FOSTERING SUSTAINABLE FEEDSTOCK PRODUCTION FOR ADVANCED BIOFUELS ON UNDERUTILISED LAND IN EUROPE

D 4.3

PRODUCTION OF A ROADMAP FOR THE REMOVAL OF THE MAIN ECONOMIC AND NON-ECONOMIC BARRIERS TO THE MARKET UPTAKE OF ADVANCED BIOENERGY IN THE CASE STUDY SITES INCLUDING ROLES AND RESPONSIBILITIES OF EACH RELEVANT STAKEHOLDER GROUP IN THEIR IMPLEMENTATION AND ASSOCIATED TIMELINE.

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Food and Agriculture Organization of the United Nations

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1. Introduction

The sustainability assessment carried out in FORBIO provided a number of interesting facts about the performances of the selected advanced biofuel value chains. General trends have been identified and peculiarities of each of the case study have been detected as well. These findings have been discussed with local stakeholders in each of the case study sites and further information has been collected to complement such analysis. During in-person meetings, webinars and workshops the main barriers to the sustainable uptake of these value chains have been identified. In this report, there is the proposition of the most effective countermeasures to mitigate the limitations posed by economic and non-economic barriers to the uptake of advanced biofuels value chains from biomass produced on underutilized lands in Italy, Germany and Ukraine.

The aim of this report is to map the barriers to the uptake of the selected value chains, but the analysis showed that there exist a number of inefficiencies that although do not constitute an actual barrier for the development of an advanced biofuel industry, over the long run may limit their feasibility. These will also be discussed in this report which aims at providing a roadmap to obtaining the most efficient and sustainable strategy for the market uptake of advanced bioenergy on underutilized lands.

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2. Italy

In the Italian case study, we analysed the feasibility of producing 40,000 tons of lignocellulosic ethanol per year using feedstock from contaminated lands in the Sulcis Region of Sardinia. In this case study there is an array of environmental, technical, cultural, social as well as economic barriers to the uptake of these value chains. Some of these have a very local character, others must be dealt with at the national level and others are necessarily addressable only at the condition that European Policies and Actions support the necessary change. At any rate, the case study of Italy seems to serve as the perfect example for the development of a strategy and roadmap to support the market uptake of advanced biofuels from underutilized lands in Europe.

THE STRATEGY

EUROPEAN and NATIONAL LEVEL ACTIONS

To date the technology to produce sustainable advanced biofuels is available. Pre-commercial plants exist in Europe and soon Commercial scale plants will begin production. The principal technical bottleneck of these value chains is represented by the availability of feedstock at competitive prices. The primary policy bottleneck of these value chains is represented by the lack of effective and fair mechanisms that support price competitivity.

In the Sulcis area there is a total of 18,706 ha of contaminated land on which food and/or feed production is banned, according to the outcomes of previous project deliverables and Law 9 of 06/03/2014 enacted by the Municipality of Portoscuso. The production of lignocellulosic biomass for ethanol in the ***target area*** would generate enough biomass to supply a 40,000 t/year ethanol biorefinery. In theory then, feedstock availability is very likely in the case study area. In the sustainability assessment and during multistakeholder discussions, meetings and workshops, the potential issues surrounding the feasibility of these value chains have been listed starting from environmental barriers, followed by potential social barriers, to conclude by analysing and detecting techno-economic barriers. In the development of a sound strategy for the market uptake of advanced biofuels from underutilized lands in the Sulcis, the principal barriers to overcome in order to enable the environment for the constitution of the second generation ethanol value chain is linked to the economic and financial

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features of the system. Therefore, chronologically it is pivotal that fundamental financial and economic barriers are understood and removed first. Along these lines, to date in the Sulcis area, the potential constitution of an advanced biofuel value chain has been advocated for mainly by the Italian company Mossi and Ghisolfi, through its operative firm Biochemtex. Elsewhere, other technology providers have played this role as well. Biochemtex owns the PROESA technology that represents a tested pathway for the conversion of cellulose into fermentable sugars. The technology provider however is not to be confused with an energy company, or an oil company, fuel supplier, fuel blender or similar. The core business of Biochemtex is the development of efficient transformation processes and to market those patented processes through their licenses and support the constitution of the value chain in various phases. The actual production and sale of the final product, in this case second generation ethanol, is not the natural core business of the technology provider.

Therefore, firstly, it is paramount that a fuel market player is interested in building an advanced biofuel value chain sourcing feedstock from the contaminated lands of the Italian ***target area***. In the case of FORBIO unfortunately, it was not possible to have a fuel market actor as a member of the consortium, but several exchanges with representatives of the main fuel market companies operating in Europe have been held during the workshops and meeting organized in the context of FORBIO.

Customers in Italy (and in the majority of Europe) purchase fuel blends at the pump most of the times completely ignoring that the petrol contains a certain share of bioethanol in it. In fact, only starting from October 2018 there has been the necessity to write value of the blend (“E5” or “E10”) on the fuel nozzle at the pump in Italy. Therefore, market uptake actions not necessarily need to target consumers (though as we will see later, this may actually help greatly the development of the sector) but primarily need to enable the environment for a fuel actor to step into the game.

Investors would show interest in a biorefinery provided that there exist the conditions for the investment to be profitable over the long run. The primary concern of investors in the advanced biofuel sector is the unpredictability of future market conditions as a consequence of lack of long-term policies on the matter. Without long-term policies the bankability of their projects is negatively affected and investments will not take off. A first responsibility of European level policymakers and Member States is to develop consistent, long-term policies that govern the market penetration of advanced biofuels. Since typically the economic lifetime of a biorefinery is 20-25 years, investments should be spread throughout such a lifetime and policies that mandate a certain blend for only a

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decade (as it was the case of the RED and now of the recent RED II) may not represent a sufficient incentive to support long-term bankability of investments in this sector. As supported by the Subgroup on Advanced Biofuels of the Sustainable Transport Forum of the EU (SGAB, 2017), the lack of solid and agreed policies that look at advanced biofuels role in the energy and transport sector beyond 2030 is the principal responsible for the low market uptake of these fuels.

That being said, however, the Renewable Energy Directive II (RED II) for the year 2021-2030 does provide a few details on how the advanced biofuel sector in Europe could develop by including fixed mandate on market operators for advanced renewable fuels. By 2030 the Directive fixes advanced biofuels contribution to achieving the 6.8% share of renewable and low carbon fuels to 3.5%, while biofuels produced from Annex IX part B feedstocks would be limited to max 1.7%. As recommended by other authors, it is paramount that European Policymakers extend beyond 2030 to at least 2040 the obligations of the Renewable Energy Directive II. Since GHG emission reduction targets are already set by the Commission at 60% in 2050, it would seem logical that the strategy to reach such reduction, and thus the role and mandate of advanced biofuels, is included as a preliminary strategy to be reviewed (mandatorily to strengthen the goals) in 2030 and 2040.

By indicating a direction for the sector and a minimum target also beyond 2030, the long-term investments necessary to support to development of the sector would be enabled.

