ELEMENTS FOR A LONG-TERM LOW-CARBON STRATEGY

Prepared by **Universidad Nacional del Centro de la Provincia de Buenos Aires** for **Fundación Ambiente y Recursos Naturales** within the framework of a collaborative project with **ClimateWorks Foundation.**

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Elements for a long-term low-carbon strategy

Authors

Gabriel Blanco / Daniela Keesler
Centro de Tecnologías Ambientales y Energía, Facultad de Ingeniería, Universidad Nacional del Centro de la Provincia de Buenos Aires.

Collaborators

Enrique Maurtua Konstantinidis / Jazmín Rocco Predassi
Fundación Ambiente y Recursos Naturales
Carlos G. Tanides
Fundación Vida Silvestre Argentina

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Translator

Elisa Predassi Bianchi

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1. INTRODUCTION

The *Report on Global Warming of 1.5 °C*, of the Intergovernmental Panel on Climate Change[1] (IPCC), presents a series of emission pathways that should be achieved so that global mean temperature of the Planet is not increased –or is most likely not increased– 1.5 °C above pre-industrial values. All of these pathways coincide regarding the fact that global greenhouse gas emissions (GHG) for 2050 should be next to zero or even negative. As signatory of Paris Agreement[2] and adherent to UN Sustainable Development Goals[3], Argentina is not exempt from the responsibility to reduce its emissions. Therefore, it is necessary to establish a strategy aimed at guiding and coordinating the actions to be carried out for reaching those long-term objectives.

2. OBJECTIVES

This paper intends to discuss different elements that should be addressed in a long-term low-carbon strategy, resilient to climate change, which will place Argentina on a more sustainable development pathway.

The document is aimed at showing the complexity of the actions to be taken, their challenges and difficulties. To that end, possible scenarios are set forth, as reference to reach zero emissions by 2050 in two large sectors of the economy representing the main GHG emission sources in Argentina: energy, and agriculture, forestry and other land use (AFOLU), including forests.

3. REFERENCE SCENARIOS

As starting point and based on 1.5 °C temperature increase compatible scenarios presented by the IPCC, the need to explore scenarios that will align Argentina with this 2050 global objective is set forth. To this end and within the framework of this project, scenarios were developed that will allow the country to reach zero emissions for that year.

According to the *Third Biennial Update Report (BUR)*[4] *submitted by the Argentine Republic to the United Nations Framework Convention on Climate Change*, the country's greenhouse gas emissions were 364.4 $MtCO_2e$ in 2016. This figure represents 0.70% of the global GHG emissions for that year, taking into account global emissions informed by the United Nations Environment Program (UNEP) in its annual *Emissions Gap Report 2017*[5].

If the targets set forth in the National Determined Contribution (NDC) for Argentina for 2030[6] are analysed and compared to the global emissions for the same year of IPCC report 1.5° C compatible alternative pathways, it is observed that the emissions committed in the country's NDCs would represent between 1.20% and 2.19% of those global emissions (Table 1); a much higher percentage as compared to the current emissions of the country.

1. IPCC. (2018) Special Report on Global Warming of 1.5 °C. **https://www.ipcc.ch/sr15/**
2. United Nations. (2015). Paris Agreement. **https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en**
3. United Nations. (2015). Sustainable Development Goals. **https://www.un.org/sustainabledevelopment/es/objetivos-de-desarrollo-sostenible/**
4. Ministry of Environment and Sustainable Development (2019). Third Biennial Update Report. Available at: **https://www4.unfccc.int/sites/SubmissionsStaging/NationalReports/Documents/9587041_Argentina-BUR3-1-3er%20Informe%20Bienal%20de%20la%20Republica%20Argentina.pdf**
5. UNEP (2017). The emissions gap report 2017. United Nations Environment Programme (UNEP), Nairobi. Available at: **https://www.unenvironment.org/resources/emissions-gap-report-2017**
6. Ministry of Environment and Sustainable Development (2016). Primera revisión de su contribución determinada a nivel nacional. Available at: **https://www.argentina.gob.ar/sites/default/files/ndc-revisada-2016.pdf**

TABLE 1 - PERCENTAGE REPRESENTED BY ARGENTINA'S NDC AS COMPARED TO PATHWAYS OF IPCC REPORT ON GLOBAL WARMING OF 1.5.C°

ALTERNATIVE PATHWAYS FOR 1.5° C	IPCC GHG 1.5 GLOBAL EMISSIONS IN 2030 ($GTCO_2E$)	ARGENTINA'S UNCONDITIONAL CONTRIBUTION (0.483 $GTCO_2E$)
1.5 °C	22.1	2.19%
1.5 °C-low overshoot	27.9	1.73%
15 °C-high overshoot	40.4	1.20%

Source: Own elaboration.

This analysis evidences that Argentina's effort should be higher, and that the country's NDC is not enough for being aligned with the objective of maintaining global mean temperature below 1.5°C. Therefore, more ambitious reduction goals are needed. This paper intends to produce a contribution through the elaboration of different and more ambitious scenarios for Argentina.

4. METHODOLOGY FOR THE DEVELOPMENT OF SCENARIOS AND RESULTS

There follow the descriptions of the methodologies used to develop the different low-carbon scenarios for the two above-mentioned sectors: energy and AFOLU, and the obtained results are included. In order to complete result analysis, two additional scenarios were developed for the energy sector: a trend scenario and an intermediate scenario.

4.1. ENERGY SECTOR

For modelling energy scenarios to the year 2050, the same model of the *Energy Scenarios Platform 2040* exercise, based on LEAP (Long Range Energy Alternative Planning) software was used, adapted and modified by widening the time horizon considered.

A total of five scenarios were developed, three of them reference models that will allow reaching net zero emissions by 2050.

1. Trend scenario. As its name suggests, it follows the current trend both for energy demand and supply.

2. Intermediate scenario. Enhanced efficiency measures for demand and an electricity matrix with stronger presence of renewable sources were implemented in this case.

3. Low-carbon reference scenario 1. Based on electricity for supplying both residential, commercial and public demand, and transport demand. The use of hydrogen was considered for large thermal energy industrial consumption.

4. Low-carbon reference scenario 2. Based on a larger hydrogen production and use, both for industry and transport, maintaining electricity for residential consumption.

5. Low-carbon reference scenario 3. Based on high biofuel production for transport, while maintaining electricity for residential consumption and hydrogen for industry.

As observed, three low-carbon reference scenarios with efficient demand and different energy supply alternatives for reaching the net-zero GHG emission goal for the year 2050 were formulated.

Likewise, for each scenario different technologies efficiency improvements based on learning curves, both in demand (efficiency of electro-domestic devices, transport engines, industry, etc.) and in electricity generation (in charge, performance and stable capacity credit factors), were proposed.

Each of the premises considered for developing the different scenarios is described in the following points.

4.1.1. Trend scenario

This scenario corresponds to a demand following the growth trend observed during the last years in population, number of households, number of cars per inhabitant, GDP and commercial, public and industrial energy demands. Efficiency measures included in the Energy and Climate Change National Action Plan[7] were modelled on this basis.

For energy supply, the actions established in this Plan as well as the objectives included in Laws number 26,190 of Electric Energy and number 27,191[8] of National Promotion Regime for Renewable Energy Sources Use for Electric Energy Production, and the biofuels blend percentages established by Law number 26,093 of Regulation and Promotion for Biofuel Sustainable Production and Use, and later resolutions (currently 10% for biodiesel in gas oil and 12% for bioethanol in naphtha) were also considered.

For fossil fuel supply, *2030 Energy Scenarios*[9] of the former Ministry of Energy and Mining (MINEM, for its acronym in Spanish), published in December 2017, were taken into account.

Ongoing population and consumption growth continuously push energy final demand increase. Figure 1 shows this projection for the 2020-2050 period, where final energy demand is doubled, rising from 64 thousand ktoe to over 128 thousand ktoe (kilo tonne of oil equivalent = 41.87MJ or 11.63MWh).

7. National Climate Change Cabinet. (2019). Plan Nacional de Adaptación y Mitigación al Cambio Climático. **https://www.argentina.gob.ar/sites/default/files/pnamcc_0512_ae_v9.pdf**

8. Energy Secretariat of the Nation (2009/2016). Ley 26.190 y 27.191 de Régimen de Fomento Nacional para el uso de Fuentes Renovables de Energía destinada a la Producción de Energía Eléctrica y su Modificación. Available at: **http://www.energia.gob.ar/contenidos/verpagina.php?idpagina=3876**

9. Ministry of Energy and Mining. (2017). Escenarios Energéticos 2030. Available at: **http://datos.minem.gob.ar/dataset/9e2a8087-1b49-446a-8e86-712b476122fb/resource/04dbee7f-0b6f-48d0-b460-8d7fa3b282c7/download/minem-documento-escenarios-energeticos-2030pub.pdf**

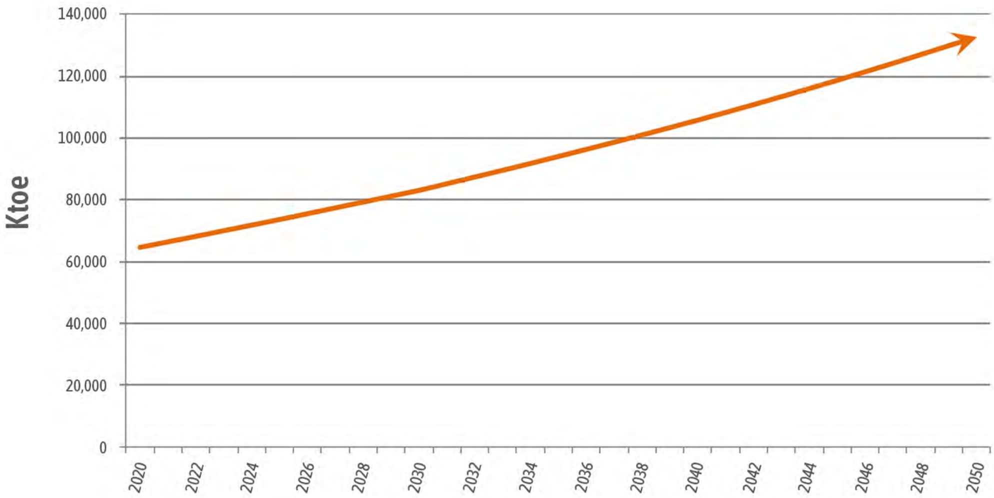

FIGURE 1 - FINAL ENERGY DEMAND FOR TREND SCENARIO, IN KTOE, ANNUAL EVOLUTION

Source: Own elaboration.

Installed capacity increase for electricity generation to the year 2050 as compared to current increase, to supply this rising demand, would be 300%, as observed in Figure 2.

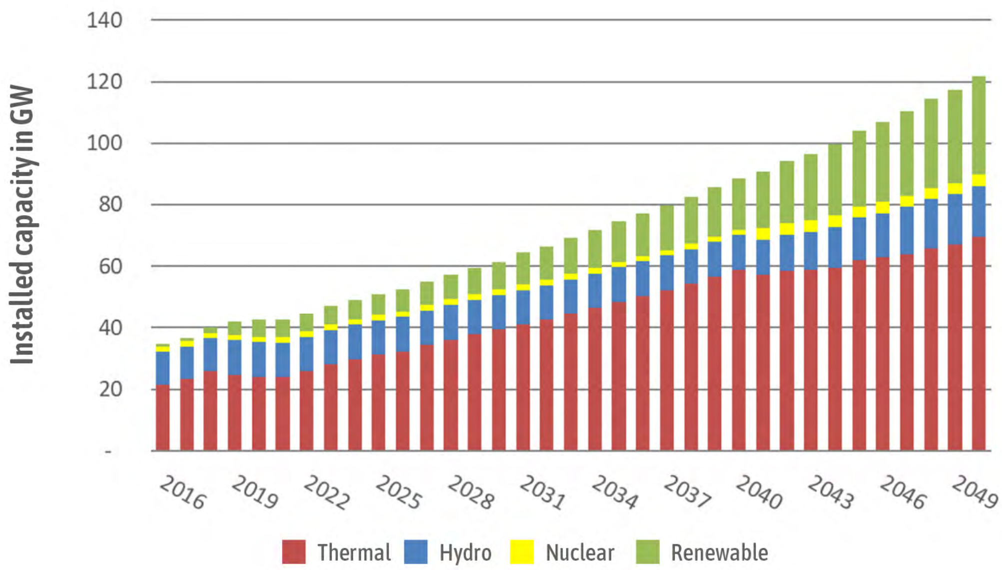

FIGURE 2 - ELECTRICITY GENERATION INSTALLED CAPACITY FOR TREND SCENARIO, ANNUAL EVOLUTION

Source: Own elaboration.

