





Adaptation to the Impact of Climate Change within the Electricity Sector in Santiago de Chile

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Content of the Presentation



- The CAS (Climate Adaptation Santiago) Project
- The Metropolitan Region of Santiago de Chile (MRS)
- Necessary steps for planning and implementing adaptation programs
- The electricity sector in Chile and in MRS
- Future development of the electricity sector in MRS on the basis of climatic and socioeconomic scenarios
- Development of adaptation measures in the electricity sector for MRS
- Conclusions



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Climate Adaptation Santiago de Chile (CAS) Project description



 Joint research project with Chilean and German partners and funded by the International Climate Initiative of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and coordinated by the UFZ in Leipzig

Main objective:

Development of climate change adaptation measures for the MRS in the most highly affected sectors: energy, water and land use

CAS aims to provide answers to questions such as:

- What are the principal climatic changes expected in the MRS?
- What are the impacts of these changes for the MRS?
- What risks and vulnerabilities are related to climate change in the MRS?
- Which are suitable adaptation measures and how can they be implemented in MRS and other Latin American Megacities



Santiago de Chile - Facts





Inhabitants: 17 Mio. in Chile

6.7 Mio. in MRS

BIP per cap.: 13,500 US\$

BIP in Santiago: 43.5% of total BIP

- Mediterranean climate with dry and hot summer and wet and cold winter
- Average maximum temperatures: 28-30°C
- Average minimum temperatures: 0-5°C
- Precipitation mostly in June, July and August (winter months)
- Precipitation amount: between 200 and 500 mm per year

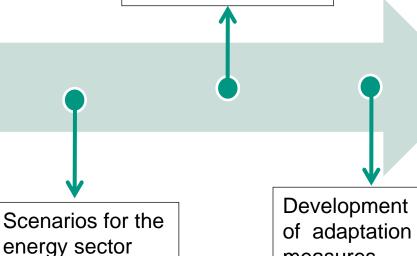


Steps towards planning and implementing adaptation measures



- socioeconomic framework scenarios
- climate scenarios (downscaling)
- analysis of actual situation

Impact of climate change on the energy sector/ identification of problems



measures

Products:

- Climate Adaptation Plan for the MRS: including 14 concrete measures
- Manual for Implementation
- Manual for Practitioners
- Information material for two selected municipalities



Applied methodology

Karlsruhe Institute of Technology

- Literature review
- Expert and stakeholder interviews/involvement
- Scenario analysis
- Model calculations
- Round tables and workshops

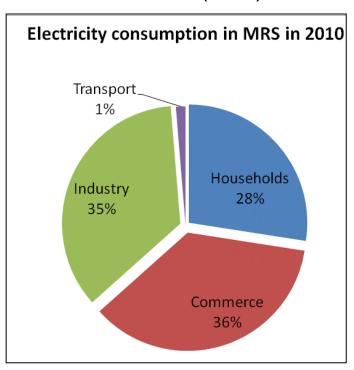




The electricity sector in Chile and in the MRS



- Electricity consumption in MRS in 2010 about 17 TWh
- Only 21% of this amount is produced within MRS
- The average consumption in households is 900 kWh per capita and year
- Electricity production in MRS is based on Hydro-Power (50%) and Thermal Power Plants (50%)





Fuente: Transelec, 2008



Development of Scenarios



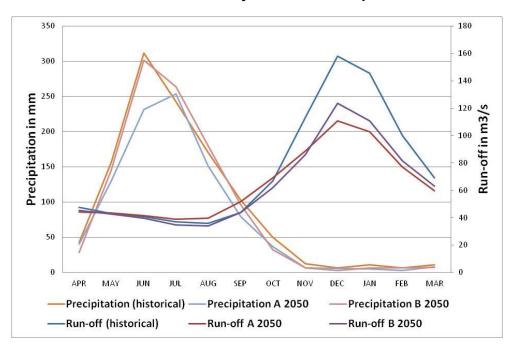
| Climatic scenarios | Socioeconomic framework scenarios |
|--|--|
| Performed by the University of Chile | Performed by ITAS in close cooperation with PUC |
| Selection of two IPCC climate scenarios (worst case A2 and best case B1) | Socioeconomic framework scenarios (incl. technical and institutional driving factors für MRS until the year 2050) Business As Usual (BAU) Collective Responsibility(CR) |
| | |
| Downscaling of these scenarios to MRS | Operationalization of the framework scenarios for the energy sector |



