Spanish Biorefineries

Manual

BioPlat
SPANISH BIOMASS TECHNOLOGY PLATFORM

SUSCHEM ES
Sustainable Chemistry

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BIOPLAT, the Spanish Biomass Technology Platform and SusChem-Spain, the Spanish Technology Platform for Sustainable Chemistry, have jointly prepared this *Spanish Biorefineries Manual*. The purpose of the Manual is to contribute knowledge about this promising bio-industrial sector and to identify the strategic advantages that are open to those who choose to avail themselves of this opportunity in Spain, as is already the case in other Member States of the EU. Given that, as shall be seen throughout the Manual, Spain has the resources and is particularly well positioned to do so successfully.

Before going any further, both Platforms wish to thank the Ministry of Economy and Competitiveness, in particular the Directorate General for Innovation and Competitiveness and the Subdirectorate General of Public-Private Collaboration, for the exceptional support they provide to all the activities that are undertaken within both Platforms. Without their support, it would have been practically impossible to carry out work such as this; which has involved large, small and medium-sized enterprises, public and private technological centres, universities, foundations, science and technology parks and publuc administration organisms of different autonomous communities and of the Gobernment of Spain have collaborated providing input to the work done. For more than two years, this multidisciplinary set of agents has shared their corporate and their research experience, their vision of the biorefineries that should be established in Spain and, above all they have shared great expectations as to the possibility of establishing this new concept of an industry supplied by biomass, one that has enormous potential for contributing to achieving several of the objectives that are pursued by socio-economic and environmental policies, both at the national and at the European and international level. BIOPLAT and SusChem-Spain are deeply grateful to all those who have been involved in the preparation of this Manual, not only for their valuable contributions but also for the effort and enthusiasm they have shown throughout this time. The publication of this *Spanish Biorefineries Manual* marks the start of a collaboration between the two Platforms and the sectors that they represent, biomass on the one hand, and sustainable chemistry on the other, because the fact is that there is still much to be done to achieve a solid implementation of a real bioeconomy for Spain. A wonderful challenge.

The *Spanish Biorefineries Manual* begins by addressing basic biorefinery concepts. It then goes on to analyse the biomass that exists in Spain, both qualitatively and quantitatively and the fact is that we are talking about indigenous resources that have characteristics that differentiate it from the biomass of other European countries. Once the diversity and the enormous amount of biomass resources that Spain possesses has been made manifest, the Manual then defines the transformation or recovery processes that can be applied to such resources in biorefineries and it outlines the types of biorefineries that are suitable for development in Spain. After presenting the technical aspects of the Manual, it then moves on to address the environmental, socio-economic and political framework within which biorefineries may be deployed in Spain. It finally analyses Spain's strategic position as far as the development of this bio-industrial sector is concerned, the added value that the country would enjoy if it were to commit to deploying biorefineries, and a series of final recommendations for the creation of a favourable environment that is conducive to investment in the field of biorefineries. The Manual ends with a sample of the initiatives that have already been undertaken in the field of biorefineries in Spain; because in spite of it being an industry that may well be considered as incipient, due to its limited deployment to date, in recent years consistent public-private initiatives have been launched that have had very favourable results.

EXECUTIVE SUMMARY

The Spanish biomass, bioenergy and chemical sectors have shown that they are increasingly interested in developing industries in Spain that jointly produce bioenergy/biofuels and other chemical/food bioproducts; in other words, in developing biorefineries. This interest is motivated by a series of **factors that place Spain in a strategic position** for the development of installations of this type:

- From the point of view of **the availability of biomass resources:** in Spain there is a more than ample (and historically underutilized) wealth of biomass of a diverse nature waiting to be exploited and recovered in industrial quantities. There is also great potential for the development and production of specific biorefinery crops on land that is currently fallow. This land should be put to good use, based on sustainability criteria established for that purpose.

