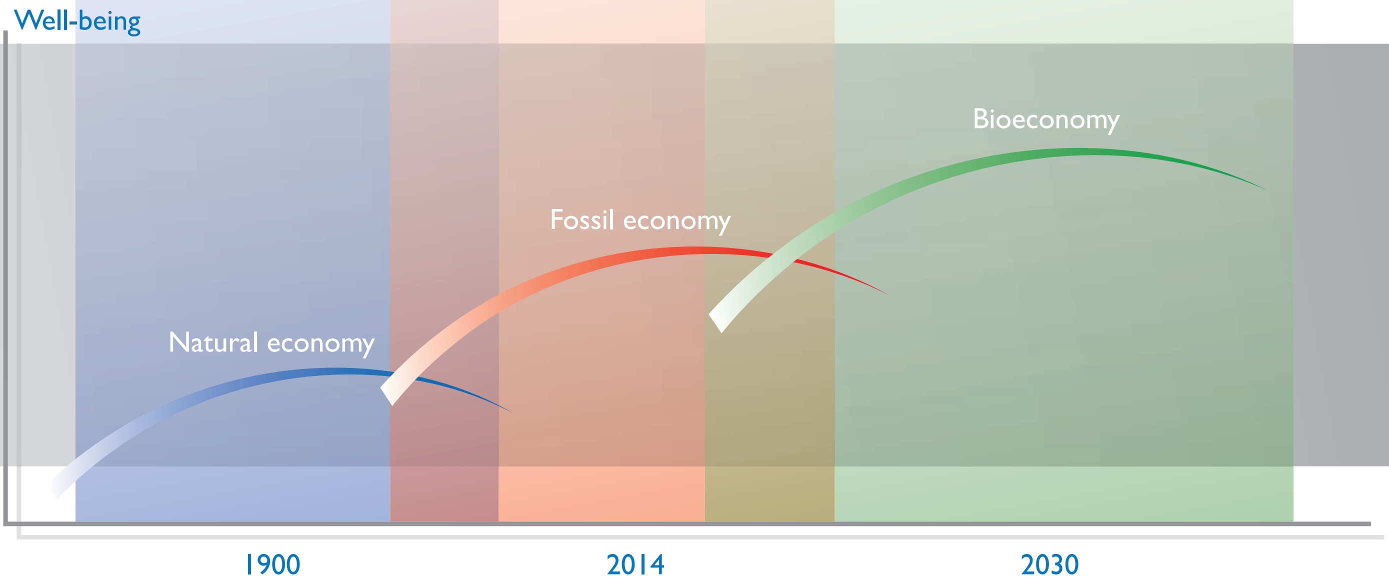
THE ARGENTINEAN BIOECONOMY:

scope, present state and opportunities for its sustainable development



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I. INTRODUCTION

The bioeconomy, understood as the set of economic sectors utilizing biological resources and processes for the production of goods and services, is a concept increasingly accepted as an alternative for the development of an economy that, at the global level, needs to confront the compounded challenges of an ever growing demand for food, fiber and energy of a population that is in route to reach 10 billion people by the end of this century, and at the same time reverse, or at least mitigate, the negative environmental and climate change impacts of current economic organization patterns. It is increasingly evident that current extreme dependency on fossil resources is not sustainable, and new more environmentally friendly social and economic alternatives are imperative. I this context, the bioeconomy has ceased to be an option limited to seeking reduction in fossil fuel dependency; based on a solid and permanently evolving scientific and technological base, it is consolidating as necessary condition for any strategy seeking a transition to a more equitable and sustainable society.

For Argentina, the bioeconomy represents a particularly important alternative. It is an approach that is based on some of the country's areas of strength, such as biomass availability, well-developed capacities in the scientific and technological disciplines supporting the new developments, and long standing entrepreneurial and institutional structures linked to the agricultural sector. A bioeconomy based development strategy also contributes to other important objectives. First it builds on the country's know how on biomass production, a strength that is recognized both in the country and internationally. More so, there is a broad consensus that current biomass production and productivity levels could be substantially increased in the coming years. An effective and efficient bioeconomy, better exploiting the wide diversity of biomass types existing throughout the country, could also help design a more balanced territorial development strategy.

These strengths are already in evidence in a number of diverse situations, allowing assert that in Argentina the bioeconomy is already a process underway. The emergence and consolidation of national bioeconomy firms, the massive utilization of GMOs and environmentally friendly agronomic strategies in agricultural production, biofuel production and the increasing utilization of some of their by-products in different regional development initiatives, and for the production of biobased materials, are clear examples of such a process and of the potential benefits that a broader bioeconomy approach could contribute to an integral strategy for the country's economic and social development.

This document is a first contribution to the analysis of the potentialities of a bioeconomy approach, as an alternative for the sustainable economic and social development for a country with Argentina's strengths. With this in mind, the document includes six sections, besides the present introduction. The second section discusses the main components of the concept of the bioeconomy and how different countries in the world are dealing with them. The third section goes in depth into the type of opportunity that the bioeconomy offers as basis for a long-term development strategy for Argentina. In the fourth section there is an analysis of the country's capabilities in biomass production and in the scientific and technological areas needed to support a bioeconomy based development. The fifth section is about a number of bioeconomy experiences already underway in Argentina; the purpose being to highlight the nature of existing potentialities. Following, the section six presents a first estimate of the current economic size of the Argentinean bioeconomy. Finally, the seventh and last section offers a first approach to the type of challenges that a country like Argentina will need to confront in the transition to a bioeconomy based social and economic development strategy, and presents some of the questions that need to be answered for its design and implementation.

II. THE BIOECONOMY CONCEPT

The world today is at a crossroads, both because of the challenges that need to be confronted and because of the opportunities emerging from the new technologies. The need to anticipate and respond to the demands generated by population increases and economic growth over the next few decades, together with uncontestable evidences of increasing restrictions regarding the resource availability for facing them in a sustainable manner –including energy resources–, highlight in a compelling way that the "business as usual" scenario is no longer a feasible option[(1).]

The availability of arable land, renewable fresh water and fossil fuels is increasingly limited, and these resources cannot continue to be subject to unrestricted utilization as they have been for the last

(1)See Gerland, Patrick (2014).

150 years, since the discovery of oil as source of energy set in motion the most important period of economic growth in the whole of history. Also climate change projections suggest that global balances of greenhouse gases are not immune to present forms of economic organization, and it is necessary to find ways to promote a "cleaner economic development".

In response to these concerns, advances in biology, chemistry, information and communication technologies, and engineering are making possible new production paths for the production of goods and services based in more sustainable forms of natural resources use, that were impossible to anticipate just a few years ago.

In this context, the bioeconomy is a new vision of a future society much less dependent on fossil fuels to meet its demands of energy, raw materials and other industrial inputs; as such, it is seen as an opportunity to face in a coherent way the complex challenge of generating new sources of sustainable economic and social development.

During the last decade the bioeconomy has clearly been identified as a desirable development strategy, both at the international and national levels, making emphasis, in some cases, on the type of resources used –biological resources– or, in others, on the knowledge intensity implied (see Box 1). Independently of the emphasis –the use of biomass or the role assigned to knowledge– the common thread in all the different approaches is the role of innovation –technological, logistical, entrepreneurial, markets– aiming at improving the way solar energy is captured and transformed in other sources of energy, goods and services, as an alternative to improve the environmental performance of production, distribution and consumption activities, and to promote a more efficient and sustainable use of natural resources, in general. Within this framework, and taking into consideration the particular characteristics of a country like Argentina, we propose a broad definition of bioeconomy covering all activities based on or using biological resources and processes, including the biomass production itself –in all its forms– and the goods and services produced both "up-stream" and "down-stream"(2).

The present cycle of economic organization and growth is mostly dependent on the exploitation of fossil fuels –oil and gas– for the production of energy, chemicals, and other industrial inputs. Engineering and modern chemistry applied to photosynthesis processes of millions of years ago, are behind most of modern industrial advances and current forms of economic and territorial organization. But, at the same time, they are widely recognized as one of the main drivers of the processes of climate change currently affecting our world(3).

The bioeconomy, on the contrary, is founded on a concept that could be described as "real

(2) In terms of the concrete formulation of this concept, the definition adopted in this document and which is used for the estimation of the size of the Argentinean bioeconomy – presented below in section six – is the following: "The bioeconomy is the production of biological renewable resources and its conversion into food, feed, biobased products and bioenergy. It includes agriculture, forestry, fisheries, the production of food, pulp and paper, as well as parts of the chemical, energy and biotechnology industries (health and phama)".

(3) It would not be an exageration to say that oil is the key factor defining current economic and social organization. The discovery of the first oil well by Edwin Drake in 1859, was the starting point for the expansion of markets, and a variety of industries and applications at home level; a process that later went global with the introduction of the internal combustion engine, cars and auto transportation, innovations that were determinant in relation to the development of the economy and international trade, and also in the patterns of human settlements, and as drivers of countless economic and political conflicts at regional and global levels. Also, the products of the petrochemical industry are essential inputs for agrifood production (through fertilizers, agrochemicals, packing materials, etc.), and many other industries and services, through the provision of inputs and energy for the production processes. For an extensive discussion of all these links see Haggett, 1998.

BOX 1: The bioeconomy concept

A relatively new perspective that emphasizes the "biologization" of the economy through a greater knowledge intensity. The definitions of bioeconomy used by different countries and international organzations over the last decade, include:

"The bioeconomy refers to the application of knowledge in life sciences in new, sustainable, environmentally friendly, and competitive products" (EC, 2005)….

"……the aggregate set of economic operations in a society that uses the latent value incumbent in biological products and processes to capture new growth and welfare benefits for citizens and nations" (OECD, 2006)…

"The bioeconomy refers to the set of economic activities relating to the invention, development, production and use of biological products and processes. If it continues on course, … could make major socioeconomic contributions ……expected to improve health outcomes, boost the productivity of agriculture and industrial processes, and enhance environmental sustainability". (OECD, 2010).

"A bio-based economy is one that focuses on biological tools and products in the production of treatments, diagnostics, foods, energy, chemicals, and materials". (BiotecCanada, 2009).

"…. encompassing all those sectors and their related services which produce, process or use biological resources in whatever form" (German Bioeconomy Council, 2010).

"…the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products and bioenergy" (EC, 2012).

"A bioeconomy is one based on the use of research and innovation in the biological sciences to create economic activity and public benefit"(The White House, 2012).

"Bioeconomy refers to all economic activity that is derived from the continued commercial application of biotechnology. It encompasses the production of renewable biological resources and their conversion into food, feed, chemicals, energy and healthcare wellness products via innovative and efficient technologies. (Malasya, http://www.biotechcorp.com.my/bioeconomy/, 2012).

"…. a transition from an economy that to a large extent is based on fossil-derived raw materials to a more resource-efficient economy based on renewable raw materials produced by the sustainable use of ecosystem services from land and water (Swedish Research and Innovation Strategy for a Bio-based Economy, 2012).

"…encompassing the sustainable production of renewable resources from land, fisheries and aquaculture environments and their conversion into food, feed, fiber biobased products and bio-energy as well as the related public goods (The European Commission, 2014).

"A bio-based economy can be defined as an economy based on the sustainable production of biomass to increase the use of biomass products within different sectors of society" (Future Opportunities for Bioeconomy in the West Nordic Countries, 2014).

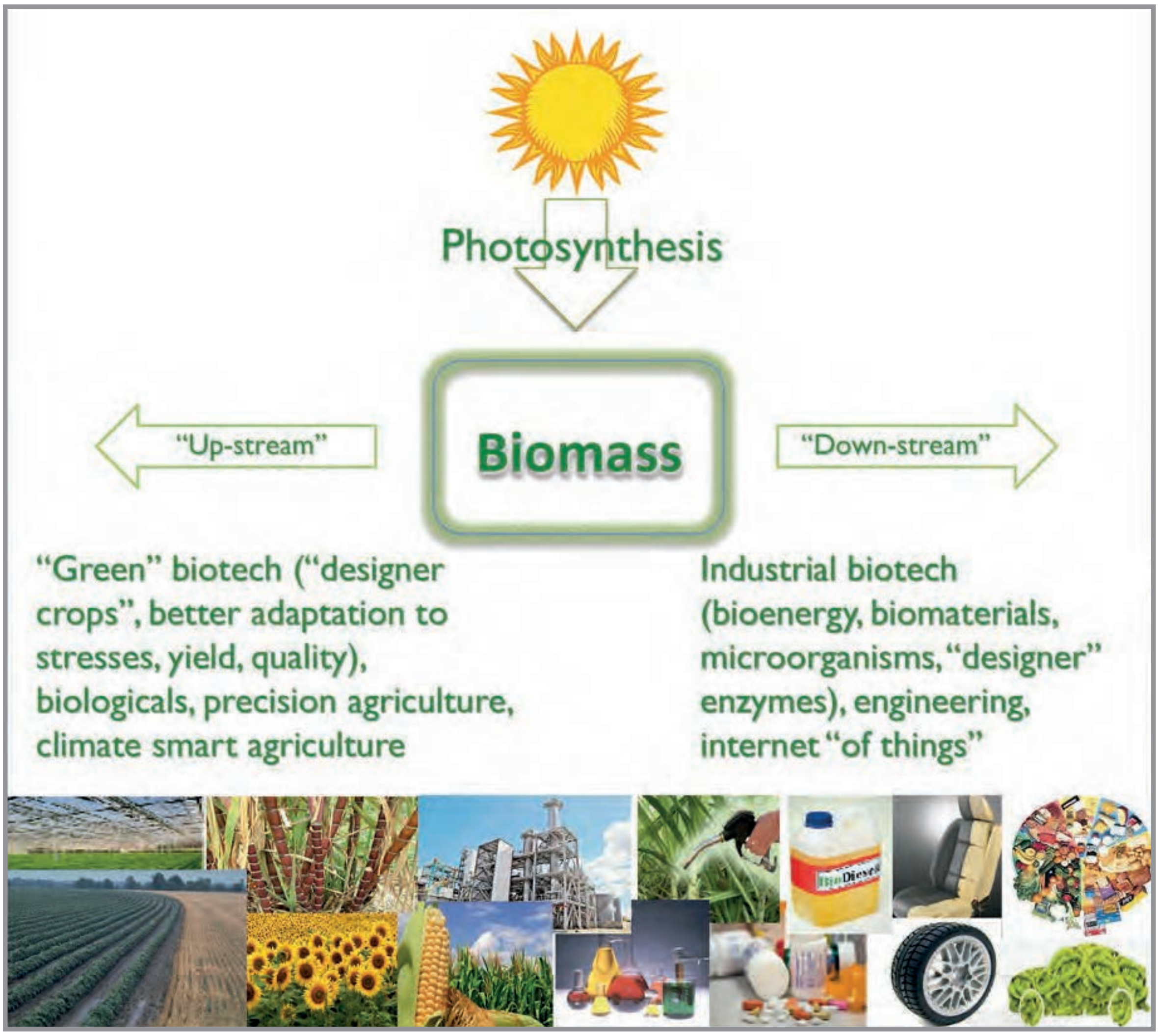
"Bioeconomy refers to an economy that relies on renewable natural resources to produce food, energy, products and services.(Sustainable growth from bioeconomy (The Finish Bioeconomy Strategy, 2014)

Source: the authors.

time photosynthesis", where the use of biomass as source of energy and carbon, sets within the same geological age the carbon emission and capture processes, and by doing so it offers a significant improvement in the environmental performance of involved economic activities.

