Regulatory Frameworks in Latin America and the Chilean Experience

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ELECTRICITY GENERATION: INSTALLED CAPACITY AND GENERATION

Latin America and the Caribbean

Year	Electricity Generation GWh			Install Capacity MW		
	Hydro	Thermal	TOTAL	Hydro	Thermal	TOTAL
1992	395,449	249,102	644,551	98,308	67,414	165,723
1993	426,817	253,696	680,513	101,240	69,935	171,175
1994	443,216	274,891	718,107	104,713	76,263	180,976
1995	463,398	290,950	754,349	107,160	79,567	186,727
1996	486,713	312,472	799,185	113,047	82,688	195,735
1997	505,588	341,309	846,896	116,314	85,795	202,109
1998	516,958	366,940	883,897	118,505	90,773	209,278
1999	524,187	388,392	912,579	121,650	93,586	215,236
2000	550,956	410,255	961,212	124,586	98,779	223,365
2001	547,884	402,980	950,865	126,163	101,996	228,159
2002	540,052	447,256	987,308	126,163	113,241	239,404

Year	Electricity Generation %			Install Capacity %		
	Hydro	Thermal	TOTAL	Hydro	Thermal	TOTAL
1992	61%	39%	100%	59%	41%	100%
1993	63%	37%	100%	59%	41%	100%
1994	62%	38%	100%	58%	42%	100%
1995	61%	39%	100%	57%	43%	100%
1996	61%	39%	100%	58%	42%	100%
1997	60%	40%	100%	58%	42%	100%
1998	58%	42%	100%	57%	43%	100%
1999	57%	43%	100%	57%	43%	100%
2000	57%	43%	100%	56%	44%	100%
2001	58%	42%	100%	55%	45%	100%
2002	55%	45%	100%	53%	47%	100%

Source: OLADE/CE - SIEE

Big hydro dependence ..

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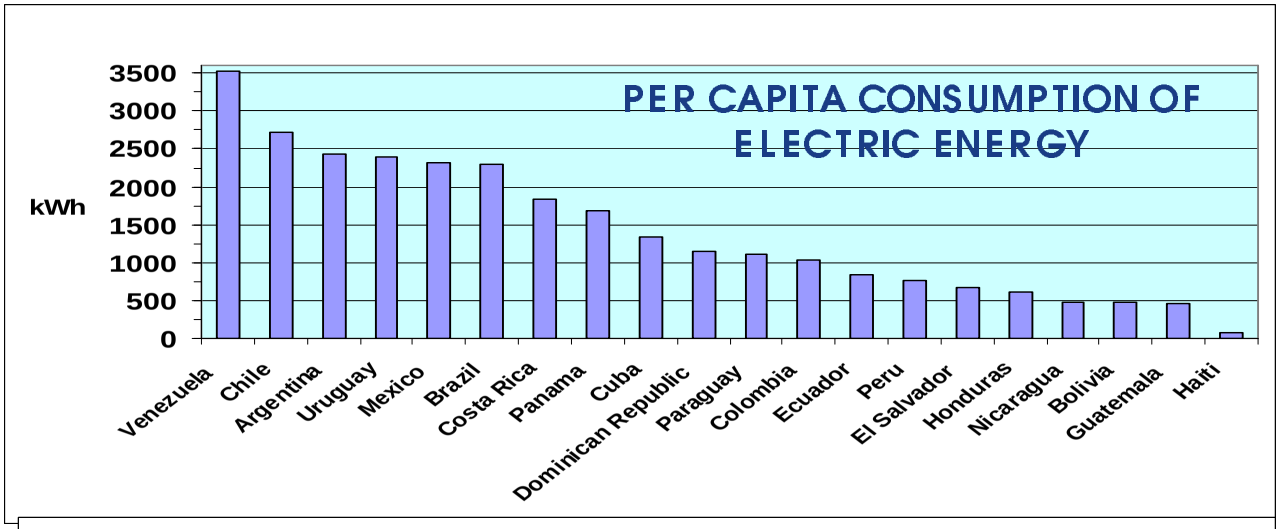
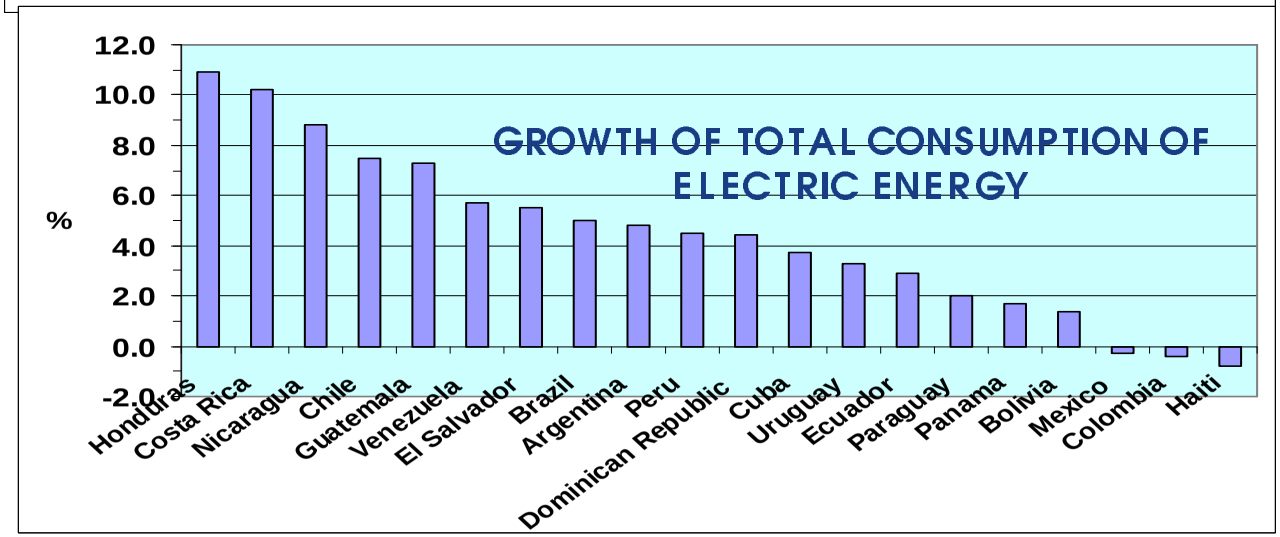
WITH BIG DIFFERENCES INSIDE THE REGION





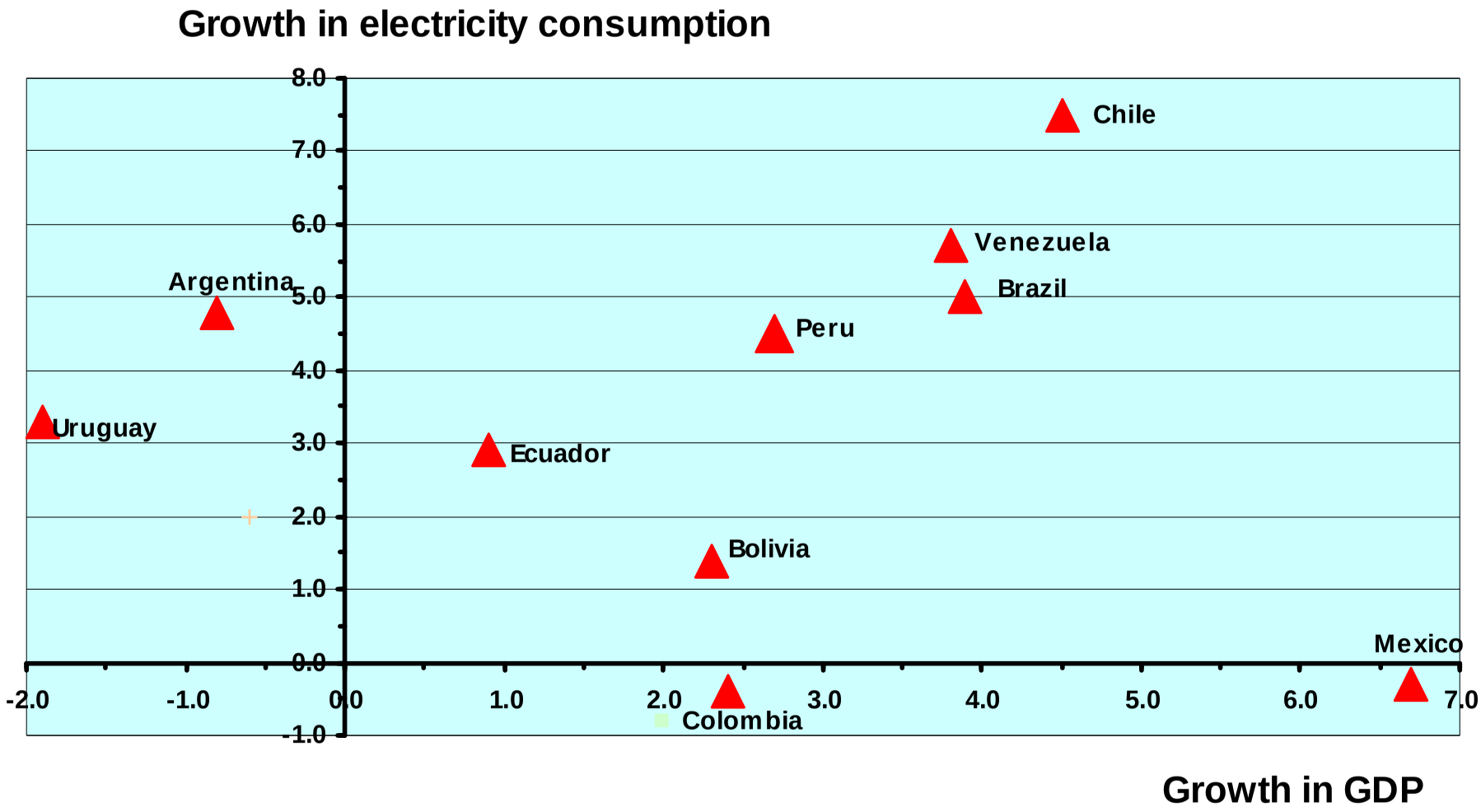
Year 2000

Big differences between countries

Source: 2003 Statistical yearbook for Latin America and the Caribbean - ECLAC, United Nations Publication

