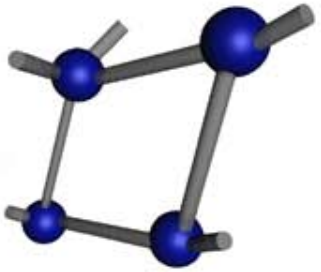
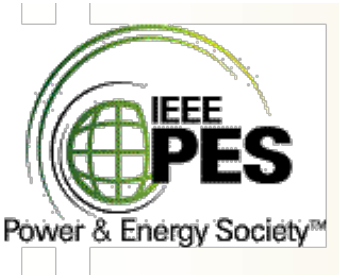


The challenge of achieving a low carbon economy in a fast developing country:
The Chilean experience

Sebastian Mocarquer, *IEEE Member (smocarquer@systep.cl)*
Hugh Rudnick, *IEEE Fellow (hrudnick@systep.cl)*



Detroit, July 24 th – 28 th, 2011

Presentation overview

- Chilean electricity market
- Low carbon economy
- Economy and social development
- Enviromental, social and political problems
- Adaptation
- Final remarks

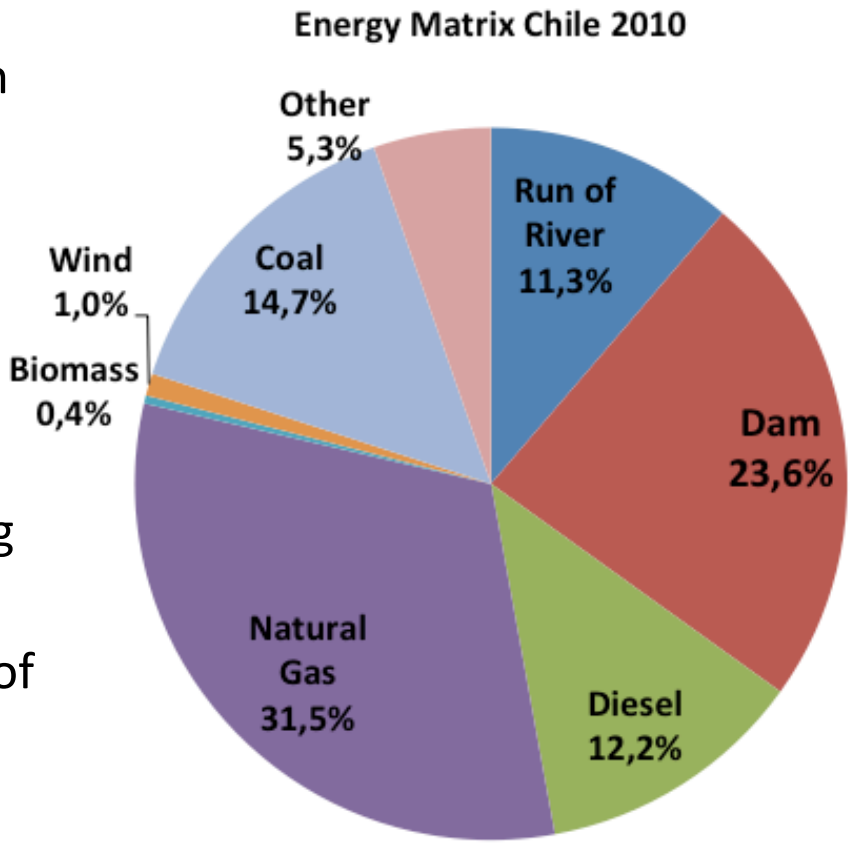
Chilean electricity market

Northern Interconnected System (SING)	
Max Demand (MW)	1,900
Sales (GWh)	13,656
Installed Capacity (MW)	3,573
Population	5.70%

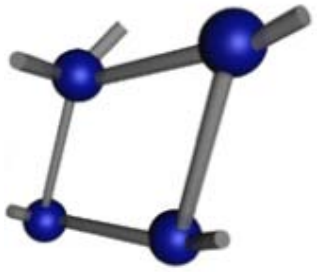
Central Interconnected System (SIC)	
Max Demand (MW)	6,139
Sales (GWh)	39,964
Installed Capacity (MW)	11,147
Population	92.60%

Chilean electricity market

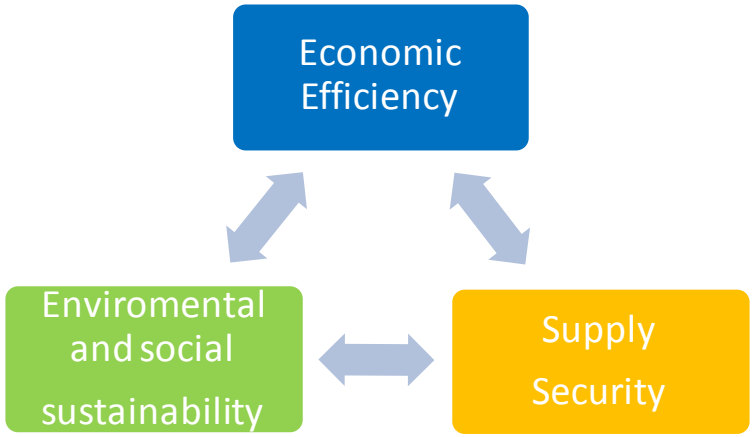
- Electricity sector based on a competitive market
  - Private competitive investment in generation
  - Regulated private investment in T&D
- Energy
  - Prices set in contract auctions (financial)
  - Spot market with marginal pricing
- Capacity payment
  - Price regulated: investment cost of supplying the marginal peak demand



