Should Chile use Renewables, Fossil Fuel or Hydropower for future electricity supply?

Evidence from a Contingent Valuation Study

Claudia D. Aravena Novielli
Queens University Belfast

10th IAEE European Conference 2009
7th – 10th September, Vienna
• Introduction
• Objective
• Methodology
• Results
• Conclusions
• Increase in energy demand
  • Special case of developing countries.

• Energy generation is one of the principal contributors to Global warming
• Increase in energy demand
  • Special case of developing countries.

• Energy generation as one of the principal contributors to Global warming
• Chile and other developing countries are characterized by:
  – Few developments of renewable energy projects.
  – No green power programs.
  – Few incentives for development of other alternative sources.

• But there is a need for:
  – Supply the energy needed and fulfil the environmental national goals.
• Principal Barrier

  – High cost of renewable energy sources

  – But... Does it include the cost of the externalities? What would happen if it is included? Would RE become more competitive?
• Principal Barrier

- High cost of renewable energy sources

- But... Does it include the cost of the externalities? What would happen if it is included? Would RE become more competitive?
• Principal Barrier

- High cost of renewable energy sources

- But... Does it include the cost of the externalities? What would happen if it is included? Would RE become more competitive?
• High and Increasing Demand of Electricity
  – 7% next years

Growth in
• Population
• Economic Activities
The current sources are not enough to supply the increasing demand for the next years

Restriction of Gas Supply from Argentina

ENERGY CRISIS
Current Energy Generation in Chile

- Fossil Fuels: 40%
- Hydropower: 59.98%
- Renewables: 0.02%
- FOSSIL FUELS
  - Oil
  - Coal
  - Gas

- RENEWABLE ENERGY
  - Wind power
  - Solar power
  - Biomass

- HYDRO POWER
  - with large dams in Chilean Patagonia
• Air pollution

• Negative health effects

• Visual effects

• Dependence
- **FOSSIL FUELS**
  - Oil
  - Coal
  - Gas

- **RENEWABLE ENERGY**
  - Wind power
  - Solar power
  - Biomass

- **HYDRO POWER**
  - with large dams in Chilean Patagonia
• Flooding more than 5000 Has

- cultivated lands
- wetlands
- primitive territories, with high diversity of fauna and flora
- important cattle farming
- agricultural and tourist areas
- biodiversity conservation zones, in which some endangered species as “huemules” exist, etc.
• Installation of a network of pylons crossing the Patagonian lands, which have high value in landscape and tourism.
• FOSSIL FUELS
  - Oil
  - Coal
  - Gas

• RENEWABLE ENERGY
  - Wind power
  - Solar power
  - Biomass

• HYDRO POWER
  - with large dams in Chilean Patagonia
Study the attitudes and preferences of the population in the central part of Chile.

Introduction and development of different energy sources and their environmental and social impacts.

Elicit WTP for renewable energy (RE) versus other sources (HE, TE). Future energy path.

Design and application of policies for the development of renewable energy sources.
CONTINGENT VALUATION

Analyse the willingness to pay of households for generating the energy by using renewable sources (which would be more expensive than traditional hydropower or fossil fuels), in order to avoid the environmental and social impacts of hydropower (large dams) and fossil fuels.

Use of Questionnaires
• Considering an indirect utility function:

\[ V_{oq} = V_{oq}(s_q, y_q), \quad \text{Status Quo (HE/TE)} \]
\[ V_{1q} = V_{1q}(s_q, y_q - \text{Bid}), \quad \text{Renewables} \]

• The probability of an individual to answer yes to the Bid is: (Haab and McConnell, 2003)

\[ \text{Pr}(yes) = \text{Pr}\left[ \varepsilon_q < (V_{0q}(s_q, y_q) - V_{1q}(s_q, y_q - \text{Bid})) \right] \]