In Italy, the Ministerial Decree 10/10/2014 mandates increasing shares of advanced biofuels in the mix. These shares are expressed in energy terms rather than in volume or mass terms. In 2018 and 2019, the Decree mandates at least 1.2% of the energy consumption for the transport sector is provided by advanced biofuels. In 2020 and 2021 this value increases to 1.6%. In 2022, when biofuels should cover a share of at least 10% of the energy in the transport sector, 2% of this energy should come from advanced biofuels. The Decree makes no distinction between petrol and diesel, but it cumulates the final energy use of the two since over time the market share and thus the consumption at the pump of these two fossil fuels may vary.

The existence of said policy in Italy should represent a reliable pillar to the development of an advanced biofuel sector. However, in the real world such policy instrument is not enough. The current system of sanctions for fuel market operators that fail to blend the share of advanced biofuel indicated by the Decree with fossil petrol or diesel is regrettably weak and consequently rather ineffective. The sanctions are only monetary and their value is often times lower than the extra expenditure that a fuel market operator would incur if it purchased the set quantity of advanced biofuel. A fuel supplier that fails to fulfil a quota obligation is liable to pay a penalty of €750 for every missing certificate (10 Gcal) of biofuel set in Decree 20 January 2015 (ePURE, 2016). When referring to ethanol, 10 Gcalories are the energy content of approximately 1.15 tonnes of biofuel. As reported in D3.3, producing 1 ton of lignocellulosic ethanol in the Italian case study scenario would cost approximately EUR 950 and therefore 10 Gcal would cost about EUR 1,114. Paying the penalty would save the fuel supplier some EUR 364 per certificate, thus making blending advanced bioethanol into petrol economically less convenient than paying penalties. Clearly another fundamental step at the national level is the review of the penalty system and the simultaneous discussion on premium price to attribute to lignocellulosic ethanol production.

Moreover, another flaw of the set of policies that govern the use of biofuels (both traditional as well as advanced) in Italy (and in other EU Member States) is the tax imposition system applied. Ethanol, and even lignocellulosic ethanol, receives the imposition of an excise if the product is not at least *partially denaturated alcohol* (PDA). In Italy, the excise for non-PDA ethanol is EUR 10,350/m^3 therefore the producer must comply with the denaturation process if intends to stay in business.

Unleaded petrol is subject to the imposition of an excise duty of 0.728 EUR/litre (EC, 2018) and when ethanol is blended with the fossil fuel, the blend undergoes the same taxation regime as pure petrol, thus taking away the possible cost reduction at the pump for blends containing a high share of bioethanol. Italy is authorized by the Commission to apply differentiated rates of excise duty to the fuel mixtures "petrol/ethyl alcohol derivatives whose agricultural component is of agricultural origin" (EC, 2008). Between 2008 and 2010 the Italian government destined about 73 million euros to reduce the excise duty on bioethanol and this translated into a value of the excise of EUR 289/m^3 (Assocostieri, 2008). However, since the end of the incentives, in 2010, there is no trace of a special differentiated rate on bioethanol vs petrol. Based on our research, as of today, bioethanol and petrol have the same tax imposition in the Italian fuel system, thus consumers do not see any advantage or incentive in purchasing E5 or E10 at the pump. The excise reduction should be instead re-introduced by the Italian government with regard to advanced bioethanol along the lines with what set by Ministerial Decree 10/10/2014 regarding blending quantities, to provide an incentive to increase the share of advanced biofuels into the petrol blends and thus making the renewable component of the fuel more economically appealing. By lifting completely the excise on advanced bioethanol, the incentive would be even more obvious. As of November 2018, petrol in Italy is sold at the pump at

EUR 1.65/litre. According to this roadmap, with a revised excise taxation system (i.e. where the excise is lifted from advanced ethanol share of the petrol blend) the cost at the pump would drop to EUR 1.640/litre. In 2022, when according to Italian law the share of advanced ethanol in the blend should be at least 2%, the cost *ceteris paribus*[1] would be reduced to EUR 1.635. By 2030, when the RED II mandates at least 3.5% of the blend to come from advanced biofuels, the price at the pump would be EUR 1.625/litre. This would represent predominantly a psychological incentive for drivers to purchase the fuel that has a lower, even if marginally lower, cost at the pump while being more sustainable than its more costly fossil alternative.

The other component of the final fuel price is the fuel production costs. The severe limitations to the uptake of these technologies posed by the volatility of the ethanol price (intended as its component derived from raw production costs) on the international market hinder the possibility that these value chains pick up until investors see a steady trend towards competitiveness with other biofuels and other fuels in general. The lack of instruments to govern and possibly induce such a favourable scenario is likely the main barrier to the market uptake of advanced bioethanol in Europe. This is also a disincentive for fuel companies since the raw cost of petrol is EUR 550/t as of 2018 (Unione Petrolifera, 2018), which is almost half the production cost of lignocellulosic ethanol. An incentive formula should be adopted to cover the gap between the fluctuations of the ethanol market worldwide and the actual production cost of second generation ethanol at the conditions of this study. This formula would establish a *premium* price for advanced bioethanol.

As we have seen in D3.3 the production cost of lignocellulosic ethanol is EUR 940/t, and the premium for this biofuel should be calculated as follows:

EUR 940/t - International ET_{OH} Market Price.

In the unlikely event that the international market price of ethanol goes above the sum of the current production cost estimated (EUR 940/t) the biorefinery would give back the subsidies until parity with costs plus margins is reached. In this way, a biorefinery can plan long-term investments and gain high bankability for their proposed projects. It should be noted that, in order to comply with the RED II targets (i.e. 3.5% advanced biofuels in the transport sector by 2030), Europe will need some 40-50 additional commercial biorefineries to be built in the next decade (and some 12-13 million tons of biomass to dedicate to it, 20-30%

- [1] this case includes the projections of cost at the pump which is based on the assumption that the cost of petrol and ethanol are projected to show zero change, even though this is not likely, in order to keep reference conditions stable, thus *ceteris paribus*. In reality likely ethanol price will drop over time thus adding even more to the creation of an incentive for consumers.

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more than the 2009's EU-27 pellet production (Sikkema *et al*, 2011)). If on the one hand this target seems rather ambitious, on the other hand it prefigures potential benefits for the economies of scale linked to the large diffusion of these technologies. In fact, the principal component of the lignocellulosic ethanol production studied in FORBIO is represented by the discounted CAPEX investment. If economies of scale play a role in abating such high investment costs, and provided that OPEX cost stay at least constant, the final production cost of advanced bioethanol is expected to decrease steadily.

In any case it is likely that public funding will be necessary to support the fast deployment of the required biorefineries to support the mandates of the RED II. Therefore, the Parliament will probably have to decide on the provision of subsidies to the production of advanced ethanol via the support to achieving a premium price versus subsidies and co-financing of the biorefineries (and perhaps the entire value chains), in order to obtain the same final goal, i.e. the reduction of production costs and associated lower raw material price for the ethanol production. It is out of the scope of this report to forecast the possible magnitude of this reduction, but it seems likely that the expected diffusion of these technologies will lead to growingly favourable market conditions and production costs for advanced biofuels. This strategy however, tends to prefer forms of public support to the deployment of newer and more cost-efficient technologies, from the research & development to the actual participation through flagship projects as shareholder, to the support to reduction of operational costs, including feedstock supply. The Commission and individual member states should at any cost prefer supporting those projects that show the closest adherence to the set of Best Management Practices listed in D 3.3 for the attainment of the highest sustainability standards (and meeting the needs of the REDII). For instance, support could be given only to biorefineries that incorporate on-site enzymes and yeast production rather than a third-party off-site production scheme because as described in the case of the indicator on air quality, this would have remarkably positive impacts on the GHG profile of the ethanol produced.

