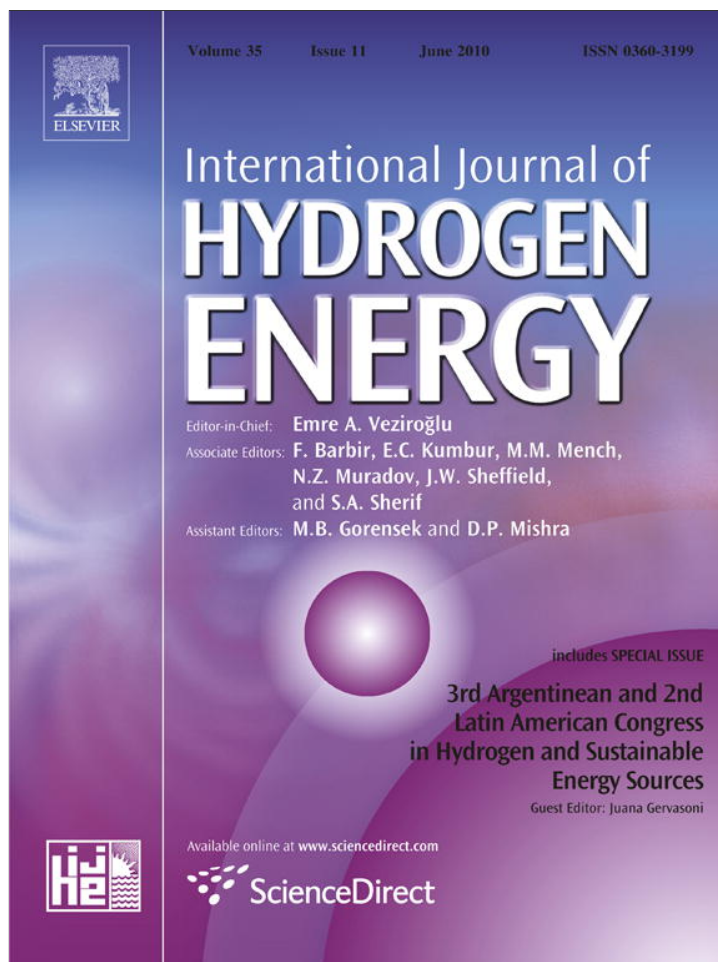


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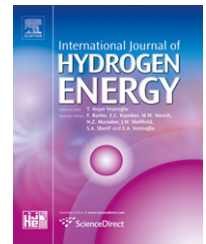


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# Latin American electricity markets and renewable energy sources: The Argentinean and Chilean cases

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## ABSTRACT

From the mid eighties on, most of Latin American Countries reformed their energy systems. The impact of these reforms over electricity markets was different in each case. However, in the majority of these cases there was a shift to private participation, instead of State, and a convergence of electricity systems to hydro and thermal technologies. This is the case of Argentina and Chile.

In this context, the aim of this paper is to discuss the current situation of renewable energies in Chilean and Argentinean electric markets and the potential to increase their share in total energy supply. To this purpose, we firstly study electricity deregulation process and its current situation. Secondly, we analyze renewable energy share in these electricity systems comparatively to worldwide situation. Finally, we briefly present the policy instruments used in each country.

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## 1. Introduction

Nowadays, because of its environmental, social, and supply security benefits, renewable energy is supported in many countries. Empirical evidence shows that the leaders in the development of renewable energy have intensively used energy policy to that purpose. Nonetheless, this has not been the case of most of Latin American Countries (LAC). Even with a good endowment of renewable sources, the majority of these countries have not (yet) highly encouraged their use. Relative high endowment of natural gas (relative to local consumption) and the restructuring of energy chains, recently carried out, seem to be the main drivers of this situation.

From the mid eighties on, most of LAC reformed their energy systems. The impact of these reforms on electricity markets was different in each case. However, in the majority of these cases there was a shift to private instead of State

share, and a convergence of electricity systems to hydro and thermal technologies.

