New Zealand’s energy consumption and energy-related greenhouse gas emissions between 2006/2007 and 2012/2013

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Outline

- Background
- Literature
- Research Questions
- Models
- Results
- Conclusions
NZ context

Low-emissions transition

- Government’s target of net-zero carbon by 2050
- Energy sector accounts for 40% of the total GHG emissions
- Achieving government’s target relies on the understanding of NZ’s energy consumption
- Studying factors that influence energy consumption.

Energy consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>Energy consumption (Terajoules)</th>
<th>Energy related greenhouse gas emissions (kt CO2-e)</th>
<th>Total output (million NZ$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>538,735.07</td>
<td>36,658.86</td>
<td>36,658.86</td>
</tr>
<tr>
<td>2013</td>
<td>516,664.80</td>
<td>35,597.94</td>
<td>35,597.94</td>
</tr>
</tbody>
</table>
Research questions

- What drives changes in energy consumption and CO$_2$-e emissions?
- Which factor has increased/decreased energy consumption and CO$_2$-e emissions?
- Do the factors that influence energy consumption and CO$_2$-e emissions vary across sectors?
- What key sectors should we pay attention to when designing energy and climate policies?
Sample of literature

Environmentally-extended input-output (EEIO) analysis:

- An extended of traditional IO analysis first proposed by Leontief (1936).
- EEIO analysis establishes the linkage between economic activities and related natural resource utilization or pollutant emissions, thus integrating monetary flows with resource and emission flows (Cao et al., 2019).
- Moreover, it enables the calculation of direct and embodied resources consumption or pollutants emissions induced by different economic sectors and different final demand (Xie et al., 2019).
- Wide application:

Estimate patterns of energy consumption (He et al., 2019a; Liang et al., 2010), carbon emissions (Jiang et al., 2019; Zhang 2019), NOx emissions (He et al., 2019b), and evaluate the consequences of energy policies (Wu et al., 2019)

Structural decomposition analysis (SDA):

- SDA is based on IO analysis (Bagheri et al., 2018).
- The implementation of the SDA method is always for a given period (Guevara and Domingos 2017).
- The D&L technique - Dietzenbacher and Los (1998) because it involves fewer calculations.
Data

- National accounts input-output tables (Stats NZ)
  Year ended March 2007 and 2013

- Energy consumption data (MfE)
  Fuel combustion activities:
  Liquid fuels, Solid fuels, Gaseous fuels.

- Energy-related greenhouse gas emissions data (MBIE)

Wen et al. (2021)
Methodology

- **Input-output tables**
  - Integrate 106 sectors into 15 sectors for matching energy consumption and \( \text{CO}_2 \)-e emissions data.

- **Environmental input-output analysis**
  - Represent the economy based on input-output tables with energy consumption and \( \text{CO}_2 \)-e emissions data.

- **Structural decomposition analysis**
  - Assess driving factors and trace the energy/emissions flow.
## Scheme of input-output table of national economy

<table>
<thead>
<tr>
<th>Sector</th>
<th>Intermediate use</th>
<th>Final use</th>
<th>Total output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>Household expenditures</td>
<td>Government expenditures</td>
<td>Capital investment</td>
</tr>
<tr>
<td>1</td>
<td>$x_{11}$</td>
<td>$x_{12}$</td>
<td>...</td>
</tr>
<tr>
<td>2</td>
<td>$x_{21}$</td>
<td>$x_{22}$</td>
<td>...</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>n</td>
<td>$x_{n1}$</td>
<td>$x_{n2}$</td>
<td>...</td>
</tr>
</tbody>
</table>

Imports

Value added

Total input

$X_1$ $X_2$ $...$ $X_n$
Factors driving energy-related emissions change

- Production structure effect
- Demand structure effect
- Consumption volume effect
- Carbon intensity effect
- Population effect

Change in energy-related emissions
Structural decomposition analysis

\[ \Delta CO_2_{-e} = CO_{2-e}^T - CO_{2-e}^t = (CI^T L^T D^T S^T P^T) - (CI^t L^t D^t S^t P^t) = \Delta E_{CI} + \Delta E_L + \Delta E_D + \Delta E_S + \Delta E_P \]

Carbon intensity effect
Production structure effect
Demand structure effect
Per capita consumption volume effect
Population effect
Direct and indirect energy-related CO₂ equivalent emissions by sector in 2006/2007 and 2012/2013

About 60% of energy consumed by electricity generation and transport.