New and conventional technologies (biotechnology, bioinformatics, nanotechnology, information and communication technologies) contribute to the bioeconomy. In the "up-stream" phase, they contribute to the design of crops for specific uses and their better adaptation to different environments and production conditions, as well as to a more efficient use of all resources involved in the production processes. In the "down-stream" phase, they contribute to the development of new processes for the transformation of biomass resources into industrial inputs and consumption goods, such as biopesticides, biofertilizers, environmentally friendly solvents, detergents, surfactants, industrial dyes, and new biobased materials (plastics, fibers, textiles), and also energy sources, such as biofuels –bioethanol, biodiesel – biogas, heat and electricity (Figure II.1.).

FIGURE II.1 Interaction between biomass and knowledge in the bioeconomy



Source: The authors.

These processes and products –usually referred to as bioproducts or biobased products – are key aspects calling attention to the bioeconomy which, in this sense, it does not constitute a sector in itself, but cuts across and builds on many different areas of the economy: agriculture, forestry, fisheries, segments of the food, textiles, pharma, chemical, cosmetics, and mass consumption products industries, besides the financial, logistics and trading activities associated with them (Box 2).

BOX 2: Bioeconomy products in different sectors (not exhaustive)

Agriculture: More productive and better adapted to stresses/plagues/problems and specific consumer demands, wider and more effective use of genetic diversity by the seed industry, improvements in the strategies for pest and disease control, more efficient management of nutrients, water, and energy cycles.

Forestry: More productive and better adapted to specific environments, problems, pests and diseases, improve production of bioenergy, fibers and chemicals.

Fisheries: Better and wider utilization of aquatic resources (oceanic and fresh water) for food (improved sustainability, better products' logistics), use of algae for bio-energy and bio-inputs for a diversity of industries.

Food: Improved availability of food, functional foods, new ingredients and additives, lengthening of product life cycles, more effective (intelligent) recyclable packing materials.

Chemical: New products environmentally friendly and healthy, synthesis processes, bioenergy, biopolymers, degradable detergents, bio-based recyclable plastics.

Industry: Recyclable inputs and raw materials, anticorrosive materials, improved water treatment, gas purification systems, degradable lubricants with specific characteristics, packing materials.

Transport: Fuels, lubricants, anti-freeze and other fluids for the car industry, plastics and different moldings for car and other industries.

Textile: Fibers, fabrics, rugs, protection covers, fillings, tinctures, special fibers.

Environment: Bioremediation products, water purification systems, detergents and biodegradable home-cleaning products.

Communications: PC cases, optical fiber covers, writing instruments, inks and recyclable papers.

Construction: Paints, resins, insulation materials, wood protection products, fire protection products, adhesives, construction materials.

Recreation: Sports shoes, sports equipments, camera casings, thermycal clothings, golf, tennis, camping equipment, CDs, and DVDs.

Health and hygiene: Pharmaceuticals, new dental materials, disinfectants, plastic lenses, cosmetics, detergents, etc.

Source: The authors

These approaches are still in an early phase of development, and represent only a small fraction of the existing activities. However, their viability, in most cases, is fully proven; and looking into the future there is little doubt that the scientists will be able to offer what is expected. All existing evidence suggests that, most probably, current projections may end up underestimating their potential[(4)].

The key question is not if the new concepts are achievable or not, but their usefulness as an instrument for countries with limited resources to confront existing poverty conditions and improve their insertion in the global economy (German Bioeconomy Council, 2010).

Interactions between biomass, knowledge and innvoation, and the environmental "circularity" implicit in the concept, are the main aspects that make the bioeconmy a powerful instrument to confront today's interrelated challenges of achieving food security, resource depletion and climate change; and, at the same time, support a new wave of sustainable economic growth, based on the development of the new activities and biobased products' value chains. The transition to economies built on these concepts is already underway, and there is ample evidence of their potential impacts on a wide set of sectors, ranging from food to health, transport, construction industry and recreation activities.

III. A CONTEXT OF NEW OPPORTUNITIES FOR SUSTAINABLE ECONOMIC DEVELOPMENT IN ARGENTINA.

The new international context calls for the development of a society less dependent on fossil resources, making a better and more efficient use of its renewable resources. A society quite different from the one we have today. A more decentralized society, with other scale requirements, using a different science and technology base, with new intersectoral relations –urban/rural, agriculture/industry, etc.-, and different international economic relations, as a consequence of the changing balance in strategic resources (from oil to biomass).

This means a different economic scenario regarding comparative advantages, sectors, countries and their relative competitiveness; and demands, as in any other change in scenarios, new policies and institutions to contain and provide directions for decision making by the different social and economic actors, aimed at optimizing benefits from existing opportunities, as well as to minimize the costs of transition into the new situations. This, in fact, is already being recognized in an important number of countries in different parts of the world, which have defined formal strategies to exploit the opportunities provided by the bioeconomy (see Box 3).

In this sense, opportunities emerging in Argentina should be considered in the context that the majority of the sectors –or market segments– that make-up the bioeconomy are new, of relatively recent appearance, and consequently not yet consolidated, and where entry barriers are also low and in state of consolidation. This situation provides opportunities for extraordinary benefits to be captured by those countries entering early into the new markets.

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(4) Biotechnology is, perhaps, the main component of the set of knowledge and technologies that make the bioeconomy the reality of our time, but is by no means the only relevant technological platform. For instance, cell phones and other large scale devises for capture and data transmission, complement the new biological technologies and make possible the development of a more productive and effective agriculture with respect to its impacts on the environment. Other technologies, such as nanotechnology, also contribute to these processes, through a convergence in which advances in one field feeds into the other fields, and facilitate a much faster emergence of new alternatives. For a detailed discussion of the inner workings of this convergence see National Research Council, 2014.

BOX 3: Some countries with formal bioeconomy strategies

Austria: Bioeconomy Background Paper (2013) Australia Bioenergy – Strategic Plan 2012-2015-.

Brazil: Biotechnology Development Policy (2007).

Canada: Blueprint Beyond Moose and Mountains (2011).

Denmark: Agreement on Green Growth (2009).

European Commission: A Bioeconomy for Europe (2012).

Finland: Finnish Bioeconomy Strategy – Sustainable Growth from Bioeconomy (2014).

Germany: National Policy Strategy on Bioeconomy (2013). National Research Strategy BioEconomy 2030 (2010).

Great Britain: UK Bioenergy Strategy (2011).

India: National Biotechnology Development Strategy (2007/2014).

Ireland: Delivering our Green Potential (2012).

Japan: Biomass Industrialization Strategy (2013).Biomass Utilization Plan (2009).

Malaysia: National Biotechnology Policy (2005). Bioeconomy Initiative and National Biomass Strategy 2020 (2011).

The Netherlands: Bio-based Economy 2010–2015.

Russia: Bioindustry and Bioresources – BioTech 2030 (2012).

South Africa: South Africa – the Bioeconomy Strategy (2013).

Sweden: Research and Innovation Strategy for Bio-based Economy (2011).

EEUU: National Bioeconomy Blueprint (2012).

Norway: Future Opportunities for Bioeconomy in the West Nordic Countries, 2014.

Source: The authors on the basis of http://biooekonomierat.de/en/bioeconomy/international0/.

From the Argentinean vantage point, the present scenario appears as very different from the one the country confronted at the beginning of the last century, when it inserted itself into the international markets mainly as a provider of agricultural commodities, following the industrial revolution and during the beginning and consolidation of the oil based global economy. During that period and, as part of the processes emerging from the industrial revolution and the discovery and development of oil as the dominant source of cheap energy, Argentina joined the world economy through what can be described as "short value chains", where local agriculture was part of the times' global value chains, contributing with raw materials, but with very limited added value in services (financial, local and international transport), or transformation (processing of food and fibers), except for a few domestic consumption oriented industries.

This system served the young republic to attract immigrants and capital for developing agriculture, and provided the basis for a dynamic economic growth. However, soon it was argued that such development would not be enough to support a rapidly growing urban population, and set the stage for the idea of conflicts between agriculture and industry sectors as opposed and lacking evident interactions and retro-feeding among them[(5)]. Such views created the pendular policy cycles between "agricultural development", seen as a "traditional" sector without capacity to generate the needed employment, and therefore to be taxed with the objective of generating fiscal resources to protect and promote "industrial development", conceived as the desired progress[(6)]. For many decades this has been the prevailing vision in Argentina, and led to the import substitution economic development strategy. In doing so, it was ignored the thick fabric of interactions and complementarities existing between the agriculture and industry sectors, and losing the potential synergies among them.

Approaching the economic development discussion from the bioeconomy's perspective, allows thinking over the nature of interactions between agriculture and industry, and going beyond the traditional view. The "biologization" of the economy is an economic growth strategy that cuts across sectors, and where interactions are expanded to include a much more complex and strategic set of input-output and intersectoral relations. A modern and more competitive model of industrial development based on effective and efficient utilization of biomass resources, calls for a careful analysis of potential synergies and complementary development alternatives. In other words, a new paradigm for social and economic development based on the country's areas of genuine competitiveness.

The convergence of all the factors mentioned above, which define our current way of living (demand increases, climate change, natural resources restrictions, beginning of the "end of oil era"), and the consolidation of biotechnology as an effective instrument for better use of biological processes, are opening a new cycle of opportunities where, again, the capacities to efficiently produce biomass resources come to center stage[(7)].

The challenge for Argentina is not to repeat past errors, and go beyond the existing vision of agriculture and industry as antagonistic sectors, and move to take advantage of the new cycle in a more integral manner, bringing together agriculture (main source of biomass, not only in the Pampean region), with manufacturing alternatives aiming at producing bioenergy and bioproducts; and integrating local activities into global processes –the global bioeconomy– through final products, or at least, intermediate inputs resulting from biomass processing.

A brief overview of what is happening at the global level with the development of the bioeconomy, points to the existence of three types of situations (countries)[(8)]:

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(5) See the closing address at Bioeconomia Argentina, 2013 by Dr. Aldo Ferrer. (https://www.youtube.com/watch?v=EvmiH4bXDd0).

(6) This dichotomy has in many discussions been characterized as emerging from the "Cepalinean" vision of the world, because of its origins in the ideas put forward by Raul Prebisch in the United Nations Economic Commission for Latin America (CEPAL), that reflect a very inward looking perspective of international economic relations and which originated what is today known as the import substitution pathway to the economic development theory.

(7) Is not that biomass will replace petroleum – that is probably, impossible. What is possible is that while a new energy matrix comes into play (with greater participation of different renewable sources such as eolic, solar and eventually H) biomass plays an important role, facilitating a cleaner, more environmentally friendly energy model.

(8) For a more complete discussion of this classification see Kircher, M. 2012.

(1) Those with wide availability of natural resources for biomass production, and at the same time, a well developed and mature industrial and science and technology base (EEUU, Canada, Russia);

(2) Those with a well developed industrial and science and technology base, but lacking of substantial biomass production capabilities (most of the European countries);

(3) Those which count with large current or potential biomass production and relatively good science and technology capabilities, but are still deficient in their industrial infrastructure (Brazil, Malaysia, Colombia, Mexico)[(9)].

Argentina is part of this later group, where the opportunity is, clearly, in its condition as large biomass producer (current and potential, both in quantity and diversity). The strategic challenge is how to build on this basis and the existing scientific-technological capabilities, the industrial development pathways to effectively benefit from that potential.

In this sense, the main drivers are in the energy and food sectors, where there is great potential for growth, particularly in the later where estimates point out that current production levels could be increased by over 50% during the next decade. Such improvement would allow the country to continue to be a strategic component of global food security and, at the same time, take advantage of "cascading" technologies and processes to produce – in similar way to what happens in the oil industry – food products, bioenergy, diverse biomaterials, industrial inputs, etc., adding value in many different industries. This process would facilitate matching production to the new demands emerging from an increasingly urban population, with very specific form, time and space requirements, and also would contribute to a better environmental performance of both products and production processes[(10)].

In the energy area, besides conventional biofuels –ethanol, biodiesel– the opportunity comes from the implicit circularity of the bioeconomy, and the possibility to transform present costs –those associated to the disposal of industrial and urban waste and effluents– in strategic inputs, making both a positive contribution to a more sustainable energy matrix, and improving industrial competitiveness by reducing energy costs at the local level[(11)].

The bioeconomy opportunities for Argentina should be analyzed within this socioeconomic and environmental context. The advantages derived from the large availability of biomass are in no way minor. However, biomass resources are not a homogeneous category; quite on the contrary, there are significant differences arising from localization, energy density and transportability of the different types of biomass available. Also because of its physical characteristics (volume) and its low unit price, "biomass does not travels well", and is not economically efficient to move it large distances before processing it. This opens significant opportunities for local development and should be reflected in whatever strategies are developed for biomass utilization.

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(9) There is, of course, a fourth category, that of many other countries – mainly relatively small – that have both limited access to natural resources and no, or at most a weak industrial infrastructure.

(10) The predominant public-private consensus is that grain production could grow to 150 million tons during the next decade.

(11) For a discussion on the potential impacts and benefits in the rural areas see Golden, Jay S. y Robert B. Handfield (2014).

The production and supply of biomass in Argentina is widely distributed around the country. This is a strong source of competitiveness for the different production regions and a good starting point for the development of new value chains with a wide territorial deployment. It also highlights the potential of a bioeconomy approach for regional development strategies. With this approach we should not be talking about one Argentinean bioeconomy, but several quite different among them, as a result of the different characteristics of the biomass produced in each region, as well as the specific strategies and pathways that each region adopts for optimizing the use and value added process over their natural resources. The type of industry and value chains to promote should emerge as a result of existing agroecological conditions (biomass supply), the physical and institutional infrastructure, and the existing science and technology capability.

IV. BIOMASS PRODUCTION AND SCIENCE AND TECHNOLOGY CAPABILITIES AS PLATFORM FOR THE DEVELOPMENT OF THE BIOECONOMY IN ARGENTINA

Argentina is part of the group of countries with substantive annual biomass production. In this context it is relevant to have an approach to the current and potential production levels of the main types of biomass. In the same way it is important the analysis of the scientific and technological capabilities, as a first step towards the discussion of strategies to optimize their utilization in support of the bioeconomy development.

