FOR BIO

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

D2.6

FEASIBILITY STUDY UKRAINE

TECHNICAL AND ECONOMIC FEASIBILITY

CTXI

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691846.

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Fostering Sustainable Feedstock Production for Advanced Biofuels on underutilised land in Europe

Introduction

This technical and economic feasibility study intends to analyze the different options available for the development of a sustainable feedstock production in Ukraine, based on Salix viminalis L. to produce advanced biofuels as, for example, lignocellulosic ethanol.

Theoretical assessment of the underutilized lands availability within the target area (100 km radius zone near Ivankiv town) was done with the use of deep statistical analysis under preparation of the Deliverable 2.5 – Agronomic feasibility Ukraine. It was shown that potential of underutilized lands in the 100 km zone from Ivankiv town estimates in 46-67 thousand hectares annually. Two categories of land was considered as an underutilized in the assessment:

- abandoned agricultural land, i.e. land that is not needed any more for the production of food and feed crops or for other purposes;
- degraded or low productive land, i.e. land that is not suitable or no longer suitable for conventional commercial agriculture (see D2.5 Article 2.4).

Assessment of the theoretical land availability confirmed the fact that the biorefinery should be located in Ivankiv town as the centre of the region with the biggest land potential (on average 13 000 ha annually. See Table 6, 6a of the D2.5) and as in the administrative centre with high unemployment level per capita.

Therefore, in this deliverable will be identify the potential of underutilized lands at the radius of 50 km from potential biorefinery location with regard to roads distribution and general development of transportation system in the region.

For the purpose of this study, the supply chain process has been ideally divided in two major steps, which are in practice interrelated:

- Biomass production, from planting until harvesting
- Handling, conditioning and transporting biomass from the field to the biomass processing plant gate

A hypothetical scenario in which the biomass is transformed in lignocellulosic ethanol has been devised. Each step includes more unit processes that require input flows and produce output flows.

Biomass production

Agricultural operations

The first step in cultivation of bioenergy feedstocks consists of soil preparation, aiming at restoring the physical structure of the soil to guarantee the health of the crop.

Industrial plantation of willow will be planted on land where crops have not been grown for more than 15 years.

For preparation of fields in the *preparatory year* will be done the following agricultural operation:

- disking up to 12 cm depth,
- Water supply for spraying,
- preparation and spraying of herbicide, using Glyfosate (450 g/l),
- **fertilizing** treatment, using mineral fertilizer,
- ploughing (up to 30 cm) after the herbicide waiting period (2-3 weeks).

In the *first year*, a tractor with a special purpose planting machine will do pre-plant soil preparation – cultivation and planting. In addition, the **planting** material must be treated with herbicides. Preparation of seedlings will be performed manually, their transportation will be carried out by a tractor-trailer. Next, the operations on planting material tending, which combine chemical and mechanical methods of weed control, will be done. Immediately after planting in fields, **herbicide** with Pendimethalin as an active ingredient (concentration 330 g/l) spraying with simultaneous treatment of nitrogen fertilizers, Carbamide (N46.2), will be done.

Next, inter-row tillage will be done by a soil cutter. After that, if necessary, the first disking between rows must be carried out. Then the herbicide spraying and the second disking between rows must be done. Every third year after **defoliation**, willow harvesting will be done by a self-propelled combine. *Tractor-trailers will be used for biomass transportation.*

After harvesting operations, **fertilizers** will be applied to overcome the lack of plant nutrients according the volumes of plant nutrients depletion and the soil analysis. In

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case of plant damage, necessary measures will be taken according to the situation. List of technological operations with approximate terms and some details is given in TABLE 1.