- From the point of view of the **involvement of key sectors of the economy:** both the primary sector (agriculture, forestry and livestock) and the secondary sector (agri-food industries, forestry, chemicals, materials, etc.) are seeking to increase their competitiveness and to penetrate new markets for their products. The opportunity that biorefineries present is of great interest to private agents operating in those sectors.

- From the point of view of **scientific and technological capabilities:** in Spain there are sufficient scientific-technological resources associated with the field of biomass in general, and with chemistry and bioenergy in particular, whose excellence has been endorsed by first-rate publications and projects. In addition, the country has a strong and acknowledged biotechnology capacity for developing ad-hoc plant material, biocatalysts (enzymes and microorganisms) and other specific developments for industrial processes that require such materials.

- From the point of view of the **creation of employment and the generation of local wealth:** the high rate of unemployment in Spain must act as the driving force behind the creation and maintenance of jobs associated with innovative productive models, capable of generating high added value using the human capital and the resources that are found in the territory, such as biomass.

- From the **environmental** point of view: the exploitation of indigenous biomass contributes to converting potentially problematic waste into a resource and to making substantial savings as far as emissions of greenhouse gases are concerned, guaranteeing a socio-economic model based on sustainable development and actively contributing to mitigating the most important threat to society today: climate change.

- From the point of view of the **reindustrialization of the country:** the loss of industry is an incontestable fact that hampers the competitiveness of Spain. Industries such as biorefineries, whose activity promotes rural development and ensures environmental sustainability through the creation of opportunities that involve socio-economic dynamization and territorial articulation, are strategic for relocating European industry within the framework of the Union.

- From the point of view of **contributing to public policies at the European and the national level:** the firm commitment of the European Union to generating productive models that contribute to creating a European environment governed by the bioeconomy and the circular economy, together with the continuity given to such models by both the Central Government and the Autonomous Administrations in Spain, constitutes an appropriate framework for the development of a Spanish biorefineries roadmap that ensures the sound deployment of such biorefineries in Spain

To create boundary conditions that favour the development of biorefineries in Spain, it is necessary to take into account the following **recommendations:**

1) **Promote investment in research, innovation and training, in order to generate knowledge about the universe of biorefineries and to transfer that knowledge in an effective way to the market, given that improvements in technological learning curves will imply substantial progress in their competitiveness, allowing biorefineries to constitute economically viable alternatives to the traditional production systems.**

- Substantial funding of Research, Development and Innovation must be ensured at European, national and autonomic levels; a funding that considers that the deployment of biorefineries in the territory is a strategic priority. Corporate investment in biorefineries must also be promoted.

- Appropriate public-private models must be developed that make it possible to finance pilot projects and to demonstrate diverse biorefinery platforms capable of recovering indigenous biomass.

- Work should take place to ensure that private financial and capital risk entities are aware of biorefineries, so that they can extend their portfolio of financial products adapted to industrial facilities of this type and so that they can ensure their complementarity with public financing instruments.

- Given the particularities of this discipline, priority must be given to staff training. Not only from the point of view of training workers who are currently active, but also to training new professionals (University and Vocational Training academic programmes).

2) There is a need for a strong commitment both politically and on the part of the stakeholders concerned.

- An[1] Inter-Ministerial Biomass Committee must be set up, composed of those Ministries that are involved in the sector (Industry, Energy, Rural Affairs, Agriculture, Waste, Environment, Employment, etc.). It should also involve those Autonomous Communities that are interested in recovering the biomass that is found in their territories, and in generating socio-economic opportunities for their citizens.
- Coordinated work within this Inter-Ministerial Biomass Committee would improve synergies and coherence between the policies and actions of the various Ministries and the Autonomous Communities and at the same time it would contribute substantially to creating a robust bioeconomic policy in Spain, with strong ties to the territory, the primary sector and the markets of high added value.
- This Inter-Ministerial Committee must design a strategy to maximize the mobilisation of national biomass, so that it can be recovered in biorefineries located in different geographic areas. In this way, working at a local level will contribute to facing the social challenges that threaten society in the twenty-first century at the global level: food security, energy security and climate change.