IV. 1. Biomass production in Argentina

The diversity of biomass available in Argentina can be utilized in a wide variety of activities. The most important are: production of renewable energies; food and fiber production; production of biomaterials as inputs for a diversity of industrial uses.

a) Biomass production for renewable energy

The current international scenario is characterized by high levels of uncertainty about the future supply of conventional energies, mainly as a consequence of the raise and instability of oil prices and climate change. All this has increased the importance of biomass production for bioenergy production. Argentina has very favorable conditions for the production of the main sources of biomass to generate bioenergy, including woodfuel and agro-fuels. In addition we should also add the urban waste and residues, which can also serve as raw materials for bioenergy production.

The main sources of direct biomass supply are native and cultivated forests. Additionally, there are also other important indirect sources to be highlighted:

I) residues of forestry activities;

II) residues from the pruning and harvest of olives, sugar cane, rice, vineyards, citric and other tree fruit production;

III) residues and by-products of wood mills, the cotton industry, rice and yerba mate mills, sugar cane industry, and by-products of olive oil pressing, among others.

The detailed estimate of the production of biomass as source for renewable energies in Argentina was made by international technical cooperation, that analyzed the spatial deployment of production and consumption of biofuels using the Integrated Supply and Demand of Woodfuels[12]. The results of the WISDOM (the project acronym in English) have been published in 2009, under the tittle "Análisis del Balance de Energía derivada de Biomasa en Argentina".

Supply estimates show that sustainable annual production of woody biomass from native forests and plantations is about 193 million tons of dry matter, of which 143 million tons (equivalent to 42,900 ktep/year) are physically accessible, and are potentially available for energy uses. In addition, there are other 3 million tons of woody biomass coming from wood mills by-products and from the pruning of tree crops, making a total of 146 million tons of potentially available resources from forestry and tree crops. Of this total, about 124 million tons (equivalent to 37,200 ktep/year) are available from commercial sources. This total can still be increased further in 3 million tons, if other non-woody biomass potentially available are included (coming from by-products of different agroindustries, such as sugarcane, rice milling, peanuts and other annual crops).

This estimate of 127 million tons per year is more than half the domestic supply of primary energy in the country. This potential supply is mostly a surplus, because total internal consumption of biomass for energy has been estimated in only 7.9 million tons per year. This highlights the enormous non-used potential of renewable biomass for energy existing in the country.

b) Production of crops that could serve for food and/or agro-fuels

The main sources of agro-fuels are 1) crops; 2) crops by-products; and 3) livestock by-products.

b.1. Crops that could be utilized for biofuels production. The most important are sucrose and starchy crops, oil crops and other energy crops. Production levels for the 2010/11 crop year in Argentina are included in Table IV.1[13].

Cuadro IV.1. Production of main crops in 2010/11 which could be biofuels' feedstocks (million tons)

Sugar cane		Cereals		Oilseeds			
Crushed sugar cane	Production in sugar equivalent*	Corn	Sorghum	Soybean	Sunflower	Peanut	Others**
19,81	2,09	23,01	4,46	48,89	3,67	0,70	0,06

Source: Centro Azucarero Argentino and MINAGRI data.
Notes: * Metric tons of sugar in Calorie Value equivalents. ** Canola and linseed.

b.2. Agricultural by-products from primary production, such as stubble from maize, wheat, soybeans, etc. For the estimates of stubble biomass only the three main crops cultivated at national level were included. Starting with 2010/2011 production, total available biomass was calculated; the volume available as stubble

(12) Project FAO-TCP/ARG/3103, implemented through an inter-institutional group involving people from the Secretariats of Energy, Agriculture and Environment and Sustainable Development, INTA, INDEC and others, under the coordination of INTA's Water and Climate Department.

(13) Because of their reduced participation, other energy crops (such as elephant grass, *Spartina, Cyperuslongus, Arundo dona*) were not considered for the estimation.

was calculated using a 50% ratio, on the basis of the criterion that the remaining portion needs to be left on the fields to maintain nutrient balances and assure a sustainable production cycle (Table IV.2.).

Table IV.2. Supply of main crops' biomass stubble in 2010/11*
(million tons)

Crop	Grain production in 2010/11	Harvesting index**	Stubbling index	Stubble volume Total	Available
Soybean	49,0	0,45	0,55	26,95	13,48
Corn	23,6	0,47	0,53	12,51	6,25
Wheat	14,5	0, 35	0,65	9,43	4,71
Total				48,89	24,44

Source: Trigo, E., Regúnaga M et al (2012).MINCYT.
Note: * The estímate has been done for the main 3 crops, which represented near 90% of total grain production in the selected year. **Satorre, E. et al, 2008. The harvesting index does not include the roots volume neither the biomass lost with the leaf senescense; therefore the real stubble contribution in higher.

b.3. Livestock by-products such as manure and chicken beds, etc. Table IV.3. includes and estimate of total manure generated in the main livestock production activities taking place in medium and large farms.

Table IV.3. Theoretical volume of manure available in commercial firms in Argentina
(million tons)

	Beef cattle	Dairy cattle	Swine	Poultry
Total	10,49	5,86	2,24	0,13

Source: Trigo, E., Regúnaga, M. et al (2012) based on information from FAO, INTA and SENASA.

Another alternative raw material for biodiesel is livestock tallow. Even though the meat industry is significant and there is a high potential supply of tallow, its price is not competitive with that of soybean oil, and for this reason this option was not included in the estimates(14). This consideration and the previously mentioned approach to estimate livestock by-products only to those generated in medium and large farms (commercial), implies that the estimate of potential livestock biomass supply is a quite conservative one.

Other by-products from industrial processing of agricultural raw materials were not included, due to their relatively small scales.

c) Solid urban waste

According to the National Observatory on Solid Urban Waste, the provinces of Buenos Aires, Córdoba and Santa Fe and the City of Buenos Aires produce about 8.2 million of tons/year of solid urban waste (SUW). It is estimated that 50% of the SUW are organic, so about 4.1 million tons/year are potentially available for industrial processing as energy or biomaterials.

(14) There is also the fact that oil companies do not accept biodiesel from tallow, since in non-tropical countries there are still not resolved problems with keeping biodiesel fluid at temperatures below 10/12°C (in the case of soybeans the problem appears below 2°C).

d) Total biomass production for general use

The biomass production estimates presented in the previous paragraphs correspond to volumes which are not comparable among them, because the various types of biomass have different dry matter content, energy density, nutritional characteristics, etc. In spite of this comment, and having made the previous warning, Table IV.4. summarizes biomass availability from all sources, mentioning the units for each one in particular.

Table IV.4. Potential supply of different sources of biomass in Argentina in year 2011*

Biomass sources for alternative destinations	Units	Physical Volume
1. Woodfuel	Million tons dry base	146
2. Agrifood and / or biofuels		
Agricultural crops		
• *Sugar-starch*		
Sugar cane	Million tons cane humid base	19,81
Corn	Million tons of grain	23,01
Sorghum	Million tons of grain	4,46
• *Oilseeds*		
Soybean	Million tons of grain	48,89
Sunflower	Million tons of grain	3,67
Peanut	Million tons of grain	0,70
Others (Linseed, Canola)	Million tons of grain	0,06
Agricultural crops' byproducts–available stubble	Million tons dry matter	24,44
Livestock byproducts – available manure		
• *Beef cattle*	Million tons	10,49
• *Dairy cattle*	Million tons	5,86
• *Swine*	Million tons	2,24
• *Poultry*	Million tons	0,13
3. Solid urban waste (SUW)	Million tons of SUW	4,10

Source: Trigo, E., Regúnaga, M. et al (2012). MINCYT.

Note: * It should be noted that it is the annual production. The total production is 294 million tons; the total volume row has not been included in the table because it includes non homogeneous products.

In summary, and recognizing that we are not talking about a homogeneous category, the main source of biomass is that of the woodfuels, with around 146 million tons per year of dry matter (approximately 50% of the total of all the different types included in Table IV.4.). Grain production is the second, with a total of 81 million tons per year, which represent 27.5% of the total. Third in importance is biomass in the form of crop stubbles, with 24.4 million tons per year, or about 8.3% of the total. In fourth place come 19.8 million tons per year of sugar cane for milling, which is about 5.8% of the total (a volume that supports a production of around 2.1 million tons of sugar per year and the corresponding bagasse). Total manure production from livestock accounts for 18.7 million tons per year (6.4% of the total); and solid urban waste amounts to 4.1 million tons per year, representing 1.4% of the total of Table IV.4.

IV.2. Biotechnological science and technology capabilities in Argentina[15]

As indicated above, to effectively benefit from existing opportunities in the international bioeconomy, it is not enough to have abundant sources of biomass; there is also the need to have a strong human resources base and science, technology and innovation infrastructure in general, and in the field of biotechnology in particular.

Biotechnology involves a wide set of strongly science based techniques, which are interdisciplinary, and require significant investments both in R&D and at the innovation level. There is a need of highly trained human resources in both the specialized research institutions and at the industry level, together with usually sophisticated scientific equipment and up-scaling infrastructure to facilitate the transition of ideas and products from the laboratory to the market.

Biotechnology capabilities in Argentina build on a strong background in biological sciences (biology, chemistry, etc.), in medical sciences and engineering, which are already contributing in a significant manner to the consolidation of strong R&D in a number of segments of the biotechnology. Because of this, and since it offers strong opportunities in many areas of agriculture, health and the environment, over the last two decades biotechnology has become one of priorities of national science, technology and innovation policies.

Several government agencies design and implement policies and programs in support of biotechnology related activities, mostly within the responsibility of the Ministry of Science, Technology and Productive Innovation (MINCYT). The priority assigned to biotechnology within Argentinean public policies and investments is clearly reflected in the last two national science and technology plans ("Plan Estratégico Nacional de Ciencia, Tecnología e Innovación Bicentenario 2006-2010", and, "Plan Nacional de Ciencia, Tecnología e Innovación Productiva Argentina Innovadora 2020"). Within this framework a number of R&D institutions are quite active in most of the biotech related disciplines, forming a significant platform for the future development of the field.

As a consequence of this political priority, financial and infrastructure support to the scientific sector has improved significantly over the last two decades, mainly through the increased budgets assigned to programs administered directly by MINCYT, CONICET, and also those of the national universities. Within the MINCYT programs the most important are the "Fondo Nacional de Ciencia y Tecnología" (FONCYT) designed to finance basic and applied scientific research, and the "Fondo Tecnologico Argentino" (FONTAR) designed to fund R&D and innovation activities in the private sector. Both are supported by international funding from the World Bank and the Inter American Development Bank. These resources are complemented by other cooperation efforts, such as the Centro Argentino-Brasilero de Biotecnología, CABBIO, and the BIOTECSUR Platform, which is an initiative co-funded by the European Union and the MERCOSUR countries, and aimed at promoting joint work by research groups of the MERCOSUR region.

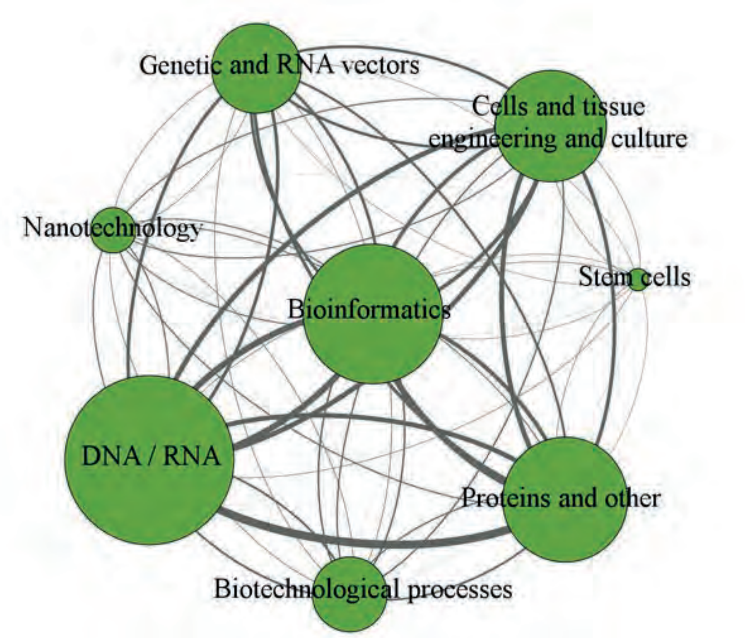
(15) The analysis in this section is based on the studies developed for the Biotecsur Project (www.biotecsur.org) and the "Encuesta Nacional de Grupos de Investigación en Biotecnología", a survey of research groups undertaken by MINCYT in 2013, and which had a wide coverage, so assuring a good characterization of the situation.

Biotechnology capabilities in the Argentinean R&D system are quite significant. In spite the fact that most of the research groups in the field are of relatively recent creation –the largest number of them (54%) are in operation only since 2000, 33% came into being during the 1990s, and only 13% before that decade–, the use of biotechnology based techniques goes back to the decade of 1980.

The majority of the R&D groups working in biotechnology do so within the national universities environment (43% of the total), 40% are part of Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), 14% are located in decentralized public research and technology agencies (such as Instituto Nacional de Tecnología Agropecuaria, Instituto Nacional de Tecnología Industrial, Comisión Nacional de Energía Atómica) and the remaining 3% in hospitals and other health system institutions.

In terms of the techniques applied, the most frequent is that of DNA/RNA (reported by 86% of the groups), followed by bio-informatics techniques (68%), cell/tissue culture and engineering (57%), protein and molecular engineering (54%), genetic and RNA vectors (38%), and biotechnology processes (28%); work in nanotechnology applications to biotech and stem cells, show much lesser frequencies. Figure IV.2. highlights the complexity of the networks that have been developed, on the basis of shared objectives or resulting from the utilization of the same techniques.

FIGURE IV.2. Networks of biotechnology techniques used and / or implemented by the research groups



Source: MINCYT National Survey on Biotechnology Research Groups. 2014.

Note: The size of the circles and the width of the lines represent the relative magnitudes.

In general there is a high level of interaction among the groups around R&D objectives, and to a lesser extent for training or information exchange. Interactions are also active in seeking funding support; this is particularly the case with the different programs administered by MINCYT. Cooperation and interactions with agencies and institutions of other countries are also high (40% of the groups report this type of interactions), probably as consequence of the global nature of biotechnology.

In total there are about 1,400 scientists doing R&D in biotechnology. 55% of this total is at the doctoral level, and the remaining 45% are at the MSC or university degree level. In disciplinary terms there is a clear dominance of natural sciences graduates (63%, with a majority in biology and biotechnology degrees). The second area in importance is that of the medical sciences (24%), with biochemistry, general medicine and pharmacy as the main areas of specialization. Other disciplines represented are agricultural and fisheries sciences (8%), and the different engineering and other technological fields (4%).