4.1.2. Intermediate scenario

This scenario assumes higher energy demand efficiency measures than those considered in the sectoral plan, which include:

- Having 50% households incorporate solar water heaters.
- Reaching 25% electrification in residential, commercial and public demand.
- Achieving 100% replacement to electric urban buses.
- Reaching 30% of electric cars in the automobile fleet.

A reconversion of the electricity generation matrix to renewable sources was also considered, but maintaining cogeneration cycles and some thermal generation cycles, such as gas turbines, to ensure the needed reserve margins. Biofuel blend was kept constant at 10% and 12% for biodiesel and bioethanol, respectively.

The objective of proposing this intermediate scenario is to show that partial actions are not enough to reach null emissions. As seen in section 4.1.4 Emission calculus for each scenario, a total reconversion of each sector is necessary.

4.1.3. Low-carbon reference scenarios

It is necessary to transform both demand and supply for reaching zero emissions in the energy sector by 2050. In this exercise, the same demand measures were assumed for the three proposed low-carbon scenarios:

- Gradual residential demand electrification reaching the year 2050 with a 100% electrified residential demand.
- On the basis of this demand, it was assumed an annual improvement of consumption efficiencies based on learning curves of different technologies, reaching 2050 with a 30% efficiency increase in all electricity consumptions: residential, transport, industry, commercial and public. Section 4.1.6 presents a more detailed analysis of possible future improvements in final efficiency consumptions. For the analysis of these reference scenarios, a similar average annual improvement value for all final consumptions was taken into account, but reality is usually much more complex.
- As regards residential consumption for 2050, it was assumed the replacement of natural gas water heaters with solar water heaters over the total national households, dwellings being houses (apartments not included).
- In the transport sector, a modal demand change was modelled, considering an urban bus service improvement that would allow a reduction of circulating private cars, as these passengers encouraged by an upgraded public bus service would adopt this form of transportation for daily commuting in the great urban centers of the country (Autonomous City of Buenos Aires, Rosario, Córdoba, Mendoza).

When modeling efficiency improvement, the so-called “rebound effects” cannot be ignored. Numerous studies have demonstrated that the efficiency measures adopted and the technological advances in search of energy savings seldom attain their aims in practice; on the contrary, in many cases, it has been proved that these improvements increase consumption even more. This is due to many factors, among which an improved efficiency of one resource encourages consumption by users, thus the technological advance achieved to generate energy use savings does not show the expected results. It may also happen that the energy savings attained are translated into higher expenses in another area. Once again, in the overall assessment, saving objectives are not fulfilled.

On average, rebound effects accounted for in various energy efficiency measures studied have amounted to 100% or even more, what means that energy savings have been null[10]. In this modelling exercise, rebound effects on energy consumption were not included, but they should at least be mentioned.

As regards energy supply, from a wide range of possible actions, the following were adopted:

- Biofuel was proposed for aviation.
- For great industrial energy consumptions, particularly for steal and cement production, replacing fossil fuels (natural gas, coal, etc.) with hydrogen was considered.
- For electricity generation, improvements in charge, performance and stable capacity credit factors were considered.
- Liquefied petrol gas (LPG) consumptions, for industrial and residential use (where electrification is not possible), and fuel oil, mainly used in industry and to a lesser degree in the agriculture sector, were converted to hydrogen or biofuels, depending on the scenario.

Table 2 shows a matrix including the fuel considered for each final demand sector in the three proposed low-carbon scenarios.

TABLE 2 - FINAL DEMAND SECONDARY ENERGY FOR EACH LOW-CARBON SCENARIO

	RESIDENTIAL	TRANSPORT	INDUSTRY	AVIATION	LPG/FUEL OIL
SCENARIO 1	Electricity	Electricity	Hydrogen	Biofuels	Hydrogen
SCENARIO 2	Electricity	Hydrogen	Hydrogen	Biofuels	Biofuels
SCENARIO 3	Electricity	Biofuels	Hydrogen	Biofuels	Hydrogen

Source: Own elaboration.

Likewise, having as an objective not only reducing emissions but also avoiding the use of technologies that, while not being GHGs emission sources, could generate adverse effects for the natural and social environment where they are applied, the following socio-environmental restrictions were considered for the low-carbon reference scenarios:

- No new nuclear power plants are incorporated.
- No new hydroelectric power plants over 50 MW are considered.
- Hydrocarbon production (petroleum and gas) as well as imports/exports are eliminated.

10. Bruns Stephan B., Moneta Alessio y Stern David I. (2019). Estimating the Economy-Wide Rebound Effect Using Empirically Identified Structural Vector Autoregressions. LEM Papers Series from Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy.

- An increase of the cultivated area for biofuel production (agricultural frontier) is not considered, except for the biofuel based scenario.

- Lithium production limitation for electric vehicle batteries is assumed, except for the scenario contemplating transport sector electrification.

Section 6 analyses the need of assessing low-carbon reference scenarios contribution to sustainable development through metrics allowing a systematization of that assessment.

Low-carbon reference scenario 1

The main difference among the three scenarios in found in the transport sector. In this case, both passenger and freight transport and agricultural machinery were converted to electric consumptions.

Figure 3 shows in detail the evolution of the primary energy supply matrix for this scenario. The amount of energy is considerably lower that for the trend and intermediate scenarios (lines blue and red, respectively), largely due to the higher efficiency of electric consumption as compared to the same consumption directly supplied by fossil fuels.

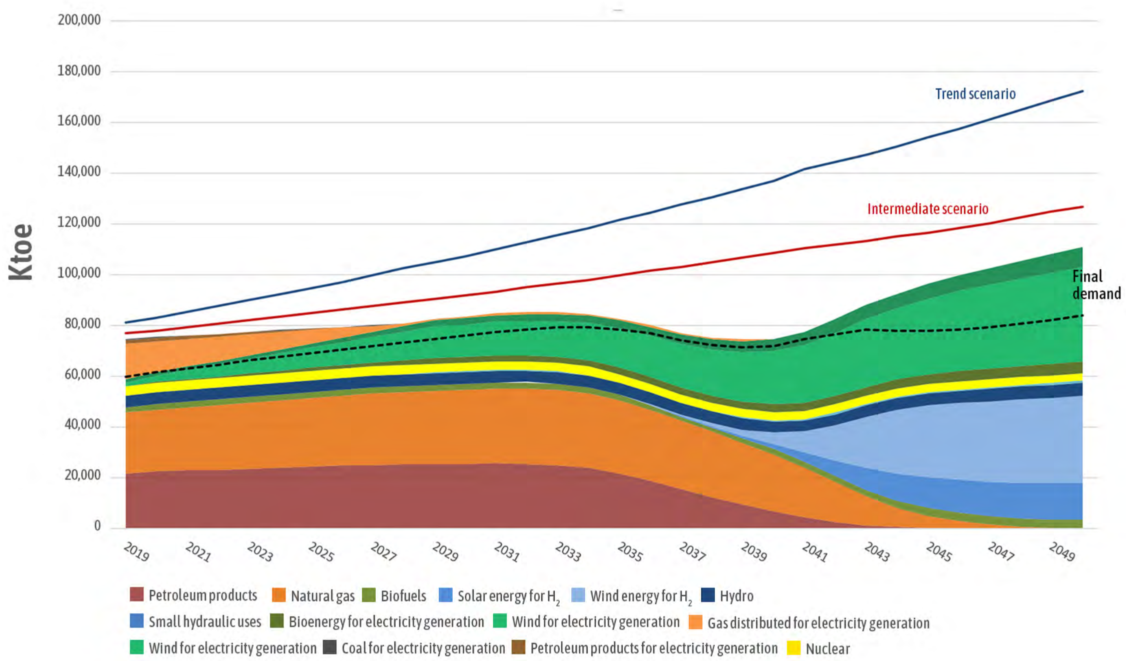

FIGURE 3 - PRIMARY ENERGY SUPPLY FOR LOW-CARBON REFERENCE SCENARIO 1, ANNUAL EVOLUTION

Source: Own elaboration.

The high electrification of final demand increases electric energy supply up to reaching an installed capacity of 237 GW in 2050. Besides, in order to achieve null emission, the current electric matrix –mostly based on fossil fuels– need to be reconverted to a totally renewable one, taking into account appropriate reserve margins to ensure supply. This conversion is shown in Figure 4.

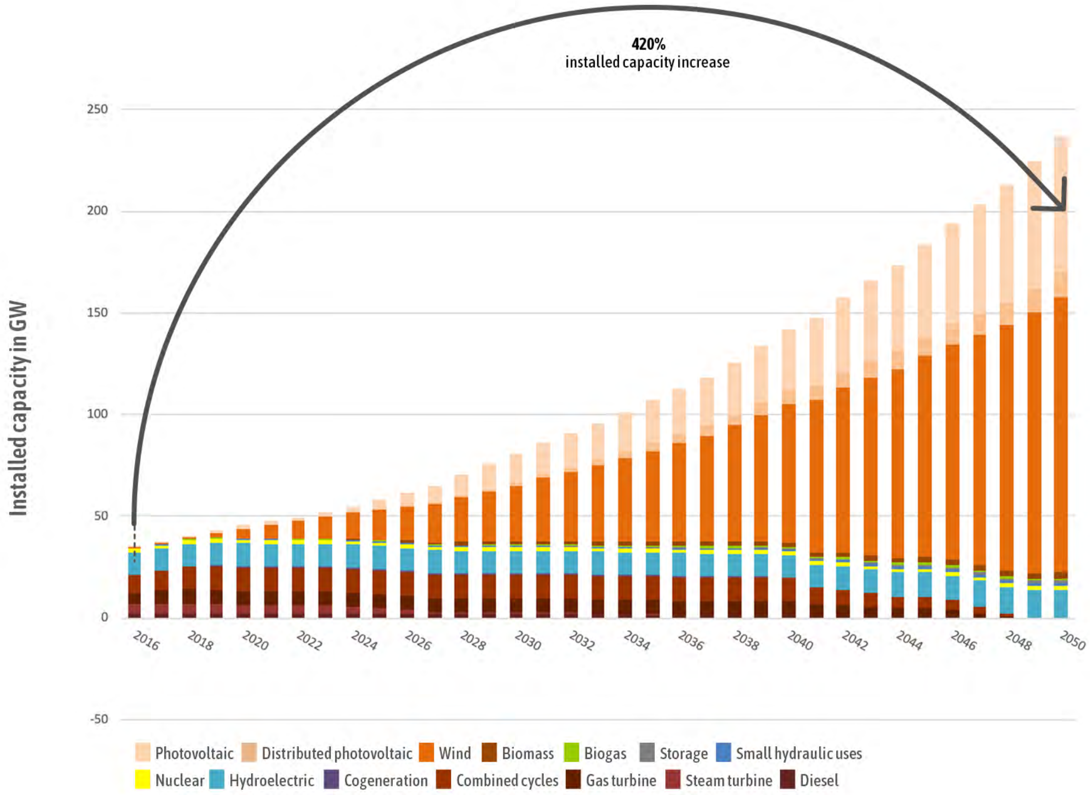

FIGURE 4 - INSTALLED CAPACITY OF EACH TECHNOLOGY FOR ELECTRICITY GENERATION FOR LOW-CARBON REFERENCE SCENARIO 1, ANNUAL EVOLUTION

Source: Own elaboration.

In this scenario, consumption of other fuels, such as LPG and fuel oil, was also replaced by hydrogen. Hydrogen requirements would amount to 24,571 ktoe for the year 2050; it was proposed using renewable energies –solar and wind¬ for its generation, which considering performances and efficiencies throughout the process represent an installed capacity of 613 GW in 2050.

Figure 5 shows total installed capacity both for electricity and hydrogen generation. Nuclear plants and large dams currently existing in the country, still in operation, are comprised in this non-renewable capacity but, as above-mentioned, the incorporation of the new capacity of these technologies is not included.