• Assuming linear utility function

\[ V_{iq} = \alpha_i s_q + \beta_i y_q \quad \text{where} \quad \alpha_i s_q = \sum_{k=1}^{m} \alpha_{ik} s_{qk} \]

\[ \text{Pr}(yes_q) = \text{Pr}\left( \alpha s_q - \beta(Bid_q) + \varepsilon_q > 0 \right) = \text{Pr}\left( - (\alpha s_q - \beta(Bid_q)) > \varepsilon_q \right) \]

• Estimation: Interval data probit model. (Alberini, 1995)
• Comparison: Pair-wise bootstrapping (Hutchinson et al 2008)
• **Elicitation Format: Double Bounded Referendum**

  ![Elicitation Format Diagram]

• **Bid Design** (Scarpa and Bateman, 2007):
  - Hydropower (200, 500, 1000, 2000, 3000, 6000 CLP)
  - Fossil Fuels (500, 1000, 2000, 3000, 6000, 10000 CLP)

• **Payment Vehicle** ➔ Fix Part of Monthly electricity bill
• Brief description of the current energy situation of Chile.
• 2 Scenarios:
  • 1- **Hydropower** in Chilean Patagonia versus Renewable Energies.
  • 2.- **Fossil fuels** in the Central Chile versus Renewable Energies.
• **Renewable Energies** considered:
  – Biomass
  – Wind Power
- Personal interviews to households

- 2 Cities: Santiago and Concepcion

- Respondent: Responsible of paying the electricity bill.

- Sample selected from stratification of the cities and random selection of streets and houses.
• 726 responses were obtained
• Total responses:
• **Effective responses**: 711
• 328 correspond to Santiago.
• 383 correspond to Concepción.
• Elimination of Protest Answers
• Responses by source:
• **686 Responses for Hydropower**
• **664 Responses for Fossil fuels.**
• **Used**: 663 responses.
<table>
<thead>
<tr>
<th></th>
<th>Sample</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>51.6%</td>
<td>68.1%</td>
</tr>
<tr>
<td>Female</td>
<td>48.4%</td>
<td>31.9%</td>
</tr>
<tr>
<td>Age</td>
<td>43</td>
<td>49</td>
</tr>
<tr>
<td>Members of the Household</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Number of Children</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Education (Level of Education)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly income (Chilean Pesos)</td>
<td>720664</td>
<td>751000</td>
</tr>
<tr>
<td>Electricity Bill (Chilean Pesos)</td>
<td>20669</td>
<td>n.a.</td>
</tr>
<tr>
<td>Member of an Env. Organization</td>
<td>1.2%</td>
<td>n.a.</td>
</tr>
</tbody>
</table>
Know any current energy source | 75 %