The aspects above, concerning European- and National-level actions, would be urgently required for enabling the market uptake of sustainable lignocellulosic bioethanol produced in the Sulcis case study area.

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REGIONAL LEVEL ACTIONS

The sustainability assessment carried out in the context of FORBIO revealed that at the local level, there are no major economic barriers to the uptake of advanced biofuel value chains in Sardinia, Italy, whereas only non-economic barriers exist at this level. Actions to remove non-economic barriers at the regional level would interest the current land use of the fields interested by the ban enacted by the Municipality of Portoscuso. First of all, the current ban on agricultural activities in the area lacks adequate enforcement. During the multistakeholder discussions and field visits, agricultural activities such as low density grazing and livestock raising (predominantly sheep) and to a lesser extent horticulture (artichoke farming, etc.) was witnessed within the ***target area***.

The few vegetable producers should have their fields surveyed by the Regional Environmental Protection Agency and if concentrations of heavy metals and/or other pollutants are found below the thresholds imposed by law, the agricultural activity can continue, and thus the Regional contamination map – on which the cultivation ban imposed by the Municipality of Portoscuso is based – should be updated. In case these areas show concentrations beyond the thresholds set by law, these farms should be reconverted to producing dedicated energy crops only.

As for the majority of the remaining land, this is currently used by herders more or less formally grazed. Being the land tenure system efficient and land owners being for the vast majority separated entities from the herders, the conversion of those contaminated pastures to bioenergy feedstock production areas is feasible.

Action 1): opening up a discussion table to reorganize in a transparent and fair way agricultural activities currently taking place in the ***target area***.

A first barrier that would require careful planning and communication is the reconversion of the workforce employed in those illegal agricultural and especially pastoral activities. The reconversion of horticulture, as discussed in the paragraph above should not be very problematic and can be done quickly, in between two production seasons.

Concerning pastoral activities, typically a sheep herd has an economic lifetime of about 5 – 7 years. As consequence the reconversion of herders to labour force that could be employed in the biomass industry would require a minimum of 1 to a maximum of 5 years. Local authorities responsible for enforcing the current ban are the actors expected to convey a first discussion table with the herders, pasture land owners and the associations who represent both of them (e.g. Coldiretti, CIA, etc.). The plan for the conversion of their agricultural activities is

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to be explained and presented in detail. On the one hand, the land owners need to be confronted with the parties in the pursue of an agreement as to either i) move the herds; ii) sell the herds; or iii) exploit the current herds until the end of their economic lifetime, but without gradual reconstitution and by agreeing to avoid grazing on the area subject to Law 9 of 06/03/2014. Herders who choose options i) and ii) should have a period of time to relocate their herds, in this strategy proposed as 12 months. A period of up to 5 years is necessary to requalify herders who decide to keep the animals until the end of their economic lifetime, while providing that no grazing activities take place on the contaminated soils and forage is procured from other areas. For these stakeholders, the voluntary inclusion into the advanced biofuel value chain should be guaranteed since the beginning of the operations so that they can make more informed choices.

Action 2): perform an independent publicly-funded study on the monitoring of contamination of soil, air and water in the municipalities surrounding Portoscuso (where an agricultural ban exists) that could also be interested by severe contamination.

To date there are numerous dossiers and journalistic reports covering the contamination aspect of the Sulcis area. However, some of these reports contradict others, data and sources are not always cited or not cited appropriately, and there exists the criticism that these results are not produced by an independent entity nor discussed transparently enough. Therefore, there exists the need to carry out an actual scientific study which complements the work of the Regional Environmental Protection Agency (ARPA Sardegna) in order to provide science-based evidence of the real level and range of contamination in the Sulcis Iglesiente and to transparently communicate its results to the local population and stakeholders for their appropriate information.

VALUE CHAIN LEVEL ACTIONS

Specific actions at the value chain level concern its planning and organization in order to remove all possible economic and non-economic barriers to the uptake of advanced bioenergy value chains in the area.

The assessment of the indicators on logistics and transport of biofuels highlighted the presence of an industrial site in the area of Portovesme (Municipality of Portoscuso, Sardinia, Italy) with direct access to a sea port as well as to a well-developed road system interconnected. This peculiar combination makes the site an excellent candidate to host a 40,000 t/yr bioethanol plant. The roads are more than adequate to transport biomass from the fields within the

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target area to the hypothetical biorefinery and the equipped industrial sea port of Portovesme would make it an excellent location for shipping the final product to the rest of the continent.

From the sustainability assessment carried out in the course of the FORBIO project, has emerged the clear advantage of the lignocellulosic ethanol technology to abate greenhouse gas (GHG) emissions when compared to petrol. Formidable emission reductions are possible with this technology. However, in the value chain planning phase it would be particularly relevant the consideration linked to the logistics of the supply of processing inputs to the biorefinery and in particular that of enzymes and yeast. These two fundamental inputs in fact, are required in high volumes by the PROESA process and their production (especially in the case of enzymes) is particularly costly in terms of resources. The energy used for the production cycle, in addition to the energy used for the transport to the biorefinery, once embedded in the input will represent the single largest contributor to the GHG emissions profile of the value chain. To this end, it is fundamental that the value chain in planned in a manner such that the production of enzymes takes place on-site, using the excess energy (both electricity and heat) generated by the ethanol production process. This would reduce even further the already favourable emissions profile of this technology and will present to the market one of the least carbon-intensive fuels available today.

Another fundamental milestone for enabling the value chain concerns the designing of the supply component of the value chain. In the *target area* there are currently 1,000 ha of land reached by irrigation infrastructure. This would represent a major non-economic barrier to the choice of the feedstock and its management regime. As demonstrated by the sustainability assessment, the amount of biomass required to supply the hypothetical biorefinery in Portovesme would require at least 7,200 ha of irrigated land. Since the infrastructure covers only 1,000 ha in the *target area* and in light of the strong concerns voiced by several stakeholders during the discussions and workshops, the most effective solution would target the existing area equipped with irrigation systems and rely solely on this one for the production of irrigated biomass, specifically irrigate giant reed. Water availability was felt as a major barrier but the analysis carried out demonstrated that water is actually available in the amounts required for the cultivation of giant reed. The reservoirs, for the second consecutive year are being emptied to the sea because the abundant rainfalls of the last autumn (Sept-Nov 2018) have filled them to their limit and beyond. That being said it is not conceivable that the strategy for the production of biomass for the production of advanced biofuels requires the humongous investments necessary to expand the coverage of the irrigation network.

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Conversely, public funds should be dedicated to the updating of the system and the drastic reduction of losses. In fact, for every cubic meter of water that leaves the reservoir, in Sardinia only one third of the water reaches the field. Once in the field, classic sprinklers reduce furtherly the share of water that reaches the plant and so on. The investment in making aqueducts and other structures for the transport of water more efficient is highly suggested from a sustainability standpoint. In this scenario, where 1,000 ha are under irrigated regime for the production of giant reed for the biorefinery, the remaining 15-16,000 ha required would be under rainfed management. These would be planted with both annual as well as perennial energy crops. Rainfed giant reed yields on average some 10 t/ha of dry matter per year, and a plantation has an economic lifetime of about 20-25 years, comparable with that of the biorefinery. Native grasses as well as introduced annual species were found to reach similar yields under rainfed conditions. The arrangement of the supply pattern and therefore of the land cover patters should be discussed and defined in the context of the working table for the organization of the land use reconversion of those contaminated sites. The areas with higher concentrations of heavy metals should be planted with giant reed, which is particularly sturdy and highly resistant to accumulation of contaminants. Conversely, areas presenting lower concentrations of pollutants will be devoted to annual crops for biomass production.