From LAC group we deeply study the cases of Argentina and Chile, as they present many similitudes that make them interesting to be compared. They both belong to the same integration region: MERCOSUR,<sup>1</sup> they have mature electricity systems, and in both cases the reforms have been quite successful in introducing competition. Moreover, as a result of similar reasons, both countries have an electric system highly dependent on Natural Gas. Recently, in a context of volatility of energy prices, lack of investment in electricity systems, high rate of growth of energy demand, and a deep fall on Argentinean Natural Gas reserves, they both have experienced supply problems. In response to this situation, Argentina as well as Chile, has turn to renewable energy policy.

In this framework, the goal of this study was to identify Argentinean and Chilean electricity main characteristics, to

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discuss the current situation of renewable energies in both systems, and the energy policy instruments implemented. To some extent we use the analytical framework to identify which are the key issues in each country's power sector, and the most important instruments of energy policy used to promote renewable energy in each case.

## 2. Electric markets in Argentina and Chile

During the eighties and nineties, most of LAC reformed and "liberalized" their electric systems [2,4,18,23,24]. Arentsen and Kûneke [1] define *liberalization* as a change in the dominant coordination system from hierarchy to network, and/or a change in the additional coordination system (with a constant dominant coordination system) from network to price mechanism. A change in the dominant coordination system results in a completely new organizational model of the sector.

For LAC the reforms implied the change from "Central Control" (CC) to "Open Market" (OM) coordination schemes [6]. The main attribute of OM scheme is the deregulation and total openness of the system to private agents. Moreover, in this scheme, the utilities are not constrained in their supply, they can purchase electricity from any power generator. The big buyers, which are the "free clients" among this system, are able to agree the electricity and power prices with the generators. While generation is operated under market conditions, the distribution and transmission of electricity are regulated monopolies which have to guarantee a "free access" to producers and consumers. This is a *necessary condition* for the OM to work.

Argentina and Chile went into the process in the same way. They changed from CC coordination scheme towards OM scheme in a short time. Thus, currently, they have similar energy systems. However, in some way they are different.

Chile was the first LAC to reform its electricity system at the beginnings of the eighties, and has pioneered the modernization and deregulation processes of the electric industry worldwide. Raineri [21] states that more than two decades after the experience, with a deregulated and privately owned electric industry; the sector still goes under continuous adjustments. These, respond to a learning process of what has worked and what has not.

Currently, the Chilean electricity system is divided in four segments, from North to South: the *Sistema Interconectado del Norte Grande* (SING), the *Sistema Interconectado Central* (SIC), *Sistema Aysén* and the *Sistema Magallanes*. In cooperation the SING and the SIC represent 99 percent out of the total of the installed capacity, which is 12 847 MW. The electricity mix is 37 percent hydro, and 61 percent thermal, from which 37 percent out of total is natural gas. This composition of the electricity mix becomes the country in highly dependent on hydrocarbons, which constitutes a big problem. Chile is a net importer of primary energy resources. In 2005 it imported 98 and 75 percent of its oil and natural gas requirements, respectively. In a frame of constant price and supply changes, this directly affects the economic system.

Raineri [21] examines the performance of Chilean system and shows that it has experienced three important crises

since the late 1990s. The first crisis, happened in 1998–1999 when the SIC, a mostly hydraulic system, suffered a severe drought which resulted in an electricity rationing at the residential and industrial level. The second one, in 1999, affected the SING which is a thermal system. During that year, the SING experienced a fast growth on demand and generation capacity. Though, these growths were not complemented by the required norms to coordinate the operation of large new power plants, on the one hand; and the large consumption of mining companies, on the other hand. Finally, the third crisis, which affected the Chilean ESI since 2004, was due to a constrained natural gas exports from Argentina to Chile, whereas the Chilean ESI has become increasingly dependent on natural gas imports from that country. Moya [14] point out that after the economic protocol for natural gas import from Argentina was approved, combined cycle generators (CCG) entered the central system (three plants with 350 MW each) and the northern system (five plants with a total of 1480 MW). This was partly due to their low costs, which made them very attractive in a competitive environment. A substitution process took place in the northern system. It had the unexpected consequence of capacity over-investment of about 120%.

In a frame of natural gas availability and variable costs being the main economic signal for system dispatching, natural gas lower variable cost displaced higher coal-based units. Then, Chile changed its energy mix, and replaced carbon by natural gas, improved its efficiency, and reduced electricity costs. As previously mentioned, from 2004 on Argentina has reduced natural gas exports. Therefore, Chilean future security of supply seems to be restricted.

