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Investing in energy generation sources in the national electrical sector

Energy: Electricity and Utilities

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Major investment projects 2017-2025

Introduction

This document intends to provide an estimate of investment requirements in the national electrical sector for the next decade, based on the information available for major mid-term energy generation projects. For such purposes, the energy demand and the total installed power during the 2006-2016 period are analyzed first; and, projections about the future behavior of these two variables during the 2017-2025 period are prepared afterwards. The annual added electric power for the entire period under analysis is followed up, and an estimate of the expenses needed to cover such increase is then presented.

The *primary energy matrix* shows natural resources' share in the total energy demand of a country (for example, how resources such as oil, gas, firewood, coal, oils and alcohol; or energy sources such as solar, wind, nuclear or hydraulic power weight in the demand). By analyzing this matrix, public policies may be designed taking into account which energy resources should be fostered and which should be reduced.

Argentina's energy matrix has historically been hydrocarbons-dependent, for fuel and gas production as well as for electric power generation. In this regard, the Ministry of Energy and Mining of the Republic of Argentina (MINEM) estimates that, over the last ten years (2006-2016), hydrocarbons' share in the production of resources applied to energy generation (whichever their form, i.e.: electricity, fossil fuels, natural gas, coal, biofuels, etc.) totaled 86%, on average. However, a downwards trend could be noticed in the last few years as public and private investments, alike, gear towards cleaner energy sources (renewable). In our country such trend is evidenced by programs such as GENREN or, more recently, RenovAR (whereby over 2400 megawatts –MW– for wind and solar power generation were awarded in 2016 by means of public bids).

This high dependence on hydrocarbons, which is evidenced in the primary energy matrix, logically affects the secondary matrix as well as the electrical matrix. While the secondary matrix shows the share of energy products (i.e. those resulting from transforming primary resources or from using power generation sources) in the final consumption of the economy, the electrical matrix shows the share of the different sources of power generation (thermal, hydropower, nuclear, renewable and imported energy) in the total volume of electric power produced or of the existing installed capacity. In Argentina, for example, thermal and hidropower sources, which depend on fossil fuel to operate and generate energy, account for over 60% and 30%, respectively.

The first section of this document shows how the energy demand and the installed capacity have evolved over the 2006-2016 period. In addition, changes in the first variable are forecast up to 2025, using the econometric model (regression analysis). Section two addresses investments and presents an estimate of the total amount required to implement all the projects planned for the sector. To conclude, the document presents some final considerations.

II. Electric power demand and installed power Contribution of thermal sources

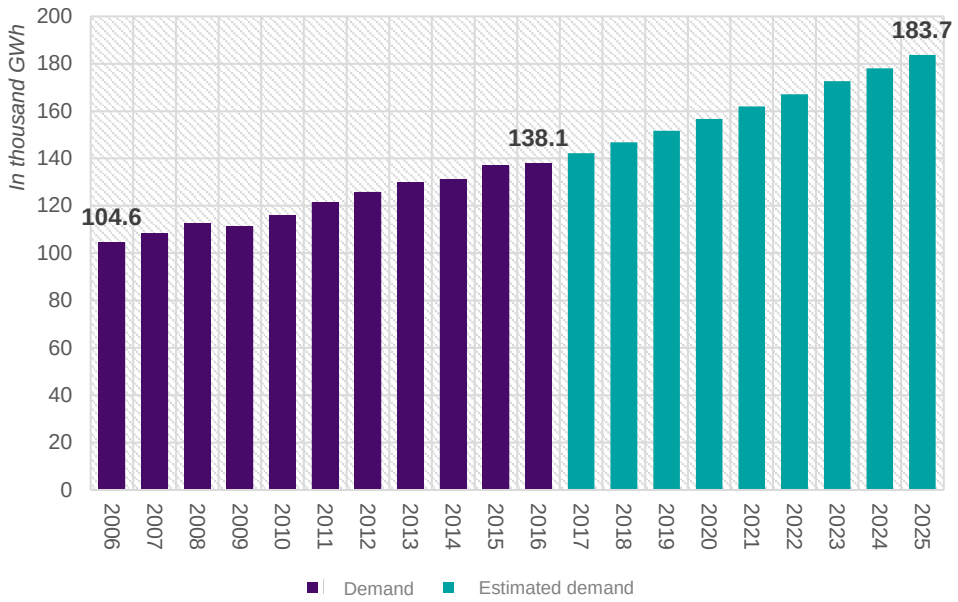
Investments in energy generation depend heavily on recent and future evolution of the energy demand. As shown in ***Figure No. 1***, the national energy demand has increased over the last ten