Low carbon economy and energy policy

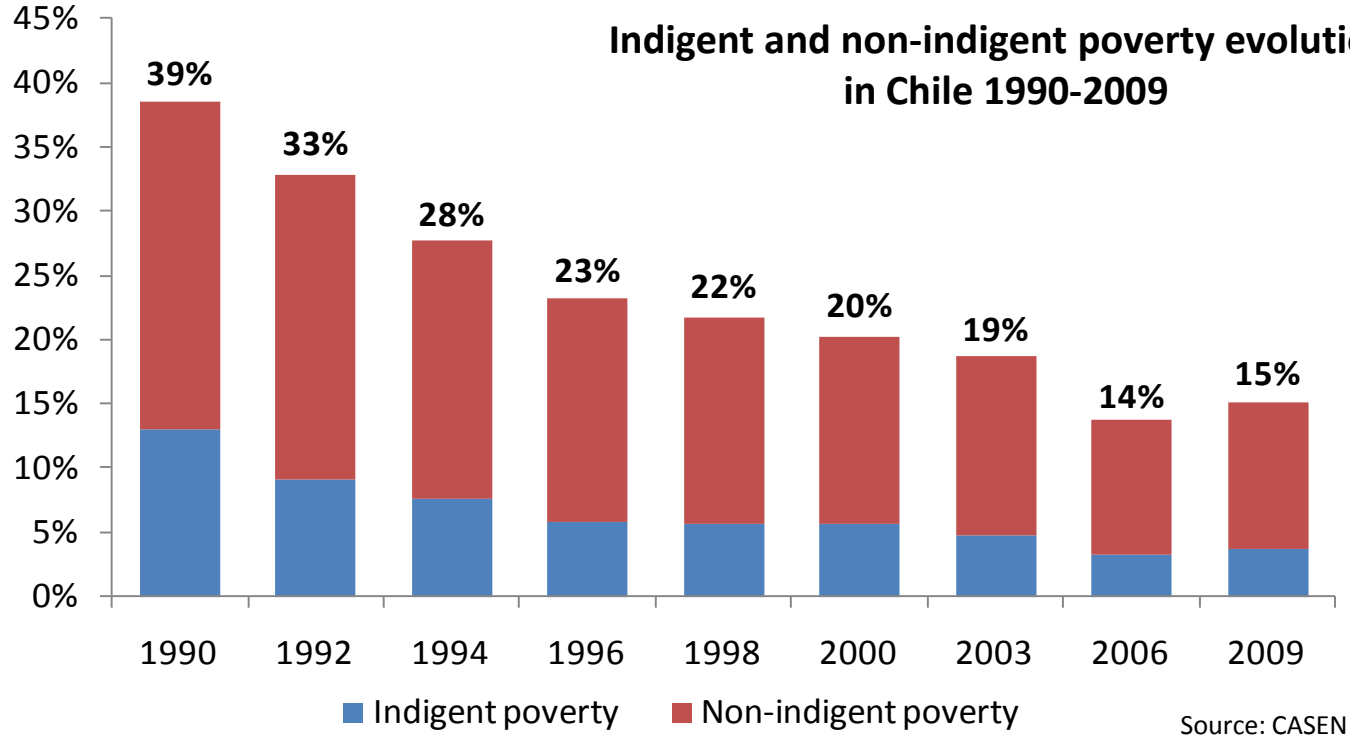


- Reduction of GHG is a global goal, but specially for developed countries responsible for 46% of emissions.
- Strong urge for developing countries to achieve a developed status in the near future, hence overcoming social shortfalls like poverty and income disparity.
- Establishing a low carbon economy requires a balanced energy policy to comply with all objectives:



Social development and poverty reduction

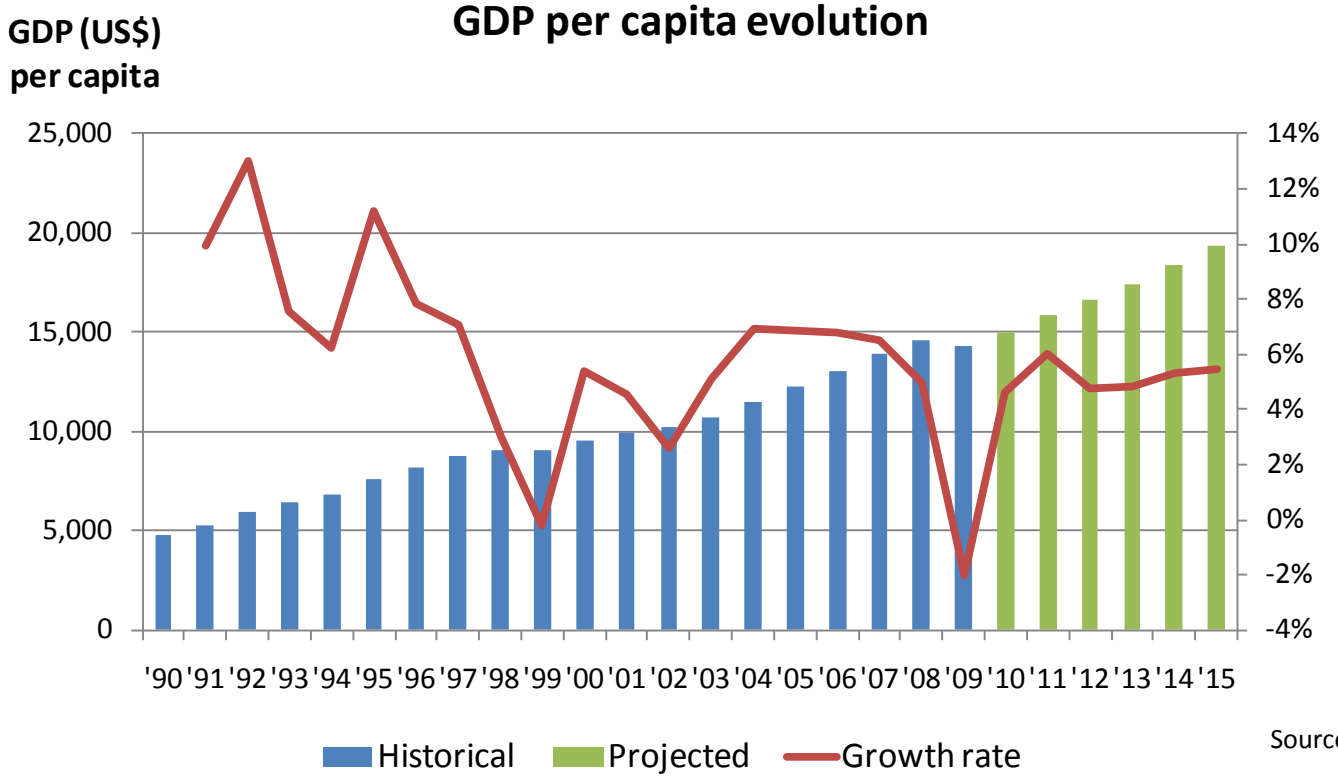
- Poverty reduction is a major goal for Chile, as for all fast developing countries.
- The Chilean Government has set the goal of eliminating extreme poverty by 2014 and overcoming poverty by 2018.