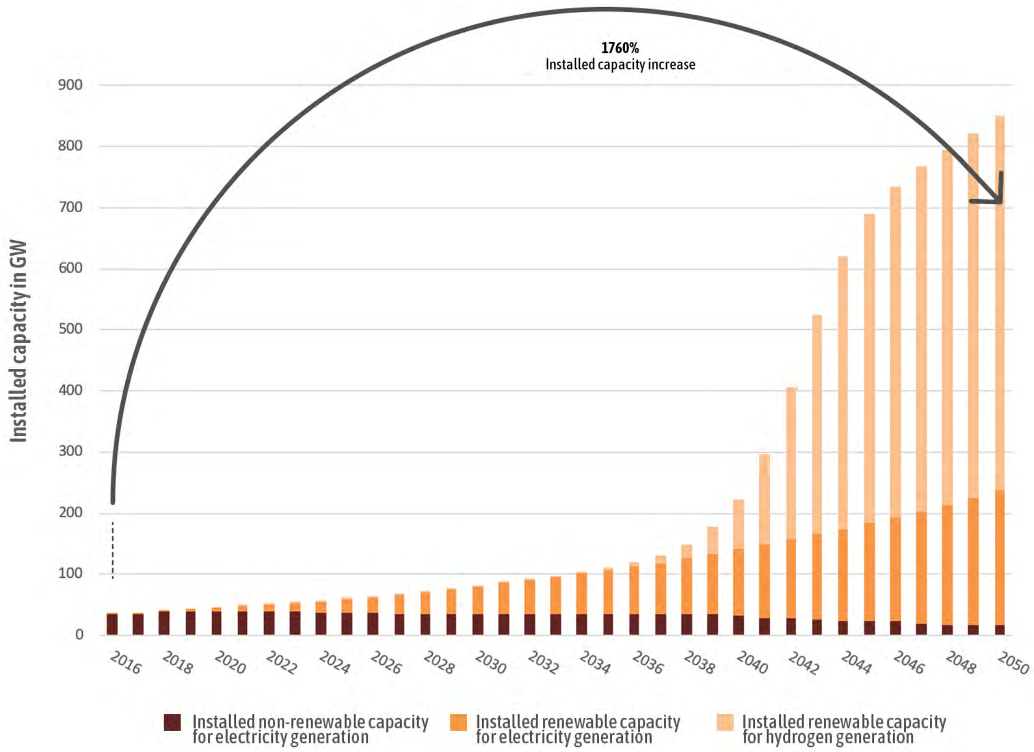

FIGURE 5 - TOTAL INSTALLED CAPACITY FOR LOW CARBON REFERENCE SCENARIO 1, ANNUAL EVOLUTION

Source: Own elaboration.

Low-carbon reference scenario 2

Figure 6 shows the composition of the primary energy supply matrix for the low-carbon scenario 2, and compares it with the total primary energy supply for the trend and intermediate scenarios.

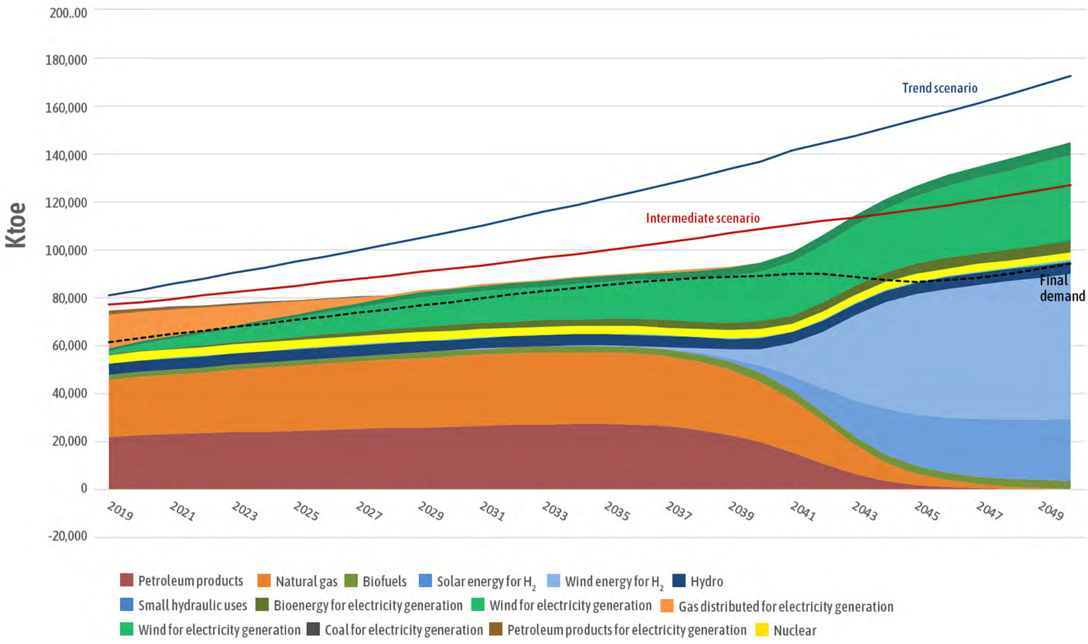

FIGURE 6 - PRIMARY ENERGY SUPPLY FOR LOW-CARBON REFERENCE SCENARIO 2, ANNUAL EVOLUTION

Source: Own elaboration.

As in the previous scenario, electricity generation installed capacity is transformed into renewable, taking out of service all thermal centrals of the country, but maintaining the existing nuclear plants and large hydroelectric dams. Installed capacity in the year 2050, ensuring the necessary reverse margin for not risking energy supply security, would reach in that year 224 GW, as seen in Figure 7.

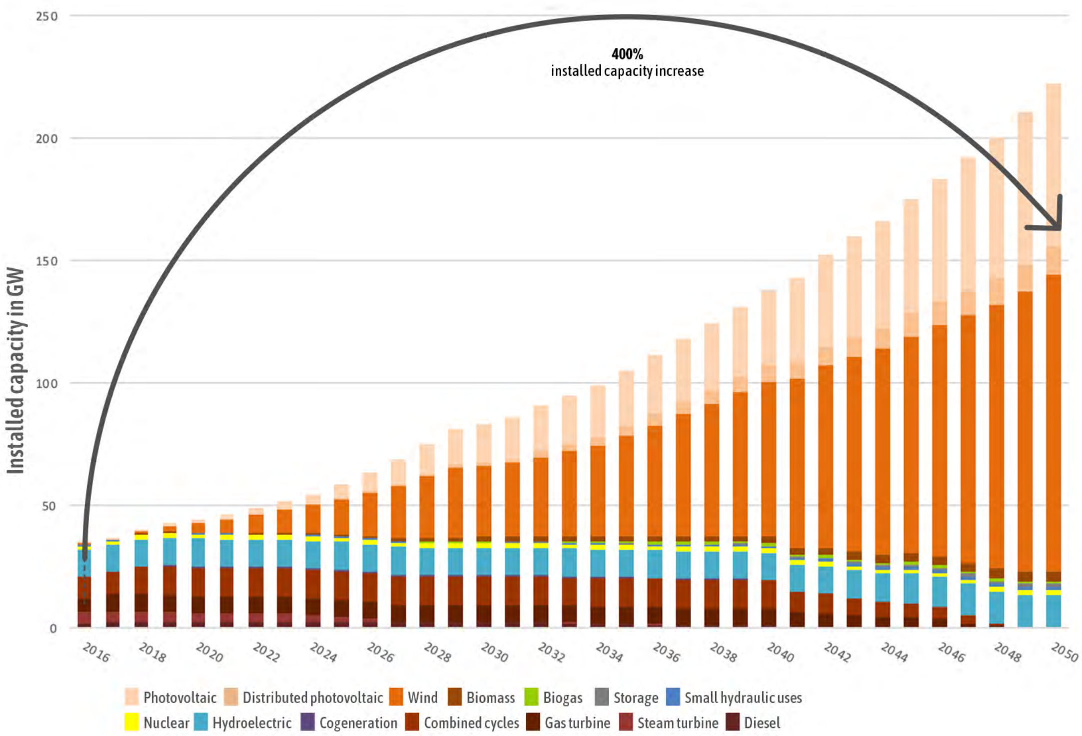

FIGURE 7 - INSTALLED CAPACITY BY TECHNOLOGY FOR ELECTRICITY GENERATION FOR LOW-CARBON REFERENCE SCENARIO 2, ANNUAL EVOLUTION

Source: Own elaboration.

Low-carbon reference scenario 2 maintains hydrogen use to replace LPG and fuel oil consumption.

The difference is observed in transport, which in this case is converted in all areas (private, passenger, freight, agriculture) to hydrogen, reaching 100% conversion in the year 2050. Hydrogen consumption would then amount to 43,280 ktoe in 2050, requiring 1150 GW installed capacity, both solar and wind, for generation (Figure 8).

The high demand of hydrogen at the end of the analysed period pushes primary energy supply, placing it even above demand for the intermediate scenario. This is due to the fact that hydrogen production is not as efficient as electricity direct use in final consumptions (Figure 6).

Figure 8 shows total installed capacity, both for electricity and hydrogen generation in this scenario.

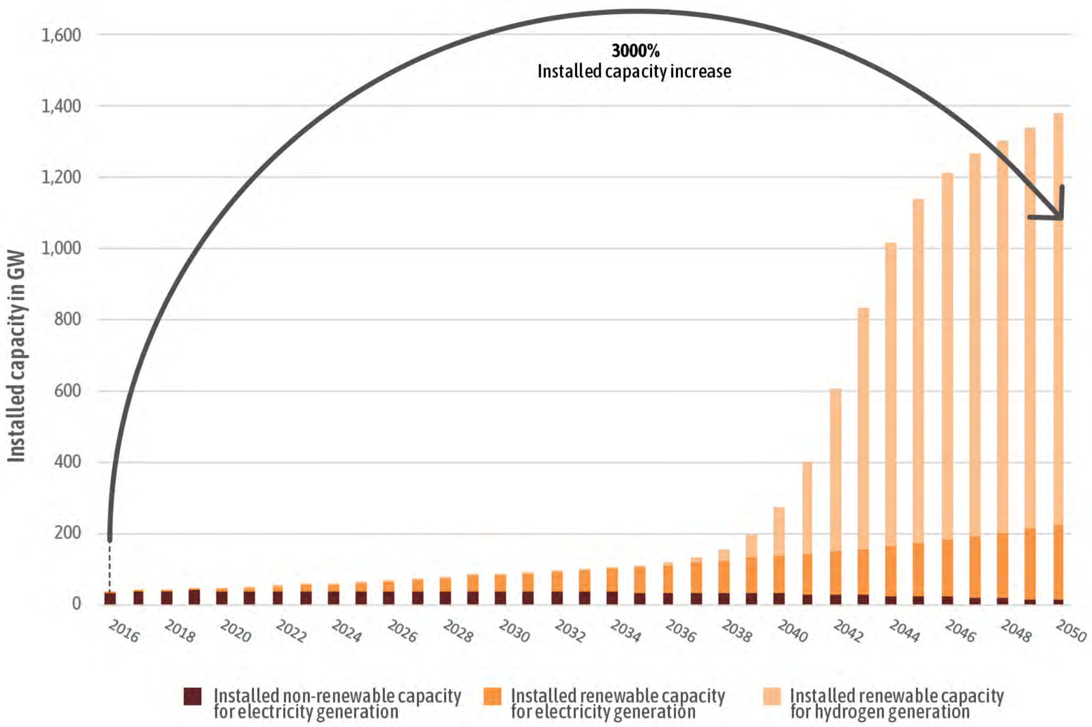

FIGURE 8 - TOTAL INSTALLED CAPACITY FOR LOW-CARBON REFERENCE SCENARIO 2, ANNUAL EVOLUTION

Source: Own elaboration.

Low-carbon reference scenario 3

In the third scenario, just as in the two previous ones, the electrification measures of residential, public and commercial consumptions; hydrogen use for large industrial thermal energy consumptions and for replacement of LPG and fuel oil; and biofuel use for aviation, are replicated. But in this case, transport is completely converted to biofuel use for the year 2050. Figure 9 shows the primary supply matrix for this scenario.

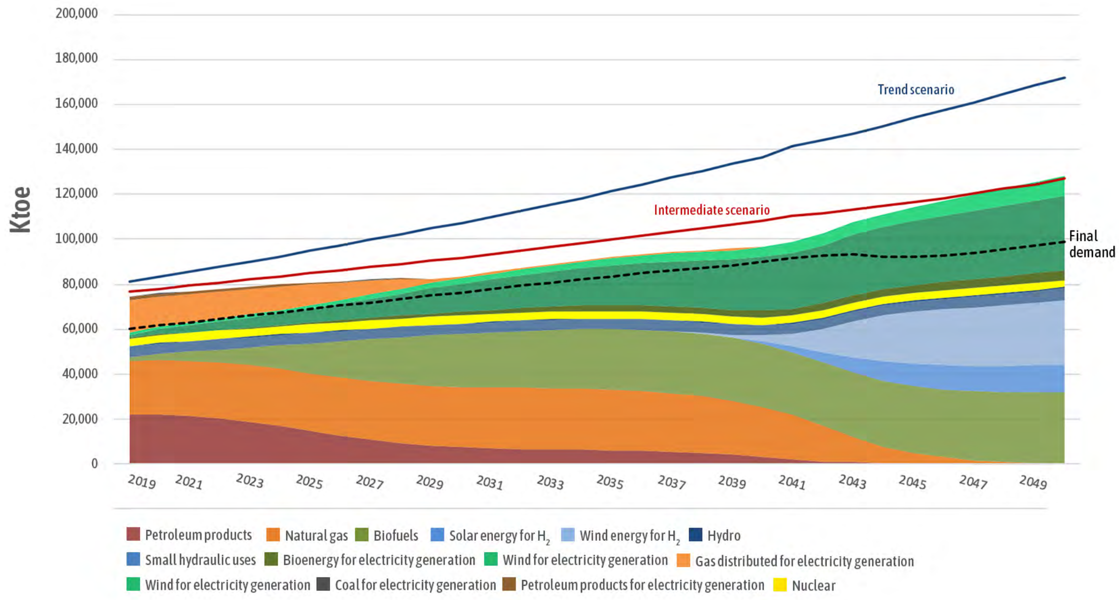

FIGURE 9 - PRIMARY ENERGY SUPPLY FOR LOW-CARBON REFERENCE SCENARIO 3, ANNUAL EVOLUTION

Source: Own elaboration.