The results of on-going activities are applications on human health (54%), agricultural applications (37%), livestock (35%), bio-informatics (29%), environment (23%), manufacturing processes (18%). There are also a number of non-specific applications (36%), aiming at the development of new tools and methodologies for R&D.

Regarding limiting factors for further development of biotechnology activities, access to equipment and inputs, funding, and human resources in some key areas are the three aspects most frequently mentioned.

At present biotechnology research most important product is in the form of publications in the different biosciences areas. However, there is an increasing number of groups that have developed different modes of interaction with private entities (small and medium enterprises, non-governmental organizations, etc.) for technology transfer, particularly in related to piloting and fine-tuning specific technologies, and scaling-up innovative processes. Among the 70 groups that have developed this type of relations, 52% did so with local companies, 31% with NGOs, 12% with local subsidiaries of multinational companies, and the remaining 5% with foreign companies. In terms of activities developed, the largest share is in cooperative R&D projects (39%), followed by technical assistance and advisory services to private firms (32%), joint patenting (6%), information exchange (6%), and training of human resources of private entities (5%).

Lack of appropriate knowledge about the R&D capabilities existing in the different R&D groups, and limitations with respect to correctly reading the demands of technology or technical support on the part of the private entities, have been identified as the main limitations needed to be resolved for improving interactions. Bureaucratic management and absence of facilitating mechanisms for public-private partnerships and interactions in general are also identified as factors restraining more intensive relations. In an attempt to resolve this weakness, in recent times MINCYT has created a number of different instruments directed to facilitate effective links between private enterprises and the science and technology groups, and to promote the creation of start-ups on the basis of promissory R&D results from existing programs.

V. SOME BIOECONOMY EXPERIENCES ALREADY UNDERWAY IN ARGENTINA

The capacities mentioned with respect to biomass production and existing science and technology infrastructures are already contributing to the development of the bioeconomy in Argentina. A significant number of on-going experiences highlight the potential the bioeconomy approach has to offer. Among them:

a. The existence of biotechnology enterprises in a number of important sectors of the economy.

b. Pioneering introduction and massive utilization of GMOs in agricultural commodities' production.

c. Utilization of environmentally friendly agronomic management strategies in major commodities' production systems.

d. A dynamic and highly competitive vegetable oil sector, with strong biofuels and biorefineries components.

a. Development of biotechnology firms in many relevant sectors

A key aspect for the development of the bioeconomy is the role that knowledge-based enterprises – biotechnological, in particular – play in that process. In this sense it is important to note that in Argentina there are incipient but increasing initiatives in the sector, which could eventually serve launching platforms for future development of the bioeconomy, including promotion policies, an appropriate regulatory process and proactive macroeconomic environment demanded by this type of investments.

According to a recent study published by MINCYT in 2014(16), in 2012 in Argentina there were about 180 firms operating in the biotechnology sector(17). This number of biotechnology firms is substantially smaller than that of the OECD countries leading the sector: USA some 8,000 firms; Spain, 3,000; France, 1,500; Korea, 885; and Germany, 693. But the number of local firms is not much different from the one reported in countries such as Italy (265), Brazil (237), Israel (233), Finland (157), and Sweden (129). Even more, if differences in these countries GDPs are taken into consideration, the situation in Argentina compares in favorable terms to this second group of countries.

This positioning of the country started more than three decades ago. When in the years of 1980s biotech applications in human health and plant genetics started to arrive to the markets, Argentina already had a few commercial developments in those fields. Microbial enzyme production, plant micropropagation, chemical reactives and interpheron were the first scientific developments to reach the Argentine market, and they did almost simultaneously to what was happening in the USA and Europe (Bercovich y Katz, 1990; Dellacha J.et al, 2002 y 2003).

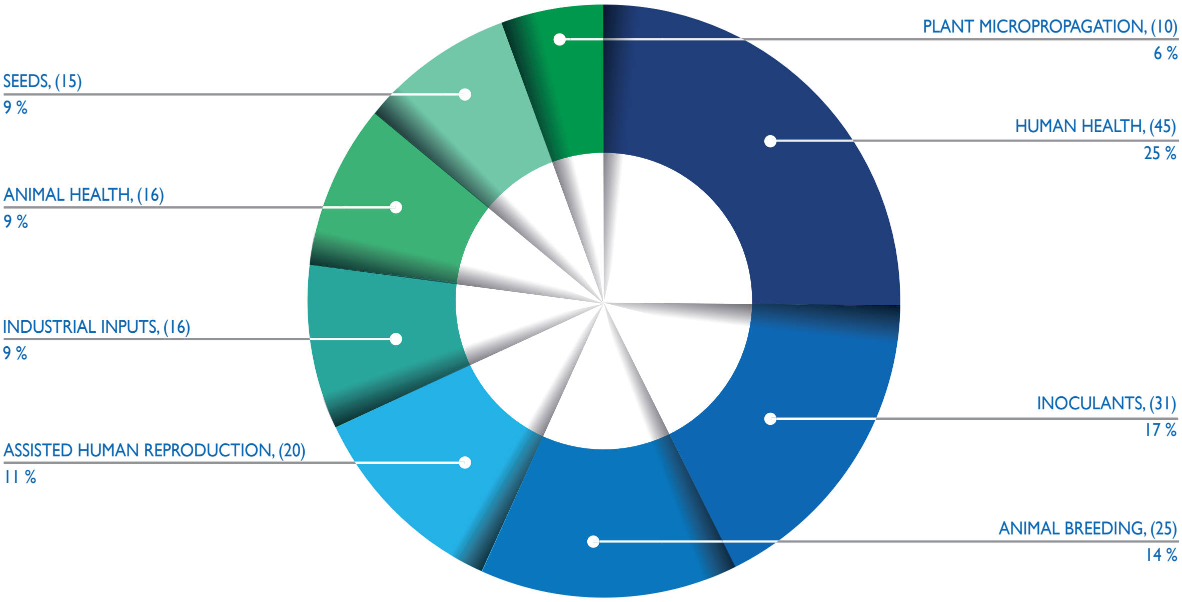
According to the already mentioned MINCYT survey, the majority of the biotechnology firms existing in 2012 were created during the last two decades: 84 between 2000 y 2012; and 39 between 1990 and 2000. Ninety percent of the firms were owned by local capitals and the rest were subsidiaries of multinational companies, mainly in the seed industry. This highlights that we are talking about a young sector – almost half of the firms have been in business during less than a decade – with a majority of locally owned firms of small and medium size. It is interesting to note, however, that there is an increasing presence of relatively important local economic groups, which in the future could support some substantive biotechnology based business developments.

Firms in operation in 2012 were involved in a wide range of activities, including seed production, pharmaceutical production both for human and animal health, microbiological inputs for plant production, industrial enzymes, and services for animal production and assisted human reproduction. Figure V.1 shows the numbers and percentages of firms in the different product areas.

(16) Bisang, R. Las empresas de Biotecnología en Argentina. MINCYT, 2014.

(17) Firms that produce biotechnological goods or use techniques considered as modern biotechnology, and were classified as biotechnological according to the criteria used by the OECD.

FIGURE V.1. Number and percentage of biotech firms specialized in different subsectors in 2012



Source: Bisang, R. Las empresas de biotecnología en Argentina. MINCYT, 2014.

Total sales of the 178 firms surveyed in 2012 were about USD 6,600 millions, but only about USD 2,100 millions (at the average A$/USD exchange rate going in 2012, of A$ 4.55 per US dollar). The difference arising from the fact that in the mentioned group there are two different types of firms: those that are exclusively biotechnology based and those that also operate in non-biotech markets. The largest share of sales was in the seed sector (78% of the total), followed by human health (8%), animal health (6%), industrial inputs (5%), and inoculants and other microbiological inputs for plant production (3%).

In spite of being a relatively "new" industry, in 2012 the value of production of the biotechnology industry was about half of that of the software or the meat processing industries; one third of dairy processing; and slightly larger than the value of production of the wine production, textile or shoes manufacturing industries. Since we are talking about a "horizontal" industry, cutting accross traditional industrial sectors, it is of high relevance in terms of multiplying effects, but it does not appear in conventional national accounts registries.

Exports of biotechnology products were USD 339 millions in 2012, with 43% coming from seeds, 21% from industrial enzymes, 20% from pharmaceuticals (human applications), 9% from animal health products, and 7% from inoculants. Even though volumes are relatively small vis a vis the country's total exports (of about USD 80,000 millions in 2012), Argentina is positioning itself as a relevant player in several of the biotechnology based international markets, such as seeds, pharmaceuticals, and support to animal production products (genetics, reproduction and health). In this sense exports of biotech products are already of relevance when compared to other traditional sectors: the value of exports of biotech products is similar to exports of textiles and cloth manufacturing, fish and processed seafood, and higher than that of honey (where Argentina is one of the leading world exporters), and processed wool.

In global biotechnology companies innovation investments play a crucial role. In 2012 Argentinean biotech firms invested only USD 81 millions in R&D (60 % of that was in seeds and 30% in human health). This figure is relevant in the domestic context, but very small in comparison to the levels invested by firms of this sector in the leading OECD countries(18). According to an OECD estimate, in 2011 R&D investments in purchasing parity price were USD 27,374 millions in USA; USD 2,790 millions in France; USD 1,230 millions in Japan; USD 1,168 millions in Germany; USD 1,083 millions in Korea; USD 945 millions in Canada; and USD 749 millions in Spain. The magnitude of Argentinean investments were similar to those invested by Australia, Finland, and Russia, but larger than those of Mexico, South Africa, and Portugal.

Human resources employed in the biotechnology industry in 2012 were close to 1,500 people. Of this total, 700 were in the seed sector, 306 in human health, 156 in inoculants, and 125 in animal health.

The importance of all these indicators is not just in their present magnitude, but because they show existing organizational and managerial capacities available to exploit emerging opportunities in the field, and allow transforming them in concrete improvements at the production level, something that is of strategic value for future development of the Argentine bioeconomy. In this sense the existence of firms in a wide spectrum of sectors –seeds, plant micro-propagation, biologicals (inoculants, growth coadjuvants, fertilizers), animal breeding and health, human health and pharmaceuticals, and microorganisms and enzymes for industrial application-, is also a strength to highlight, given the transversal nature of the bioeconomy.

From the strength and weaknesses perspective, the high level of development of the seed industry –both in terms of the number of firms as well as the type of technologies they use (molecular markers and other related new technologies, transgenesis, etc.)– is without doubt a strength, since it facilitates the rapid delivery of the potential new scientific development into biomass production activities. In turn, industrial biotechnology applications, which are usually known as white biotechnology, use live organisms or enzymes for:

- the production of biodegradable products;
- the generation of new organic transformations to improve the efficiency of production processes; and
- the reduction of waste streams and residues from industrial processes.

However, the white biotechnology is the area with less level of development and insertion in the local economy (about 2/3 of the value of production in these activities goes to the export market, Bisang, 2014).

b. Massive development and use of GMOs in agricultural production

Argentina developed the institutional infrastructure for the evaluation and market release of GMOs very early, almost simultaneously to what was happening in other leading countries, such as the USA (setting-up the National Biosafety Committee, CONABIA, and the National Seeds Institute, INASE, and strengthening agricultural biotechnology research at the National Agricultural Research Institute, INTA, among others). Almost immediately there were started the field experimentation and all the studies needed for the release of the first relevant GMO event –the herbicide tolerant soybean–; and its marketing was authorized in 1996/97. Since then, there have been approved a relatively large quantity of transgenic varieties for soybeans, maize and cotton. Table V.1. summarizes the situation up to the present. As it can be seen in the table, local producers have available to them single and stacked events varieties with tolerance and/or resistance to herbicides and diverse stresses.

(18) The largest local capital firms qualify under the technical criteria, but because of their size they are in the small and, exceptionally, medium size category.

Table V.1. GM events approved in Argentina

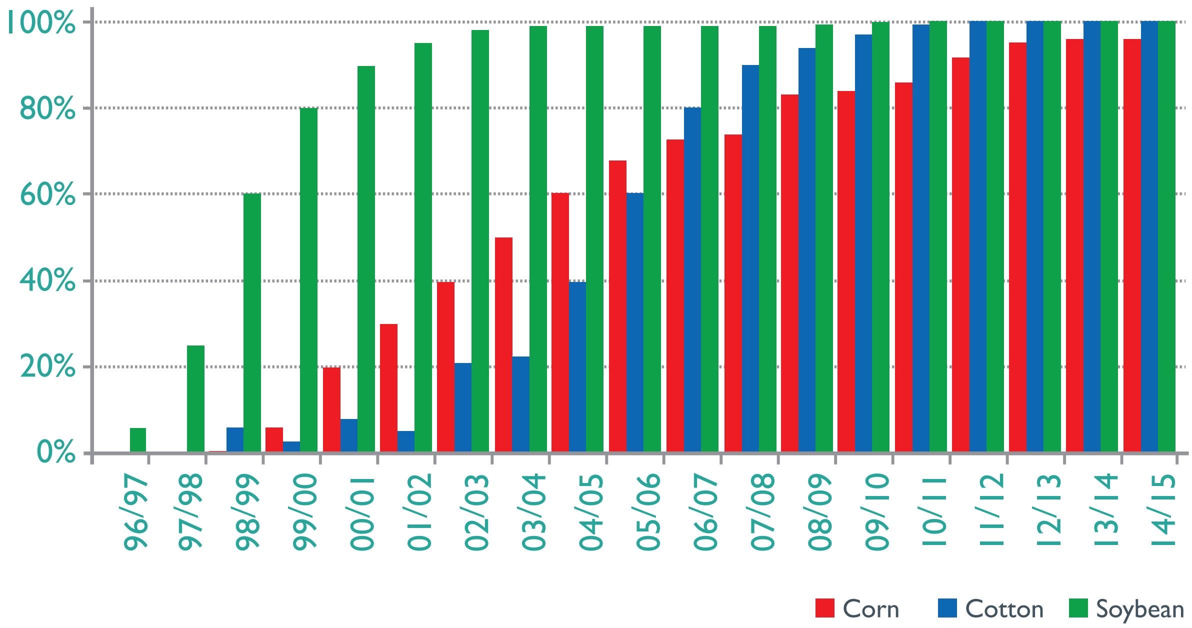
Crop	Introduced trait	Transformation event	Applicant	Resolution
Soybean	Glyphosate tolerance	40-3-2	Nidera S. A.	SAPyA N° 167 (25-3-96)
Corn	Lepidoptera resistance	176	Ciba-Geigy S.A.	SAGPyA N° 19 (16-1-98)
Corn	Amonium Gluphosinate tolerance	T25*	AgrEvo S.A.	SAGPyA N° 372 (23-6-98)
Cotton	Lepidoptera resistance	MON531	Monsanto Argentina S.A.I.C.	SAGPyA N°428 (16-7-98)
Corn	Lepidoptera resistance	MON810	Monsanto Argentina S.A.I.C.	SAGPyA N°429 (16-7-98)
Cotton	Glyphosate tolerance	MON1445	Monsanto Argentina S.A.I.C.	SAGPyA N°32 (25-4-01)
Corn	Lepidoptera resistance	Bt11	Novartis Agrosem S.A.	SAGPyA N°392 (27-7-01)
Corn	Glyphosate tolerance	NK603	Monsanto Argentina S.A.I.C.	SAGPyA N°640 (13-7-04)
Corn	Lepidoptera resistance and Amonium Gluphosinate tolerance	TC1507	Dow AgroSciences S.A. and Pioneer Argentina S.A	SAGPyA N°143 (15-03-05)
Corn	Glyphosate tolerance	GA21	Syngenta Seeds S.A.	SAGPyA N°640 (22-08-05)
Corn	Glyphosate tolerance and Lepidoptera resistance	NK603x MON810	Monsanto Argentina S.A.I.C.	SAGPyA N°78 (28-08-07)
Corn	Lepidoptera resistance , Amonium Gluphosinate and Glyphosate tolerance	1507xNK603	Dow AgroSciences S.A. and Pioneer Argentina S.A	SAGPyA N°434 (28/05/08)
Cotton	Lepidoptera resistance and Glyphosate tolerance	MON531x MON1445	Monsanto Argentina S.A.I.C.	SAGPyA N°82 (10/02/09)
Corn	Glyphosate tolerance and Lepidoptera resistance	Bt11xGA21	Syngenta Agro S.A.	SAGPyA N°235 (21/12/09)
Corn	Glyphosate tolerance and beetle resistance	MON88017	Monsanto Argentina S.A.I.C.	SAGPyA N°640 (07/10/10)
Corn	Lepidoptera resistance	MON89034	Monsanto Argentina S.A.I.C.	SAGPyA N°641 (07/10/10)
Corn	Glyphosate tolerance, Lepidoptera and beetle resistance	MON89034 x MON88017	Monsanto Argentina S.A.I.C.	SAGPyA N°642 (07/10/10)
Corn	Lepidoptera resistance	MIR162	Syngenta Agro S.A.	SAGPyA N°266 (19/05/11)
Soybean	Amonium Gluphosinate tolerance	A2704-12	Bayer S.A.	SAGPyA N°516 (23/08/11)

