Diversification of Chilean Energy Matrix: Recent Developments and Challenges

By Shahriyar Nasirov and Carlos Silva*

As a result of market-driven policies and integration into the global economy, Chile has become one of the fastest-growing economies in Latin America over the past decade. The Chilean economy grew at an average rate of 5.0% between 2003 and 2013 (World Bank, 2013). However, the Chilean government has failed to spur adequate development of the power sector to keep pace with economic growth. As a consequence, the country is facing high energy prices from a critical lack of investment in the sector. This is a principal concern for coming years. This is an especially concerning situation in a fast developing economy with increasing energy consumption, and almost no fossil fuels.

Chile's power sector had 17,600 MW of installed capacity and 65,913 GWh of energy generation in 2012 (CNE, 2013). The sector is divided into two main interconnections, SING and SIC. The SIC system has hydro-thermal generation and covers the central and southern regions of the country, including the main consumption centres around the capital, Santiago. The SING has thermal-based generation and provides primary electricity demands for mining and mineral industries in the north of the country. As Chile's economy continues to grow, it is expected that energy demand will increase from under 65 TWh in 2012 to over 100 TWh by 2020 (IEA, 2012). Therefore, the country will have to add over 8 GW of new generation capacity by 2020 in order to meet the expected expansion in demand.

Chile has struggled to obtain a reliable energy matrix for decades. In the 1980s, Chile relied heavily on power from hydro resources. However, in the mid-1990s, a combination of continued rapid growth in energy demand, increasing environmental concerns regarding large hydro, and the unreliability of hydropower due to droughts, prompted the Chilean government to diversify energy sources by encouraging use of natural gas from Argentina. The low cost of imported natural gas made combined-cycle plants attractive compared to large hydro plants and coal. As a consequence, the sector invested heavily, including building four pipelines from Argentina, new gas distribution networks and a half a dozen new combined-cycle gas fired power plants, costing around of US$4 billion, and forming Chile's gas infrastructure (Speiser, 2008). In 2004, natural gas accounted for 26% of Chile´s total energy consumption of which 80-90% came from Argentinean gas suppliers. However, that year the Argentinean government started restricting gas exports to Chile in order to ease its own domestic gas shortages. Shortly after, the gas supply was restricted between 30% and 50% (CNE, 2008). In the following years, Argentina became a non-reliable partner to a point where gas supplies practically halted. This brought about another energy crisis where generators were forced to replace gas-fired electricity with expensive diesel operation.

Recurring droughts, unreliable gas imports and rising demand have troubled the Chilean power sector and forced the Chilean government to search for additional sources of energy to foster more reliable supplies. This article studies strategically important energy alternatives currently under consideration in Chile, including development of clean energy sources (Renewable Energy Technologies, Energy Efficiency (EE) programs), traditional energy sources (large hydro, large coal fired plants and LNG), and the nuclear energy option. We mainly focus on recent developments and remaining challenges.

Clean Energy Sources

Entrance of Renewable Energy Sources (RES)

Chile is considered to be one of the most attractive countries for the development of RES thanks to strong power demand growth, one of the highest electricity prices in the region and rich, local renewable sources. With the purpose of attracting renewable energy investment, several new regulatory incentives have been introduced. In 2008, the Chilean government took an important step forward by approving the Law 20,257 that introduced the obligation of companies to include at least 5% of their electricity from non-conventional renewable energy sources by 2010 in a Renewable Portfolio Standard (RPS) scheme. Since Chile does have a significant number of large hydro plants, the RPS only applied to Non-Conventional Renewable Energy, and excluded hydro plants over 20 MW. This quota of renewable energy covered 2010 to 2014 with 5% as the transition period, and was then set to increase 0.5% each year from 2015 through to 2024, by which time generators should be producing 10% of their power from renewable sources. In case companies do not comply with the quota, they would be subject to a fine of approximately US$28 for every MWh incompliant. If the incompliance is repeated, the fine rises to a total of 42 US$/MWh.