GDP AND ELECTRICITY CONSUMPTION

Year 2000



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DRIVERS OF REGULATION AND PRIVATIZATIONS

- Sustain investment with high demand growth
- New open market policies
- Fiscal deficit :
  - need to sell State assets
  - Lack of new financial resources
- Inefficient resources allocation
- Low quality levels

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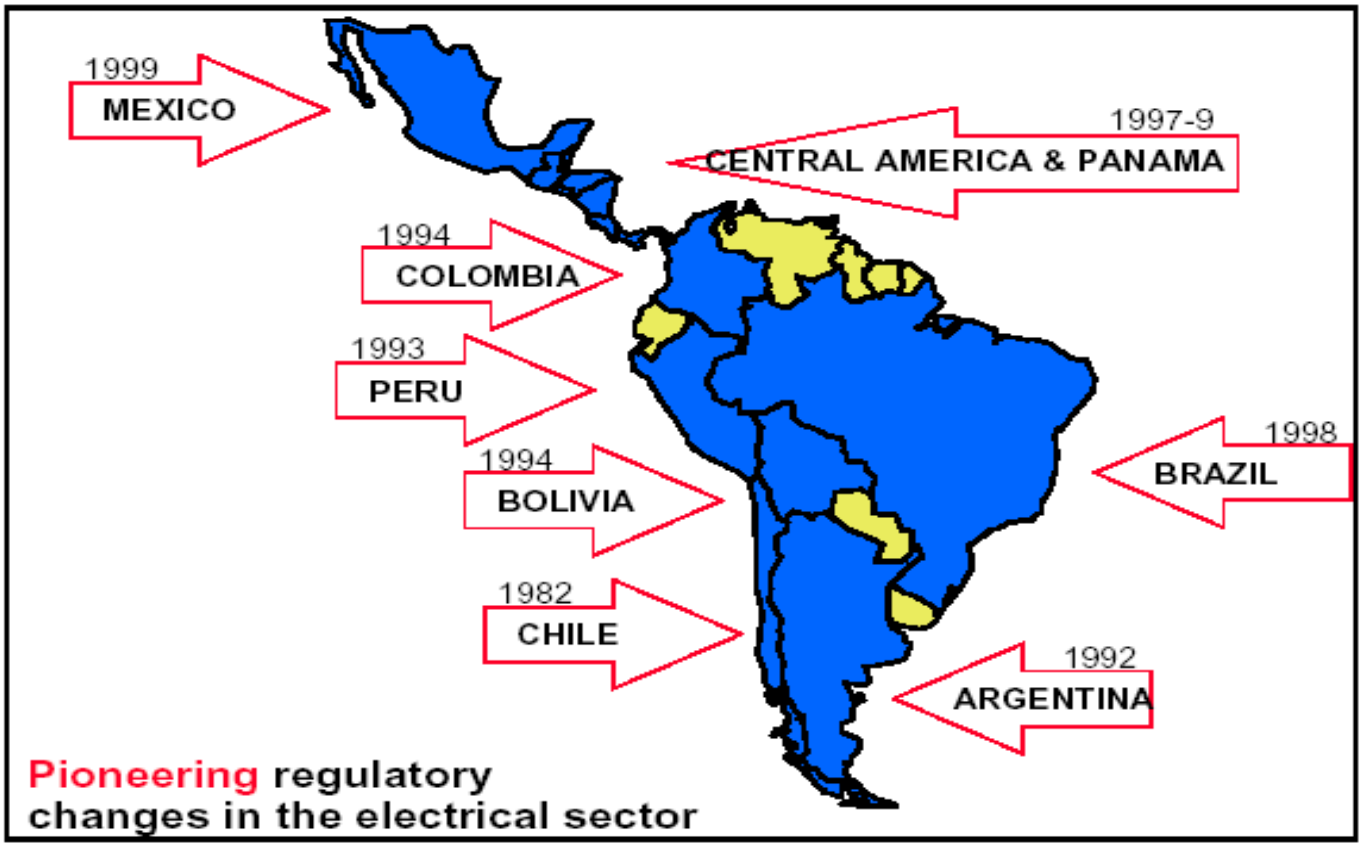
ELECTRICITY MARKET REFORMS



Chile pionner in the region in the 80´s

Other countries in the 90´s

In general terms, the Chilean model was implemented with few modification in Latin America.

Source: Hugh Rudnick , IEE-IEEE Lecture , London, April 5, 2000

REGULATORY SCHEMES ON GENERATION

- Centralized polls governed by ISO (Independent System Operators). With short term marginal cost and market offers based schemes (Colombia).
- The short term marginal cost is given by variable costs: fuel and maintenance. The variable costs are audited or based on referential costs.
- Unregulated prices for large consumers.
- Regulated consumers under a capped level based on energy or demand consumption.
- The regulated prices based on an average of the medium term marginal cost.
- Competition at generation level, therefore the new power plants : technology, location and operation year, are only defined by the market.

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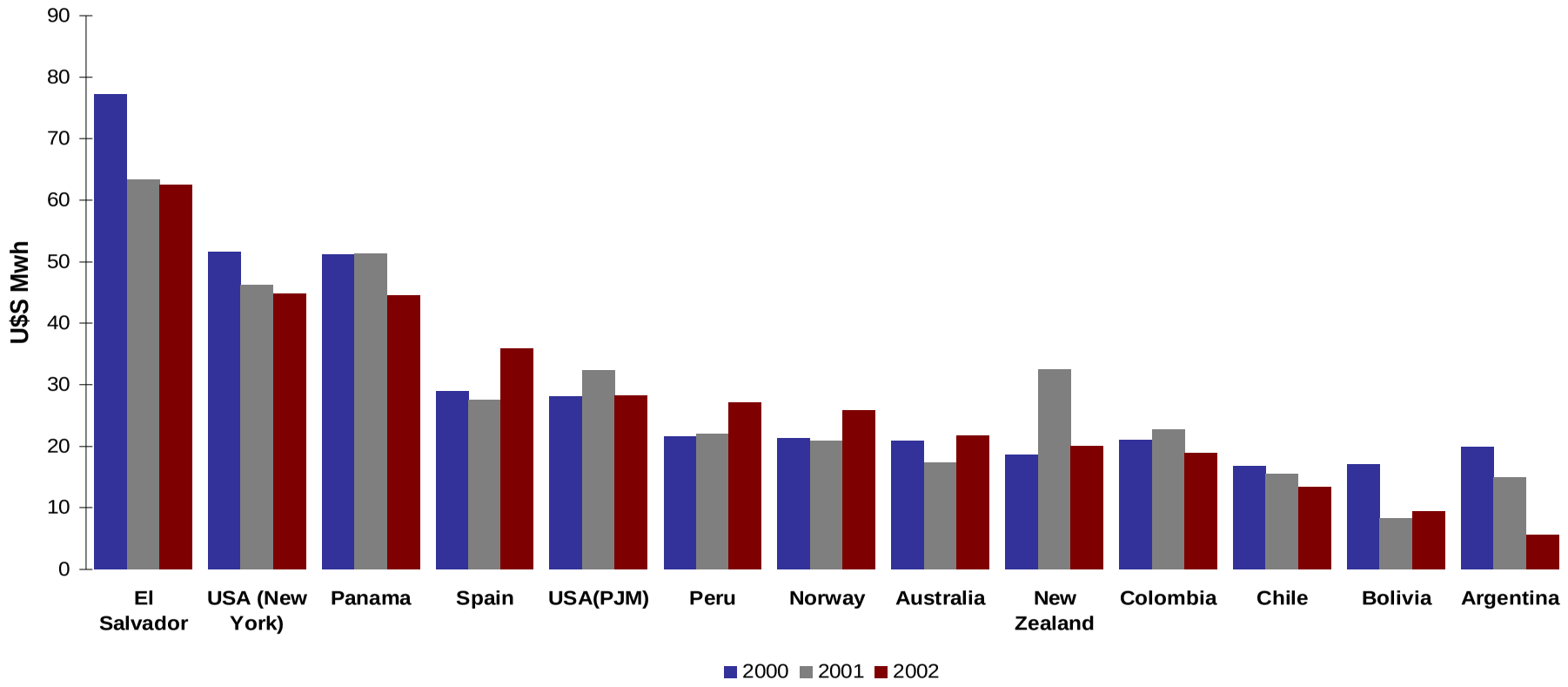
REGULATORY SCHEMES ON GENERATION

- Generators receive incomes for sales for three concepts:
  - energy
  - capacity firm (capacity that they can guarantee with a high probability)
  - Ancillary services : reserve, reactive energy, frequency regulation

