Development of a methodology to evaluate technology-specific discount rates for energy system optimization models

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Outline

Context

Aim of the work

Methodology

Results

Conclusions and perspective

15th June 2023
Semi-annual ETSAP Meeting
Context: the need for clean finance investments

- Clean energy investments must ramp-up to meet decarbonisation targets
- How to distinguish green from brown investments?

Annual global investment in clean energy in 2030 in IEA scenarios

IEA. CC BY 4.0.
ESOMs

- Multi-regional
- Partial equilibrium in competitive market with perfect foresight
- Technologically integrated and explicit

Hurdle rates

- Barrier for investments in high-risk projects
- In energy modelling, uplift the capital cost
- Usually based on educated guesses and/or assumptions
Aim of the work: What and how

WHAT?

Establish a methodology to clearly evaluate hurdle rates

Assign hurdle rates to technologies and combine the methodology with the EU Taxonomy

HOW?

Assess the impact of the hurdle rates in the technology choice in ESOMs and investigate the EU Taxonomy role in a decarbonisation scenario
Methodology: Summing up

- Economic database
- HR evaluation
- Technology database
- From ESOM
- Thresholds database
- EU Taxonomy

hurdle_part1.py

hurdle_part2.py

taxonomy.py

Technology database

Updated

Output data

Input data

ESOM

hurdle_part2.py

From ESOM Technology database EU Taxonomy

hurdle_part1.py

Economic database HR evaluation Technology database From ESOM Thresholds database EU Taxonomy
Methodology: Evaluation of the hurdle rates

- **Approach**: *Weighted Average Cost of Capital (WACC)*

\[
\text{WACC} = \text{WACC}(\text{CostOfEquity, CostOfDebt})
\]

\[
\text{CoE} = \text{CoE}(RfR, \beta_u, MRP)
\]

\[
\beta_u = \beta_u(\beta_L, D/E)
\]

\[
\text{CoD} = \text{CoD}(\text{EuropeanRfR, CDS})
\]

### Sector Hurdle rate values

<table>
<thead>
<tr>
<th>Sector</th>
<th>Hurdle rate values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>WACC formula</td>
</tr>
<tr>
<td>Transport</td>
<td>WACC formula</td>
</tr>
<tr>
<td>Power, Hydrogen and CCUS</td>
<td>Directly from literature</td>
</tr>
<tr>
<td>Commercial and Residential</td>
<td>Not treated</td>
</tr>
</tbody>
</table>

- **RfR**: risk-free rate
- **\(\beta_u, \beta_L\)**: unlevered and levered beta
- **MRP**: market risk premium
- **D/E**: debt-to-equity ratio
- **EuropeanRfR**: risk-free rate at EU level
- **CDS**: 10-year credit default spread of the country
Methodology: Application of the hurdle rates

- Technology name
- Input commodity
- Output commodity
- Emission activity
- Efficiency
- Year of availability

Is the tech already installed at the base year?

- NO
  - Import list of output commodities and beta, D/E associated with
  - Compute HR using the WACC formula
  - Assign HR according to the input commodity too
  - Import list of output commodities and HR associated with
The EU Taxonomy provides Technology Screening Criteria (TSC) for these six environmental objectives:

- Climate change mitigation
- Climate change adaptation
- Transition to a circular economy
- Pollution prevention and control
- Sustainable protection of water and marine resources
- Protection, restoration of biodiversity and ecosystems
Methodology: Integration of the EU Taxonomy and the nexus with the hurdle rate (II)

- Technology name
- Input commodity
- Output commodity
- Emission activity
- Efficiency
- Year of availability

Is the efficiency (and/or the emission activity) <(or >) EU Taxonomy threshold?

- EU Taxonomy thresholds:
  - Efficiency
  - Emission factors
  - List of technologies eligible by default

Import HR values

YES
Assign a penalty

NO
Assign a premium

Update HR value
Methodology: the TEMOA-Italy model

The model base year

SINGLE REGION

2006
2008
2010
2012
2014
2016
2018
2020
2022
2025
2030
2035
2040
2045
2050

Ref.: Nicoli et al., *Can We Rely on Open-Source Energy System Optimization Models? The TEMOA-Italy Case Study*, Energies, 2022
## Results: The studied scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Hurdle rates</th>
<th>Decarbonization target by 2030 (MtCO2)</th>
<th>Decarbonization target by 2050 (MtCO2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIC</td>
<td>Only a few</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR</td>
<td>Methodology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BAU w/ Taxonomy (26 bps)</td>
<td>Methodology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZE w/ Taxonomy (26 bps)</td>
<td>Methodology</td>
<td>226</td>
<td>36</td>
</tr>
<tr>
<td>NZE w/ Taxonomy (5 bps)</td>
<td>Methodology</td>
<td>226</td>
<td>36</td>
</tr>
<tr>
<td>NZE w/o Taxonomy</td>
<td>Methodology</td>
<td>226</td>
<td>36</td>
</tr>
</tbody>
</table>

15th June 2023

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Results: The impact of HRs within TEMOA-Italy sectors (I)

- Power sector

Share of renewable energy sources in the electricity mix

<table>
<thead>
<tr>
<th>Year</th>
<th>HR</th>
<th>BASIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022</td>
<td>50%</td>
<td>60%</td>
</tr>
<tr>
<td>2025</td>
<td>60%</td>
<td>70%</td>
</tr>
<tr>
<td>2030</td>
<td>70%</td>
<td>80%</td>
</tr>
<tr>
<td>2040</td>
<td>80%</td>
<td>90%</td>
</tr>
<tr>
<td>2050</td>
<td>90%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Decarbonisation scenario: Reduction of CO2 emission of 55% as to 1990 level by 2030, reaching 36 MtCO2 by 2050 (to be tackled by afforestation too (*))

Results: The EU Taxonomy within a decarbonisation scenario

Cumulative investment cost, 2025-2050

Total clean investment cost, 2025-2050

(*) MASE, Strategia italiana a lungo termine sulla riduzione delle emissioni dei gas ad effetto serra
Conclusions

❖ **Open-source** codes and database allow the community to share and update data
❖ Hurdle rates do not affect the results significantly, but they do enrich the analysis
❖ The methodology allows to evaluate in a flexible way the impact of schemes on costs

Perspective

Expand the methodology including:
❖ The **residential and commercial** sectors
❖ Other EU Taxonomy criteria
❖ The **social discount rate**
Thank you for the attention!