Argentina

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National Energy Introduction

Located on the southern half of South America, the Argentine Republic (Argentina) is home to a population of approximately 45 million people of Mestizo and European descent. The national language is Spanish, and approximately 80% of the population practices Christianity as a form of religion. The nominal gross domestic product (GDP) for the residents of Argentina is $9887, making it the world's 53rd largest economy and the 3rd in Latin America. The capital, Buenos Aires, is the largest city in Argentina and is located on the northeastern coast, west of the Rio de la Plata estuary [1].

Argentina's economy has become increasingly service-driven upon entering the twenty-first century [2]. The top economic sectors are commerce, tourism, manufacturing, and agriculture. Argentina's main trade partners are Brazil, China, and then the United States. Their main exports are refined petroleum products, vehicles, corn, wheat, soybeans, and related products. Argentina's main import products are petroleum, natural gas (NG), machinery, motor vehicles, organic chemicals, and plastics [3].

Energy Policies

The early twenty-first century saw the Argentina government continues to deliver policies that favored fossil fuel resources. However, the Argentina government is transitioning to policies that now favor renewable resources with the 2016–2025 Renewable Energy Program, The energy generation breakdown is shown in Fig. 4.

During the early twentieth century, the Argentina's electricity sector was vertically integrated and government-owned.

However, during the early 1990s, Argentina experienced a series of energy crises due to the lack of maintenance of nearly half the country's thermal power plants [11]. Since then, Argentina has undergone a process of institutional reform and privatizing the energy sector. These reforms vertically and horizontally unbundled segments of the electricity sector, such as the generation, transmission, and distribution. There was a separation of regulatory functions and policy-making and was the inclusion of the private sector to all segments of the electricity sector [2].

The Ministry of Energy and Mining (MINEM) regulates the electricity sector by means of policies and guidelines. The National Electricity Regulatory Entity (ENRE) supervises the electricity sector and enforces the policies of the MINEM. The management of the wholesale electrical market is carried out by the Argentine Wholesale Electricity Market Administrator Company (CAMMESA). When it comes to the monitoring and investigation of the national and municipal governments, that falls under the jurisdiction of the Federal Electrical Energy Council (CFEE). The commercialization of private concessionaires is carried out by the CAMMESA, and the studies/planning of the energy sector is carried out by the Secretariat of Strategic Energy Planning [9].

In 2015, Argentina launched the 2016–2025 Renewable Energy Program (RenovAr). The purpose of the RenovAr is to increase the penetration of renewable energy in the grid by 20% by 2025. The total energy requirement for the initial contracts is 600 MW of wind energy, 300 MW of solar energy, 65 MW of biomass, 20 MW of small hydroelectric projects, and 15 MW of biogas [9]. Argentina is expected to save US$300 million per year in fuel imports from this initiative [9].

Trends in Generation Technologies

Natural gas represented 52% of total primary energy consumption in 2015 and is used widely in the electrical, industrial, and residential sectors. Petroleum represented 36% of total primary energy consumption and is used in the transportation sector.

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Hydroelectricity is the third largest primary energy resource and is the bulk of renewable energy currently exploited, followed by biofuel and biomass, which are used by the transportation sector and the surplus exported [8].

From Fig. 1, it is apparent that hydrocarbon fuels are the primary fuel source (67%, 2016), followed by renewables (28%, 2016) and nuclear (5%, 2016). The demand for hydrocarbons has had a consistent growth over the decades, aside from a decline during their 2000 recession. Renewables have seen a minimal growth, and most of them were primarily driven by hydroelectricity generation.

Domestic Resources

Argentina has a landmass over a million square miles and an Atlantic coastline that spans approximately 3100 miles north to south. Five countries share a border with Argentina: Chile to the west, Bolivia to the northwest, Paraguay to the north, and Brazil and Uruguay to the northeast. The western border is defined by the Andes Mountains to the west of Argentina. Due to the Andes, most of the western and southwestern regions of Argentina experience levels of the rain shadow effect. The northeastern regions of Argentina are closer to the Tropic of Capricorn and experience temperate climate patterns [4].

Argentina has two main ocean currents, shown in Fig. 2, that impacts the regions' climate. There is the Falkland Current that flows north from West Wind Drift around Cape Horn and brings dense cold subarctic water [5]. Then, there is the Brazil Current that flows south from the Atlantic South Equatorial Current and brings lighter warm subtopic water [6].

The South Atlantic High (SAH) and South Pacific High (SPH), shown in Fig. 3, are the two main air masses that impact the air circulation of Argentina. Due to the Andes position to the west of Argentina, the SPH impacts are limited to the Patagonia region, and so the SAH is the dominating air mass. The SPH brings moist, cold air north from Patagonia, and the SAH brings moist, warm air southwest from the Atlantic Ocean [7].