Source: CASEN survey 1990 - 2009

Economy growth targets

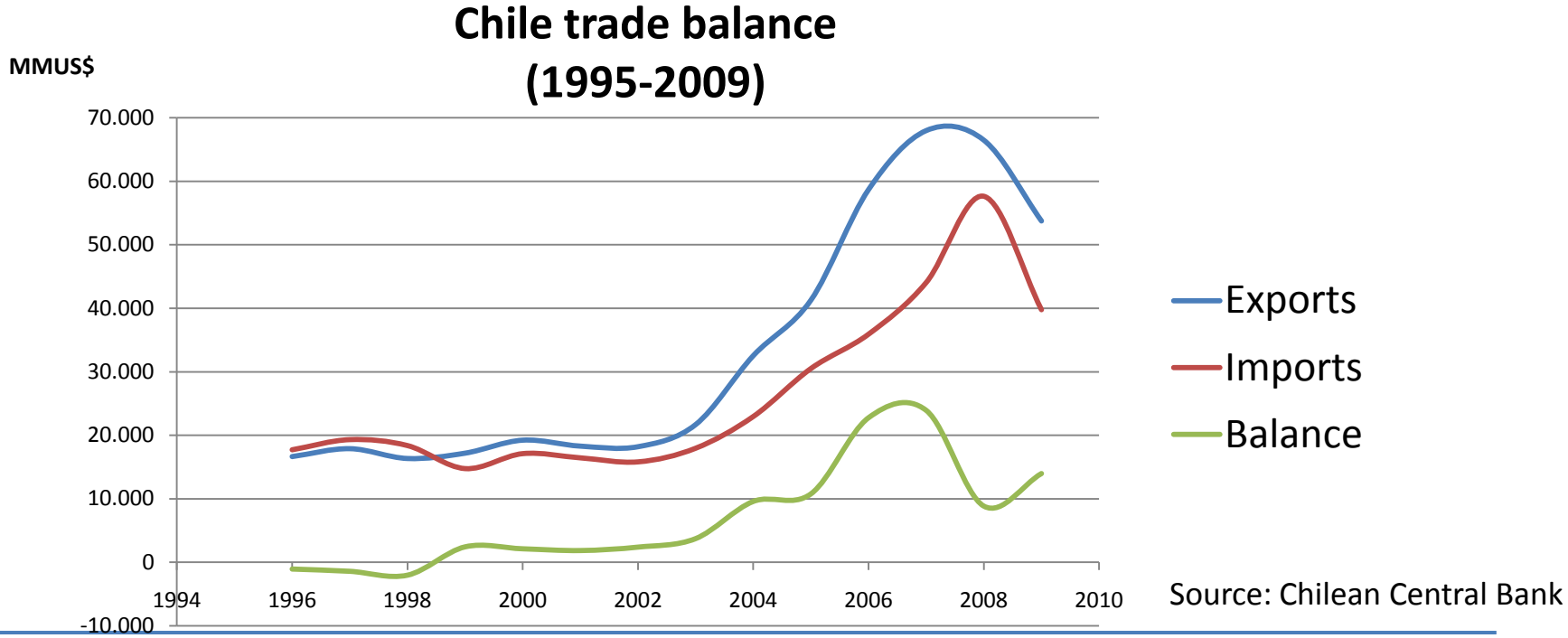
- **Accepted paradigm:** strong correlation between economic growth and poverty reduction.
- Target of growing 6 % annually in order to reach the GDP per capita that currently Portugal and the Czech Republic have.



Source: Systep

Economy growth and global markets

- Economy growth relies on exports , hence the need to access and compete in international markets.
- Most developing countries base their economies on exports of primary goods, often energy intensive.