years, and, based on our own estimates, it is expected to continue showing such upwards trend during the next decade[1]. In this regard, the agents of the Wholesale Electricity Market are the major consumers in the system (distribution companies, large users –GUMA–, smaller large users –GUME– and individual large users –GUPA–), as, according to CAMMESA's data, they consume more than 96% of the total energy demanded per year, followed by the system's own losses and consumption (3%), hydropower stations pumping (0.4%), and exports to neighboring countries (0.3%). Over the last ten years, the average 3% annual growth in energy demand has been stable during most of the period, except for a 1% year-on-year drop in demand registered in 2009 (with respect to 2008), as a result of the decrease in local activities triggered by the global economic crisis. Nevertheless, during the 2006-2016 period, the demand increased from 104,600 GWh to around 138,100 GWh, which represents a 32% accumulated year-on-year increase.

Figure No. 1

Evolution of the energy demand and future estimations 2006-2025 Period

(In thousand GWh)



Note: A lineal regression model was built to estimate the energy demand during the 2017-2025 period, where the dependent variable is the *energy demand* and the variable used to explain the behavior or changes in energy demand is the *national GDP*. Setting aside the causality issue that may result from this model, it is reasonable to use it since the statistical correlation between both series during the period under review is 90%, and since no economy may grow without a rise in energy demand (particularly when GDP is impacted by the industrial sector mainly). In addition, time (*t*) and square time (t^2) variables were added to the model to show estimates net of the tendency impact present in this type of series.
Source: prepared by us based on CAMMESA and IMF databases.

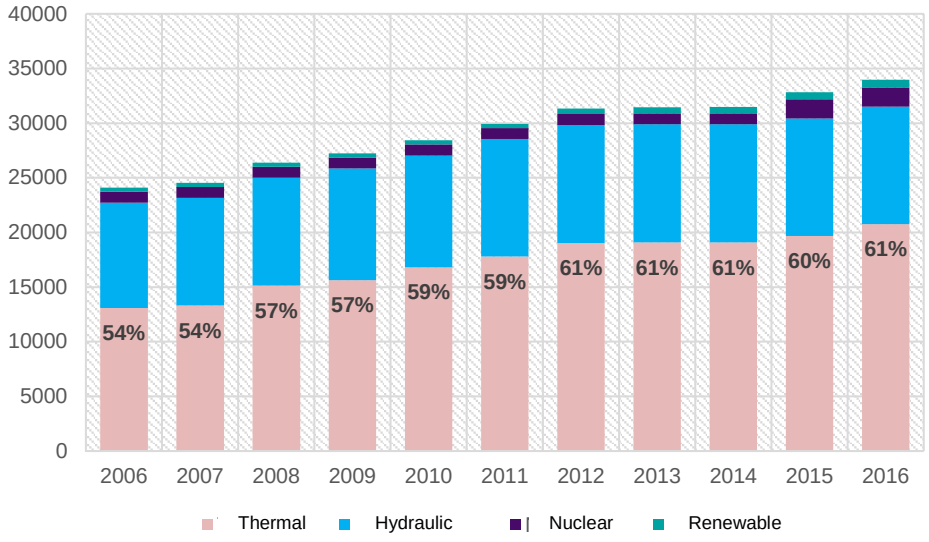
Energy demand is also affected by the levels of economic activity (measured by GDP) and by the population growth rate, among other variables. While they have different impacts on it, the activity level is the most adequate variable to explain demand and make projections during the 2017-2025

[1] For more information about the estimation method applied to the 2017-2025 demand, see footnote of *Figure No. 1.*

period[2]. The outcomes of this exercise are shown in ***Figure No.1***. The econometric model estimates that demand will grow at a 3.2% average annual rate between 2017 and 2025, reaching 183,700 GWh (i.e.: a 33% increase with respect to 2016 demand).