Farmers involved in the value chain would be supported through the institution of a consortium of biomass producers, which will negotiate for them the most effective contractual forms: those who will plant perennials will have the choice of medium- or long- or very long-term contracts, respectively 5, 10 or 20 years. Minimum-price formulas will vary among contracts in order to reflect the availability of farmers to supply exclusively the biorefinery in Portovesme for increasing amount of time. Contractual forms will be negotiated by the cooperatives in the interest of the associates and by finding a fair agreement with the biomass buyer. Current production costs in the ***target area*** as estimated in FORBIO however already represent a better alternative to the production of most common crops such as wheat, even without factoring the incentive represented by the Common Agricultural Policy and other national and regional economic subsidies.

Farmers who do not intend to sign medium- or long-term contracts with the biomass buyer will have the opportunity to engage in the production of biomass from annual species such as native species or sown annual grasses. These should also place themselves within the same cooperatives as those associates who grow perennial energy crops so that the negotiations with the biomass buyer will be structured to cover every possible supply route. Annual contracts or 2-year contracts should be offered to the farmers with increasing benefits as

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they find advantageous conditions in supplying long-term and at stable prices a secured amount of raw material. Annual contracts may be appealing to farmers who intend to plant Smilo grass (*Piptatherum miliaceum)* on their fields to test their performances and those of their fields without being bound to long-term contracts for the supply of biomass to the biorefinery. Gradually, farmers may move (or start with from the beginning too of course) to biannual plants such as the native milk thistle (*Silybum marianum)*, as species well known and appreciated in the region of Sardinia.

Benefits of feedstock diversification are multiple and encompass the development of integrated pest control plans, biodiversity enhancement at landscape level, reduced logistical issues for the conservation of feedstock, thus more homogenous and constant supply to the biorefinery. The flexible array of contracts proposed would be impossible to manage with single farmers, but with one single cooperative which would divide the typologies in up to four contract forms and specifications, this system is expected to work efficiently. The cooperatives are a central part of this strategy for a number of key reasons.

Another non-economic barrier to the uptake of advanced biofuels produced in Sulcis concerns the acceptance of the novelty invariably constituting this value chain. During the several discussions with local stakeholders, some particularly "old-fashion" value chain actors presented some scepticism towards the reliability of the advanced biofuel technologies and benefits. There is the need to provide capacity development support and better inform the stakeholders about these technologies and to familiarize them with a specific programme to start immediately (also through further H2020 projects like FORBIO) and to accompany stakeholders during the constitution of the cooperatives and the development of common goals and realistic expectations.

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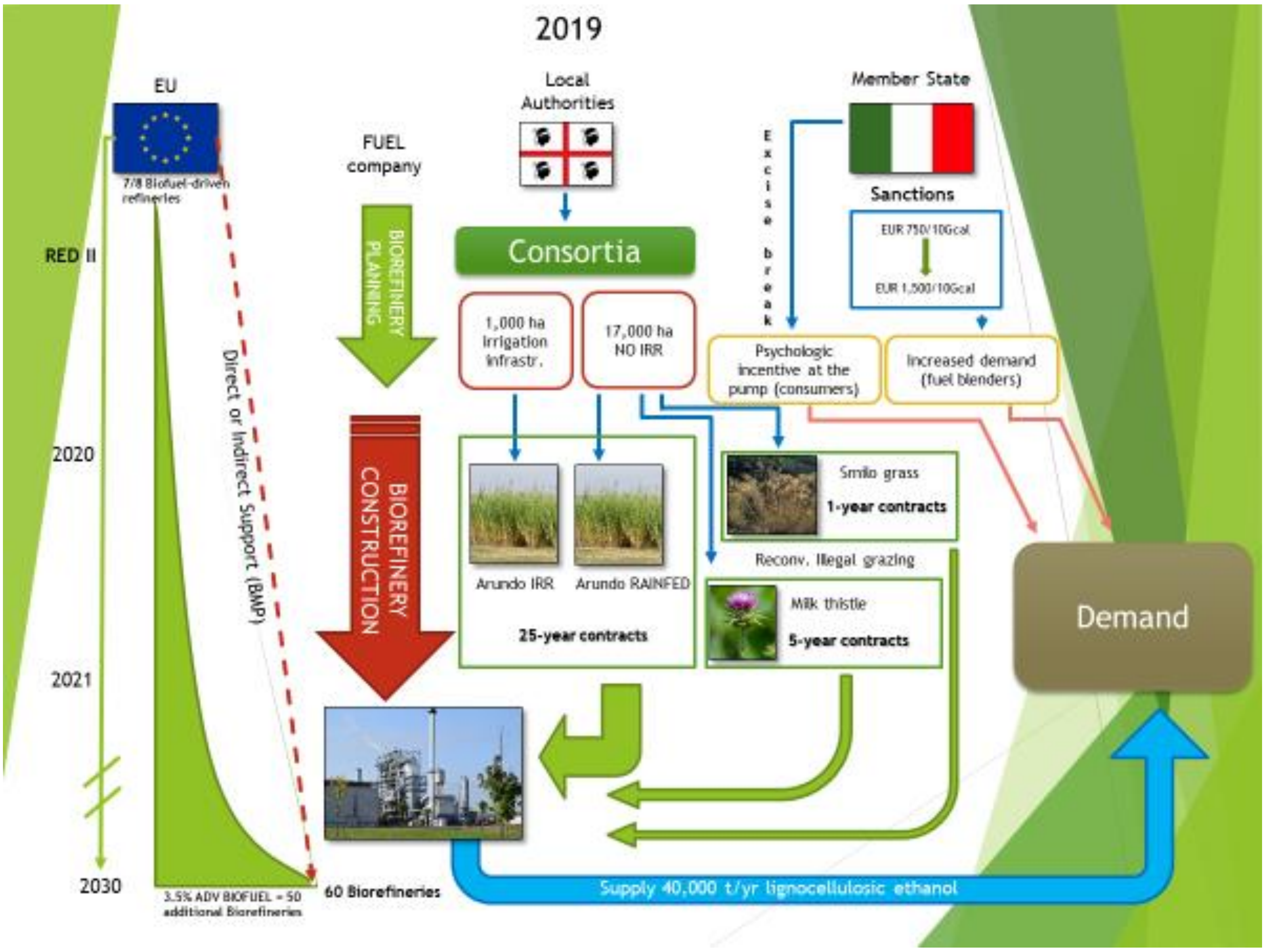
THE ROADMAP

As we have seen in previous parts of this report and in other deliverables the production of advanced bioethanol in Italy in the case scenario presented is environmentally and socially sustainable. Given the current market conditions and the existing policy landscape, specific recommended actions as laid in the strategy would need to be adopted in order to enable the market uptake of these value chains.