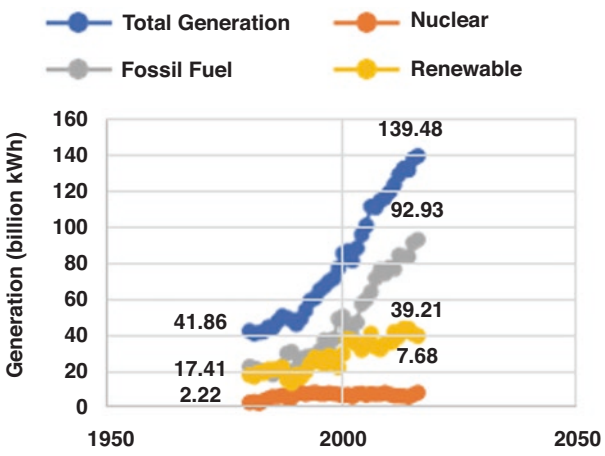

Fig. 1 Argentina's annual power generation [8]

History of Energy

Like other middle-income countries that developed a modern grid in the twentieth century, this growth was powered by fossil fuel and government control of the energy sector. However, the reforms have been made in the early 1990s, and now, the grid is privatized and less centralized.

Breakdown of Energy Generation "Mix"

Fossil Fuels

Oil

As shown in Figs. 5, 6, and 7, Argentina has steadily increased their production, consumption, and imports of petroleum products. This is driven by the growing demand by the middle-class population and industrial and transportation sectors [9].

Coal

As shown in Figs. 8, 9, and 10, Argentina has had a steady consumption of coal. However, their production of coal has steadily declined, while their levels of coal imports steadily increased to meet the consistent demand.

Natural Gas

As shown in Fig. 11, Argentina has steadily increased their production of natural gas (NG) until peaking in 2006, and then the production declined until 2015. Figure 12 shows that the consumption of NG has steadily increased over the decades to meet energy needs. The exponential importing of NG from Fig. 13 aligns with the dip of NG production and will be further discussed in the section "Energy Resiliency".

