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PROJECT FINAL REPORT

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4.1 Final publishable summary report

Executive summary.

Cost-efficient, environmental-friendly and socially sustainable biomass supply chains are urgently needed to achieve the 2020 targets of the Strategic Energy Technologies-Plan of the European Union, which are likely to be impeded by the potential scarcity of lignocellulosic biomass from agriculture. Innovative techniques for crop management, biomass harvesting and pre-treatment, storage and transport offer a prime avenue to increase biomass supply while keeping costs down and minimizing adverse environmental impacts. The Logist'EC project aimed at developing new or improved technologies for all steps of the logistics chains, and to assess their sustainability at supply-area level for small to large-scale bio-based projects. It encompassed all types of lignocellulosic crops: annual and pluri-annual crops, perennial grasses, and short-rotation coppice, and included pilot- to industrial-scale demonstrations, in particular around 2 existing bioenergy and biomaterials value-chains in Europe (in Eastern France and Southern Spain).

Logist'EC delivered the following types of results:
- Benchmarks for currently-commercial technologies, and the improvements developed during the project,
- A set of methods, models tools to integrate, design and assess supply chains,
- Data bases on logistic chains (relative to individual pieces of equipment, feedstock management, yields, and sustainability criteria),
- Some examples of chain implementation, documenting their feasibility, the application of the data bases and tools, and their overall performance and sustainability.

Overall, the information and tools delivered by the project provided a first step to guide in incremental improvements as well as systemic changes in biomass feedstock supply chains from energy crops. For instance, the use of briquetting (a form of biomass densification) proved very efficient to cut down costs and greenhouse gas emissions in the Miscanthus case-study in Burgundy. The Spanish case-study emphasized the role of policies and institutional relations on the sustainability of biomass supply from energy crops.
The Logist'EC project issued a set of recommendations for the 2 case-study value-chains as well as for all individual components of the logistics chains. Its results are being taken up by future users ranging from farmers' cooperatives and business developers to scientists and policy-makers.

Please provide a summary description of the project context and the main objectives. The length of this part cannot exceed 4 pages.

Cost-efficient, environmental-friendly and socially sustainable biomass supply chains are urgently needed to achieve the 2020 and 2030 targets of the European Union, which are likely to be impeded by the high supply cost and potential scarcity of agricultural and forestry biomass in Europe. Innovative techniques for crop management, biomass harvesting, storage and transport offer a prime avenue to increase biomass supply while keeping costs down and minimizing adverse environmental impacts. Significant challenges for the deployment of optimal feedstock supply chains include the scattered and bulky nature of biomass, its high moisture content, and potential for degradation during storage and transport. Biomass logistical systems face considerable challenges in the various dimensions of sustainability, whether economic, environmental or social. The problems around managing, designing and implementing a bioenergy scheme are complex and multi-faceted. There are many stakeholders for each project and many requirements that must be satisfied for the successful long-term operation of a project.

Avenues to improve the sustainability of feedstock logistics systems thus include:
- Increased efficiency of harvesting, pre-processing, and transport equipment,
- The densification of biomass prior to transport, with or without thermal pre-treatment, to produce a carrier that can be handled in already existing transport, handling and storage equipment,
- An optimal integration of system components,
- Lower impacts of road transport by a reduction in transportation distances,
- Adaptation of logistics operations (in particular storage) to high-moisture biomass, or enhancement of drying conditions,
- Feedstock production systems providing year-round supply with high productivity per unit area and consistent biomass properties.

The Logist'EC project funded by the 7th Framework Programme of the European Commission aimed at addressing these challenges. Its main tenet was that stepwise developments in the components of biomass logistics would lead to an optimization at supply-chain level, making the most of the developments carried out in the individual components. This is reflected in the project structure, with 3 work-packages focusing on these steps while a fourth work-package dealt with chain integration and assessment. Spatially-explicit modelling of production fields, storage sites and transportation routes allowed for an optimization of the supply chains by combining the most appropriate technologies, as driven by the requirement of the biomass conversion processes, and the seasonality of end-product demand. The development of a comprehensive framework for sustainability assessment, encompassing economic, environmental and social criteria was intended to provide guidance in the chain optimization and to propose solutions tailored to various possible end-users, whether private stakeholders or policy makers.

As a basis for supply chain integration and full-scale demonstrations, two case-studies based on currently-operating value-chains in Europe were developed. The first one involves a 16 MW bio-electricity plant running on agricultural and forest biomass in Miajadas (Southern Spain), which uses mostly wood products but expressed interest in increasing the share of biomass from energy crops. The company running the plant (Acciona Energia) had established 30 ha of poplar prior to the project's start, and had prepared 15 ha of triticale

cultivation and 50 ha for sorghum to test and demonstrate innovations on crop management (e.g., mixed cropping of cereals with legumes), and logistics.
The second case-study involved a farmers' cooperative (Bourgogne Pellets) based in Burgundy (Eastern France), which developed perennial grasses (Miscanthus and switchgrass) on commercial farms, to make pellets or biomass chips for various local and national markets. The area currently managed by the cooperative is about 500 ha, and the Logist'EC project has been looking at ways to improve the logistics and scale up the production, which is currently limited by market demand.
Thus, these case-studies offer two contrasting business cases: on the one hand a large-scale conversion plant with a regular demand for biomass and a broad supply area, collecting biomass over distances possibly longer than 100 kms; on the other hand, a small-scale unit with locally-sourced biomass, coming from fields located within 10 to 50 kms around the plant. These two situations may be considered representative of the two main models currently existing for bio-based value-chains and logistics, and a good basis to transfer the results of Logist'EC to new biomass projects, including second-generation biofuels.

The **first work-package** of Logist'EC focused on feedstock production, the first step of the logistics chain, which is of prime importance since it contributes a major fraction of environmental impacts and economic costs. It therefore impacts the sustainability of the supply chain, but also the rest of the logistics since it determines the amounts, density and quality of available biomass around the biomass processing units. The type of energy crops, their management, as well as insertion in cropping systems determines yield potentials and biomass quality, possible options for biomass densification or transportation, the profile of production costs, etc. Lastly, some aspects of environmental impacts of energy crops are still unclear: at the start of the project there were relatively few data on the effects of perennial grasses or woody species on soil organic carbon, especially after the destruction of the stands.

More specifically, this work-package (WP) aimed at:
- Gathering and organizing existing data on production, biomass quality and environmental impacts of energy crops and at synthetizing them using meta-analysis methods.
- Setting up new field experiments to fill knowledge gaps and incorporated this knowledge and experimental data into soil and agroecosystem models, in order to improve their quality for prediction.
- Assessing of a first innovative crop management system for feedstock production: the intercropping of energy crops with legumes, and the use of biomass conversion process residues as fertilizers.
- Designing and assessing cropping systems including energy crops.

A **second WP** focused on the adaptations of agricultural machinery for cost-efficient biomass harvesting and handling. Such machinery already exists for the harvesting and immediate post-harvest conditioning of energy crops. By comparing the performance of each harvesting system under experimental conditions, we aimed to: generate data on aspects that are currently poorly quantified, highlight the positive aspects of each system and identify potential routes to improvement.
Its specific objectives consisted of:
- Reviewing the performance of currently available, large and smaller scale, harvesting technologies and subsequent harvested crop management.
- Where practical and financially affordable within the project, making engineering developments to those technologies and systems and test them in the field.

- Determining how the timing of the harvest operation affects crop quality, costs and re-growth potential.
- Identifying the extent to which year round supply with minimal storage may be possible via extended harvest windows for each crop.
- Producing recommendations, underpinned by a robust data set, of improved harvesting systems (machinery and management) as part of an improved logistics chain for biomass energy crops.

A **third WP** investigated densification options for both woody as well as grassy energy crops. The focus was on briquetting (and to some extent pelletization) rather than on conventional baling technologies, which are already available, since briquetting as well as pelletization were expected to result in denser materials, more suitable for industrial use.
In addition, two pre-treatment technologies (torrefaction and Torwash) have been developed and tested on specific crops, both in combination with briquetting as densification step rather than pelletization. The research on the different technologies has been done in collaboration with industry partners, end enabled the development/modification of innovative equipment and systems designed specifically for the energy crops considered within this project.

The work within this work package pursued 3 objectives:
- Developing the densification of both grassy and woody energy crops without any additional (thermal) processing of the crops, mainly through briquetting.
- Developing thermal pre-treatment processes to improve the overall chain from energy crops to solid bio-energy carrier.
- Testing the transport, handling and storage quality of the different solid bio-energy carriers produced with the above-developed densification and thermal pre-treatments

Assessing the overall performance and sustainability of logistic chains and identifying key points of improvement was at the heart of the Logist'EC project and one of its major research objectives. The objective of the **fourth WP** of the project was to develop a holistic framework to integrate chain components and assess their environmental, economic and social impacts of biomass supply chains based on two case studies in Burgundy (France) and Miajadas (Spain).

This include developing and demonstrating:
- An integrated model of the logistics chain, with a spatially- and temporally-explicit approach, enabling the modelling of feedstock supply and optimization of the biomass supply-chains from field to plant gate taking into account transportation distances, economy of scale, uncertainty and available technical and management options.
- Methodologies for environmental assessment of the optimized logistical chains based on the LCA and Emergy approach.
- An investigation of social, economic, environmental sustainability and regulatory barriers to innovation in the logistical chain.
- A holistic framework by using the SUstainability Multiscale Multimethod Assessment (SUMMA) approach to synthesize the economic, environmental and social assessments, bringing in focus the multi criteria nature of the challenges of biomass logistical systems.

The overall objective of **WP5** was to demonstrate, under real operational conditions, how the best technologies coming out of WP 1 to 4 for the different steps of the logistics chains can be combined to improve biomass supply at plant-gate, with respect to current practices. Demonstrations took place at industrial pilot-scale to confirm the feasibility and benefits of these technologies, equipment or systems, and also to show to the key players involved in the biomass supply chains the advancements achieved.