Crop	Introduced trait	Transformation event	Applicant	Resolution
Soybean	Amonium Gluphosinate tolerance	A5547-127	Bayer S.A.	SAGPyA N°516 (23/08/11)
Corn	Lepidoptera resistance and Amonium Gluphosinate tolerance	Bt11xGA21x MIR162	Syngenta Agro S.A.	SAGPyA N°684 (27/10/11)
Corn	Tolerance to Glyphosate and to herbicides inhibiting the acetolactate synthase enzyme	DP-098140-6	Pioneer Argentina S.R.L.	SAGyP N° 797 (01/12/11)
Corn	Lepidoptera and beetle resist Glyphosate and Amonium Gluphosinate tolerance	Bt11xMIR162x MIR604xGA21 and intermediate blends	Syngenta Agro S.A	SAGyP N° 111 (15/03/12)
Corn	Beetle resistance	MIR604	Syngenta Agro S.A.	SAGyP N° 111 (15/03/12)
Corn	Lepidoptera resistance, Amonium Gluphosinate and Glyphosate tolerance	MON89034x TC1507xNK603	Dow AgroSciences S.A. and Monsanto Argentina S.A.I.C	SAGyP N° 382 (23/07/12)
Corn	Lepidoptera resistance and Glyphosate tolerance	MON89034x NK603	Monsanto Argentina S.A.I.C	SAGyP N° 382 (23/07/12)
Soybean	Lepidoptera resistance and Glyphosate tolerance	MON87701x MON89788	Monsanto Argentina S.A.I.C	SAGyP N° 446 (10/08/12)
Soybean	Tolerance to herbicides like imidazolinonas	CV127	BASF Argentina S.A.	SAGyP N° 119 (07/03/13)
Corn	Lepidoptera resistance, Amonium Gluphosinate and Glyphosate tolerance	TC1507x MON810xNK603 TC1507xMON810	Pioneer Argentina S.R.L.	SAGyP N° 417 (15/10/13)
Corn	Lepidoptera resistance, Glyphosate and Amonium Gluphosinate tolerance	Bt11xMIR162xTC1507 xGA21 and all intermediate blends	Syngenta Agro S.A.	SAGyP N° 88 (11/04/14)
Soybean	Tolerance to 2,4 D, to Amonium Gluphosinate and to Glyphosate	DAS-44406-6	Dow AgroSciences Argentina S.A.	SAGYP N° 98 (09-04-15)

Source: MINAGRI data (2015). www.minagri.gob.ar .

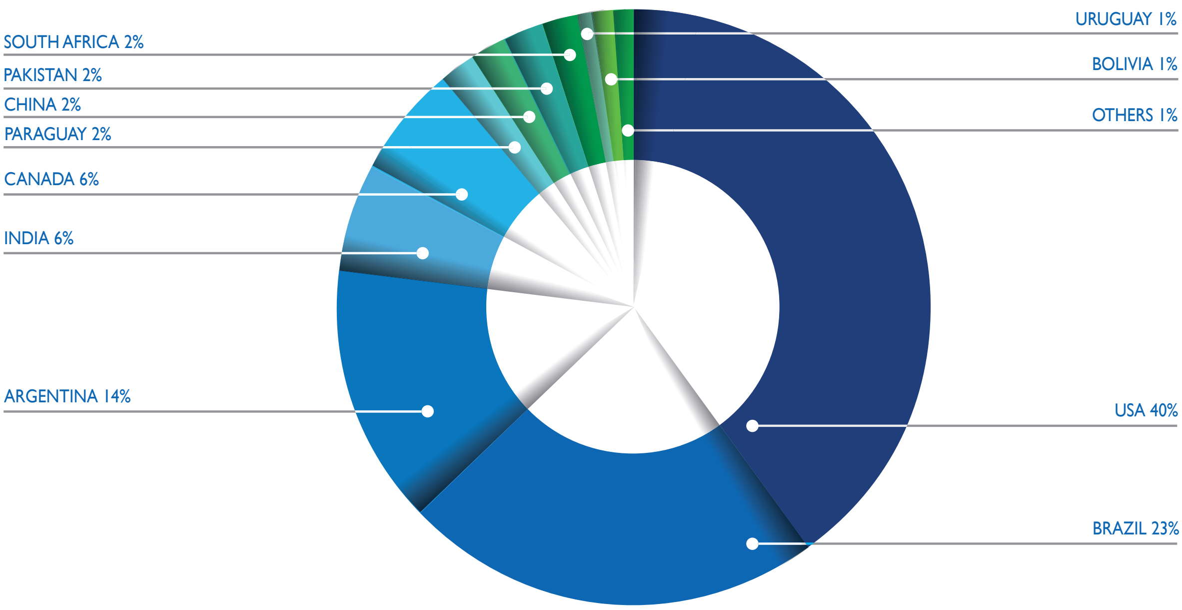
At present Argentina has 24 years of experience on biosafety regulatory issues, and 19 years with actual utilization of transgenic events in the production of grains, in more than 20 million hectares every year. This has allowed significant improvements in water utilization, crop management, and also a reduction in agrochemical use (especially those that are more negative for ground water), biological pest controls, production cost reductions, and productivity improvements. In 2014, more than 95% of the cultivated area with soybeans and more than 90% of the area planted with maize and cotton were GMO crops (see Figure V.2.). Argentina has the third largest area planted with GMO crops, behind the USA and Brazil (see Figure Figure V. 3.).

FIGURE V.2. Intensity of use of GMOs in soybean, corn and cotton in Argentina
(% of total planted área)



Source: www.argenbio.org

FIGURE V.3. Planted area with GMO crops in 2014. Participation of major GMO producing countries in world total area
(shares of total world planted area with GMO crops*)



Source: www.argenbio.org
Note: * Total area planted with GMOs in 2014: 181.5 million hectares.

As indicated previously, the preexisting experience in the seed industry on the development and release of varieties and hybrids well adapted to local conditions, has been a critical platform for the introduction of transgenic crops, as well as for the utilization of other advanced breeding techniques, such as molecular markers. This background is very important for the rapid introduction of new developments in the future (GMOs, molecular markers, NBTs, etc.), and also for the development of more productive varieties for crops of local interest, such as wheat, sugarcane, and other intensive horticultural crops. This is already showing a number of public-private initiatives involving different institutions (INTA, Universidad de Buenos Aires, Universidad Nacional del Litoral, CONICET research centers, Instituto de Agrobiotecnología de Rosario, Bioceres Semillas, Tucuman's Estación Experimental Obispo Colombres, etc.). Box 4 summarizes the case of Bioceres Semillas, as an example of this type of developments.

BOX 4: Bioceres Semillas

Bioceres is a biotechnology firm resulting from a public-private joint venture, which develops and markets products designed to improve crop yields and to add value to biological raw materials. Its membership integrates 23 agricultural producers and 293 private stockholders, who contribute to funding, management and value capturing strategies, associated with a number of public institutions (Universidad Nacional del Litoral -UNL-, CONICET, MINCYT), which bring human resources and research infrastructure to the project.

Bioceres has developed a network of R&D alliances with different institutions. The Rosario Agro Biotechnology Institute, INDEAR, is its main R&D partner, and facilitates access to technologies and product development; INMET is a spin-off from INDEAR specialized in the development of metabolic engineering solutions for the better use of biomass resources in the production of high value molecules.

On the basis of work by researchers from the UNL and the National Research Council (CONICET) a new drought resistance event (HB4) has been developed, and is in the process of being inserted in different crops (wheat and soybeans). At the same time, there is advanced work for the production of enzymes in safflower. This work covers chymosin - an enzyme used in cheese production– and cellulase – which has potential in second generation biofuels.

Bioceres also has alliances with other local and international firms for product development and to facilitate market access in products where they do not have enough experience. Alliances for product development include joint ventures with Verdeca for the development and deregulation of soybeans varieties; with Trigall Genetics for the development and deregulation of wheat varieties; with Semya for next generation biological; and with S&W Seed Co. of California for a variety of issues of common interest. There are also other joint ventures of different levels with local and international firms, such as Advanta, Arcadia, Pioneer, Rizobacter, and GDM Seeds. Market access is under the responsibility of the Seeds Division of Bioceres, which commercializes all the products under the Bioceres Seeds brand.

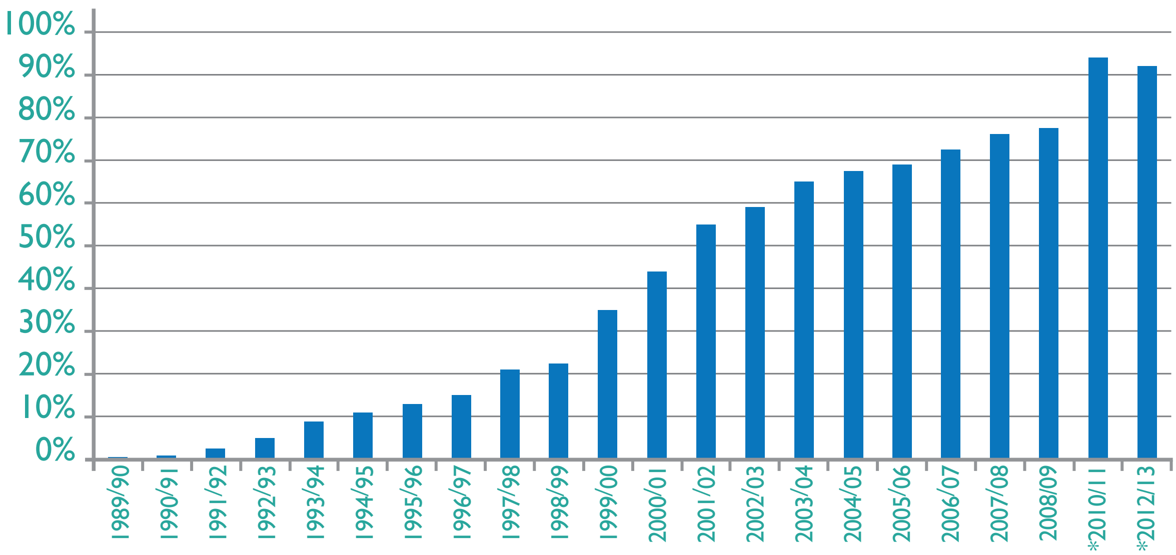
c. Widespread utilization of environmentally friendly production systems (sustainable biomass)

The progressive deterioration of soils in the Pampean región, which started at the end of the 1980s following the abandonment of crop-livestock rotations ("grassland farming") –prevailing in Argentina since the establishment of modern agriculture– set in motion a process of revision of the conventional tilling systems utilized for many years (similar to those used in the USA, Europe and other countries with mechanized agriculture).

The creation of the "Asociación Argentina de Productores en Siembra Directa" (AAPRESID) in 1989 was a key landmark for the development and promotion of a new agricultural paradigm, based on no-till. This NGO of agricultural producers interested in soil conservation, was supported by other private entities such as the "Asociación Argentina de Consorcios Regionales de Experimentación Agrícola" (AACREA) and several of the country's academic and technological institutions (INTA among them). They developed and promoted the main components of a new more sustainable, as well as productive, approach to agriculture, which is based on increased knowledge and technologies aimed at implementing a more productive and sustainable use of natural resources (which currently is known as "sustainable agricultural intensification").

Figure V.4. shows the rapid and massive adoption of no-till cultivation in Argentina (which is the available indicator). However, the technological package of this type of "sustainable intensification" is more than no-till. The system includes the use of improved seeds –including herbicide tolerant and insect resistance genes–, crop rotations, integrated pest management, management of the soils microbioma, soil nutrition improvement based on use of biologicals supplemented with fertilization; and intensive use of information and communications technologies (ICTs), together with "precision agriculture" practices in more recent times.

FIGURE V.4. Share of area planted with direct sowing in Argentine grain production
(percentages of total area planted with annual crops)



Source: AAPRESID, 2012, and Bolsa de Cereales for the last two years.
Note: * The increase registered during the last two crop years is partially associated with the fact that the methodology implemented by Bolsa de Cereales weights the area planted with direct sowing for each crop.