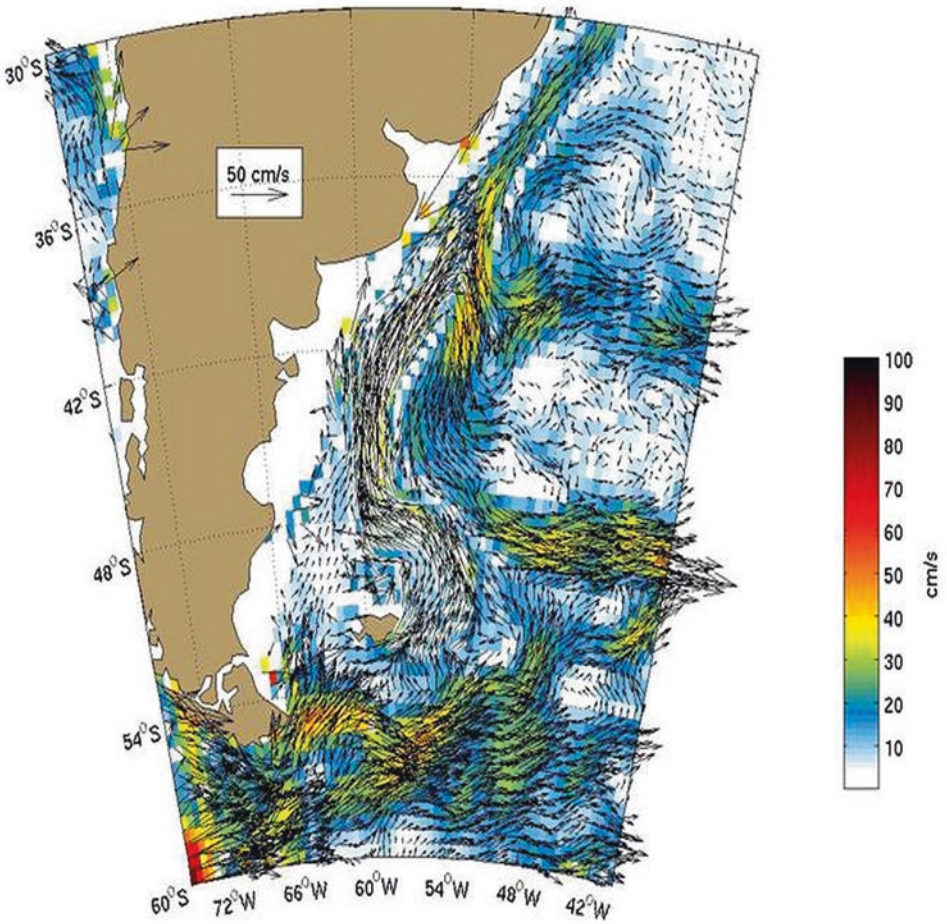

Fig. 2 Falkland and Brazil currents

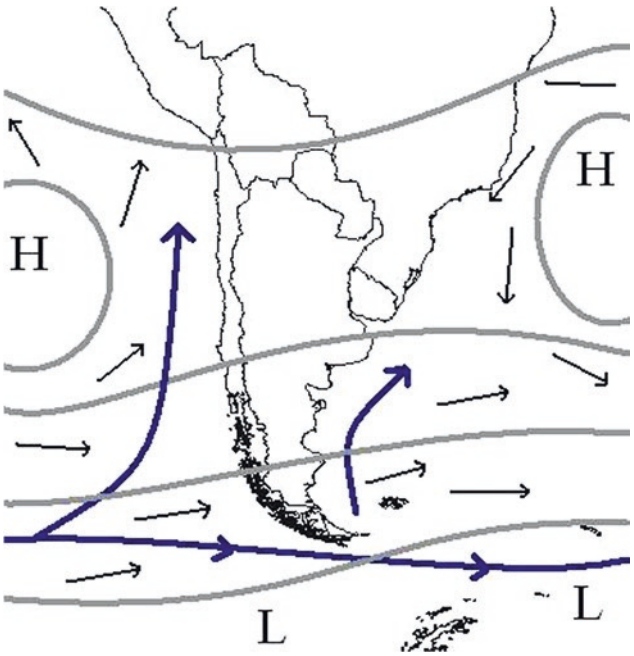

Fig. 3 SPH and SAH air circulations

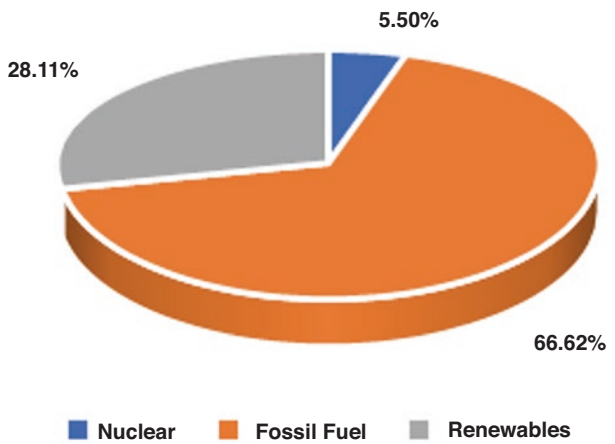

Fig. 4 Argentina's annual energy generation (2016)

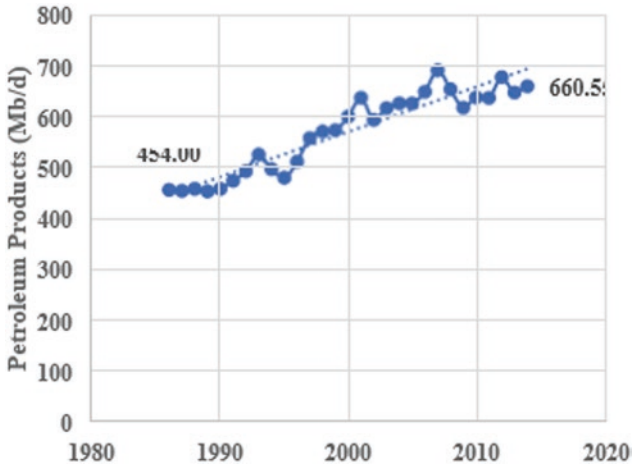

Fig. 5 Argentina's annual petroleum production [8]

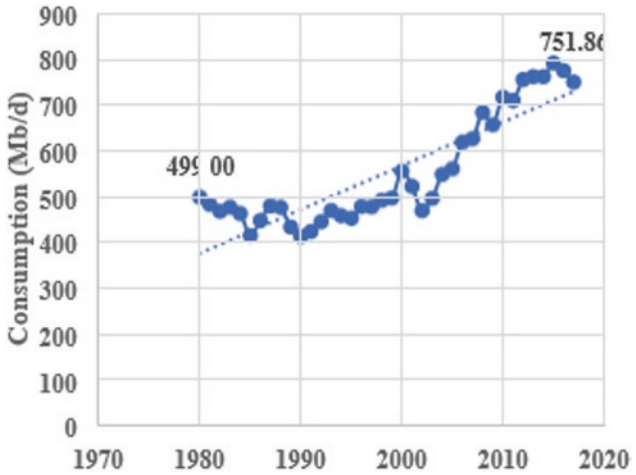

Fig. 6 Argentina's annual petroleum consumption [8]

Fig. 8 Argentina's annual coal production [8]