3) Improve competitiveness and optimize the markets associated with biorefineries within the framework of the bioeconomy.

- It is essential to ensure a stable supply of biomass to the biorefineries; therefore, the establishment of a consolidated biomass market should be encouraged in Spain, identical to markets that exist for other *commodities*.
- In all cases, sustainable resource management must be guaranteed, making use of existing tools (such as forest certification systems, for example), and in the case of biomass from plantations, ensuring that such plantations do not compete with plantations that are used purely for food purposes and that they do not require an intensive use of inputs (water, fertilizers etc.).
- It is essential to promote the creation of the logistic networks and supply chains that biorefineries require, as well as a number of initial pilot and demo biorefinery facilities, duly integrated and diversified in the territory and able to absorb the amount of existing biomass in Spain.
- The outputs that are generated in biorefineries are bioenergy and bioproducts; therefore, a demand for such outputs must be guaranteed in the relevant markets by facilitating the development of standardized mechanisms for the evaluation of sustainability, the creation of differentiating labels and innovative public procurement.
- The increased long-term competitiveness of the new biorefinery production systems must be promoted, based on improving efficiency in the use of resources, minimizing the potential administrative constraints for placing new products on the market and promoting their internationalisation.

[1] In line with the already proposed and never executed PRE/472/2004 ORDER of 24 February, which created the Inter-Ministerial Committee for the use of biomass energy. Link: https://www.boe.es/diario_boe/txt.php?id=BOE-A-2004-3635.

CONCLUSIONS AND RECOMMENDATIONS

WHY DOES SPAIN HAVE A STRATEGIC POSITION FOR THE DEVELOPMENT OF BIOREFINERIES?

Spain has a high biomass potential that constitutes a solid basis and an outstanding starting point for the development of biorefineries, given that biomass is the raw material from which one will obtain energy, chemicals, materials, food and feed. It is already possible to use a large volume of biomass that is increasing every year and is currently underused. In addition, both because of its climate and its geography, Spain possesses optimum conditions for the primary production of certain biomasses, which would make it possible to use land hitherto marginalized or abandoned and to revitalize rural and industrial areas.

Apart from the important creation of jobs linked to biomass production and logistics, the exploitation of Spain's potential biomass would help to ensure the supply of raw materials to biorefineries and to reduce energy dependency by producing bioenergy and/or biofuels in these facilities.

Spain has a network of universities and centres of excellence with broad multidisciplinary knowledge in such relevant fields for biorefineries as chemistry, energy and biomass. These centres are recognised both nationally and internationally. Spain also has a large industrial fabric. The Spanish trinomial "science-technology-business" has accumulated considerable knowledge and it has a long tradition in terms of cooperation, a favourable prognosis indeed when it comes to developing a global and integrated system based on the use of biomass as a raw material for the production of bioenergy and chemicals, materials, food and feed that otherwise could not be obtained.

Deploying biorefineries will make it possible to introduce new business concepts that respond to the growing demand on the part of many sectors of the population and of the private sector, for technological innovations and sustainable solutions that imply savings in energy and resources while at the same time endeavouring to protect the environment.

The Spanish chemical sector is the leading industrial investor in Research, Development and Innovation. It generates 12.4% of Spain's Gross Industrial Product and 600,000 direct, indirect and induced jobs[2]. It is also the second largest exporter in the Spanish economy and the leading investor in environmental protection. Biorefineries would encourage the creation of chemical industry based on home-produced, indigenous biomass resources, whose products would provide an answer to a strategic commercial demand, providing it is economically viable.