So far, energy generation from RES has met or even surpassed the defined

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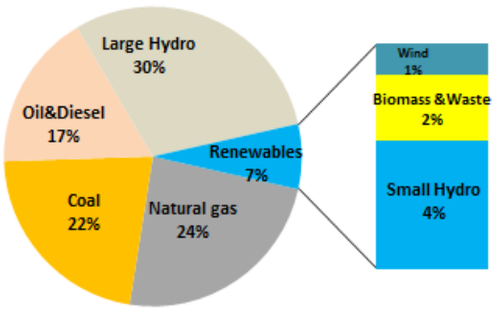


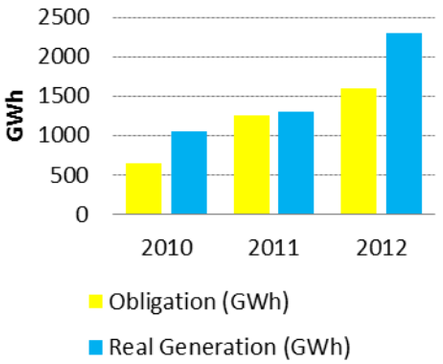
Sources: BNEF, CNE and own elaboration

Figure 1: Electricity Generation by Source, 2012

quota of 5% during the 2010 to 2012 period (See Figure 2). Renewable energy generation reached 7% of the country´s total energy generation in 2012. Until early 2012, small hydro and biomass were leading renewable technologies, accounting for almost 90% of total renewable generation (See Figure 1). However, recently other renewable technologies, including solar and wind, have started to play a more significant role. Moreover, in 2012, Chile´s renewable energy sector received $2bn investment of which 67% has been invested in new wind projects and 15% in solar projects (BNEF, 2013).

In 2013 the Chilean government introduced new incentives by doubling the renewable-energy target from the previous goal of 10% by 2024 to 20% by 2025. This modification was included in the recently approved Law 20,698. This new target provides an even more attractive incentive for the development of the renewable energy industry. However to reach to the 20/25 target, a total of around 6,000 MW of new renewable capacity must be added to the current energy matrix in the next 10 years, which means around 600 MW every year. That is 400-500 MW more than the average annual renewable capacity that entered the matrix during the last five years.

Although the Chilean government has shown significant interest in prioritizing local energy production from RES, a number of obstacles remain for the implementation of renewable projects. In 2012, around 9,000 MW in projects were side-lined, despite having their environmental approval from Chile's Environmental Impact Assessment System. Only a few projects have materialized because of barriers. Most of these projects are wind and solar technologies (See Figure 3). The most common barriers are the high cost of initial investment, the limited access for financing, opposition from local communities; difficulties in connecting to the grid and lack of interest from large consumers in signing long-term contracts (PPAs) with intermittent sources. Removing these barriers and creating further incentives remains a key challenge for the development of Chilean renewable energy sector.

