Evaluating the Implication of COP21 for Energy Security in EU28

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Context and motivation

RIPPLES project: Results and Implications for Pathways and Policies for Low Emissions European Societies.

• What is the impact of Nationally Determined Contributions (NDC) on economy and climate?
• Which steps are needed to attain deeper, more ambitious decarbonisation targets.
• Socio-economic consequences of climate policy and COP21 objectives.

Energy security:

• What is the impact on energy security?
• Which of climate scenario is the most suitable for European countries?
Energy Security definition

• Energy security policies must ensure (IEA):
  - Uninterrupted availability of energy sources at an affordable price.
  - Cover or reduce risks that affect energy sector.
  - Sustainable development of economy.

• The best way of approaching the question of energy security is to identify and to describe the energy security dimensions.
Energy Security dimensions

1) **Availability** – the availability of energy resources, diversification and the energy (in)dependency.

2) **Affordability** – “the capacity to produce energy services at the lowest cost, to have predictable energy prices and to enable equitable access to energy services” (Sovacool and Mukherjee, 2011)

3) **Sustainability** – preserve and protect the environment and living conditions, tackle climate change. The effects should persist over time.

4) **Resilience to risks** – “How the energy services can survive unexpected events that disrupt efficient operation?” (Sovacool and Sanders, 2014)

5) **Economic development** – the ability of domestic economy to maintain or raise the standards of living

6) **Electricity grid reliability** – the capacity of power system to maintain the supply-demand equilibrium at any time.
POLES: year-by-year recursive simulation process
Security dimensions (3) and indicators (18)

Availability

- Energy diversity indexes, where $p_i$ is a share of energy source or supplier:
  - Shannon-Wiener Index:
    $$SWI = -\sum_{i=1}^{n} p_i \log(p_i)$$
  - Herfindahl–Hirschman Index:
    $$HHI = \sum_{i=1}^{n} p_i^2$$
- Energy intensity.
- Import dependency (ratio).

Affordability

- Energy bill per dwelling

Electricity

- Capacity factor
  - Biomass
  - Oil
  - Coal
  - Natural gas
- Share of solar and wind
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Scenarios up to 2050

**Baseline**: no climate policy scenario, used for benchmarking.

**INDC +30**: Until 2030 countries limit their ambition to the NDCs. The strong acceleration in climate policy and a significant breakthroughs of investment costs are necessary after 2030 to reach 2°C/3°C target.

**Early action**: early climate policy action is combined with a significant breakthroughs of investment costs in 2020.

**1.5°C**: no-RIPPLES scenario, that reaches 1.5°C in 2100, relying on very high carbon prices and a high share of solar and wind in electricity generation.
Scenarios:

<table>
<thead>
<tr>
<th>Type</th>
<th>Type</th>
<th>Carbon price 2050 ($/tCO2)</th>
<th>Emissions 2050 / 2000</th>
<th>World carbon budget 2011-2050 (GtCO2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>7°C</td>
<td>0 DEV*</td>
<td>-29% EU28 / +97% World</td>
<td>1700</td>
</tr>
<tr>
<td>INDC + 2030</td>
<td>3°C</td>
<td>586 DEV*</td>
<td>-87% EU28 / -65% World</td>
<td>1150</td>
</tr>
<tr>
<td>Early action</td>
<td>2°C</td>
<td>586 DEV*</td>
<td>-90% EU28 / -79% World</td>
<td>815</td>
</tr>
<tr>
<td>1.5°C</td>
<td>1.5°C</td>
<td>2045 DEV*</td>
<td>-88% EU28 / -103% World</td>
<td>760 400 (for 2011-2100)</td>
</tr>
</tbody>
</table>

* DEV – all developed countries, EU28, Russia, South Korea
** INDEV – other countries (Africa, Asia, South America, Mexico)
World in Baseline scenario

Compared to 2010:

- Primary energy, coal and gas consumption +70%

- Oil consumption remains stable.

- High increase of biomass consumption (+220%).

- Solar and wind account for 22% in electricity generation.
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Diversity : Primary Energy consumption

- Primary consumption remains stable in **Baseline** scenario and decreases in mitigation scenarios (-29%).
- Increased diversity in all scenario (in average +25%) → primary energy diversity does not the result of a strong climate policy (in EU28).
- **1.5°C** scenario has the lowest increase of diversity.