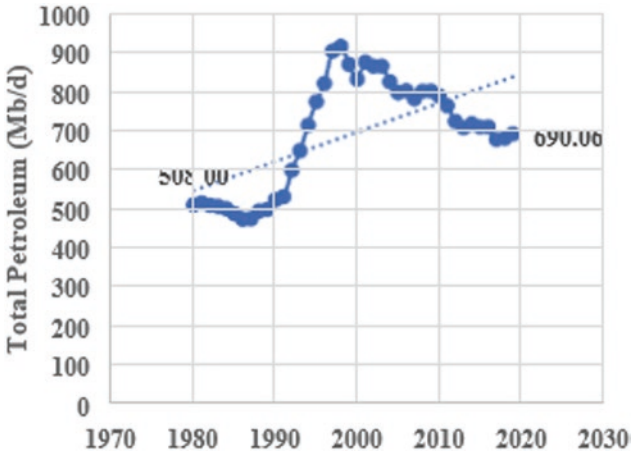

Fig. 7 Argentina's annual petroleum imports [8]

Fig. 9 Argentina's annual coal consumption [8]

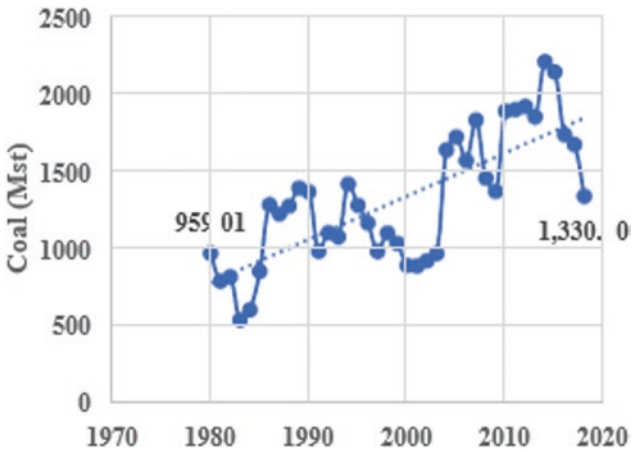

Fig. 10 Argentina's annual coal imports [8]

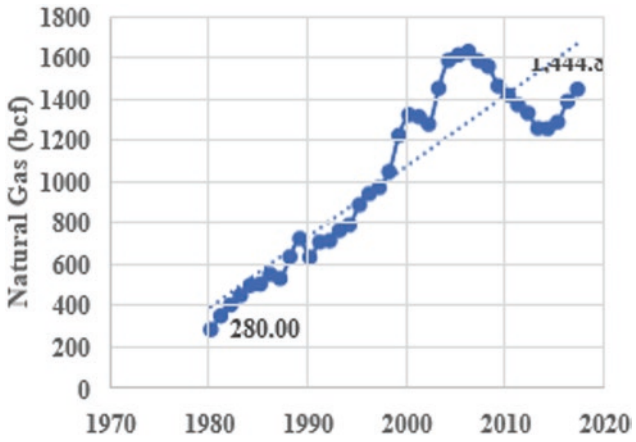

Fig. 11 Argentina's annual NG production [8]

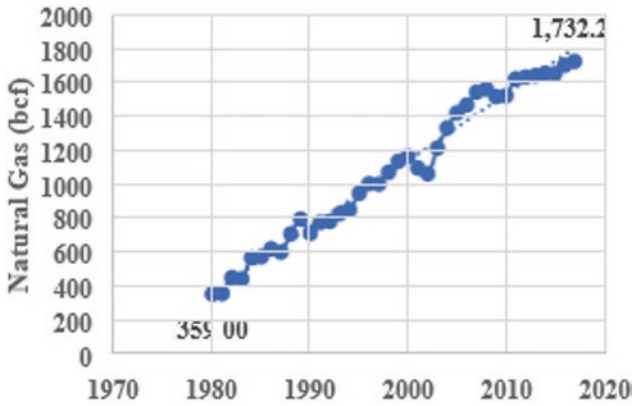

Fig. 12 Argentina's annual NG consumption [8]

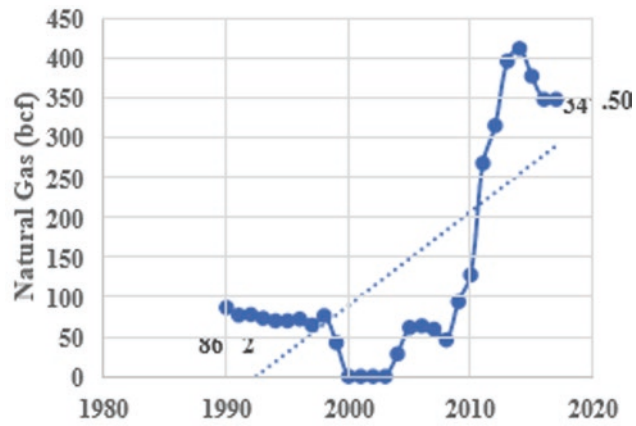

Fig. 13 Argentina's annual NG imports [8]

Renewable Energy Generation

Photovoltaics (PV)

Solar photovoltaics is an underutilized energy resource in Argentina. Aside the Andes to the west and the plateaus of Patagonia to the south, over half of Argentina consists of plains ideal for gathering solar resources [2]. However, the highest density of solar resources can be found in the northwestern region of Argentina.

