Bioenergy - I:
From Concept to Commercial Processes

March 5-10, 2006
Tomar, Portugal

Biogas Potential
In Chile

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SCHOOL OF BIOCHEMICAL ENGINEERING
Presentation outline

- Chilean energy law and its changes
- Biogas potential classification
- Real Biogas Potential in relation to the global energy matrix in Chile
Biogas Potential in Chile

13 Regions
15 mill. Hb.
Biogas Potential in Chile
### Chilean Electric System

<table>
<thead>
<tr>
<th>System</th>
<th>Hydro MW</th>
<th>Hydro %</th>
<th>Renewable Wind MW</th>
<th>Renewable Wind %</th>
<th>Biomass MW</th>
<th>Biomass %</th>
<th>Thermal MW</th>
<th>Thermal %</th>
</tr>
</thead>
<tbody>
<tr>
<td>SING</td>
<td>13</td>
<td>0,4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.620</td>
<td>99,6</td>
</tr>
<tr>
<td>SIC</td>
<td>4.619</td>
<td>59</td>
<td>0</td>
<td>0</td>
<td>153</td>
<td>2</td>
<td>3.108</td>
<td>39</td>
</tr>
<tr>
<td>Aysén</td>
<td>17</td>
<td>50</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>44</td>
</tr>
<tr>
<td>Magallena</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>78</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4.649</strong></td>
<td><strong>40</strong></td>
<td><strong>2</strong></td>
<td><strong>0,0</strong></td>
<td><strong>153</strong></td>
<td><strong>1,3</strong></td>
<td><strong>6.822</strong></td>
<td><strong>58,7</strong></td>
</tr>
</tbody>
</table>

*Biomass is discounted*
Chilean electric systems

The national electric generation matrix is quite clean, with an important component of renewable energies (hydraulic energy).
**Work approaches of the National Energy Commission (NEC) in NCRE**

**Strategy:** Identification and elimination of potential barriers that limit the development of the NCREs:

- Potentials and most attractive sites.
- Technology and costs under the Chilean reality.
- Business modalities and funding sources.

**Improving knowledge about:**
Principal changes of the Law

- Improve the technical and economical profitability of NCREs
- Legal assurance is given to the access to distribution networks to draw the energy generated by generators of <9 MW.
Small generation companies: commercialization options

- right to participate in the spot market and access to distribution networks.

- supply to distribution companies under better conditions established in the law.
### Probable impact of legal modifications

<table>
<thead>
<tr>
<th>Project</th>
<th>Power (MW)</th>
<th>Location</th>
<th>IRR preLaw</th>
<th>IRR postLaw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minihydr</td>
<td>3.5</td>
<td>IX Region</td>
<td>5.8 %</td>
<td>15.3 %</td>
</tr>
</tbody>
</table>
Biogas Potential in Chile

POTENTIALS

- Theoretical potential (resources)
- Technical Potential
- Real Potential (legal framework)
POTENTIALS

Theoretical potential (resources)

Technical Potential

Real Potential (legal framework)
Wood, chips

**Difficult collection**

**Combustion Biomass**

- Forestry
- Agroindustry
- Plantations waste
- Pruning and weed waste
- Livestock slaughtering
- Lipids
- WTP sludge
- Municipal solid waste (MSW)
- Poultry manure
✓ Alcoholic fermentation  
  (barley, grapes, apple)  
✓ Milk waste  
  (cheese borders and grease)  
✓ Fruit and vegetable waste  
  (dehydrated, frozen, pulp and juice production and canned)  
✓ Infusion beverages  

Anaerobic Digestion  

Forestry  
Agroindustry  
Plantations waste  
Pruning and weed waste  
Livestock slaughtering  
Lipids  
WTP sludge  
Municipal solid waste (MSW)  
Poultry manure
cereals, fruits, vegetables

Anaerobic Digestion

Forestry

Agroindustry

Plantations waste

Pruning and weed waste

Livestock slaughtering

Lipids

WTP sludge

Municipal solid waste (MSW)

Poultry manure
Forestry
Agroindustry
Plantations waste
Pruning and weed waste
Livestock slaughtering
Lipids
WTP sludge
Municipal solid waste (MSW)
Poultry manure

Anaerobic Digestion

municipal parks wastes
Forestry
Agroindustry
Plantations waste
Pruning and weed waste
Livestock slaughtering
Lipids
WTP sludge
Municipal solid waste (MSW)
Poultry manure

hooves, bones, hair, hide, rumen
Anaerobic Digestion

- Industrial waste
- Livestock slaughtering

- Forestry
- Agroindustry
- Plantations waste
- Pruning and weed waste
- Livestock slaughtering
- Lipids
- WTP sludge
- Municipal solid waste (MSW)
- Poultry manure
44% of sludge is biomethanized

Biogas 30% internal use
70% lost in burners

WTP: LA FARFANA

- Forestry
- Agroindustry
- Plantations waste
- Pruning and weed waste
- Livestock slaughtering
- Lipids
- WTP sludge
- Municipal solid waste (MSW)
- Poultry manure
## SLUDGES

<table>
<thead>
<tr>
<th></th>
<th>TON/DAY</th>
<th>60 % Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SANTIAGO</strong></td>
<td>208</td>
<td>260</td>
</tr>
<tr>
<td><strong>The entire country</strong></td>
<td>474</td>
<td>593</td>
</tr>
</tbody>
</table>

Biogas potential: ~ 50,000 m³/d (~ 250,000 KWh)
44% of sludge is biomethanized

Biogas 40% internal use
60% lost in burners

Landfill disposal
Another treatment system

Forestry
Agroindustry
Plantations waste
Pruning and weed waste
Livestock slaughtering
Greases
WTP sludge
Municipal solid waste (MSW)
Poultry manure
Anaerobic reactors