Roadmap of the Italian case study

As explained in the strategy for the market uptake of advanced bioethanol produced in the case study area in Sulcis, Italy, operations could begin in 2019. By then, in Europe there will be around 7 or 8 biofuel-driven biorefineries. It is important to notice that each of these commercial and pre-commercial projects has benefitted of some form of incentive and subsidy from the European

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Commission either in the form of participation through a BBI or Flagship project or via indirect measures. As the Renewable Energy Directive II was signed by the Parliament this year, it laid down a few relevant measures and goals for the advanced biofuel sector. By 2030, about 3.5% of the transport fuel employed in the European Union will be advanced biofuel. This includes renewable diesel, HVO, and lignocellulosic ethanol, as well as biomethane from various origins. In order to meet the 3.5% target, the European Union will require some 50 additional biorefineries to produce enough advanced biofuels. It seems plausible that some form of contribution and support from the EC will be dispensed to the interested stakeholders as it has been the case for the current 7/8 biofuel-driven biorefineries found in the EU countries.

The typology of support will have to be defined by the Commission as appropriate, but in this roadmap seems quite logic that some form of contribution will be foreseen.

As we have seen this could be key to making lignocellulosic ethanol commercially viable since the main responsible for the uncompetitive production cost of this fuel is linked to the high capital investment necessary at year 0.

Gradually but exponentially, as the economies of scale begin to play a role, marginal costs will be reduced and the support of the Commission is expected to decrease proportionally with the decrease of construction cost for the biorefineries and thus towards the second half of the next decade there should be a distinct increase in the pace of biorefineries deployment.

The Member State, in this case Italy, is suggested to put in place at least two key measures to enable to increased demand for advanced biofuels. Firstly, the current system of sanctions against those fuel companies who fail to blend the minimum share of advanced bioethanol in their petrol is recommended to be revised. To date the sanctions system makes no difference between application of a fine for failing to mix advanced bioethanol vs conventional bioethanol. The sanction makes sense in the case of conventional bioethanol where, in most cases, works as a deterrent against fraud, but in the case of advanced bioethanol the sanction is weak to the point that a fuel blender would have an actual economic advantage in paying the sanction rather than purchasing advanced bioethanol at today’s production cost. The sanctions for the specific case of advanced bioethanol (which Italy mandates to necessarily constitute 1.6%, 1.8%

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and 2.0% of the volume of petrol sold in petrol stations in 2018, 2019 and 2020 respectively) should be increased (it is suggested doubled) to EUR 1,500/10Gcal in order to have effective results.

The aforementioned action would have no cost implication for public spending. However, another important aspect which implications in terms of lack of fiscal revenue would have is the re-introduction of the excise break posed on ethanol, but in this case expressively for advanced bioethanol, between 2008 and 2010. As we have seen this action would have a psychological effect at the pump, incentivising the fuel that is known to contain a higher share of renewable, higher-octane, greener biofuel is recommended. A few Euro cents less per litre would suffice to induce consumers towards a blend that contains more sustainable biofuel, and is cheaper, than one without these advantages.

At this point the demand that supports the mandate of the REDII would be created at the national level.

The supply to support such a demand would require the establishment of Public Private Partnership for the planning phase of the value chain. The later stages would continue on a free market basis.

A fuel company that is required by the sanctions' system to purchase or produce more advanced biofuel would begin to plan investments, possibly supported to some extend by the contribution of the EU to meet the RED II mandate. The role of local authorities in conveying all relevant stakeholders around the same table would be paramount. Local authorities in Sardinia would convey working groups of concerned stakeholders to form consortia or associations of producers that can meet the demand of the fuel company interested in investing private and public funds in the area.

The associations of biomass producers would establish within the working groups their willingness and availability to produce biomass for energy purposes, in close contact with the fuel company. At this point there would be, for the Sardinian case study, two main production regime options: 1) farmers whose land is found within the area reached by the irrigation infrastructure (about 1,000 km) would be offered a preferential role in producing irrigated giant reed on those lands; 2) the remaining supply will be sourced from some 17,000 ha of rainfed land. Part of this land would also be allotted to perennial giant reed

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production (though with expected lower yields in rainfed conditions). Part of the consortia and working groups would be also the local banks that are expected to provide access to finance more easily if thoroughly involved in the process since the beginning.

Farmers that choose to grow giant reed would negotiate, through their representatives in the consortia/producer organizations, a 25-year contract for the exclusive supply of their biomass to the biorefinery with the convened fuel company representatives.

The reconversion of illegal farming activities on the territory will be exploited through the modular and scalable approach described in the strategy above where herders who decide to reconvert only at the end of the economic lifespan of their herds will have 5 years to do so.

Those farmers who wish to maintain a certain degree of freedom in negotiating contracts will be offered medium term contracts (3 to 5 years) and will be invited to produce semi-perennial biomass such as cardoon or milk thistle.

Farmers who wish to maintain complete freedom from contracts, and that do not require the support of a long-term contract to access finance, will be permitted to enjoy 1 year contract with biomass buyer and grow annual species such as smilo grass.

At this point, the fuel company would have a clear understanding of the likely supply of biomass and its cost and consistency over time, and can conclude the planning and begin construction.

In Crescentino, Italy, Biochemtex built its first lignocellulosic 40,000t/yr plant in just 13 months. In this exercise we propose the same development and thus, with beginning construction in 2020, by 2021 the Sulcis biorefinery should be ready.

After the first year, while the biorefinery is being built, the associations of producers will start the growing season and deliver the first harvest at the end of the first growing period.

The biorefinery would begin to supply the 40,000 t/yr of ethanol to fulfil the national demand created.

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3. Germany

In the German case study with the two categories of underutilized land, namely disused sewage irrigation fields and lignite reclamation sites, the analysis focused on biomethane production from spontaneous grass as well as from dedicated crops, namely alfalfa and *Sorghum*. As in the other case study countries, none of the environmental and social aspects assessed seem to represent a barrier to the sustainable market uptake of these value chains. That being said however, some criticalities do exist. For instance, the choice of multi-purpose feedstock such as alfalfa and *Sorghum* may represent a barrier to the supply of the biomass to biodigesters because of potential competition with other uses.

In contrast, there is no regional buyers market for the advanced processing of biomass on a larger, much more capital-intensive industrial scale, in particular, of whole-crop, green and lignocellulosic feedstock (LCF).

The value chains selected more importantly, are based on a number of assumptions that require a set of rather inelastic existing conditions. The case of the spontaneous grass at disused irrigation fields entails the pre-existence of a modern biorefinery for the extraction of amino acids and lactic acid whose construction is independent from the creation of the bioenergy component of the value chain because this would merely be a co-product of lesser importance. The production of biomethane at the lignite reclamation sites on the other hand, requires that the retrofitting of existing biogas plants to the production of biomethane also takes place independently. If the aforementioned conditions are met the bioenergy value chains can materialize, not without some additional actions that will be set in the strategy below, otherwise these would simply not be feasible.