[2] A snapshot of the Spanish Chemical Sector, 2016. FEIQUE.
Link: http://www.feique.org/pdfs/Radiografia_Economica_del_sector_2016.pdf

For its part, the Spanish biotechnology industry has great potential for development. Although medical biotechnology has to date accounted for 60% of the new products on the market, while industrial biotechnology has accounted for 26%[3], with the introduction of biorefineries the creation of new products derived from biomass would provide a major boost for the biotechnology sector, specifically for the development of industrial biotechnology. This emerging and expanding market, with high potential as far as the development of new bioproducts and biofuels is concerned, involves a broad spectrum of potential customers. Obtaining these new products, which traditionally come from oil, would reduce the consumption of finite resources and would prove environmentally advantageous to Spain.

3.7 billion euros will be invested in deploying the bioeconomy during the period 2014-2020

The European Commission has made a major commitment to move towards the circular economy by establishing a zero waste programme for Europe[4] and by adopting, in December 2015, a package of measures on the circular economy[5]. These measures seek to extract maximum value and to use all raw materials, products and waste, thereby promoting energy efficiency and reducing greenhouse gas emissions. Reusing biomass waste - produced both by the primary sector and by the population at large and industry - in biorefineries would fit perfectly with this policy by contributing to the transition toward the circular economy while avoiding the penalties associated with waste generation and/or landfill.
The early positioning of Spain and, therefore, its leadership in initiatives that promote the European circular economy is very important for the continuous development of our competitive industry and is something that can create employment and generate sustainable growth. The development of biorefineries, as well as research on new processes that take place in them, will make it possible to obtain vital knowledge with which to achieve rapid progress in new technologies for the use of biomass, not to mention new market niches. This transition would culminate in the obtaining of bioenergy, food and new products and materials of high added value.

The synergy of different markets - energy and products of high added value -, the existence of Spanish companies that have already entered the bioindustry sector and a highly developed cooperative system will make it possible to extrapolate the current business model to the biorefinery sector. Furthermore, the work of the Spanish Technological Platforms - as core stakeholders that articulate the different sectors and that know the key players involved in the development of biorefineries - provides a framework that encourages interconnection, networking and the achievement of a high degree of potential cooperation.

More than 3.7 billion euros will be invested in deploying the bioeconomy during the period 2014-2020, thanks to major European initiatives involving public-private collaboration such as the JTI Bioindustries[6] and the SPIRE PPP[7]. This makes it possible to envisage a major impetus being given to the implementation and development of markets based on the use of biomass as a raw material. Multinational companies with funds to invest, the 2014-2020 European framework budget and the

[3] ASEBIO Report 2013. Status of and trends in the biotechnology sector in Spain. ASEBIO.
Link: http://www.asebio.com/es/documents/InformeASEBIO2013_web.pdf

[4] COM (2014) 398 final. Towards a circular economy: a zero waste programme for Europe.
Link: http://eur-lex.europa.eu/resource.html?uri=cellar:50edd1fd-01ec-11e4-831f-01aa75ed71a1.0001.01/DOC_1&format=PDF

[5] COM (2015) 614 final. Closing the loop: an EU action plan for the Circular Economy.
Link: http://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF

[6] JTI Bioindustries. Link: http://bbi-europe.eu

[7] Sustainable Process Industry through Resource and Energy Efficiency (SPIRE) Public-Private Partnership (PPP). Link: www.spire2030.eu

important involvement of the governments of the Member States, through the development of new policies based on the circular economy and the bioeconomy, augur well for a promising future for these industries, and Spain should take a leading position in this new era of biorefineries.

But European initiatives are not the only ones that are being implemented. At the national level, the *Spanish Bioeconomy Strategy: Horizon 2030* was drawn up during the course of 2015. It seeks to take advantage of the advances that are taking place in different areas in order to improve competitiveness. As a result of this strategy, it is expected that action plan will be implemented with specific measures to develop the bioeconomy. In this context and in order to achieve those objectives, biorefineries must be an important axis. Finally, at the regional level, thanks to the Intelligent Specialization Strategy (RIS3), the Autonomous Communities have drawn up their own respective multiannual strategies and have included the bioeconomy as one of the areas to be promoted.