On the other hand, ***Figure No. 2*** shows the counterpart of changes in energy demand: the behavior of installed power during the 2006-2016 period broken down per source of generation. As it may be noted, thermal power generation sources (i.e., thermal power plants operating with combined cycles, steam and gas turbines, and the diesel equipment of the distributed energy program) have the greatest share in the total installed power.

Figure No. 2
Evolution of installed power 2006-2016 Period
(In MW)



Note: The percentages included in this figure represent the share of thermal power generation sources in the total annual installed power.
Source: prepared by us based on CAMMESA and IMF databases.

During the last decade, these sources have increased their share by around 7 points, from the 54% reached in 2006 to 61% in 2016. Within this category, combined-cycle thermal power plants have the greatest share, as they account for 45% of the energy provided by thermal sources and around 27% of the total energy generated. It is followed by hydraulic sources (32%), nuclear sources (5%) and, finally, renewable sources (2%). It is worth noting that despite the recent growth in renewable energy sources, so far thermal sources' growth has remained stable, even after the drop in oil and gas prices, which has unfailingly contributed to strengthening the presence of these fossil fuel dependent sources. Nevertheless, it must also be pointed out that the sector's investments are gearing towards cleaner energy generation sources, particularly since the introduction of the National Regime to Foster the Use of Renewable Sources of Electric Power (Law No. 27191/2015)[3]

[2] This variable arises from the IMF's database (World Economic Outlook 2016), which presents forecasts of most economic variables, including GDP.

[3]This law sets as a target reaching 8% share of renewable sources in the total electricity produced by late 2017 and 20% by 2025. For such purposes, the law will grant a series of tax benefits such as: an anticipated VAT refund regime during the

and the RenovAR program, whereby over 2400 MW were awarded in 2016 by means of public bids (to be implemented in the next few years). Striking a balance between the supply and demand in the electrical market has become a difficult task over the last few years. The growth in demand experienced during the last decade (fostered by frozen tariffs and a scheme of subsidies to consumption) jointly with a stagnated supply (due to the lack of predictability in the business environment, lack of incentives to investments, low tariffs and rising prices of inputs, among other reasons) have been the main reasons for the problems in the supply of electricity experienced by the country in the last few years. This problem may be analyzed and quantified by watching the evolution of the *maximum power demand* (i.e. the highest peaks of demand registered per year, which may undermine the system by showing its level of *vulnerability*[4]).

It is worth noting that the supply of electric power is determined by the total power *available*, i.e. the effective power resulting from deducting equipment *unavailability* from total power (due to programmed maintenance, lack of fuel and flaws in the energy generation and transportation cycles). If this variable is compared with the demand for maximum power, the period during which the electrical supply was tested may be determined. For example, according to CAMMESA, during the four last years of the 2006-2016 decade, the maximum power demand reached, on average, 95% of the available power, with maximum consumption levels of 96% and 97% and some short terms when 100% was exceeded (which triggered the import of energy). Besides, it is estimated that growth in the maximum power demand of the last few years nearly duplicated that of the available power, and this gap is primarily explained by the *unavailability* of equipment (21% on average). Jointly, these circumstances evidence the situation of the system and the increasing need for new investments.