Wind

As shown in Figs. 14 and 15, wind generation was nonexistent until the 2000s. There was a gradual growth, but it did not exponentially increase until 2010. However, when compared to the wind resources of Argentina, this is a relatively underutilized resource.

Due to the South Pacific High (SPH) flowing north from around Cape Horn, the Patagonia region is dense in wind energy resources, while the northern half of Argentina is not as wind-dense as the Patagonia region. However, northern Argentina still receives ideal wind resources from the South Atlantic High (SAH).

Hydro

In Fig. 16, we can see that over the past decades Argentina's hydroelectricity generation has more than doubled and is currently the country's largest source of renewable energy.

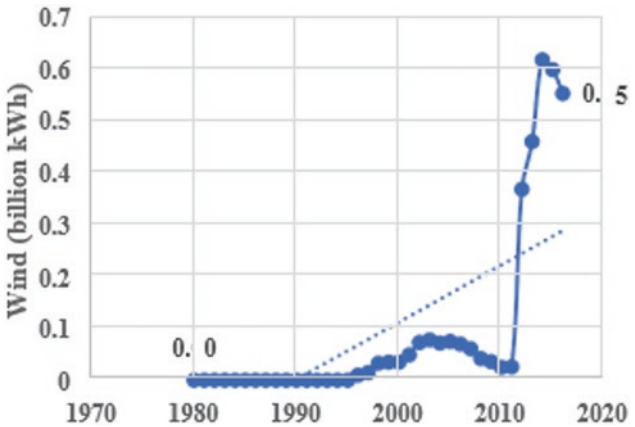

Fig. 14 Argentina's annual wind power generation [8]