INTERNATIONAL WHOLESALE ENERGY PRICE



Minimum energy prices in Argentina

Maximum energy prices in El Salvador

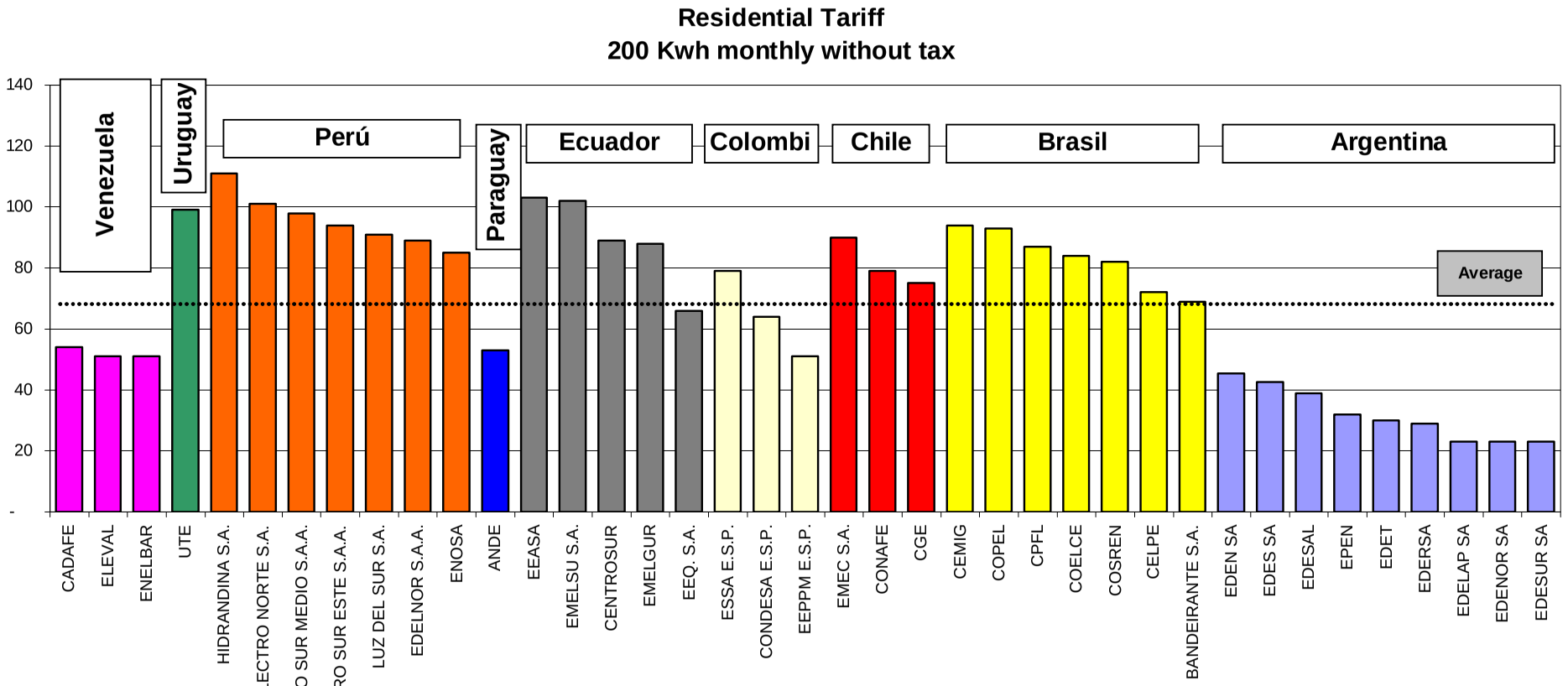
REGULATORY SCHEMES ON TRANSMISSION

- Transmission open access regulation.
- It defines a main grid in high voltage paid by generators and customers.
- Current facilities tariff based on fixed + variable costs or only variable costs.
- Main Grid expansion based on
  - REFERENTIAL GRID STUDIES: Chile, Peru
  - PUBLIC AUCTION : Argentina
- Transmission charges are paid :
  - STAMP: directly by generators and load as an stamp charge (according of the real generation of the power plants or according of the demand of the load)
  - REAL USE: directly by generators and load in proportion of the real use of the facilities

REGULATORY SCHEMES ON DISTRIBUTION

- Distribution companies have concession areas (normally cities) where they are obligated to give service to the customers.
- Commercialization business normally is assumed by distribution companies.
- Incentive based regulation in distribution (efficient model company, price cap).
- Tariffs are calculated for a period of years (normally for four years or more).
- The generation costs and transmission charges , normally are passed through by distribution companies to regulated customers.

SOUTH AMERICA END REGULATED TARIFFS

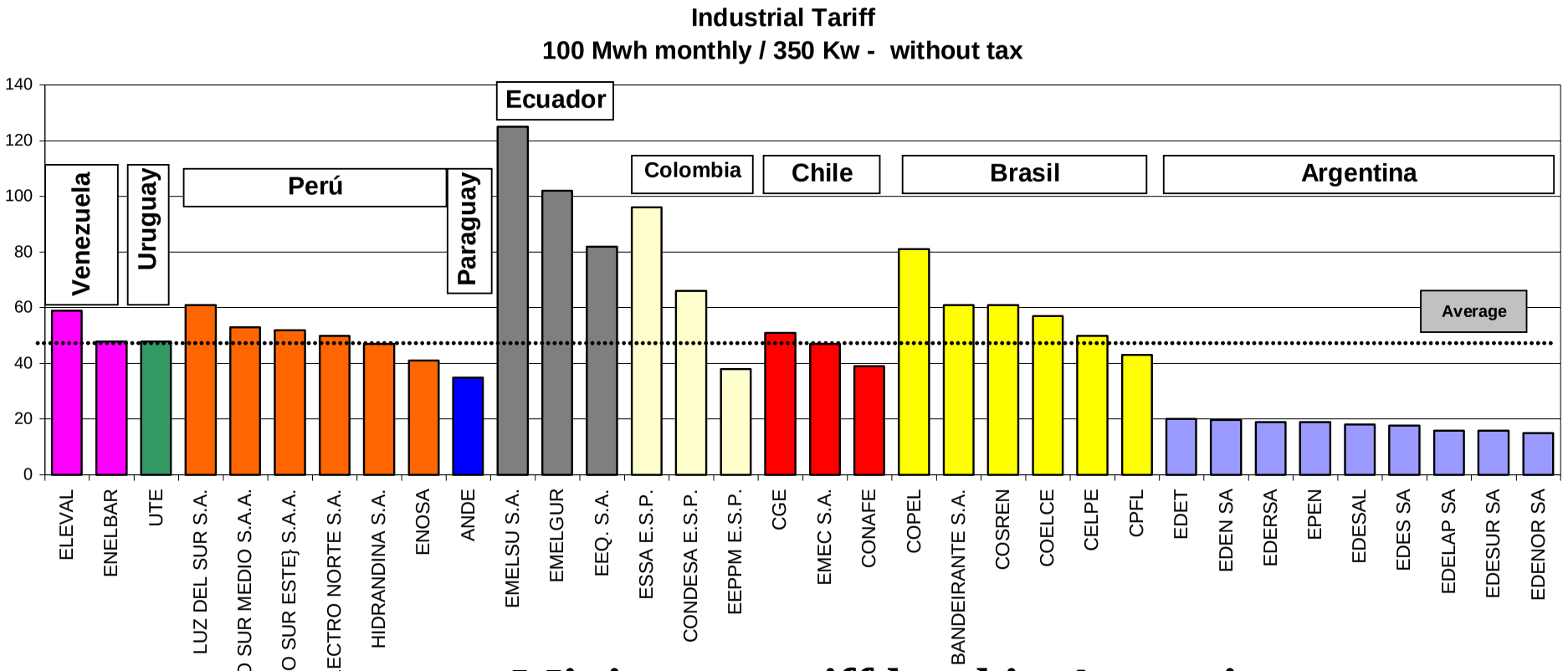


Minimum tariff level in Argentina

Maximum tariff level in Peru and Ecuador

Source: CIER

SOUTH AMERICA INDUSTRIAL TARIFFS



Minimum tariff level in Argentina

Maximum tariff level in Peru and Ecuador

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SUCCESSES

- Competition in the generation level has provoked low prices in generation.
- Reduction of technical and non technical losses in distribution networks.
- Productivity increase in generation, transmission and distribution levels.
- Growth in the electrification levels.

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PROBLEMS

- It is not clear the best way for pricing transmission grid:
  - STAMP (Peru, Colombia, Bolivia)
  - REAL USE of the facilities (Chile and Argentina)
- Problems in the best way to calculate capacity firm of power plants
  - Including short term dispatch signal ? ➔ Peru, Bolivia
  - For drought ? ➔ Chile
- It is not clear the best way to measure the real cost of services in distribution companies
  - Which could be an adequate capital cost?
  - Which are the real cost ?
  - Should include the tariff models efficient signals? and how?
- Increasing divergences among generators inside the Economical Dispatch Centers.
- Regulatory frameworks are instable and are changing constantly, particularly in the generation and transmission levels.