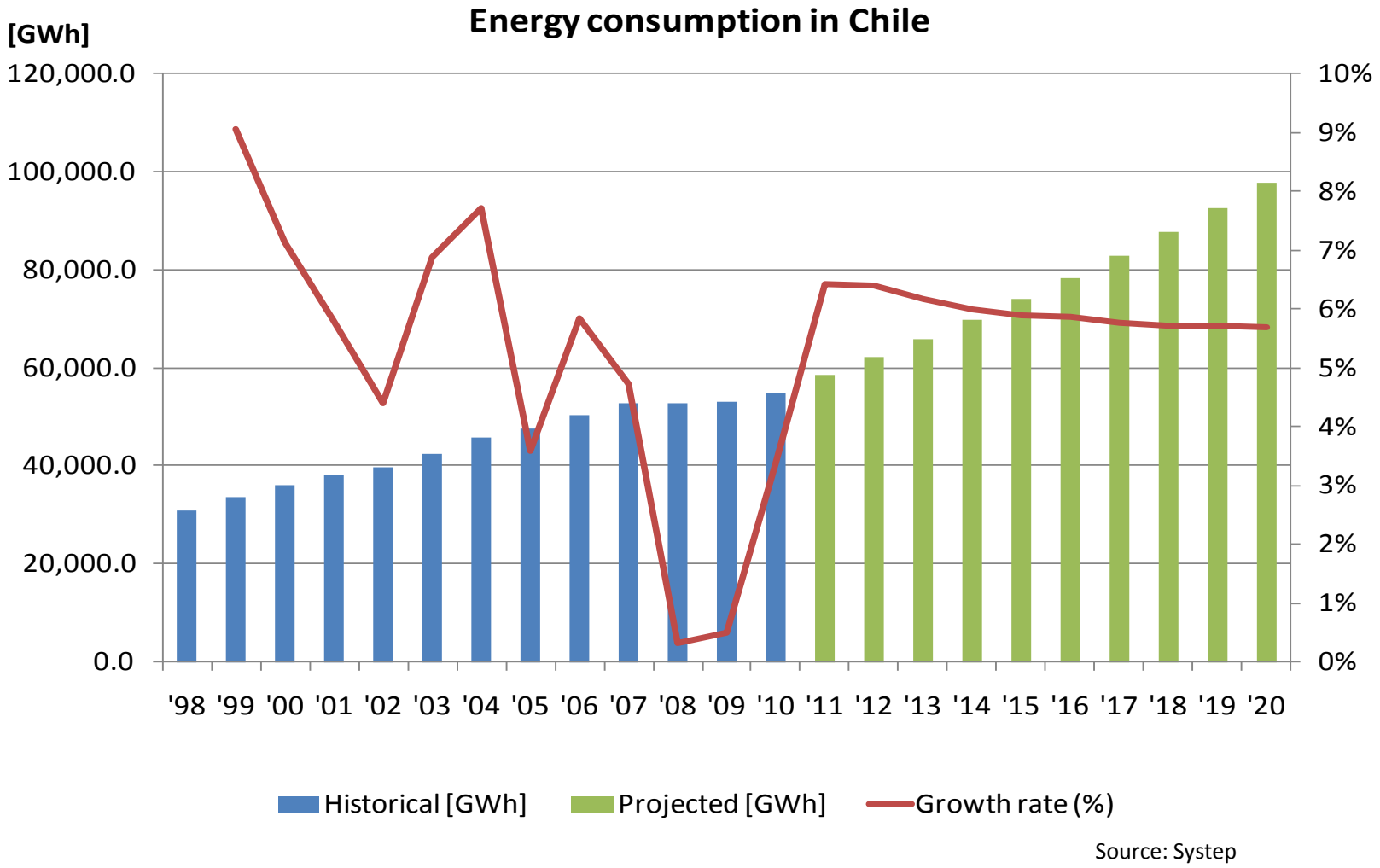


Source: Chilean Central Bank

Global economy means global enviromental restrictions

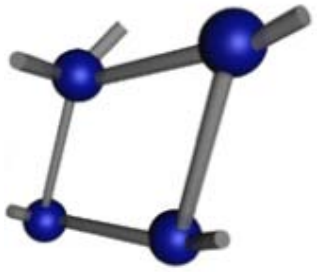
- Developed countries will eventually have to commit to binding emissions reduction
- Restrictions to international trading reducing the competitiveness.
- Carbon footprint labelling: Tesco UK.

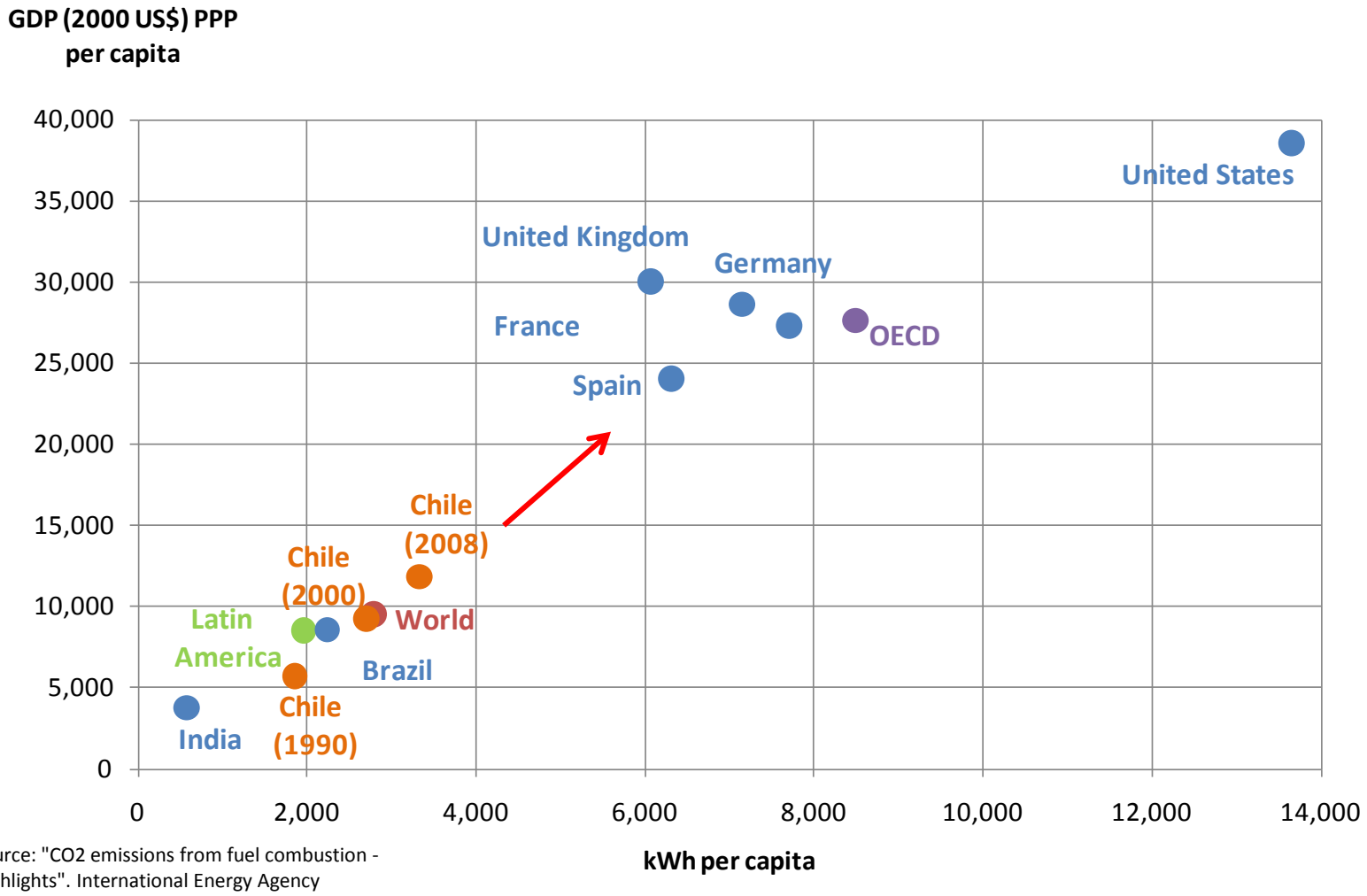
Energy requirements to fuel a growing economy