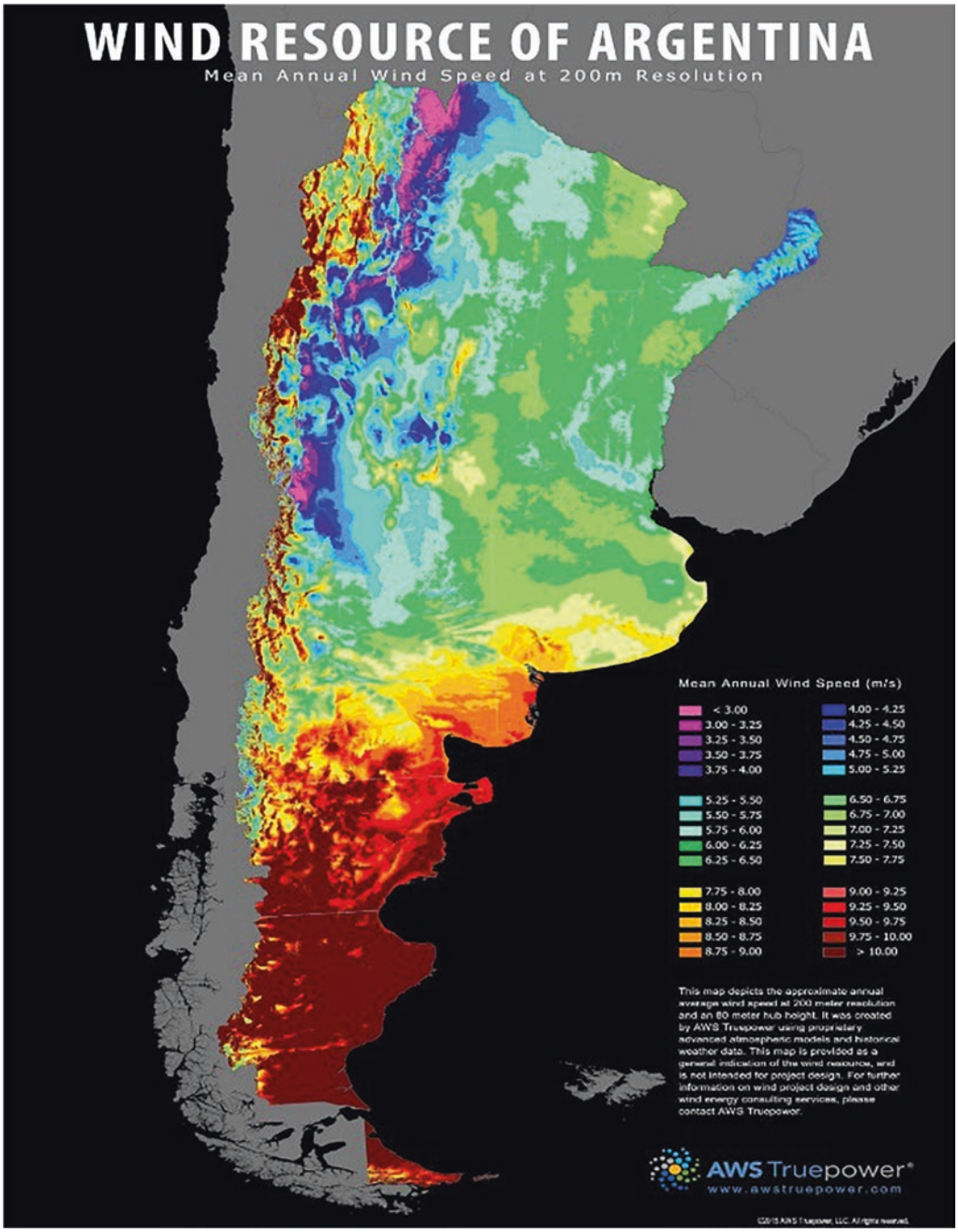

Fig. 15 Argentina's wind resource map

The main drivers of this growth have been the joint binational hydroelectric plant projects Argentina pursued with Paraguay (Yacyretá Binational Entity) and Uruguay (Salto Grande) [9].

Ocean

Based on the information collected from the US Energy Information Administration (EIA), at this time Argentina does not have any form of operating tidal power. However,

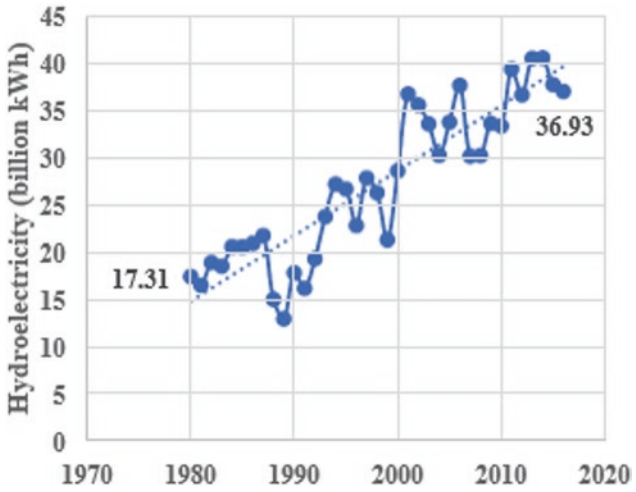

Fig. 16 Argentina's annual hydroelectricity generation [8]

based on the cold reservoir, that is, the Falkland Current, and the hot reservoir, that is, the Brazil Current, it is believed that there is great potential for tidal power, and this is worth further investigation.

Geothermal

Due to Argentina's proximity to the Pacific Ocean and the Andes Mountains, there is a considerable amount of geothermal energy to the west. However, like wind and solar, this is another underutilized resource with great potential. Based on the EIA data, there does not appear to be any measurable levels of geothermal energy consumption in the country (Fig. 17).

Biomass

See section "Biofuels".

Biofuels

Figures 18 and 19 show that from the 1980s until the 2000s biomass and biofuel production was nonexistent. However, by 2007, a biofuel law was put into place, and it mandated that gasoline would be mixed with bioethanol and diesel was to be mixed with biodiesel [2]. This law paired with the large agricultural output of Argentina caused a significant growth in production of both fuel sources. The excess biomass and biofuel are exported to Argentina trade partners.

Energy Storage Technologies

Country's Current Implementation of Energy Storage Techniques

The data from the EIA show that the only energy storage system in Argentina is the Rio Grande Hydroelectric Complex (RGHC) in the Calamuchita providence. The RGHC primarily operates to manage floods and provide municipal water. The RGHC has an installed capacity of 750 MW and an annual average power generation of 977 GWh [10]. Based on the data from Fig. 20, while pumped hydroelectric storage has increased annually, the storage system does not operate near the rated value.

Due to the development of Argentina's hydroelectric infrastructure and a lack of investment toward wind, solar, and geothermal infrastructures, it is understandable that there is also a lack of compressed air, batteries, and fuel cells storage infrastructure to store the excess energy that would be generated by those resources.

Energy Resiliency

Electrical Grid

The Argentina's grid has nearly maximum population coverage with regions in the south still deficient.

Argentina's total electricity coverage for its population was approximately 100% in 2016 [12]. However, there are communities in the rural southern regions of Argentina that still have deficient access to electricity [11].

Akin to the United States, generation plants are a mix of private and state-owned utilities.

The transmission system is named the Argentine Interconnection System (SADI) and covers three quarters of the country's northern region [2]. The SADI consists of two subsystems: the High Voltage Electric Power Transport System (STAT) and the Trunk System (ST). Transener is the company that manages the STAT, while Distrocuyo, Transba, Transpa, Transnoa, Transnea, and Transcomahue are the companies that manage the ST. Distribution at the local level is managed by private concessionaires of a province [9] (Fig. 21).

