Impact of the Spanish electricity system transition on water resources using energy modelling and life cycle assessment

Cristina de la Rúa, Yolanda Lechón and Helena Cabal
Energy Systems Analysis Unit
CIEMAT
**INTRODUCTION**

The Nexus Energy-Water

**ENERGY FOR WATER** & **WATER FOR ENERGY**

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**Electricity consumption (GWh)**

Source: Aldaya and Llamas, 2013

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**Life cycle water consumption (gal/MWh)**

Source: Meldrum et al., 2013
Hydro, 15% of total gross production in 2010, 2013 and 2016
Life Cycle Assessment (LCA)

To assess the potential environmental impacts and resources used throughout a product’s life cycle from raw material acquisition, via production and use phases, to waste management.

UNE-EN-ISO 14040-44
Functional unit: 1 kWh
Ecoinvent v3.1 database (adjusted)

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Acidification</th>
<th>Eutrophication of freshwater bodies</th>
<th>Ecotoxicity of freshwater bodies</th>
<th>Water consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment method</td>
<td>Accumulated exceedance (Seppälä et al., 2006; Posch et al., 2008)</td>
<td>ReCiPe (Struijs et al., 2008)</td>
<td>USEtox method (Rosenbaum et al., 2008)</td>
<td>Swiss Ecoscarcity model (Frischknecht et al., 2007)</td>
</tr>
<tr>
<td>Units</td>
<td>moles of H+</td>
<td>kg of P equivalent</td>
<td>CTU (comparative toxic units)</td>
<td>Litre water equivalent</td>
</tr>
</tbody>
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**TIMES-Spain energy model**

- Optimisation model -> optimum energy system at minimum cost and maximum social welfare and sustainability
- Covering the whole energy system
- Technology rich
- 1 region
- Time horizon 2050
- Interconnections with France and Portugal for electricity exchange
METHODOLOGY

TIMES-Spain energy model

Identification of the different current and future technologies in the Spanish electricity system

Life Cycle Assessment

Environmental impacts of each technology per kWh.
Acidification, eutrophication, toxicity, and water consumption

Evolution of the electricity system until 2030 under EU 20-20-20 energy and climate package, and EU 2030 climate and energy strategy

Estimation of the impact that different electricity generation scenarios might have of different aspects of the W-E nexus
METHODOLOGY
Scenarios

**GHG emissions**
- 2020: BaU
  - Target 2030: -21%
  - Target 2030: -30%

**Renewable energy share**
- 2020: BaU
  - Target 2030: +20%
  - Target 2030: +27%

**Efficiency**
- 2020: BaU
  - Target 2030: +20%
  - Target 2030: +27%

**Electricity interconnection**
- 2020: BaU
  - Target 2030: 10%
  - Target 2030: 15%
RESULTS

Electricity production

![Diagram showing electricity production](image-url)

**BAU**

![Bar chart showing electricity production in BAU scenario](image-url)

**TARGET2030**

![Bar chart showing electricity production in TARGET2030 scenario](image-url)
RESULTS
Acidification

Potential increase in water and soil acidity caused by sulphur and nitrogen oxide emissions
RESULTS

Marine eutrophication

Increased of some limiting nutrients that trigger the growth of algae. As consequence, the light does not reach many other plants affecting to the whole ecosystem. The dead organic matter remains on the bottom of the water body, which decreases the available oxygen.
RESULTS
Ecotoxicity of fresh water bodies

When released to the environment, some polluting substances that reach fresh water have the potential to damage humans or ecosystems.
RESULTS
Water consumption

Water consumption in relation to water availability

<table>
<thead>
<tr>
<th></th>
<th>WATER CONSUMPTION</th>
<th>m3 eq/l/Wh</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td></td>
<td>0.00E+00</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td>1.00E-03</td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td>2.00E-03</td>
</tr>
<tr>
<td>2025</td>
<td></td>
<td>2.50E-03</td>
</tr>
<tr>
<td>2030</td>
<td></td>
<td>3.00E-03</td>
</tr>
<tr>
<td>2035</td>
<td></td>
<td>3.00E-03</td>
</tr>
</tbody>
</table>

- **BAU**
- **TARGET2030**
Other impacts different than Climate Change should be taken into consideration when analysing energy and electricity systems impacts.

Not only operation but all the fuel cycle should be considered in the impact analysis.

The reduction in electricity production with coal and the renewable technologies penetration lead to lower acidification and eutrophication impacts.

Fresh water ecotoxicity decreases in the first periods to increase from 2025 with the massive penetration of solar PV technologies.

Impact on water consumption is also reduced until 2030 when it starts increasing mainly due to CSP penetration.
REFERENCES

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