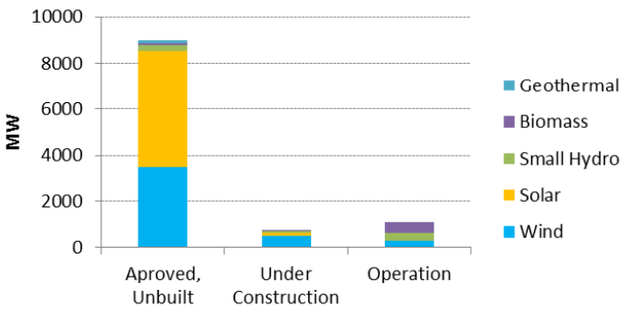


Sources: CDEC and own elaboration

Figure 2: Compliance Evaluation of generation obligation from RES

Energy Efficiency (EE) Programs

Growing concerns regarding energy prices from a fast increase in energy consumption and barriers facing energy projects, have led to a rising awareness of the need to develop energy efficiency (EE) programs in Chile. Energy efficiency is considered to be one of the most cost-effective alternatives for reducing costs and increasing energy security of the country. The savings from EE programs in Chile have been estimated between 1,700 MW and 4,100 MW by 2025 (OECD, 2010), showing that the country has a tremendous potential in this area. Traditionally, EE has not been a priority of the Chilean government without a permanent state policy. Although there have been several unrelated attempts to promote EE (including the Energy Conservation and Rational Use programme), these have had a minor effect. However, the situation improved with the formation of the Energy Efficiency Country Program (PPEE) (2005-2010) in 2005. The PPEE initially started under the Ministry of Economy in 2005 and in 2010 it was transferred to the National Energy Commission (CNE). After the reforming of the institutional framework of the energy agencies, the PPEE was transferred to the Chilean Energy Efficiency Agency (CEEA) in 2012, and made responsible for implementation of energy efficiency studies and initiatives. During this short time, energy efficiency programs drew significant attention, especially from 2006 to 2009, when the annual budget of the energy efficiency programs increased from USD 1 million to more than USD 34 million (CCAP, 2012). However, this budget has decreased in the last few years to around USD 6 million in 2012 due to the shifting of priorities within the government (LYD, 2011 reference).



Source: CER, 2013 and own elaboration

Figure 3: Status of Renewable Energy Projects in Chile, 2012

In contrast to the growth trend in gross domestic production (GDP) between 2005 and 2011, Chile was able to

reduce its energy intensity over 10 % during these years (See Figures 4 & 5). However, achievements on energy intensity reductions were primarily the result of development of the clean gas infrastructure rather than EE programs.

One of the few promising EE initiatives was the National Efficient Lighting Strategy (NELS) in 2013. In this effort the Ministry of Energy of Chile, along with Foundation Chile, have successfully introduced a framework on transition to NELS. The NELS would help to save annually US $486.4 million in energy costs. This represents a total of 2.8 terawatt hours of electricity or the equivalent of almost 5% of total yearly energy consumption.

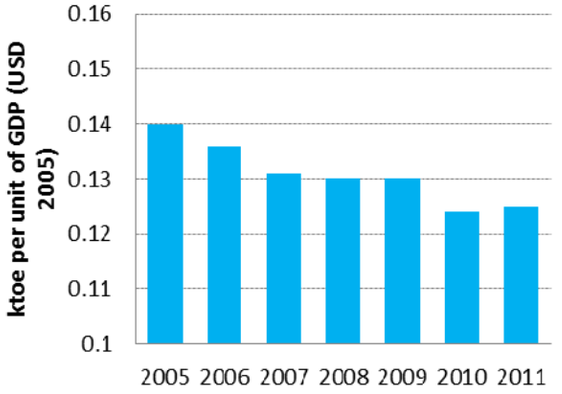
However, to be able to achieve higher targets and get closer to the EE savings potential, the government needs to take a more consistent approach towards it. At this point, if the budget for EE continuous the decreasing trend of the last few years it looks almost impossible to advance in this area. Future plans and strategies must be translated into concrete actions and energy efficiency must become a country wide practice for all public and private investors.

Development of Traditional Energy Sources

Chile is also trying to diversify its sources of traditional energy supply. These include liquefied natural gas (LNG), large hydro plants, and further development of cleaner coal-fired plants as an alternative source of energy in the mid-term, until technologies such as renewable energies can provide a greater portion of the energy matrix.