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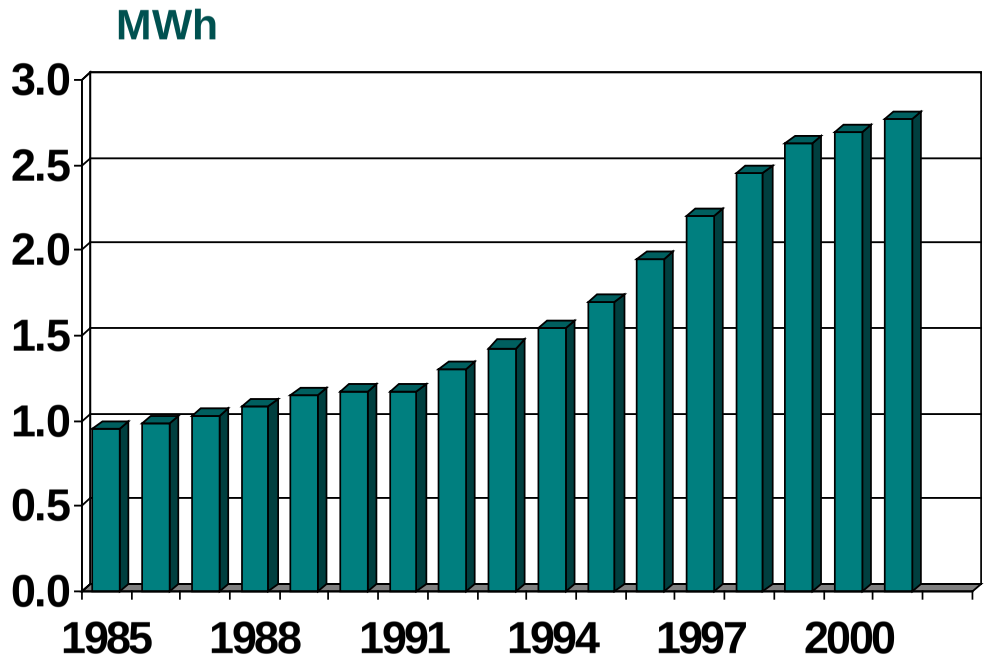
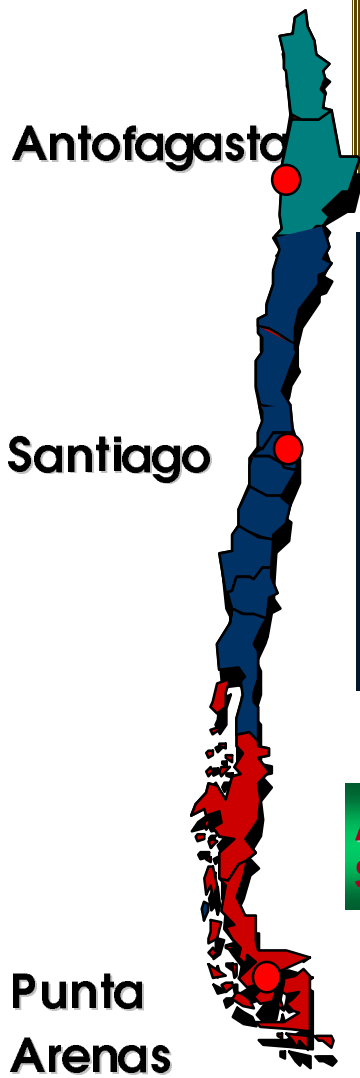
CHILE´S ELECTRICTY CONSUMPTION PER CAPITA



- Demand is growing steadily since the 80´s 7% in average
- Regulated customers represent above 60% of the demand

ELECTRIC SYSTEMS – Key figures: 2002



SING 24.4%

- Generation (GWh) = 10,400
- Installed Capacity (MW) = 3,634
- Maximum Demand (MW) = 1,420
- Population = 5.7%

SIC 75%

- Generation (GWh) = 31,971
- Installed Capacity (MW) = 6,737
- Maximum Demand (MW) = 4,878
- Population = 92.6%

Aysen + Magall System 0.8%

- Generation (GWh) = 262
- Installed Capacity (MW) = 88
- Maximum Demand (MW) = 50
- Population = 1.7%

TOTAL

- Generation (GWh) = 42,633
- Installed Capacity (MW) = 10,459
- Maximum Demand (MW) = 6,348
- Population (million): 15

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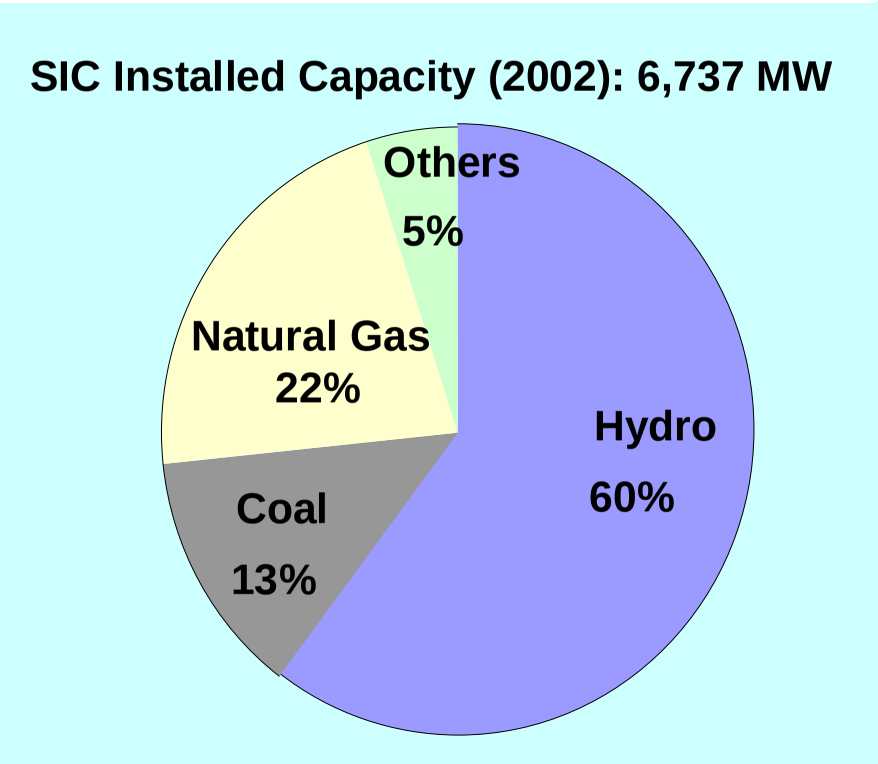
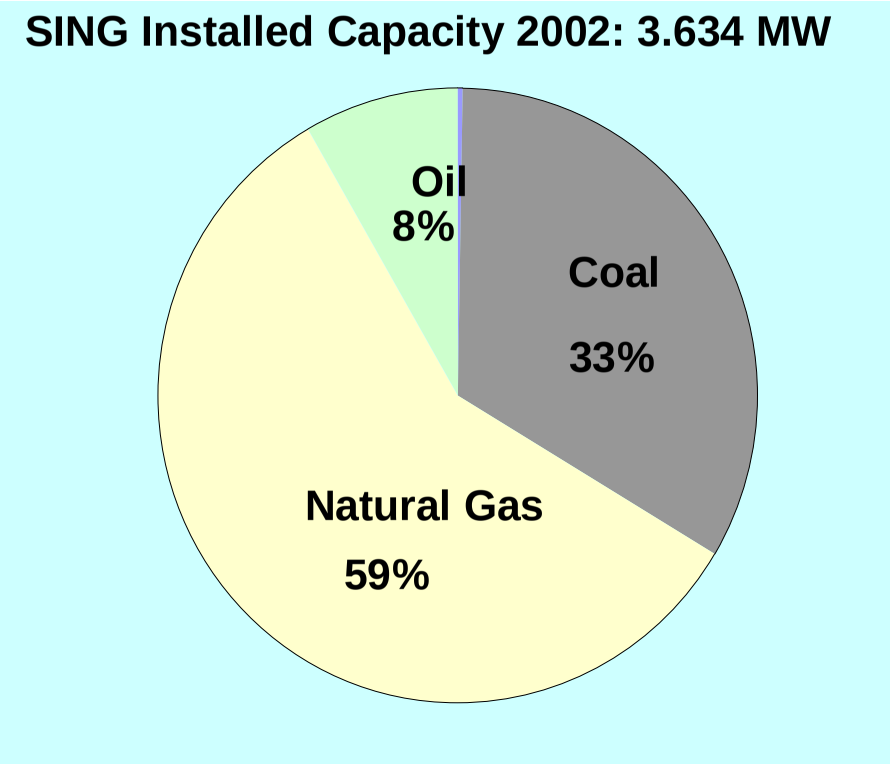
HYDRO PLANTS ARE A MAYORITY IN THE SIC ...