This high rise in biofuels estimated consumption for the year 2050 leads to 700% increase of the area assigned to plantations for their production as compared to the current situation. This means that the area required for production only would surpass by 8 million hectares the total area currently assigned to agriculture, all cultures included, as shown in Figure 10.

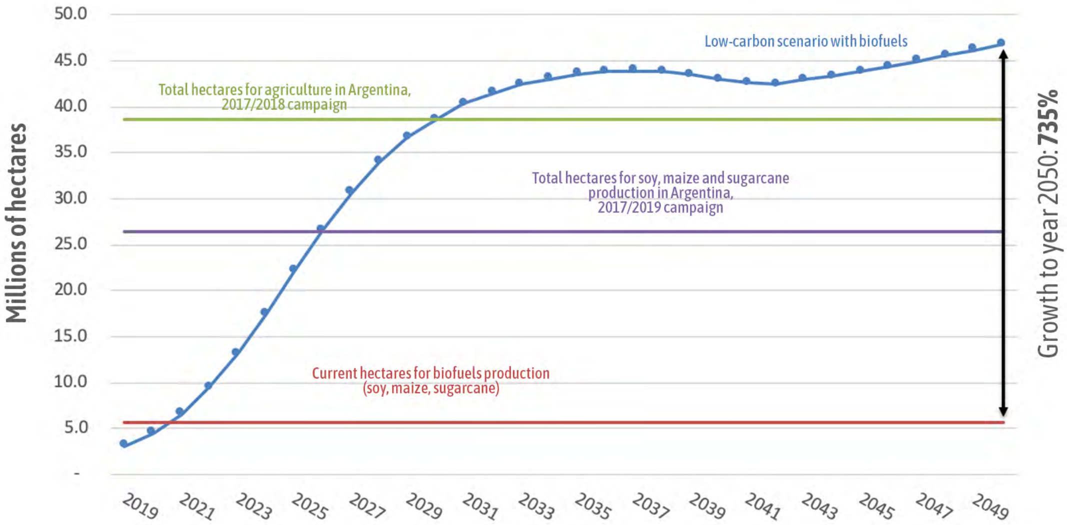

FIGURE 10 - HECTARES FOR BIOFUEL PRODUCTION IN LOW-CARBON SCENARIO 3, ANNUAL EVOLUTION

Source: Own elaboration.

Figures 11 and 12 show the installed capacity required for electricity and hydrogen generation for this scenario.

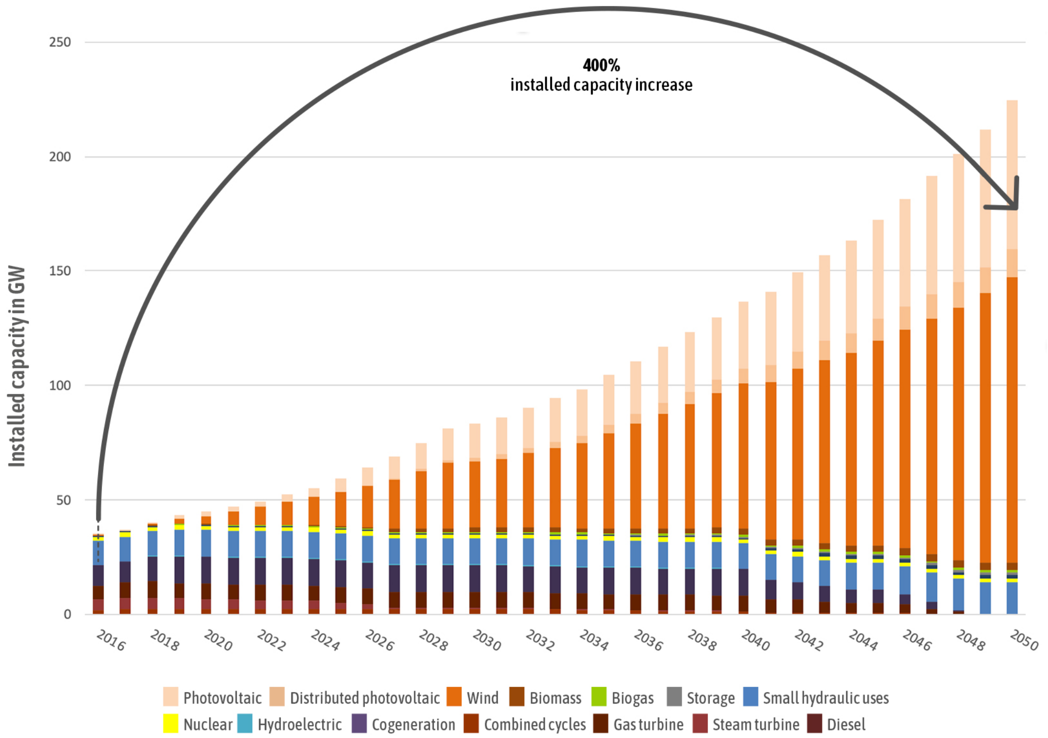

FIGURE 11 - INSTALLED CAPACITY BY TECHNOLOGY FOR ELECTRICAL GENERATION FOR LOW-CARBON 3 SCENARIO, ANNUAL EVOLUTION

Source: Own elaboration.

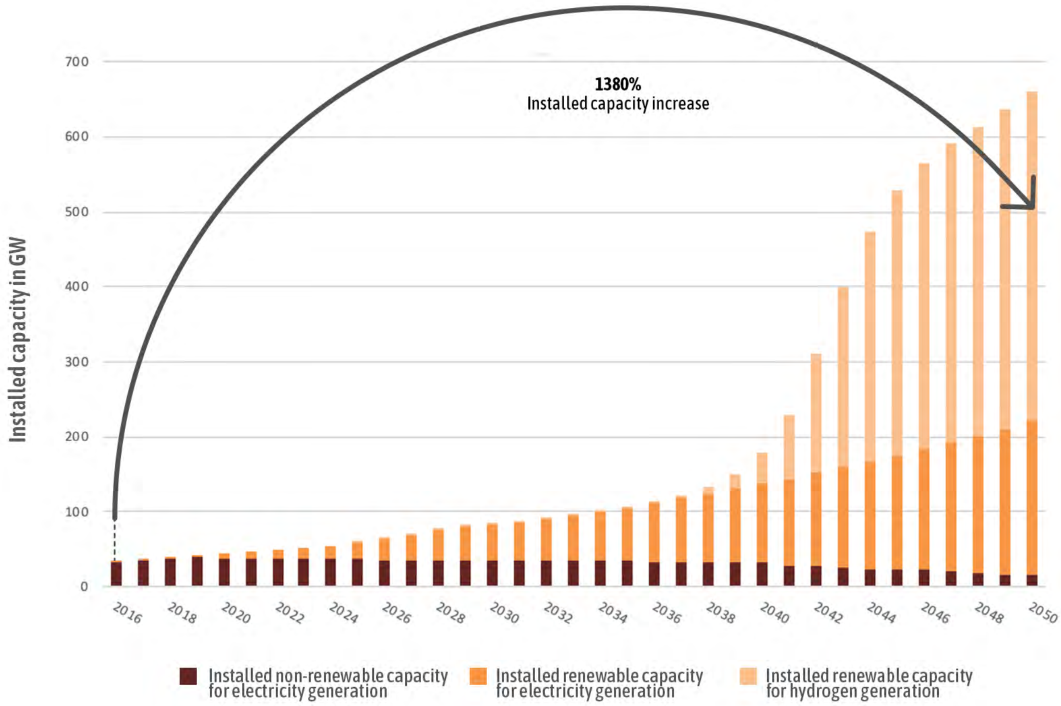

FIGURE 12 - TOTAL INSTALLED CAPACITY FOR LOW-CARBON SCENARIO 3, ANNUAL EVOLUTION

Source: Own elaboration.

4.1.4. Emission calculus for each scenario

Once each of the energy demand and supply scenarios had been modelled, energy and transport sector emissions were calculated. These emissions include emissions due to burning of fossil fuels for final demand (residential, industrial, transport, etc.) as well as for electricity generation in thermal plants and the so-called “fugitive” emissions, produced by fossil fuel exploration, extraction and treatment (natural gas, petroleum and mineral coal).

For emission calculation, the emission factors by fuel used in the *Third Biennial Update Report submitted by the Argentine Republic to the United Nations Framework Convention on Climate Change*[11] were considered. Emission factors are disaggregated by fuel (natural gas, fuel oil, diesel, etc.), use (electricity generation or final demand) and gas (carbon dioxide, methane, etc.).

Figure 13 shows the results for each of the five scenarios analysed.

For the trend scenario, emissions would reach 416 $MtCO_2e$ in the year 2050. And just as demand is doubled for this scenario, so are emissions, notwithstanding the measures adopted in sectoral plans and the renewable energy goals established by legislation.

11. Ministry of Environment and Sustainable Development (2019). Third Biennial Update Report submitted by the Argentine Republic to the United Nations Framework Convention on Climate Change. Available at: **https://www.argentina.gob.ar/sites/default/files/3er_iba.pdf**

In the intermediate scenario, it is observed that emissions also keep increasing, not at the same rate as in the trend scenario, but they maintain their upward trend, reaching 245 $MtCO_2e$ in 2050. It may also be seen that they will keep increasing beyond this year.

For the three low-carbon scenarios proposed, the zero-emission objective is reached in the year 2050. While it will surely continue the same way beyond that year –due to the fact that all consumptions were reconverted to clean energies–, it must be kept in mind that it will be still crucial to seek maximum efficiency in consumptions and to take action on the demand curve in order to reduce its upward trend.

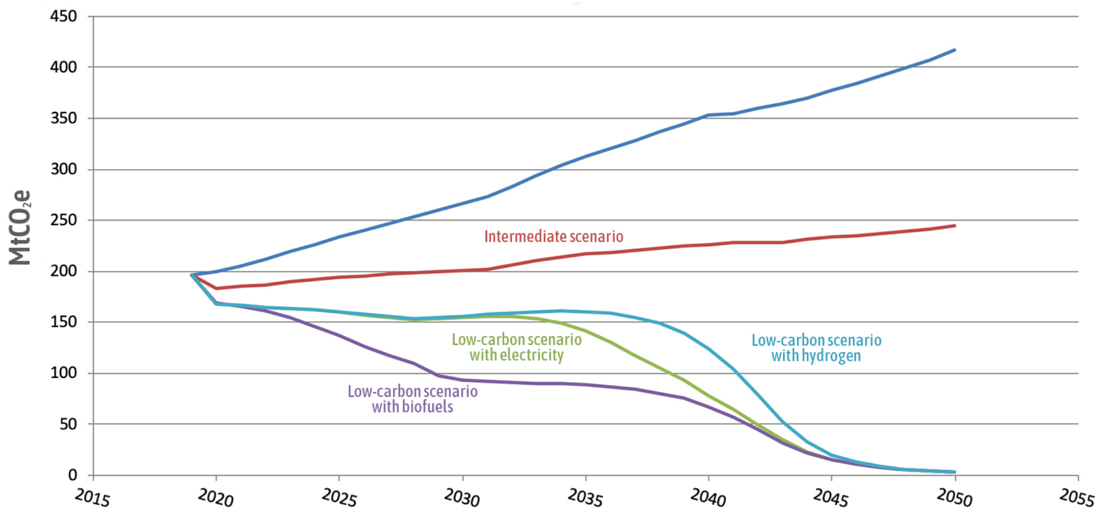

FIGURE 13 - GHG EMISSIONS FOR THE DIFFERENT PROPOSED SCENARIOS, ANNUAL EVOLUTION

Source: Own elaboration.