Improved logistics were demonstrated at pilot and industrial scales in 2 regions (Eastern France and Southern Spain) for existing bio-energy and bio-materials value chains. It has been used 4 different feedstocks: annual grassy (triticale and sorghum), perennial energy crops (Miscanthus), and woody energy crops (poplar). All technology developments were carried out with industrial partners, to speed up their transfer to market. Project results were disseminated to the relevant stakeholder groups via scientific and technical conferences, targeted events in connection with the demonstration sites, the project web site and newsletter. Besides, other demonstration cases were focused on concrete steps of the logistic chain.

Regarding harvesting, the most promising engineering developments from WP2 were demonstrated at farm scale. Approximately 10 hectares of grassy energy crops (Italy) and 10 hectares of woody energy crops (UK) were harvested, to show that the prototype concept stage can be scaled up to full operation

Regarding pre-treatment, in addition to the two overall chain demonstrations in the project in Spain and France, pre-treatments of energy crops were demonstrated at separated sites in the Netherlands and Denmark. The pre-treatment willow and triticale pellet torrefaction was made in the semi-industrial pilot plant at ECN in the Netherlands, whereas the subsequent briquetting was demonstrated at the also already existing semi-industrial pilot plant at CFN in Denmark. Willow torrefaction and briquetting was successfully carried out, while it proved impossible to briquette torrefied triticale.

The **last WP of the project** pursued the following dissemination objectives:

- Making the best possible use of the project results by the stakeholders of the biomass industry through extensive interactions with end-users of the project results;
- Ensuring fruitful exchange with the scientific community, including individuals and collaborative initiatives, senior and early scientists;
- Informing European citizens and policy makers about the stakes of the project, the challenges encountered by the biomass industry, the impact on citizens’ well-being, and the contributions brought by the project to answer stakeholders’ needs and meet consumer demands;
- Making a discerning analysis of the research and technical outputs of the project, and ensure that they are effectively disseminated among the above stakeholder groups;
- Disseminating project results based on participatory methods during stakeholder workshops with targeted participants identified through the stakeholder platform.

This WP addressed the integration in agriculture and sustainability based on the results generated by the other activities of Logist'EC, and by creating a dedicated networking framework. It resulted in the identification of the best conditions/practices for the implementation of supply-chains based on energy crops and the dissemination of this information. It also ensured that all the results from Logist’EC reached their potential end-users through dedicated workshops targeting different kinds of stakeholders with adapted content and format. A stakeholder platform was set up to ensure that all the targets of the project could be achieved, serving both as a way of disseminating the project results and discussing the most promising results and how they should be transferred.

In addition to classical approaches to dissemination, such as the production of scientific publications, participation in scientific and technological events, maintenance of a website and the production of factsheets, this WP also placed an extra effort on learning methods and the active involvement of a diversity of stakeholders through the organisation of field visits around the demonstration sites of Logist'EC. The latter approach includes the organisation of workshops which specifically target and involve the following stakeholders' groups: agriculture, NGOs, EU networks, and Central and Eastern European stakeholders.

Please provide a description of the main S & T results/foregrounds. The length of this part cannot exceed 25 pages.

The results obtained during the course of the Logist'EC project include:
- A set of benchmarks for currently-commercial technologies, and the improvements developed during the project;
- A set of methods, models tools to integrate, design and assess supply chains;
- data bases on logistic chains (relative to individual pieces of equipment, feedstock management, yields, and sustainability criteria);
- Some examples of chain implementation, documenting their feasibility, the application of the data bases and tools, and their overall performance and sustainability.

We hereafter present results obtained in these categories through in each work-package of the project, dealing with the components of the logistics chains (from feedstock production to biomass pre-treatment), their overall optimization and sustainability assessment, and the demonstrations in a set of case-studies. Activities related to the dissemination of project results are presented in the Impact section of this report.

Regarding feedstock production systems (WP1):

1. Yield, quality and environmental impacts of lignocellulosic crops

A database including 858 yield data of 36 energy crops from 28 scientific papers was elaborated. A meta-analysis aiming at ranking the yields of energy crops was carried out. More specifically, a statistical analysis based on direct and indirect comparisons was performed to compare the mean yield values of the species included in the database. Miscanthus x giganteus was significantly more productive than most of the other energy crops included in the database. Giant reed (Arundo donax) and Pennisetum purpureum were significantly more productive than Miscanthus x giganteus but both were studied at a limited number of sites. By contrast, Erianthus, Phragmites australis, Phalaris arundinacea, Miscanthus sacchariflorus and Miscanthus sinensis were the least productive species. This database and on-farm data of Miscanthus x giganteus gathered in the Bourgogne Pellets supply area were also used to develop a Bayesian statistical model to predict the yields of energy crops using site-specific measurements. Two applications were developed to predict (i) the future yields of Miscanthus x giganteus using past yield data, (ii) the yield of an energy crop in a given area from yield data collected in the same area, but for a different crop species. The first application was used to predict the future yields of Miscanthus x giganteus in the supply area of Bourgogne Pellets.

In terms of modelling, improvements were made to the STICS crop model to simulate the biomass production and environmental impacts of Miscanthus x giganteus cropping systems in the long term. This model was then validated on a large database and in various pedoclimatic environments in France and United Kingdom. The model accurately simulated biomass production and nitrogen content in aboveground biomass, from planting until 4 to 20 years of cultivation. The model also reproduced the effect of management practices on the harvest biomass and N export. Yield gap analysis using simulations with and without active stresses revealed that Miscanthus x giganteus biomass production was limited by both water and N availability during the establishment phase but mainly limited by water availability during the post-establishment phase.

2. Reverting from perennial grasses

Several partners set up experiments on the destruction of perennial energy crops following a common protocol. Reverting Miscanthus x giganteus or giant reed is possible with conventional farm practices but one year of production is lost in all cases. Overall, the combination of mechanical and chemical weeding seems to represent the best option to remove giant reed and Miscanthus x giganteus. The main limit of this strategy is the large use of a non-selective herbicide use such as glyphosate and its associate environmental impact (water pollution, reduction in biodiversity, etc.). In England, previous cropping with Miscanthus x giganteus did not reduce arable yields (compared with continuous arable crops). In addition, there were no apparent effects on the destruction of perennial crop on the nitrogen dynamics of the soil system. However, a higher soil carbon concentration than in annual crops was still visible in the surface layer three years after the crop removal. In Italy, higher CO2 emissions from soil were observed during the destruction phase compared to mature crops and this increase was higher when soil tillage was performed.

3. Innovation in feedstock production: biomass crop-legume intercropping

Intercrop is defined as the cultivation of two (or more) species in the same space and for a significant time. As legumes are able to fix nitrogen from the atmosphere, they could play a major role to reduce N fertilization of annual and multiannual energy crops if they are grown with them. As a result, grass-legumes intercrop, already used for various purposes such as grain production and forage production, could be interesting for bioenergy production. Two experiments were set in the North of France to assess the performances of various grass-legumes intercrops. They included annual winter crops (triticale with pea, vetch or red clover) and multi-annual crops (e.g. tall fescue with alfalfa). Results showed that intercrops, even without N fertilizer application present higher yields and lower environmental impacts than sole crops. They generally showed higher economic and energetic efficiency compared to sole crops. Indirect and direct CO2 emissions are also in favour of intercrops. Lastly, intercropping grass with legumes did not affect the yield of the following crop (winter wheat in the experiment) compared to sole crops. An SRC intercropping experiment was also established, by growing Eucalyptus with a legume tree (black locust). At the end of the first year, the survival rate reached 87% and 81% for Eucalyptus and black locust respectively. Eucalyptus showed a smaller height than black locust the first year of growth but this relative difference decrease during the second year. Lastly, the SRC intercropping did not affect the height of both species.

4. Use of biomass pre-conditions residues as fertilizers

Giant reed is a promising perennial crop for bioenergy, given its high yield potential under reduced level of inputs and rainfed conditions. A pot experiment with giant reed was established to test the use of liquid residues from wet torrefaction of biomass for fertigation. The aim of this experiment was to test the effects of two liquids (prewash residues (PW) and Torwash residues (TW)) on the growth of giant reed and on soil properties and leached water quality. Main findings showed a lower aboveground biomass in TW, probably due to the limited evapotranspiration of plants, which responded to stress by increasing the production of roots. As a conclusion, while the PW could be used for fertigation and restoring the K content in the soil, the TW seems to not be suited for fertigation and its high content of volatile fatty acids suggests a better reuse for other applications (i.e. anaerobic digestion).

5. Design of innovative cropping systems based on biomass crops

Two design workshops involving local experts and scientific experts were organized in the supply area of the two case study of the Logist’EC project: the first was held in Dijon (France) in March 2014 and the second in Miajadas (Spain) in December 2014. For the Bourgogne Pellets case study in France, the main goal that the cropping systems needs to fulfil is to decrease the greenhouse gas emissions by 75% compared to the most widely practiced cropping systems (with an oilseed rape-wheat-barley crop sequence). For the Miajadas case study in Spain, two goals were identified with the local experts: saving water and energy (by 50% compared to the cropping system practiced in the study area, i.e. involving a maize-tomato crop sequence).

Four cropping systems including Miscanthus x giganteus as an energy crop were designed for the Dijon plain and one cropping system was designed for irrigated land in the supply area of Miajadas. In the Dijon plain, the cropping systems designed achieved good results regarding environmental and energy indicators, mainly because Miscanthus x giganteus requires low quantities of N fertilizer and pesticides, and stores carbon in the soil. However, a trade-off needs to be found among (i) environmental and energy impacts and (ii) profitability and food capacity. In Miajadas, including rainfed crops (such as cereals) allowed to achieve the goal previously defined about water savings.

Regarding harvesting and handling (WP2):

A thorough review of possible harvesting options for short rotation coppice and energy grasses was completed. Although data existed prior to the project beginning there was no study of the complete harvest system, including the implications for post-harvest management. In addition, much of the available information was in what was described as the grey literature (sales materials and farming papers) leading many to question its accuracy.