<table>
<thead>
<tr>
<th></th>
<th>EU15</th>
<th>EU other</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>2\textsuperscript{nd} best</td>
<td>3\textsuperscript{rd}</td>
<td>2\textsuperscript{nd}</td>
</tr>
<tr>
<td><strong>INDC + 2030</strong></td>
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<tr>
<td><strong>1.5°C</strong></td>
<td>3\textsuperscript{rd} best</td>
<td>4\textsuperscript{th}</td>
<td>2\textsuperscript{nd}</td>
</tr>
</tbody>
</table>
Diversity: Electricity production

- Electricity production increases in all scenarios because electricity is a key lever to reduce GHG emissions.
- Electricity diversity increases between 2010 and 2050 in all scenarios, except for 1.5°C (high share of intermittent renewables).
- The highest diversity of European electricity is in Baseline scenario, but higher in INDC+30 and Early action scenarios for the rest of the World.

<table>
<thead>
<tr>
<th>Year</th>
<th>EU15</th>
<th>EU other</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>1st</td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>INDC + 2030</td>
<td>2nd</td>
<td>3rd</td>
<td>1st</td>
</tr>
<tr>
<td>Early action</td>
<td>3rd</td>
<td>2nd</td>
<td>1st</td>
</tr>
<tr>
<td>1.5°C</td>
<td>4th</td>
<td>4th</td>
<td>3rd</td>
</tr>
</tbody>
</table>
Diversity : Natural gas imports

• Gas imports to Consumption ratio: 70% in INDC+30 and 80% in other scenarios

• Share of Russian gas imports: 48%-55%

• The best diversity of imports is in Early action scenario, however there is little difference compared to Baseline.

• The only way to reduce gas dependency of some EU countries: common European gas market.
Dependence: Energy intensity

• European dependency on energy decreases in all mitigation scenarios.

• The energy intensity decreases more quickly in no-EU15 countries.

• Which scenario is the most suitable?
  • **1.5°C** for a half of EU28.
  • INDC+30 and **Early action** for another half.

• Country specific climate policy is more suitable that a common one (that is one of objective of RIPPLES project).

Energy intensity of GDP in EU28 (toe/$)
Import dependency ratio

• Increased biomass consumption, but 300 Gtoe in all scenarios. At worst, the import ratio is 37% for Greece (1.5°C).

• A strong decrease of gas import dependency ratio in no EU15 countries.

• Number of countries per scenario with the lowest import rate compared to other scenarios:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Biomass</th>
<th>Oil</th>
<th>Coal</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>2</td>
<td></td>
<td>Any significant change, except for:</td>
<td>1</td>
</tr>
<tr>
<td>INDC + 2030</td>
<td></td>
<td></td>
<td>Poland (0% → 100%)</td>
<td>7</td>
</tr>
<tr>
<td>Early action</td>
<td>6</td>
<td>All</td>
<td>R. Czech (100% → 0%)</td>
<td>6</td>
</tr>
<tr>
<td>1.5°C</td>
<td>15</td>
<td></td>
<td>R. Czech (100% → 0%)</td>
<td>15</td>
</tr>
</tbody>
</table>
Affordability: energy bill per dwelling

- **Small difference** between no 1.5°C scenarios, but slight increase for EU15 countries (8) and two no EU15 countries (Bulgaria and Estonia).

- Currently, Bulgaria has the highest rate of fuel poverty in EU28 → cannot afford climate policy

- Energy bill is 30-70% higher in 1.5°C.

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Capacity factor of power plants

If share of Solar + Wind in electricity generation < 55%:
  • No significant relation between share of I-RES and back-up capacities.

If solar + wind > 55%:
  • Capacity factor of oil and gas plant decreases.

If solar wind > 75%:
  • Low use of coal plants.
# Energy security in EU15 ➔ Early action

## Grid Analysis

<table>
<thead>
<tr>
<th>Diversity</th>
<th>Import dependency</th>
<th>Affordability</th>
<th>Solar Wind</th>
<th>Energy security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary energy</td>
<td>Electricity</td>
<td>Gas imports</td>
<td>Energy intensity</td>
<td>Oil</td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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# Energy security in no EU15 ➔ INDC +30

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- The climate policies are rather positive or neutral effect on European energy security:
  - Decrease energy dependency (included imports of fossil fuel and biomass).
  - Diversify primary energy consumption.
  - Does not increase energy expenditure in well balanced mitigation scenarios.
  - Positive impact is higher for developing countries.

- Can lead to some negative impacts in the case of high share of intermittent renewables and high carbon prices (e.g. +50/+70% for energy bill in dwellings).
Thank you for your attention