Energy Scenarios to 2040:

What it Takes to Reach INDCs and Beyond

April 2016
Enerdata: a global energy intelligence company

- **Independent** energy research & consulting company since 1991
- Spin-off of CNRS research center
- **Expert** in analysis and forecasting of global energy & climate issues
- **In-house** and globally recognized databases and forecasting models
- Headquartered in the Grenoble (French Alps) research cluster
- Offices in Paris, London and Singapore + network of partners WW
- **Global reach**: clients in Europe, Asia, Americas, Africa
EnerFuture workshop

- Introduction
  Methodology and scenarios overview

- Ener-Blue
  INDCs based scenario

- Ener-Green
  2°C max. increase scenario

- Supply

- Focus on China

- Focus on EU-28

- Conclusions
Methodology and scenarios overview
EnerFuture: global energy scenarios to 2040

Alternative assumptions for key drivers: resources, climate and energy policies, available technological options ...

POLES Model

With identical macro-economic hypothesis: population, GDP growth ...

Demand
Global & regional dynamics, fuel mix, efficiency ...

Supply & Prices
Availability, self-sufficiency, trade, bills ...

Sustainability
CO₂ emissions ...

... allows us to explore different pathways for energy markets
Description of the EnerFuture scenarios

<table>
<thead>
<tr>
<th>Ener-Blue</th>
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<th>Ener-Brown</th>
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<td>▪ Increase in developing countries</td>
<td>▪ Global stabilization</td>
<td>▪ Limited improvement on energy intensity</td>
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<td>▪ Stable in OECD</td>
<td>▪ Ambitious energy efficiency policies</td>
<td>▪ High growth in developing countries</td>
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<td>▪ Controlled through INDCs</td>
<td>▪ Regular updates of efficiency targets</td>
<td>▪ Growth in OECD too</td>
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<td>▪ Tensions on available resources</td>
<td>▪ Fossil fuel subsidies phase-out</td>
<td>▪ Fossil fuels renaissance</td>
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<td>▪ Increasing energy prices</td>
<td>▪ Strong development of renewables</td>
<td>▪ Lower energy prices</td>
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<td>▪ Diversification towards renewables</td>
<td>▪ Price increase reflect policies and CO₂ constraints</td>
<td>▪ Strong fossil fuel technological improvement</td>
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<td>▪ Continued efforts on renewables</td>
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Key energy indicators by scenario

Primary demand

Share fossil fuels in energy mix

Energy intensity

GHG emissions level

Source: EnerFuture
Ener-Blue: key outputs

based on INDCs’ targets achievement
Expected economic recovery will drive up energy consumption...

Population

GDP

Energy demand

Source: UN World Population Prospects (2015 Revision)

Source: IMF outlook (2014 – 2020)
CEPII Baseline (2021 – 2040)

Source: EnerFuture
Comparison base year: 2010
... pulled by developing countries, when OECD demand stabilizes.

2014 (13.3 Gtoe)

2040 (17.3 Gtoe)

OECD 30%
Non-OECD 70%

OECD 40%
Non-OECD 60%

USA
EU-28
Japan
S. Korea
Rest OECD
China
India
Russia
Brazil
Rest Non-OECD

Source: EnerFuture, Ener-Blue scenario
Fossil fuels’ domination decreases from 80% to 70% of the mix...

... impacted by the high increase in renewables sources.

Source: EnerFuture, Ener-Blue scenario
Understanding our Energy Future - April 2016
INDCs are key targets to ensure global GHG emissions reductions ...

**Reduction efforts of CO₂ intensity* in G20, INDC target recalculated vs 1990**

- **USA**
  - -26% to -28% GHG emissions by 2030 vs 1990

- **EU-28**
  - min.-40% GHG emissions by 2030 vs 1990

- **China**
  - -60% to -65% (CO₂ intensity) by 2030 vs 2005

- **Russia**
  - -25% to -30% GHG emissions by 2030 vs 1990

- **Brazil**
  - -33% to -35% (carbon intensity) by 2030 vs 2005

- **India**
  - -43% GHG emissions by 2030 vs BaU

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* CO₂ intensity of GDP: ratio of CO₂ emissions to GDP, excl. LULUCF

**Source:** UNFCCC, submitted INDCs

G20 represent ~85% of GHG global emissions

... but ambitions remain different depending on the countries.
In Non-OECD countries, energy intensity is more than halved over 2010-2040...

...and converges toward OECD countries’ levels.

Source: EnerFuture, Ener-Blue scenario
INDCs lead to a growing decoupling between GHG emissions and GDP, mostly in OECD...

...however these improvements are not sufficient to cope with global climate challenges.

Source: EnerFuture, Ener-Blue scenario
Ener-Green key outputs

from COP21 INDCs to a 2°C ambition
GHG emissions reductions implied by INDCs are not sufficient to reach the 2°C target ...

... Strengthened efforts and policies are necessary to ensure GHG emissions compatible with the UN 2°C goal.

* excl. LULUCF

Source: UNFCCC, submitted INDCs and EnerFuture

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70% of additional emissions reduction should come from Non-OECD

... and China would represent ~1/3 of the global additional efforts to be made to reach the +2°C objective.
Reaching the 2°C target leads to an important shift in the energy mix...

- Very high growth of RES (+ nuclear development)
- While coal production would dramatically decrease.

Source: EnerFuture, Ener-Blue & Ener-Green scenarios
To reach the 2°C objective, the coal share in power would decrease dramatically...