TABLE 1. TECHNOLOGICAL OPERATIONS FOR INDUSTRIAL PLANTATION

Year	Agricultural operation
O year	Disking up to 12 cm depth
	Water supply for spraying
	Preparation and spraying of herbicide
	Mineral fertilizers transportation
	Fertilizer spreading
	Ploughing up to 30 cm depth
1° year	Pre-plant cultivation
	Preparing and loading of seedlings
	Seedlings transportation
	Planting to 20 cm depth with inter-rows: double 1.5 cm and single 0.75 cm with insecticide treatment
	Water supply for spraying
	Preparation and spraying of herbicide
	First inter-row cultivation with folding power harrow between adjacent rows
	First inter-row disking
	Water supply for spraying
	Preparation and spraying of herbicide with carbamide
	Second inter-row disking
3° year	Harvesting on 3 year
	Biomass handling
	Preparation and spreading of fertilizer
6th year	Harvesting on 6 year
	Biomass handling
	Preparation and spreading of fertilizer
9th year	Harvesting on 9 year
	Biomass handling
after harvesting	Preparation and spraying of herbicide
	Plowing
	Heavy harrowing

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Handling, transport, logistics

The supply chain strategy is a compromise between the demand of biomass of the bioethanol plant during the year, the agricultural practices, the yield and the biomass harvesting period, the storage methods and facilities, as well as the transport logistics.

An industrial plant has a fixed storage capacity that usually cannot allow to store the entire seasonal production, due to the high biomass volumes required for the production of lignocellulosic bioethanol. Thus, next to the direct delivering after harvesting, middle storages or field storage should be envisaged.

The supply strategy and logistic involves the following steps:

- Transport from the field to a bioethanol plant (or field storage or to a middle storage yard)
- Middle storage or field storage or storage at the plant
- Transportation from middle storage to a bioethanol plant

After harvesting operations, the treatment/handling of biomass near the field should be considered, including also the biomass transport in a radius of 2 km.

Furthermore, this section aims to identify the potential of underutilized lands at the radius of 50 km from potential biorefinery location with regard to roads distribution and general development of transportation system in the region.

The length of roads within Ivankiv region is 533.5 km, including the length of roads of national importance (Kyiv - Ivankov – Ovruch) - 78 km. The length of streets settlements - 543.9 km, the total length of Ivankiv town streets - 46 km.

The transportation roads from Ivankiv town to the remotest borders of adjoining regions (Vyshgorodskyi, Borodianskyi, Poliskyi, Malynskyi) are shown at the Figures 1-4. As it can be seen, the transportation distance does not exceed 55 km (except Malynskyi region).

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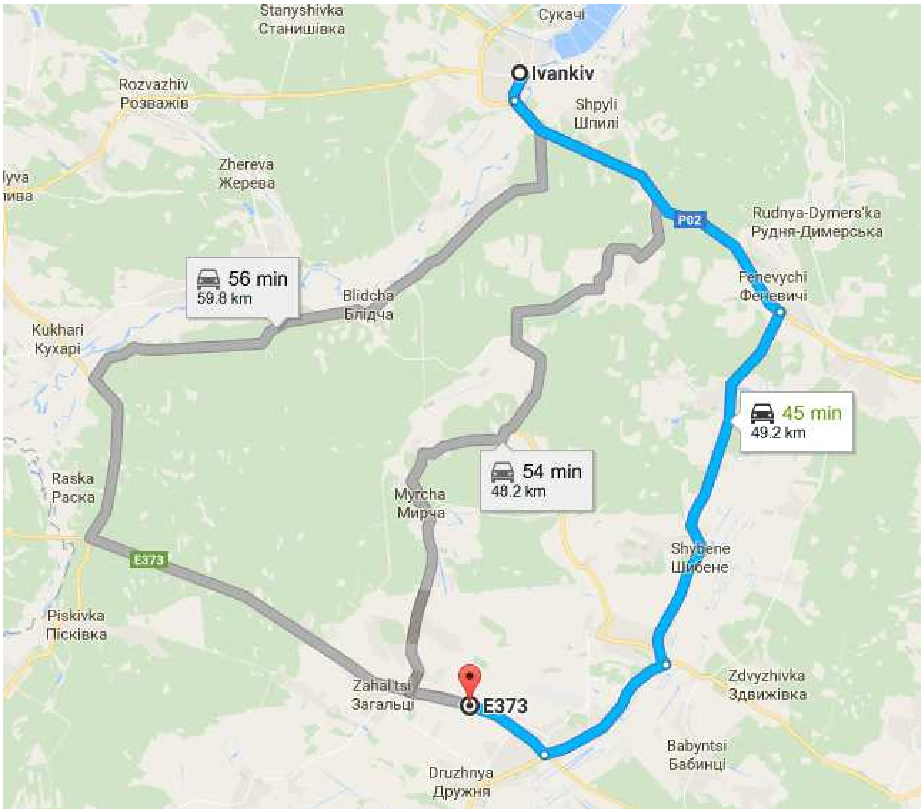