1. Energy Grasses.

In the UK it was possible to harvest the energy grass Miscanthus with a conventional forage grass mower and baler. This was efficient and employed machinery already in ownership that would have otherwise been idle at that time of year. Larger scale growers and contractors found the combination too slow and preferred to utilise self-propelled forage harvesters and larger balers more often used for cereal straw - again deploying machinery not normally utilised at that time of year. The exceptional yield of the 2014 season proved very challenging for the forage grass machinery and highlighted its limitations. It was not able to break the long stiff stems into short enough pieces to allow the baler to operate satisfactorily.

Bourgogne Pellets were able to provide excellent insight into alternative methods of utilising a self-propelled forage harvester to cut Miscanthus. Cutting the crop into very short lengths with the forager allowed the baler to produce bales of greater density, but it was found that these bales were more prone to falling apart when being handled. Blowing the cut and chipped Miscanthus from the forager into trailers and storing loose in barns was shown to be cost effective if transport distances were short. The packing density within the trailers was too low for long distance transport.

In Italy a private partner of the project (Nobili) designed and built a mower / mulcher that replicated the cutting of heavy energy grass crops by a forage harvester, but at much lower initial capital cost. This opens the opportunity of accessing suitable cutting machinery where self-propelled forage harvesters are unavailable.

This harvest system was studied in depth, using several configurations involving one to three passes on the field. Overall it proved more efficient than current alternatives, and produced bales of a relatively high density which is also more efficient for transport.

2. Short Rotation Coppice.

There were more options available for harvesting short rotation coppice than for energy grasses. These machines resulted in a different products being removed from the field; bales, wood chips, billets and whole stems (rods). Not all are immediately usable for bio-energy and so it was decided to make each harvested product into the most widely accepted product for end users: wood chips with a moisture content under 30%.

Several machines were discounted at the stage of clearing the field of the standing crop. One was slow to operate and left a large number of bales to be handled (Bio-Baler), two others lead to prohibitive capital and depreciation costs (a sugar cane harvester and a forestry brash bundler). All three harvesters would also have required post-harvest processing to produce the wood chips demanded by the end users, and were not considered further.

Alternatively, three versions of forage harvester were investigated. A very small machine designed to be affordable for purchase by small scale growers in more isolated areas (where contractors would be too expensive) was expensive to operate due to very low work rates. A medium scale cutting head fitted to a smaller self-propelled forage harvester, developed and demonstrated within the project by one of the partners (CRL), proved an attractive alternative to the large scale head and forager operated as a contract machine by them. The lower capital cost of header and forager did not result in a large reduction in work rate.

The alternative to a forage harvester was a whole stem or rod harvester. This cleared the field very efficiently, but left stems of up to 8m length in heaps around the field margins. Of all the machines tested this was the least usable product and therefore required secondary processing. Wood chips produced by a forage harvester are generally around 50% moisture content. On farm storage is thus necessary in general, over a 6-month period. Storage tests showed this allowed drying to under 30% moisture in most cases, but at a loss of up to 20% of the total dry matter in large storage piles. When similar measurements were made of smaller piles (1 tonne each) of whole stems around the field margins, the losses only amounted to 5%.
However, the rods still needed to be chipped. This involved handling them again and the energy required to chip the dried rods was twice that required to chip when fresh. A whole system (clearing the field plus post-harvest management) analysis was carried out looking at financial, greenhouse gas and energy costs of the forage harvesters and the whole stem harvester. The medium and large scale forage harvester systems were the preferred options on all three criteria.
One additional factor not considered in the analysis is that at the present time the whole stem harvester is the best option on wet sites. They are available on tracks and carry the harvested load to the headland themselves, avoiding adding trailer traffic to the field as with the forage harvesters.

3. Harvest timing

There are advantages to having a long harvest window: allowing each machine to cover more fields in a season thereby reducing costs, adding flexibility to a system that relies on harvesting at non-conventional times when the weather may be poor, reducing the on farm storage time or diversifying the potential markets.

In Italy a wide range of harvest dates for giant reed were investigated. This included cutting twice each year, in summer and again in autumn. Despite running machinery over the field twice the system was attractive, especially for anaerobic digestion where the more digestible crop increased gas yields.

As energy grasses mature in autumn and into winter the dry matter yield declines. This is due to leaf loss and some decomposition of stem material. Harvesting early offers the chance to capture the greater yield, but requires that the greater moisture content be dealt with. In Italian conditions it was possible to cut and dry Miscanthus in the field in September. This was much less reliable in the UK, however, September harvesting was pursued for anaerobic digestion (where high moisture content is acceptable or desirable). A separate study successfully preserved September cut Miscanthus as silage for later feeding to an anaerobic digester. Gas yields were only moderate.

Cutting green crops with leaves still attached removes many more nutrients from the field than leaving until late winter when a fully senesced crop may be harvested. Those nutrients contained in the biomass are also considered a negative impact on fuel quality for combustion, but they are of little consequence in anaerobic digestion, and can be returned to the field in digestate. Cutting early affects the translocation of nutrients and especially carbohydrates to the rhizome. This may have implications for regrowth the following year.

A set of studies of the effect of autumn harvesting on subsequent yields revealed some variability in response. Nitrogen and other elements may be added to the system through fertilisers. In France yields appeared to decline after 4 years of autumn harvest without additional N applications. In the UK, yields were severely reduced after 2 years of autumn harvests even with additional N applications. However, crops showed relatively rapid yield recovery after a further 2 years of late winter harvests, suggesting that alternating harvest time may allow capture of a greater total yield over a longer time scale if a market for anaerobic digestion and combustion existed in the local area.

A small study of the effect of cutting short rotation coppice willow late in spring, after bud burst and leaf emergence, and in mid-winter showed large scale differences in regrowth in the first 2 months after late spring cutting that disappeared completely later in that season. After 2 years there was no significant effect on yield.

Regarding biomass densification and pre-treatment (WP3):

The focus of this work package was on the conversion of biomass from energy crops into a densified product to improve the logistics, handling and storage. This approach allows for the decoupling of biomass availability and use in time, scale and location.

1. Densification of untreated energy crops

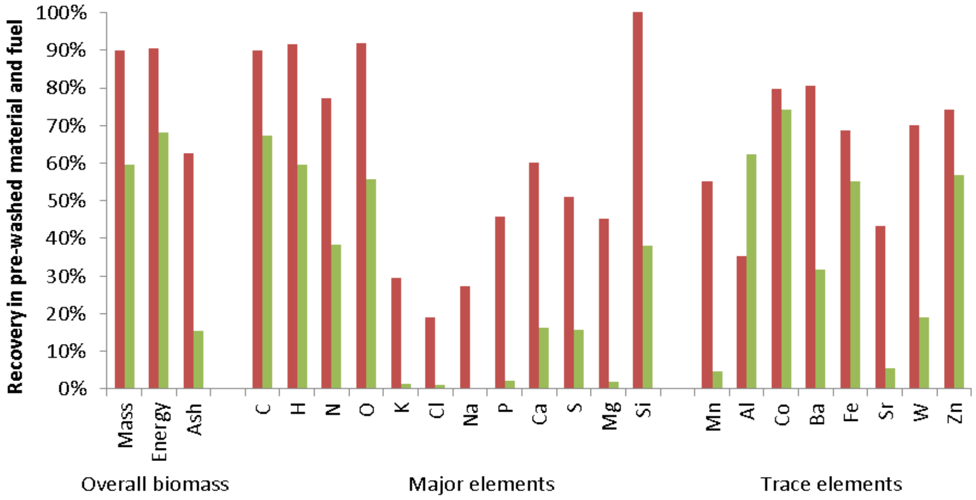
A single-pellet press was used to study the pelletization properties of seven different kinds of biomass (triticale, fescue, sorghum, Miscanthus, fresh Miscanthus, willow, alfalfa) and to determine the best production conditions to obtain high quality pellets. Results showed that Miscanthus at fresh state was not suitable for pelletization due to its high moisture content. The quality of the pellet was measured by its density because this ensures a better durability. Densities between 1126 and 1233 kg/m3 were obtained for the tested biomass samples at an optimum moisture content of 10% and at a die temperature of 90ºC. The maximum pellet density that can be achieved is that corresponding to the plant cell wall density (1420-1500 kg/m3).

The influence of press channel temperature (also referred as ‘die temperature’) on the friction during pelletization was measured for above mentioned biomass except fresh Miscanthus. All types of biomass experienced a sudden slope change when the die temperature increased to a certain level. In order to produce mechanically strong pellets with a high density, it is necessary to heat the die above this temperature prior to pelletization. Based on the results, sorghum can be pelleted at a die temperature below 60ºC, triticale and fescue require temperatures above 60ºC and Miscanthus, alfalfa and willow require a die temperature over 90ºC. When pelletization triticale and fescue in a bench-scale rotating pellet mill, steady production was found at a die temperature which is in the region where friction decreased with die temperature. In this case pellets with a density of 1135 kg/m3 were produced for triticale and 1182 kg/m3 for fescue. These densities are slightly higher but in good agreement with those found using the single pellet press (1126 kg/m3 and 1178 kg/m3).

The briquetting trials demonstrated that densities between 931 and 1152 kg/m3 were achieved for the biomass used (triticale, Miscanthus, sorghum and willow) at different die temperatures. The highest density achieved in briquettes for each kind of biomass was 1085 kg/m3 for triticale, 969 kg/m3 for Miscanthus, 1097 kg/m3 for sorghum and 1152 kg/m3 for willow. All these densities were obtained at the lowest die temperature considered. Thus, lower temperatures increase the friction and backpressure and result in a higher density briquette. However, higher die temperatures require lower power consumption. Depending on the location of the briquetting plant, in relation to the place where the briquettes are consumed, transport costs may be of a larger importance than power consumption for briquetting. A calculation for each specific project, comparing extra production costs to saved logistic costs (due to a higher density) and finding the optimum, would be necessary.