Argentina deregulated the electricity industries in 1993 based on similar conditions of Chilean deregulation [3,8,19,23]. Pollit [20] compared Argentinean and Chilean cases. He found that Argentina was one of the first countries in the world to implement a comprehensive reform of its electricity sector, and among developing countries only Chile has had a comparably comprehensive and successful reform. In Argentinean electricity industry, liberalization and reform consisted in two main points. These points were: establishing competition in power segment and, setting up the impossibility of vertical integration between generation, transmission and distribution segments. The law 24065 set mandatory "open access" facilities for transmission and distribution, and the utilities were placed under a public utility obligation to supply all the energy requirements within their concession areas.

Argentina has got two different markets. The most important one, the "*Sistema Argentino de Interconexión* (SADI)", represents 91% out of the total of power generation. The total power capacity in 2007 was 24 407 MW, twice Chilean power capacity. The electricity mix is 42 percent hydro, 4 percent nuclear and 53 percent thermal. As most of the power capacity is thermal, the Argentinean case is characterized by the linkage between hydrocarbons and electricity chains [10]. Furthermore, one of the main characteristics of the Argentinean energy system is its high dependence on hydrocarbons, particularly natural gas and petroleum. In 2006, natural gas and petroleum accounted for the 89% out of the Total Primary Energy Sources (as defined by IEA).

Dyner [8] noted that electricity and gas domestic prices are fixed by the government. The prices have been fixed since the beginning of the last Argentinean economic crisis, in 2002, and have only seen minor adjustments. This situation, and other reason, led to the crisis of the sector. Nowadays, as a result of this and other reasons,<sup>2</sup> natural gas is scarce. Furthermore, since 2004, the country is going through a supply problem which has led to the interruption of supply contracts with Chile, plus natural gas importation from Bolivia in order to deliver a growing energy demand for power, residential and industrial sectors.

In conclusion, even when they have some differences, both countries have an OM scheme in their electricity systems, which is highly oriented to private operation. Moreover, their energy mixes are equally dependent on Argentinean natural gas. The recent shortcoming of this key resource in Argentina has consequently led to the need for planning and forecasting.

### 3. RES in the electricity markets

According to Cleveland and Morris [5] *Renewable Energy is any energy resource that is naturally regenerated over a short time scale and either derived directly from solar energy (solar thermal, photochemical, and photoelectric), indirectly from the sun (wind, hydro-power, and photosynthetic energy stored in biomass), or from other natural energy flows (geothermal, tidal, wave, and current energy); in contrast with non renewable energy forms, such as oil, coal and uranium.*

This wide definition comprises not only the new renewable sources, but also any conventional renewable sources. The International Energy Agency [13] classifies renewable energy sources in relation to its technological development. The first generation, developed at the endings of S. XIX, includes: Large Hydro power, Biomass Combustion, and Geothermal Power and Heat. These are the renewable sources with highest share in energy balances. The second generation technologies, available mostly from the eighties, are broadly developed in the energy mix of developed countries. They are: Solar Heating and Cooling, Wind Energy, Solar Photovoltaics, and Modern Forms of Bioenergy (which includes biomass-based power and heat generation, co-. ring, biofuels for transport and short rotation crops for energy feedstocks). Finally, the third generation of renewable energy is still under technological development, and is composed mainly by non commercial sources, such as: Concentrating Solar Power, Ocean Energy, Enhanced Geothermal Systems, and Integrated Bioenergy Systems.

According to some resemblances (grade of technological and economic development), the last two generation of renewable sources can be grouped: New Renewable Energy Sources (NRES). Because of its low technological development,

<sup>2</sup> Argentinean peso devalued over 300% in December 2001. This led to increases in natural gas prices, and consequently increasing electricity costs for industry. Likewise the government reduced tariffs for domestic users of electricity and gas, tariffs that have been increased only marginally since 2002, Electricity and Distributed Gas Company's profitability.

and its high cost-effectiveness, the NRES are less competitive in relation to fossil fuel and conventional technologies. Thus, they have not succeeded in the market. For this reason, and particularly in developing countries, energy policy is required.