4.1.5. Key factors in energy GHG emissions

The Kaya Identity[12] permits to express GHG emissions related to energy generation and use in an economy as the product of four factors:

1. Human population.
2. GDP per capita (GDP related to population).
3. GDP energy intensity (consumed energy per unit of GDP).
4. Energy emissions intensity (emissions per unit of energy consumed).

Thus, it is possible to analyse the behaviour of each of the intervening variables in the result of energy sector emissions, and to evaluate which of them has a higher incidence on emission trend and projection. It must be noted that the four variables are not independent from each other; the relationship among them is complex and not always quantifiable.

12. Kaya, Y. (1990): "Impact of Carbon Dioxide Emission Control on GNP Growth: Interpretation of Proposed Scenarios", paper presented to the IPCC Energy and Industry Subgroup, Response Strategies Working Group, Paris.

Following this logic, the four factors of the Kaya Identity were analysed for each of the proposed scenarios, as seen in Figures 14 to 18. For a better visualisation of their behaviour, each variable was normalised, taking as a basis its current value (year 2019). Besides, the curves of final energy consumption and total emissions were added to this analysis, in order to show their trend and compare them to the behaviour of the Kaya Identity variables.

In the trend scenario (Figure 14), as already mentioned, the growth of population and GDP per capita are the variables responsible for the sustained increase of GHG emissions, as their growth pushes the final energy demand and, therefore, the rise of fossil fuel use, the main cause of GHG emissions.

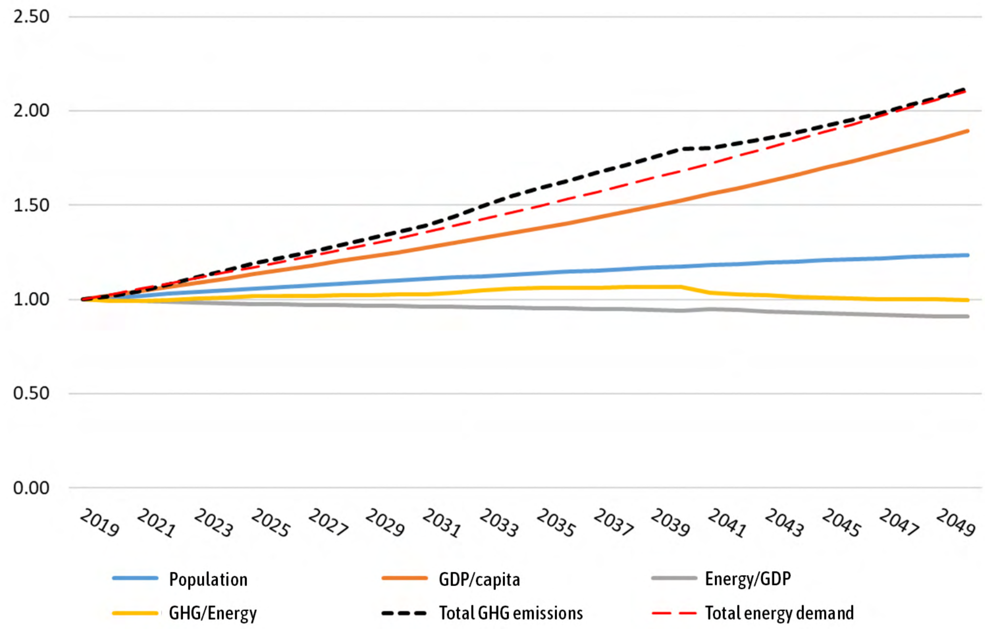

FIGURE 14 - KAYA IDENTITY FACTORS FOR TREND SCENARIO, ANNUAL EVOLUTION

Source: Own elaboration.

In the intermediate scenario (Figure 15), energy intensity (Energy/GDP) shows a negative trend, that is, it tends to decline, due to the enhanced implementation of demand efficiency measures. Also emission intensity (GHG/energy) drops due to the incorporation of a larger proportion of renewable energies in the energy matrix. Notwithstanding all of these measures, emissions continue their upward trend, mostly pushed by the increase of GDP/per capita and population growth.

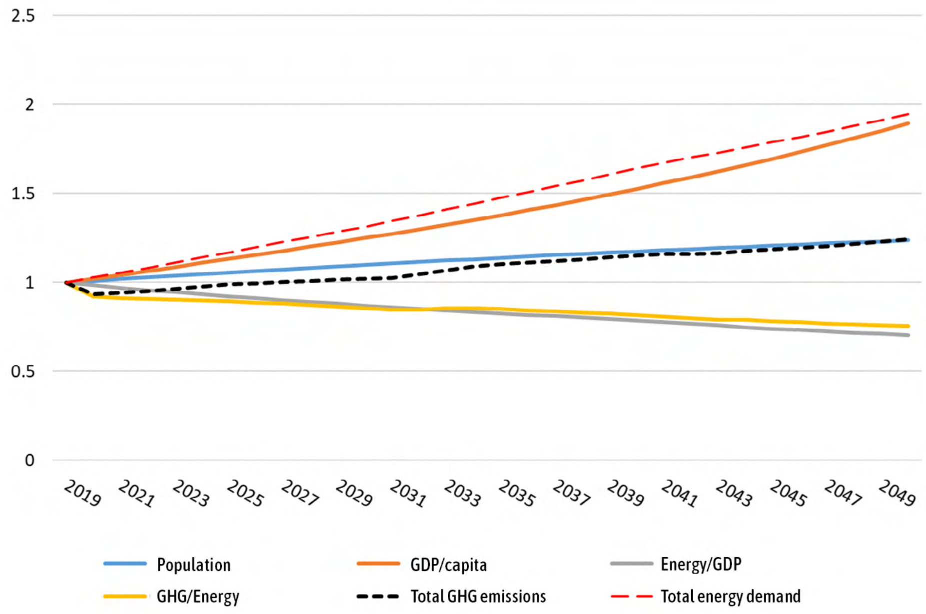

FIGURE 15 - KAYA IDENTITY FACTORS FOR INTERMEDIATE SCENARIO, ANNUAL EVOLUTION

Source: Own elaboration.

In the three low-carbon scenarios (Figures 16 to 18), total energy demand increases to a lesser proportion due to the proposed strong efficiency measures for demand, which prompt a decrease in the country's energy intensity. But the main reason for the reduction of total GHG emissions –until complete elimination– is the conversion of the electric matrix and of all final consumptions to null emission energy sources (GHG/energy).

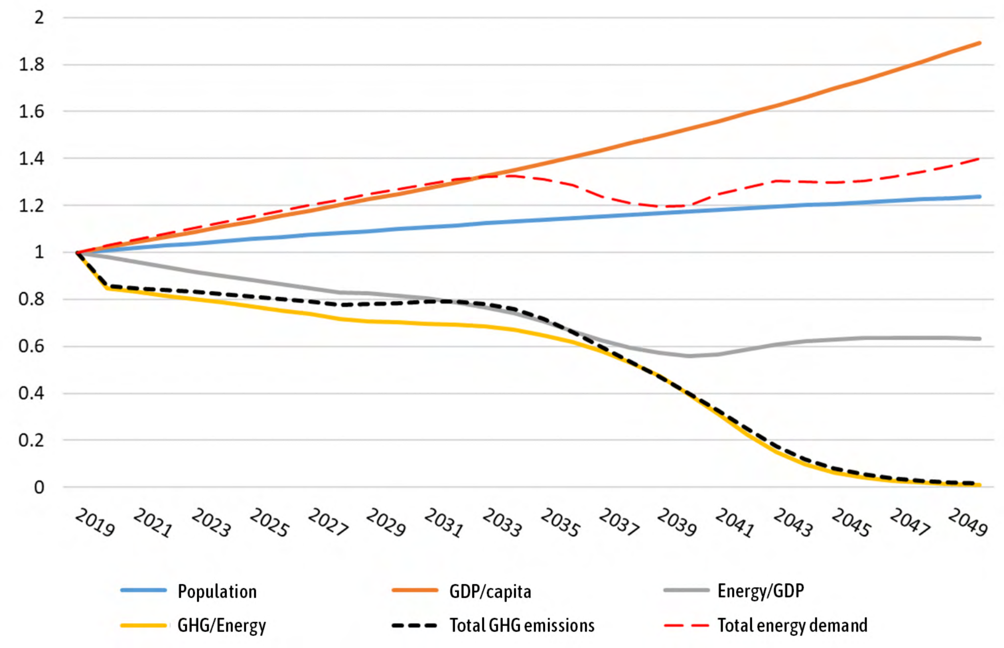

FIGURE 16 - KAYA IDENTITY FACTORS FOR LOW-CARBON REFERENCE SCENARIO 1, ANNUAL EVOLUTION

Source: Own elaboration.

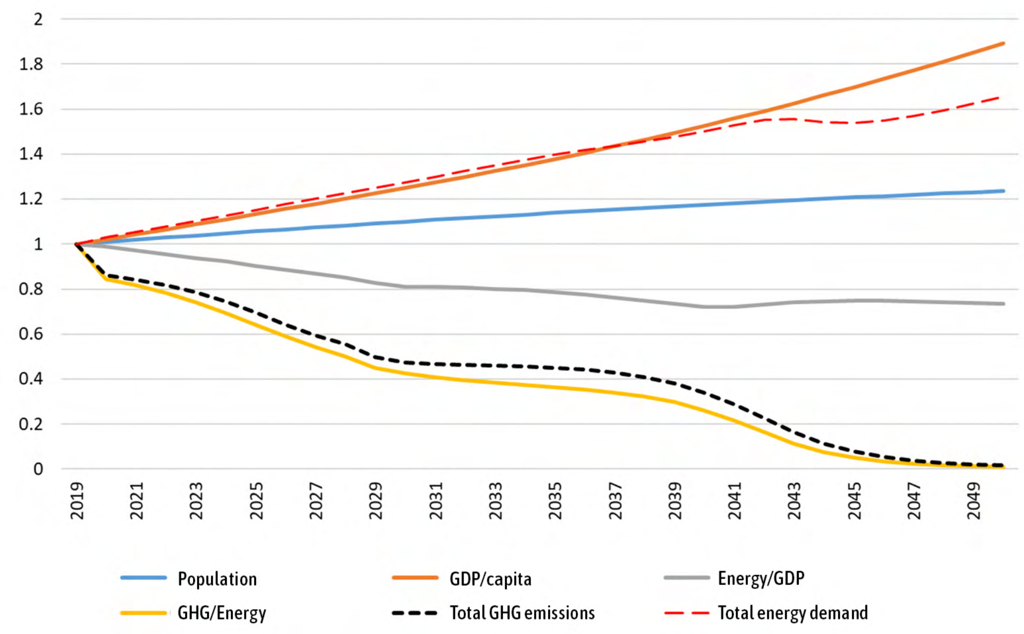

FIGURE 17 - KAYA IDENTITY FACTORS FOR LOW-CARBON REFERENCE SCENARIO 2, ANNUAL EVOLUTION

Source: Own elaboration.

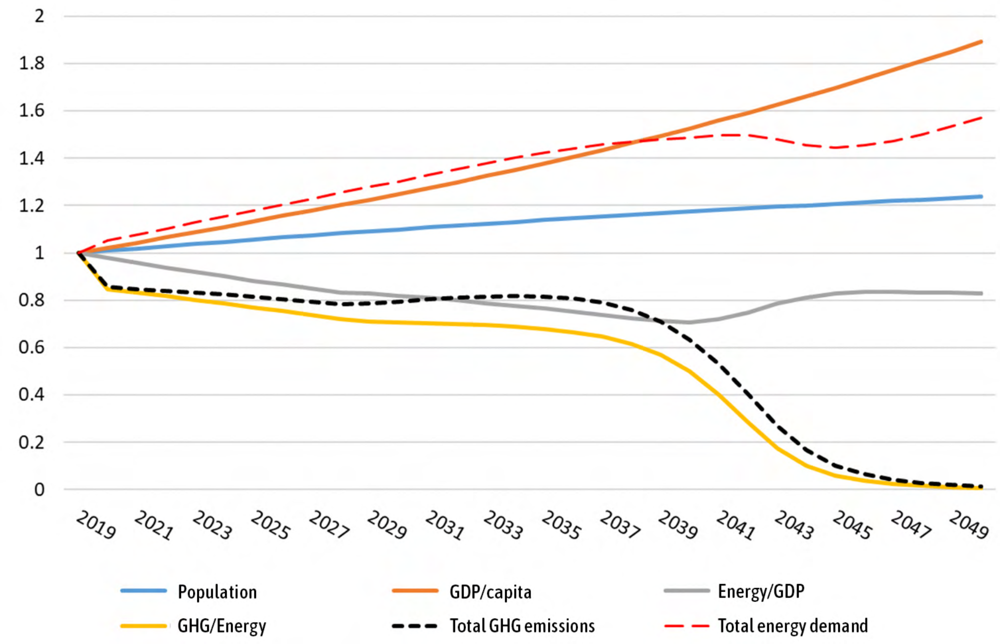

FIGURE 18 - KAYA IDENTITY FACTORS FOR LOW-CARBON REFERENCE SCENARIO 3, ANNUAL EVOLUTION

Source: Own elaboration.