FIGURE 1. ROAD CONNECTION BETWEEN IVANKIV TOWN AND THE BORDER OF BORODIANSKYI REGION

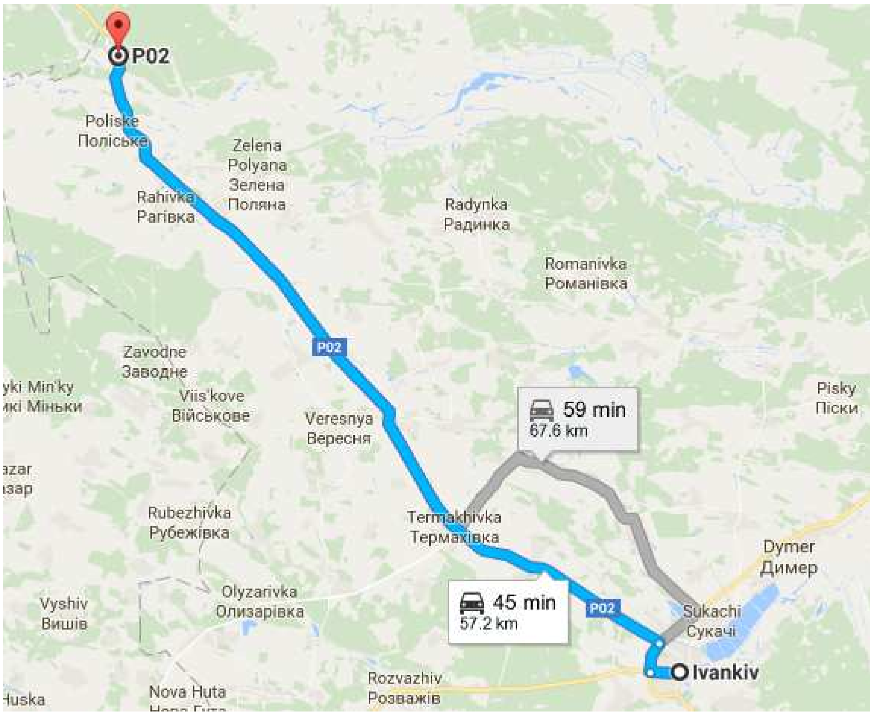

FIGURE 2. ROAD CONNECTION BETWEEN IVANKIV TOWN AND THE BORDER OF POLISKYI REGION

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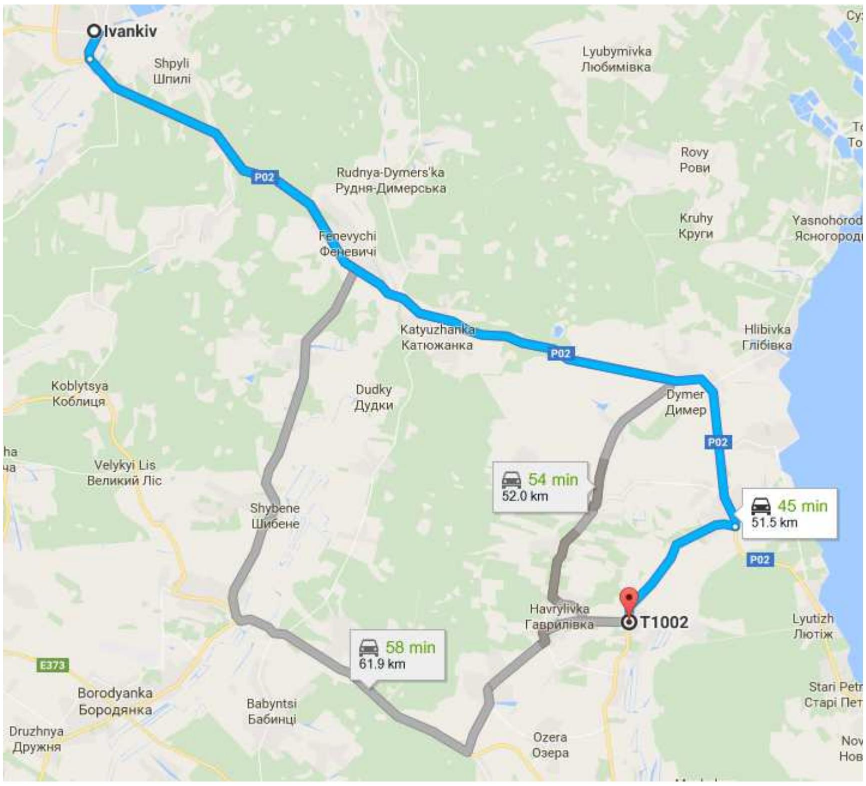

FIGURE 3. ROAD CONNECTION BETWEEN IVANKIV TOWN AND THE BORDER OF VYSHGORODSKYI REGION

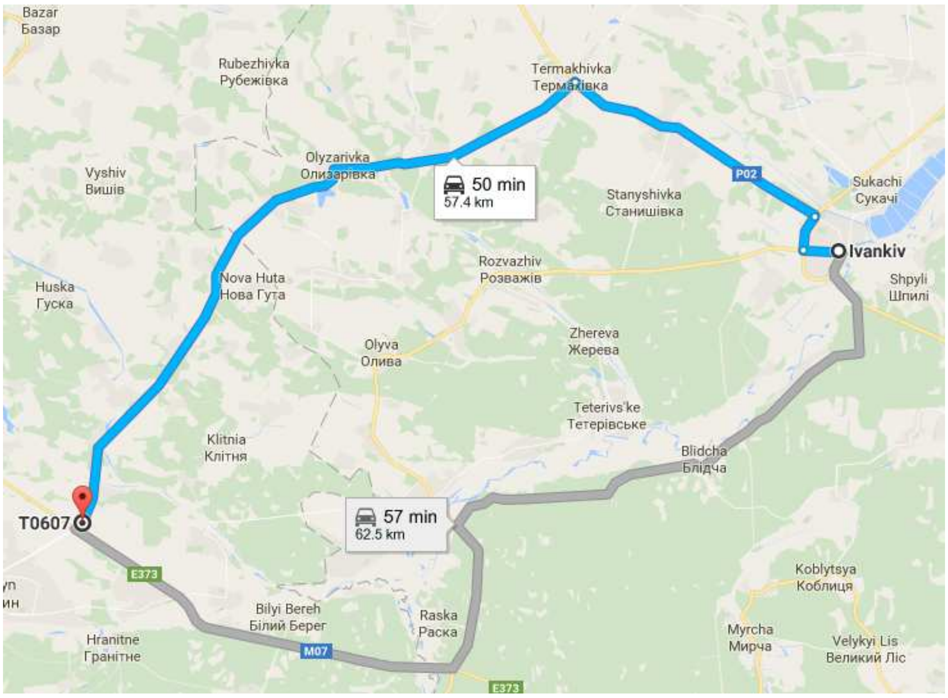

FIGURE 4. ROAD CONNECTION BETWEEN IVANKIV TOWN AND THE BORDER OF MAKARIVSKYI REGION

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Density of the underutilized lands availability within regions in 50 km zone from Ivankiv town presented in the TABLE 2 and Figure 5. For Ivankivskyi, Poliskyi, Vyshgorodskyi and Borodianskyi regions, the value of underutilized lands includes the potential of the total region. For Masynskyi region only part of the underutilized lands considered in the assessment because of the road distance between Ivankiv town and possible location of the free lands. Nevertheless, even part of the Malynskyi region represents big potential of underutilized lands within 50 km radius from potential biorefinery.