As reported by IEA [13], in 2006 in LAC 68 percent out of the Total Electricity Supply came from large hydro power, 27 percent from thermal, 2 percent from nuclear and the remaining 2.5 from NRES, mainly biomass and a little share of geothermal and wind power. This situation is exactly the opposite of the OCDE countries. In those countries Total Renewable Energy Supply includes not only large hydro, geothermal and Solid Biomass, but also Municipal Waste, Biogas, Liquid Biofuels Solar (Thermal and Photovoltaic), tide and wind power.

In this context, the Argentinean and Chilean cases are particularly interesting. If studied from a wide standpoint, including the three renewable energy technologies, their situation seem to be promising. Even when both countries have electricity systems center on thermal power, they have a high share of hydro energy. In 2007, the 42 and 38%, in Argentina and Chile respectively, out of total installed power capacity was large hydro. However, the situation is different if we perform a more detailed analysis. None of the two countries have an important share of NRES in their Total Electricity Supply. This situation is similar to most LAC.

In spite of its high natural endowment, neither Argentina, nor Chile has gone to a high development of the renewable resources, except for the case of hydro. Argentina, for instance, has a huge wind potential which enables it to get to high penetration into the SADI. However, the total wind power capacity in 2008 was only 29, 8 MW out of 25 508 MW. Chile, on the other hand, has a good allowance of geothermal, wind, biomass and small hydro power. According to CNE [7], these potential could account for 12 000 MW of energy power.

### 4. NRES regulation in Argentina and Chile

As stated in Section 2, the reform process followed by Argentina and Chile were very similar. They were mainly based on a competitive mechanism for allocation of power energy resources. Accordingly, both countries currently have preponderance of private agents, and investment decisions mainly based on private profitability.

Usually, NRES have a small rent, relative to conventional technologies, as private estimations do not take into account social and environmental impacts. Thus, when there is hydro and natural gas availability, investment will turn away from NRES. This is particularly true when these resources are as important as they are in Argentina and Chile.

In the Argentinean case, the regulation dates from the late nineties on. For the electricity sector, the regulation is focused in promoting the use of renewable energies, and setting fiscal incentives. When choosing instruments to incentive renewable investments, Argentinean authorities chose "quota scheme" instead of "price scheme". There is a fixed share of power energy which must be delivered by NRES. However, there is also a subsidy. Thus, renewable electricity prices show an "over price" scheme. The renewable generator is paid

a price above market price. Nevertheless, these sorts of prices schemes do not assure investor profitability.

In accordance with Haas et al. [12] is not the quota scheme but the price scheme, particularly *feed-in-tariffs*<sup>3</sup> (FITs), which has been successfully chosen in the NRES leaders, such as Germany, Denmark, Spain and United States. Empirical evidence shows that developed countries which preferred FITs (in addition to other instruments) were more successful than those who preferred quota schemes or other price systems [17].

For Argentina, the NRES regulation is launched by several law and regulatory decrees from the *Secretaría de Energía de la Nación*. The majority of the legislation emerged recently, particularly from 2004, when Argentina begun to go through the mentioned energy supply problem.

The first law emerged was the *Ley 25.019 (19/10/1998) Energía Eólica y Solar*, which has been recently modified by *Ley 26.190 (02/01/2007) Régimen de Fomento Nacional Para el Uso de Fuentes Renovables de Energía Destinada a la Producción de Energía Eléctrica*. The later has been regulated by the decree 562/2009. As stated in both, the law and the decree, a Renewable Portfolio of 8 percent out of the total of electricity consumption by 2016. This portfolio includes different NRES, such as wind power, solar photovoltaic, tide, small hydro (30 MW), and biogas.

Within the baggage of policy instruments, subsidies as well as financial incentives can be found firstly, the legislation sets a fee (subsidy) of 0.015 Argentinean pesos by kWh for every NRES electricity, except for solar photovoltaic whose fee is 0, 90 Argentinean pesos by kWh. Summing up, the NRES producer gets the market price (according to the short-term marginal cost) set up in the wholesale market, plus a fee for the renewable technology. Secondly, the decree creates two alternative financial instruments. On the one hand, differing the payment of the Value Added Tax for a period of ten years; on the other hand, using an accelerated amortization method for durable capital. Both alternatives have a similar effect over the investment future profitability. They increase the Net Present Value of the NRES project, and make it relatively more attractive.