Source: Systep

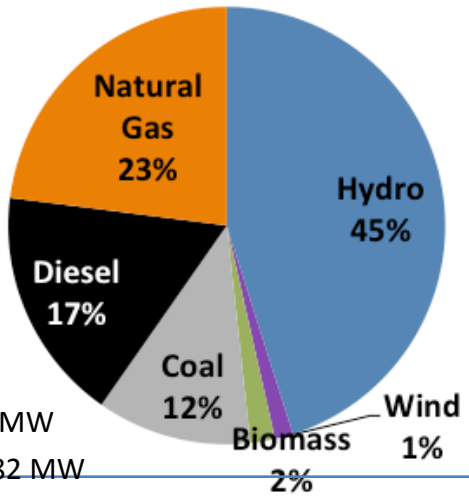
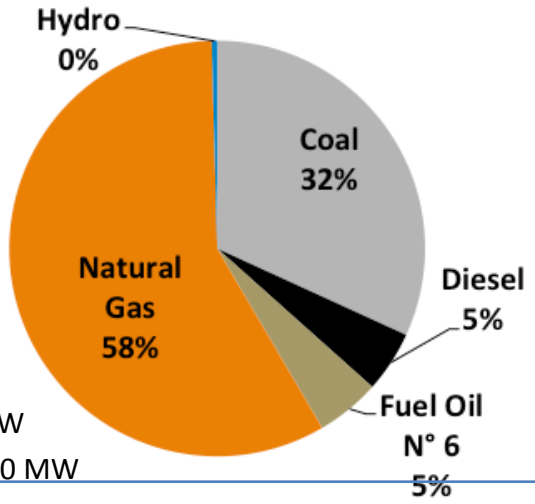
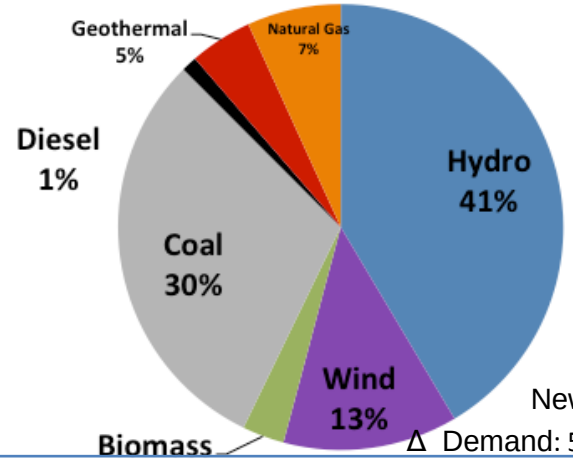
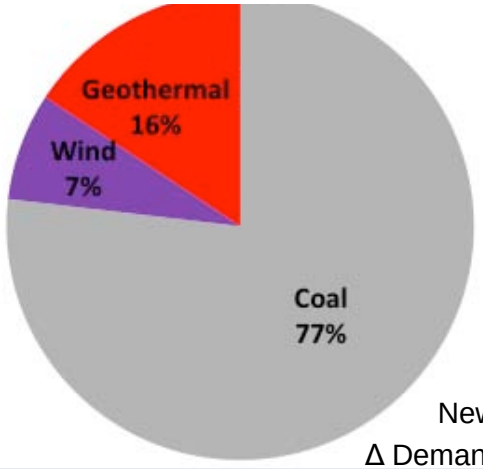
Ecomical growth versus energy consuption





Source: "CO2 emissions from fuel combustion - Highlights". International Energy Agency

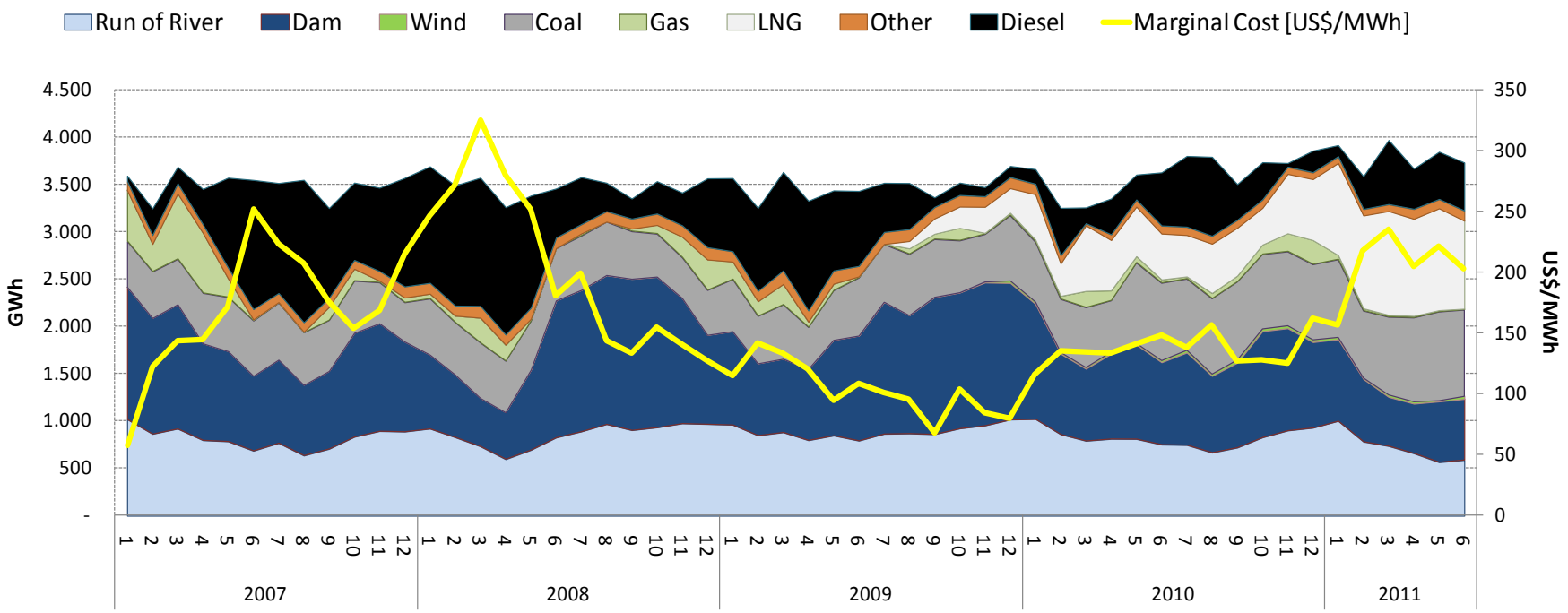
Chilean energy matrix: current and new capacity

	Central Interconnected System	Nothern Interconnected System
2010	 Total: 11.845 MW Demand: 6.482 MW	 Total: 3.574MW Demand: 1.900 MW
2020	 New: 5.280 MW Δ Demand: 5.125 MW	 New : 2.550 MW Δ Demand: 1.515 MW