Santiago de Chile in 2050 - by Climate Change



- In the near future (2045-2065 period) the MRS will be a dryer, hotter city with a high number of days with extreme temperatures and increased drought during the winter and summer.
 - Increase in temperature by about 1.5°C
 - Increase in number of days with temperatures above 30°C
 - Decrease in number of days with temperatures below 0°C







Parameters for the scenarios BAU and CR (selection)

| Parameter | BAU | CR | | | |
|---|----------------------------|----------------------------|--|--|--|
| Politics | Liberalised markets | Heavily regulated markets | | | |
| Life style | Indivudualistic | Social | | | |
| Population in 2050 | 8.5 Mio | 7.9 Mio | | | |
| Persons per household 2.5 | | 2.7 | | | |
| Increase of GDP (real) | Between 2.5 and 5 % per | Between 2 and 4.5 % per | | | |
| Increase of GDP (real) | year | year | | | |
| Efficiency of operay use | Increase according to last | Increase according to last | | | |
| Efficiency of energy use | years | years plus 10% | | | |
| Private cars | Increase from 1.1 Mio | Increase from 1.1 Mio | | | |
| Filvate cars | to 3.8 Mio | to 3.2 Mio | | | |
| Distance travelled by private | Decrease from 20,000 km | Decrease from 20,000 km | | | |
| cars | to 15,000 km to 12,000 km | | | | |
| Percentage of distance travelled by electric vehicles | 10 % | 35 % | | | |





Climate change impact on electricity demand

- Higher cooling demand in the sectors households, industry and commerce
- Lower heating demand mainly in the household sector (not considered because heating is mainly based on gas)
- Higher electricity demand for refrigeration (only in buildings without cooling)





Electricity demand in MRS (PJ)

| | History | BAU | | CR | |
|-------------|---------|-------|-------|-------|-------|
| | 2010 | 2030 | 2050 | 2030 | 2050 |
| Residential | 16.8 | 33.2 | 53.2 | 25.3 | 35.6 |
| due to CC | | 1.0 | 2.4 | 0.8 | 1.6 |
| Total | | 34.2 | 55.6 | 26.1 | 37.2 |
| Commercial | 22.0 | 59.5 | 102.7 | 41.2 | 56.1 |
| due to CC | | 3.4 | 8.9 | 2.4 | 4.9 |
| Total | | 62.9 | 111.6 | 43.6 | 61.0 |
| Industry | 21.6 | 46.4 | 68.6 | 33.2 | 41.9 |
| due to CC | | 0.1 | 0.3 | 0.1 | 0.2 |
| Total | | 46.5 | 68.9 | 33.3 | 42.1 |
| Transport | 0.8 | 3.1 | 5.8 | 4.1 | 13.1 |
| due to CC | | | | | |
| Total | | 3.1 | 5.8 | 4.1 | 13.1 |
| Total | 61.2 | 142.2 | 230.3 | 103.8 | 146.7 |
| due to CC | | 4.5 | 11.6 | 3.2 | 6.6 |
| Total | | 146.7 | 241.9 | 107.0 | 153.3 |





