An input-output model for Irish economy- a preliminary study of stepwise substituting imported fossil-fuel electricity with renewable electricity

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More ambitious national Renewable targets

- In November 2016, EU revised RED target of at least 27% renewables of final energy consumption by 2030.
- Ireland is still heavily dependent on imported fossil fuels.

![Electricity output 2010](chart1.png)

- 90%

![Electricity output 2015](chart2.png)

- 84%

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>2010 Output</th>
<th>2015 Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>0.62</td>
<td>0.43</td>
</tr>
<tr>
<td>Peat</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>Oil</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0.18</td>
<td>0.26</td>
</tr>
<tr>
<td>Hydro</td>
<td>0.10</td>
<td>0.02</td>
</tr>
<tr>
<td>Wind</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>Landfill Gas</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Biogas</td>
<td></td>
<td>0.01</td>
</tr>
</tbody>
</table>
Electricity fuel mix has changed considerably

- Study facilitates an I-O analysis

Production structure (Monetary-terms) + Physical socio-economic indicator (e.g. GHG, employment)

Economy-wide impacts of shifting from imported fossil-based electricity to renewables
Environmental and socio-economic impact from decarbonising the economy- an IO perspective

Difficulty: Energy sectors are aggregated and environmental do not match the economic sectors

Approach: Irish I-O table is split so are sector’s GHG emissions and employment numbers

Analysis: Partial input-output substitutions of imported fossil fuels used for electricity with renewables
i. Disaggregation

Gas – Electricity prices (business & residential)

Source: SEAI
i. Disaggregation

Gas-electricity quantity (consumption)

\[ W_i = \frac{CF_{1i}PF_{1i}}{CF_{1i}PF_{1i} + CF_{2i}PF_{2i}} \]

- Gas and Electricity flow in 2010 - ~3800 ktoe

Source: SEAI
i. Disaggregation
Electricity-fossil & renewable

Electricity capacity (2010)
- Combined Cycle Gas Unit
- Open cycle gas unit
- Other gas power unit
- Coal fired steam
- Peat power unit
- Oil power unit
- Onshore wind unit
- Off shore wind unit
- Hydroelectric

Electricity-
- Fossil ~86%
- Renewable ~14%

O&M (2010)
- Combined Cycle Gas Unit
- Open cycle gas unit
- Other gas power unit
- Coal fired steam
- Peat power unit
- Oil power unit
- Onshore wind unit
- Off shore wind unit
- Hydroelectric

- 30% 16%
- 26% 10%
- 16% 4%
- 15% 8%
- 9% 9%
- 9% 2%
- 5% 1%
- 6% 2%

✓ ~86% Electricity-Fossil
✓ ~14% Electricity-Renewable
i. Disaggregation
Imports & primary inputs

**Imports for NACE 35**

- **Price factor**
  - Coal: 0.17
  - Gas: 0.26
  - Oil: 0.57

**Imports**

- Mining: 1030 million €
- Petroleum: 92 million €
- Chemical: 51 million €
- Services: 143 million €

**CF (Energy balance)**

- 15% non-fuel imports

**Imports**

- NG: 25%
- El-Fossil: 72%
- El-Renewable: 3%

17.5% VA - Gas
82.5% VA - Electricity

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Workshop on Sustainability Performance of the Energy Systems
i. Disaggregation
NACE35- GHG & Employment- disaggregated

![Disaggregated GHG & Employment](chart.png)

- **Gas**: 19%
- **Electricity-fossil**: 11%
- **Electricity-renewable**: 70%
ii. Substitution IO model

- Two substitution scenarios: 2% of fuel at 5 intervals
  - Scenario Gas: imported gas-value substitution
  - Scenario Coal: imported coal-value substitution

- Five direct substitution rates in I-O & in extensions:
  - $sub_{r1}$: subtracted from the imports coefficient of ‘electricity-fossil’ and added to the relevant coefficient in the I-O table
  - $Sub_{r2}$: Coefficient deduced from ‘electricity-fossil’ coefficient and added to ‘electricity-renewable’
  - $Sub_{r3}$: Coefficient deduced from ‘electricity-fossil’ GHG emissions.

- Balance the I-O table by adding an adjusted row

\[
x = Lf
\]

\[
L = (I - A)^{-1}
\]

\[
x_{v, m} = [\pi_{v, m} L] f
\]

\[
x_{e, 1} = [s_{e, 1} L] f
\]
Results

Trend of socio-economic changes

% IMPORTS SUBSTITUTION

% EMPLOYMENT CHANGES

% GHG CHANGES

-1.7
-1.1
-0.5

0
1
2
3
4
5

Gas imports substitution  Coal imports substitution
Result

Socio-economic benefits from decarbonising the economy

Non-energy sectors in both scenarios: 8-10% (Employment) 4-5% (Value-added)
Result
Socioeconomic losses and gains of electricity sectors

\[ y = -0.1107x + 0.0298 \]

\[ y = 0.5913x - 0.1834 \]

\[ y = -0.035x + 0.0094 \]

\[ y = 0.1345x - 0.0417 \]

\[ y = -0.2226x + 0.0298 \]

\[ y = 0.6098x - 0.081 \]

\[ y = 0.1387x - 0.0184 \]

\[ y = -0.0703x + 0.063 \]

\[ y = -0.2226x + 0.02 \]
Results
Sectors’ import

Each 2% substituting fuel imports for electricity with renewable electricity

% increased of imports - Electricity - renewable

Gas substitution
Coal substitution

Each 2% substitutions scenarios

€m imports reduction - All sectors

-50.0
-40.0
-30.0
-20.0
-10.0
0.0
1
2
3
4
5

Gas substitution
Coal substitution
Discussing remarks

- Decarbonizing scenarios are not very promising for job creation and value-added
- Renewable electricity is dominated by on-shore wind energy which relies totally on imports for turbine infrastructure
- On the other hand around 60% of job creation is associated to the infrastructure
- Required investment in renewables infrastructures to support the local market?
- Impacts on socio-economic indicators?

Source: SEAI
Concluding remarks

- IO-based analysis:
- Portrays all the economic activities of the system 😊
- Coefficients and multipliers rely on strong assumptions 😞
- Implicit assumptions in expanding renewable electricity 😞
  - There is (excess) capacity in all sectors and factors, e.g. (un)employed factors of production
- ...

Future work

- IO to CGE model linked with energy systems
  ✓ Analysing e.g.:
    - Impacts of **price changes** and **changing elasticities**?
    - Coal and gas substitution with renewables?
    - Overall environmental and socio-economic outputs of low carbon energy scenarios?
    - …?