Source: ITD October 2010, CNE

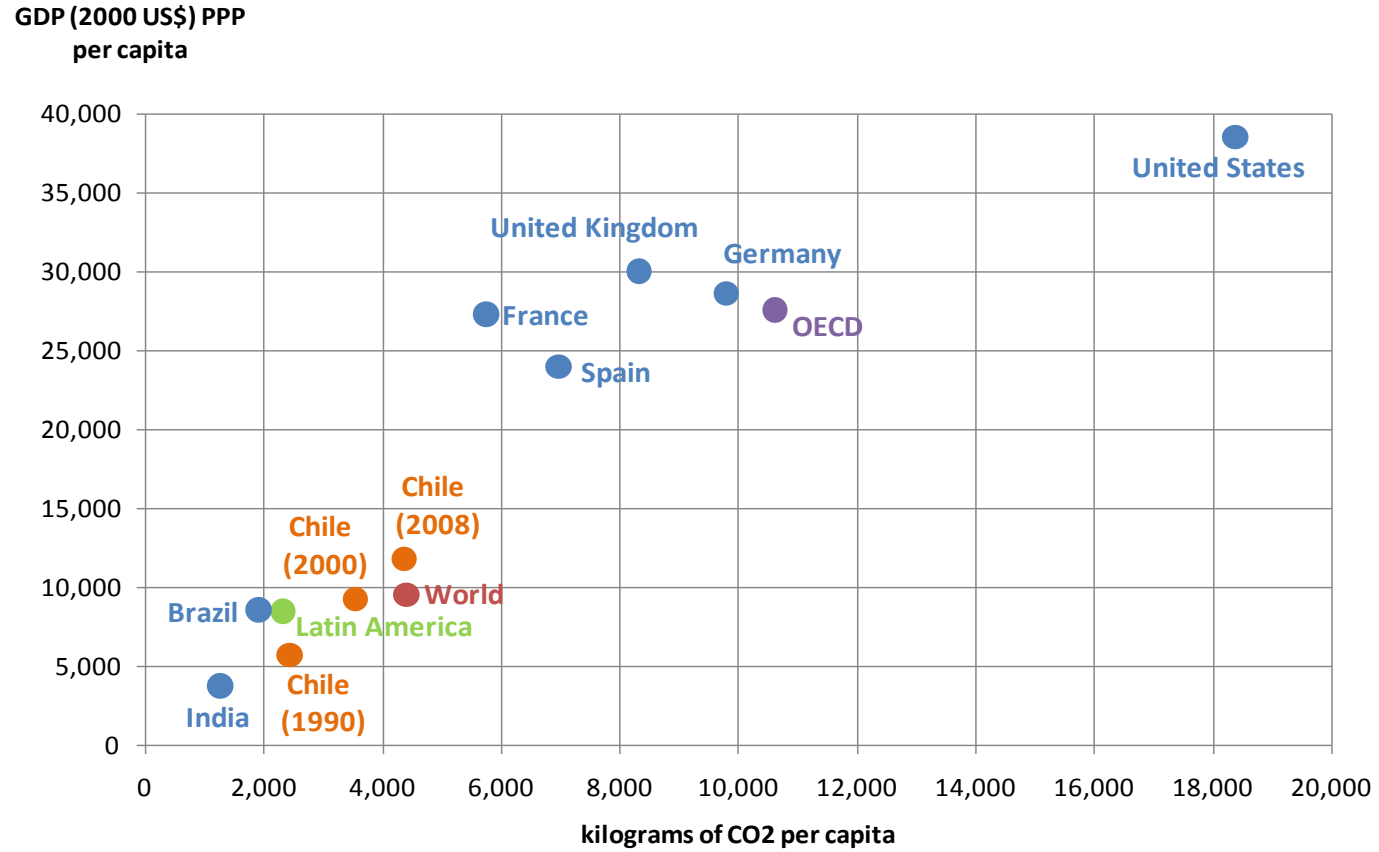
Why energy cost is a sensible issue in Chile?

- Generation by technology and marginal costs (2007-2011)
  - Dependence on hydro and imported fuels
  - High volatility of marginal cost
  - Highest energy price in the region



GDP and CO_2 emissions

- GHG emissions in the Latin American corresponded worldwide to only 4.9% in 2004.

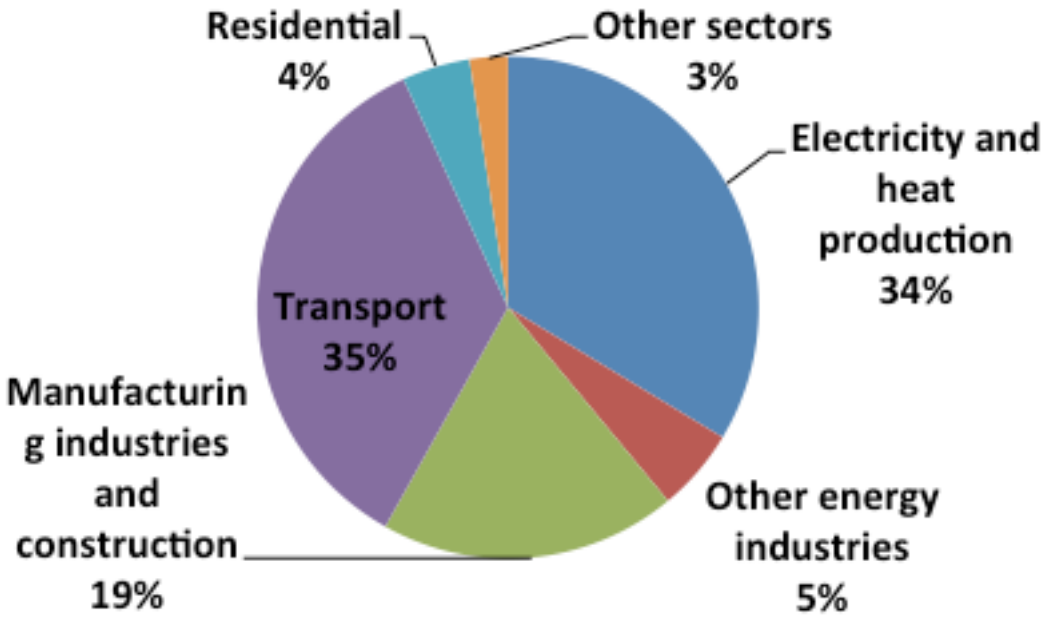


Source: "CO2 emissions from fuel combustion - Highlights". International Energy Agency

CO_2 emissions targetted reduction

- Chile has set a voluntary target of capping emissions by 20 % by the year 2020.

Total CO2 emissions by sector in Chile for 2008



Source: CO2 emissions from fuel combustion - Highlights. IEA.

Options for low carbon energy matrix development

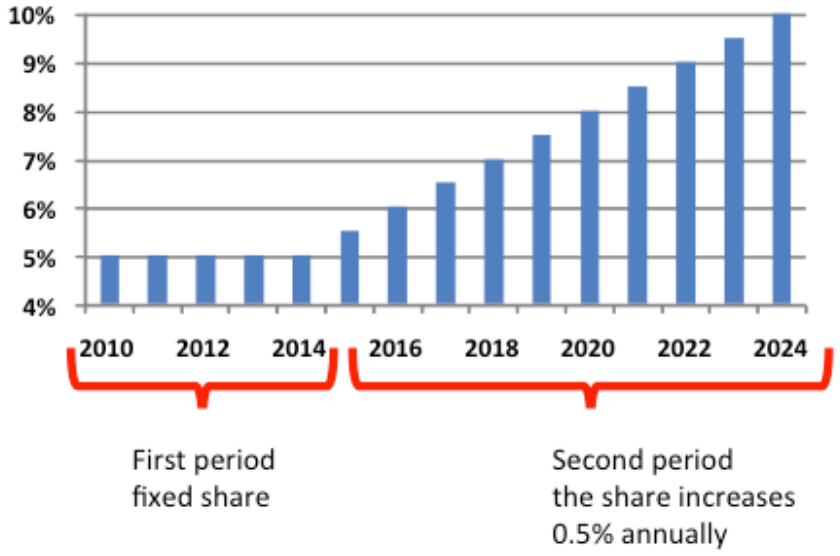
- Large hydro developments
  - Potential for over 16.000 MW.
  - Most hese resources are located either in indigenous populated areas, regions with a touristic potential or in unexploited natural reserves.