Load Factor SIC :0.74

Capacity additions have kept pace with demand

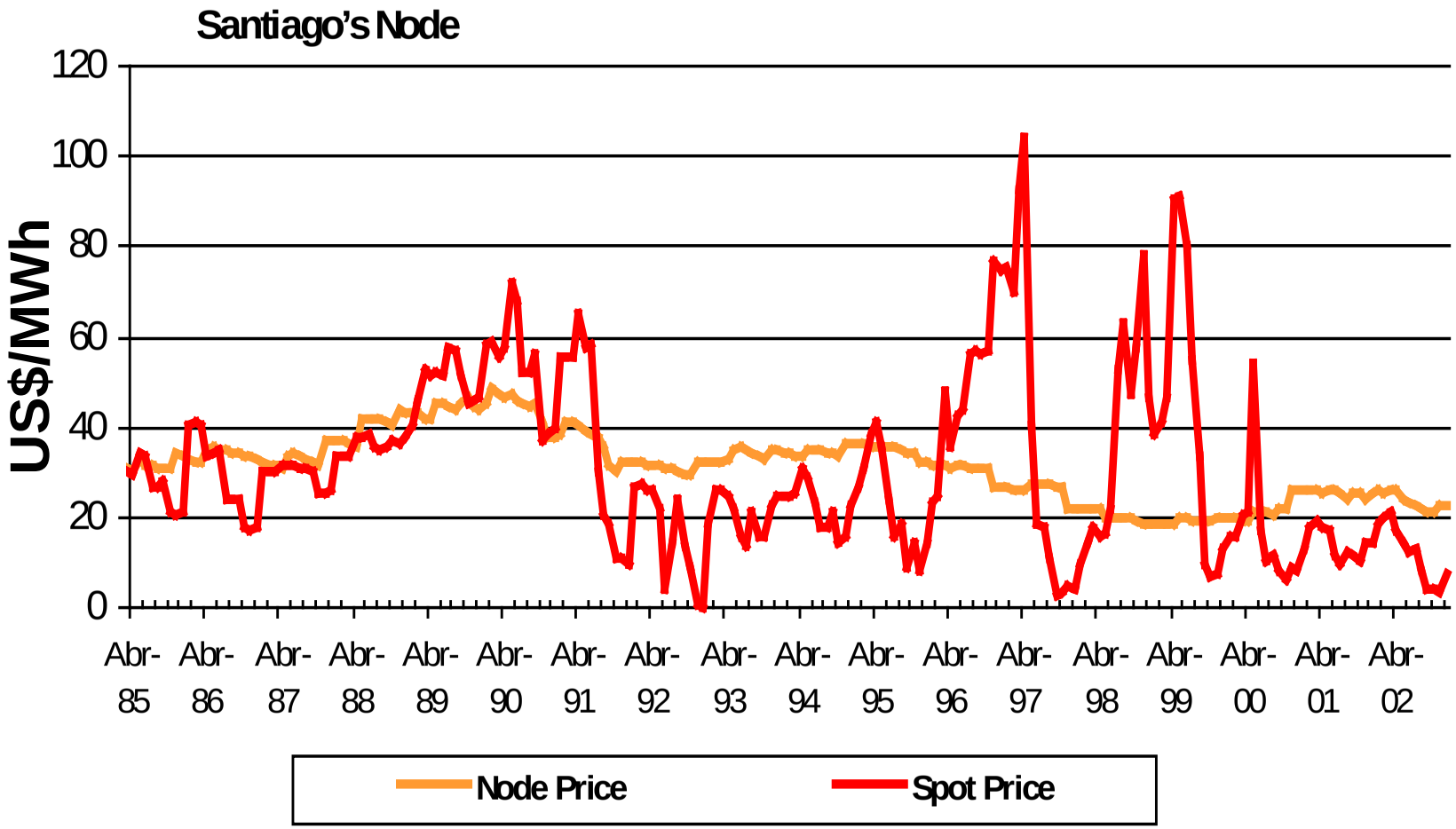
SING : upper than 90%

Irrational over installation

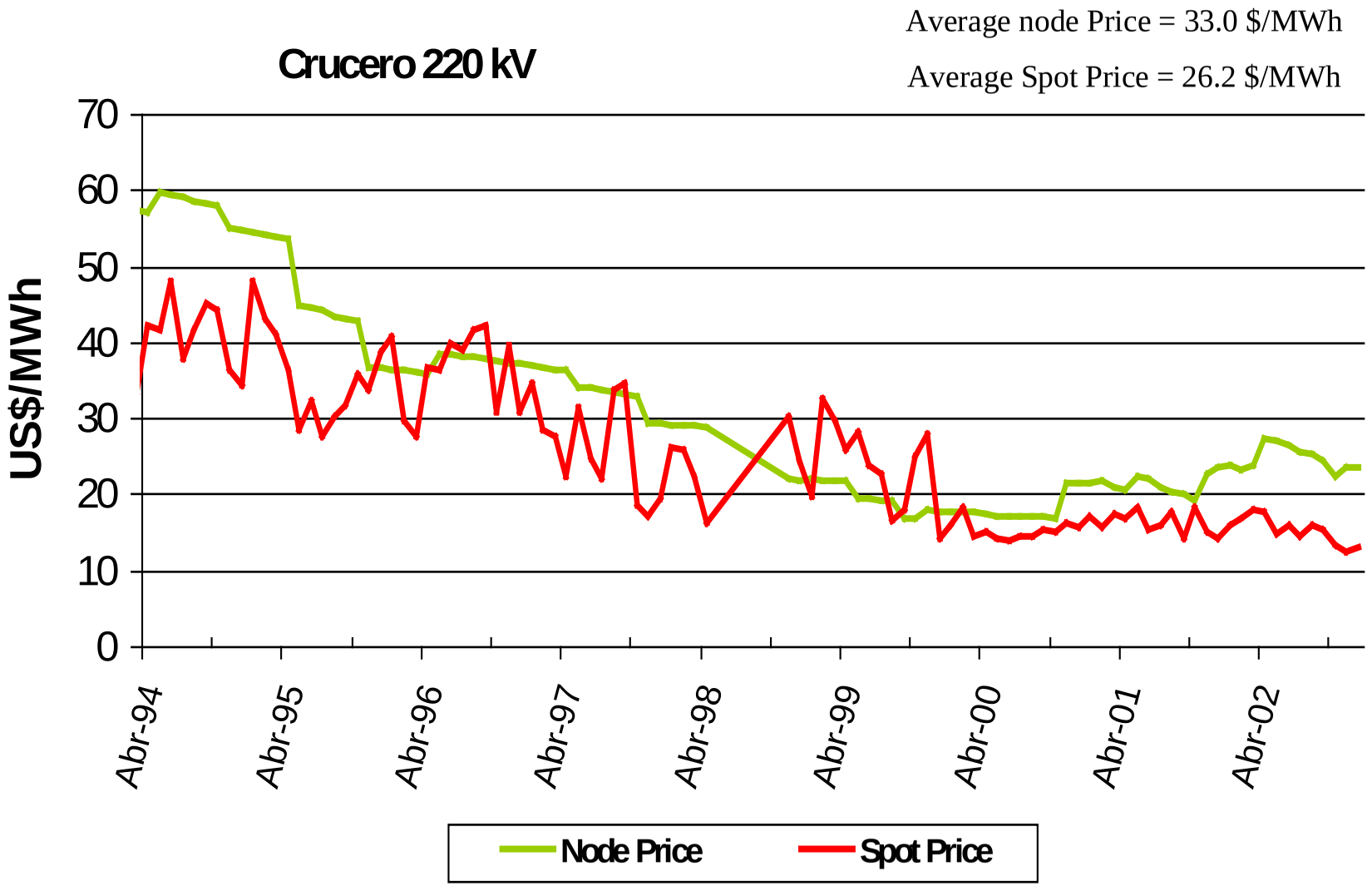
THE SPOT PRICE HAS A WIDE VARIATION WHILE NODE PRICE (REGULATED) IS MUCH MORE STABLE