However, the public acceptance for a further expansion of biogas units in the region is very low (only 39 %), for example in contrast to solar systems (75 % according to Forsa, 2009). And also the federal government`s energy concept, the national biorefineries roadmap and the long-term energy strategy of *Brandenburg* (MWE 2012) call in unison for a wide-ranging material and energetic utilisation of renewable resources. The most important objective is the fullest possible use combining diverse biomass sources as well as different value chains and technologies. Some integrative biorefinery concepts have already been pursued for a number of years in *Germany* (BMELV, 2012). However, up to now there is no real processing capacity in the region be it as single-output

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ethanol plant, LCF biorefinery or another high-order integrative material utilisation.

THE STRATEGY

In the interesting case study of the former irrigation fields, the production of biomethane from spontaneous grass would not be the main product of the biorefinery. In fact, the plant would be built for the production of amino acids and lactic acids which represent high added-value products. Therefore, in the sustainability assessment the existence of the biorefinery was taken as a given and an exogenous aspect with regard to the bioenergy part of the value chain. In this scenario, the production of biomethane would contribute to the overall economic sustainability of the value chain by covering production costs (management and logistics, as no cultivation costs were assumed in this case study). If the profitability of the biochemicals and the existence of a market for those products were confirmed, then the share of revenues attributable to the bioenergy share of the value chain would be relevant. It is outside the scope of the FORBIO project to incentivize the development of a biorefinery whose main product is biochemicals and thus actions to support this endeavour will not be proposed in this strategy. However, the sustainability assessment has proven that the production of biomethane (or biogas) to be either sold once injected into the natural gas grid or employed on-site to generate the heat and the power needed by the biorefinery processes is feasible. In the context of the bioeconomy then, the production of bioenergy should be incentivized because it has the chance to enhance the efficiency of integrated systems which use the energy contained in the biomass to process added-value biochemicals for the market. The bioeconomy concept encompasses a number of aspects, including bioenergy. For this reason to date the European Union does not regulate the bioeconomy with a dedicated directive rather it regulates each of its components separately. In fact, the overarching direction intended for this broad sector (which includes agriculture, a share of the industry, etc.) is set forth in a strategy published by the Commission in 2012. With this strategy, the European Commission is committed to take action through existing policies such as the Common Agricultural Policy (CAP), or in the case of the bioenergy component of the bioeconomy through the relevant sections of the Renewable Energy Directive (I and now II) (Bioeconomy Strategy, 2012).
The strategy proposed in the context of the FORBIO project could provide policy recommendations to policymakers on how to best use the various instruments available to support the development of these sustainable bioenergy value chain.

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One example is represented by the CAP. In recent years, the CAP has increasingly included measures to protect grasslands from overgrazing and overexploitation for conservation purposes. In this sense, the land owner would receive a compensation for the land that is not overexploited or converted to agricultural land. Along the same lines, the local administration, responsible for the definition of the areas that can benefit from the European contributions distributed through the CAP should consider including the sustainable grassland management of the former irrigation sewage fields within the regimes of land management which are eligible for receiving subsidies through the CAP.

The size and scattered ownership of the fields in the former sewage irrigation area makes the planning of a single large investment challenging. The formation of consortia also seems quite complex but not unrealistic. A strategy which starts with the planning of small uses of the biomass, one a few pilot plants, could be upscaled to one or two medium-size biorefineries that produce power and use it for internal demand, while the surplus is sold. The role of biomass production on underutilized lands in Germany seems particularly relevant from the point of view of generating ecosystem services, especially in the lignite district. This is mainly due to the positive effects on soil quality and soil formation dynamics set forth by the enhanced use of best management practices (BMP), such as the use of legume crops as well as the abundant use of organic fertilizers, e.g. fermentation residues from biogas plants.

At the beginning, post-mining cropping deals with initial ecosystems on humus poor raw soils with developing soil functions and an instable structure. Unsurprisingly, the first yields are quite low due to nutrient deficiency and low biological activity. A major concern of the so-called "biological restoration" is to restore the soil fertility by a proper, conserving-type of management. Within the first crop rotation specific topsoil target values must be achieved (cross compliance). Otherwise, the land cannot be released from mining supervision and transferred as property. Until then the later owners carry out the initial cultivation by order of the mining company. In the initial phase of reclamation, the biological management is subordinated under the priority of soil restoration targets. The expected return of investment for the companies is low or even negative.

At disused irrigation fields, in situ phytoremediation is an intended cross-cutting effect making sense in terms of landscape maintenance, especially on heavy metal-polluted sites. Quite promising is a several years (interim) or permanent use for feedstock production. But at the moment there is a gap of development-policy incentives and concrete public funding opportunities to start such

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ambitious remediation projects. First of all, policymakers, municipalities, rural districts, other stakeholders and the concerned public, need to become aware of the hazard potential originating from fallen dry sewage irrigation land. Next, the chances of cropping for securing livelihoods and "upgrading" of otherwise difficult to use land must be emphasised. The principle idea is to improve both land quality as well as the economic value. In addition, the decontamination and surface protection can be charged as a compensation measure according to nature protection and building laws (compensation for the interferences of infrastructure projects and site development, "ecoaccount"). In this sense, feedstock cropping would be a temporary or permanent "safety measure" leading to a step-by step but lasting improvement of the soil properties and natural soil functions.

Though in the case of large extensions of land the amount of manure necessary to support this BMP regime is quite significant, if feasible this action is highly recommended. The creation of habitats, the impacts on water and soil quality and other positive environmental effects expected in the target scenario would enable a number of ecosystem services. Quantifying the intrinsic value of ecosystem services is complex and consensus is not reached in the high level fora dedicated to this topic. However, forms of financial support linked to the provision of ecosystem services begin to appear, at the regional and national level. This strategy recommends the provision of such forms of compensation for the creation of ecosystem services in the case of the *Lusatian Lignite Mining District*.

This would enable the faster uptake of the biomass supply chain and thus contribute to widen the revenue margin for farmers and land owners interested in producing biomass for energy purposes.

For the reasons laid down above, it is recommended that the planning of bioenergy developments in the underutilized lands subject to this study in Germany takes into account a broader reach and encompasses the multiple cascade use of biomass for material, biochemicals and residually for energy purposes. Thus, the German case studies teach us that bioenergy can play a role in the broad context of the bioeconomy but it is imperative that sound and transparent planning is adopted when devising these value chains.

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4. Ukraine

In the Ukrainian case study, we analysed the feasibility of producing 33,440 tons of lignocellulosic ethanol per year using feedstock from the underutilized lands in the non-exclusion zone of the Ivankiev Region. In this case study there is an array of environmental, technical, cultural, social as well as economic barriers to the uptake of these value chains. Some of these have a very local character, others must be dealt with at the national level and others are necessarily addressable only at the condition that European Policies and Actions support the necessary change. At any rate, the case study of Ukraine represents an interesting opportunity for the market uptake of advanced biofuels from underutilized lands in Europe.

THE STRATEGY

As we have seen in the case study of Italy, the EU-RED II has set ambitious goals for the provision of advanced biofuels by 2030. As about 50 additional biorefineries will need to be operational by the end of the next decade, ethanol production cost will be likely reduced. In order to enable the deployment of such a relevant number of biorefineries however, some form of support from the European Commission is expected. The entity and the mechanisms for the deployment of such support will be discussed and decided within the European Commission and this strategy, as in the case of Italy, can only take stock of the outcomes of such discussions. However, important recommendations can be made. Firstly, and consistently with what said earlier, support to the deployment of the additional biorefineries should be granted to the most virtuous projects, which in the case of the lignocellulosic technology studied in FORBIO means the provision of on-site enzymes production. This would ensure particularly favourable GHG performances of the fuel produced.