By way of summary, one may conclude that Spain is in a strategic position for the development of biorefineries for the following reasons:

- **In Spain there is a more than ample (and historically underutilized) wealth of biomass of a diverse nature waiting to be exploited and recovered in industrial quantities.**
- **There is great potential for the development and production of specific biorefinery crops on land that is currently fallow.**
- **In addition, the country has a strong and acknowledged biotechnology capacity for developing ad-hoc plant material, biocatalysts (enzymes and microorganisms) and other specific developments for the industrial processes that require such materials.**
- **Spain needs to be reindustrialised and it has to pay special interest to those industries whose activity promotes rural development and ensures environmental sustainability, through the creation of opportunities that involve socio-economic dynamization and territorial structuring.**
- **There is a compelling need to create and maintain jobs associated with innovative productive models, capable of generating high added value, ensuring sustainable development and actively contributing to mitigating climate change.**
- **Corporate stakeholders and scientific-technological agents, both public and private, are highly interested in developing industries that jointly produce bioenergy, biofuels and other chemical or food bioproducts.**
- **In Europe there is a firm commitment to relocate European industry within the framework of the Union and to generate productive models that contribute to creating a European environment governed by the bioeconomy and the circular economy. Spain is also contributing to this new model thanks to the development of different national and regional strategies.**

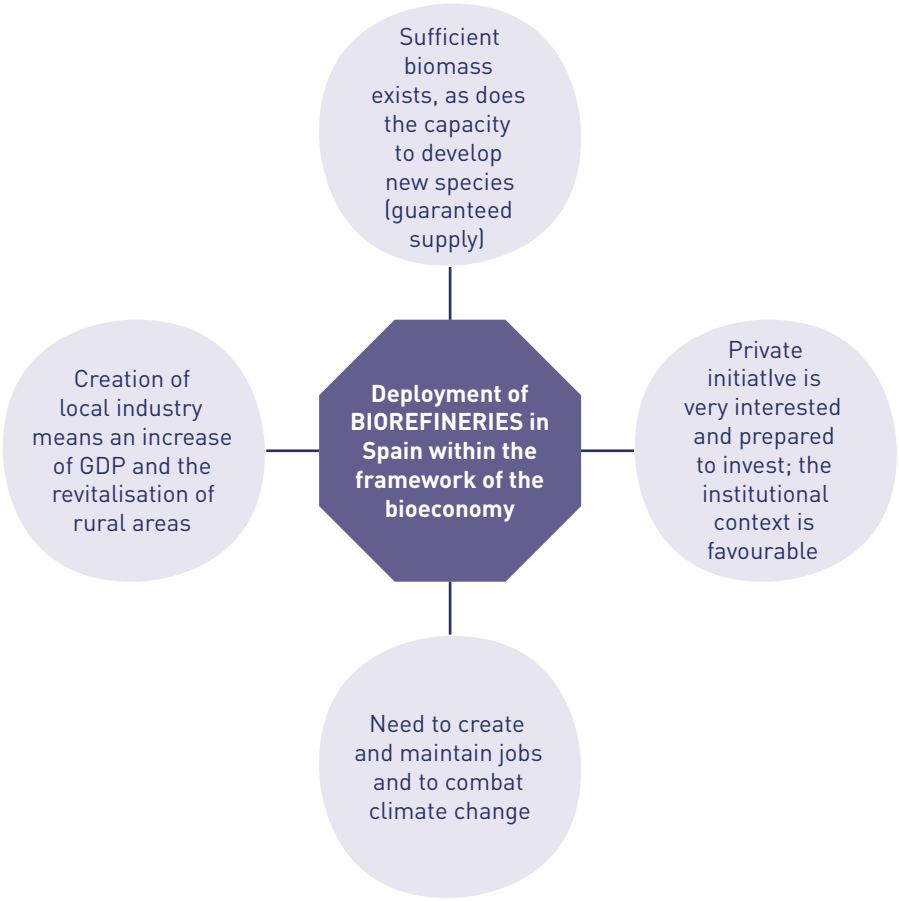

Figure 16. Strategic arguments for deploying biorefineries in Spain.