<table>
<thead>
<tr>
<th>Preferences for sources for future generations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
</tr>
<tr>
<td>Gas</td>
</tr>
<tr>
<td>Coal</td>
</tr>
<tr>
<td>Hydro power</td>
</tr>
<tr>
<td>Wind power</td>
</tr>
<tr>
<td>Solar power</td>
</tr>
<tr>
<td>Biomass</td>
</tr>
<tr>
<td>Sea power</td>
</tr>
<tr>
<td>Geothermal Power</td>
</tr>
<tr>
<td>Nuclear Power</td>
</tr>
<tr>
<td>Have seen a dam directly</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Know about the Patagonian HP Projects</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TV</td>
<td>68%</td>
</tr>
<tr>
<td>Newspaper</td>
<td>31%</td>
</tr>
<tr>
<td>Radio</td>
<td>28%</td>
</tr>
<tr>
<td>Internet</td>
<td>14%</td>
</tr>
<tr>
<td>Friends</td>
<td>10%</td>
</tr>
<tr>
<td>Others</td>
<td>10%</td>
</tr>
<tr>
<td>Have visited Aysen</td>
<td>10%</td>
</tr>
<tr>
<td># of visits</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reason of visit</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tourism</td>
<td>69%</td>
</tr>
<tr>
<td>Work / Business</td>
<td>14%</td>
</tr>
<tr>
<td>Family</td>
<td>9%</td>
</tr>
<tr>
<td>Other</td>
<td>11%</td>
</tr>
<tr>
<td>Plan to visit the region</td>
<td>21%</td>
</tr>
<tr>
<td>Estimates</td>
<td>Source: RE instead of Hydropower</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Constant</td>
<td>2.347 (19.58)</td>
</tr>
<tr>
<td>Bid</td>
<td>-0.701 (18.00)</td>
</tr>
<tr>
<td>WTP</td>
<td>3347 (6.8 USD)</td>
</tr>
<tr>
<td>Std.Error.</td>
<td>130.40</td>
</tr>
<tr>
<td>Variable</td>
<td>Source: RE instead of Hydropower</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td></td>
<td>Coefficient</td>
</tr>
<tr>
<td>Constant</td>
<td>1.67 (2.98)</td>
</tr>
<tr>
<td>Bid</td>
<td>-0.79 (18.81)</td>
</tr>
<tr>
<td>Female</td>
<td>0.23 (1.33)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.02 (3.74)</td>
</tr>
<tr>
<td>Education</td>
<td>0.07 (2.34)</td>
</tr>
<tr>
<td>Income</td>
<td>0.0009 (3.19)</td>
</tr>
<tr>
<td>Dam</td>
<td>0.24 (0.53)</td>
</tr>
<tr>
<td>Heard about Project</td>
<td>-0.004 (0.024)</td>
</tr>
<tr>
<td>Plan Visit</td>
<td>0.57 (2.90)</td>
</tr>
<tr>
<td>Visited</td>
<td>-0.58 (2.10)</td>
</tr>
<tr>
<td>Know Source</td>
<td>0.38 (1.87)</td>
</tr>
<tr>
<td><strong>Mean WTP</strong></td>
<td>3486 (7.1 USD)</td>
</tr>
<tr>
<td><strong>WTP St. Error</strong></td>
<td>106.94</td>
</tr>
</tbody>
</table>
• Households in Chile have a positive WTP for the introduction and development of renewable energy compared with the traditional energy sources developed in the country nowadays (HE and TE).

• Concern for the environmental and social impacts that HE and TE projects would produce.

• WTP no statistically significant between the two HE and TE. Then,
  – 1\textsuperscript{st} Renewable Energy
  – 2\textsuperscript{nd} TE, HE ??
• Indication of the value of externalities generated from the different energy sources.

• Important consideration for evaluating energy programs and making decisions.

• Work ongoing: Aggregation, costs and Environmental Pricing
  – RE vs HE \(\rightarrow\) 340 millions of USD
  – RE vs TE \(\rightarrow\) 410 millions of USD

• Education and Income have significant effect on WTP-RE.

• Some factors that influence the willingness to pay for renewable energy vary depending on the alternative energy source (HE, TE) considered.
• **RE instead of Hydropower:**
  – Younger people have higher WTP.
  – Families who are planning to visit it.

• **RE instead of Fossil Fuels:**
  – Knowledge of the current sources

• No signs of effects in campaigns against projects in Patagonia. Better focus on would be needed.

• **Policy Implication:** Consideration of diversification in the energy mix with introduction of Renewable Energy.

• Introduction of policy instruments and green energy programs based on charges or tariffs for costumers and subsidies to the producers.
Questions

Contact Details:
Claudia Aravena
caravena02@qub.ac.uk
• **SCENARIO**

• Brief description of the current **energy situation of Chile**.

• Presentation and description of the **hydropower projects** in Chilean Patagonia (Patagonia, location of projects and impacts).

• Presentation and description of the **renewable energy sources** and its impacts.

• Description of the **fossil fuel sources** and its impacts.
• Introductory section

1.- Attitudinal questions
   – Different Energy Sources.
   – Information on visits of Patagonia.

2.- Contingent Valuation

3.- Background questions
   • (gender, age, education level, income and others)

4.- Interviewer questions