One key aspect to enable the production of lignocellulosic ethanol in Ukraine is linked to an open question concerning the possibility that the EC provides some form of support also the Non-EU member states, perhaps through some form of direct contribution to EU-based companies and service providers involved with the planning and building of the biorefinery.

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At any rate, the current policy landscape of Ukraine does not seem to prefigure a strong demand for liquid biofuels to be absorbed by the domestic market. Conversely, the favourable policy conditions for the generation of electricity and heat from renewable sources are the response to a relevant domestic demand for substituting imported natural gas with domestic supply of alternative fuels.

In this context, in the case study area there exist concrete potential to enable an efficient and sustainable value chain. To this end it is paramount that the Ukrainian government entails high level discussions with neighbouring EU-Member States to devise commercial agreements for the supply of advanced bioethanol to those states and contribute to meeting the RED II mandate.

Pivotal in this strategy, as mentioned earlier, is the role of the Law on "Heat and Energy Supply" (see reference list). Thanks to this piece of regulation, in fact, the production and commercialization of lignocellulosic ethanol and the surplus electricity and heat generated by the hypothetical biorefinery in Ukraine would make the value chain not only environmentally and socially sustainable, but also economically sustainable. The current political situation makes the purchase of natural gas particularly costly for Ukraine and as a response the Government enacted the amendment to Law 1959-VIII in March 2017 which includes rather appealing incentives for the domestic production of alternative and renewable electricity and heat. If on the one hand the extension of these incentives is desirable for sustaining the economic viability of heat and power from biomass, on the other hand a peaceful conclusion of the conflicts is hoped. Though it would be important that the Government of Ukraine changes the formula to calculate the incentive to the production of heat and power from the current basis (10% discount over the cost of natural gas) and moves towards a fixed incentive irrespectively of the price for natural gas paid.

Once the incentive system on power and heat from biomass is secured, the consolidation of the demand for lignocellulosic ethanol would be the priority. Bilateral or multilateral discussions between the Ukrainian government and the governments of neighbouring EU Member States (EU-MS) should culminate with long-term supply agreements. These agreements are required because to date, in many other EU-MS in addition to Italy, the sanction systems for incompliance with blending mandates are weak and inefficient, particularly when advanced ethanol is concerned. Although Ukraine has the potential to produce lignocellulosic ethanol at a lower price than the other case studies, given the international market price of ethanol alone the production of lignocellulosic ethanol would not be profitable in Ukraine either. This is a shared barrier with other FORBIO case study countries and with the majority of EU MS. Therefore, the agreements between Ukraine and neighbouring EU-MS should take into account the favourable production cost achievable in Ukraine, but on the other hand should be devised in a manner such that the domestic demand is supported by a sensible system of sanctions and excise breaks.

The main barrier at the local and operator level in Ukraine is represented by the land tenure aspects linked to long-term investments. Local authorities, as in the case of Italy, have the opportunity to contribute to mitigating this barrier, in collaboration with the stakeholders (e.g. farmers, etc.) and the Central Government. The authorities of the Ivankiev Oblast would be responsible for conveying working group of relevant stakeholders. The composition of the working group would clearly see the necessary participation of relevant local authorities' departments, farmers and agri-holdings interested in the taking part in the value chain, representatives of the fuel company who would plan and build the biorefinery, the Central Government and representatives of the civil society.

In this case, it is recommended that the Central Government considers the development and issuance of a long-term permit system that allows the cultivation of perennial crops for a sufficient time-frame to justify the initial investment and guarantee enough time to get generate revenues. The farmers or agri-holdings would be involved as members of a purpose-created consortium. The consortium would negotiate with the biomass buyer, likely the fuel company that will build the biorefinery, the conditions of the contracts. This was not felt to represent a barrier in Ukraine and it seems likely that a 25-year contract will be negotiated for the production of willow chips for the entire 16,720 ha inscribed within the *target area*.

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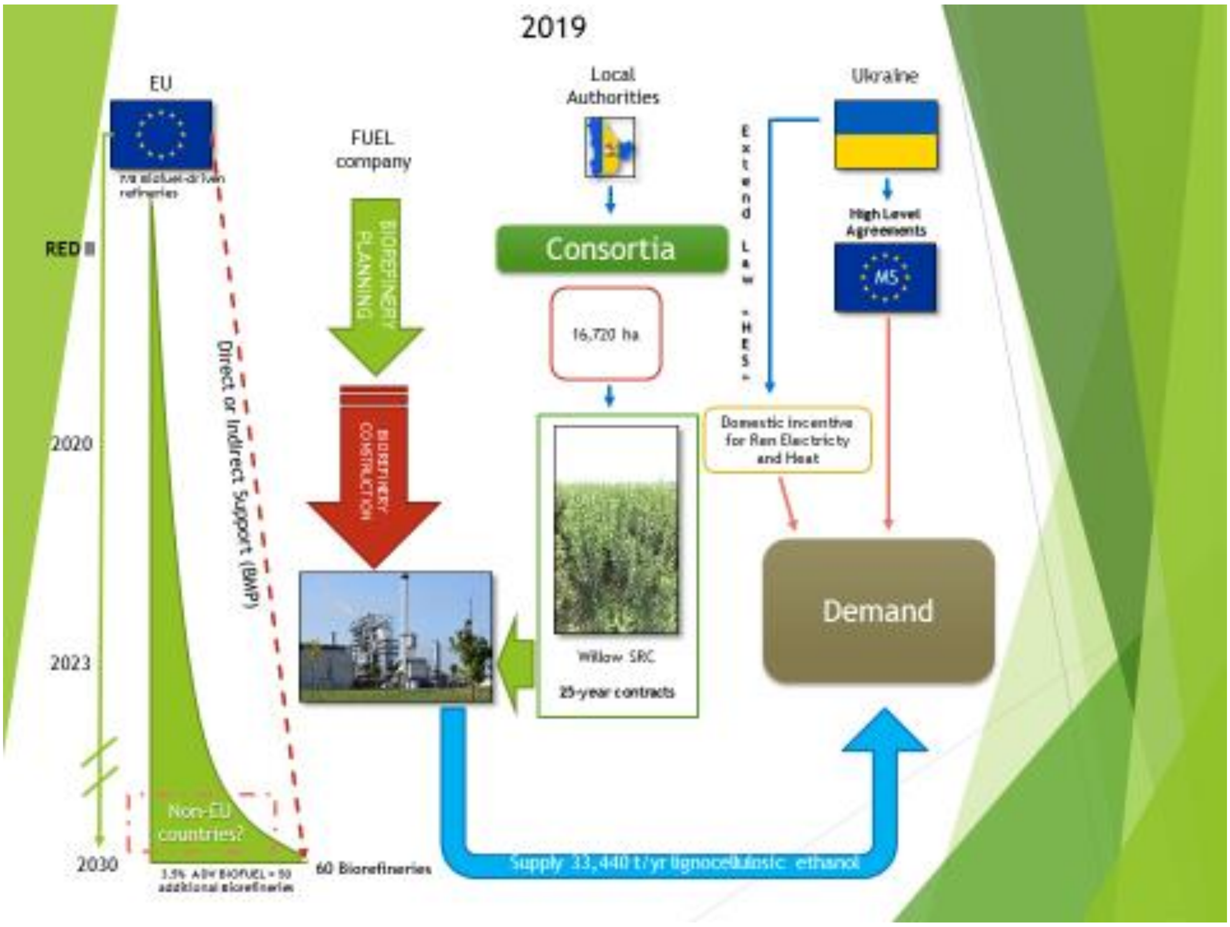
THE ROADMAP

As we have seen in previous chapters and in Deliverable 3.3 the production of advanced bioethanol in Ukraine in the case scenario presented is environmentally and socially sustainable, and given the current incentive system for the co-products (heat and power) also economically feasible. Given the current market conditions and the existing policy landscape, specific recommended actions as laid in the strategy would need to be adopted in order to enable the market uptake of these value chains.