II. Investments expected in the national electrical sector

The development of a series of investments in generation stated in monetary values is difficult as no information is available. However, this issue is addressed from two viewpoints in this section. First, for the period 2006-2016, the difference between the total installed power each year and that of the prior year was calculated to obtain a series of *actual investment*s stated in MW/year. For the period 2017-2025, information provided by publicly available sources was used, which was updated by taking into account the most recent data on generation projects. The main sources applied include the Ministry of Energy and Mining of the Republic of Argentina (MINEM), Compañía Administradora del Mercado Mayorista Eléctrico S.A. (CAMMESA) and the Argentine Chamber of Construction (CAMARCO). Finally, the *total monetary investment* amounts were estimated by multiplying the series obtained in the previous step by the average capital cost per MW installed (CAPEX) obtained from the U.S. Energy Information Administration (EIA)[5]. In this sense, the EIA estimates that the average CAPEX for a thermal generation plant would be around US$ 1040 per kW installed, whereas it would be around US$ 3000 per kW installed (at 2013 values) for an hydropower plant,

development of the renewable energy source; an accelerated amortization system to be applied to goods and works allocated for such purposes; offsetting tax losses; tax and import duties exemptions; among others.

[4] A country faces energy vulnerability when it cannot take decisions on energy policies freely, or when taking such decisions may involve a collectively bearable economic or political cost. Energy vulnerability does not necessarily implies energy dependency, i.e. a country may be energy-dependent without being vulnerable (if the cost is bearable and if there is diversification in supply) and it may be vulnerable but independent (if the production cost is extremely high or if technology is obsolete).

[5] "*Capital Cost Estimates for Utility Scale Electricity Generating Plants*", U.S. Energy Information Administration (EIA), November, 2016 (https://www.eia.gov/analysis/studies/powerplants/capitalcost/).

US$ 5900 per kW installed for a nuclear plant and US$ 1800 per kW installed for a renewable energy (wind) plant. **Chart No. 1** summarizes the results obtained. Three aspects should be noted. First, it is worth remarking that as their contribution of power to the system is intermittent, renewable source generation projects imply an *adjustment variable* in the obtainment of the final investment figures, both in terms of firm MW added to the system and in terms of monetary investments. For this reason, final results are presented with and without these projects. Secondly, as there is no information available on capital costs as per the size of each project, the monetary investments presented, obtained by using an average of these costs, are the total investments by generation source. Finally, it should be noted that the estimates presented in this section do not consider the necessary expenses incurred in the transportation and distribution of energy which, together with expenses incurred in generation, are key to achieve the sustained development of the national electrical system in the future.

Chart No. 1

Main generation investment projects for the next decade

Source	Project	2017-2025 Added power estimated by 2025 (in MW)	Total investments estimated (in million US$)
Thermal	Vuelta de Obligado (*extension*)	270	
	Guillermo Brown (*extension*)	280	
	CC of 800 MW (*)	800	9.927
	Distributed Generation	300	
	Other not specified	7.890	
TOTAL THERMAL		**9.540**	
Hydropower	Pte. Kirchner	884	
	Gob. Jorge Cepernic	466	
	Los Blancos	320	
	Los Tordillos	162	
	Chihuidos	637	
	Portezuelo del Viento	210	14.463
	El Tambolar	70	
	Aña Cua	273	
	Garabí	1.459	
	Potrero del Clavillo	340	
TOTAL HYDROPOWER		**4.821**	
Nuclear	Atucha III	760	
	Embalse Río Tercero	52	
	Reactor CAREM-25	25	10.921
	5ta central nuclear (*project*)	1.000	
TOTAL NUCLEAR		**1.837**	
Renewable	GENREN: Wind and Photovoltaic	450	
	RenovAR 1 and 1.5	2430	6.984
	RenovAR 2 (**)	1000	
TOTAL RENEWABLE (***)		**3.880**	
TOTAL (without renewable sources)		**16.198**	**35.311**
TOTAL (with renewable sources)		**20.078**	**42.295**

Note: (*) project that would bear the name *Manuel Belgrano II*; (**) for the RenovAR program, round 2, the bid was similar to that of round 1, i.e. 1000 MW; (***) to comply with Law No. N° 27191 the renewable power to be added should be extended by around 8000 MW through 2025.
Source: prepared by us based on CAMMESA, MINEM, CAMARCO, EIA and other sources.