Climate and Natural Disasters

Over the past decades, precipitation and temperature have increased steadily across Argentina. Precipitation has

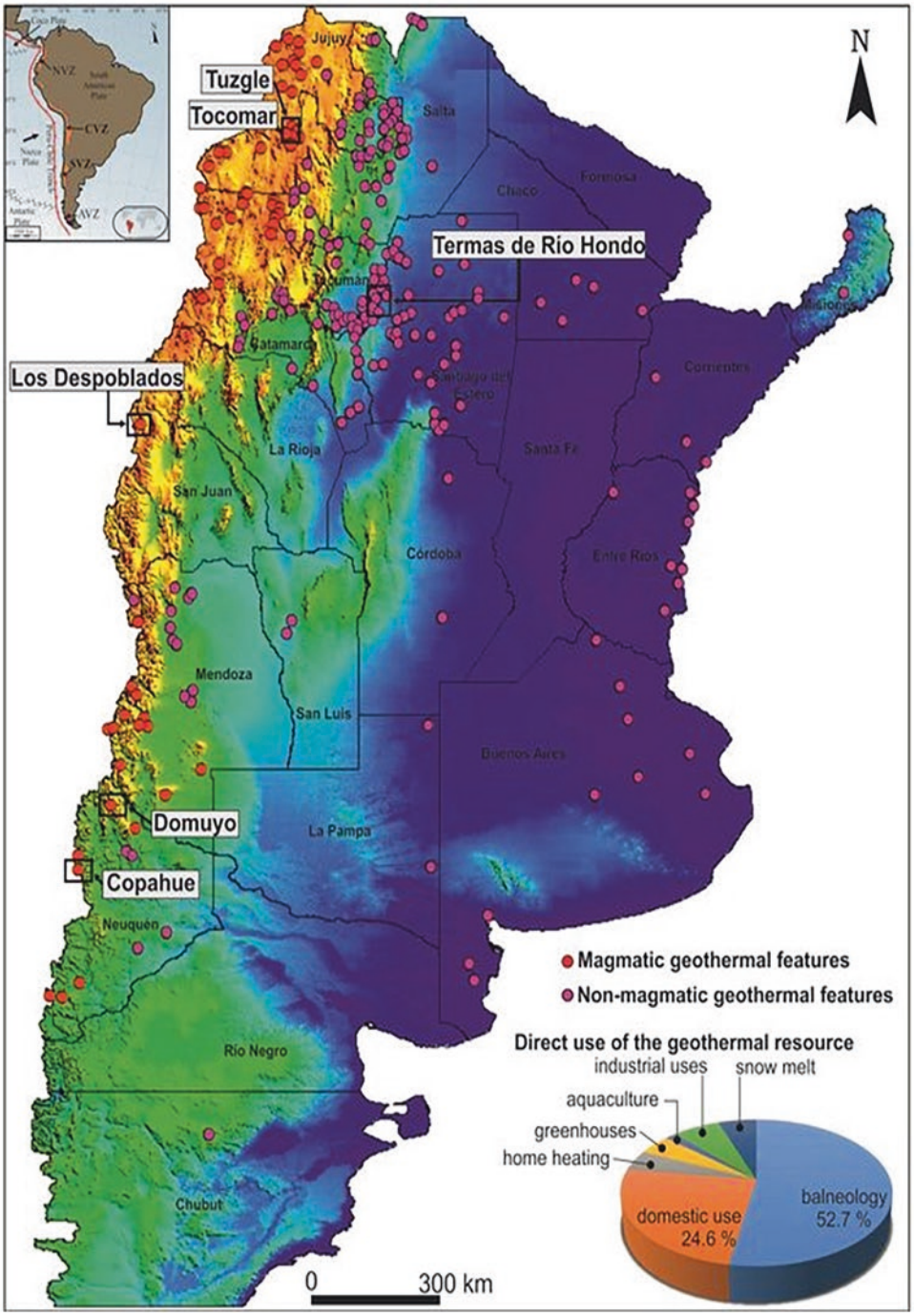

Fig. 17 Argentina's geothermal resource map

increased the most along the northeast region of Argentina at a rate of 10% since the 1970s and 40% in parts of the Buenos Aires province. From 1901 to 2012, the temperature has increased on average by 0.5 °C [14]. The higher temperature has caused a retreat of glacial ice and decreased snowfall in the Patagonia and Andes Mountain regions [14]. The major challenges Argentina is going to face from climate change is the managing of their excess water resources in the northeast region and the decline of water resources in the southern and western regions. The population most sensitive to these challenges is the rural communities dependent on agriculture [15].

