Biogas from landfills and waste water treatment plants

The chilean experience

Monterrey- México
January 2009
General facts about Chile

- Population: 16 M (Santiago, 6 M)
- Area: 756,000 Km2
- Exports 2006: 58,2 B
- GDP per capita: 9,700 US$ (13,700 US$ PPP)
- Copper: market share of 36%
- Primary energy consumption: 1,8 TOE/hab
  (China = 1,4  France = 4,4  USA = 7,9  Latin America Average = 1,1)
General facts about Chile

Primary Energy: Fuels
General facts about Chile

Energy Dependency

<table>
<thead>
<tr>
<th>Year</th>
<th>Produccion</th>
<th>Importacion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>64%</td>
<td>36%</td>
</tr>
<tr>
<td>1982</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>1984</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>1986</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>1988</td>
<td>54%</td>
<td>46%</td>
</tr>
<tr>
<td>1990</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>1992</td>
<td>49%</td>
<td>51%</td>
</tr>
<tr>
<td>1994</td>
<td>44%</td>
<td>58%</td>
</tr>
<tr>
<td>1996</td>
<td>35%</td>
<td>65%</td>
</tr>
<tr>
<td>1998</td>
<td>33%</td>
<td>67%</td>
</tr>
<tr>
<td>2000</td>
<td>35%</td>
<td>65%</td>
</tr>
<tr>
<td>2002</td>
<td>29%</td>
<td>71%</td>
</tr>
<tr>
<td>2004</td>
<td>33%</td>
<td>67%</td>
</tr>
<tr>
<td>2006</td>
<td></td>
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</tr>
</tbody>
</table>
The Natural Gas Sector

Protocolo de Integración Gasífera (1995)

The “rush” for Natural gas took place at the end of the nineties

More than 3 bn US$ in investments (pipelines, local distributors).

Main 5 Natural Gas Distribution Companies:
Metrogas: Market

Metrogas is the largest Natural Gas distributor in Chile.

- Operations started in 1997
- 450,000 Customers (as of end 2008)
- Over 400 Large customers (industries)
- 4700 km of pipelines
- > 1,000 MMUS$ Investments
- Turnover: 300 MMUS$/y
- 2006: Commercial and Residential demand: 317 [MMm³/year].
- 2004: Industrial Demand 532 [MMm³/year].
- Before the Natural Gas crisis, Metrogas reached 85% of Industrial market share, replacing liquid and gaseous fuels.
Metrogas: distribution networks & GasAndes pipeline
Biogas, main drivers

- Energy Crisis
- Market Conditions
- Environmental benefits
Energy Crisis

- Lack of investments in the upstream/midstream sector in Argentina; gas-elec prices “frozen” by regulatory decrees.

- Argentina reduced gas exports to chile (2007: exports = less than cooking /heating needs for the residential-commercial sector)

- Impact on the electricity sector: need to convert Combined Cycle Gas turbines to Diesel, more coal fuelled plants in operation, serious risks of electricity shortages.


- 2007-2008: Propane Air plant put in service to produce Synthetic natural gas.

- Nevertheless, small-medium customers never suffered gas shortages, so far.

- Government and Private sector took right decisions: investment incentives (Power sector – Upstream Gas), call for demand efficiency, strategic projects (GNL, Propane Air for back up), promotion of renewable energy (wind, Geothermal, Biomass)

- Chile before 2004: focused on cost efficiency;

- Chile after crisis: cost efficiency, diversification of the energy matrix and secure fuel supplies
Biogas is part of the country’s energy strategy

- Landfills
- Water Treatment Plants
- Liquid Industrial Waste Treatment Plants
- Coal Mines
- Biomass
Biogas, main drivers

- Energy Crisis
- Market Conditions
- Environmental benefits
## Biogas Potential in Chile