This new agricultural approach brings together different scientific disciplines, such as ecology, eco-physiology, genomics, biotechnology, crop nutrition and biological protection against biotic and a-biotic stress, ICTs, etc. In this context, **good agricultural practices** –GAPs– have a strategic importance, as they are the tools allowing the adaptation of new knowledge to agricultural innovation processes. At the same time they contribute to resource conservation and to the reduction of global warming. Argentina has been pioneering in this field, with the creation of a network of GAPs in 2014, which includes all the major agricultural public and private institutions in the country. This network works to define and measure the main components of GAPs, and coordinates the different institutions training and promotion programs (see Box 5 for more details).

BOX 5: Good Agricultural Practices Network

In May 2015, after more than a year of preparatory work, and following an initiative of the Buenos Aires Grain Exchange, the Good Agricultural Practices Network was formally constituted. The initiative is the result of an inter-institutional dialogue, bringing together the main public and private entities interested in sustainable agriculture in Argentina. The network was created because it was felt that a formal mechanism was needed to fully exploit the work and information available in a field where cooperation is essential for success.

Good Agricultural Practices have been defined as a production strategy which assures that all production processes, from seeding to harvesting and post-harvest, fully meet health, safety and sustainable production requirements.

The network understands that GAPs are a strategic instrument for adequately meet the challenge posted by the qualitative and quantitative demands that are expected from agroindustry, which imply an integrated view of health, safety and sustainability issues.

The network promotes that resources and products are used responsibly with no negative effects on human and animal health, nor on the environment, and protecting the safety of workers involved in the production processes.

Member institutions include:

Source: www.redbpa.org.ar

In summary, sustainable intensification works to increase production with reduced soils erosion and better soil/water management, through minimizing tilling, fossil energy use, and reducing greenhouse gases emissions. The basis of the system is the permanent soil coverage using the stubble of the previous crop, which promotes carbon sequestration, together with a crop nutrition strategy based on biological and soil structuring, rather than massive use of fertilizers. Crop rotations and integrated pest management contribute to improve soils structures and to reduce the use of agrochemicals in crop protection, so limiting the groundwater contamination and agricultural greenhouse gases emissions.

d. High production potential and competitiveness of vegetable oil, biofuels, and other biorefinery products.

d.1. The soybean, vegetable oil, and biodiesel production "cluster"

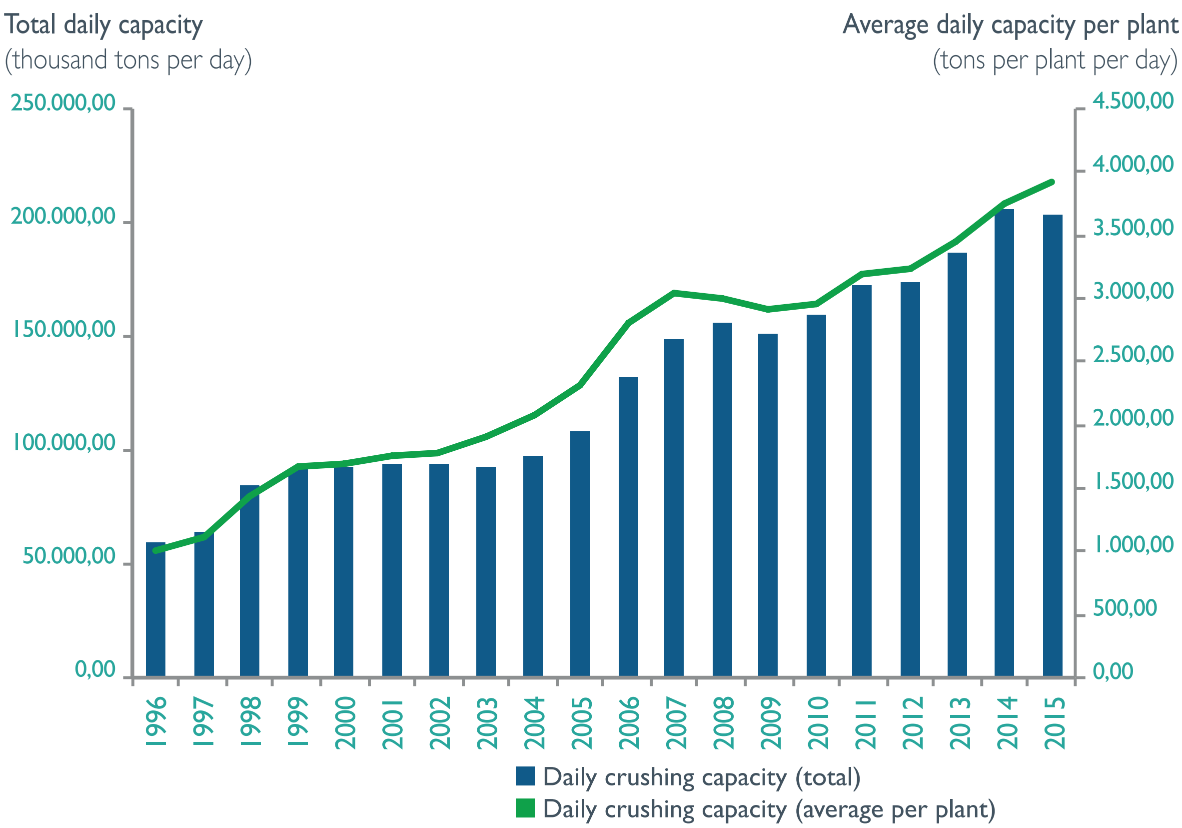
As it was detailed in Tables IV.1.to IV.4., the supply of raw materials for biodiesel production in Argentina is quite large and largely exceeds present and potential domestic biodiesel demand.

Argentina has been for quite some time the main exporter of soybean oil and meal. More recently the emergence of a strong world biodiesel demand has triggered a diversification of vegetable oil utilization, through the inclusion of biodiesel into the production and exports of the oilseeds value chain. This has also increased the production of biorefineries' industrial by-products.

The high level of competitiveness of Argentine soybeans production is also the case of the vegetable oil and biodiesel industries. Over the last two decades there has been a significant increase in oilseeds crushing and biodiesel processing capacities, with large, modern and highly efficient plants, localized mostly next to export port facilities. All these strengths are without any doubt, key elements in the making of Argentina the world leader in biodiesel exports.

Figure V.5. highlights the dynamism of soybean processing capacity, which by early 2015 has reached about 200 thousand tons per day (some 66 million tons per year, with an estimate of 330 days of operation).

FIGURE V.5. Evolution of soybean crushing capacity in Argentina

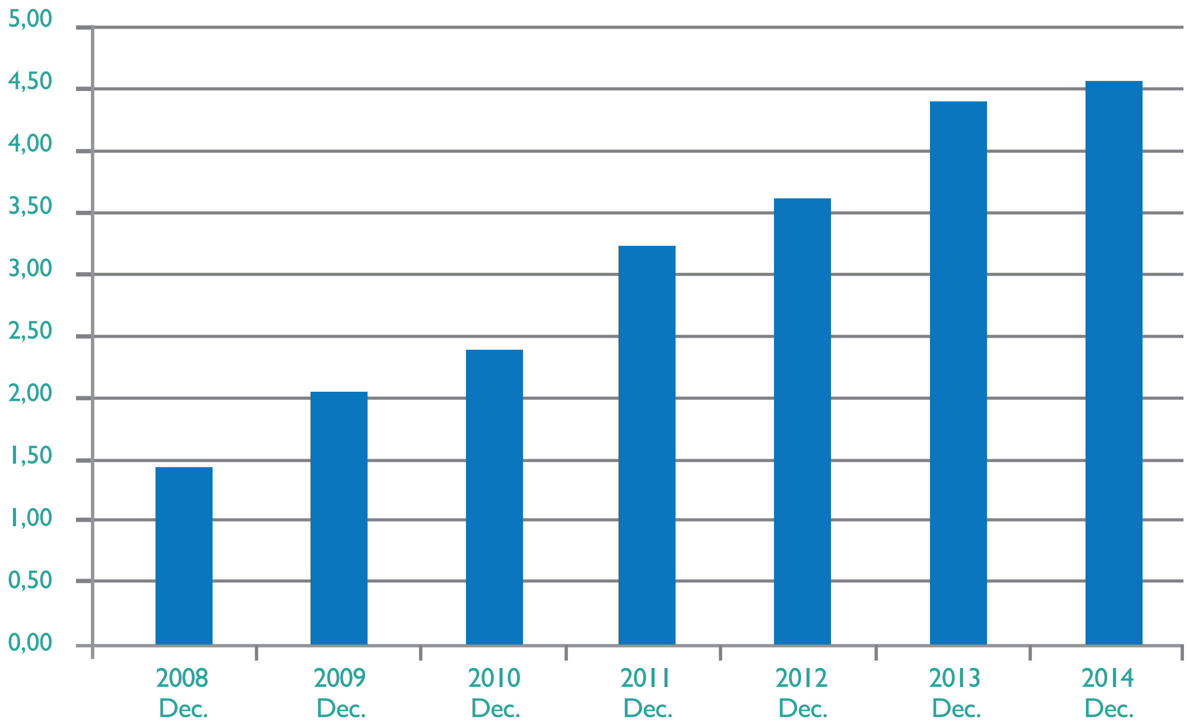


Source: Based on data published in J.J. Hinrichsen annual reports for the period 1996-2015.

The 14 largest processing plants, with 72% of total capacity are in the Santa Fe Province, and have a daily production average capacity of 10,200 tons per plant, per day (much larger than the average plant size in Europe, Brazil, and USA) and are located next to export facilities (differing of what is the mode of most of the plants in competing countries). These characteristics, together with the efficiency and competiveness of primary production in Argentina are the key factors explaining the strengths of the country's oilseeds value chain.

The development of biodiesel refineries is more recent, but there has also been a significant growth with large size plants, when compared to those of other competing countries. Figure V.6. shows the evolution of biodiesel production capacity; it reached 4,3 million tons per year by the end of 2014. Such capacity is enough to meet local and world biodiesel imports estimated for 2015. Also in the case of biodiesel the prevailing model is that of modern and large plants, located close to export gateways. The main 10 plants are located in the ports of the Province of Santa Fe, and they represent 77% of total capacity, with an average daily processing capacity of 330 thousand tons per plant.

FIGURE V.6. Evolution of annual biodiesel production capacity in Argentina
(million tons per year)



Source: CARBIO y J. J. Hinrichsen data. 2015.

The soybeans based "cluster" (primary production, oils extraction, biodiesel production, and exportation of the different products) is highly competitive on international standards; such competitiveness is based on the intensity and efficiency of its technological infrastructure throughout the value chain, the average size of the processing plants, and the localization of strategic facilities close to or at the export sites.

High and low scenarios for the potential evolution of Argentinean biodiesel production up to the end of the decade, including projections for 2021, are presented in Table V.2.

Table V.2. Biodiesel production in Argentina in year 2011 and projections for the year 2021*
(million tons)

Products	Production 2011	Projections 2021	
		Low assumptions	High assumptions
Biodiesel	2,42	3,92	4,43

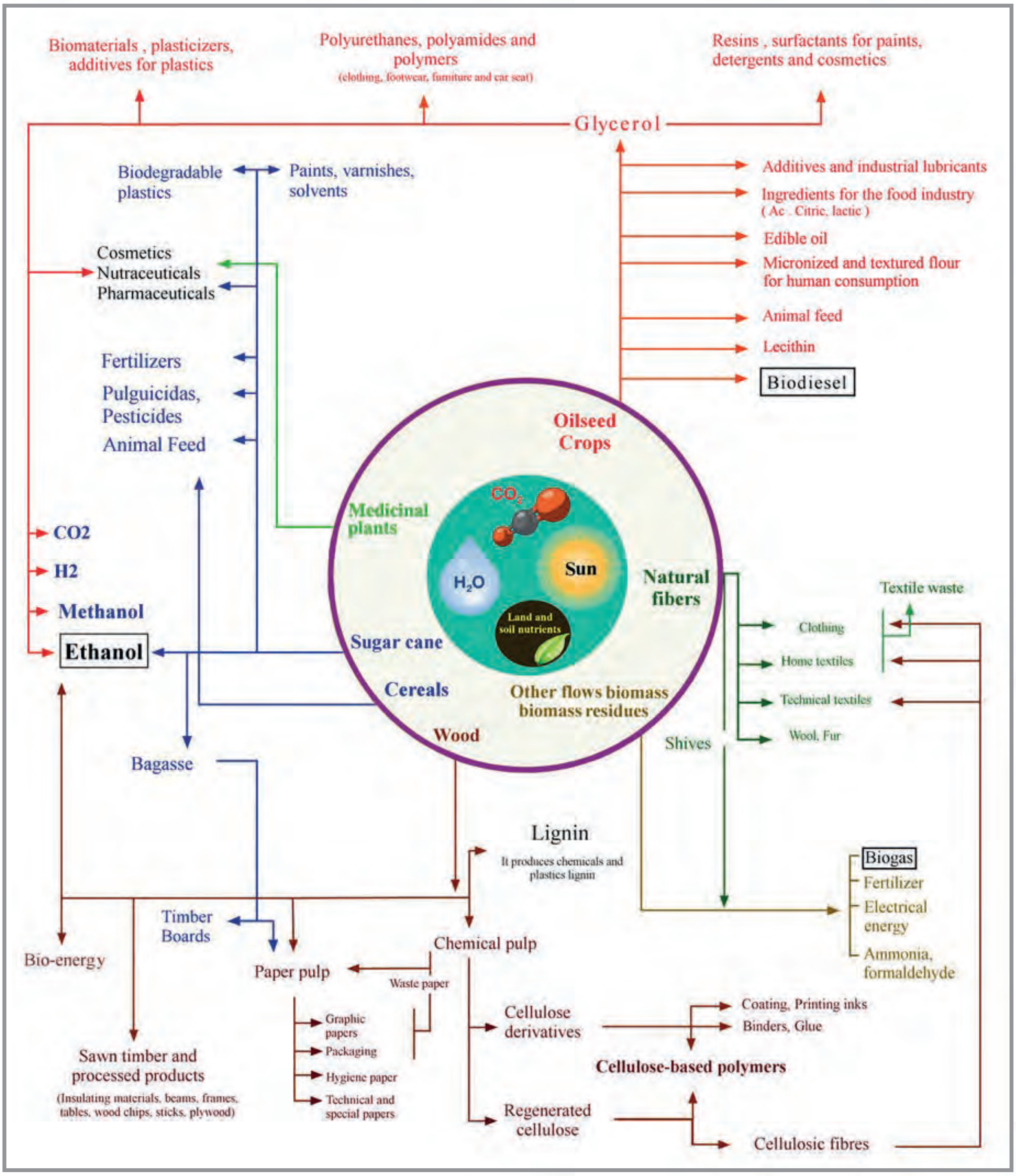
Source: Trigo, E., Regúnaga, M. et al, 2012.MINCYT.
Note: * Estimates based on different scenarios of evolution of local and international demand of biodiesel.