- Nuclear
  - Nuclear power plants were being considered, but are still in a very early stage of evaluation and affected by the recent events.

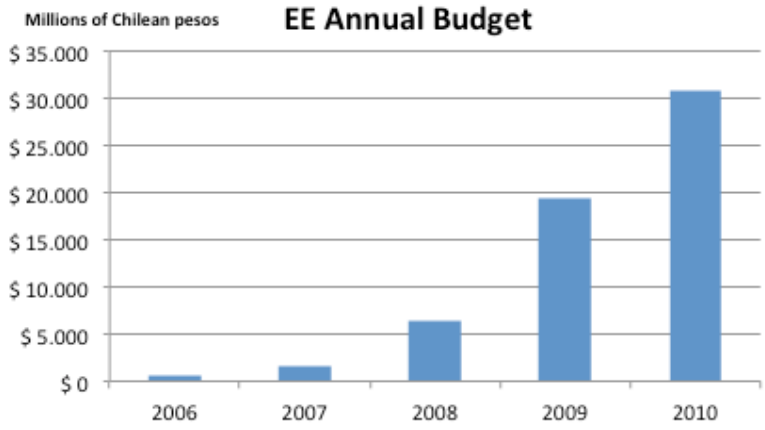
- Carbon Tax and Cap & Trade schemes are not considered.

Options for low carbon energy matrix development

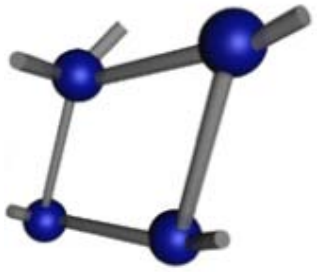
- Renewable energy:
  - Obligation for power traders to certify that a percentage of the energy contracts being traded comes from NCRE.
  - Great potential for mini hidro, wind, solar, geothermal, biomass.



- Energy efficiency
  - Should be an important tool but with a little effect.



Levelized cost by technology



- Levelized cost of different alternatives for power generation expansion in Chile.

Technology	Investment Cost [US$/kW]	Operating Cost [US$/MWh]	Average Capacity Factor [%]	Area [Ha/MW]	CO2 emissions [Ton CO2/MWh]	Levelized Cost [US$/MWh]*
Dam	1950	5	65%	3,3	0,00	38
Run of River	2100	5	65%	1,5	0,00	41
Geothermal**	3550	2	85%	0,1	0,00	47
Small Hydropower	3000	5	65%	1,5	0,00	55
Coal	2350	48	85%	0,3	0,75	83
Nuclear	6000	17	85%	0,2	0,00	89
Wind	2000	8	30%	16,7	0,00	96
CC LNG	750	91	65%	0,2	0,48	105
Solar PV	3200	0	25%	6,7	0,00	165
Diesel	720	218	65%	0,2	0,82	234

Source: Systep

* Transmission cost not included

** Exploration cost not included

Widespread rejection to coal fired thermal plants

Organized opposition to large hydro developments

The New York Times

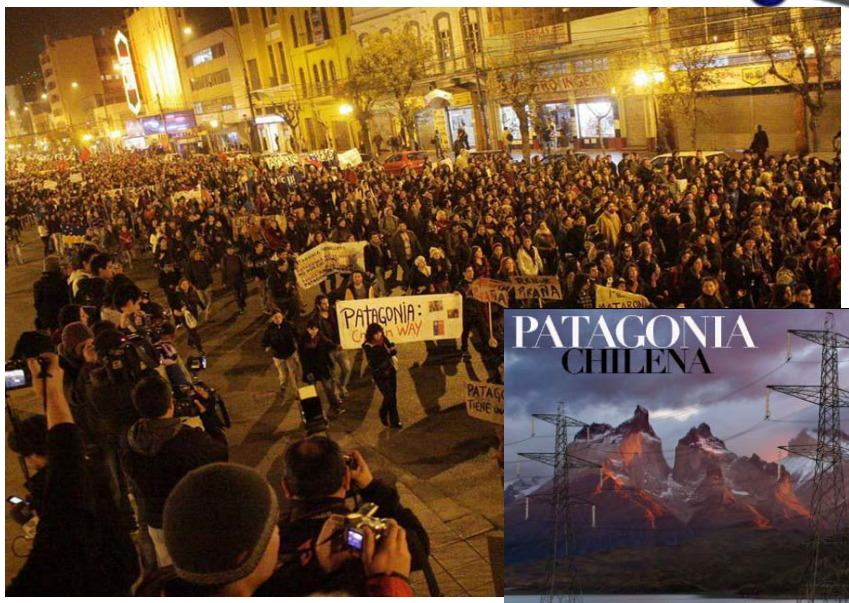
The Opinion Pages

EDITORIAL

Keep Chilean Patagonia Wild

Published: May 23, 2011

An environmental review commission in the Aysén region of southern Chile has made a potentially disastrous decision, voting to approve the construction of five hydroelectric dams, two on the Baker River and three on the Pascua. The damage these dams would do to the environment is tremendous, and their construction — in a largely unspoiled natural haven — would open the way for further development, including more dams.



THE WALL STREET JOURNAL.

THE AMERICAS | JULY 11, 2011

U.S. Greens vs. Chile's Poor

Environmental groups in America lobby to block Chilean energy development.

Chilean President Sebastian Piñera says that by generating high levels of growth, his government's economic policy can set the country on the path to becoming a developed nation within a decade. That would be especially good news for the millions of Chileans who still live below the poverty line. But it's not likely to happen if environmentalists have their way in blocking Chilean energy development.

