Global fuel mix since 2000 shows enormity of shift – adage “costs more and takes longer” will apply.
- The capital cost required to transition global energy generation is daunting.

(1) Vaclav Smil, University of Manitoba.
IV. Phase 3 Factor Considerations
Phase 3 Factor Considerations – Transitions are Tough

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**Share in Primary Energy Over Time**

- Transition time to renewables, given the scale of the problem, has regularly been underestimated
  - Early cost reductions and growth rates do not scale – transitioning becomes more difficult with time
- Intermittency and grid quality/transmission distance are complex and costly challenges to solve
- Transition goals often ignore the lack of commercial alternatives for cement, steel, plastics (all required for renewables), heavy duty engines (planes, ships, trucks), and ammonia (processed from natural gas and required to feed 40-50% of global population).

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(1) Vaclav Smil, University of Manitoba. CLSA, 2016.
"Over the past two decades, Germany has focused its political will and treasure on a world-leading effort to wean its powerful economy off (of) traditional energy sources”


**Germany Case Study**

US$222 billion has been spent on renewable subsidies since 2000

Marginal decrease in hydrocarbon use
Electricity prices have doubled
CO₂ emissions have declined minimally

For over a decade there has been a global effort to increase renewable energy generation.

Despite almost $3 trillion in capital, renewable energy still constitutes a very small portion of global energy supply.

"Since 2004 the world has invested US$2.9 trillion in green energy sources...the central message of the report is clear. The renewable energy market continues to make remarkable progress."

Phase 3 Factor Considerations – Policy Does Not Equal Action

- 181 Parties have ratified the COP21 Paris Agreement.
- In June, a report by CANEurope found that all 28 EU member nations were failing to meet Paris Agreement obligations(1).
- Currently operating coal capacity, reflecting expected retirements and before including new builds planned for the coming decade, will produce emissions well beyond Paris targets(2).

(1) “CANEurope” refers to the Climate Action Network Europe, June, 2018.
(2) Climate Analytics, 2016. Coal capacity reflects known projects with estimated retirement dates and capacity factors based on country averages if not publicly stated.
## Phase 3 Factor Considerations – Headlines (Maybe) Tell Part of The Story

<table>
<thead>
<tr>
<th>Media</th>
<th>Reality</th>
</tr>
</thead>
</table>
| “Coal’s days numbered as countries pledge to end use” – FT, November 2017 | • The list includes 20 countries representing 2% of global coal consumption
• The largest coal consuming country on the list is Canada
• Canada generates 5% of their total energy with coal and represents 0.5% of global coal consumption |
| “UK carbon emissions in 2016 are about 36% below 1990” – The Guardian, March 2017 | • The UK has outsourced carbon pollution overseas by importing more steel, cement and other goods from places such as China
• **If emissions related to imports are included, the UK is approximately flat from 1990**
• Approximately 13% of Chinese emissions and 20% of India’s emissions were related to manufacturing for export
• By having a coal-heavy electrical grid, **Chinese steel emits 23% more CO₂ per ton** than steel produced in America and Germany |
| “HSBC will stop providing financing for new coal-fired power plants as part of its efforts to support a transition to a low-carbon economy” – HSBC, April 2018 | • This announcement excluded Vietnam (9th largest coal consumer), Indonesia (15th largest coal consumer) and Bangladesh
• A few weeks later **HSBC announced the financing of half a dozen new coal plants in Vietnam and Indonesia** |

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(3) ESG Clarity, June 2018.
Phase 3 Factor Considerations – Economics and Capital Will Decide

- In the United States, competitive economics suggest gas should be the predominant electricity new-build.
  - The US represents 17% of electricity generation today, but will only represent 5% of generation growth to 2030(1).
- In China and India, coal economics are expected to still be relatively more compelling vs. gas in 2020.
  - China and India represent >50% of the expected growth in electricity generation between now and 2030(1).
- Once built, facilities are expected to be operational for 30-40 years.
- Large scale renewables generation requires massive storage infrastructure, a conducive natural environment and a sophisticated grid – this is not the case in most of the developing nations that will drive energy demand growth.

2020E New-Build Levelized Cost of Energy (US$/MWh)(2)

V. Closing Considerations
Closing Considerations

Key Considerations

1. We will need all molecules

2. Global energy transition speed will be overestimated

3. Renewables will continue to grow, but in absolute terms will remain a minor component of global energy in the medium term

4. Gas will play an increasingly important role in global energy growth

5. The decisions made by China, India and Africa over the next decade will dictate the future of energy