... despite the deployment of carbon capture and storage technology which would reach 20% of coal installed capacities in 2040

Source: EnerFuture, Ener-Green scenarios
All sectors should contribute to the necessary energy demand stabilisation...

... accompanied by an increased electrification.

Source: EnerFuture, Ener-Blue and Ener-Green scenarios
Understanding our Energy Future - April 2016 26
Additional costs and investments will be needed to reach the 2°C target...

... on the other hand, climate and energy policies should enable to decrease significantly the energy import costs.

* Excluding subsidies.

Source: EnerFuture, Ener-Blue and Ener-Green scenarios

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EnerBlue – EnerGreen – EnerBrown

Focus on supply

- oil
- gas
- coal
- nuclear
- renewables
Fossil fuels stay at 76% in Ener-Brown and 70% in Ener-Blue, but fall down to 50% in Ener-Green.

RES + Nuclear vary from 24% (Ener-Brown) to 50% (Ener-Green).
Global oil demand is strongly impacted by climate and energy policies

China becomes the biggest oil consumer around 2020, followed by the USA and India.

Top oil producers, Ener-Blue

Source: EnerFuture
Global gas consumption continues to increase excepted in Ener-Green

Global gas production, 2000-2040

Source: EnerFuture

7 countries concentrate ~60% of the global production.
Global coal production decreases only in Ener-Green, but sharply.

China remains the biggest coal consumer (~75% of the Asian demand in 2040 in Ener-Blue), followed by India and the USA.

Source: EnerFuture
Nuclear development participates to climate and energy policies, especially in Asia...

- China: 22% of the total installed capacities
- Japan restarts, India + rest of Asia grow, CIS too...
- Germany completes its phase-out

Source: EnerFuture, Ener-Blue scenario
Renewables will continue to develop strongly in all regions of the world...

... and China will represent more than 40% and 30% of the total installed wind and solar capacities respectively.

Source: EnerFuture, Ener-Blue scenario
Regional focus: China
In China, huge additional efforts will be required to enable the global 2°C target...

... with long-term GHG reduction mainly driven by power and industry.

Source: EnerFuture
RES in China: around 40% of total installed capacities in 2030 (Ener-Blue)...

**New installed capacities in China, Ener-Blue**

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<td><strong>Renewables (GW)</strong></td>
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<tr>
<td>of which wind (GW)</td>
<td></td>
<td>8</td>
<td>21</td>
<td>52</td>
</tr>
<tr>
<td>of which solar (GW)</td>
<td></td>
<td>0</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td><strong>Fossil (GW)</strong></td>
<td></td>
<td>66</td>
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<td>57</td>
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<td>of which oil (GW)</td>
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</tr>
<tr>
<td>of which gas (GW)</td>
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<td>11</td>
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<td>of which coal (GW)</td>
<td></td>
<td>63</td>
<td>93</td>
<td>45</td>
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<td></td>
<td>1</td>
<td>10</td>
<td>6</td>
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**Official targets and indicators, Ener-Blue**

**Target 2020**

- **Wind**: 200 GW
- **Solar**: 100 GW
- **Nuclear**: 85 GW

**2014-2030 Capacities & Production**

- **Wind**: x4 x6
- **Solar**: x10 x19
- **Nuclear**: x6 x7

... and more than 50% of additional capacities after 2025.

*Source: EnerFuture, Ener-Blue, scenario*
Regional focus: European Union
EU’s 2030 target on emissions mainly reached via the deployment of renewables & efficiency

... with a decarbonisation principally achieved in the power and transport sectors.
Enabling the 2°C target will heavily depend on demand reduction and renewables...

... but options will also include fossil fuel switch (coal to gas) and processes improvement.
In the power sector, EU’s climate policies mainly affect coal generation costs, benefiting gas…

... but its attractiveness is eventually reduced as renewables become a very competitive option.

Source: EnerFuture, Ener-Green scenario
Conclusions
EnerFuture scenarios – wrap up

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| **KEY OUTPUTS** | | |
| ▪ Demand: +30% over 2014-40, up to +50% in Non-OECD | ▪ Global demand stabilization below 14 Gtoe | ▪ Demand continuous growth: +45% over 2014-2040 |
| ▪ Energy mix transformation: less fossil (70% in 2040), RES share >20% by 2040 | ▪ Fossil fuels share <50% by 2040- big coal decrease | ▪ Fossil fuels stay at 75% and grow in volume, with gas gaining market share |
| ▪ Energy intensity divided by 2 over 2014-2040 | ▪ RES + nuclear development: 70% of power capacities (2040) | ▪ 40% of global natural gas supply will come from shale gas in 2040 |
| ▪ GHG emissions stabilization around 44 GtCO2eq, thanks to RES and Energy Efficiency | ▪ GHG emissions reach ~21 GtCO₂eq; 70% of reduction efforts in Non-OECD countries | ▪ RES power production also grows: x2.3 over 2014-2040 |
| ▪ CO₂ shadow price ~30€/tCO₂ in 2040 (~70€/tCO₂ in the EU) | ▪ Add. costs + investments (CO₂ shadow price >400€/tCO₂) balanced partially by lower fuel costs | ▪ GHG emissions growth: +33% over 2014-2040, reaching 53 GtCO2eq |
Thank you for your attention!

About Enerdata:

Enerdata is an energy intelligence and consulting company established in 1991. Our experts will help you tackle key energy and climate issues and make sound strategic and business decisions. We provide research, solutions, consulting and training to key energy players worldwide.

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