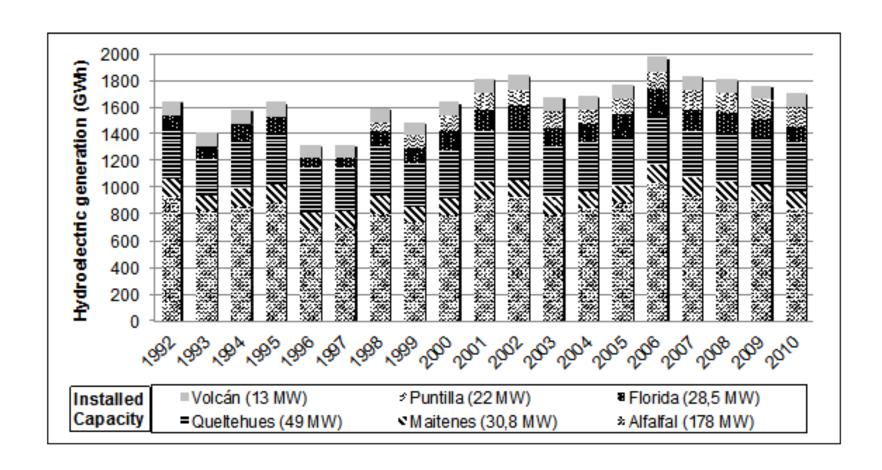
Thermal power plants

- Higher temperatures result in a decrease in efficiency
 - Increased use of fuel for same amount of electricity
- Maximum output is reduced
 - Lower electricity production at high load factor (but in average less than 2%)





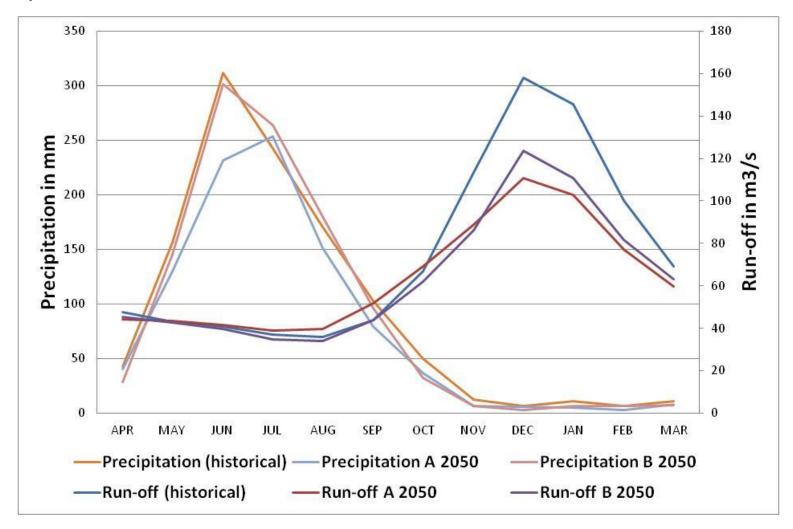
Hydro-Power Plants







Hydro-Power Plants







Hydro-Power Plants

| | Electricity production | Calculated electricity production | | | |
|------------|------------------------|-----------------------------------|-----------|-------------|---------------|
| | 1996- 2010 | 2020-2039 | 2040-2059 | 2020-2039 | 2040- 2059 |
| | | A2 Scenario | | B1 Scenario | |
| | Annual average in GWh | | | | |
| Alfalfal | 870 | 1,026 | 857 | 935 | 829 |
| Queltehues | 361 | 388 | 372 | 378 | 365 |
| Maitenes | 130 | 128 | 125 | 126 | 124 |
| Florida | 148 | 143 | 122 | 132 | 119 |
| Puntilla | 122 | 108 | 102 | 105 | 101 |
| Volcan | 105 | 108 | 102 | 105 | 101 |
| Total | 1,736 | 1,901 | 1,681 | 1,782 | 1,639 |