TABLE 2. DISTRIBUTION OF UNDERUTILIZED LANDS POTENTIAL DEPENDING OF THE DISTANCE FROM IVANKIV TOWN

REGIONS	DISTANCE[1] FROM IVANKIV TOWN TO THE REMOTEST POINTS OF THE REGION, KM	UNDERUTILIZED LAND WITHIN 50 KM ZONE, THOUSAND HECTARES
IVANKIVSKYI	40	13.00
POLISKYI	52	4.08
MALYNSKYI	85	2.03 (part of the region)
VYSHGORODSKYI	55	1.45
BORODIANSKYI	49	0.79
POTENTIAL IN THE REGIONS THAT LOCATED IN 50 KM RAGIUS FROM IVANKIV		**21.35**

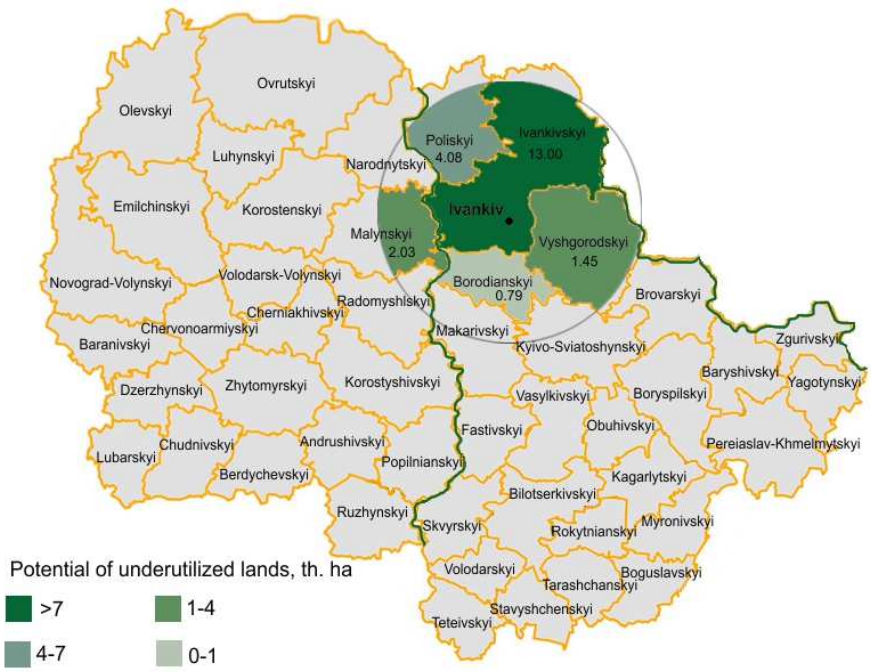

FIGURE 5. AVERAGE UNDERUTILIZED LANDS POTENTIAL WITHIN 50 KM ZONE FROM IVANKIV TOWN

1. [1] Measured by roads

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Taking into account the results of field trials of the *Salix viminalis* L. (varieties "Tora", "Tordis", "Inger") growing at the case study site (50 ha experimental field with sandy, sandy loam soils that is used as a mother plantation) and the possible biomass yield of industrial plantation (10 dry tons/hectare/year), the teoretical potential of bioenergy feedstock growing on underutilized lands withing the considered area could be estimated as following: **21.35*10*0.94=200 th. dry tons/year** (where 0.94 – coefficient of technical availability).

It is planned to store wood chips in piles in the open air (Figure 6). According to the recommendations of Salix Energy LLC (first Ukrainian company that grow willow at commercial scale), piles' height should be up to 4 m. At that, willow chips lost 7-10% of moisture over 2-3 months, but it should be periodically stirred. A telescopic wheel loader is used for cargo operations and stirring.

Willow chips will be transported from a harvester to a local storage located on the edge of the plantation field (transportation distance is considered to be 2 km). After harvesting, willow chips will be transported by all available means of transport to a central store or to the bioethanol plant directly.