Average node Price = 31.4 $/MWh

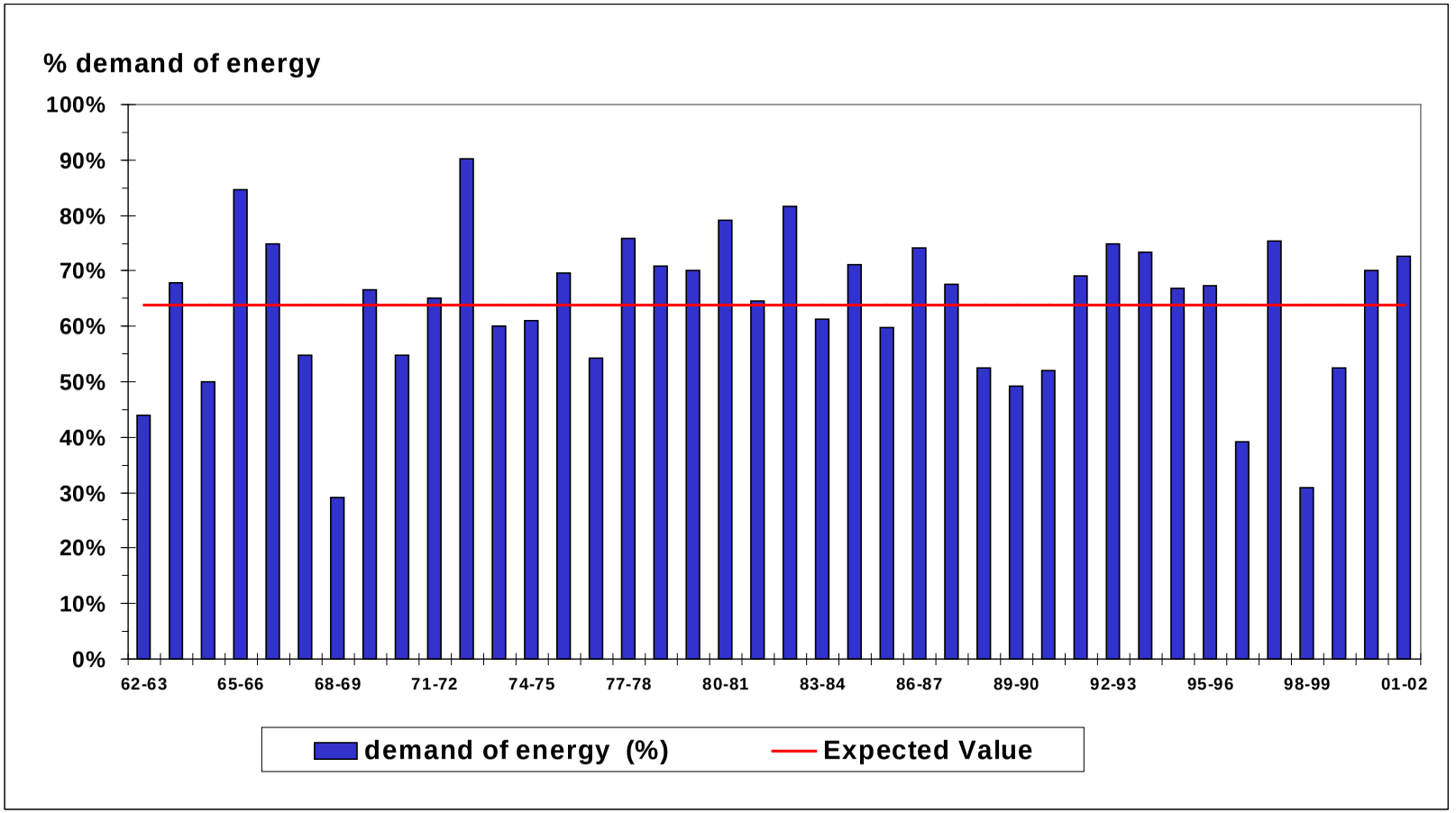
Average Spot Price = 30.8 $/MWh



PRICES HAVE DECLINED AFTER ARRIVAL OF GAS AND NEW COAL PLANTS

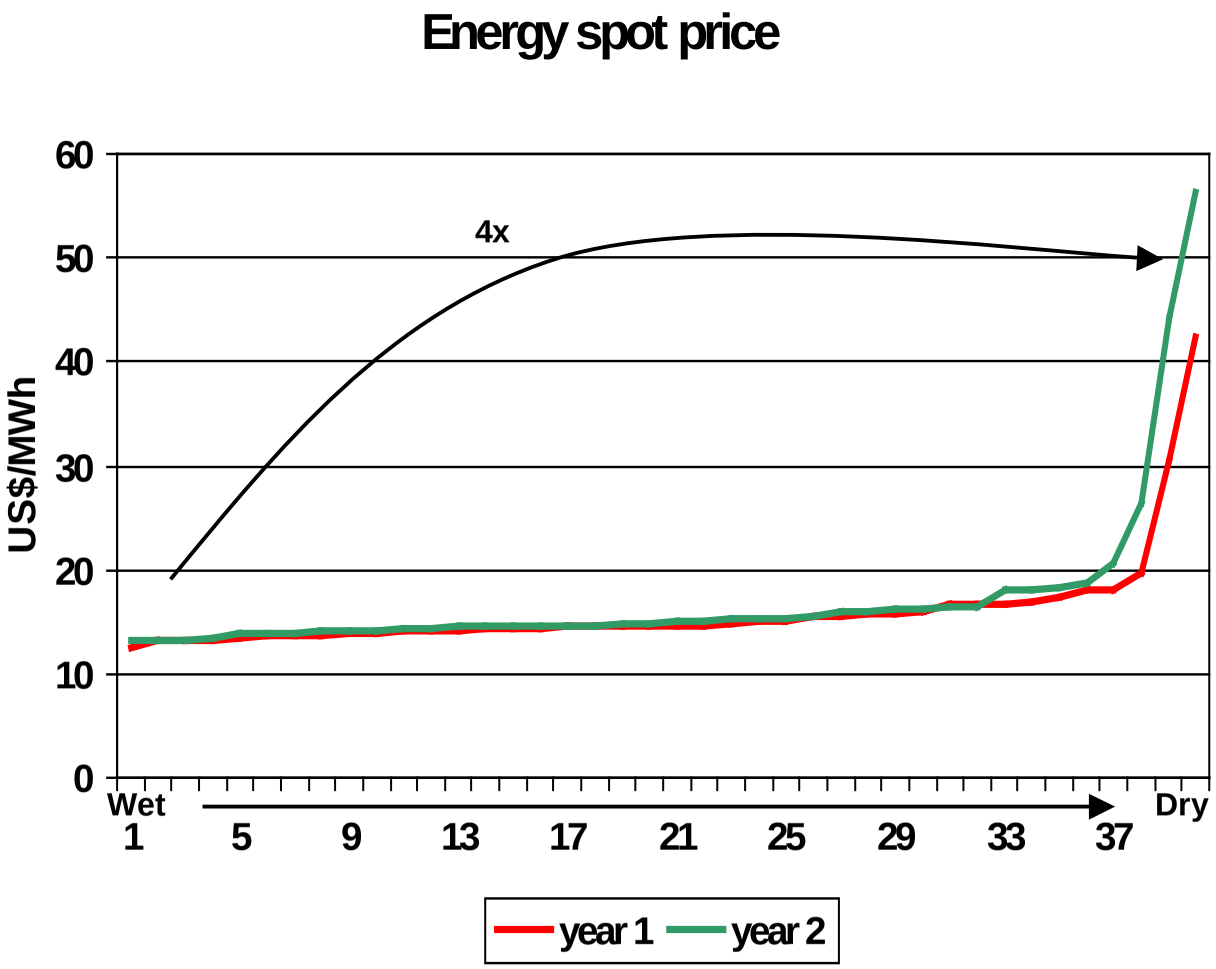


BUT, HYDRO AVAILABLE ENERGY IS VERY VARIABLE ...



And just can supply only the 30% of the demand in drought and 90% in wet cases

PROVOKING INSTABLE SPOT PRICES



Spot price in the driest scenario is much more than 4 times the price in the wettest

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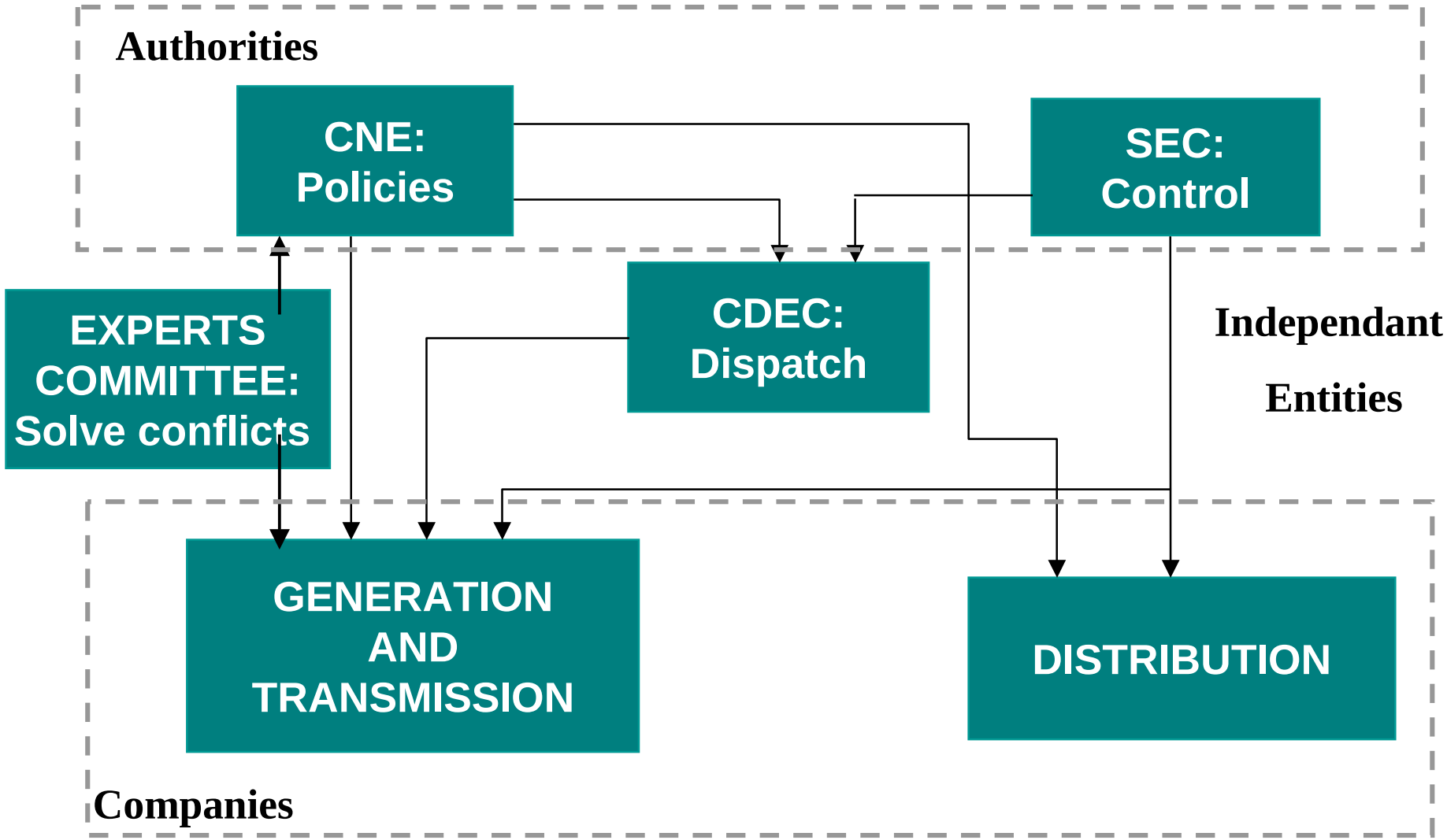
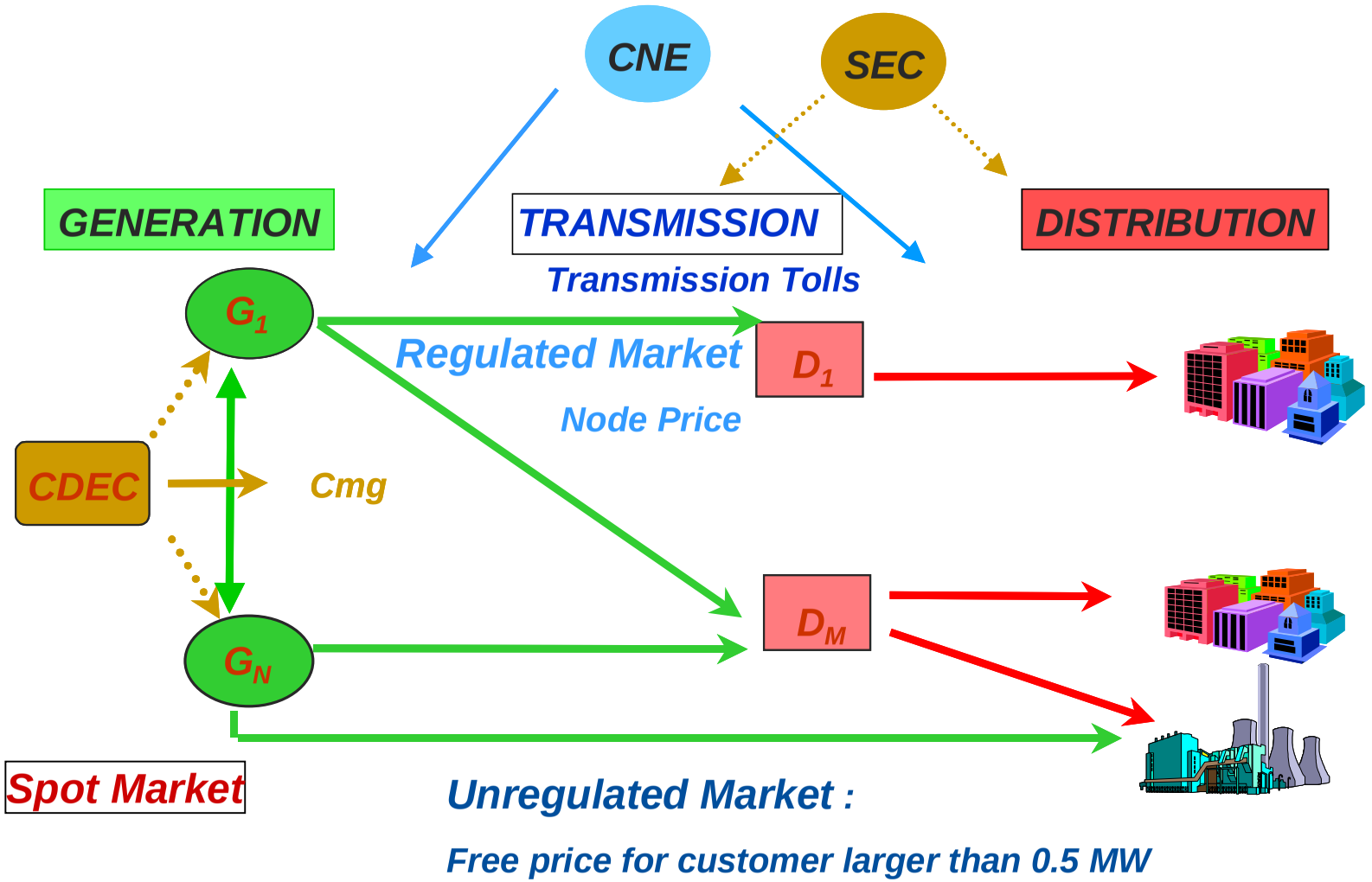
KEY REGULATORY ENTITIES