Electricity supply in MRS for different scenarios

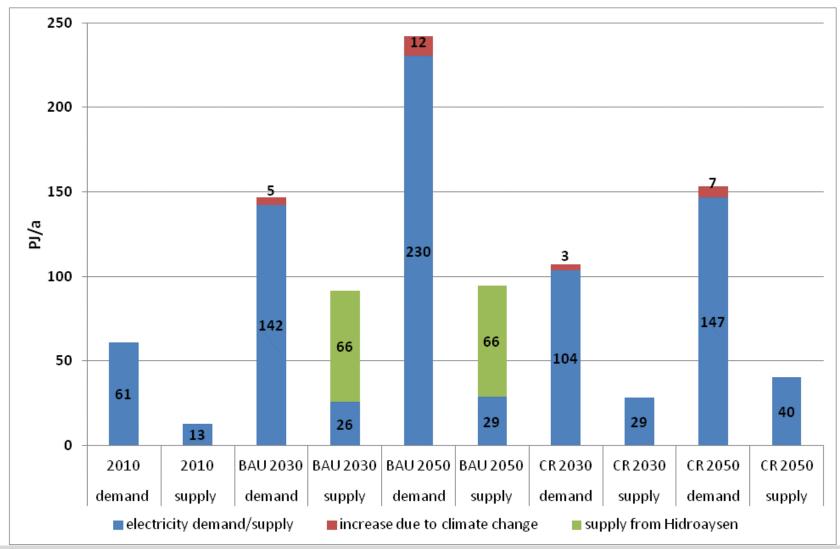


| PJ/y | Historical | BAU-scenario | | CR-scenario | |
|-----------------------------------|------------|--------------|------|-------------|------|
| F 3 / y | 2010 | | 2050 | 2030 | 2050 |
| Hydroelectric | | | | | |
| Existing | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 |
| Alto Maipo | 0.0 | 9.9 | 9.9 | 9.9 | 9.9 |
| Additional mini- hydroelectric | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 |
| | 6.1 | 16.0 | 16.0 | 16.4 | 16.4 |
| Solar | 0.0 | 0.1 | 1.5 | 2.1 | 10.0 |
| Wind | 0.0 | 0.0 | 0.0 | 0.5 | 2.0 |
| Thermoelectric | | | | | |
| Renca | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nueva Renca | 6.9 | 9.0 | 9.0 | 9.0 | 9.0 |
| Decentral biomass | 0.0 | 0.6 | 2.2 | 0.6 | 3.0 |
| | 6.9 | 9.6 | 11.2 | 9.6 | 12.0 |
| Local electricity | 13.0 | 25.7 | 28.7 | 28.6 | 40.4 |



Balance of electricity demand and supply







Development of Measures



Starting point:

- Energy demand will increase due to growth in population, increase in GDP and due to climate change effects
- There will be a risk of reduced electricity generation from hydro-power
- There will be an increase on the dependency of electricity supply from outside the MRS

General Measures:

- Diversification of energy sources, mainly by reducing the high dependency on hydro-power
- Limitation of increase in energy demand



Development of Measures



Actual problems for implementing measures

- Lack of information, sensibilization and awareness
- Lack of experts and expert knowledge advising the regional and local administration
- Incoherent actions of different political and sectorial decision makers at different regional levels
- Lack of suitable incentives to implement already existing technologies or to improve energy efficiency



Measures



- Establishing of energy expert groups within the regional government and communities
- 2. Energy action plan for the MRS
- 3. Education and information about climate change and energy related issues
- 4. Diversification of energy sources in energy production



Establishing of energy expert groups



- Highly qualified scientific and technical energy experts
- Advisors/consultants for decision makers, households, industry
- Formulation of energy policy guidelines
- Development of public and private programmes and initiatives to promote renewable energies and energy efficiency improvements

The group should be part of the Regional Government's and the community's staffs and should work in close cooperation and coordination with important actors in the energy field



Energy Action Plan for the MRS



- Analysis of the actual situation and outlook for the next 20 years
- Analysis of the potentials of increasing energy efficiency
- Analysis of the potentials to use local renewable energy resources (solar, wind, waste, biomass)
- Definition of target values for the use of different energy sources and for energy efficiency improvements
- Implementation of a monitoring system



