Emission Standard for Stationary Generators in the Metropolitan Region

Cecilia Barrios
Air Pollution Control Area
Overview

- PM, CO and O3 are usually above the Air Quality Standard in Metropolitan Region of Chile.

- Last years annual average of PM2.5 is increasing due rapid economic growing, usage of combustion sources and fossil fuels.
Stationary Generators

- Diesel Powered
- From less than 100 to 8.000 units within 10 years
- High prices of electric demand in peaks.
- 15 minutes of over-consumption to pay for the highest demand
- Use: Prime or Emergency.
- Peak hours coincide with worst ventilation conditions (winter period after 18:00 hours)
- Total installed power is 1,8 GW (79% Emergency - 21% Prime)
- Thermal Power Plant in Santiago has 370 MW
### Estimated Number

<table>
<thead>
<tr>
<th>Power Range [kW]</th>
<th>Installed Gen-sets</th>
<th>New Gen-sets (annually)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emergency</td>
<td>Prime</td>
</tr>
<tr>
<td>40-150</td>
<td>2.648</td>
<td>151</td>
</tr>
<tr>
<td>150-300</td>
<td>1.265</td>
<td>565</td>
</tr>
<tr>
<td>&gt; 300</td>
<td>2.526</td>
<td>539</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6.439</strong></td>
<td><strong>1.255</strong></td>
</tr>
</tbody>
</table>

Emergency Engines: 93% installed at Residential Building and Commercial Sector
Prime Engines: 73% installed at Commercial Sector - 27% Industrial Sector

### Emissions

![Emissions Diagram]
## Emissions during Winter Period
**April 1\textsuperscript{st} - August 31\textsuperscript{st}**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>40-150</td>
<td>6,78</td>
<td>23,51</td>
<td>202,71</td>
<td>0,84</td>
</tr>
<tr>
<td>150-300</td>
<td>10,84</td>
<td>59,73</td>
<td>207,02</td>
<td>6,16</td>
</tr>
<tr>
<td>&gt; 300</td>
<td>39,73</td>
<td>239,10</td>
<td>646,98</td>
<td>27,06</td>
</tr>
<tr>
<td></td>
<td><strong>57,4</strong></td>
<td><strong>322,3</strong></td>
<td><strong>1.056,7</strong></td>
<td><strong>34,1</strong></td>
</tr>
</tbody>
</table>

### Emission Source

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gen-sets</td>
<td>57,4</td>
<td>322,3</td>
<td>1.056,7</td>
<td>34,1</td>
</tr>
<tr>
<td>Industrial Sector</td>
<td>549,6</td>
<td>3.317,0</td>
<td>5.611,7</td>
<td>3.328,7</td>
</tr>
<tr>
<td>Mobile Sources</td>
<td>846,2</td>
<td>89.077,7</td>
<td>18.796,0</td>
<td>9.084,1</td>
</tr>
</tbody>
</table>

Gen-sets/Industries: 10,4% PM, 9,7% NOX, 18,8% CO, 1,0% HCT

Gen-sets/Transport: 6,8% PM, 0,4% NOX, 5,6% CO, 0,4% HCT
Particle Measurement on Stationary Generators

- Official measurement is gravimetric method. It provides incomplete information about the toxicity of the fine particles.

- New measurement approach was investigated: focusing on submicrometer particles

- 6 Prime engines measured with NanoMet directly in the stack.

- 3 sensors included in this unit measure:
  - Active surface concentration (LQ1-DC)
  - Soot (PAS2000)
  - Particle number concentration (CPC)
**Measurement Set up**

Rotating disc diluter to reduce particle concentrations

Evaporation tube to evaporate volatile particles

- **LQ1-DC**
  - Surface concentration
  - Range: 0 ... 2'000 μm²/cm³
  - Sample flow: 1.5 lpm

- **PAS 2000 (EcoChem)**
  - Soot (±EC) concentration
  - Range: 0.1 ... 1'000 μg/m³
  - Sample flow: 2 lpm

- **CPC (TSI)**
  - Number concentration
  - Range: 0.1 ... 10'000 #/cm³

Monitor for particle surface concentration

Monitor for soot concentration

Monitor for particle number concentration
Measurement Results

No correlation of measured EC concentrations with official PM emission values can be observed!!!
Measurement of Prime Engines at Different Loads

Official Measurement is not available at the same conditions. Requirement is measure at maximum load.
Emission Standard Project

• Started in April 2006

• Target: Reduce the emissions

• Emission Standard Project have been discussed considering:
  ▪ Information provided by regulated sector
  ▪ Recommendations from experts
  ▪ Comments during Public Consultation of Draft Version
  ▪ Results of Cost-Benefit Analysis (over the Draft Version)

• Technology information were supported by the Swiss Agency for Development and Cooperation (DEZA).

• September 2007: Presentation to Ministers (Approval)
Emission Standard Project

Applicability:
All stationary generator with nominal power >= 40 kW

Registration Number:
Given by Supervising Authority for every generator.