From the analysis of Kaya Identity results, it is observed that it is possible to take action on emission intensity in energy generation by changing the technologies and sources supplying it. It is also possible to turn economy more efficient by reducing its energy intensity through a more efficient use of resources. However, it is extremely complex to take actions which modify lifestyles and/or living standards, which compel us to change production and consumption (GDP/capita) patterns and family planning (population growth).

4.1.6. Considerations on energy consumption efficiency improvement

Working on rational and efficient energy use can provide important savings in the short and medium-term at a relative low cost. Experts assert that energy savings might be up 5 to 10%, only by adopting awareness-building measures as regards energy use, time adjustment and setting changes of equipment, among other actions with very low implementation barriers.

To adequately determine the saving potential for energy efficiency, a bottom-up analysis of measures must be carried out, taking into account each energy form comprised in the final uses affected and adding the results. This type of study is beyond the scope of this report.

Some research work, among which *Escenarios energéticos para la Argentina* (Energy scenarios for Argentina) *by Fundación Vida Silvestre Argentina*, have demonstrated that in a consumption scenario such as Argentina's, energy savings in a fifteen year period might be around 12.5% for electric energy consumption and 25% for gas, both in the residential sector and in the commercial and public sector[13].

13. Fundación Vida Silvestre. (2013). Escenarios Energéticos para la Argentina (2013-2030) con políticas de eficiencia. Available at: **https://d2qv5f444n933g.cloudfront.net/downloads/escenarios_energeticos_para_la_argentina_2013_2030_con_politicas_de_eficiencia.pdf**

For example, Table 3 shows that energy efficiency measures already adopted in Argentina (EE-I) would lead to savings of 25 TW/year in 2030, while the strengthening of these policies, according to the criteria suggested by *Fundación Vida Silvestre Argentina* (EE-II), would contribute with 26 TW/year additional savings, both of them generating a total reduction of 51 TWh/year.

TABLE 3 - SECONDARY ENERGY IN FINAL DEMAND

Total savings [GWh/year]					
EE-I	**2012**	**2015**	**2020**	**2025**	**2030**
LIGHTING	3,642	7,193	10,307	13,101	16,397
REFRIGERATORS	1,085	1,615	3,307	5,512	8,016
AA	66	181	312	425	476
TOTAL EE-I	**4,793**	**8,989**	**13,926**	**19,038**	**24,889**
EE-II	**2012**	**2015**	**2020**	**2025**	**2030**
LIGHTING	0	270	1,680	4,429	7,752
REFRIGERATORS	0	25	483	1,575	3,212
AA	0	4	53	219	432
ELECTRIC ENGINES	12	404	3,882	7,286	11,893
TVS	0	83	587	1,428	2,320
TRANSFORMERS	0	19	125	208	334
TOTAL EE-II	**12**	**805**	**6,810**	**15,145**	**25,943**
TOTAL EE-I + EE-II	**4,805**	**9,794**	**20,736**	**34,183**	**50,832**

Source: *Escenarios energéticos para la Argentina*, Fundación Vida Silvestre Argentina.

Summing up, from *Fundación Vida Silvestre Argentina*'s report, it is concluded that:

- In the electricity sector, the savings potential is 12.5% (conservative) in fifteen years, incorporating only the studied sectors.

- For natural gas, the savings in residential consumption and in industrial heat and electricity capacity[14] represent 25% average in a fifteen year period.

In brief, the lowest savings obtained is 12.5% in fifteen years. In a thirty year horizon, savings are much higher.

As already pointed out, the rebound effect cannot be ignored, being its consequence a reduction of the estimated savings of efficiency measures. Anyhow, even taking into account the said effect, measures for achieving a more efficient energy use are needed, both for environmental and economic reasons[15].

14. Industry scenario is comprised in electricity sector (only electric engines were considered) and cogeneration.
15. Greening L., Greene D. y Difiglio C. (2000). Energy efficiency and consumption –the rebound effect– a survey. Energy Policy.

4.2. AGRICULTURE, FORESTRY AND OTHER LAND USE SECTOR

Avoiding emissions in agriculture, forestry and other land use (AFOLU) sector is a complex task due to the quantity of sources and sinks, and to the intrinsic relationship among them.

Livestock and land use change, particularly deforestation, represent the main emission sources of this sector in the country. Livestock emissions can be reduced with better practices and management of cattle and pasture lands. In spite of this, eliminating these emissions without reducing the level of activity is a beyond-reach objective, at least for the time being.

Therefore, in the AFOLU sector, the *land use* category emissions were taken into account; for the other agriculture and livestock emissions, a trend evolution for the past ten years was considered.

Two scenarios based on carbon sequestration were then proposed: the first one, based on forestation through planted forests; and the second one, on reforestation of native forests. In both of them, deforestation of native forests is reduced to zero during the analysed period.

As there are no more changes in forest land use for other uses, the following categories also disappear:

- Forest lands converted to cultivated soils,
- Forest lands converted to grasslands,
- Biomass burning due to converting forest lands to cultivation soils,
- Biomass burning due to converting forest lands to grasslands.

4.2.1. Scenario with planted forests

This scenario considers expanding cultivated forest lands with commercial species, such as conifers and eucalyptus. It is well-known that forest ecosystems are important carbon sinks. This is due to their great capacity for absorbing atmospheric CO_2 during photosynthesis processes and converting it into carbon[16]. For this reason, the net emission balance in the AFOLU sector could be reached if the area destined to this activity were sufficiently large.

The area destined to cultivating commercial species in 2016 covered 1,384,131 ha., according to data compiled for the the *Third Biennial Update Report submitted by the Argentine Republic to the United Nations Framework Convention on Climate Change*[17]. Applying the factors and methodology used in that report, Argentina would need to increase the area destined to planted forest 460% for the year 2050, and expanding it to 7,784,000 ha to reach zero emission balance in the AFOLU sector, as shown in Figure 19.

16. IPCC. (2006). Directrices del IPCC de 2006 para los inventarios nacionales de gases de efecto invernadero. Volumen 4, Capítulo 1. Available at: **https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/4_Volume4/V4_01_Ch1_Introduction.pdf**

17. Ministry of Environment and Sustainable Development. (2019). Third Biennial Update Report submitted by the Argentine Republic to the United Nations Framework Convention on Climate Change . Available at: **https://www4.unfccc.int/sites/SubmissionsStaging/NationalReports/Documents/9587041_Argentina-BUR3-1-3er%20Informe%20Bienal%20de%20la%20Republica%20Argentina.pdf**

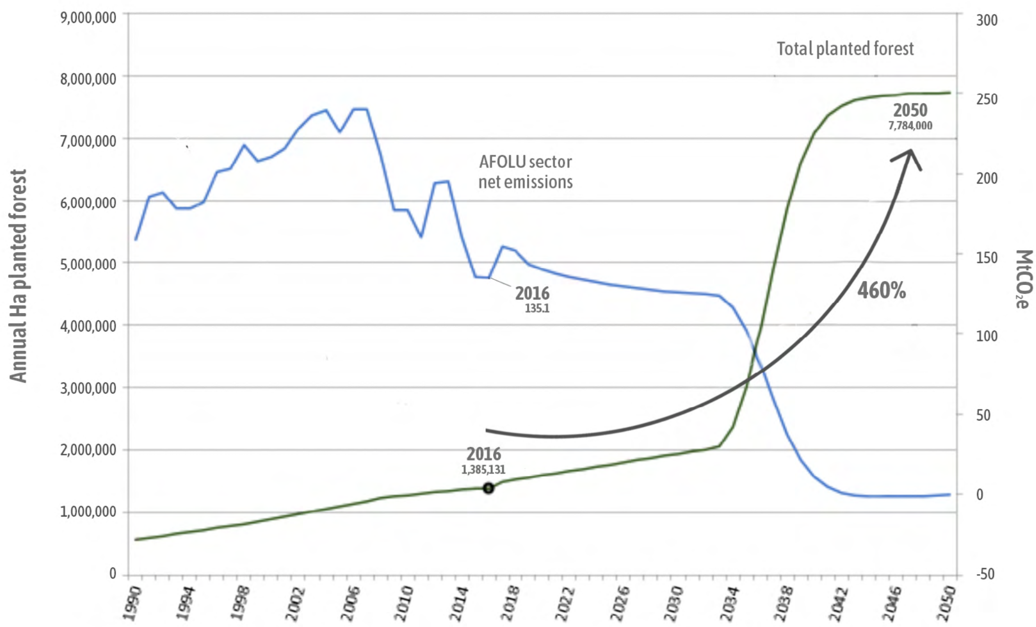

FIGURE 19 - CULTIVATED FOREST HECTARES NEEDED TO REACH ZERO EMISSION BALANCE IN THE YEAR 2050 FOR THE AFOLU SECTOR, ANNUAL EVOLUTION

Source: Own elaboration.

4.2.2. Scenario with native forests

With the same objective as the previous scenario –reaching zero emission in the AFOLU sector through atmospheric CO_2 capture–, only native forests act as sinks in this second scenario. To achieve this goal, not only should their reforestation be reduced to zero but also their recovery through reforestation should be promoted, letting planted forests category follow its trend development according to the historical data of the past years.

For calculating CO_2 capture generated by growth in the different native forests region in Argentina, the same factors used for the *Third Biennial Update Report submitted by the Argentine Republic to the United Nations Framework Convention on Climate Change* were applied (Table 4).

TABLE 4 - FACTORS USED FOR CALCULATING CARBON CAPTURE OF NATIVE FORESTS

FOREST REGION	% C (A)	GROWTH (TN/HA) (B)	UNDERGROUND/AIR BIOMASS RATE (C)	NEW GROWTH (TN/HA) = B * (1 + C)
ANDEAN-PATAGONIC FOREST	0.48	3.9	0.24	4.8
ESPINAL	0.48	0.7	0.23	0.9
MONTE	0.48	0.2	0.32	0.3
PARQUE CHAQUEÑO	0.48	1.0	0.28	1.3

FOREST REGION	% C (A)	GROWTH (TN/HA) (B)	UNDERGROUND/AIR BIOMASS RATE (C)	NEW GROWTH (TN/HA) = B * (1 + C)
SELVA MISIONERA	0.47	2.7	0.24	3.4
SELVA TUCUMANO-BOLIVIANA	0.47	2.5	0.24	3.1
HUMID PARQUE CHAQUEÑO	0.48	1.0	0.28	1.3
DRY PARQUE CHAQUEÑO	0.48	1.0	0.28	1.3
NON WOODED AREAS	0.48	0.2	0.32	0.3

Source: Third Biennial Update Report, Environment and Sustainable Development Secretariat (2019).

For reaching the zero emission goal, native forests area should be increased from the 28,291,759 already existing in 2016 to 86,241,966 ha in 2050. This means that its surface should be tripled, as shown in Figure 20. This requires an appropriate recovery and management of the different native forest regions most affected by the current deforestation, including the Parque Chaqueño, the Selva Tucumano-Boliviana, the Selva Misionera and the Espinal.

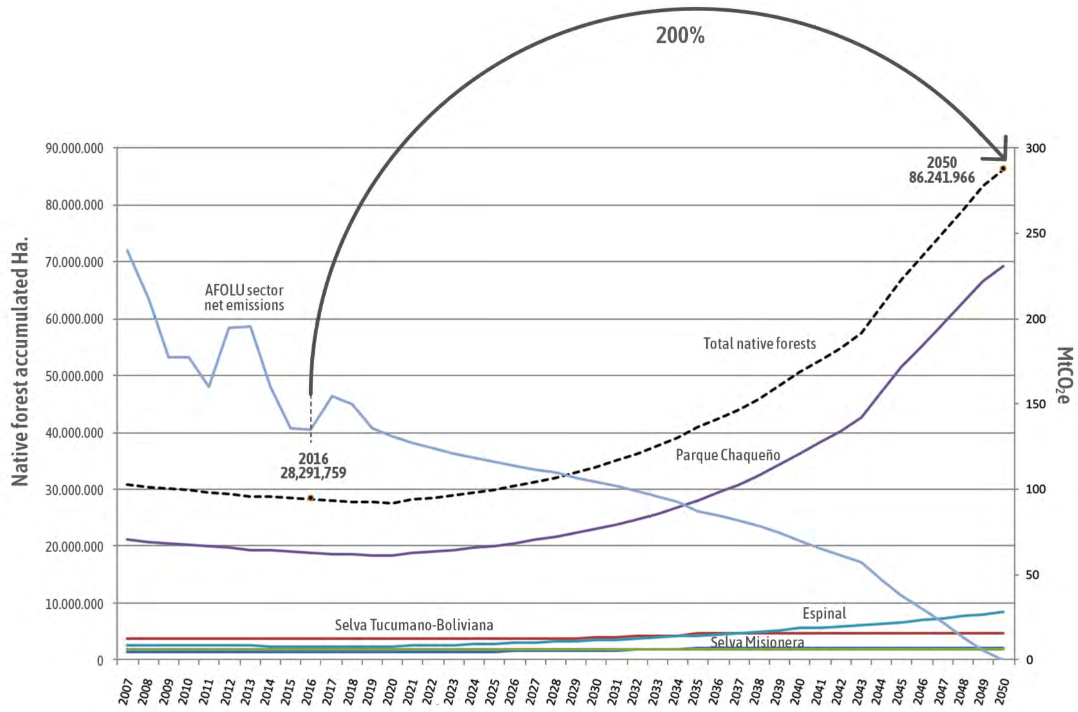

FIGURE 20 - NATIVE FOREST AREAS NEEDED TO REACH ZERO EMISSION BALANCE IN 2050 FOR THE AFOLU SECTOR, ANNUAL EVOLUTION

Source: Own elaboration.