WHAT ADDED VALUE IS INDUCED BY DEPLOYING BIOREFINERIES IN SPAIN?

- Biomass resources would be recovered that are not currently used or are abandoned, causing very serious environmental problems such as wildfires, the emission of greenhouse gases and different types of pollution (of aquifers due to plagues of insects, among others).

- It would create new opportunities for biotechnological development in both the scientific-technical and the industrial fields. It would also make applied knowledge in the field of engineering more valuable, given the multidisciplinary nature of industrial installations of this type.

- It would help to reindustrialise Spain. Certain industries would most likely be located in rural areas of the territory, thereby promoting the socio-economic revitalisation of these rural areas in a way that is both effective and sustained over time.

- It would create new jobs associated with the continuous supply of biomass required by industries so that they can maintain a constant production; as well as in the actual industries themselves, for operation and maintenance purposes. It would create quality jobs associated with a productive model that is sustainable and of high added value.

- New opportunities would emerge for the biotechnology, energy and chemical sectors (not to mention the agricultural, forestry, livestock, food and waste sectors, among others), interested in using the immense potential of biomass that exists in Spain, favouring the establishment of synergies and creating new ways of business development.

- It would imply making progress along the bio-economic path that the European Union has defined, with all the competitive advantages that that would entail for Spain.

Within the context of the bioeconomy and the circular economy, the industrial development of biorefineries in Spain should be framed as key policies by which to develop a different, more intelligent and sustainable form of growth, both in Spain and in Europe. The use of biomass as renewable biological resources offers great possibilities as it makes it possible to supply industries such as biorefineries that are able to respond simultaneously to the demand for food, energy, biofuels and other bioproducts of high added value while at the same time generating economic growth and jobs in the territory, improving the economic and environmental sustainability of primary sectors such as agriculture, forestry and livestock among others, as well as their processing industries. It would also reduce dependence on fossil fuels, thereby contributing to balancing the Spanish trade balance (a structural deficit caused by the import of energy products) and to mitigating climate change, which is an unavoidable and urgent obligation.

It would create new jobs associated with the continuous supply of biomass

Biorefineries comprise local industries and clusters capable of promoting a more innovative and competitive society given that they use biomass resources in a highly efficient manner, reconciling aspects that are essential for a population in exponential growth, such as food security and energy security, without contributing to accelerating climate change.

This capacity to respond to social challenges so closely interrelated as food security, the scarcity of natural resources, the dependence on fossil resources and climate change while at the same time building sustainable economic growth, makes biorefineries a key instrument that contributes to the establishment of a genuine productive sector that is based on the bioeconomy, both in Spain and in Europe.

In order to achieve the deployment of biorefineries in Spain, sound and coherent policies should be put in place that integrate the interests of the stakeholders involved therein (agricultural and forestry sectors, farmers, waste, rural environment, biotechnology, biochemistry, energy, biofuels and the environment, among others), both in the different regions of Spain and in the country as a whole, in relation to Europe. Spain in particular has a high first-generation biofuel production capacity (biodiesel and bioethanol) and there is therefore a clear potential for converting this capacity, at least partially, into biorefineries, given that many of their elements are compatible. A firm commitment to the bioeconomy, the bases of which are kept stable over time, will encourage private investment in biorefineries and related activities (biomass logistics, etc.), both in research and in industrial and market developments, whether consolidated or new.

There is also a need for the express support of public administration bodies, able to promote the connection between research and the application of the results of that research, to encourage collaboration among researchers, innovators, producers, end users, policy makers and the civil society, and to exploit the political-administrative mechanisms needed to minimize the bureaucratic procedures and the legislative barriers that might impede the optimal development of biorefineries in Spain.