<table>
<thead>
<tr>
<th>Fuente</th>
<th>Biogás [Mm³/año]</th>
<th>Metano [Mm³/año]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantas de Tratamiento de Aguas</td>
<td>137.369</td>
<td>82.421</td>
</tr>
<tr>
<td>Rellenos Sanitarios c/captación de biogás</td>
<td>115.551</td>
<td>57.775 *</td>
</tr>
<tr>
<td>Rellenos Sanitarios s/captación de biogás</td>
<td>53.671</td>
<td>26.835</td>
</tr>
<tr>
<td>RILES</td>
<td>47.838</td>
<td>28.703</td>
</tr>
<tr>
<td>Pre-tratamiento aguas residuales urbanas</td>
<td>80.652</td>
<td>50.811</td>
</tr>
<tr>
<td>Biomasa de principales cultivos de temporada</td>
<td>387.791</td>
<td>240.430</td>
</tr>
<tr>
<td>Biomasa de residuos de poda y desmalezados municipales</td>
<td>425</td>
<td>297</td>
</tr>
<tr>
<td>Biomasa de desechos industria vitivinícola</td>
<td>27.561</td>
<td>17.088</td>
</tr>
<tr>
<td>Biomasa de residuos sólidos industria cervecera</td>
<td>8.752</td>
<td>5.533</td>
</tr>
<tr>
<td>Biomasa de industria de Lácteos</td>
<td>3.580</td>
<td>2.148</td>
</tr>
<tr>
<td>Biomasa de industria conservera de frutas y verduras</td>
<td>65.163</td>
<td>39.098</td>
</tr>
<tr>
<td>Biomasa bebidas de infusión</td>
<td>2.412</td>
<td>4.387</td>
</tr>
<tr>
<td>Biomasa residuos de matadero</td>
<td>29.775</td>
<td>19.353</td>
</tr>
<tr>
<td>Biomasa residuos industrias aceites y grasas</td>
<td>132</td>
<td>92</td>
</tr>
<tr>
<td>Biomasa a partir de estiércol (avícola, vacunos y porcinos)</td>
<td>1.027.453</td>
<td>607.872</td>
</tr>
</tbody>
</table>
| **Total**                                                  | **1.988.125**    | **1.125.068** **

* Estimación Metrogas R.M: 74.841 Mm³/año.

** 3.082.378 m³/día.

Less than 1% on the market!

** Fuente:
- Estudio de potencial de biogás. Proyecto Energías Renovables no Convencionales en Chile (CNE/GTZ). Septiembre 2007
Biogas To Market?

- Where is it?
- How much is it?
- Who will need it?

**Relevant Market**: Metrogas focused on the largest biogas producers, located as near as possible to the existing grid.
Sources of Biogas

- Relleno Santiago Poniente (COINCA)
- Planta de Tratamiento de Aguas “La Farfana”
- Planta de Tratamiento de Aguas “El Trebal”
- Relleno KDM
- Relleno Lepanto
- Relleno Santa Marta
Sources of Biogas

- In the vicinity of Santiago, biogas produced by landfills and WWTP is mostly flared.
- Concentrating on landfills and WWTP, the potential of production would be around 250-300,000 cubic meter per day equivalent of Natural gas imported, and is expected to grow 5% per year.
- ... cooking- heating needs for almost 200,000 houses in Santiago (= 1 M inhabitants)

**Potencial de Biometano RM (Agregado)**

![Graph showing potential of biogas production from 2008 to 2017](image-url)

**Fuente:** Estimación Metrogas (información entregada por plantas tratamiento de aguas y rellenos sanitarios)
Biogas: project alternatives

- **Medium- Low Btu**: For direct use in industries - town gas factory
- **High -BTU**: Power Production/cogeneration
  - **Heat/electricity**
  - **Natural Gas grid injection (more efficient)**
- **Vehicular Fuel (NGV)**
Biogas upgrade to pipeline Quality

**Biogas**
- Metano: 50 – 75%
- CO2: 25 – 50%
- Nitrógeno: 0 – 10%
- SH2: 0 – 3%

**Gas Natural**
- Metano: 95.9 – 97.8%
- CO2: 0.4 – 1.2%
- Nitrógeno: 0.8 – 1%
- SH2: 0%

High Heating Value (kCal/m3)
- 4500 Relleno Sanitario
- 5800 Planta Tratamiento Agua

High Heating Value (kCal/m3)
- 8900- 9300

Landfills
Waste Water Treatment Plant
Biogas: additional market considerations

- High oil & gas prices favor Biogas projects but also...
- Direct incentives (grants), indirect (tax deductions, renewable energy quotas, etc.)
- Gas Quality (for grid injection)
- Direct End-use of Biogas or electricity production?
  - A matter of relative prices of fuel /electricity (who pays more?)
  - Nonetheless, direct end-use more efficient