500MW of coal generation mothballed and retired.
Contribution of each factor to the decrease in energy-related CO$_2$ equivalent emissions
Contribution of decomposition factor to the decrease in energy-related CO₂ equivalent emissions by sector between 2006/2007 and 2012/2013

The share of renewables in TPES increased from 31.7% in 2007 to 38.2% in 2013.
Carbon intensity by sector in 2006/2007 and 2012/2013

- Agriculture, Forestry and Fishing
- Electricity Generation
- Oil & Gas Extraction & Processing
- Petroleum Refining
- Mining & Construction
- Chemicals
- Pulp, Paper & Print
- Food Processing, Beverage & Tobacco
- Textile
- Non-Metallic Mineral
- Basic Metals
- Mechanical and Electrical Equipment
- Other Manufacturings
- Transport
- Commercial & Residential

Carbon intensity (kt CO\textsubscript{2}-e/million NZ$)

2006/2007
2012/2013
Energy consumption by final demand

- **Consumption**: 2007: 200,000, 2013: 200,000
- **Investment**: 2007: 50,000, 2013: 50,000
- **Government**: 2007: 10,000, 2013: 10,000
- **Export**: 2007: 150,000, 2013: 200,000

- **2007**:
  - Consumption: 40%
  - Investment: 11%
  - Government: 10%
  - Export: 39%

- **2013**:
  - Consumption: 41%
  - Investment: 11%
  - Government: 11%
  - Export: 38%
Energy-related greenhouse gas emissions

Energy-related greenhouse gas emissions by final demand (Kt CO2-e)

- Consumption: 2007 - 14000, 2013 - 16000
- Investment: 2007 - 4000, 2013 - 5000

Comparative percentages:
- Consumption: 2007 - 40%, 2013 - 38%
- Investment: 2007 - 12%, 2013 - 11%
- Government: 2007 - 11%, 2013 - 11%
- Export: 2007 - 37%, 2013 - 40%
Carbon intensity by final demand category

<table>
<thead>
<tr>
<th>Category</th>
<th>2006/2007</th>
<th>2012/2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption</td>
<td>0.1913</td>
<td>0.1628</td>
</tr>
<tr>
<td>Government</td>
<td>0.1628</td>
<td>0.1133</td>
</tr>
<tr>
<td>Capital formation</td>
<td>0.1555</td>
<td>0.1335</td>
</tr>
<tr>
<td>Exports</td>
<td>0.2859</td>
<td>0.2806</td>
</tr>
</tbody>
</table>
Energy-related CO₂ equivalent emissions changes during this period by sector and demand component.
Conclusions

- Reducing **carbon intensity** has been proven to be the most effective way to restrict the growth of energy-related GHG emissions.

- Changes in the **structure of production and demand** contributed to a decline in energy-related GHG emissions.

- Changes in **population and consumption volume** increased energy-related GHG emissions.

- **Private consumption** and **exports** were the main sources of energy-related GHG emissions.

- “**Energy Generation**” and “**Transport**” are the two key sectors for decarbonization in New Zealand.
Policy recommendations

- **Promoting renewable energy**
  - 100% renewable electricity by 2030
  - NZ battery project – pumped hydro storage (Lake Onslow)
  - Hydrogen projects
  - Offshore wind potential coupling with hydrogen production

- **Decarbonize transportation - electrification of transport**
  - Phase out fossil-fuel vehicles & increase low-carbon transport alternatives
  - Incentives for EV purchases (charging infrastructure, range anxiety, and peer effects)
  - Smart integrated traffic systems
  - Strict emissions standards
Policy recommendations

- Changes in carbon intensity drove emissions up for “Chemicals”, “Non-Metallic Mineral” and “Food Processing, Beverage & Tobacco”.
  - Electrification of those sectors may be a solution to reduce emissions
  - Coal/gas boilers transition
  - Adoption of the efficient production process
  - Replacement of outdated machinery equipment

- Private consumption and exports were the main sources of indirect energy-related emissions.
  - Retrofit insulation schemes
  - Energy-efficient building standards
  - Energy Star certificated appliances, e.g., hot water cylinder and refrigerator, washing machine, etc.
  - Optimize the mix of exports, e.g., increase the share of less carbon-intensive products.
References


Thank you for your attention!

- **Dr Le Wen**
  - Research fellow, Energy Centre, University of Auckland
  - Research interests:
    - Renewable energy & electricity price
    - Energy efficiency & energy consumption
    - EV adoption via consumer behaviour
    - GHG emissions & climate change
    - Offshore wind coupling with hydrogen production
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