Hour meter:
A non-resettable hour meter shall be installed on all engine. (Prime or Emergency, New or In-use)
## Limit Values

### In-Use Gensets

<table>
<thead>
<tr>
<th>Power Range</th>
<th>MP [mg/ Nm3]</th>
<th>NOX [mg/ Nm3]</th>
<th>CO [mg/ Nm3]</th>
<th>HCT [mg/ Nm3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime</td>
<td>150-300</td>
<td>45</td>
<td>5.000</td>
<td>600</td>
</tr>
<tr>
<td>Prime</td>
<td>&gt;=300</td>
<td>30</td>
<td>5.000</td>
<td>600</td>
</tr>
<tr>
<td>Emergency</td>
<td>&gt;=300</td>
<td>180</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
</tbody>
</table>

### New Gensets

<table>
<thead>
<tr>
<th>Power Range</th>
<th>MP [mg/ Nm3]</th>
<th>NOX [mg/ Nm3]</th>
<th>CO [mg/ Nm3]</th>
<th>HCT [mg/ Nm3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime</td>
<td>150-300</td>
<td>45</td>
<td>3.000</td>
<td>600</td>
</tr>
<tr>
<td>Prime</td>
<td>&gt;=300</td>
<td>20</td>
<td>3.000</td>
<td>600</td>
</tr>
<tr>
<td>Emergency</td>
<td>&gt;=300</td>
<td>75</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
</tbody>
</table>

- Conditions: 1 atm, 25ºC, 5%O2
- Technical problems in measurement of low power engines
Some Reasons of Limit Values

Prime:
• After-treatment technology only for high emission engines
• Engines with high technology level emit less than 20 mg/m3N
• Incentive to previous investment in high quality and technology
• New engines: Low Emission Engine or High Emission Engine+DPF
• 20 - 45 mg/m3N are cost-effective limit values

Emergency:
• Operates in average 15 hours per year
• Most of them are low power
• Requirements in range 40-300 kW shall be registration and hour meter.
• Cannot operate more than 26 hours per year (30 minutes per week for maintenance and testing)
Test methods

MP: EPA-5
NOX: EPA-7E
CO: EPA-10 or EPA-3A
HCT: EPA-25A
O2: EPA-3A
Gas Volume: EPA-2 or EPA-2A

- Measurement at maximum load: 80% - 100% load
- Same condition for all stationary sources
- Application of simplified methods is qualitative
- Different methods are not comparable (EPA-5, Opacity, Smoke density, Bacharach scale)
- Measurement in Particle Number is not official
### Compliance Schedule

<table>
<thead>
<tr>
<th>Power [kW]</th>
<th>In-Use</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emergency</td>
<td>Prime</td>
</tr>
<tr>
<td><strong>150 - 300</strong></td>
<td>Not required</td>
<td>Measurement of PM, NO\textsubscript{X}, CO y HCT each 3 years.</td>
</tr>
<tr>
<td><strong>P≥300</strong></td>
<td>1 PM measurement 6 months since coming into force</td>
<td>1st meas. 18 months after coming into force</td>
</tr>
</tbody>
</table>

- Period for fulfilment assumes selection, design, installation, test, etc. of appropriate after-treatment technologies or delays in imports and previous tests.

- For Emergency engines is not necessary any changes.
## Cost Benefit Analysis

### Filters Cost
- Installed Gen-sets: 2.076 [thousand US$ per year]
- New Gen-sets: 298

### Measurement Cost
- Installed Gen-sets: 130
- New Gen-sets: 43

### Compliance Cost
- Installed Gen-sets: 2.206
- New Gen-sets: 341 [thousand US$]

### Health Benefit
- Installed Gen-sets: 2.993
- New Gen-sets: 150

### Net Social Benefit at Present Value:

<table>
<thead>
<tr>
<th>Period</th>
<th>Net Social Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 years</td>
<td>1.043</td>
</tr>
<tr>
<td>10 years</td>
<td>-784</td>
</tr>
</tbody>
</table>
## Expected Results

<table>
<thead>
<tr>
<th>PM [tpy]</th>
<th>Installed Gen-sets</th>
<th>New Gen-sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>57.35</td>
<td>3.7</td>
</tr>
<tr>
<td>With standard</td>
<td>16.85</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Reduction</strong></td>
<td><strong>71%</strong></td>
<td><strong>49%</strong></td>
</tr>
</tbody>
</table>

**PM Emissions within 10 years**

![Graph showing PM emissions reduction](image)
After-treatment technology on Gen-sets

Conditions: PM at 25°C, 1 atm, 5% O2

29 Gensets with after-treatment technology

- 8 CARB Certified: 5 - 17 mg/m³
- 18 “mechanical Filter” (accumulator): 5 - 56 mg/m³
- 3 Unknown filters: 22 – 60 mg/m³

Particle Number Measurement should be necessary!!!!!
Final Notes

• Stationary engines are also important. Should they become a problem to regulate them?

• Local regulation cannot require to use best available technology to eliminate ultrafine solid soot particles.

• Emission standard should be revised each 5 years.

• It is necessary requires an official test method in particle number, in order to assure an emission reduction. (Avoiding bad filters)

• This is the first regulation for stationary engines.

• Next step: Off-road engines
Acknowledgments

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• R. Grossmann - Terra Consult
Thank you for your attention!!

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