It should be noted that the Argentine biodiesel production potential, processing local soybean oil, is much higher than the assumptions indicated in Table V.2.; the table estimates require only a fraction of total Argentine soybean oil production -approximately 30% of the total-, since those volumes were estimated on the basis of FAO-OECD biodiesel world demand and trade estimates for 2021. This allows saying that the potential supply of biodiesel could not only meet the anticipated domestic and international trade demand, but also could serve as platform for other type of important industrial developments associated with the new alternatives provided by the biorefineries.

d.2. Potential supply of industrial inputs/products processed in biorefineries.

Given the high production potential of the different sources of renewable biomass available in Argentina, it is of interest to schematically explore the diversity of products that can be generated from a biorefineries approach. Figure V.7. presents existing "down stream" industrial options starting from the main biomass sources. It is to note the high value opportunities that exist, many of which are today covered through imported oil derivatives.

FIGURE V.7. Alternatives for industrial use of biomass in Argentina (2015)



Source: The authors on the basis of file: ///Users/eduardotrigo/Downloads/14-01_ industrial_ material_ use_ of_ biomass_in_europe_2013_nova_institut%20(3).pdf

Given the present and potential production volume of biodiesel and its by-product, the glycerol, it is of interest to look at the opportunities in the domestic market for glycerol chemical derivatives. These alternatives could be very attractive in terms of adding value to a very low priced product in Argentina, such as the glycerol[19]. Within the wide spectrum of potential products, we have selected just a few

(19) It should be noted that by the end of 2014, there were already in operation two plants for glycerol processing in the ports of the Province of Santa Fe (RENOVA and ECOFUEL S.A.), with a processing capacity of 54 thousand tons each.

chemicals, which have significant demand in Argentina, with prices which are 10 times or more over the price of glycerol in the domestic market.

On the basis of the 2011 yearly production of glycerol, there is the possibility of producing about 162 thousand tons of ethylene glycol; or 221 thousand tons of propylene glycol; or 145 thousand tons of citric acid. These three products have significant consumption levels in Argentina. In the case of ethylene glycol (or 1,3 propanediol), there is no local production, and consumption is up to 70 to 80 thousand tons per year, which are imported in whole at a price ranging from USD 900 to 1,000 per ton; the main use of ethylene glycol is PET production (polietilene terephthalate) for containers and textile use. Propylene glycol is used mainly in polyester resins and in humectants, with a yearly consumption of about 10 thousand tons, which are imported at a price ranging from USD 1,400 to 1,600 per ton. In the case of citric acid, annual consumption is about 25 thousand tons, with prices of about USD 1,200 per ton; citric acid goes 50% to juice and non-alcoholic beverages production, 30% to food production, 10% is used in pharmaceutical production, and 5% in solid detergents production. Table V.3. compares the potential production of these glycerol based products and present consumption and imports, and its prices.

Table V.3. Chemicals obtained from processing of glycerol: potential production, consumption and imports in 2011

Products	Potential production in 2011 (thousand tons)*	Consumption (thousand tons)	Imports (thousand tons)	Import price (dollars/ton)
Ethylene glycol	162	70-80	70-80	900-1.000
Propylene glycol	221	9-10	9-10	1.400-1600
Citric acid	145	20-25	20-25	1.200

Source: Data from Trigo E., Regúnaga, M., et al. 2012. MINCYT.

Note: *These are the máximum alternative productions that could be obtained from the processing of the glycerol produced in such year.

d.3. Other biomaterials and meals derived from soybeans

Besides biodiesel and glycerol derivatives, soybean crushing produces oil and high protein meals that could also serve as basis for other bioproducts. Vegetable oil could serve as basis for biodegradable lubricants, surfactants, colorants, and a variety of polymers. In the case of meal, besides animal feed, it could be utilized for the production of protein concentrates, isolated proteins, and different types of micronized, texturized and activated meals. All these products have prices significantly over those of the traditional food and feed uses.

The high present and potential production volumes of soybeans crushed[20] could serve as a strong platform for projects aiming at the further industrialization into higher added value products, both as biomaterials or high value food and feed ingredients.

(20) For 2021 production was projected to be between 66.0 and 77.6 million tons of grain, which could allow the production of the following by-products: i) 11.88 to 13.97 million tons of vegetable oil; ii) 52.8 to 62.1 million tons of meal.

d.4. Regional development alternatives producing maize by-products

Theoretical ethanol supply from maize processing is very large (more so, if sorghum and other grains are added). Assuming that the total 2011 maize production was used in dry milling, ethanol production could have reached 9,300 million liters, and 7.4 million tons of DDGs and CO2 (its main by-products). Estimates for 2021 would reach 11,700 to 14,000 million liters of ethanol, 9.3 million tons of DDGs and 11.1 million tons of CO2 (Table V.4.).

Table V.4. Maximun potential production estimates of corm ethanol and corn byproducts obtained with dry milling in Argentina in 2011 and 2021*

Total production	Units	2011	Projections 2021	
			Low assumptions	High assumptions
Corn	Million tons	23,0	28,8	34,6
Ethanol	Million liters	9.325	11.674	14.026
DDGs**	Million tons	7,39	9,26	11,12
CO2	Million tons	7,39	9,26	11,12

Source: Trigo, E., Regúnaga, M. et al, 2012.MINCYT.

Notes: * Assuming the processing of total corn production. ** DDGs (distillers dried grains) are very nutritious feed for dairy production.

The development of maize dry milling plants for the production of ethanol and by-products in Argentina is already underway. Towards the end of 2014 there were eight plants in operation, with a total processing capacity of about 800 thousand cubic meters (about 2 million tons of maize).

These initiatives are of strategic importance, since most of the new plants are located in the hinterland and not close to the ports. Actually there is an important regional development potential, not only through ethanol production, but also linked to improved food production (livestock and dairy), and other industrial productions incentivized by low cost energy availability. Box 6 describes the cases of ACABIO and Bio 4 S.A., both in the Province of Cordoba, and that of BIOTERAI in the Province of Chaco.

BOX 6: ACABIO and BIO 4 S.A. in Córdoba, and BIOTERAI in Chaco

ACABIO is an initiative of the Association of Argentinean Cooperatives, ACA, a second degree organization with a constituency of 65 first level agricultural coops, with about 20,000 thousand direct members, supplying maize for industrial processing. Located in Villa Maria, Cordoba, it is at the center of a large dairy and grain production region; it generates 92 direct jobs, and more than 150 indirect jobs.

The project objectives focus on adding value to grain production, on developing the bioenergy business to help in the diversification of the energy matrix, through increasing the share of renewable sources and environmental sustainability, and facilitating the further integration of the member coops into the food and energy industries.

The project is based on a highly automated process, with recuperation of CO_2, co-generation of electricity (6 MWh), production of DDGs (dry) or WDGs (wet), extraction of maize oil for the production of biodiesel, and zero effluents released into the environment.

Existing capacity allows processing 380 thousand tons of maize per year, to produce 145 thousand cubic meters of bioethanol per year (mostly going to gasoline fuel blend); about 70 thousand tons of DDGs (or 175 thousand tons of WDGs per year), which are enough to feed 70 thousand cows per year*; generate 33 thousand tons of CO_2, mostly going to beverages; and 2,000 thousand tons per year of maize oil.

BIO 4 S.A. is a private association of 29 members (the majority of them involved in farming), seeking to add value to maize produced in the region, through associativism and an agroindustrial vision. The firm put up the first maize ethanol plant in Argentina, located in the city of Rio Cuarto, in Cordoba. It generates 125 permanent direct jobs, 37% of which are university graduates.

Through industrial transformation Bio 4 increases by three the value of the maize produced in the region, and also saves significant figures in transportation export costs to the harbors. Most of the ethanol produced goes to fuel blends (intended to reduce green house gasses emissions), and the sales of by-products –WDGs and DDGs – which mostly go to the regional livestock industry (dairy and meats productions).

Production capacity is enough to process 210 thousand tons of maize per year, which means 83 thousand m3 of ethanol and 191 thousand tons of wet by-products (WGDs with 35% of dry matter), or 74 thousand tons of DDGs (with 90% of dry matter). Since 2014, the firm has been certified as ISO 9001:2008, for its main products (bioethanol, WDGs and DDGs).

BIOTERAI S.A. is a family business –AED company- producing ethanol, associated initially with a large scale feedlot located in Avia Terai, Province of Chaco. The project provides direct employment to about 60 people, and in the future it will incorporate the production of buffalo milk for cheese production, as well as energy co-generation. It is expected that these activities will contribute to lowering the cheese production costs, and improve its competitiveness and employment creation capacities.

Ethanol production capacity is about 350 thousand liters/day (320 thousand tons per year) which are integrated with a feedlot producing about 100 thousand head/year, and using 100 thousand tons of dry matter coming from the WDGs as feed (cheaper than the DDGs, since there are no drying costs) with high protein and energy content (60% of total), complemented with maize stubble. The plant competitiveness is based, on one hand, on the lower regional maize prices (19-20% cheaper that the Rosario port prices), and on the other hand, because it uses cheap energy from woody biomass and cotton agricultural residues for the production of electricity and steam. These factors contribute significantly to reduce the costs of ethanol and feed for livestock production.

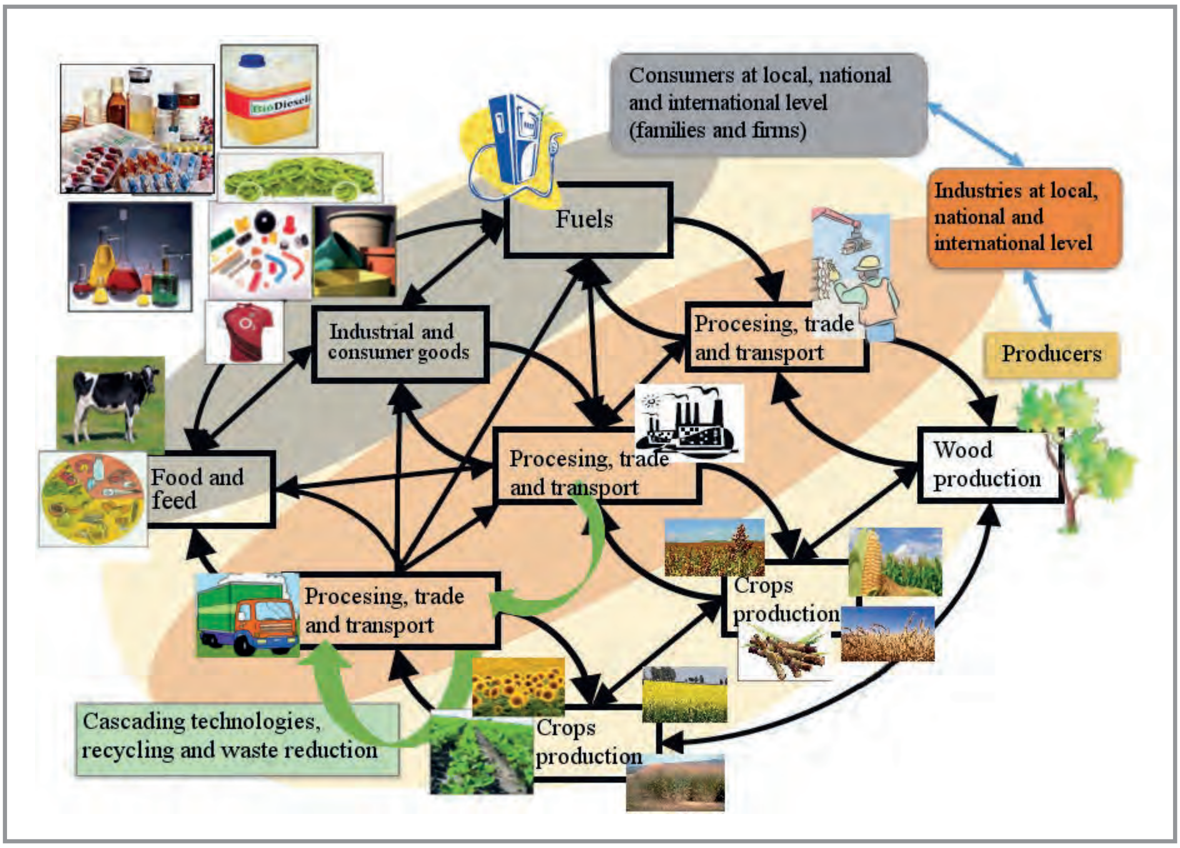
Note: * DDGs have a nutritional value, in metabolizable energy, similar to that of maize gran, and three times in protein value, and can make up to 15%-30% of the daily feed ration for dairy cows.

VI. AN ESTIMATE OF THE CURRENT SIZE OF THE ARGENTINEAN BIOECONOMY[21]

As indicated above, the bioeconomy is not a well defined sector, but rather an industrial strategy that cuts across the whole economy, and includes a wide variety of sectors and parts of sectors, traditional and new, which share the use of biological resources or processes as a central component of their production (see Box 2). This is triggering a profound transformation in existing inter-sectoral relations, making the concepts of sectors and value chains become fuzzy notions, as they are increasingly interlinked in new and complex ways, as a result of changes in natural resources use, the role of knowledge, capital and labor, the generation and capturing of externalities, and the distribution of economic benefits in the new activities (von Braun, 2013).

Traditional value chains, conceived as linking activities from production of raw materials up to transformation and consumption, adding value in each step, in a relatively lineal way (making-up what is usually known as "industry"), within the bioeconomy loose much of their original meaning; emerges what can be described as a "value network", where different raw materials contribute to different value chains, depending on demand conditions, technological availability, and the opportunity costs of involved resources in each specific situation (see Figure VI.1.).

FIGURE VI.1. Value networks in the bioeconomy



Source: the authors on the basis of Virchow, D.et.al (2014)

(21) This section is based on the document published by Wierny, M, et. al.(2015).

Industrial strategies in the bioeconomy emphasize the interrelations that exist among different value chains. Instead of looking at an "industry", the "value network" approach looks at the set of goods that could be produced from a given raw material, and even taking into account the fact that raw materials themselves can be substituted. The focus is on the synergies and how chain interactions and the total value generated by the system could be optimized. Within this "network approach" inefficiencies are highlighted, and it is possible to identify productivity improvement opportunities at the local, national or international levels. In this sense, recycling potential and cascading approaches at processing play a significant role for the development and capturing of added value at the local level[(22)]. The use of cascading approaches and value chains interrelations are strategic to increase natural resources' use efficiency, innovation and new business development, and to reduce the potential conflict existing between alternative uses.

All these dynamics makes the measurement of what is the present and potential contribution of the bioeconomy to the GDP in the different countries a complex undertaking. Today there is no standard methodology for a precise measurement of what is the contribution of the bioeconomy to the GDP and its comparison to what happens in other economies. The difficulty is associated with its horizontal nature, with the type of technologies on which it is based, and the fact that the bioeconomy is a new issue and, in many cases, not present in the discussion an implementation of public policies, both at the national and international levels.