FIGURE 6. CHIPS PILE

Equipment that needed to perform technological operations on mother and industrial plantations presented in the Table 12 of Deliverable 2.5.

For the evaluation of the logistical supply chain costs of this report, the area was restrained to a realistic 50 km radius from the plant.

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From farm to fuel

Lignocellulosic Bioethanol production

For the purpose of this techno-economic feasibility study, a scenario including a bioethanol plant in Ukraine has been hypothezised, with the following assumptions:

- Technology: Lignocellulosic bioethanol technology for fuel production
- Plant Capacity: 40.000 tons/year
- Mean biomass productivity: 10 dry tons/hectare/y
- Area needed for biomass production: 21.350 hectares
- Collection radius from the plant: 50 km
- Coefficient of technical availability: 0.94
- Harvesting method: single-pass by self-propelled forage harvester with parallel loading on Tractor-trailers.

A flow diagram of a lignocellulosic ethanol enzymatic process is provided below for reference:

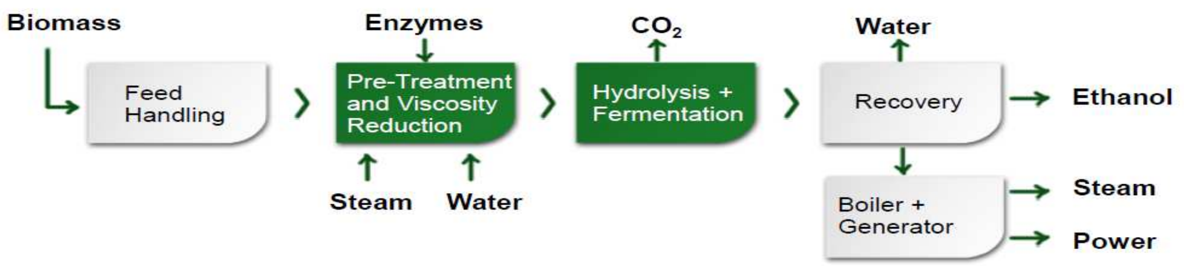

FIGURE 7. PROCESS FLOW DIAGRAM FOR LIGNOCELLULOSIC ETHANOL PRODUCTION

Based on its previous experience with similar supply chains, Biochemtex with support by SecBio, has developed a cost model per dry ton of biomass.

The model follows the 2nd to 10th year production of Salix Viminalis L., including amortization of installation (year 1) and eradication (year 10) costs.

The model has been adapted for the Ukraine site, considering the actual costs derived from the agronomic field trials experience.

Results are summarized in TABLE 3. The same data are shown in the Figure 8.

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This model shows a theoretical cost **about 29 €/dry ton** of biomass for biomass delivered to the plant gate and collected within a 50 km radius.

TABLE 3. BIOMASS COST DELIVERED AT PLANT GATE

ITEM	€/TON
LANDOWNER FEE	1.3
FERTILIZATION COSTS	3.2
HARVESTING (SINGLE PASS FOR ONE ROW)	3.2
PRO-ANNO INSTALLATION + ERADICATION COSTS	13.9
CAPITAL REMUNERATION (2.5%)	3.5
TECHNICAL FIELD COST	**25.2**
BIOMASS HANDLING AND TRANSPORT (50 KM)	3.5
FINAL COST AT PLANT GATE	**28.7**