As it can be appreciated, the accumulated investments in generation estimated for the next years, without taking into account the renewable sources, would be over US$ 35,000 million (or US$ 42,000 million including renewable sources). This figure accounts for approximately 16,000 MW added to the current power (or around 20,000 MW, including renewable projects). Out of this substantial increase estimated in power, thermal and hydropower sources have the highest influence with a share of 60 % and 30 %, respectively. In spite of the fact that these sources will go on contributing the most to the system in the near future, both in terms of monetary investments (adding an amount higher than US$ 24,000) and in terms of total installed power (where more than 14,000 MW are expected to be added to the system) is not new, what is new is the projection made for renewables which, although not added to the amounts mentioned before, would account for a significant portion of totals if they were added.

As it relates to *thermal sources*, the expansion of Vuelta de Obligado (with a maximum power of 800 MW) and Guillermo Brown (870 MW) plants, together with the construction of a new combined cycle plant of 800 MW, are the main projects to be carried out in the mid-term. Even though the first two plants already supply energy to the system, they do it under their capacity, offering together power slightly over 1100 MW, which would be extended to 1670 MW in the next years, where the combined cycles of both plants will be closed and power will increase by 270 MW and 280 MW, respectively. The remaining plant, on the other hand, which might be named Manuel Belgrano II, is not expected to start working in the short term, but is estimated to offer additional power to the system by approximately 800 MW. However, this and other two projects are being reviewed and might be delayed. Moreover, there are projects in place to expand the Distributed Energy program. This plan was launched by Energía Argentina S.A. (ENARSA) in 2007 to offer additional power to the system using transportable equipment; although highly expensive (as fuel is burnt), it might expand in the next years to go on covering part of the necessary power gap. At present, the program offers around 900 MW and it is estimated that it will grow by 300 MW in the next years. Finally, a significant number of generation projects are being planned, which are based on thermal sources, accounting for 7890 additional MW. In total, the investment in the generation of thermal sources would be around US$ 9900 million, accounting for 9500 MW.

In connection with hydropower sources, the list of projects is not so large. The natural conditions, together with the hydric wealth in the country, mainly in what is known as surface waters (rivers, lakes, lagoons and wetlands), entail a golden opportunity for power generation. In this sense, pending projects include the hydropower plants, Kirchner and Cepernic, which were intended to generate power of around 1740 MW after their installation and operation (1140 MW the first plant and 600 MW the second one). However, the Government is seeking to reduce the inherent cost, proposing the awardee a reduction of 390 MW in the final power of the joint project, in such a way that the first plant would produce around 880 MW and the second plant would produce approximately 470 MW (these power figures were finally considered for the preparation of Chart No. 1). Other hydropower projects that might be operating in the next years are the plants Los Blancos, Los Tordillos, El Tambolar, Portezuelo del Viento, Aña Cuá, Garabí, Potrero del Clavillo and Chihuidos. From this list, the most important one is the multipurpose project Chihuidos, seeking to

add more than 630 MW to the system and implying works for 5 years. In total, the investment in the generation of hydro sources would be over US$ 14,000 million (accounting for 4800 MW).

In terms of nuclear sources, the most significant projects include the development of Atucha III (added to the operating plants Atucha I, Atucha II and Embalse Río Tercero), and a fifth plant that might contribute power worth 1000/1100 MW and might be financed by a Chinese loan. In total, investments in nuclear generation sources might reach US$ 10,900 million (or additional 1800 MW).