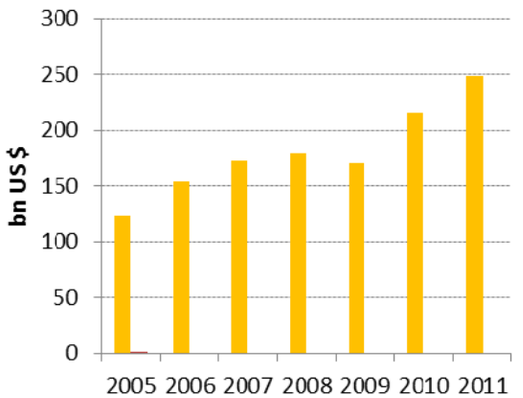
Large Hydro Option

Chile is also considering developing unexploited large hydroelectric resources as a more conventional alternative source. Hydroelectricity is known as a mature technology in Chile since it has been in the region a long time. Ten years ago hydroelectricity represented 78% of total electricity production in Chile, nowadays it only contributes 30%. However, there are still large amounts of unexploited resources that would add significant energy to the matrix; unexploited capacity of large hydro resources in Chile was estimated about total of 21,279 MW (Rudnick et al, 2008). In 2008 the Chilean government approved HidroAysén, the largest energy project in the country´s history. The HidroAysen project requires a $3.2 billion investment and consists of a total of five hydroelectric dams in the Aysen region of Chilean Patagonia (Barrionuevo, 2011). It is expected to generate 18,430 GWh of electricity annually which would account for 28% Chile´s 2012 annual consumption. Despite the potential benefits, the financing of the project and particularly possible environmental impact of the plants and of the transmission line remain a major challenge. Most of the opposition to the project comes from Chileans and foreigners who consider Patagonia a ¨treasure of nature¨ that should remain untouched.



Sources: World Bank Indicators, 2005-2011 and own elaboration

Figure 4: Energy Intensity Indicators in Chile, 2005-2011



Sources: World Bank Indicators, 2005-2011 and own elaboration

Figure 5: Growth Trend of GDP in Chile, 2005-2011

Liquid Natural Gas (LNG)

Another alternative for Chile to replace its natural gas imports from Argentina is to increase LNG import capabilities. LNG is considered one of the more reasonable options since LNG can use the existing natural gas infrastructure that was constructed in the late 1990s to transport and generate electricity from the no longer availble Argentinean natural gas. Chile expedited construction of two regasification terminals: Mejillones, in the north, and Quintero, close to Santiago. Most of Chile's LNG imports come in tank ships from Equatorial Guinea, Trinidad and Tobago, Qatar, and Yemen (EAI, 2013). Additionally, some mining companies have shown an interest in expanding port capacity to increase LNG imports in the SING. Currently, LNG provides 23% of the demand in the SIC, the central main grid, and 10% in the SING, the northern grid (CNE, 2012). But, given the declining trends natural gas prices are showing, due to shale gas development, all energy intensive sectors are ready to switch their suppliers as soon as

cheaper gas is made available. Further, building terminals for LNG imports could play a major role in meeting rising energy demand generally and especially in easing mounting power demands in the crucial mining industry. Considering Chile already has strong economic ties with the Asian continent, it is likely the country would participate in the global LNG trade with rich Asian countries, primarily Indonesia, Malaysia, and Brunei.

Coal Plants

Coal has been, and still is, considered to be one of the key elements of Chile's energy security strategy. During the mid-1990s, Chile replaced its major coal plants with combined cycle plants to use the Argentinean natural gas for electricity generation. However, as a result of the collapse of Argentinean gas exports to Chile, coal consumption received renewed attention as a reasonable alternative. Although Chile possesses more reserves of bituminous coal than larger countries in South America such as Venezuela and Argentina, this coal has high exploitation costs, which eventually forced the government to close the mines and shift from local production to a dependency on imports. In 2011, coal accounted for 22% of total electricity production in Chile with 95% imported largely from Colombia (40%), Indonesia (30%) and Australia (15%) (See Figure 1). At present, SING and SIC combined have 2,050 MW of coal-fired electricity capacity, and some additional capacity is currently under construction and in the pipeline. In 2011 the Chilean government gave final approval for the operation of the controversial Isla Riesco, which is a sub-bituminous coal-mining project in Patagonia, in the extreme south of Chile. It is estimated that the project could meet 30% of the country's coal needs but it is facing considerable opposition from environmentalists (EIA, 2013).

Although coal provides both technical and economic stability to the Chilean electricity system and its significant role in the technology mix is growing, investments in coal generation brings new challenges. CNE projections indicate that installed coal capacity will increase from 16% in 2007 to 26% in 2020 and, as a result, Chile's GHG emissions are expected to double between these years (CNE, 2012). Parallel to coal investments, it is important to replace older plants with more efficient, environmentally friendly technologies with less local pollutants, such as NOx and SOx as well as particulate matter. One alternative that looks promising is coal gasification technologies that could make the use of coal in Chile's electricity matrix more efficient and sustainable in the future.

Nuclear Energy Option

Among the alternatives, the future use of nuclear power in Chile has been proposed as way of handling both the country´s energy and global warming dilemmas. As nuclear power is still considered to be one of the cheapest sources of electricity generation, nuclear power could be an important part of energy diversification.