2. Densification of pre-treated energy crops

TORWASH is a technology that is under development at ECN for the conversion of herbaceous biomass into an attractive solid bioenergy carrier. The feedstock for TORWASH often combines three undesirable characteristics: 1) high moisture content, 2) high salt content, and 3) bulky and difficult to comminute. Herbaceous biomass is typically not suitable for direct utilisation as fuel for combustion or gasification. These fuels display an increased moisture content that corresponds to lower net calorific values, while the increased salt concentration – in particular potassium and chloride – can cause problems such as corrosion, agglomeration, slagging and fouling upon thermal conversion. Furthermore herbaceous biomass can result in issues during size reduction due to its flexible nature. Lastly, the bulky nature and the high moisture content result in relatively expensive logistics costs. By using TORWASH, all of these undesirable characteristics were drastically improved. The product of TORWASH is a solid bioenergy carrier with characteristics equal to those of torrefied wood pellets. Within the Logist’EC project Arundo Donax Giant Reed was successfully subjected to batch TORWASH experiments. The recovery rates during the pre-wash and TORWASH step are displayed in the figure below.



Mass recovery of Arundo Donax Giant Reed after pre-wash (red) & TORWASH (green)

TORWASH, also known as wet torrefaction, is a hydrothermal treatment step that is performed under pressure, at temperatures between 150 and 250°C. The treatment changes the structure by making the fibres brittle therefore the biomass becomes easy to mill. Simultaneously water that permeates the biomass dissolves most chloride and alkali salts. After the heat treatment, the biomass is mechanically dewatered, in order to remove the majority of the water and salts without the use of thermal drying. The combination of washing, thermal treatment and mechanical dewatering allows typical for salt removal rates in excess of 98%. The resulting pressure cake contains less than 35% moisture.

Untreated, torwashed and pelleted Arundo Donax Giant Reed

The combination of washing and TORWASH demonstrates a very effective means to separate combustible matter from ashes. The overall result is that 84% of the ash forming components from Arundo Donax Giant Reed are removed. The resulting ash content of 0.6 wt% is very promising and confirms that this is an attractive fuel. Based on the chemical composition the produced solid bioenergy carrier complies with the ENplus A1 standard, which is the most stringent standard for white wood pellets. The dissolved matter in the washing liquid and the TORWASH liquid are dissolved sugars and ash components, the sugars can be fermented to produce biogas to sustain the process, while the ash components can be precipitated.

Torrefaction is a thermochemical process that finds its roots in the roasting of coffee beans and gives coffee its characteristic flavour. For biomass, it is used as a pre-treatment process in the typical range between 250-300°C in order to upgrade the biomass and convert it into a high-value solid bioenergy carrier. The chemistry behind torrefaction involves mainly the removal of oxygen from the biomass structure after exposure to a hot, inert atmosphere. This causes the biomass to transform into a hydrophobic, homogeneous and dense solid energy carrier, which typically contains about 70% of the mass and 90% of the energy initially present in the biomass. Torrefaction side-products are vapours and gases which can be combusted to generate process heat, creating a self-sustaining overall process. The torrefied product can be further processed into densified pellets or briquettes obtaining a high-quality product adjusted to logistics and end-use requirements.

Chipped Willow and Triticale pellets were successfully torrefied at the ECN pilot torrefaction plant with a throughput of approximately 50 kg/h. It should be noted that torrefaction, unlike TORWASH, does not typically result in ash removal; the volatilisation of some organic matter normally results in a slight increase of the ash content. The torrefied Willow was successfully briquetted by CF Nielsen, although briquetting of pre-compacted materials proved to be more difficult. The pre-pelleted torrefied Triticale was successfully densified in ECN’s lab-scale pellet mill, as displayed below. This figure indicates that the volumetric energy density of bulky biomass streams can be significantly increased through torrefaction and densification.

Untreated Willow and torrefied Willow briquettes (left) and pre-pelleted Triticale and torrefied Triticale pellets (right)

3. Transport, handling and storage testing

The moisture content is the main control parameter during storage and based on this, the storage strategy to follow is defined in order to avoid material degradation and dry matter losses.

Regarding traditional herbaceous crops such as cereal, where bales are the main handling unit and the biomass moisture content decreases to low values prior to harvesting, densification treatments are perhaps not interesting enough. In this case the discussion is focused on the best way to store the bales in order to avoid water increase resulting from rainfall. The use of warehouses forms a good alternative when the storage costs increase is lower than 7 €/tonne. Moreover, in the tests conducted with small amounts of biomass, it was verified that dry matter losses are lower during indoor storage conditions compared to outdoor storage.

When the biomass moisture content at harvesting is higher, which is the case with SRC or spring herbaceous crops like sorghum, it is necessary to focus on adequate drying processes in order to control dry matter losses. In the case of poplar storage under Mediterranean weather conditions, both whole logs and chips moisture contents decreases from 45% to 10%. However, chips appeared more susceptible to degradation, which warrants a proper management of the chips pile to control auto fermentation processes. Sorghum is known as a difficult biomass in terms of handling and storage, since it is very complicated to achieve low moisture content prior to bailing. Therefore the biomass losses during the storage stage are high, in excess of 30% of the total amount of biomass stored during 6 months of the tests.

The behaviour between “fresh” untreated and treated biomass concerning moisture content is very different. The moisture content in untreated biomass is high at the beginning, showing a decrease under appropriate storage conditions. Conversely, treated materials shows a very low initial moisture content, while after treatment the sample gains some moisture until the equilibrium moisture content is reached.

Untreated biomass briquettes stored outdoors and exposed to rainfall lose their shape in a relative short time. Thermochemically treated and densified biomass, such as torrefied pellets that is stored outdoors, also suffers somewhat from adverse weather conditions, although to a much lower extent than untreated materials. The first small-scale Logist’EC tests demonstrated that torrefied biomass needs to be densified afterwards (as pellets or briquettes) to ensure better weather resistance.

From these tests it is concluded that thermal pre-treatments do not convert biomass into a hydrophobic material, although it significantly hinders water uptake and improves biomass storage features during much longer timeframes than untreated biomass. Furthermore, downstream densification is required to increase the volumetric energy density. It was proven that the untreated material that was only densified through pelletization does not resist rainfall. However, it should be noted that the scale of the experiments conducted in this study was small, with nearly all the material constantly exposed to weather conditions. Further optimisation of torrefaction and densification of triticale and willow is therefore deemed possible.

Regarding systems integration and sustainability assessment (WP4):

1. Methodology and models for assessment

Assessing the performance of logistics chains based on a comprehensive set of sustainability criteria and identifying points of improvement was at the heart of the Logist’EC project and one of its major research objectives. A holistic framework was developed to integrate chain components and assess the environmental, economic and social impacts of biomass supply chains based on the two case-studies of the project in Burgundy (France) and Miajadas (Spain). The framework enables an economic optimization of the supply chains and an overall sustainability assessment of technical and management options, also comprising environmental and social aspects, making the most of the progresses achieved in the logistics components.

As part of the framework a novel feedstock model with a high spatial resolution was developed to predict the most probable location of future fields planted to energy crops, in the vicinity of the biomass conversion plant, based on landscape features as well as yield potentials and farmers' survey data. The model produces maps of energy crops fields and yields for a given production target and maximum transportation radius from the plant, which were used in the economic optimization.

The developed mathematical programming supply-chain model integrates and optimizes the logistics system by choosing among different technology and management options including transport routes, storage sites, pre-conditioning and processing technologies (e.g. pelletization or briquetting), harvesting (cutting date or type of technology used), and feedstock type. Transportation distances are calculated with real road data, and the model can deal with certain kinds of uncertainty.

In terms of environmental sustainability, biomass logistics chains were evaluated using Life-Cycle Assessment (LCA), which is widely used for regulatory purposes for bioenergy chains. A complementary method to LCA, Emergy Assessment was used to estimate the environmental support provided by nature and society to the system under study (biomass supply chains in this case). The social and economic dimensions influence supply chain development and impacts on society were also in focus.

Most biomass logistics systems are located in rural areas where there exists a trend of declining agricultural employment. Therefore, any new economic activity in rural areas is likely to generate new jobs as well as stimuli for the local and regional economy. To estimate the total impacts (direct and indirect effects) of biomass supply-chains on the economy as well as job creation and the increase in demand for goods and services, the Input-Output methodology was used. In addition, a qualitative social sustainability assessment combining perspectives from institutional theory, supply chain management and innovation studies was developed and applied to the Miajadas case.

2. Case studies

In the case-study involving Miscanthus biomass in Burgundy, the economic optimization model simulated the flows of three harvested products – chips and bales as long and short strands – through transport, storage up to the sales of the end-products: chips, bales as short strands, pellets and briquettes. Simply expanding Miscanthus cropping areas and biomass consumption appeared neither a cost saving nor an environmental-friendly alternative to the current situation, due to the increase of transportation distances and storage lengths. This means that the concept of economy of scale did not apply here, but on the other hand costs and environmental impacts per tonne of biomass delivered did not increase as the biomass supply expanded.

By contrast, allowing innovative technologies such as decentralized briquetting with a mobile facility led to an increase of the overall profit up to +75% and a 15% reduction of climate change impact. At field gate, harvesting in autumn led to significantly higher climate change impact (+30%) due to the need for nitrogen fertilizers to compensate for fewer nutrients stored in rhizomes. However, at plant gate, such increase is compensated by a reduction of transport and storage leading to a climate change impact increase of only +5% and a significant increase of the profitability (+50%).

The case based on the Spanish Miajadas Biomass (energy) Plant (MBP) is quite different from the Burgundy case. While Miscanthus is the only feedstock for the Burgundy Pellets plant, the MBP has been using approximately 20 different species fuelling power generation, including herbaceous and woody residues. The analysis of the MBP case takes into account a new regulatory framework enforced in 2014, after which special subsides for energy crops came to an end, and power tariffs earned by MPB no longer depends on the type of feedstock used. Thus, additional costs for energy crops have become a barrier rather than a reason for differentiated incentives in the bioenergy sector. Accordingly, the economic assessment of the MBP case has focused on the costs of using dedicated energy crops as fuel, and to contrast the use of energy crops to the use of agricultural residues for the herbaceous part of the feedstock supply. With the given purchase costs for straw and stover the energy crops (i.e. triticale, sorghum and poplar SRC) are not competitive without dedicated subsidies. Energy crops appear to be more than twice as expensive as a fuel source compared to straw and stover. The average costs differ less than 5% between triticale and sorghum. SRC poplar seems to carry the highest costs, which appear to be related to the fact that irrigation is required – at least for the demonstrations carried out at Miajadas.