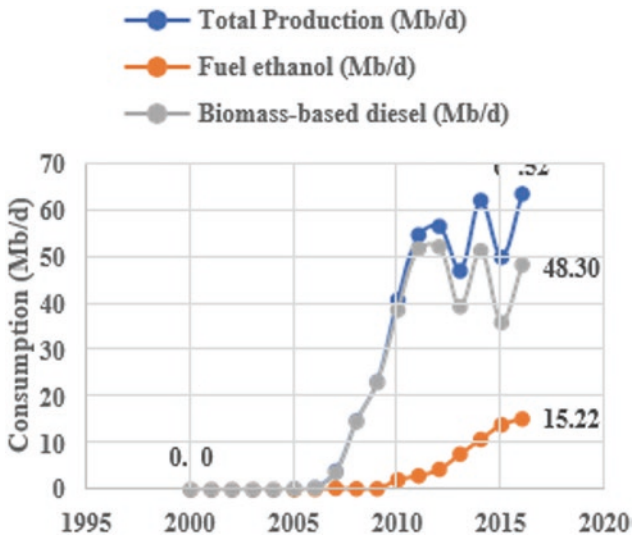

Fig. 18 Argentina's annual biomass/biofuel production [8]

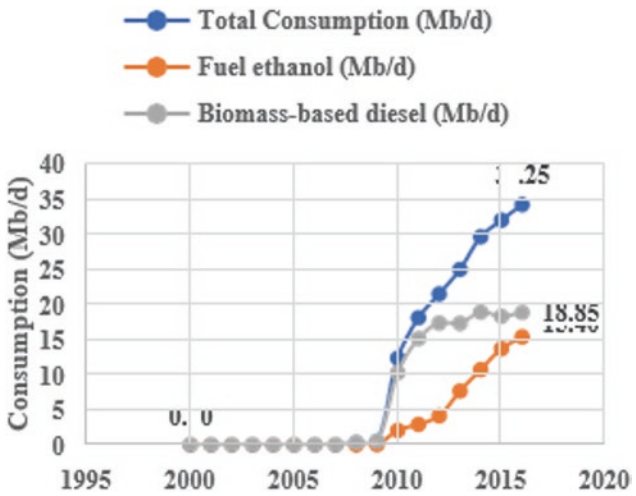

Fig. 19 Argentina's annual biomass/biofuel consumption [8]

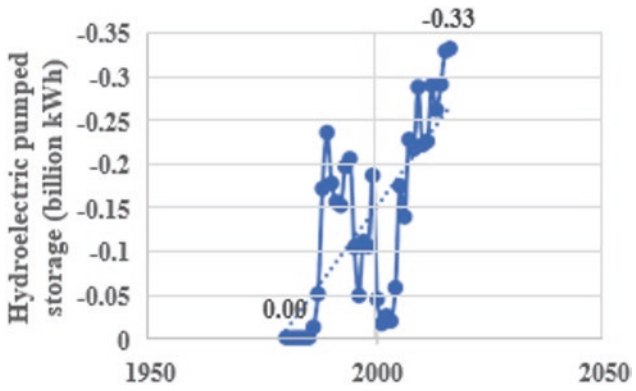

Fig. 20 Argentina's annual hydroelectric pumped storage [8]

Fig. 21 Argentina's interconnection system

Grid Resiliency

Aside from an NG shortage in 2004 and a regional blackout in 2019, the twenty-first century Argentina grid is resilient and transitioning at a rate expected for a country with their GDP size. Argentina is seeking foreign investments to catalyze this transition. However, with America's own aging grid, it is not believed that Argentina could expect direct financing from the United States.

Regarding the 2004 Energy Crisis, Argentina experienced an economic recession in 2000 that caused a decline in natural gas consumption, which decreased natural gas production. However, by the end of 2002, the economy had recovered and the demand rapidly increased. The production could not meet the local demand, and ultimately Argentina had to restrict their NG exports to their trade neighbors like

Chile, Brazil, and Uruguay [13]. While Argentina was able to avoid a power shortage, the relationship with their trade partners soured.

On June 16, 2019, all of Uruguay, most of northern Argentina, and parts of Paraguay experienced a large-scale blackout event. A total of 48 million people went without power for 24 hours. The distribution of potable water was limited, local gubernatorial elections were impacted, and medical patients that depended on home devices were prompted to attend local hospitals. The cause of the blackout is credited to Transener and the failure of communication between a team completing maintenance on a transmission tower and the Automatic Generation Shutdown system (DAG) [14].

Geopolitical Circumstances

Relations with Global Community/ Socioeconomic Influence

Argentina has grid interconnections with Brazil, Uruguay, Chile, and Paraguay. The two Brazilian interconnections go to and from Rincón de Santa María, Argentina (Ar) to Garabí, Brazil (Br) and Paso de los Libres, Ar to Uruguayana, Br. The three Uruguay interconnections go to and from Concepción del Uruguay, Ar to Paysandú, Uruguay (Uy), the Colonia Elía, Ar to San Javier, Uy and the Colonia Elía, Ar to San Javier, Uy. The Chilean interconnection goes to and from Termoandes Cobo, Ar to Atacama, Chile (Ch). Paraguay has two interconnections that go to and from El Dorado, Ar to Carlos López, Paraguay (Py) and Clorinda, Ar to Guarambaré, Py. While Argentina does not currently share an interconnection with Bolivia, both the countries share a mutual interest in future projects [9].

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