5. RESULT ANALYSIS

The first observation arising from the proposed scenario analysis is that the path to a low-carbon future requires not only technological changes, but mainly economic and social changes. This will demand an integral strategy covering all of these aspects and all of the sectors of society in a systemic and multidisciplinary way.

This type of strategy should be capable of dealing with matters such as financing of required actions, different economic policy instruments for promoting changes and transition of employment sectors towards new jobs, allowing capacity and life-quality improvements of those involved. It should also address changes in the educational system, and in the science and technology system, so that they might both accompany the needed changes in all sectors of economic and productive life. Finally, a long-term strategy should review the regulatory framework so that the transformations might have the necessary legal support.

In Argentina, a strategy incorporating decarbonisation of the productive matrix should promote, in the first place, rational and efficient energy use, energy demand electrification wherever possible, and electricity production using renewable sources. This rational and efficient resource use should include a transport modal shift, promoting public and non-motorised, for then thinking about a technological change towards electric or hydrogen-powered vehicles.

Regarding land use, the strategy should foresee a deep revision of the agricultural practices and technological packages used in the sector. As for native forests, deforestation should be halted immediately and reforestation begun where forests have been lost, as well protection and regeneration of the many services provided by these ecosystems should be started.

6. SCENARIOS WITHIN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

For being sustainable in time, a long-term decarbonisation strategy should take into account a large variety of economic, social and environmental factors that will be affected by it and will determine its success. Thus, it is indispensable to count with a tool for assessing the impact of each measure on those factors and, as a consequence, its contribution to the sustainability of the country's development.

To begin with, a decarbonisation strategy should leave aside the cost-benefit analysis as sole indicator in decision-making and include other socioeconomic and socio-environmental aspects, the monetisation of which is difficult or impossible. Among them, the following are highlighted as examples: reducing accidents and health impacts due to air pollution derived from a more sustainable mobility system, or the positive effects on employment, capacity strengthening and energy independence obtained from distributed energy generation through the development of renewable energies with local technologies.

To ensure the medium and long-term success and projection of this strategy, a special and appropriate tool is needed, consisting in the elaboration of a sustainable development indicator system allowing the systemic and integral evaluation of each of its measures.

There exist a number of proposals for sustainable development indicators, at global level and for Latin America, such as those by the Economic Commission for Latin America and the Caribbean (ECLAC)[18 19], the Organization for Economic Cooperation and Development (OECD), and the United Nations Commission on Sustainable Development[20 21]. In the case of Argentina, there are also some sustainable development indicator systems, such as the Sustainable Development Indicator System for the Argentine Republic[22], the Sustainability Indicator System for Prospective Energy Scenarios Evaluation of the Energy Strategic Plan 2011-2030[23], the Argentine Bioenergy Sustainability Indicators[24], as well as the work being carried out by the National Council for Social Policies Coordination to adapt the Sustainable Development Goals at the local level[25]. All of them may be used as a basis for developing an appropriate indicator system.

These initiatives consider indicators covering the following areas for each sustainability dimension.

18. Rayen Quiroga M. (2001) "Indicadores de sostenibilidad ambiental y de desarrollo sostenible: estado del arte y perspectivas". Originally developed for United Nations Environment and Human Settlements Division, ECLAC. Updated and enlarged by the author, Rayén Quiroga, with the collaboration of Franco Fernández, Matías Holloway and Pauline Stockins, as part of the work of the Statistics and Economic Projections Division, within the framework of "Strengthening the Capacities of Latin American and Caribbean Countries for Monitoring the Fulfilment of the Millennium Development Goals" project.

19. Andrés Schuschny y Humberto Soto. (2009). Guía metodológica Diseño de indicadores compuestos de desarrollo sostenible. Comisión Económica para América Latina y el Caribe (CEPAL).

20. United Nations. Statistics Division. (2017). Marco de indicadores mundiales para los Objetivos de Desarrollo Sostenible y metas de la Agenda 2030 para el Desarrollo Sostenible. Labor de la Comisión de Estadística en relación con la Agenda 2030 para el Desarrollo Sostenible. A/RES/71/313

21. United Nations. Statistics Division. (2016). Update on the work to finalize the proposals for the global indicators for the Sustainable Development Goals. Inter-Agency and Expert Group on Sustainable Development Goal Indicators (IAEG-SDGs). E/CN.3/2016/2

22. Environment and Sustainable Development Secretariat. (2015). Sistema de Indicadores de Desarrollo Sostenible: 8va Edición. Ciudad Autónoma de Buenos Aires. Available at: **http://estadisticas.ambiente.gob.ar/archivos/web/Indicadores/file/multisitio/publicaciones/Indicadores_2015_internet.pdf**

23. UNICEN. Sistema de indicadores de sustentabilidad para la evaluación de escenarios energéticos prospectivos del Plan Estratégico de Energía 2011-2030. An indicator system allowing the quantitative assessment of the environmental, social, economic and political sustainability of all proposed actions was developed within the framework of the Energy Strategic Plan (PLAENER, for its acronym in Spanish) of the former Energy Secretariat of the Nation, analysing 2011-2030 period. The work was coordinated by the *Universidad Nacional del Centro de la provincia de Buenos Aires,* and financed by the United Nations Development Program (UNDC).

24. Universidad Nacional de San Martín. Indicadores GBEP de Sustentabilidad de la Bioenergía en Argentina. This project was developed by the Ministry of Agriculture, Livestock and Fishery, in its Agroenergy Directorate, with the technical assistance of the *Universidad de San Martín,* was carried out with the financial support of the Inter-American Development Bank and the administrative assistance of Rural Change Unit. It focused on measuring the environmental, social and economic aspects of production and liquid biofuels most developed in the country, emphasising the support to the needed actions for improving public policies on bioenergy sustainability.

25. National Council for Social Policies Coordination (2017). Metas e indicadores: Listado provisorio de metas e indicadores de seguimiento de ODS. Argentina.

ENVIRONMENTAL	Soil
	Water
	Air
	GHG
	Biodiversity
	Forests
	Other natural resources and ecosystem services
SOCIAL	Employment
	Health
	Access to services: electricity, natural gas, other modern energy, drinking water, public transport, other transports
	Gender
	Education/awareness
	Social acceptability/conflictivity
	Food sovereignty
	Energy independence
	Fair work transition (training/education)
ECONOMIC	Productivity
	Trade balance
	Diversification (production/resources)
	Economic concentration
	Development and technological innovation
	Cost-benefit relation

An appropriate indicator system allows to know if the objectives are being achieved, if the measures are having the desired impact or not, or if, on the contrary, they are having a negative impact on a socioeconomic sector or on a socio-environmental factor which had not been foreseen. That is to say, by supplying integral information systematically elaborated about the possible (positive or negative) impacts of the different measures and by contributing to citizen participation through ordered mechanisms and pre-established methodologies, it allows guiding and strengthening decision-making processes.

This provides a different perspective as regards the possible State interventions for the design, monitoring and evaluation of public policies and sectorial or transversal programs, for prioritising some actions and not others through taxation schemes or subsidy systems, and strategic plans for research and development and for tertiary or university education to accompany the process, among others.

The scope of the present study does not comprise the development of an indicator system; however, a low-carbon long-term strategy resilient to climate change impacts should not ignore counting with a sound sustainability indicator system, including precise procedures and access to the needed information in order to ensure transparency and replicability of the calculation process.

7. BARRIERS FOR THE IMPLEMENTATION OF A LOW-CARBON STRATEGY

The needed energy sector transformations, in whatever the low-carbon reference scenario studied or in a combination scenario, will find implementation barriers, both economic and financial, but also those imposed by the existing infrastructures and by technology development and access[26]. Eventually, there will also be cultural barriers, always difficult to deal with and overcome[27].

There follows a brief description of some of those difficulties, which should be analysed in detail when developing a long-term strategy.

Economic and financial barriers

In this category, it is important to mention access to the needed financing[28] for the new infrastructure required in each scenario (intelligent transmission networks for electric energy, modal shifts in the freight and passenger transport system, etc.), as well as for the development of technologies or merely for access to existing technologies currently owned by other countries or enterprises.

Overcoming these barriers will demand restructuring the current tax scheme and a series of economic instruments for promoting actions to be carried out or discouraging those to be avoided.

Another barrier to face will be the costs of already assigned assets in infrastructure and technology for the current energy (both supply and demand) and transport systems, which have not yet been able to recover the provided capital[29] [30].

Work and cultural barriers

The required transformations also need evolution regarding employment, for reconverting jobs linked to some productive sectors (petroleum) and for generating new positions in other sectors which will have to substantially develop (renewable energies). This transition should be fair for workers having to migrate to other occupations, and consider needed training for some and compensation for others.

Cultural barriers for the changes these scenarios imply will be relevant[31]. Changes in habits and individual and social behaviours will not always be accepted by persons, either individually or collectively[32]. Therefore, a multidisciplinary analysis of cultural barriers will be essential when elaborating a strategy.

26. Centro Mario Molina. (2014). Análisis de barreras para la instrumentación de tecnologías de baja intensidad de carbono y propuestas para su eliminación. Available at: **http://centromariomolina.org/wp-content/uploads/2014/12/Resumen-Barreras.pdf**

27. Wagner, L. *et al.* (2019). Aspectos socio-ambientales de la transición energética. FARN - Climate Transparency. Available at: **https://www.climate-transparency.org/wp-content/uploads/2019/01/Argentina-policy-paper.pdf**

28. Guzmán, S. (2016). Financiamiento Climático: Retos y Oportunidades para Argentina. FARN. Available at: **https://farn.org.ar/wp-content/uploads/2016/07/03Guzma%CC%81n.pdf**

29. Caldecott, B. *et al.* (2016). Stranded assets: a climate risk challenge. BID. Disponible en: **https://publications.iadb.org/publications/english/document/Stranded-Assets-A-Climate-Risk-Challenge.pdf**

30. IRENA (2017). "Stranded assets and renewables: how the energy transition affects the value of energy reserves, buildings and capital stock", International Renewable Energy Agency (IRENA), Abu Dhabi. Disponible en: **https://www.irena.org/DocumentDownloads/Publications/IRENA_REmap_Stranded_assets_and_renewables_2017.pdf**

31. Blanco, G. *et al.* (2014). Drivers, Trends and Mitigation. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available at: **https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter5.pdf**

32. Swim, J. *et al.* (2011). Human Behavioral Contributions to Climate Change. American Psychologist. Available at: **https://www.apa.org/pubs/journals/releases/amp-66-4-251.pdf**

Path dependence

The difficulty for facing and overcoming barriers linked to access to financing, stranded assets, already deployed infrastructures and technologies, workers involved, and individual and social habits and behaviours, clearly shows that we are what has been called "path dependents". The concept of path dependence means that once a society has adopted a particular development path, based on certain natural resources, infrastructures and technologies for their exploitation and use in goods and services production, it is extremely complex to leave it[33]. This fact questions the idea of using certain resources, such as natural gas, for energy transition. Evidence proves that once a path is undertaken, changing it is very hard.

8. ELEMENTS FOR A LONG-TERM STRATEGY

In this section, it is proposed a series of elements which should be thoroughly discussed and analysed at the time of elaborating a long-term strategy, not only low-carbon and resilient to climate change impacts, but also addressing the socio-environmental and socioeconomic impacts and inequities of the current development model[34], positioning the country on a sustainable development path, in the real sense of the term.