Two methods for environmental sustainability assessment reached different conclusions. When agricultural residues are included as feedstock, the estimation of environmental impacts using LCA do not include the impacts related to producing the crops. In the emergy assessment on the other hand all the resources used for the crop production are included as the residues would not be available without this input. This difference implies that the use of residues (straw and stover) appear to be very superior compared to the energy crop scenarios in LCA but not in the emergy assessment. Regarding energy crops, none of the investigated species (sorghum, triticale, poplar SRC) clearly out-performed the others.

Regarding socio-economic quantitative impacts, using purpose-grown energy crops will generate somewhat higher impacts than agricultural residues, certainly in line with the fact that energy crops carry higher costs than residues. The multiplier effect in the case of energy crops is 2.17 and 1.99 for the straws scenarios, (Thus, the total economic effect of increased sale of 1 € of biomass to the plant is an additional 1.17 or 0.99 € due to spill over effects – in total 2.17 and 1.99€). While costs for supplying energy crops are approximately twice as high as market prices for residues, the multipliers differ just about 10%. The qualitative assessment indicated that biomass energy production in the Spanish case has had significant positive impacts. Stakeholder interviews highlighted socioeconomic benefits; in particular local employment creation, rural reactivation, economic diversification, and increase in local investments. They also indicated that there are positive impacts in terms of preservation of natural heritage and environmental awareness. On the other hand, institutional relations, and especially the change in national energy price regulations, have limited the potential for growth and innovation. A key challenge currently is to build renewed trust in the market for biomass. Governance aspects appear critical and should be considered in more details in the social sustainability of bioenergy projects.

The most striking result when comparing the 2 case-studies involves the cost of biomass procurement. Producing, harvesting, storing and transporting the Miscanthus to the plant in Burgundy amounts to a cost of approximately 70 € per t dm. The cost for supplying triticale, sorghum and SRC poplar biomass to the MBP in Miajadas is approximately twice as high. This may be due to lower biomass yields for rainfed crops in Miajadas, compared to Burgundy, and larger input requirements for annual crops in general, compared to perennial grasses. Finally, Miajadas involved much longer transportation distances than the local value-chain of Burgundy.

Regarding demonstration and pilot-scale tests (WP5)

The demonstration activities held in WP5 served as a very interesting platform to study different cultivation and harvesting techniques for energy crops under real operational conditions. It helped test new or improved technologies in the logistics chains under different conditions. Based on the results obtained, stakeholders gained a more realistic view of the new systems developed in the project. As was seen in these trials, it is very important to take into account the different variables which can affect final result, such as harvesting machinery, baling techniques, and transport.

These demonstrations involved various types of biomass feedstocks, and in 4 different European countries (Spain, France, Italy and UK):

- Herbaceous annual crops: sorghum, triticale and oats
- Herbaceous perennial crops: Miscanthus
- Woody SRC (short rotation coppice): poplar and willow

Therefore, based on the studied cases carried out during the Logist'EC project, here are main results achieved and some general recommendations that could be given to stakeholders for the different species studied.

1. Bio-electricity value-chain in Spain

Cereal-legume intercrops were tested at commercial scale in Spain in two different growing seasons, involving different treatments and nitrogen input levels. It appeared unpractical to recommend cereal-legume intercrops in this area since it did not result in an increase in biomass production compared to sole crops – as opposed to the pattern observed in the wetter and cooler climate of Northern France.

On the other hand, sorghum was cultivated during one season (2013/2014). Cultivation practises, harvesting and storage trials were held. Lower yields than estimated were obtained, 7,850 kg dry matter (DM)/ha, whereas yields in the 10,000-13,000 kg DM/ha range had been obtained previously in this cultivation region. This could be explained due to the bad weather conditions during the crop cycle (high rainfalls which caused waterlogged soils). Then, regarding storage trials of sorghum, relevant differences between the various biomass samples analysed are observed. This is due to the diverse characteristics that present the different parts of a fibber sorghum plant.

The use of an economic resources planning (ERP) tool to improve logistics chains in the power plant of Miajadas (Spain) was tested during triticale harvesting in spring 2013. This system provided valuable information for improving logistics chain, helping to optimize transportation routes and to cut supply costs. Also, the ERP Service was updated regarding new features like financial management, biomass tracking, storage monitoring and optimization, through a new Android application enabling feedstock positioning on a map and real-time quality and quantity management, including Spanish and French language implementation. These new features allow tracking of feedstock deliveries and may be used for economic optimization.

Demonstration of new poplar supply systems was done in Miajadas (Spain). It consisted of improved crop management, harvesting, storing and road transport for biomass from short rotation coppices during the 2013, 2014 and 2015 seasons.

Two different harvesting techniques were demonstrated for poplar SRC. "Biopoplar harvester", which is based in harvest and chip system, and a more conventional system involving a feller buncher harvester. The former can harvest poplar and chip it simultaneously, resulting in a higher efficiency rate when compared to the latter.

In 2014, storage trials of whole logs were performed, and in 2015 storage trials of the wood chip in piles at different heights were tested in the Acciona Power Plant at Miajadas (Spain). Moisture content of whole logs decreased from 47% to 11% at the end of the storage trials. In the case of wood chips, moisture decreased from 38% to an average value under 20%. Thus, poplar biomass dries faster when stored as whole logs rather than chips.

Also biomass losses were lower with whole logs than with chips, amounting to 16.5% and 20%, respectively. Regarding energetic characterization of the final product after storage, the ash content was lower in whole logs compared to chips.

In summary, to minimize dry matter losses during storage it is recommended to keep the storage of wood chips as short as possible and to use the chips as soon as they reach a moisture content compatible with boilers (under 25%). Storing biomass as whole logs should be preferred if the storage time is longer than 6 months.

2. Miscanthus-based value-chain in Burgundy

Demonstration activities at pilot-scale of a new supply chain for the perennial energy crop Miscanthus were held in Burgundy (Eastern France).

The demonstrations of Miscanthus harvesting and supply chain were made in collaboration with cooperative farmers (cultivation), machinery manufacturers (harvesting), fuel suppliers, management tool developers and end-users (quality requirements) and scientists (follow-up and analysis of the results). The area for the demonstrations covered at least ten hectares.

During the project various harvesting practises and different storage conditions were investigated. Besides, pelletization trials were done involving different operating conditions to optimize the process and products obtained.

Some of the main conclusions obtained from the different tests carried out during the project were:

- Miscanthus harvesting in one pass system increases productivity, saves time and thereby costs.
- The use of additives for Miscanthus pelletization increases production during the process and helps to decrease energy consumption, although pellet quality obtained is not of the highest standard since it has low durability (92-93%) and high ash content (> 2%).

Demonstration of harvesting system improvements for energy crops (sorghum and willow) was successfully carried out.

3. Harvesting systems

In the case of sorghum, a new harvester (WS 320 BIO) was developed for bale production and was tested in the field. In combination with the CBB 200 pre-chopper it produced very short pieces, which is good for obtaining heavier bales and optimize transport costs and logistics. Besides, bales with fine chips can also be used in different application like litters for a variety of animals and pets. Moreover, using the WS 320 BIO harvester in combination with a rake and the Krone Big Baler ensured a high throughput with fibre sorghum, especially when the crops are flattening on the ground due to atmospheric conditions (September being a wet period in Italy). The sorghum crop was harvested efficiently in this configuration with very little damage to the stools.

Modifications and improvements were successfully brought to a SRC willow header and its harvesting system platform. The header's good performance resulted in a quality of chip suitable for all applications and a throughput commensurate with mid-scale SRC production.

Regarding costs, the initial capital cost of the header is lower than the original large header, which was more attractive to smaller producers aiming at a local market.

4. Densification and pre-treatment of biomass

Concerning biomass densification, treated and untreated biomass were tested during the project. The advantages of different densification technologies were compared, but also of thermal pre-treatment (torrefaction and TORWASH).

Two different types of biomass species were torrefied in a pilot plant, namely willow wood and triticale pellets. The good temperature distribution in the torrefaction reactor during all tests performed resulted in an evenly torrefied product. The effect of the light grinding motion of screw conveyors on the durability of the triticale pellets after torrefaction was limited. Therefore, the amount of fines in the product bunkers was small.

The performed pilot tests successfully produced torrefied material from two feedstocks that were new to the pilot plant installation: 1.3 tons of torrefied willow biomass were produced, and more than 800 kg of torrefied triticale pellets were produced in a total of about 60 hours of plant operation. The torrefied materials were transported to a facility where the briquetting tests were realised.

Briquetting of willow was achieved at 101-110 kWh/ton power consumption, and a die temperature of 215°C. Briquettes were produced with a specific density of around 1200 kg/m3, and a bulk density of about 600 kg/m3. Additionally, the new concept of the developed prototype for chipping high-density briquettes was successfully demonstrated. Torrefaction temperature variance (250°C and 260°C) did not have a significant effect on performance or quality.

In the case of torrefied triticale pellets, several attempts were made in which process parameters were varied. However, it was not possible to press this material into a briquette. Reasons for this effect are either destruction of the triticale fibres during pelletization, which would provide cohesion in the briquette or the extensive decomposition of the lignin structure (that would provide the natural glue in the briquetting process). Anyhow, briquetting of the torrefied triticale pellets would not provide further advantage given their already high bulk density of almost 600 kg/m3.

Overall, the demonstrations on harvesting systems and densification provided data on commercial, operational conditions which could be readily used by biomass developers to select technologies and improve biomass supply chains. By definition the whole-chain analysis of the case-studies lead to practical conclusions specific to their particular configurations and settings. However, they may be deemed representative of two main business models around bio-based value chains today, in terms of scale and feedstock supply mix. Results on possible improvements in the chains, feedstock selection or crop management may be also readily transferred to value-chains using perennial grasses (from the Burgundy case) or a mixture of feedstocks (from the Miajadas case). The economic optimization model and the database on the performance of the technologies explored in Logist'EC appear as the most advanced building blocks of this transfer, together with the technical documentation produced and the results from sustainability assessments.