<table>
<thead>
<tr>
<th>Proceso</th>
<th>Eficiencia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flaring</td>
<td>0%</td>
</tr>
<tr>
<td>Power production</td>
<td>35% - 42%</td>
</tr>
<tr>
<td>Upgrade to Natural gas</td>
<td>82% - 94%</td>
</tr>
</tbody>
</table>
Biogas, main drivers

- Energy Crisis
- Market Conditions

Environmental benefits
Environmental benefits
Global Warming

• Methane capture
  • 21 times more effective than limiting Carbon Dioxide going to the atmosphere
  • allow landfill owners to obtain Carbon Credits (ACM001)
    ➔ Large investments in biogas wells and extraction systems, even in abandoned landfills
    ➔ Owners looking to get additional returns...
Environmental benefits

Local pollution reduction

- Replaces fossil fuels
- Compared with the alternative of “flaring”, 30% reduction of Nox and 70% reduction of MP.

Fuente: Factores de emisión EPAAP-42
Santiago, what we should see...
Santiago: what we actually see (most of the time)
Santiago: what we actually see (most of the time)

Flaring Biogas does not seem to be a smart choice...
Metrogas: CDM Projects

Landfill & Water Treatment Plants: Biogas Recovery

- Methodology AM0053: "Injection of Biogenic Methane into a Natural Gas Distribution Grid".
  - Approved in 137 days without any objection.

- AM00069: Biogenic methane use as Town Gas Factory feedstock and methane emission reduction of flare efficiency.
Biomethane Projects: Barriers

The case of Landfill projects:

• When developing a new project over a registered one, landfill owners fear losing their current stream of CER’s from the already registered project.

• For this reason Metrogas asked Executive Board to provide a solution and implement a mechanism allowing the modification of a registered project, particularly in order to upgrade the use of the biogas, a much more sustainable project.

Allowing a verification modification plus a new Project based on the same biogas will provide a solution coherent with the sustainable principles imbedded in the Kyoto Protocol and CDM.
Metrogas: CDM Projects

Two other methodologies developed by Metrogas:

**Industrial Fuel Switching**

- Natural Gas produces lower emissions of CO2 per unit of energy than other Fossil Fuels. Combustion is easier and more efficient. Nestlé–MGM International 2002/2004
  - Methodology: “Consolidated baseline methodology for fuel switching from coal to petroleum fuel to natural gas” ACM009 (Formerly AM008)

**Cogeneration**
Biogas To Market

The challenges
Biogas To Market

- **High Capex & Opex:**
  - Large investments to process/transport small volumes in comparison to large scale natural gas production/transport...
  - the distance to the existing grid (either electricity or gas distribution grid)
  - Economics highly sensitive to Oil – Natural Gas & Electricity price...

- **Risks**
  - Production
  - Technology for upgrading
Fuels Price evolution

Evolución precio semanal de combustibles
US$/MMBTU FOB 2000-2008
Biogas To Market

- **Incentives are a key factor:**
  - What we already have:
    - Tax exemption for bio fuels (for transportation)
    - 5% -10% target of renewable electricity (including biomass) from 2010 onwards; traditional power producers must meet the target or pay a fine.
    - Natural Gas Quality standards in Chile (NCh2264) and “substitute gas” that may be mixed with NG.
  - But not enough:
    - Generalized perception that these projects are risky, technology is not mature and costs may overrun.
    - Serious need to perform basic engineering before proceeding, at a high cost
    - Grants / subsidies at the early stage of the project would be a good solution.
    - Access to accurate information / analyses of which technologies suit best to a specific project, would be very useful.
La Farfana Project
La Farfana project

- La Farfana Plant processes over 60% of the waste water in Santiago – anaerobic digestion process.

- Biogas production = 24 [MCM /y] ~ 60-65 % methane content.

- Supplies energy needs for the town gas factory (35,000 customers) October 2008

- Economic & environmental benefits
La Farfana – Town Gas factory pipeline

~ 13,6 km

Trazado de 13,6 km

Cruce Autopista A. Vespucio

SECTOR LA FARFANA

La Farfana

Nuevo ducto

Ducto a rehabilitar
Biogas pre-treatment process

High H2S content (800-2000 ppm) reduced down to 25 PPM, then the gas is dried and compressed.
Biological filter to remove H2S

2 stage reaction:

1.- Scrubber (Raw biogas with H2S is put in contact with water and NaOH)
   \[ H_2S + NaOH \rightarrow NaHS + H_2O \]

2.- Reactor (Thiobacillus)
   \[ NaHS + \frac{1}{2}O_2 \rightarrow S + NaOH \]
Instalaciones en La Farfana
Biogas at the Town Gas Factory

Initial mixture 77.1%  
70.0% Biogas  
30.0% Otro Combustible

Craking

Heating 22.9% (Se calienta 100% con Biogas)

CO + H2

Gas Básico

Proceso de Mezcla y enriquecimiento

High Heating Value (HHV) improvement

Mezcla 22.000 m3 de gas básico PCS = 3045 Kcal/m3N.