In the Chilean case regulation is more recent. The first legislation was set in 2004. This constitutes one of the main barriers to development of NRES [7]. In this case, the exception is geothermal energy, for which Chile has a wide history of development. The regulation for geothermal resources focuses on promoting the resource exploration, due to its high sunk costs because of the risk of the activity. To this purpose, there are one law (*Law 19.657, Ley Sobre Concesiones de Exploración y Explotación Energía Geotérmica*) and two national decrees (Dto. 142 and Dto. 32).

The rest of the NRES, have been promoted from the reform of the General Law of Electric Services *Ley General de Servicios Eléctricos*. Firstly, the *Law 19940*, also named *Ley Corta I*, improves the economic situation for small power plants and cogeneration plants. This law allows these plants to sell the

energy in the spot market (the short-term marginal cost) and the reminder power at its corresponding power nodal price. These plants are also excluded (total or partially) from the tolls for the use of the transmission system.

Moreover, those plants smaller than 9 MW, that sell their energy to the spot market have two additional advantages. They are subject to stabilization mechanisms for their prices, and they can connect their power to any utilities grids. Secondly, the *Law 20018*, or *Ley Corta II*, set aside the NRES to enter in any public supply, in order to provide electricity. In same way, this is the regulation point that in Chile assures the stability to the profitability of NRES investments. Through the opportunity to enter a public tenders, the renewable generators can sign long range contracts. More recently, in April 2008, a new policy instrument was introduced through *Law 20057 (Ley para el desarrollo de las ERNC)*. In this new law, those firms which commercialize more than 200 MW, both in the SIC and the SING, are constrained to show a share of NRES out of the total of electricity traded [7].

## 5. The current scenario: real possibilities for renewable energy in Argentina and Chile

Despite having a relatively diversified primary energy mix, both countries have a big share of hydrocarbons out of the total of primary energy supply. However, there is a high contribution of hydro energy to power. In this sense, international organizations discuss the role of hydro power in Latin America for the objective of security of supply.

As previously stated, both Chile and Argentina have gone through energy supply problems, which became security of supply (in short and medium range) the aim of energy policy. In this frame, due to their lower cost and rapidity of penetration, energy policy tends to conventional technologies.

Therefore, even when there has recently been a development of regulatory framework, high relative cost of new renewable technologies remain as the main barrier to entry [22]. Besides, cultural characteristics do not contribute to change consumption customs, making rational consumption and renewable energies policies problematic.

Consequently, NRES investments face different problems in developing countries such as Argentina and Chile, problems they do not face in developed countries. There is an unfriendly environment for NRES investments. Therefore, there not seem to be high possibilities of energy mix diversification in the short term.

## 6. Conclusions

The aim of this paper was studying electricity systems in Argentina and Chile after deregulation, the role of RES in their energy mix and promoting instruments for each case. We found that, from a narrow point of view, neither Argentina nor Chile have highly developed their renewable resources. However, both have a high endowment of RES, particularly hydro, geothermal, and solar and wind energy.

International experience shows that many developed countries have increased the share of RES in their Total

<sup>3</sup> This is a *Price Incentive Mechanism* in which the generator's fee is previously established, while quantities are market set. The *feed-in-tariff* is a very attractive mechanism, as it guaranties the NRES price per kWh for a period of time.

Electricity Supply. To this purpose different mechanisms are available: green certificates, R&D subsidies for renewable resources, internalization of external costs and environmental taxes. Whatever the instrument of policy is, the role of Governments is crucial. Energy policy has been particularly relevant in those countries [9,11,15,16].

As a reaction security of supply problems, Argentina and Chile began to promote NRES. Chilean instruments of policy seem to be more effective than Argentinean ones. Particularly, while the former has a profitability guarantee to investment, the later has no such guarantee. Through the establishment of a fixed profitability to the small NRES generators, Chile is tending to a FITs scheme, even when not in a strict sense. The FITs have been the most effective promoting mechanism in NRES most important countries. However, these countries are in a very initial stage of policies and the results should be evaluated from a long term point of view.

Finally, even though Argentina and Chile have strong potentialities for NRES use, and there has been a recent political will to promote them, from the standpoint of these authors there is still a lot of problems to face. Most of the obstacles relate to environmental principles, the use of common and deployable resources, the urgency of short and medium term security of supply, and economic allocation priorities.

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