Information and education



Information and Education of young people and adults about

- Climate change and expected impacts
- Possible and necessary mitigation and adaptation measures

in order to reduce resistance against common practice in the use of energy or the implementation of new technologies



Diversification of energy sources



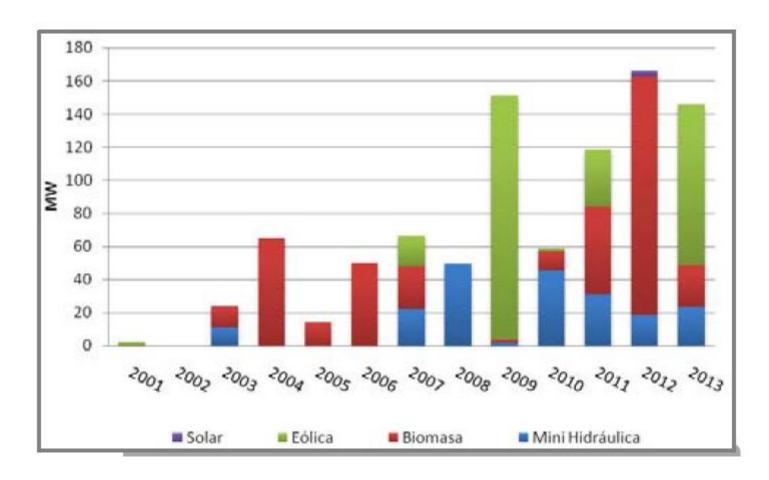
- Reduction in the dependency on specific energy sources, e.g. hydro power plants (HidroAysen)
- Reduction of the risk of interruptions of the transmission lines (long distances)

But this requires regulatory changes in the power transmission and distribution system (e.g. preference for local renewables, better connection of different grids, implementation of Smart Grids, flexibility in final customer tariffs)



Diversification of energy sources





Capacities of Renewable Energies installed in each of the given years (source: Reporte CER Mayo 2013)



Diversification of energy sources



Status of projects in the field of Renewable Energies

(source: Reporte CER Mayo 2013)

| Status | In Operation | In Construction | Environmentally approved | Qualified/ planned | |
|-----------------|------------------------|-----------------|--------------------------|-----------------------|--|
| | $\mathbf{M}\mathbf{W}$ | | | | |
| Biomas | 419 | 27 | 108 | 1,837 | |
| Wind | 302 | 271 | 4,031 | 104 | |
| Mini-Hydropower | 303 | 60 | 270 | 1,212 | |
| Solar | 4 | 69 | 3,262 | 70 | |
| Geothermal | 0 | 0 | 50 | | |
| | | | | | |
| Total | 1,028 | 427 | 7,721 | 3,223 | |



Summary and Conclusions – General results



- Increase in temperature by about 1.5°C
- Less precipitation and resulting decrease in stream flow
- Increase in electricity demand mainly due to increasing population and increasing GDP
- Impact of climate change on electricity demand (cooling, refrigeration) is very small
- Impact of climate change on electricity supply also very small, but may increase after 2050 (less production by hydro-power plants)
- Electricity supply in 2050 strongly depends on electricity production outside the MRS resulting in an increase of risks of disruptions of the delivery



Summary and Conclusions - Measures



For implementing adaptation measures in an effective way, it is necessary:

- to have detailed information about the actual situation
- to develop scenarios and adaptation measures in close cooperation with stakeholders and decision makers
- to inform relevant people and the public about climate change effects and relevant adaptation measures
- to have appropriate political and institutional framework conditions for implementation

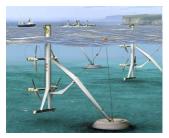












Energía del océano



Energía desde biomasa



Energía eólica



Electricidad y calor usando energía solar



Energía hidráulica



Energía geotérmica