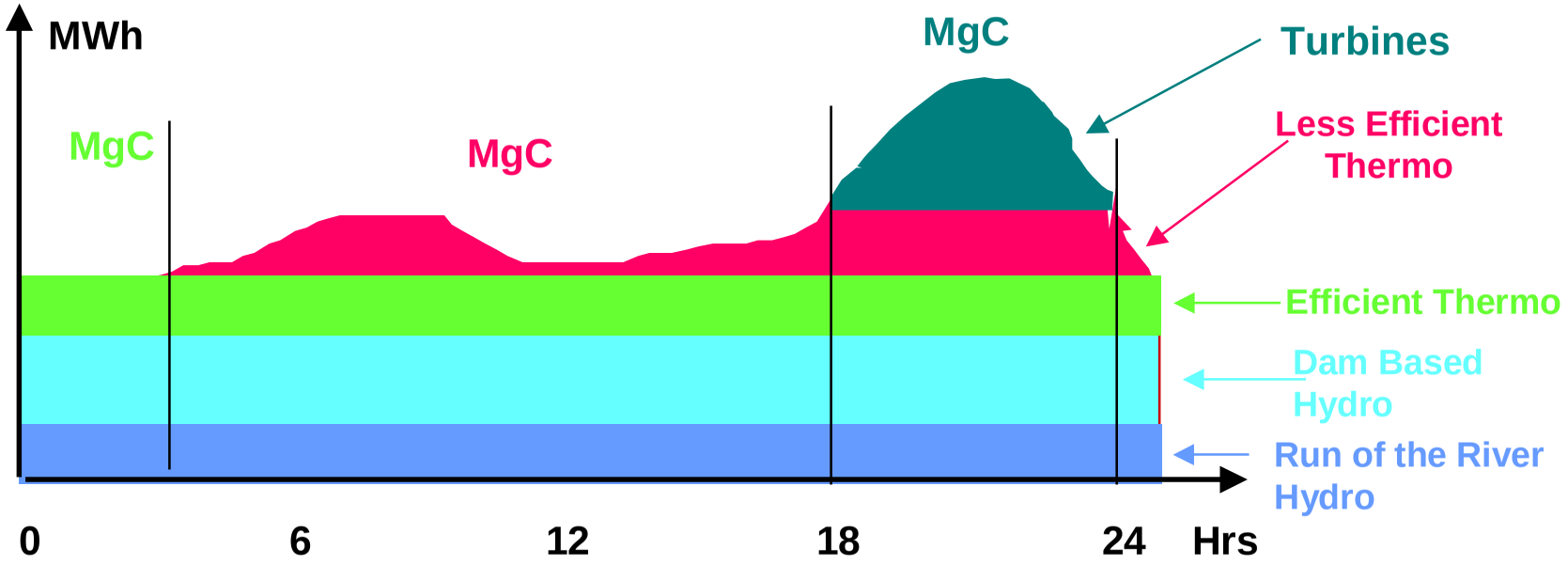


INDUSTRY´S SEGMENTS



GENERATION SEGMENT: SHORT TERM MARGINAL COST

- Marginal costs is given by variable costs: fuel, etc
- CDEC plans the operation based in a unit commitment, using the marginal cost signal.
- CDEC continuously monitors the system (minimum cost and minimum shortage-risk criteria).

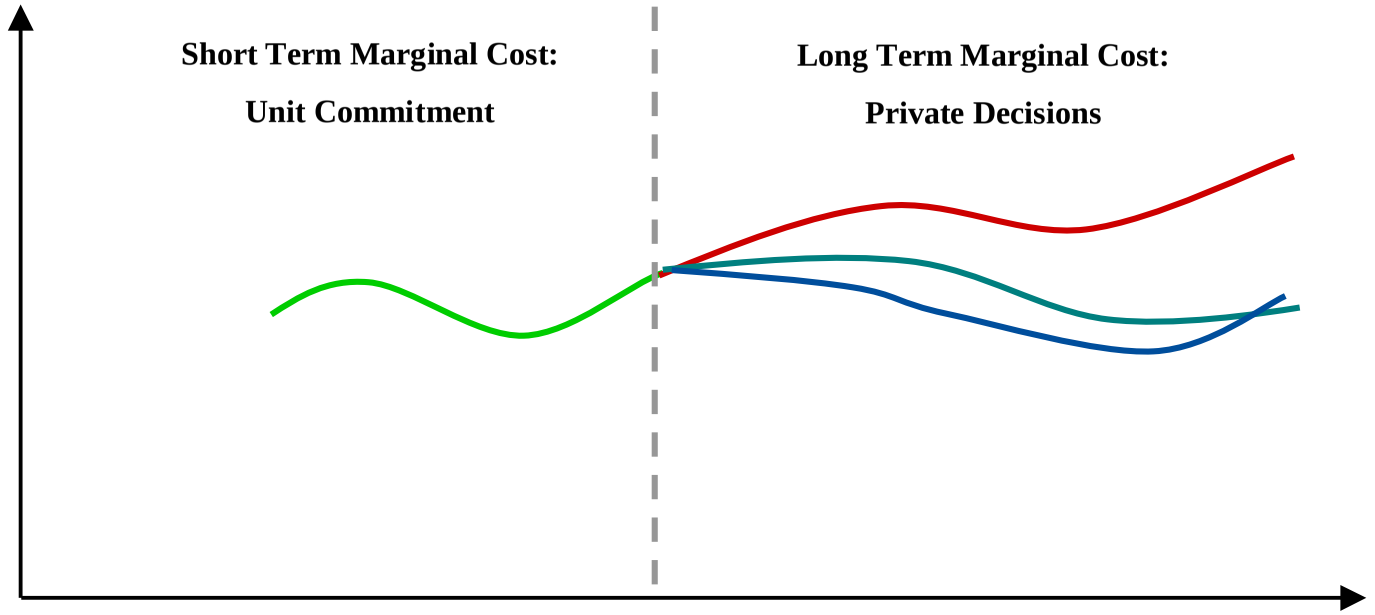


MgC: Marginal cost

GENERATION SEGMENT: LONG TERM MARGINAL COST

- Long Term Marginal Costs is given by private decisions, orientated to maximize the benefits of the companies (including their current commercial situation). Companies take decisions about:
  - Technology (coal, CC, hydro, diesel, wind , etc)
  - Location of new power plants
  - New power plants incorporation to the system