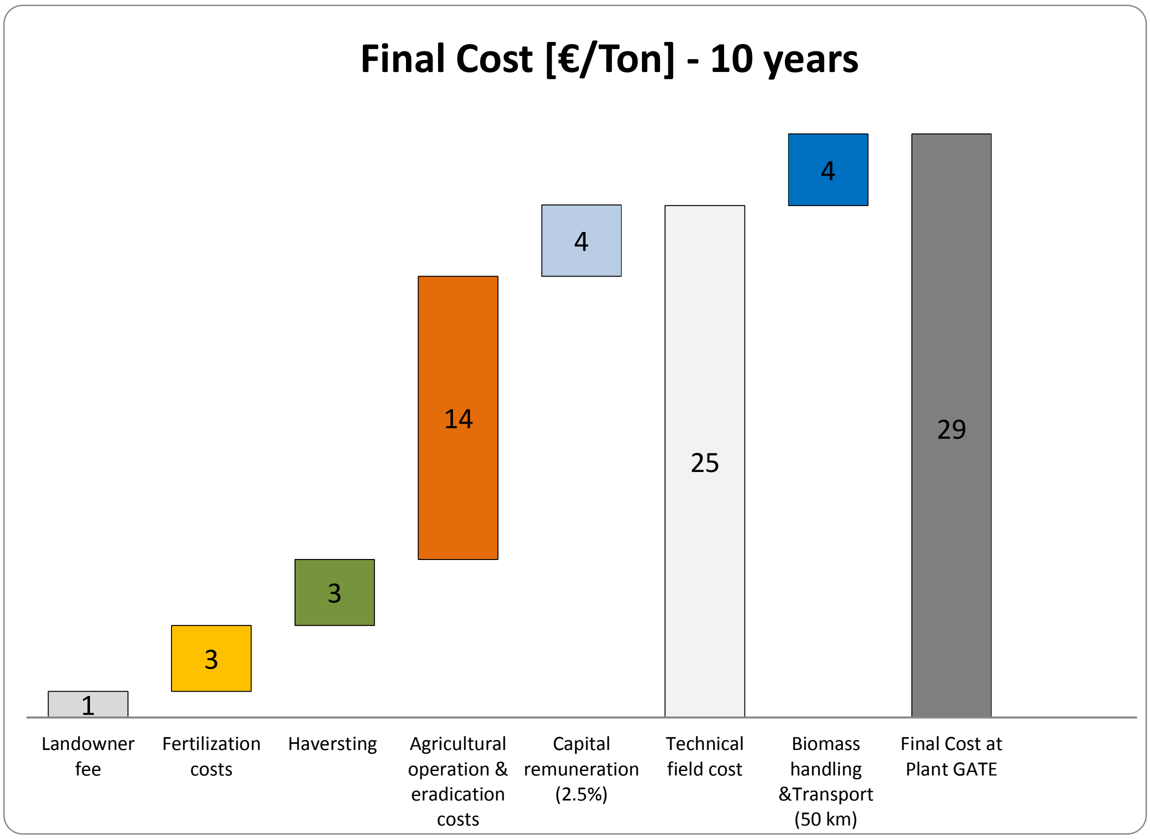

FIGURE 8. BIOMASS COST DELIVERED AT PLANT GATE

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Discussion

An overview for determining the costs of delivering biomass to a bioethanol plant in Ukraine is shown in the TABLE 3.

The technical feasibility study is based on hypothesis of investment decisions on the production plant that are quite realistic, but cannot presently provide the necessary details. Furthermore, it does not allow for dynamic modelling: however it still can be taken as a useful tool for some considerations.

Indeed, since Ivankiv area presents underutilized fields, the re-use of existing areas for biomass storage could demonstrate to be useful and economically attractive. In this sense, the hypothesis of having a large, low capex, in-house capacity for multiple months of biomass storage could be a key for different priorities in the supply chain management and design (e.g. the chipped material, the need for intermediate or in-field storages).

As it can see in the table 3, contrary to the Italian case study, in this case study there aren't:

- irrigation fee;
- maintenance irrigation system;
- supply chain management.

The major impact of the technical field cost is represented by agricultural operation and eradication costs, about the 55%.

In addition, it should be noted that the transport costs represents about 12% of the final cost (including also the cost of the handling and transport of biomass near the field), in assumption of a 50 km radius from the plant.

It should be noted also that in the feasibility study Ukraine the transport cost is i 30% less than that of the Italian study case because the market price of transportation in Ukraine is 1,2 UAH/km/t=0,04 EURO/t/km.

The total final cost at plant gate here hypothesized could provide an acceptable business case for the plant owner, even if detailed sensitivity analysis would have to be performed taking into account external parameters and factors (e.g. legislation, technological optimizations, transport, biofuels market, fossil fuel price, other externalities etc.).

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