Please provide a description of the potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and the exploitation of results. The length of this part cannot exceed 10 pages.

Benefits for EU business, farmers and the industry

The overarching objective of Logist’EC was to provide a portfolio of high-performance technologies enabling the operators of current and future bio-based value-chains to optimize feedstock supply. All technological developments within the project were carried out with industrial partners, to speed up their transfer to market. Examples of direct transfer included the provision of arena for participating Finish enterprise MHG for network building and demonstration and development of the company's services and tools within the biomass logistics business. The Biomass Manager tool and mobile app offers improved efficiency regarding transport and feedstock exploitation, minimizing GHG emissions, better knowledge of feedstock availability and quality of stored feedstock. This IT tool is already used on a commercial basis for forest and agricultural biomass supply. Other examples involve equipment to harvest biomass. A SME participating to the project, CRL developed and demonstrated a medium scale cutting head fitted to a smaller self-propelled forage harvester, within the project by CRL (UK), proved an attractive alternative to the large scale head and forager operated as a contract machine by them. The lower capital cost of header and forager did not result in a large reduction in work rate. Another SME within the consortium (Nobili, IT) designed and built a mower / mulcher that replicated the cutting of heavy energy grass crops by a forage harvester, but at much lower initial capital cost. This opens the opportunity for farmers to access suitable cutting machinery where self-propelled forage harvesters are unavailable. Both harvesting systems are commercialized. Regarding the densification and pre-treatment of biomass, briquetting was adapted to a wider range of feedstocks by another SME partner to the consortium (CFN, DK), and demonstrated in an already existing semi-industrial pilot plant. Results from the case-studies of Logist'EC emphasized the interesting potential of this technology to save transportation costs.

Some of the tools and results from Logist'EC have not been commercialized yet but their potential for further exploitation and transfer is discussed in the last part of this section. Overall, the improved technologies resulting from Logist’EC benefitted the SMEs present in the consortium, and expanded their potential markets by broadening the range of feedstocks to which their technologies may apply. Such was the case with the extension of briquetting to grassy crops, for instance. This increased the potential of SMEs for sales and exports. The market for technologies related to biomass production and logistics has a high potential worldwide given the current push for bio-based products and the demand for lignocellulosic feedstock. The technologies developed here should apply to a large range of world regions. For instance, Miscanthus can be grown under temperate to subtropical climates, i.e. most areas in the world, as may other species tested in the project (e.g., poplar, sorghum).

Farmers were particular target end-users of Logist'EC, given the prominence of feedstock production on the overall performance of biomass supply chains. Logist’EC provided recommendations for farmers and advisors about the selection of species in relation to pedo-climatic conditions and the management of biomass plantations. New aspects such as the management of the destruction of perennial crops were investigated, resulting in practical guidelines to manage this part of the crops' life cycles. It should be useful to help farmers who have already grown Miscanthus x giganteus or Giant reed to deal with those. In addition, as the STICS model for Miscanthus x giganteus was tested under various pedoclimatic conditions it could be used to simulate the effect of various crop management options on the yield and on the environment. The model is available (at http://www6.paca.inra.fr/stics_eng) and may be readily used to optimize the management of Miscanthus.

In terms of cropping systems options to produce biomass, intercropping grass with legumes appeared to be promising way to reduce the use of N fertilizer inputs, hence improving the environmental profile of energy grasses. Residues from the torrefaction of grasses could also be used as an alternative to chemical fertilizers, in particular to restore the K content of the soil. However, some of these residues were better suited for other applications such as anaerobic digestion, which would provide additional amounts of bioenergy and extra revenues to farmers.

The harvesting system is a vital component of the overall agronomic package for any crop. Research such as that detailed above will help to guide farmers, avoid them making costly mistakes and add confidence that adopting such crops may work for their business.

Regarding the potential impact of Logist'EC on the bio-based industry, the demonstrations of two densification technologies (torrefaction and briquetting) were needed, as feedstock used (willow and triticale) are not commonly applied in torrefaction and, as such nor in briquetting of torrefied materials. Most development work up to now on torrefaction has focused on (clean) woody biomass streams. In addition, the briquetting of torrefied feedstock is far less developed than pelletization, while it may be relevant for energy crops to improve biomass properties prior to densification and transport (hydrophobicity, grindability, mildew), so that it could be handled in existing transport, handling and storage equipment. The pre-treatment and densification demonstrations in Logist'EC proved the feasibility of such combinations, which may be readily implemented in practice.

The knowledge and technologies developed in Logist'EC helped SME partners involved in the production, transportation and processing of biomass crops (Bourgogne Pellets, MHG or BioPoplar) to reduce their supply chain costs from crop cultivation, to harvest, storage and transport. Logist’EC provided a new optimization framework capable of dealing with uncertainties in both supply and demand with a dynamic perspective, resulting in more realistic and efficient supply scenarios. For instance, early harvest of Miscanthus and decentralized briquetting appeared as promising options to reduce costs and transportation distances in Burgundy, and could be easily implemented using the technologies developed in Logist'EC. From a sustainability viewpoint, the new knowledge generated by the project on the impacts on soil organic matter and greenhouse gas (GHG) balances of energy crops contributed to enhance the quality and performance of these feedstocks.

Ensuring a reliable and sustainable supply of feedstock is a key enabling factor for bio-energy/bio-materials value chains, as evidenced by the fact that the European Industrial Bio-energy Initiative placed 'feedstock availability' as a critical complementary activity to its core actions on biomass conversion pathways. Logist’EC examined prospective upscaling for the 2 case-study bio-based value chains, as may be anticipated for the production of second generation biofuels. Along with the outcomes of the 'sister' projects EuroPruning and INFRES (dealing with supply chains from forest and horticultural residues), such studies will facilitate solving the challenges arising from large-scale logistics. Technologies developed in these projects can address key bottlenecks such as narrow harvest windows, inconsistent biomass quality or exceedingly long transport distances, and propose an optimal combination of these technologies and feedstocks. The research done in Logist'EC also guides end users, financiers and policy makers. It fosters confidence in those sectors that the whole bio-energy supply chain will work. To reach out to such actors and substantiate the progresses made possible with the project's outcomes, technical visits and meetings were carried out, where technological improvements were demonstrated, in particular for the harvesting machinery (involving willow SRC in the UK and sorghum in Italy). These activities have served as platform to show stakeholders how these modifications done to machinery can improve harvesting efficiency. Besides, these demonstrations and technical visits have served as a basis for the dissemination of the project results to actors of the supply chain (agricultural and pre-treatment industries, biomass project developers, biomass end-users, etc.). These workshops allowed a concrete display of the project outcomes under real operational conditions, thereby encouraging the industry to adopt these developments for broader application in different countries.

Besides technological progress, improving business models and ensuring the quality of business analysis is most important and will enhance sustainable investments in the bio energy sector and therefore foster and develop the bio-energy market in Europe. As part of Logist'EC activities, the Norwegian enterprise MRBB has strengthened its network, improved its competence and services with regard to the bioenergy sector, and strengthened the company's ability to contribute to future research and development of the bioenergy business. The ERP tool developed by another partner (MHG) also facilitates the advent of new business models based on outsourcing and information sharing in real-time operations, to enhance networking among small biomass producers and trustworthiness with end-users.

In general, Logist'EC pointed at potential gains in efficiency whether at supply-chain level or in their individual components. Some of these were substantial, such as the productivity gains from harvesting grasses in the autumn, the use of crop mixtures or the densification of biomass prior to transport. According to the references produced in the project, an optimization of these chains would result in a 10% to 20% reduction in biomass supply costs and GHG emissions over Europe. This may imply large savings for procuring biomass for the bio-based industry. For instance, assuming energy crops will occupy 10 Mha in Europe in the medium term, in response to targets set by the EU in the energy sector, would imply the delivery of over 100 Mt biomass every year. Improved logistics would thereby save about 700 M€ in procurement costs and 1,000 Mt CO2 eq. in GHG emissions, according to our results.

Economic and societal impacts

The project has shone light on the socio-economic impacts of biomass supply chains at different levels - documenting and communicating them to a broad set of stakeholders. In general, costs of biomass feedstocks, transport costs (as energy crop fields are scattered), and missing or immature markets for bioenergy products are identified as the main barriers. Briquetting and autumn harvesting of Miscanthus seem to carry a potential for improved environmental and economic sustainability with positive socio-economic impacts. The industry can offer innovations, and local actors are ready to participate and invest in biomass production, but the development of the bioenergy industry appears to be dependent on predictable and supportive frameworks.

Results from Logist'EC will contribute to increase the competitiveness of feedstock producers and suppliers in Europe through a reduction of the logistics costs. Selecting the species most adapted to the local context and by following the best management practices recommended by the project will decrease costs per ton of dry matter produced. A database on energy crop yields was elaborated in the project, and could provide guidance in this respect. It was made freely available and could be updated with additional yield data in the future. Recommendations were also provided regarding the storage of biomass, and the options available to minimize dry matter losses, which may reach up to 20%. For woody biomass, demonstrations highlighted the interests of storing whole logs compared to chips, with faster drying and 20% lower losses. This means a 4% increase in biomass output per ha, combined with a 50% reduction in moisture content which facilitates transport. These improvements will have a direct impact on the improvement of economic conditions at the farm level.

The development of small- to large-scale biomass conversion plants, as facilitated by the improved logistics delivered by Logist'EC and driven by ambitious policy targets for 2020 and 2030 in the EU, will create opportunities and markets for biomass producers and suppliers. This will likely result in a net creation of jobs in relation to these feedstock supply chains in rural areas. The empirical assessments done in Logist'EC demonstrate that activity in the biomass industry can stimulate the economy. In the case of Burgundy Pellets we found a multiplier effect equal to 2.44, meaning that any time 1€ of pellets from BP is sold to a consumer, the global economy will generate in addition 1.44€. In the case of MBP, results showed that the multiplier effect is approximately equal to 2. Both case-studies evidenced a net creation of jobs from the bio-based industries (with a ratio of around 1 job for 10 ha of energy crops), generated mostly within the countries in which the plants were located. This confirmed the relevance of these bio-based value chains to rural development and local economies.