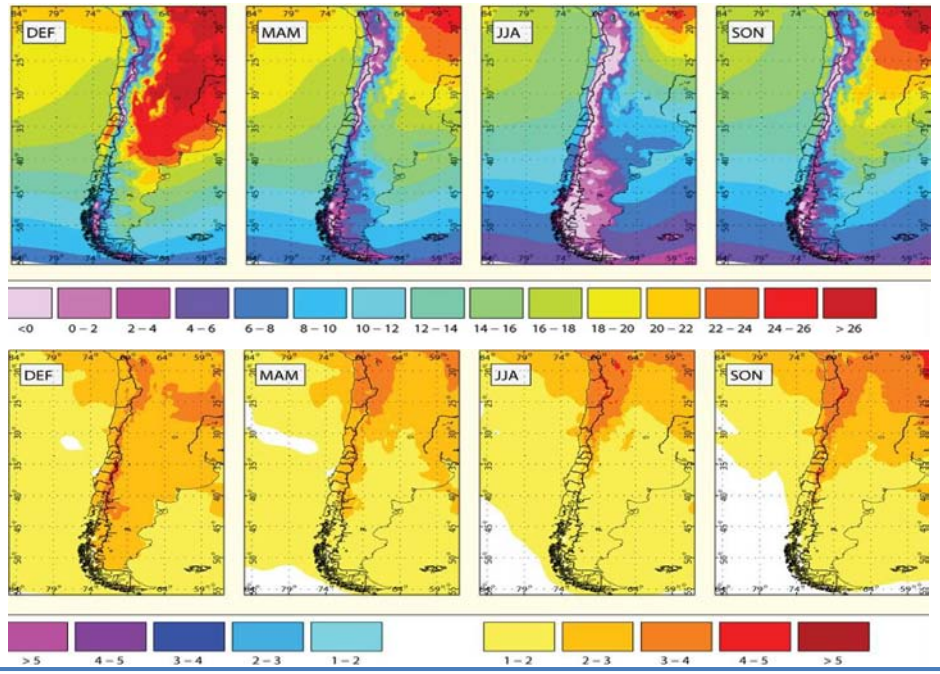
Nuclear energy after Fukushima?

- Not willing to assume political costs.

Adaptation versus mitigation?

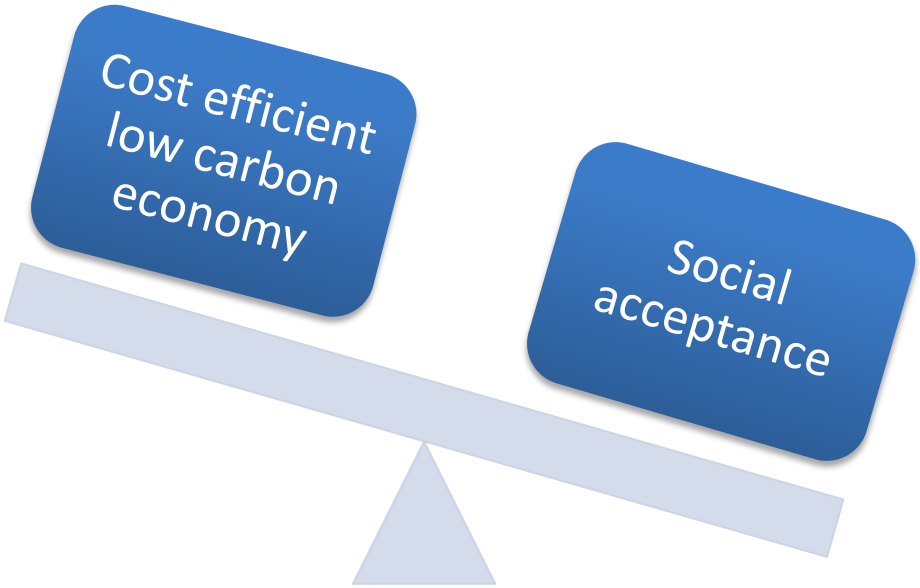
- Meanwhile climate change effects will hit hard in poorer and developing countries, which don't have the resources to adapt.
- How much attention should be drawn to mitigation instead of adaptation?

1990

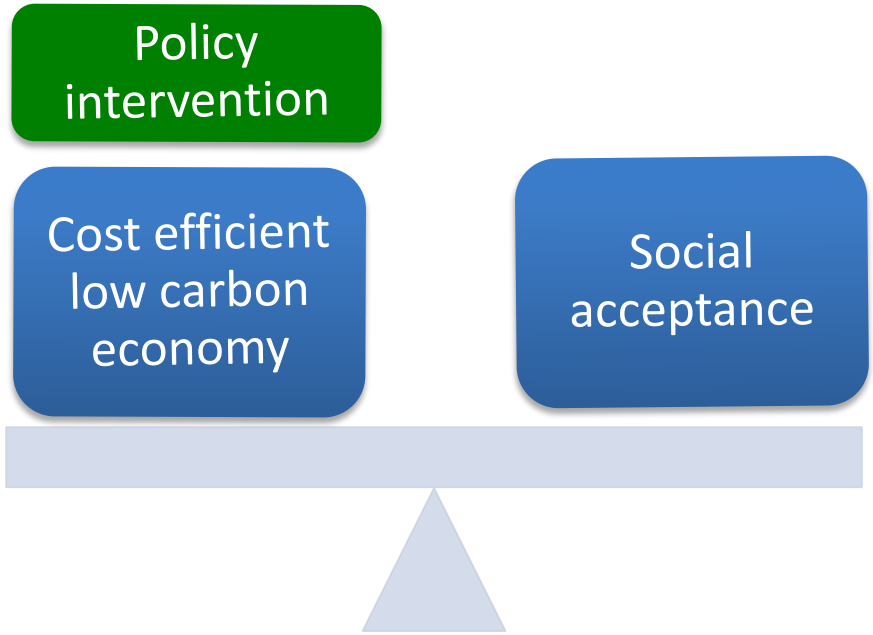


2070

Final remarks



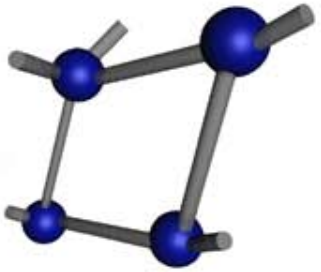
Final remarks



- Policy intervention in required to further support market through a more guided planning:
  - Education and information to public
  - Land use regulation. E.g. determining specific areas for thermal generation
  - Watershed management.
  - Transmission expansion change to permit timely investment.

Further reading

- More information of the Chilean electricity market:
  - Publications
    - http://www.systep.cl/publicaciones.php
  - Monthly reports
    - http://www.systep.cl/reportes.php



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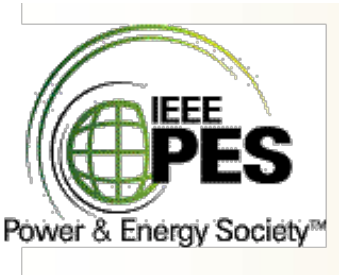

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