Roadmap of the Ukrainian case study

In addition to the consolidation of the demand and the creation of the Consortia of Producers, the working group for the development of the value chain could

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begin the planning of the biorefinery. This step would imply the opening of a tender for the construction of the plant and the related discussions on the securing of the biomass supply. The cultivation of the biomass could begin at the end of the planning process, by 2020. Willow under Short Rotation Coppice has a production cycle of 3 years. Therefore, the first useful harvest of the biomass will be in 2023. Moreover, another aspect to take into consideration with this management form is that the amount of product (i.e. biomass) delivered at the end of the three years cycle will be three times the average yearly yield on which basis the biorefinery was developed. This entails a number of logistical aspects that will need to be properly considered prior to the construction of the biorefinery. As mentioned previously, the model biorefinery of Crescentino, Italy, used as reference for this exercise was built within 13 months. Technically then, the biorefinery in Ivankiev town could be built in about 1 year too. If this is the case, then the planning of the supply of biomass to the refinery would require a further step. Since the production of willow under Short Rotation Coppice management regime requires three years until the first harvest, the biorefinery might purchase wood chips from the market (therefore at market prices rather than at the cost of production as per Deliverable D 2.6 – Technoeconomic assessment) for the first two years and then rely on the newly available woodchips production within the ***target area***. However, the economies of this hybrid supply of biomass would push further the payback time and it is likely that the biorefinery planning would be postponed until locally produced biomass is available. This solution however, does not come without risks; the main of which being the necessity for the consortia to sign long-term biomass supply agreements with a fuel company three years before the biorefinery is actually commissioned. In the course of three years there exists the possibility that some arrangements/conditions change, including those linked to the political situation at the local level (depending on when elections are planned). In this case, farmers and agricultural entrepreneurs who start a biomass production cycle with perennial crops like willow, would require a solid contract in order to receive funding from the local financial institutions.

Another important element in the planning of the developments on the underutilized lands in the ***target area*** is linked to the consequential readiness of harvests. With this term it is intended that farmers will be divided into three groups. Each group of farmers should plant their lands with willows at different years. Each group of farmers will sign the same contract for the same expected total duration of the supply but there will be three distinct beginning and end dates for the supply, mirroring the three different planting times necessary to ensure a continuous flow of biomass to the biorefinery on an annual basis and avoid inefficiencies linked to long-term storage of the biomass.

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In this way then, 1/3 of the land (some 5,570 ha) will be developed the first year of project, ideally in 2020. A second share of the underutilized land, again some 5,570 ha will be planted in 2021. In 2022, the remaining 5,570 ha of underutilized land in the *target area* will be planted with willow. At the end of the 2022 growing season, the group of farmers who planted at the beginning of 2020 will be ready for the first harvest. This harvest, which is expected to deliver about 30 tons of biomass per ha after three years (10/t/yr), will deliver enough biomass to supply the biorefinery for the production of 33,440 tons of lignocellulosic ethanol. In 2023, farmers who planted in 2021 will have their first harvest and deliver the biomass to the biorefinery. At the end of 2024, the last group of farmers, who began production three years before will also be ready to supply the biorefinery. At the end of the 2025 growing season, the second harvest of the first group of farmers will be performed and so on until the fulfillment of the contracts for the following growing seasons for all groups of farmers.

This logistical arrangement is necessary, as briefly introduced earlier, to enhance the efficiency of the value chains. In fact, storing biomass for long periods has several disadvantages. Firstly, storage costs for a facility to host some 600,000 tons of biomass for three years at the time (the amount available if all underutilized lands would be harvested simultaneously) would be particularly high. More importantly then, the biomass stored for long periods of time would decay quite considerably, by releasing carbon into the atmosphere through decomposition and respiration and reducing overall mass and quality of the biomass by the time of utilization.

With the roadmap presented above, the planning of the value chain would begin in 2019, while the first batch of lignocellulosic ethanol produced from the local underutilized lands would be available at the end of 2022. The temporal arrangement of biomass production proposed would guarantee low storage costs and efficient use of the product by the biorefinery and a continuous and steady supply overtime. This, coupled with the policy landscape in Europe and in Ukraine, may represent an interesting case for an early deployment of biorefineries to fulfill the REDII targets.

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5. Conclusions

The strategies presented in this report are intended to support decision making for actions that enhance the market uptake of advanced bioenergy in Europe. An array of solutions has been presented for consideration of European-, National-, as well as local-level decision makers. The Italian case study represented a true testing ground for advanced biofuel value chains in Europe. Contaminated sites are a real problem for European citizens' health and for the expenditure of the health departments of European Member States. The production of biomass and the efficiency of lignocellulosic crops was proven to represent an asset for the sustainable development of the areas studied. These technologies, also thanks to the international support received through a number of actions of the European Commission, European and national research institutes as well as private companies, have nowadays reached maturity. On the international market however, these compete with conventional biofuel, namely ethanol from maize or sugarcane, and in turn with petrol. The former is often subsidized, and this aspect reflects on its international market price making it far more competitive than lignocellulosic ethanol. The latter, receives the same taxation regime applied to renewable fuels and in the last decade it records low international market prices when compared to historic trends. It was recommended in this report that the Commission as well as Member States take appropriate action to curb this double competition. The principal determinant of the production cost of lignocellulosic ethanol in Italy and even more so in Ukraine is represented by the high initial investments necessary to deploy the modern biorefineries that produce sustainable ethanol, heat and power rather than the cost of feedstock. Economies of scale are expected to cut down licensing and construction costs of these facilities but without some forms of direct or indirect public support to their off-take it seems quite unrealistic that the volumes necessary to ignite economies of scale will ever be reached. The Renewable Energy Directive II mandates indirectly that these plants are built and begin production in the short term, though to date it remains unclear what forms and the magnitude of the support that these might receive.

The collaboration among EU-MS to reach these common goals is fundamental and so is the establishment of cross-border agreements with Countries that can support the renewable revolution initiated by the European Union with the first iteration of the Renewable Energy Directive and now reiterated in the New RED II. Ukraine has shown to be the perfect candidate for the mutual benefits that its participation in agreement with EU-MS can bring to achieving the mandate of the RED II on one hand, and to foster sustainable development and growth in the neighbouring country on the other hand. In conclusion, the assessment of the

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economic and non-economic barriers to the market of advanced biofuels in Europe performed in the context of the FORBIO project represents a rational compendium of actions and recommendations based on facts and measurements to guide policymakers as well as private stakeholders in the pursue of a sustainable future for the transport sector in the Union.

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