A qualitative study on the social impacts of these projects lent voice to the experience and concerns of local stakeholders, thus highlighting the influence of governance factors and potentially expanding the discourse on the social sustainability of bioenergy chains. Another way to interact with stakeholder consisted of workshops to define and assess new cropping systems ex ante. This design activity represents a fruitful way to raise discussions among local experts and scientists on the way to deal with ambitious goals at the cropping system scale, and to identify research priorities by pointing knowledge gaps on the agroecosystem. Overall, the project highlighted key enabling conditions for the actual implementation of bio-based chains, among which community engagement and public perception.

Sustainable development requires that environmental, societal and economic aspects are taken into account in a holistic way. In Logist'EC we have developed a methodology for optimisation of logistical biomass chains and demonstrated how to integrate the three aspects in a joint assessment. This has been challenging since experts from different disciplines have specific traditions and procedures. Nevertheless, in the future, such collaboration will be increasingly important to ensure correct assessment of impacts and a real sustainable development. Indeed, the project has contributed to improved interdisciplinary understanding, knowledge building and networking. A number of scientific contributions has been made – in form of papers and conference presentations.

In practical terms, Logist'EC issued a framework to associate quantitative sustainability criteria with the biomass delivered at the plant gate, as estimated by the integrated supply chain model. This can create an added-value for the resulting bio-products, ensuring for instance their compliance with sustainability criteria put forward in the renewable energy and fuel quality directives of the European Commission. For instance, regarding GHG emissions, the options tested in the various steps of the logistics chains were combined and pointed at potential savings of up to 20% compared to the current business-as-usual operations of the chains, overall. Savings may be higher when selecting particular options in some chain components. For instance, the densification of biomass, both untreated and (hydro)thermally treated, is essential to facilitate efficient logistics, storage and handling. Solid sustainable bioenergy carriers allow for decoupling between biomass availability and use, in time, scale and location. This is expected to contribute to further reduce fossil fuel related CO2 emissions by facilitating the increased use of biomass. Biomass pre-treatment and densification, as was successfully demonstrated in this project, results in bioenergy carriers that are more biologically stable and have a drastically higher volumetric energy density. These characteristics lower greenhouse gas emissions during the entire supply chain by reducing biological degradation, transport movements and parasitic energy use during handling (transhipment, milling, etc.). This allows the sustainable use of elongated logistic chains, which increases both biomass potential and opportunities for use.

Combined with the maintenance or enhancement of soil carbon stocks, following the findings and recommendations of WP1, the improved logistics delivered by Logist'EC will therefore be decisive in the compliance of biofuels with the mandatory 50% reduction compared to fossil fuels set by the RED Directive for 2017. The latter will be all the more stringent for this emerging biofuel industry that indirect land-use change effects may have be taken into account, which would increase the GHG burden of biomass. Improvements in logistics will also be beneficial to other impacts such as eutrophication, acidification or photochemical ozone creation.

Environmental labels or green certificates offer other possible routes to value the sustainability performance of the chains and to give locally-produced biomass an advantage in the competition with imported biomass.

Relevance to EC Policy

Energy crops offer a number of very important services to society as a whole, in line with several EU policy targets: they contribute, along with other renewable energy sources, to longer term energy security, they offer business diversification opportunities for farmers, in so doing introduce biodiversity to the landscape and provide further eco-system services, introduce business and employment opportunities for energy suppliers and of course most importantly contribute to limiting the detrimental effects of climate change.

In current times policy often attempts to avoid regulation, preferring industries to self-regulate. It is important that robust independent data is made available on which to base any regulation or certification scheme for an emerging industry. Data on cost, greenhouse gas emissions and energy consumption are vital to a whole system Life Cycle Analysis and this research adds much to the harvest and post-harvest management section of that analysis. To achieve the energy, business and climate changes benefits listed above there must be a strong evidence base.

In line with this requirement, Logist'EC developed and successfully applied a methodological framework to derive sustainability criteria for biomass supply chains that is consistent with the criteria put forward by the Fuel Quality and Renewable Energy Directives (FQD and RED, respectively). Actually, the framework provides more categories of criteria and may be used to extend the scope of these Directives in terms of sustainability. This methodology and the resulting indicators may be readily used by bio-products manufacturers to comply with certification schemes gradually put in place by Member States for bio-energy and biomass. Logist'EC brings R&D support for implementation of the Strategic Energy Technology

(SET)-plan by addressing a key barrier on the availability of suitable feedstock to meet the 20% renewable energy target of 2020, expressed in the RED directive and the Climate Energy package of the EC. The revised SET-plan issued in 2014 mentions the development of sustainable biomass supply chains as a key challenge in terms of industrial research and demonstration. The whole-chain case-studies of Logist'EC are directly relevant to this line of work.

Logist'EC also contributes to the bio-economy strategy of the EC by fostering the supply of biomass from energy crops. Such crops are considered as a potential lever for rural development, in particular through the recently launched European Innovation Partnership scheme on 'Agricultural Productivity and Sustainability'. It aims to “foster competitive and sustainable farming and forestry that 'achieves more and better from less'” - and is a clear outlet for the knowledge and technologies generated in Logist'EC.

By seeking to reduce the GHG emissions of biomass supply altogether with preserving or increasing soil organic matter stocks, Logist’EC can make a contribution to the 20% GHG reduction target of the Climate Energy package of the EU, and to the 2030 mitigation targets put forward during the COP21 negotiation in December 2015. Since lignocellulosic crops emit less GHG than arable crops when properly managed, the deployment of several million ha in Europe would both decrease emissions from agricultural land and allow savings when substituting fossil energy sources with biomass. These savings will be further increased by the improvements in logistics chains highlighted by Logist'EC. These savings should still be mitigated by land-use change effects, but favouring chains that minimize the need for arable land will be a key principle in this project to reduce such effects and the competition with other end-uses.

Added-value of European level

Being based on a European rather than national consortium enabled Logist’EC to cover a broad range of climatic conditions, agricultural and industrial contexts, and feedstock types to produce results relevant to the EU and other major world regions. Its outputs are thus more generic and have a high potential regarding the exploitation and impact assessment of developing bio-based value chains. The project consortium leveraged the expertise of academic and private partners in the various disciplines necessary to carry out the project (applied mathematics, economy, agronomy, chemistry and process engineering, ecosystem sciences, and policy studies), which are not easily found within one country. It is evidenced by the fact that the SMEs taking part in Logist’EC, which are leaders in their own area of the logistics chains nearly all originated from different Member States. The project also took advantage of ongoing coordination initiatives at EU level, within the EERA Bio-energy joint-programme in particular. During the course of the project, the advantage of an EU-wide consortium were evident as problems with bad weather conditions in one zone of Europe could be compensated for by more favourable conditions in another zone, providing flexibility and resilience to the consortium. Dissemination activities were also boosted through the local and national networks of the various partners and countries, as were contacts and collaborations with other projects (EuroPruning and INFRES, but also RockWood, SECTOR, BIOBOOST, S2BIOM or FUTUROL, to name a few).

Impacts via the dissemination of project results

A work-package of the project was dedicated to communications aspects and to the spreading of Logist’EC key outcomes, several dissemination activities have been performed. Direct promotion through the organisation of workshops was one of the main ways to draw attention towards the project and its results and to touch upon “hot” issues and stimulate debates among stakeholders. The results of each workshop and each WP were then displayed on several communication tools, such as the Logist’EC website, and sent through mass e-mailing systems to our target audience.
The monitoring tools of the website and social media allowed us to capture the interest and visibility of the dissemination materials produced Logist’EC. We were able to see how people opened and read their e-mails related to Logist’EC progress, how many people downloaded the materials of interest on the website. Since August 2014, the number of Logist’EC website views has increased from 799 to 1007. The first 10 countries most engaged in viewing the Logist’EC website are: USA, France, Italy, Germany, Belgium, Spain, China, Japan and UK. The project produced a set of 12 fact-sheets on a broad series of topics involving the productivity, management and environmental of energy crops; the legislation pertaining to them; the pre-treatment technologies, or the selection of harvesting systems. These factsheets are based on project outcomes and were also a good indicator of its impacts: the most viewed factsheet was “Energy Crops in a Nutshell”, which was viewed more than 500 times over the project’s duration. Logist’EC best viewed article was “Miscanthus spatial location as seen by farmers”, which was viewed 813 times. In general Logist’EC factsheets recorded a total of 1939 active readers. As a result, the project created of an active platform on which more than 50 key publications were released, for a total of 12,000 active readers.

On a more specific level, project results were disseminated to the relevant stakeholder groups via scientific and technical conferences, and targeted events in connection with the demonstration sites. In particular, a joint workshop with the two 'sister' projects of Logist'EC (EuroPruning and INFRES) was organized in Valladolid (Spain) in October 2014, as part of the International Congress of Bioenergy. The workshop topic was “Advances in baling, storage, pelletization and torrefaction to increase the competitiveness of bioenergy” and it aimed to present the latest developments carried out by these research projects in the field of solid biofuels, amongst over 100 international stakeholders. This was followed up by press releases and articles in newspapers and magazines (The Government Document by Pan European Network, Bioenergy International), which has helped to reach a wider public.

Moreover a technical workshop was organised by Logist’EC and EERA Bioenergy, highlighting project results, and where strategic research agenda was drafted for pre-treatment technologies (also in collaboration with EU projects SECTOR and BIOBOOST). A press release on the successful TORWASH trials with Arundo Donax (giant Reed) by ECN generated a lot of exposure for Logist’EC. Project results were also disseminated through various conferences presentations, poster presentations and scientific journal papers.

Exploitation of project results

The project partners will further develop the foreground results in ongoing and future projects as well as in contacts with industrial partners. The latter holds for DTU and CF Nielsen with respect to pelletization and briquetting of untreated and (hydro)thermally treated biomass, but also for ECN with respect to torrefaction of herbaceous biomass (the first successful torrefaction test at ECN with herbaceous biomass triticale was conducted within the Logist'EC project), as well as TORWASH of agricultural residues.