Chile does not possess any nuclear power plants besides two research reactors. However in 2006, the government committed to an open debate on the prospects of utilizing nuclear energy in the near future. In general, nuclear energy in Latin America is not new. Countries such as Argentina, Brazil, and Mexico produce nuclear power. The nuclear plants in Argentina provide 8% of the country's electricity generation; Brazil's plants account for 3% of the power supply, and Mexico's plants supply over 5% of the country's electricity generation. In 2007, the Chilean Commission on Nuclear Energy (CCHEN) received US$12.3 million (approximately 23% of the total budget for the Ministry of Mines and Energy) to conduct preliminary studies into the development of nuclear power (Speiser, 2009). Since that time government officials and experts have visited several countries to learn about their experiences with the nuclear power industry, seeking training opportunities for local experts and nuclear cooperation agreements. A primary program for possible Chilean nuclear power was presented in 2009, aimed at introducing the first nuclear power plant in Chile around the 2020s.

After the terrible 8.8 earthquake and tsunami in Chile on February 27, 2010 and the Fukushima Daiichi nuclear incident in Japan in 2011, things have turned dramatically. Many countries implemented regulatory changes that lead to a slowing or even cessation of plans for expansion and investments in nuclear power. Likewise, ongoing fears regarding nuclear technologies in seismic countries had a profound impact on Chilean policy makers, resulting in a complete halt to the process. Still the Chilean government is keeping the nuclear option open and it can be brought into debate anytime. However, more than ever, the government is aware than in highly seismic country, lacking necessary infrastructure, institutions and experience in nuclear civil protection, introducing a new complex nuclear power infrastructure from scratch will be a challenge for the country.

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IAEE/Affiliate Master Calendar of Events

(Note: All conferences are presented in English unless otherwise noted)

Date	Event, Event Title and Language	Location	Supporting Organization(s)	Contact
2015				
February 23-24	8th NAEE/IAEE International Conference *Future Energy Options: Assessment, Formulation and Implementation*	Ibadan, Nigeria	NAEE/IAEE	Adeola Adenikinju *adeolaadenikinju@yahoo.com*
March 15-18	5th ELAEE Conference *Energy Outlook in Latin America and Caribbean: Challenges, Constraints and Opportunities*	Medellin, Colombia	ALADEE/IAEE	Isaac Dyner *idyner@yahoo.com*
May 24-27	38th IAEE International Conference *Energy Security, Technology and Sustainability Challenges Across the Globe*	Antalya, Turkey	TRAEE/IAEE	Gurkan Kumbaroglu *gurkank@boun.edu.tr*
October 25-28	33rd USAEE/IAEE North American Conference *The Dynamic Energy Landscape*	Pittsburgh, PA, USA	3RAEE/USAEE	David Williams *usaee@usaee.org*
2016				
February 14-17	5th IAEE Asian Conference *Meeting Asia's Energy Challenges*	Perth, Australia	OAEE/IAEE	Peter Hartley *hartley@rice.edu*
February 18-19	9th NAEE/IAEE International Conference *Theme to be Announced*	Abuja, Nigeria	NAEE NAEE/IAEE	Adeola Adenikinju *adeolaadenikinju@yahoo.com*
June 19-22	39th IAEE International Conference *Energy: Expectations and Uncertainty Challenges for Analysis, Decisions and Policy*	Bergen, Norway	NAEE	Olvar Bergland *olvar.bergland@umb.no*
September 21-22	11th BIEE Academic Conference *Theme to be Announced*	Oxford, UK	BIEE	BIEE Administration *conference @biee.org*
October 23-26	34th USAEE/IAEE North American Conference *Implications of North American Energy Self-Sufficiency:*	Tulsa, OK, USA	USAEE	David Williams *usaee@usaee.org*
2017				
June 18-21	40th IAEE International Conference *Meeting the Energy Demands of Emerging Economic Powers: Implications for Energy And Environmental Markets*	Singapore	OAEE/IAEE	Tony Owen *esiado@nus.edu.sg*