These complexities are even more compounded by the fact that there is no international agreement about the products and activities that should be included in the bioeconomy. This is quite evident when comparing the concepts used by the White House in the USA and those utilized by Germany and other European countries (see Box 1). In this sense, it can be easily seen that there are several criteria in play, reflecting mostly the different views that countries and international organizations responsible for defining policies and programs have to promote its development.

The most commonly used criteria for classifying economic activities, international trade and products at the international level (CIIU, NCE, CPC), do not adequately reflect the complexity implied in the bioeconomy. In the same way, the United Nations National Accounts System (SCN08) in use today, and which provides recommendations for the measurement of production and well being, among other economic dimensions, with cross country comparability, does not provide much guidance when set in the context of the bioeconomy.

In spite of this, it is possible to develop a measurement of the contributions of the bioeconomy to the Argentinean GDP starting from a definition about the products, the inputs, and the activities to include as forming the bioeconomy. In the case of Argentina, the activities contributing to the bioeconomy of the country's GDP are included on the basis of the following criteria:

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(22) Cascading use of biomass takes place when biomass is processed into a bio-based final product and this final product is used at least once more, either for materials or energy. Cascading use of biomass is described as **single-stage** when the bio-based final product is directly used for energy. Cascading use of biomass is described as **multi-stage** when biomass is processed into a bio-based final product, and this final product is used at least once more as an input before being destined to energy use. (Defining cascading use of biomass, nova-Institut GmbH, Discussion paper, 2014, https://biomassekaskaden.de/wp-content/uploads/2014/04/14-03-14_Cascading_ use_Discussionpaper.pdf,)

a. Uses biomass as inputs
b. Uses biotechnology as an input
c. All the activities and products that use biomass and biotechnology as inputs

This definition of the bioeconomy includes the production of biological renewable resources and its conversion into food, feed, biobased products, and bioenergy. It includes agriculture, forestry, fisheries, food, pulp and paper production, as well as parts of the textile, chemical, energy and pharmaceutical industries. On the basis of such definition and a methodology specifically developed to this purpose, Wierny, et. al. (2015) estimated that in the year 2012 the Argentinean bioeconomy represented 15.4% of the country's GDP, and its added value was A$ 330,700 million (USD 72,700 millions approximately, when calculated at the official exchange rate[(23)]).

This contribution to the GDP represents an amount larger than the estimates for agriculture and agroindustry, since the bioeconomy includes other manufacturing sectors. This estimate does not include the value of the machinery and equipment used in the production of products, services and logistical activities linked to the above mentioned sectors and industries.

These figures are presented in Table VI.1. The primary production sector represents the largest share of added value of the bioeconomy: 58% (8.9% of GDP); and the remaining 42% comes from manufacturing sectors (6.5% of GDP). Of the later, about 72% of the manufacturing added value is of agricultural origin (AOM), and the remaining 28% are industrial manufactures (IOM).

Table VI.1. Share in GDP of different sectors which are part of the Bioeconomy. Year 2012*

SECTORS	ADDED VALUE BY THE BIO SECTOR			BIO share in total GDP (%)
	(Million pesos)	(Million dollars)	Share (%)	
Primary production Bio	**191.525**	**42.093**	**58%**	**8,9%**
Manufactured Bio	**139.149**	**30.582**	**42%**	**6,5%**
- Agricultural Origin Manufactures (AOM)	100.300	22.044	30%	4,7%
- Industrial Origin Manufactures (IOM)	38.849	8.538	12%	1,8%
Total sectors Bio	**330.673**	**72.675**	**100%**	**15,4%**

Source: Wierny, M. et al (2015).
Note: * Added value at producer prices.

Biofuels, which in some environments are considered to be the bulk of the bioeconomy, represent only about 3% of the total of the Argentinean bioindustry (Table VI.2). Biofuels from grains and oilseeds make up 79.5% of the total of this sector, while sugarcane based bioethanol accounts for 12%, and biogas the remaining 8.5%.

(23) 2012 yearly average, using the official exchange rate for the year (A$ 4.55 per USD).

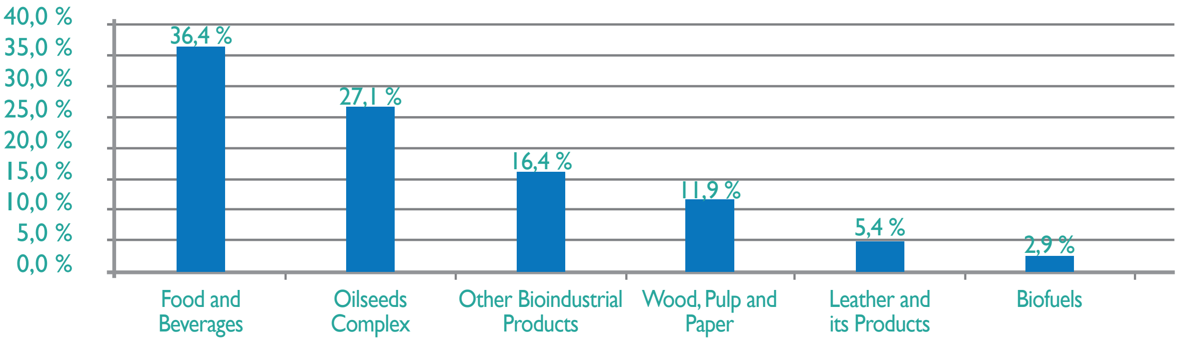
Table VI.2. Added value by biofuels in year 2012*

SECTOR	ADDED VALUE		PARTICIPATION (%)	
	(Million pesos)	(Million dollars)	Total manufactures Bio	Total Biofuels
Total Manufactures Bio	**139.149**	**30.582**	**100,0%**	
Biofuels	**4.052**	**891**	**2,9%**	**100,0%**
- Cereals and oilseeds' biofuels	3.219	708	2,3%	79,5%
- Sugar cane ethanol	488	107	0,4%	12,0%
- Biogas	345	76	0,2%	8,5%
Other Bio manufactures	**135.097**	**29.692**	**97,1%**	

Source: Wierny, M. et al (2015).
Note: * Added value at producer prices.

A high percentage of bioindustrial added value (97%) comes from other than the biofuels industries. This complex of activities is very diverse, with 27 different industrial activities making up 83.7% of the bio added value. If an aggregate is made of the main productive blocks, the main bioindustrial activity is generated by the set of food and beverages: 36.4%; 27.1% by the oil products; 16.4% by other bioindustrial products; 11.9% by the wood complex, pulp and paper; 5.4% by leather and its derived products; and 3% by biofuels (see Figure VI.2).

FIGURE VI.2. Participation of the main subsectors in the added value by the bio industries in year 2012



Source: Wierny, M. et al (2015).
Note: * Added value at producer prices.

VII. FINAL COMMENTS: ISSUES FOR A NATIONAL STRATEGY FOR THE DEVELOPMENT OF THE BIOECONOMY IN ARGENTINA

The context needed for the development of the bioeconomy

The opportunities that the bioeconomy offers to Argentina are very important and they will increase significantly in the coming decades. The drivers of this process are linked to the anticipated evolution of the food and feed markets as consequence of population and income increases, and what these processes will mean in terms of diets and food preferences. But they also respond to new demands for industrial goods and services, emerging from increasing interests in natural resource conservation, and the need of better strategies to mitigate the effects of climate change.

Argentina has some weaknesses associated to its industrial infrastructure, and its average level of competitiveness, but it also has advantages based on its wide biomass supply, both in volume and diversity. Its strengths in the science and technology area, and with respect to the solid private institutions in agriculture and agribusiness, are key assets supporting future development strategies.

The bioeconomy vision offers the possibility to confront society's demands using new and more intelligent ways of using available renewable energy sources ("clean energies", with environmental benefits). But the transition to new behaviors is not going to happen unless an adequate policy and incentives framework is developed. Existing experiences show that the bioeconomy not only calls for a new knowledge base; it also implies much wider changes in social and economic organization and in the behavior of individual actors regarding the orientation of investment and production decisions, consumer preferences, etc. Therefore, it is necessary to implement the needed changes in policy and regulations in order to promote and direct the new processes, as well as to appropriately manage the costs involved in the path from the old to the new more environmentally friendly and sustainable approaches. This has been widely recognized at the global level, and clearly is shown in the different formal strategies that have been designed, both by the OECD countries and in other parts of the world.

A bioeconomy based economic and social development strategy requires an action plan bringing together all the different areas of the public policy (macroeconomic, fiscal, trade, agricultural, industrial, science and technology) within an integral vision; and, at the same time, promoting private sector activities aimed at consolidating a process of sustained and environmentally friendly growth of employment and production, and contributing to the competitive insertion of Argentina in the global economy.

It is necessary to highlight that a transformation process of the magnitude as the one the bioeconomy implies, calls for a solid economic and institutional environment. Macroeconomic stability, long term investment incentives, legal security, transparent and stable intellectual property regulations, among other aspects, are key drivers for the development of the R&D activities and the long term investment processes required by bioeconomic developments.

A key aspect limiting Argentina's industrial development has been the absence of convergence between investment and access to credit, mainly due to the lack of a healthy and stable macroeconomy, which are necessary conditions to sustain inflationary rates at low levels, in line with world standards. In this sense, a prudent, sustainable and countercyclical fiscal policy, as well as its active coordination with monetary and exchange rate policies, are a priority to allow prevailing tax systems promoting production while at the same time protecting public revenues.

Encouraging new value networks that support the production of high added value products also implies to develop open, transparent and competitive markets. At the global level markets are increasingly internationalized; therefore, it is a high priority to review the country's international insertion strategy.

A bioeconomy with a low level of internationalization is neither advisable nor viable. So, there is the need for an in-depth review of existing trade approaches. Regional and multilateral agreements are essential platforms to reduce the transaction costs of global value chains, and to assure demand and market access for the new products of the bioeconomy, as well as the transformations it calls for.

Some specific issues to be considered in the design of a bioeconomy development agenda

Beyond the context issues mentioned, there are a number of specific issues that also need to be highlighted. They are related to the public acceptance and awareness of the new approaches; their advantages and also their implications; the kind of knowledge that needs to be generated; the human resources base; the legislation and regulatory frameworks; the funding mechanisms for the new activities; and the infrastructure issues emerging from the implied economic transformations.

Social awareness on the importance of the bioeconomy. Awareness on to what extent the bioeconomy is a desirable strategic alternative for the country is a key issue. What we have discussed in the previous sections is based on global trends opportunities. This is an important context; however a national strategy needs to reflect the country's specific conditions. The bioeconomy brings changes in the type of resources and the way they are going to be used; and this has consequences on their relative prices, and they could have significant social and economic impacts, both within and among regions and at the national level. To be able to make progress in this, there is the need to answer a number of critical questions. Some of them are: which resources are to be utilized and how are they going to be affected?; What are the benefits to be derived from the new approaches?; What are the advantages of biobased products when compared to the same products produced with conventional resources?; What are the expected impacts on regional income distribution and employment?; What are the most effective mechanisms to raise the society's awareness about the potential benefits of the bioeconomy for Argentina's sustainable development?.

Science, technology and innovation. Bioeconomy growth at the global level has been the result of the availability of a new knowledge base, which allows to resolve, at each step, the equation of "producing more with less" (the same with less, or more with the same), implicit in the bioeconomy concept. In this sense some of the questions to explore, include: Given the type of resources available and the existing capacities, which are the new disciplines and specific priorities that need to be promoted?; What are the most effective instruments to promote the type of R&D+i needed, and particularly to promote cooperative activities at the value network level?; Which are the international cooperation links and activities more effective to integrate the country's R&D system into the global disciplinary networks of interest for the bioeconomy?; What are the most effective instruments and incentives needed to promote an increased participation of the private sector in R&D activities, and to promote more productive public-private partnerships?.

Human resources. A successful transition into the bioeconomy needs scientific-technological capacities; but it also needs human resources of high technical level at the management and production levels, which should be able to understand and effectively manage the dynamics of biological processes, as well as to interact intelligently with R&D capacities. Biostrategies (bioprocesses and bioproducts) are, in general, much more knowledge intensive than conventional approaches, and in many times the biological knowledge among those responsible for implementation are at best limited. In some cases this is influenced by ideology and even religion; therefore, is it not a matter to address lightly. Some of the questions here are: What are the capacities that need to be developed in the private sector?; and in the public sector?; What is the best strategy to build these issues into the educational and labor training system?; How do we make them to co-evolve with demands from the bioeconomy?; How can specific training centers with focus on innovation and the creation of biobased products should be put in place?; How can modern process engineering technologies and green chemistry principles be more effectively integrated into technical and conventional training/educational systems?; How these initiatives should be coordinated with universities and graduate schools?.

Legislation and specific regulations. As discussed throughout the document, the bioeconmy is about changes in the usual ways things are done. Changes in the type of resources used and in the ways they are used, changes in behaviors, technologies, products and markets that today are taken as the standard, and should be fully incorporated into the legal and institutional frameworks that promote and regulate going activities. Some aspects of the bioeconomy will be able –and in practice they already are– to evolve within existing frameworks. However, as they become more predominant, they will require their own legislation and regulations, reflecting their specificities, potentials, opportunities, and emerging conflicts, if that is the case. The following are some of the questions relevant to answer in relation to the legislative and regulatory process: What are the priority legal and regulatory frameworks that should need reviews?; How to assure that markets and new regulations evolve together?; What are the most effective mechanisms for social participation in regards to the new legal and regulatory frameworks?; What are the new interrelations among the different Ministries and public institutions that need to be promoted, to better reflect emerging value networks?; What are the best incentive and regulatory schemes to promote the demand for biobased products?.

Infrastructure and funding. The migration to new forms of utilization of biomass, not only needs changes in the technologies and processes, but also in the type of investments and territorial deployment of activities, and consequently in the logistics of inputs and products. As indicated above "biomass does not travels well", and this is a factor that re-defines the role of regional economies in future economic and social development strategies. This characteristic affects the dynamics of job generation and the way in which population is settled in the territory. A strategy for the development of the bioeconomy needs, in consequence, to answer questions such as: What is the type of physical infrastructure changes required by the bioeconomy?; What are the needed changes in the present logistical matrix to reflect a new situation, needing to move millions of tons of low cost raw materials and products?; What are the investments required?; What is the role of the public and the private sectors in these processes?; How could the potential of capital markets be fully exploited to support the needed investments, and facilitate the emergence of long term credit opportunities for bioeconomy related activities?; What are the changes needed on existing financial mechanisms and instruments?.

As it can be seen, the type and diversity of changes are huge, and certainly they are not exhausted in the preceding list. This calls for the preparation of a road map, aimed at building a new strategy with an integral consideration of all factors involved.

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