Long Term Marginal Cost



TRANSMISSION SEGMENT AFTER LAW 19.940 - 2004

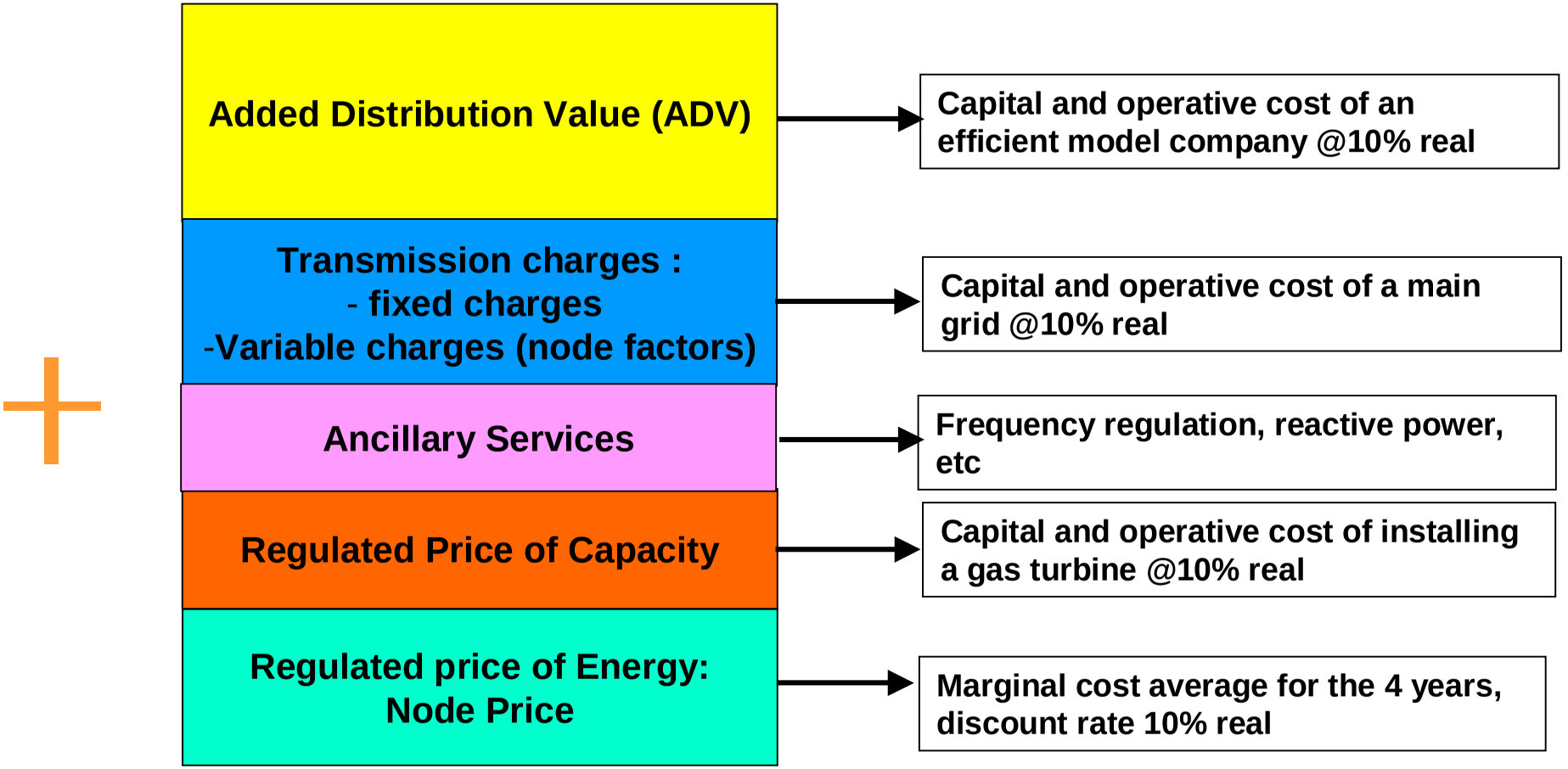
- It defines a main grid paid bay generators and cosnumers based in the real use.

- Transmission prices are regulated in the main grid:
  - Open access guaranteed by law
  - Long term expansion studies
  - National Energy Commission calculates tariffs in the main grid based in the study before.
  - New lines have to be build by the winner of a public auction based on the lower price

DISTRIBUTION SEGMENT

- Distribution companies have concession areas where they have the obligation to supply electricity to all costumers.
- Distribution companies should hold open public bids for supply contracts with Generators to serve their regulated costumers.
- Tariff is based in an efficient company model (price caps).
- It is calculated by the CNE every four years for each one.

FINALLY THE TARIFF STRUCTURE FOR END REGULATED CONSUMERS IS ..



Final Tariff for end regulated consumers

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WHY HYDRO-THERMAL PLANNING MODELS ARE USED?

- The SIC (Central Interconnected System) has a relevant component of hydro generation coming from reservoirs

- The SIC has many reservoirs with different regulation capacity :
  - Laja lake: the biggest Chilean reservoir with annual regulation
  - Colbún, Rapel : reservoir with monthly regulation
  - Pehuenche: reservoir with weekly regulation
  - Chapo lake: reservoir with monthly regulation

- In order to operate the system in a economical way it is needed to have long term hydro thermal reservoir planning models, based in the marginal cost signal.

WHY CHILE NEED HYDRO-THERMAL PLANNING MODELS

- Chile is using reservoir planning models form the 80´s, with special attention for the Laja lake.

- First generation of planning models: GOL, OMSIC
  - Developed in the 80´s and at the beginning of the 90´s
  - Were develop by the own generation companies
  - Optimized only the Laja lake operation
  - Did not include the grid
  - Were based on Stochastic Dynamic Programming (SDP)

- Second generation of planning models: PLP, OSE, SDDP
  - Developed in the 90´s
  - Based on Stochastic Dual Dynamic Programming (SDDP)
  - Mario Pereira´s development and local companies´s developments
  - Multi-dumps,
  - Include the grid (multi-nodal)
  - Some models include time series model to model the hydrology (CPARMA: Contemporaneous, Periodic Autoregressive Model)

PROGRAMING MODELS DESCRIPTION

- **GOL : Optimal management of the Laja Lake**
  - Local development used since the ´80s by the National Energy Commission to calculate regulated prices
  - Stochastic Dynamic Programming (SDP)
  - Multistage : quarter stages, over a planning horizon of 10 years
  - Does not include the grid (uni-nodal)
  - Optimize only the Laja dump

- **OMSIC : Central Interconnection System Operation monthly**
  - Local development used since the ´90s by the Load Economical Dispatch Center to calculate the marginal cost and for planning the operation of the system
  - Stochastic Dynamic Programming (SDP)
  - Multistage: monthly stages, over a planning horizon of 10 years
  - Does not include the grid (uni-nodal)
  - Optimize only the Laja dump

PROGRAMING MODELS DESCRIPTION

- **PLP : Long term Planning**
  - Local model used since 2003 by the Load Economical Dispatch Center to calculate the marginal cost and for planning the operation of the system
  - Stochastic Dual Dynamic Programming (SDDP)
  - Multistage : blocks of monthly demand, over a planning horizon of 10 years
  - Include the grid (multi-nodal)
  - Optimize Laja dump and others lake of lesser

- **OSE : Electrical System Operation**
  - Local model that is going to be used by the National Energy Commission to calculate regulated prices starting in October 2004
  - Stochastic Dual Dynamic Programming (SDDP)
  - Multistage: monthly stages
  - Multi-nodal
  - Optimize Laja dump and others lake of lesser regulation

PROGRAMING MODELS DESCRIPTION

- **SDDP :**
  - Developed by Mario Pereira in the ´80s for the CDEC and for the generation companies.
  - Because internal divergences inside the CDEC this model never was used in an official way
  - Stochastic Dual Dynamic Programming (SDDP)
  - Multistage : blocks of monthly demand
  - Multi-nodal
  - Time series model for modeling the hydrology
  - Optimize Laja dump and others lake of lesser regulation

NEW CHALLENGES IN THE MODELS

- **MARKET:** In a competitive market as the generation market, it is relevant to incorporate the market behavior:
  - Players maximize their own present benefits
  - The spot prices in the long term, are given by the investment private planning
  - Likely, the same players in the system are going to offer the generation required, building new power plants
  - Given a new power plant planning, the Dispatch Center minimize the operative costs in the short term operation

➔ Non Cooperative Games Theory : "Nash-Cournot Market Equilibrium"?

Some works in this way:

1) Ventosa-Denis-Redondo: Universidad P. Comillas: "Expansion Planning in Electricity Markets, two different approaches".

2) Centeno-Reneses- García-Sánchez: Universidad P. Comillas: "Long term Market Equilibrium Modeling for Generation Expansion Planning"

NEW CHALLENGES IN THE MODELS

- **FUELS**
  - Identify hydrological correlations inside a year, maybe improving series of time.
  - Incorporate uncertainty in others fuel supply (for instance : gas)

- DEMAND: Improve the demand modeling, particularly the behavior during droughts or other kind of fuel scarcity.

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SUCCESSES

- Stable regulatory framework, only some amendments have been made over the main law (particularly, in the transmission segment), in order to improve the market operation.
- Regulatory authorities are serious and with a high technical level.
- Competence in generation has meant a significant reduction on energy prices.
- Continue growth of the electrification of the country.
- Good quality of service.

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PROBLEMS

- CAPACITY FIRM : the capacity firm of power plants has been source of big disputes among thermal and hydro generators:
  - Should be calculated including a signal dispatch?
  - Which should be the period of the year, where the power plans should assure that capacity firm

- TRANSMISSION CHARGES : the way to calculate this charges and the way to distribute them among generators and customers were source of big disputes for many years. Fortunately, the law amendments in 2004, are going to solve this problems.

- DISTRIBUTION COMPANIES WITHOUT CONTRACTS: in the last years some of this companies have not achieved suppliers, mainly, because the regulated prices are not reflecting the real cost which means to supply these contracts. This situation has been temporally solve by an administrative resolution (RM-88), which obligates to generators to supply them according their energy firm.

PROBLEMS

- DISTRIBUTION : due to, the commercialization business is in side of the distribution companies, the generators can not access directly the free customers inside distribution networks:
  - ➔ this customers are captive of this companies
  - ➔ Therefore distribution companies should be only “cable companies”

- CAPITAL COST : the discount rate applied in transmission and distribution regulations is fixed in 10% real before taxes (more less 12.5% in nominal terms) , and it was established 20 years ago when the country had other economical situation. Now the Sovereign and Chilean blue chip bonds are in much lower levels (not higher than 7% in nominal terms), therefore the question is , should the costumer continue paying this over rent?.

PROBLEMS

- **REGULATED PRICES: Regulated prices do not respond quickly to changes in the market:**
  - Do not send an opportune and right signal of scarcity of energy in drought or scarcity of fuels:
    - Drought year 1999 s ➔ shortages
    - Rationing of gas from Argentina during 2004, provoked by the Argentinean crisis
  - The "regulated contract" is diffuse and do not protect very well to the customer:
    - Legalizations of the problems
    - In the drought 1999, customers did not receive any compensations by the shortages
  - Do not permit than private and consumers take and pay the real kind of supply that they want (risk management).
- **SOLUTION ?:**
  - **liberate the prices ?**

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CONCLUTIONS

- The market only can work if the rules are stable and clear in the time.
- The market requires technical solutions coming form technical authorities.
- In general terms, it could be said that the Chilean model has been successful, but it seems that is time for some changes.
- The models based on SDP and SDDP have been a great tool for planning the operation and for estimating prices, but it requires that they incorporate new variables as:
  - market behavior: private decisions under game theory
  - Better hydrology correlations
  - uncertainty in fuel supply (specially gas)
  - Demand behavior in drought

End

Thank you very much