Climate change impacts, vulnerability and risks

A long-term strategy should begin by identifying and evaluating present and future climate change impacts based on climate projections according to climate models. This analysis, together with vulnerability studies of human and productive systems, should allow identification of associated risks[35]. The concrete policies, measures and actions part of the strategy should internalise these impacts and their risks, reducing social and productive vulnerabilities[36].

Ecosystem-based approaches

The strategy should prioritise nature-based solutions for facing impacts, reducing ecosystem vulnerability and lowering the risks for human systems[37]. These solutions arise from actions relying on ecosystems and the services they provide to respond to various challenges for society, such as climate change, food security or disaster risk. Ecosystem-based approaches have potential for promoting and simplifying actions against climate change and, in many cases, offer more efficient and profitable solutions than more traditional technical approaches.

33. Sydow, J. *et al.* (2012). Path Constitution Analysis: A Methodology for Understanding Path Dependence and Path Creation, BuR –Business Research, ISSN 1866-8658, VHB– Verband der Hochschullehrer für Betriebswirtschaft, German Academic Association of Business Research, Göttingen, Vol. 5, Iss. 2, pp. 155-176. Available at: **https://www.econstor.eu/bitstream/10419/103713/1/3504.pdf**

34. Fundación Energías Renovables (2019). Escenario, políticas y directrices para la transición energética. Disponible en: **https://fundacionrenovables.org/wp-content/uploads/2019/06/REVISADO-Escenario-Pol%C3%ADticas-y-Directrices-para-la-Transici%C3%B3n-Energ%C3%A9tica-PUBLICADO-EN-WEB.pdf**

35. Magrin, G. (2015). Adaptación al cambio climático en América Latina y el Caribe. CEPAL. Disponible en: **https://repositorio.cepal.org/bitstream/handle/11362/39842/S1501318_es.pdf;jsessionid=290053D5BD71AF32265F28E6EA5D656D?sequence=1**

36. IPCC, WGII (2014). Impactos, adaptación y vulnerabilidad. Panel Intergubernamental de Cambio Climático. Disponible en: **https://www.ipcc.ch/site/assets/uploads/2018/03/ar5_wgII_spm_es-1.pdf**

37. Lochner, A. Soluciones basadas en la Naturaleza (NBS) como una nueva manera inteligente de gestionar el urbanismo y la ingeniería clásica. Naturalea. Available at: **https://www.naturalea.eu/Ntr/wp-content/uploads/2019/04/Informe_tecnico_NBS_es.pdf**

Community and territorial development-based solutions

The “territorial approach” is defined as a development strategy based on the specific realities, strengths and weaknesses of a community or region. It is based on the increasing awareness regarding the role of endogenous resources and on the search of sustainable development derived from local living forces and addressed to them[38]. It is also characterised by bottom-up, participative, integrated and innovative decision-making processes.

A long-term strategy based on a territorial approach for community development creates functional interdependencies. It may also help in planning the use of natural resources, preservation of environmental factors and diversification of income sources, particularly attending to rural/urban linkages, creating diversified and more stable employment opportunities.

Financing and economic-financial instruments

Access to financing for the needed transformations is a key factor to carry out this type of strategy. To that end, it will be necessary to review the tax scheme, as well as to design a series of economic and finance instruments promoting practices and actions contributing to the desired transformations and discouraging those hindering them. Thus, the current direct and indirect subsidy scheme for fossil fuels should undergo a thorough review[39].

Within this framework, decisions will have to be made not only based on the economic cost and benefic relation of the actions as in the past, but also integrally and systematically considering other consequences they might have, even those that cannot be assigned money value, such as ecosystem services or access to drinking water, among others.

Production and consumption patterns

The strategy should review current production and consumption patterns and their linkage to the natural resources and ecosystem services affected, both due to their exploitation and pollution.

The review should include what is produced, how and what for, and then examine practices and technological packages used for good and services production from natural resources and, particularly, energy resources.

As regards consumption, the strategy should address problems such as conservation and efficiency at the time of producing goods and services, particularly related to energy consumption. The use of technologies linked to consumption should be analysed and policies for avoiding the so-called “rebound effect” phenomenon should be implemented. This phenomenon evidences that even technologies developed to enhance production and consumption efficiency, reducing the use of natural resources and of the produced waste and effluents, eventually increase goods and services production. Thus, those technologies positive potential is diminished, even generating a reverse effect, that is, more resources are consumed and more pollution is generated[40].

The strategy should change goods and services production consumption logics, eliminating obsolescence programmed and induced by industry and trade, as well as perceived obsolescence.

38. FAO. (2008). Enfoques de desarrollo territorial en proyectos de inversión - Estudios de caso. Programa de Cooperación FAO/Banco Mundial Servicio de América Latina y el Caribe División del Centro de Inversiones. Available at: **http://www.fao.org/3/a-k3622s.pdf**

39. FARN. (2019). Subsidios a los combustibles fósiles 2020: Más, dame un poco más. FARN. Available at: **https://farn.org.ar/archives/27160**

40. Blanco, G. *et al.* (2014). Drivers, Trends and Mitigation. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental. Panel on Climate Change. Available at: **https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter5.pdf**

Regarding the latter, but beyond it, the strategy should work on citizen awareness-building, and also on individual and collective habits and behaviours, generating new values and redefining the sense of progress and prosperity.

Work transition

A low-carbon, but mainly sustainable development, strategy should consider the situation of workers in those productive sectors that will be affected, generating other activities in line with a more sustainable development pathway. To that end, the elaboration of the strategy should include: training of technicians, professionals and other workers so that they may undertake tasks in new activities, as well as compensation for employees whose incorporation to the new productive sector might be more difficult[41].

Gender perspective

It is expected that a sustainable development strategy, with low or null GHG emissions, be thought and developed with a gender perspective, in which current inequities between men and women regarding access to resources, vulnerability to climate change impacts and pollution, and decision-making will disappear[42].

Gender roles, power relations and incomes produce different contributions to greenhouse gas emissions and different vulnerability degrees to climate change[43].

It is critical to ensure women's access to knowledge, information and adaptation technologies, and that policies be appropriately designed according to their circumstances.

Education

The needed transformations should be supported by an education system. On the one hand, through individual awareness-building regarding the relations between human and natural ecosystems, that is between the actions and impacts they generate. On the other hand, an education system is required to provide formation and training on the new activities that will contribute to transformation in the different sectors. Education should be multidisciplinary, contrary to what happens today, so as not to ignore the integrity of Earth system.

Science and technology

As an education system is essential to accompany the transformations, so is a scientific and technological system at the service of those changes. The scientific and technological system should supply knowledge on technological matters as well as on production and consumption practices and on population habits and behaviours, in order to reduce inequalities and enter a more sustainable development pathway.

Within the framework of the strategy, technological development and innovation should be proposed as elements for reducing inequalities.

41. OIT. (2010). Cambio climático y trabajo: la necesidad de una "transición justa". Organización Internacional del Trabajo. Available at: **http://idems.org.ar/pdf/inf-estud-inv-mundodeltrabajo/empleo-cambio-climatico/OIT-Cambio-climAtico-y-trabajo-La-transiciOn-justa--2010--.pdf**

42. Stock, A. (2012). El cambio climático desde una perspectiva de género. Fundación Friedrich Ebert, FES-ILDIS. Available at: **https://library.fes.de/pdf-files/bueros/quito/09023.pdf**

43. Gonda, N. (2014). Género y Adaptación al Cambio Climático. Agrónomos y Veterinarios sin Fronteras y el Programa de las Naciones Unidas para el Desarrollo (PNUD). Available at: **https://www.undp.org/content/dam/nicaragua/docs/MedioAmbienteyGestiondeRiesgo/NIC_Genero%20cambio%20climatico%20Nicaragua_web.pdf**

Food and energy sovereignty

The strategy should include policies and measures to promote food sovereignty through the review of the abovementioned production and consumption patterns, and mainly the review of land concentration processes and of practices and technologies used in the agro-industrial sector[44] [45] [46].

Likewise, the strategy should pursue policies and measures for energy sovereignty, both in energy resources and in technology for their exploitation, refining and consumption[47], without compromising access to environmental and human rights related to health and to prior and informed consultation, among others.

Regulatory framework

A low-carbon strategy, but promoting sustainable development, should review the regulatory framework in force in order to adopt one that promotes and facilitates the needed actions and discourages or avoids actions on the contrary. It will be necessary to modify appropriation and access to natural resources, including land and energy resources.

The regulatory framework should redirect and promote infrastructure transformations, as well as technological changes for development sustainability. It should also avoid the so-called "rebound effect" phenomenon of new technologies, already described.

This new regulatory framework should also be coordinated with the abovementioned economic and financial instruments.

Communication and participation

A strategy for sustainable development should consider systematic mechanisms for citizen participation, a key factor for the viability of any policy, measure or action to be carried out.

Participation should be supported by communication mechanisms providing complete information on policies, measures and concrete actions intended to be carried out in order to avoid well-known asymmetries in the access to the said information. The strategy should work on the role of communication means.

Governance

For the success of a long-term low-carbon strategy, resilient to climate change impacts, but mainly to reach sustainable development, the current governance scheme should be reviewed at the national, provincial and municipal levels. This is due to the fact that the said scheme is based on horizontal divisions (ministries and other decentralized agencies) which prove inefficient at the time of coordinating policies and actions, including conflicting interests among them, as well as among jurisdictional divisions, which do not allow integrally coping with socio-environmental problems, understanding that political-territorial divisions do not coincide with ecosystems and their interrelations.

44. Gordillo, G. y Obed Mendez, J. (2013). Seguridad y Soberanía Alimentaria. FAO. Available at: **http://www.fao.org/3/a-ax736s.pdf**

45. Pulso Ambiental. (2020). El modelo agroindustrial actual: mal de muchos, negocio de pocos. FARN. Available at: **https://farn.org.ar/wp-content/uploads/2020/01/FINAL-PULSO_13_links.pdf**

46. Filardi, M. (2018). Un modelo agroalimentario es necesario, urgente y posible. Informe Ambiental Anual 2018. FARN. Available at: **https://farn.org.ar/wp-content/uploads/2019/07/IAF-2018-3.2.pdf**

47. Gutiérrez, Felipe. (2018). Soberanía energética, propuestas y debates desde el campo popular - 1a ed. Ciudad Autónoma de Buenos Aires: Ediciones del Jinete Insomne, 2018. 286 p.; 21 x 15 cm. ISBN 978-987-4115-07-2. Observatorio Petrolero Sur. Available at: **https://www.opsur.org.ar/blog/wp-content/uploads/2018/12/Libro-Soberania-energetica-WEB.pdf**

9. ADDITIONAL CONSIDERATIONS

The magnitude of the needed transformations, shown in the developed scenarios, will demand much more than technological changes in the different productive sectors and even more than new technologies that modify –perhaps only superficially– our consumption patterns.

A long-term development strategy should review what and how we produce and consume, without ignoring those individuals and communities that really need to increase their goods and basic services consumption, a sense equity that any strategy should promote. This should make us reformulate how we measure our development and reformulate the meaning of prosperity. The indicators used by economists, such as GDP, do not cover, and have never covered, that need.

The needed transformations will require new ways of thinking development in order to exit a model which accompanies us since the first Industrial Revolution, relying on fossil fuels, and which drove us away from Earth natural cycles. A model which climate change and other numerous environmental and social inequalities have now shown is infeasible.

A long-term low-carbon strategy, resilient to climate change impacts, should above all make us adopt a development model in harmony with the natural cycles and the possibilities our planet offers us.

10. ANNEX: THEMATIC DOCUMENTS

Within the framework of the project that produced this publication, other associated documents were elaborated. If desired to deepen on certain matters not included here, there follows the list of titles and authors of those complementary publications, available at the website of the Fundación Ambiente y Recursos Naturales (Environment and Natural Resources Foundation, FARN for its acronym in Spanish).

- Carlos Tanides (2020). Proposal for a long-term energy strategy.
- Fundación Ambiente y Recursos Naturales (2020). Considerations for the AFOLU sector for a long-term decarbonisation strategy in Argentina.
- Fundación Ambiente y Recursos Naturales (2020). A comprehensive perspective on the design of long-term low-carbon strategies
- Roque Pedace (2020). The long-term strategy: coevolution of solutions.

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Authors
Gabriel Blanco / Daniela Keesler
Centro de Tecnologías Ambientales y Energía, Facultad de Ingeniería, Universidad Nacional del Centro de la Provincia de Buenos Aires

Collaborators
Enrique Maurtua Konstantinidis / Jazmín Rocco Predassi
Fundación Ambiente y Recursos Naturales

Carlos G. Tanides
Fundación Vida Silvestre Argentina

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Translator
Elisa Predassi Bianchi

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