Finally, the projects relating to the generation of clean/renewable sources have aroused the greatest interest lately, almost exclusively due to the new renewable energy law (No. 21191/2015) and the RenovAR program. From the short list provided in the previous chart, ENARSA's GENREN program is one of the most delayed projects. With offers in excess of 1400 MW during the bid (2010) and 895 MW awarded in total, today less than half are operating. Even though it was the first renewable energy program aimed at diversifying the national electrical matrix by extending the renewable energy supply and mitigating the energy deficit currently suffered by the country, the low effectiveness level has left it behind other projects. Some of the reasons leading to the poor result of GENREN can be found in the local conditions, including the non-existence of international credit and prior exchange and capital movement restrictions. As a matter of fact, the recent elimination of these restrictions and of the limits to development has been crucial in the new local initiative fostering the investment in renewable energy: the RenovAR program. This program was devised in 2016 by the Ministry of Energy and Mining (MINEM) to meet the goals set by the new legislation. To support this program and add credibility, guaranteed by the World Bank, the Fund for the Development of Renewable Energy (FODER) was created, to which resources worth $ 12,000 million were assigned. 123 offers were received in the bid process, amounting to around 6400 MW, and the prices offered were the lowest in the last years. Among awarded projects (17) wind (70 % of total projects), solar (23 %) and biogas (7 %) generation projects stand out. This program was followed by RenovAR 1.5, intended to capture photovoltaic wind and solar projects not awarded by the first program. In this round, the Ministry received 47 bids worth 2486 MW in total (1561 MW for wind projects and 925 MW for solar projects), out of which 30 projects were selected, accounting for 1281 MW (10 wind projects amounting to 765,4 MW and 20 solar projects amounting to 516,2 MW). Considering the projects awarded in both rounds, the sector acquired around 2430 MW in renewable energy generation sources. It is estimated that among rounds 1, 1.5 and 2 of the RenovAR program and pre-existing projects, approximately 3900 MW will be added in the next decade (which might imply an estimated amount of US$ 7000 million). However, this figure, added to the fact that the existing renewable generation (of around 700 MW) would only account for 8 % of the total installed power projected by 2025, would not comply with the new renewable energy law (No. 27191). For this reason, throughout the next decade, a significant increase is expected in the number of projects involving this type of generation, which will from now on be promoted by the RenovAR program and other programs to be timely created for these purposes (this incremental required to comply with effective regulations, which would amount to approximately 8000 MW, is not taken into account because it is uncertain).

Final considerations

The purpose of this work was to show a list of the main electrical generation projects to be developed in the next decade, as well as the estimated investment and accumulated power that these projects would add to the current power. In this sense, the planned expansion projects would enable to estimate an increase of 16,000 (firm) MW in the current power (or 20,000 MW, adding renewable projects) and the monetary investment might reach US$ 35,000 million (or US$ 42,000

million with renewable projects). If these estimates become true, the total installed power might be 50,000 MW (or 54,000 MW if renewable projects are added) in the next ten years.

In this context, the estimates made for thermal sources must be taken into account; even though certain investments are tending towards cleaner technology, these sources will be those making the highest contribution to the system. This should not be surprising. The price of hydrocarbons, added to the state of technology and the time required to implement it, among other factors, make thermal generation an intelligent investment decision. In fact, a great number of projects involving this type of generation is oriented to closing cycles in thermal plants, which already provide energy to the system, installing new combined cycles, promoting the distributed generation program and implementing new co-generation projects.

In this sense, the Government has recently disclosed that, according to Resolution 420/2016 issued by the MINEM, many business groups have shown interest in the development of new projects oriented to electrical-energy infrastructure in the country, contributing to the reduction in generation costs in the Wholesale Electrical Market (MEM) and its expansion. The official balance shows that the Government has projected the submission of around 200 preliminary projects and in case all of them are carried out, they would add a new thermal power of around 35,000 MW (in new combined cycle, cycle closure and cogeneration projects). The companies that have submitted projects are YPF, Pampa Energía, Sullair, Albanesi, Isolux, Advance Corp, Enagás, CFEnergía, Araucaria, Enel, EPEC, Rio Energy y SPI Energy, Mega, Emel, SO Energy, Sadesa, Aggreko and Genneia, among others. Nonetheless, the Government must evaluate which projects are feasible and which of them are a priority in order to call for a bid in the future. Furthermore, also within this framework, the Government has received proposals in connection with new transportation and distribution works, or the supply of solutions relating to alternative fuels. Of course, in case all or part of these projects are carried out, the contribution of sources to the total power projected for the future might considerably change with respect to prior estimates, in favor of thermal projects.-

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