Biogas 13.000 m3 de Biogás PCS = 5629 Kcal/m3N

Propano 1.900 m3G de LFG gaseoso PCS = 24.350 Kcal/m3N

Gas de Ciudad de 36.900 m3G/hora

En el Global

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Biogas</td>
<td>67.8%</td>
<td></td>
</tr>
<tr>
<td>Otro Combustible</td>
<td>32.2%</td>
<td></td>
</tr>
</tbody>
</table>
Biogas at the Town Gas Factory

Biogas is further cleaned (VOC & siloxane removal) with activated carbon scrubbers
La Farfana project: environmental benefits

Green House Gas reductions

- 21.300 [tCO$_2$/año] equivalent to:
  - Avoid burning 7.800 tonnes of mineral coal per year.
  - Plant 3400 ha of woods.

Reduce local contaminants such as: NOx, PM, CO.
Biogas from Waste Water Treatment plants: next steps

- Increase biogas utilisation
  - Farfana will increase production in 2009-2010 by 15%
  - At present Metrogas only requires 80% of what is produced at La Farfana
  - Fuel switching to town gas? But also...
  - Possibility to upgrade part of the biogas and sell it as CBG (Compressed Biogas) for vehicular use...
  - ...and why not all of it to the NG grid?

- R&D, incentives key factors, but opportunities are real...
And more...

- Relleno Santiago Poniente (COINCA)
- Planta de Tratamiento de aguas "La Farfana"
- Planta de Tratamiento de aguas "El Trebal"
- Relleno KDM
- Relleno Lepanto
- Relleno Santa Marta
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Anexos
Biometanización: Descripción del Proceso

Etapa I - Limpieza:
- H2S, Agua, Partículas, Amoníaco, COV´s, Hidrocarburos Halogenados
- Oxígeno, Componentes de Silicona (Siloxanos), Nitrógeno

Etapa II - Tipos de proceso Upgrade:
- PSA (Pressure Swing Adsorption)
- Absorción con Agua (Scrubber)
- Absorción con Químicos (Selexol & Genosorb)
- Absorción con reacción química
- Separación con Membrana
- Proceso Criogénico

Estos proyectos convertirán a Chile en un referente en el uso de nuevas tecnologías para el aprovechamiento de energías renovables
Tipo de Proyecto: Cambio de combustible

Metodología:
- Nueva Metodología Aprobada, “Consolidated baseline methodology for fuel switching from coal or petroleum fuel to natural gas” ACM009 (Formerly AM008)
- Permitió disminuir la brecha de precios entre el Gas Natural y el Carbón

Ubicación: Graneros, VI región, Chile
Productos: Café, Cereales
Combustibles iniciales: Carbón, Fuel Oil y GLP
Año: 2002/04
Otros Beneficios: Reducción importante de emisiones locales (MP, NOx)
Desarrolladores:
MDL Metrogas: Cogeneration

Tipo de Proyecto: Cogeneración (Reducción de emisiones por aumento de eficiencia a través de generación conjunta de Electricidad y Calor

Metodología:
- Nueva Metodología Aprobada, “Natural Gas-Based package cogeneration” AM0014, 2004

Ubicación: Santiago, Chile

Productos: Oleaginosos (mantequilla, etc)

Características:
- 2 Motores Caterpillar G3516 y G3520
- Potencia Eléctrica: 1,03 + 1,92 MW
- Vapor: 1200 + 1550 kgv/h
- Agua caliente: 6,53 MMBtu/h
- Eficiencia Total: 73%

Año: 2003/04

Otros Beneficios: Creación de know-how en proveedores y sistema eléctrico (energía distribuida)

Desarrolladores:

Gamma Ingenieros
Unavailability of NG supplies ... a long track record