There is also a need for the express support of public administration bodies

FINAL RECOMMENDATIONS. HOW CAN WE CREATE A FAVOURABLE ENVIRONMENT FOR THE DEPLOYMENT OF BIOREFINERIES IN SPAIN?

1) **Promotion of investment in research, innovation and training,** in order to generate knowledge of the biorefinery universe and to effectively transfer that knowledge to the market. The improvements in the learning curve of the technologies will imply substantial progress in their competitiveness, allowing biorefineries to constitute economically viable alternatives to traditional production systems. Substantial funding of Research, Development and Innovation must be ensured at European, national and autonomic levels, a funding that considers that the deployment of biorefineries in the territory is a strategic priority. Corporate investment in biorefineries must also be promoted. Appropriate public-private models must be developed that make it possible to finance pilot projects and to demonstrate diverse biorefinery platforms capable of recovering the indigenous biomass. Work should take place to ensure that private financial and capital risk entities are aware of biorefineries, so that they can extend their portfolio of financial products adapted to industrial facilities of this type and to ensure their complementarity with public financing instruments. The need to train staff, given the particularities of this discipline, must be one of the priorities, not only from the point of view of training workers who are currently active, but also that of training new professionals (University and Vocational Training academic programmes).

2) **A strong commitment both politically and on the part of the stakeholders concerned.** An[8] Inter-Ministerial Biomass Committee must be set up, composed of those Ministries that are involved in the sector (Industry, Energy, Rural Affairs, Agriculture, Waste, Environment, Employment, etc.). It should also involve those Autonomous Communities that are interested in recovering the biomass that is found in their territories, and in generating socio-economic opportunities for their citizens. This Committee would improve synergies and coherence between the policies and actions of the various Ministries and the Autonomous Communities and at the same time it would contribute substantially to creating a robust bio-economic policy in Spain, with strong ties to the territory, the primary sector and the markets of high added value. This Inter-Ministerial Committee must design a strategy to maximize the mobilisation of national biomass, so that they can be recovered in biorefineries located in different geographic areas. In this way, working at a local level will contribute to facing the social challenges that threaten society in the twenty-first century at the global level: food security, energy security and climate change.

3) **Improved competitiveness and optimisation of the markets associated with biorefineries** within the framework of the bioeconomy. To do so, it is essential to ensure a stable supply of biomass to the biorefineries; therefore, the establishment of a consolidated biomass market should be encouraged in Spain, identical to markets that exist for other commodities. It is vital to mobilise both the existing biomass and other newly created (through biotechnology) and newly deployed biomass (through crops). Therefore, action should be taken in the fields of agriculture, forestry, livestock, industry and waste. In all cases, sustainable resource management must be guaranteed, making use of existing tools (such as forest certification systems, for example), and in the case of biomass from plantations, ensuring that such plantations do not compete with plantations that are used purely for food purposes and that they do not require an intensive use of inputs (water, fertilizers etc.). It is essential to promote the creation of the logistic networks and supply chains that biorefineries require, as well as a number of initial pilot and demo biorefinery facilities, duly integrated and diversified in the territory, able to absorb the amount of existing biomass in Spain. The outputs that are generated in biorefineries are bioenergy and bioproducts; therefore, a demand for such outputs must be guaranteed in the relevant markets by facilitating the development of standardized mechanisms for the evaluation of sustainability, the creation of differentiating labels and innovative public procurement. Furthermore, it must help to increase the long-term competitiveness of the new biorefinery production systems, based on improving efficiency in the use of resources, minimizing the potential administrative constraints for placing new products on the market and promoting their internationalization.

[8] In line with the already proposed and never executed PRE/472/2004 ORDER of 24 February, which created the Inter-Ministerial Committee for the use of biomass energy. Link: https://www.boe.es/diario_boe/txt.php?id=BOE-A-2004-3635.