Sanitary landfill with biogas capture

- Forestry
- Agroindustry
- Plantations waste
- Pruning and weed waste
- Livestock slaughtering
- Greases
- WTP sludge
- Municipal solid waste (MSW)
- Poultry manure
Anaerobic reactors

Sanitary landfill with biogas capture 68%

Sanitary landfill without biogas capture 32%

Forestry
Agroindustry
Plantations waste
Pruning and weed waste
Livestock slaughtering
Greases
WTP sludge
Municipal solid waste (MSW)
Poultry manure
Biogas Potential in Chile

Available biomass

Dry biomass

Wet biomass

- Liquid industrial waste (LIW)
- Municipal waste water
- Cattle manure
- Pig manure
Biogas Potential in Chile

> 10 companies

UASB and EGSB reactors

Physical-chemical or aerobic treatment

Sludges without AD

- Liquid industrial waste (LIW)
- Municipal waste water
- Cattle manure
- Pig manure
Liquid industrial waste (LIW)

Municipal waste water

Cattle manure

Pig manure
## Evolution of sewage water treatment

<table>
<thead>
<tr>
<th>Year</th>
<th>(%) of National coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>4,1</td>
</tr>
<tr>
<td>1998</td>
<td>16,7</td>
</tr>
<tr>
<td>2002</td>
<td>42,3</td>
</tr>
<tr>
<td>June 2003</td>
<td>46,8</td>
</tr>
<tr>
<td>December 2003</td>
<td>76,6</td>
</tr>
<tr>
<td>2005</td>
<td>81,8</td>
</tr>
<tr>
<td>2010</td>
<td>98,4</td>
</tr>
</tbody>
</table>

*Source: Superintendence of Sanitary Services, SISS.*
## Treatment of sewage in Chile

<table>
<thead>
<tr>
<th>Technology</th>
<th>1998</th>
<th>2002</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated sludges</td>
<td>0</td>
<td>60</td>
<td>178</td>
</tr>
<tr>
<td>Stabilization ponds</td>
<td>61</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Aerated ponds</td>
<td>9</td>
<td>41</td>
<td>70</td>
</tr>
<tr>
<td>Marine outlets</td>
<td>11</td>
<td>22</td>
<td>35</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

*Fuente: Superintendencia de Servicios Sanitarios, SISS.*
Biogas Potential in Chile

- Ponds
- Activated sludges
- SBR
- Others

NO A.D.

- Liquid industrial waste (LIW)
- Municipal waste water
- Cattle manure
- Pig manure
Biogas Potential in Chile

Collection of manure is difficult

✓ 33% of animals are in stables (center area)
✓ 5% of animals are in stables (south area)

- Liquid industrial waste (LIW)
- Municipal waste water
- Cattle manure
- Pig manure
Pig manure Biodigester

- 120 thousand pigs
- 50 % national production
- 15 thousand m³ of biogas per day
Biogas Potential in Chile

**Pig manure Biodigester**
- 120 thousand pigs
- 50% national production
- 15 thousand m³ of biogas per day

**Other treatments**
- Liquid industrial waste (LIW)
- Municipal waste water
- Cattle manure
- Pig manure

**Sludge without AD**
Biogas Potential in Chile

**POTENTIALS**

- Theoretical potential (resources)
- Technical Potential
- Real Potential (legal framework)
Biogas Potential in Chile

Dispersed Biomass

- Plantations waste
- Municipal parks wastes
- Liquid industrial waste (LIW)
Biogas Potential in Chile

- Agroindustry
- Livestock slaughtering
- Lipids
- Urban solid waste (USW)
- Cattle manure

Grouped Biomass
Biogas Potential in Chile

Concentrated Biomass

- WTP sludge
- Poultry manure
- Pig manure
Biogas Potential in Chile

Dispersed Biomass

Biogas (m$^3$/year)

LIW  Park Waste  Agriculture

min  max

0  200000  400000  600000  800000  1000000
Concentrated Biomass

![Bar chart showing biogas production from different sources.](chart.png)

- **Biogas (m³/year)**
  - Sludge: Min 2000000, Max 4000000
  - Poultry manure: Min 2000000, Max 8000000
  - Pig manure: Min 2000000, Max 4000000

- **Legend:***
  - Min
  - Max
Max. Biogas potential (m³/year)

- Poultry manure: 7727 m³/year
- Pig manure: 1770 m³/year
- Sludge: 1099 m³/year
- Sewage: 161 m³/year
- Cattle manure: 550 m³/year
- USW: 1354 m³/year
- LIW: 32 m³/year
- Agroindustry: 695 m³/year
- Slaughtehouses: 74 m³/year
- Agriculture: 969 m³/year
Dispersed Biomass

Cogenerated Energy (MWh/year)

- LIW
- Park Waste
- Agriculture

- min
- max

Biogas Potential in Chile
Biogas Potential in Chile

Grouped Biomass

Cogenerated Energy (Mwh/año)

- Agroindustry
- USW
- Slaughtehouses
- Lipids
- Cattle manure

min  max
Concentrated Biomass

Cogenerated Energy (MWh/year)

- Sludge: Min 1,000,000, Max 2,000,000
- Poultry manure: Min 1,000,000, Max 4,000,000
- Pig manure: Min 1,000,000, Max 2,000,000

[min] [max]
Conclusion

With the new law, biogas has the potential to supply around 3.5% of the electrical energy in Chile and now we have the opportunity to do it.
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