The results of Logist'EC include a number of templates for collecting data and two databases including detailed information on crop production, transportation, storage and processing. Templates and data are available for further use by bioenergy developers or the R&D community. For instance the data bases were used in the FP7 project S2BIOM to test and demonstrate tools to design biomass supply chains, and data on machinery was fed into a larger database of this project, which is publicly available. Another result is the generic model for the optimization of bioenergy value chains. By making the model available both through publication and on the internal project workspace, the model can be of use by for example industrial decision makers and governmental policy makers. The model has already been utilized to study design and operation of integrated supply networks at the local and regional scale for woody biomass to energy production and the use of timber for energy and reduction in the melting industry in Norway. The model will also be considered for a new Norwegian project that evaluates the logistics of supplying biofuel plants with a variety of bio feedstocks.
Logist'EC has provided an arena for the participating Finish enterprise MHG for network building and demonstration and development of the company's services and tools within the biomass logistics business. The Biomass Manager tool and mobile app offers improved efficiency regarding transport and feedstock exploitation, minimizing GHG emissions, better knowledge of feedstock availability and quality of stored feedstock, new business models based on outsourcing and information sharing in real-time operations and enhance networking of small producers to become trustworthy to end-users to mention some important effects. As a result of project activities and networking a joint business proposal was submitted in March 2016 to Fast Track Innovation funding (Horizon2020). Also the Norwegian enterprise MRBB has strengthened its network, improved competence and services and strengthened the company's ability to contribute to future research and development of the bioenergy business.

Logist’EC was identified as a project with a high potential for technology transfer by the H2020 project BioLinX, which “supports participants in FP7 and H2020 projects to commercialize their innovative ideas, and to connect them to new markets and regional networks focuses on energy crop value chain technologies harvest and transport.”
Among the several innovations generated by Logist'EC, 3 that in particular may directly benefit from support by BioLinX:
- The briquetting technology (high TRL) – may benefit from improved access to private finance (equity/debt), via BioLinX partner Europe Unlimited.
- The torrefaction technology (Lower TRL) – may benefit from improved access to public funding (grants), via BioLinX partner PNO Consultants.
- Approach and Software (beta version) for software for multi factor comparison to improve the value chain for decision making – may benefit from being linked to further stakeholders both internal to the BioLinX consortium (via Regional Partners REWIN for South West Netherlands and SC for Northern Italy) or external via BioLinX partnering platform, database and events.

These are examples of potential follow-up and exploitation of project results.
Regarding end-users, farmers' cooperatives have expressed interest in the above technologies, in particular regarding pelletization and briquetting. Valbiom (in Belgium) is considering developing densification of Miscanthus biomass for medium-scale presses (with throughputs larger than 200 kg DM/h), while Coops de France (in France) is seeking to develop agro-pellets from perennial grasses. The latter project received funding from various public and private bodies for technico-economical studies and pilot-scale demonstrations.

Results and practical conclusions from the whole-chain case-studies may also be transferred to other bio-based value-chains, since they may be deemed representative of two main business models around bio-based value chains today, in terms of scale and feedstock supply mix. The economic optimization model and the database on the performance of the technologies explored in Logist'EC appear as the most advanced building blocks of this transfer, together with the technical documentation produced in the project's deliverables, and the results from the economic, environmental and social assessments.

Please provide the public website address (if applicable), as well as relevant contact details. An executive summary (not exceeding 1 page).

Project logo:

LOGISTEC
Logistics for Energy Crops Biomass

Address of the project public website: **http://www.logistecproject.eu/**

Relevant contact details:
Logist'EC Coordinator:
Prof. Benoit Gabrielle
INRA-AgroParisTech EcoSys, Université Paris-Saclay
78850 THIVERVAL-GRIGNON
Tel: +33 (0)1 30 81 55 51
E-mail: Benoit.Gabrielle@agroparistech.fr

Furthermore, project logo, diagrams or photographs illustrating and promoting the work of the project (including videos, etc…), as well as the list of all beneficiaries with the corresponding contact names can be submitted without any restriction.

4.2 Use and dissemination of foreground

4.3 Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:

Title of Project:

Name and Title of Coordinator:

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box) :	***No***
RESEARCH ON HUMANS	
• Did the project involve children?	
• Did the project involve patients?	
• Did the project involve persons not able to give consent?	
• Did the project involve adult healthy volunteers?	
• Did the project involve Human genetic material?	
• Did the project involve Human biological samples?	
• Did the project involve Human data collection?	
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	
• Did the project involve Human Foetal Tissue / Cells?	
• Did the project involve Human Embryonic Stem Cells (hESCs)?	
• Did the project on human Embryonic Stem Cells involve cells in culture?	
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	
• Did the project involve tracking the location or observation of people?	
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	
• Were those animals transgenic small laboratory animals?	
• Were those animals transgenic farm animals?	
• Were those animals cloned farm animals?	
• Were those animals non-human primates?	
RESEARCH INVOLVING DEVELOPING COUNTRIES	

• Did the project involve the use of local resources (genetic, animal, plant etc)?	
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	
DUAL USE	
• Research having direct military use	0 Yes 0 No
• Research having the potential for terrorist abuse	

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	**Number of Women**	**Number of Men**
Scientific Coordinator		1
Work package leaders		
Experienced researchers (i.e. PhD holders)		
PhD Students		
Other		

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	
Of which, indicate the number of men:	

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?

○ Yes
X No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
☐	Design and implement an equal opportunity policy	X	○	○	○	○
☐	Set targets to achieve a gender balance in the workforce	X	○	○	○	○
☐	Organise conferences and workshops on gender	X	○	○	○	○
☐	Actions to improve work-life balance	X	○	○	○	○
○	Other:					

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ Yes- please specify

○ No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

○ Yes- please specify

○ No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[1]: Agricultural , foretstry, fisheries and allied sciences

○ Associated discipline**Erreur ! Signet non défini.**: other engineering sciences	○	Associated discipline**Erreur ! Signet non défini.**: earth and related environmental sciences 5.2 Economics

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	○ ○	Yes No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

○ No
○ Yes- in determining what research should be performed
○ Yes - in implementing the research
○ Yes, in communicating /disseminating / using the results of the project

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

○ No
○ Yes- in framing the research agenda
○ Yes - in implementing the research agenda
○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
○ No

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[1] Insert number from list below (Frascati Manual).

13b If Yes, in which fields?

X Agriculture
Audiovisual and Media
Budget
Competition
Consumers
Culture
Customs
Development
Economic and Monetary Affairs
Education, Training, Youth
Employment and Social Affairs

X Energy
Enlargement
Enterprise
Environment
External Relations
External Trade
Fisheries and Maritime Affairs
Food Safety
Foreign and Security Policy
Fraud
Humanitarian aid

Human rights
Information Society
Institutional affairs
Internal Market
Justice, freedom and security
Public Health
Regional Policy
X Research and Innovation
Space
Taxation
Transport

13c If Yes, at which level?

○ Local / regional levels
○ National level
○ European level
○ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**20**
To how many of these is open access[2] provided?	**5**
How many of these are published in open access journals?	**?**
How many of these are published in open repositories?	**?**
To how many of these is open access not provided?	
Please check all applicable reasons for not providing open access:	
publisher's licensing agreement would not permit publishing in a repository ☐ no suitable repository available ☐ no suitable open access journal available ☐ no funds available to publish in an open access journal ☐ lack of time and resources ☐ lack of information on open access ☐ other[3]: ……………	
15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*	**0**

16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	**0**
	Registered design	**0**
	Other	**0**

17. How many spin-off companies were created / are planned as a direct result of the project?	**0**
Indicate the approximate number of additional jobs in these companies:	

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

☐ Increase in employment, or	☐ In small & medium-sized enterprises
☐ Safeguard employment, or	☐ In large companies
☐ Decrease in employment,	☐ None of the above / not relevant to the project
☐ Difficult to estimate / not possible to quantify	

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*

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[2] Open Access is defined as free of charge access for anyone via Internet.
[3] For instance: classification for security project.

Difficult to estimate / not possible to quantify	☐

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes ○ No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes ○ No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

☐ Press Release
☐ Media briefing
☐ TV coverage / report
☐ Radio coverage / report
☐ Brochures /posters / flyers
☐ DVD /Film /Multimedia
☐ Coverage in specialist press
☐ Coverage in general (non-specialist) press
☐ Coverage in national press
☐ Coverage in international press
☐ Website for the general public / internet
☐ Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

☐ Language of the coordinator
☐ Other language(s)
☐ English

***Question F-10*:** Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES
1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]
1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)
1.3 Chemical sciences (chemistry, other allied subjects)
1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)
1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY
2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)
2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]
2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as

geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. Medical Sciences

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)
3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)
3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. Agricultural sciences

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)
4.2 Veterinary medicine

5. Social sciences

5.1 Psychology
5.2 Economics
5.3 Educational sciences (education and training and other allied subjects)
5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. Humanities

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)
6.2 Languages and literature (ancient and modern)
6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]

2. FINAL REPORT ON THE DISTRIBUTION OF THE EUROPEAN UNION FINANCIAL CONTRIBUTION

This report shall be submitted to the Commission within 30 days after receipt of the final payment of the European Union financial contribution.

Report on the distribution of the European Union financial contribution between beneficiaries

Name of beneficiary	Final amount of EU contribution per beneficiary in Euros
1.	
2.	*Overall, the demonstrations on harvesting systems and densification provided data on commerical, operational conditions which could be readily used by biomass developers to select technologies and improve biomass supply chains. By defintion the whole-chain analysis of the case-studies lead to practical conclusions specific to their particular configurations and settings. However, they may be deemed representative of two main business models around bio-based value chains today, in terms of scale and feedstock supply mix. Results on possible improvements in the chains, feedstock selection or crop management may be also readily transferred to value-chains using perennial grasses (from the Burdungy case) or a mixture of feedstocks (from the Miajadas case). The economic optimization model and the database on the performance of the technologies explored in Logist'EC appear as the most advanced building blocks of this transfer, together with the technical documentation produced and the results from sustainability asssessments.*
n	
Total	